अखिल भारतीय समन्वित खरपतवार प्रबंधन अनुसंधान परियोजना

All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन

ANNUAL REPORT

2018-2019

भा.कृ.अनु.प.- खरपतवार अनुसंधान निदेशालय, जबलपुर

ICAR - Directorate of Weed Research, Jabalpur

ISO 9001:2015 Certified

AICRP-WM in the News

कांग्रेस घास पर्यावरण के लिए खतरा : डॉ. हुड्डा

कृषि विज्ञान केन्द्र में मनाया गया जागरुकता और उन्मूलन सप्ताह

अमर उजाला ब्यूरो

फतेहाबाद। चौधरी चरण सिंह हरियाणा कृषि विश्वविद्यालय हिसार की ओर से कृषि विज्ञान केन्द्र फतेहाबाद के प्रांगण में राष्ट्रीय खरपतवार विज्ञान निदेशालय के सहयोग से गाजरघास जागरूकता एवं उन्मूलन शिविर आयोजित किया गया। शिविर में कृषि विज्ञान केन्द्र के वैज्ञानिकों ने उपस्थित किसानों एवं हिसार से आए वैज्ञानिकों का स्वागत किया।

हरियाणा कृषि विश्वविद्यालय हिसार के वैज्ञानिक डॉ. विरेन्द्र हुड्डा ने बताया कि गाजर घास जोकि कांग्रेस घास के नाम से भी जाना जाता है, मनुष्यों, पशुओं के स्वास्थ्य के लिए गंभीर समस्या पैदा कर रही है। इस घास से मनुष्यों में त्वचा संबंधी रोग, दमा, खारिश आदि बीमारियां हो जाती है। इसके अत्यधिक प्रभाव से मौत तक भी हो सकती है। उन्होंने इसे नष्ट करने पर बल दिया। डॉ. सुशील कुमार ने कहा कि कांग्रेस घास एक खरपतवार है जो रिहायशी कालोनियों, सड़कों व रेलवे लाईन के किनारे खाली मैदानों में उगती है। पिछले कुछ वर्षों से इस घास का प्रकोप खाद्यान्न फसलों, सब्जियों एवं बागों में भी बढ़ रहा है। उन्होंने इस घास के जैविक नियंत्रण के बारे में जानकारी दी। इस अवसर पर डॉ. लख्यबीर बैनीवाल, डॉ. सरदूल मान, डॉ. संदीप भाकर, डॉ. संतोष कुमार ने भी किसानों के साथ अपने विचार सांझा किए तथा आग्रह किया कि इस घास का पूर्ण से उन्मूलन करें। शिविर में 50 किसानों ने भाग लिया।

कृषि विज्ञान केंद्र में आयोजित शिविर को संबोधित करते कृषि वैज्ञानिक।

जैविक खेती से ही किसान का जीवन बेहतर बन सकता है: सिंगला

गोरखपुर। देश के अन्नदाता की आर्थिक स्थिति डांवाडोल है। इसके पीछे अंधाधुंध छिड़काव व अधिक पैदावार लेने की स्थिति जिम्मेदार है। भारत का अन्नदाता केवल जैविक खेती के जरिए ही अपने जीवन को बेहतर बना सकते हैं। ये बात जैविक खेती विशेषज्ञ डा. प्रदीप सिंगला ने गोरखपुर ... डीएन माडल स्कूल में चल रहे एक दिवसीय ... कृषि कैंप के दौरान कही। उन्होंने कहा कि ... किसान को भी तरीके से 8 घंटे खेती ... नियमित रूप से लगाने चाहिए। ... बेहतर बना सकते हैं। ... कि दीमक के लिए आप 100 ग्राम हींग को बीज के साथ या पतले कपड़े में बांधकर ... के नक्के में रखें, आपकी फसल को दीमक ... नहीं लगेगी। ... के लिए 10 किलो चूल्हे या हारे की राख ... प्रति एकड़ में डालें। इस मौके पर जगदीश ... बिश्नोई, दयानंद सिवाच, जसवंत सिवाच ... फकीर चंद धायल, जिंदर ठोलेदार, ... सरपंच जग्गा जेलदार मौजूद रहे।

... के लिए भगवान के पट खुले रहेंगे। वहां ... खासगी बाजार स्थित मोटे गणेश जी मंदिर पर सुबह भगवान का विशेष श्रृंगार होगा। इसके बाद उन्हें भोग लगाया जाएगा और आरती होगी।

मांग जनसंघर्ष मोर्चा के जिलाध्यक्ष काशीराम कुशवाह ने की है। उनका कहना है कि जबसे गिरवाई थाना बना है कि इस क्षेत्र के सैनिक कॉलोनी, बिरगंईयों का पुरा, तांगा ...

गाजर घास से पशुओं के साथ मानव स्वास्थ्य को भी खतरा

कृषि कॉलेज में गाजर घास जागरुकता अभियान

ग्वालियर। गाजरघास न केवल पशु बल्कि मानव स्वास्थ्य के लिए भी खतरा है। गाजरघास विषैला पौधा होता है। चारों में पहुंचने पर पशु उसका सेवन कर लेते हैं। इससे दुधारू पशुओं का दूध कड़वा हो जाता है। इस दूध का सेवन मानव स्वास्थ्य को भी खतरा पहुंचाता है। इसलिए गाजरघास को जड़ से समाप्त कर देना चाहिए।

राजमाता विजयाराजे सिंधिया कृषि विवि की ओर से कृषि कॉलेज में गाजरघास जागरूकता अभियान के समापन पर अतिथियों ने यह बात कही। डॉ. वर्षा गुप्ता व डॉ. वाईके सिंह ने सप्ताह भर की गतिविधियों की जानकारी देते हुए किसानों व शोधार्थियों को बताया कि समय-समय पर इस तरह के कार्यक्रम आयोजित होते हैं। इसका लाभ किसानों को होता है।

... गाजर घास के दुष्प्रभाव बताएंगे विशेषज्ञ

... पुर (कांगड़ा)। मनुष्य और पशुओं पर गाजर घास से पड़ने के ... भावों को लेकर कृषि विश्वविद्यालय में 15 से 22 अगस्त तक ... क्रम आयोजित किए जाएंगे। इसमें लोगों को गाजर घास को खत्म ... ने और उसके दुष्प्रभावों के बारे में जानकारी दी जाएगी।

दैनिक भास्कर

पीकेवी में गाजर घास उन्मूलन के विभिन्न प्रात्यक्षिक

उपकुलपति ने घास में छोड़े मेक्सीकन भंवरे

नगर संवाददाता | अकोला

ଓଡ଼ିଏଟିରେ ଗାଜର ଘାସ ନିରାକରଣ ସଚେତନତା

ଭୁବନେଶ୍ୱର,୨୪।୮(ବ୍ୟୁରୋ): ଓଡ଼ିଶା କୃଷି ଓ ବୈଷୟିକ ବିଶ୍ୱବିଦ୍ୟାଳୟ ...

ଉଦଘାଟିତ ହେଲା ଟେକ୍ନୋ ପାର୍କ କଟେଜ୍

କୃଷକଙ୍କ ଦ୍ୱାରା ବିକଶିତ ଯନ୍ତ୍ର ପ୍ରଦର୍ଶିତ

ଭୁବନେଶ୍ୱର,୨୪।୮(ବ୍ୟୁରୋ): ...

लोकमत

कृषी विद्यापीठात गाजर गवत निर्मूलन सप्ताहाचा समारोप

अकोला, रविवार, दि. २६ ऑगस्ट २०१८

अकोला : डॉ. पंजाबराव देशमुख कृषी विद्यापीठात गाजर गवत निर्मूलन जागरु कता सप्ताह १६ ते २३ ऑगस्टपर्यंत पाळण्यात आला. या सप्ताहात कृषी विद्यापीठाचे सर्व कर्मचारी, विद्यार्थ्यांनी गाजर गवत निर्मूलनासाठी जनजागृती केली. गाजर गवतापासून मानवी आरोग्यास होणारे संभाव्य धोके तसेच पिकास होणारे नुकसान याची माहिती देण्यात आली. या सप्ताहात विविध पद्धतीचे ... रोजी या सप्ताहाचा समारोप डॉ. पंजाबराव देशमुख कृषी विद्यापीठाचे कुलगुरु डॉ. विलास भाले यांच्या हस्ते करण्यात आले. गाजर गवतावर उपजीविका करू न ते नष्ट करणारे मेक्सिकन भुंगे त्यांच्या हस्ते गाजर गवतावर सोडण्यात आले. यावेळी डॉ. एस.एस. माने, डॉ. बी.व्ही. सावजी, डॉ. सुधीर वडतकर, डॉ.आर.एन. काटकर, डॉ.एम.एस. खाकरे, डॉ.ए.एन. पसलावार, डॉ. एन.आर. ... किशोर बिडवे, डॉ. संदीप लांबे, डॉ. रविश राऊत, प्रकल्पाचे प्रमुख डॉ. जे.पी. देशमुख, डॉ. संजय काकडे, डॉ. राजाभाऊ कुचडे, डॉ. अनिता चौरे, डॉ.ए.पी. करुणाकरण, डॉ. विनोद खडसे, डॉ. देशमुख, वामन मोरे, मंगेश सोळंके, स्वप्निल ठाकरे, प्रीतम चिरडे, सुमेध हिवाळे यांच्यासह सर्व विभागाचे विभाग प्रमुख, शास्त्रज्ञ, वरिष्ठ शास्त्रज्ञ, संचालक, सहयोगी अधिष्ठाता, शिक्षक, शिक्षकेतर कर्मचारी तसेच विद्यार्थी उपस्थित होते.

35 मिलियन भूमि को गिरफ्त में लिया गाजरघास ने

1955 में अमेरिका से आयात गेहूं के साथ आई थी भारत, पुणे में दिखी थी पहली बार

पत्रिका न्यूज़ नेटवर्क

patrika.com

किसानों को गाजरघास ...

'ಪಾರ್ಥೇನಿಯಂ ಗಿಡಗಳ ನಿರ್ಮೂಲನೆಗೆ ಪಣ ತೊಡಿ'

సాగులో మెలకువలు పాటించాలి

» కలుపు నిర్మూలనపై రైతులకు అవగాహన సదస్సు

» ఆర్ఎస్ఎస్ జిల్లా కోఆర్డినేటర్ నారెడ్డి నందారెడ్డి

పొలంను పరిశీలిస్తున్న శాస్త్రవేత్తలు, నందారెడ్డి, రైతులు

లింగాకర్షక బుట్టలు ఏర్పాటు చేసి కత్తెర పురుగును నివారించాలి

మజీద్‌పూర్‌లో కత్తెర పురుగు ఆశించిన మొక్కజొన్న ...

अखिल भारतीय समन्वित खरपतवार प्रबंधन अनुसंधान परियोजना

All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन

Annual Report

2018-19

भाकृअनुप – खरपतवार अनुसंधान निदेशालय

ICAR - Directorate of Weed Research

जबलपुर, (मध्य प्रदेश)

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Cover page photographs

The first photograph shows *Orobanche* infestation in brinjal. Second picture shows the release of AICRP-Weed Management Annual Report 2017-18 during XXV Annual Review Meeting of AICRP-WM held at GBPUAT, Pantnagar during 7-8 June, 2018, and third picture shows the monitoring of AICRP-WM OUAT, Bhubaneswar centre by Director-ICAR-DWR and Incharge AICRP-WM during 16-17 March, 2019.

Preface

All India Coordinated Research Project on Weed Management (AICRP-WM) was launched in 1978 with the mandate to do systematic research on weed management in the country. This project was started initially with 6 centres in different parts of the country, which later on grew to 23 centres in 2014, almost in all the important Agricultural Universities of the country. Over the last 40 years, information relating to weeds in different cropped and non-cropped situations, management practices, herbicide residues and utilization aspects of weeds has been generated. Location-specific improved technologies on weed management have been developed and adopted in large areas throughout the country. With the continuous efforts of AICRP-WM, weed management technologies are now available for almost all crops and cropping systems as well as for non-cropped situations which have the potential to increase productivity, profitability, and ensure environmental sustainability and biodiversity.

Several new initiatives were taken to improve and strengthen the research work on weed management under this project. Technical programme for 2018-19 and 2019-20 has made in tune with the research programmes of the Directorate based on the emerging challenges in weed management. Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency and herbicide use in cropping systems, weed dynamics and management of problematic weeds, monitoring, degradation, and mitigation of herbicides, were made. On-Farm Research and impact assessment of weed management technologies were also undertaken. Review of all AICRP-WM centres were made by the QRT team for the period 2012-17 during the year. Norms of the ICAR for posting of staff and release of funds were followed. Collaborations were strengthened with other AICRPs and departments at the same University. The proposals for the SFC Memo (2018-19 to 2019-20) in terms of contingencies, staff restructuring and new research programmes were approved and six centres viz., NDUAT, Faizabad; RAU, Pusa; BAU, Ranchi; DBSKKV, Dapoli; CAU, Pasighat and UAS, Raichur were closed from April, 2018.

I express my sincere gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR; and Dr. K. Alagusundaram, Deputy Director General (Agri. Engg. and NRM), for providing constant encouragement and guidance. I am also thankful to Dr. S. Bhaskar, Assistant Director General (Agronomy, Agroforestry and Climate Change) for his keen interest and support in running the project. I thank Dr. Shobha Sondhia, Incharge, AICRP-WM for help in smoothly running the project activities. Thanks are also due to Dr. Sushil Kumar, Dr. R.P. Dubey and Senior Technical Officers, Mr. O.N. Tiwari, Mr. Pankaj Shukla and Chief Technical Officer, Mr. Sandeep Dhagat for their help and cooperation.

I have great pleasure in presenting the annual report of AICRP-Weed Management for the year 2018-19 which contains consolidated information on the research achievements and other related activities undertaken at all the centres of the project during the reported period. I hope this document will be useful to all our stakeholders.

Comments and suggestions are welcome for further improvement.

Date: 30.08.2019

(P.K. Singh)
Director
ICAR-DWR, Jabalpur

Contents

विशिष्ट सारांश

निदेशालय के अंतर्गत 17 नियमित और 8 स्वैच्छिक केन्द्र देश के विभिन्न राज्यों में स्थित कृषि विश्वविद्यालयों के माध्यम से विभिन्न फसलों, फसल प्रणाली और गैर–फसलीय क्षेत्रों में खरपतवार प्रबंधन हेतु अनुसंधान कार्य कर रहे है। वर्ष 2018–19 के दौरान किये गये मुख्य अनुसंधानीय उपलब्धियां निम्नानुसार है :

डब्लू पी 1 विविध फसल प्रणालियों में टिकाऊ खरपतवार प्रबंधन तकनीकियों का विकास

- भुवनेश्वर में, सी. टी. (रोपित धान)–जेड टी–जेड टी जुताई की पद्धति से रबी (5.3 टन / हे.) एवं खरीफ में (4.47 टन / हे.) अधिक उपज दर्ज की गईं। दोनों ही मौसम में सी टी–सी टी की तुलना में जेड टी (सीधी बुवाई की धान) – जेड टी + आर – जेड टी में उपज में 25% की कमी पायी गई। दोनों ही मौसम में जेड टी–जेड टी–जेड टी पद्धति में खरपतवार सूचक परिमाण अधिकतम (25%) एवं खरपतवारों के कारण उपज में हानि 40% पायी गईं ।
- हिसार में धान–गेहूं फसल चक्र में संरक्षित कृषि में *फैलेरिस माइनर* का अंकुरण अवशेष के साथ (7.7 – 9.7 मी.^{2}) गेहूं में जेड टी में बिना अवशेष (15.3 – 30.7 मी.^{2}) के गेहूं की तुलना में जेड टी / सी टी से कम पाया गया । गेहूं की उपज (6.2 – 6.5 ट. / हे.) जेड टी / सी टी–बी एस आर में कनवेन्शनल पीटीआर (6.1–6.3 ट. / हे.) की तुलना में अधिक पायी गईं। खरीफ में सीधी बुवाई आधारित धान–गेहूं प्रणाली की उपज पीटीआर आधारित धान–गेहूं प्रणाली की उपज के समान पायी गयी।
- अधिक उत्पादकता, सकल लाभ, शुद्ध लाभ और लाभ : लागत अनुपात सी टी खरीफ धान के अंतर्गत पाया गया, तदोपरांत मक्का में अभीसामयिक जुताई (12.5 ट. / हे., ₹ 219,756, ₹ 141,256 और 2.80) और शून्य जुताई पद्धति में क्रमशः (11.0 ट. / हे. ₹ 206, ₹ 298, ₹ 131, ₹ 408 और 2.75) पाया गया। यद्यपि हैदराबाद में खेती की लागत अभीसामयिक जुताई में सीधी बुवाई की एरोबिक धान से अधिक उपज प्राप्त की गयी।
- कल्याणी में धान–सरसों–मूंग फसल चक्र में संरक्षित कृषि के अंतर्गत रोपित धान में अंकुरण के पूर्व प्रेटिलाक्लोर 0.75 कि. / हे. इसके पश्चात् विषपायरीबेक–सोडियम 25 ग्रा. / हे. रोपण के 25 दिन पश्चात्+यांत्रिक निंदाई रोपण के 50 दिन पश्चात् करने पर बहुत ही कम खरपतवारों की संख्या, बॉयोमास और उच्चतम उपज दर्ज की गई। सरसों में अभीसामयिक जुताई से पूर्व रोपित धान में (अभीसामयिक जुताई) उच्चतम उपज के साथ शुद्ध लाभ और कम वीड बायोमास पाया गया। इसके लिये खरपतवार प्रबंधन प्रणाली पेन्डीमिथलिन 1.0 कि.ग्रा. / हे. अंकुरण पूर्व + यांत्रिक निंदाई बुवाई के 30 दिन पश्चात् किया गया ।

This Directorate co-ordinates its network programme through All India Coordinated Research Project on Weed Management (AICRP-WM) which has 17 regular centres at SAUs and 8 voluntary centres all over the India in different agro-climatic zones of the country. During 2018-19 main achievement were as follows:

WP 1 Development of sustainable weed management practices in diversified cropping systems

- The practice of CT (Trans)-ZT-ZT system of tillage recorded significantly higher grain yield in *Rabi* (5.3 t/ha) and *Kharif* (4.47 t/ha). Practice of ZT (DSR)-ZT+R-ZT system resulted in 25% yield reduction as compared to CT-CT in both the seasons. Weed index values were maximum in ZT-ZT-ZT system (25%) and yield losses due to weeds were 40 % in both the seasons at Bhubneswar.
- In rice-wheat cropping system under conservation agriculture, the emergence of *Phalaris minor* was low under ZT wheat with residues (7.7-9.7/m^2) as compared to ZT-CT wheat without residues (15.3-30.7/m^2). Grain yield of wheat (6.27-6.50 t/ha) after ZT-CT-DSR were higher than after conventional PTR (6.11-6.28 t/ha). During *Kharif*, system yields of DSR based rice-wheat were similar to PTR based rice-wheat system at Hisar.
- More system productivity, gross returns, net returns and B:C ratio obtained under CT *Kharif* rice followed by maize under conventional tillage (12.5 t/ha, ₹ 219,756; ₹ 141,256 and 2.80) and zero tillage practices, respectively (11 t/ha; ₹ 206,298; ₹ 131,408 and 2.75), even though more cost of cultivation incurred towards conventional tillage, due to realization of more yield under conventional system over direct seeded aerobic rice at Hyderabad
- In rice-rapeseed-greengram cropping system under conservation agriculture (CA), transplanted rice treated with pretilachlor 0.75 kg/ha Pre *fb* bispyribac-Na 25 g/ha at 25 DAT +mechanical weeding at 50 DAT performed best with lowest weed count and biomass and highest grain yield. Rapeseed under CT preceded by conventionally transplanted rice found superior with highest yield, net return and lowest weed biomass when there was the weed management practice of pendimethalin 1.0 kg/ha *PE* + mechanical weeding at 30 DAS was involved at Kalyani.

- धान–गेहूं – लोबिया चारा फसल चक्र में, संरक्षित कृषि में संसाधन उपयोग क्षमता के तुलनात्मक अध्ययन में पाया गया कि शून्य जुताई की तुलना में पारंपरिक जुताई में 7.4% अधिक संसाधन उपयोग क्षमता पायी गई, जबकि सीधी बुवाई की अपेक्षा रोपाई की क्षमता 7.9% अधिक पायी गई। रासायनिक नींदा नियंत्रण अनवीडिड की तुलना में 85.0% अधिक प्रभावी रहा जबकि एकीकृत खरपतवार नियंत्रण सें 100.1% अनियंत्रित खरपतवार की तुलना में अधिक नियंत्रण रायपुर में पाया गया।
- संरक्षित खेती के अंतर्गत विभिन्न फसल पद्धतियों में गेहूं की अधिकतम उपज (4.6 टन/हे) एवं लाभ : लागत अनुपात (3.0) पारंपरिक परिष्करण के बाद धान की सीधी बुवाई एवं *सिसबेनिया* के समावेश एवं बिना समावेश से दर्ज की गई जबकि धान की अधिकतम उपज (5.7 टन/हे) के साथ–साथ शुद्ध लाभ ₹ 59,233 एवं लाभःलागत अनुपात (2.2) रोपित धान (पारंपरिक जुताई) एवं *सिसबेनिया* के समावेश के साथ पंतनगर में दर्ज किया गया ।
- मक्का–सूरजमुखी फसल प्रणाली में संरक्षित कृषि में शून्य जुताई सें (जेड टी–जेड टी) + आर प्रणाली में पेंडीमिथेलिन 1.0 कि.ग्रा./हे. + बुवाई के 45 दिन बाद हाथ द्वारा निराई करने पर अधिक सार्थक उपज एवं आर्थिक लाभ सूरजमुखी में दर्ज किया गया । जबकि मक्का में सी टी–सी टी पद्धति से एट्राजिन 0.5 कि.ग्रा./हे (अंकुरण के पूर्व) + बुवाई के 45 दिन बाद हाथ द्वारा निराई करने पर अधिक उपज के साथ–साथ अधिक लाभ कोयम्बटूर में दर्ज किया गया ।
- लोबिया में बाजरा आधारित फसल चक्र में, एकीकृत खरपतवार प्रबंधन (पेंडीमिथेलिन+एमाजेथापायर + एक बार निंदाई) से सबसे अधिक बीज उपज (718 कि.ग्रा./हे), कम खरपतवार घनत्व और शुष्क भार तदोपरांत एमाजेथापायर + इमाजामोक्स 80 ग्रा./हे. अंकुरण पश्चात का प्रभाव अच्छा पाया गया । उच्च सार्थक बीज उपज (762 कि.ग्रा./हे) जेड टी + आर – जेड टी + आर – जेड टी एवं सी टी – जेड टी – जेड टी (725 कि.ग्रा./हे) उपचार से ग्वालियर केन्द्र में पाया गया।
- सोयाबीन – चना फसल चक्र में संरक्षित खेती के अंतर्गत दो बार हैरोइंग, एक बार टाईन हैरो और एक बार ब्लेड हैरो (पारंपरिक जुताई) के बदले में रोटोटिल (न्यूनतम जुताई) और शून्य जुताई के साथ शाकनासी के प्रयोग के साथ एकीकृत खरपतवार प्रबंधन द्वारा मृदा के भौतिक गुण सुधरने के फलस्वरूप फसल उत्पादकता में बढ़ोत्तरी के साथ आर्थिक सुरक्षा अकोला में कछारी भूमि में पायी गई।
- जम्मू में, जैविक खरपतवार प्रबंधन परीक्षण में सबसे अधिक आलू और फ्रेंचबीन के हरी फली की उपज सरसो के बीज की खली 2.5 टन/हे + एक बार हाथ से निराई करने पर दर्ज की गई।
- जोरहट में, ताजी मिर्च के फलों की उच्चतम उपज धान के पुआल की मल्चिंग से प्राप्त की गई। इसके पश्चात् हाथ द्वारा

- In rice-wheat-cowpea, fodder cropping system under CA, CT had 7.4% higher resource use efficiency over ZT, transplanting had 7.97% higher over direct seeding, chemical weed control by 85.0% over unweeded while, integrated weed control proved to be 100.1% more efficient over unweeded, respectively at Raipur.
- Under conservation agriculture experiment, among the different establishment methods, wheat grain yield (4.6 t/ha) and B:C ratio (3.0) was recorded highest under conventional wheat after direct seeding of rice with and without *Sesbania* incorporation. Whereas, significantly highest grain yield (5.7 t/ha) of rice was achieved under conventional transplanting along with green manuring of *Sesbania* by achieving highest net return (₹ 59,223) as well as B:C ratio (2.2) at Pantnagar.
- In maize-sunflower cropping system under CA, significantly higher grain yield and economics were recorded in zero tillage in ZT-ZT+R system and in PE pendimethalin at 1.0 kg/ha + HW on 45 DAS in sunflower crop. Whereas, in maize, CT-CT system and in PE atrazine at 0.5 kg/ha + HW on 45 DAS recorded higher productivity as well as high income in maize at Coimbatore.
- In cowpea under pearlmillet based cropping system, integrated weed management (pendimethalin + imazethapyr + 1 HW) gave maximum seed yield (718 kg/ha) as well as reduced the weed density and dry weight of weeds followed by application of imazethapyr + imazamox 80 g/ha PoE. The significantly higher seed yield (762 kg/ha) was obtained in ZT+R-ZT+R-ZT and CT-ZT-ZT, 725 kg/ha at Gwalior.
- In soybean-chickpea cropping system under CA, the use of two harrowing by Tyne harrows and a blade harrow (CT) instead of roto-till (MT) and zero-till (ZT) in combination with herbicide application (IWM) not only improves the physical properties of soil, but provided added productivity and economic security in vertisols at Akola.
- At Jammu, highest potato tuber yield and frenchbean green pod yield were recorded in mustard seed meal 2.5 t/ha + one hand weeding in organic weed management trial.
- At Jorhat, the highest yield of fresh chili fruits was obtained with rice straw mulching *fb* one hand weeding

एक बार निराई एवं आक्सो–बायो डिग्रेडेबल प्लास्टिक फिल्म की मल्चिंग के समकक्ष उपज दर्ज की गई । बिना निराई के उपज में 84% की हानि पायी गई। कार्बनिक खेती के तहत् चाय के हरी पत्तियों की अधिकतम उपज बायो डिग्रेडेबल फिल्म की मल्चिंग द्वारा हरी पत्तियों को हर अवस्था में तोड़ने पर खरपतवारों के प्रबंधन पर प्रभावकारी पाया गया ।

- उदयपुर में सौंफ की अधिकतम उपज (1.44 टन/हे) बुवाई के समय प्लास्टिक मल्च के साथ मृदा सूर्यीकरण द्वारा दर्ज की गई जो कि प्लास्टिक मल्च के साथ ग्रीष्मकालीन जुताई और स्टेल सीड बेड के समतुल्य पायी गई । अधिकतम शुद्ध लाभ (₹ 66,129/हे) और लाभ : लागत अनुपात (1.71) स्टील बेड के साथ प्लास्टिक मल्च उपचार से पाया गया ।
- त्रिशूर में, हल्दी आधारित फसल चक्र में बुवाई के 45 और 90 दिन बाद विभिन्न प्रकार के प्लास्टिक मल्च उपचार द्वारा खरपतवारों के घनत्व में कोई प्रभाव नहीं पाया गया। पालीथीन शीट द्वारा खरपतवारों की वृद्धि के नियंत्रण पर सबसे अच्छा प्रभाव पाया गया जो कि शाकनाशी आक्सीफ्लोरफेन के छिड़काव के समतुल्य पाया गया। उच्चतम लाभ : लागत अनुपात आक्सीफ्लोरफेन के प्रयोग तदोपरांत पालीथीन मल्चिंग में पाया गया ।
- फाक्सटेल बाजरा में, दो बार हाथ द्वारा निराई (बुवाई के 20 और 40 दिन बाद) के फलस्वरूप उच्च सार्थक दानों की उपज (1.53 टन/हे.) दर्ज की गई जो कि स्टील शीड बेड तकनीक तदोपरांत इंटरकल्टीवेशन 25 और 40 दिन बुवाई के पश्चात् (1.4 टन/हे.) के समतुल्य बंगलुरू में दर्ज किया गया ।
- भुवनेश्वर में टेम्बोट्रियोन 100 ग्रा/हे. या टोप्रामीजोन 25 ग्रा/हे. का अंकुरण के पश्चात् के प्रयोग से सबसे कम खरपतवार इंडेक्स 6.0 प्रतिशत और उच्चतम मीठे भुट्टो की उपज 8.0 टन/हे. दर्ज की गई ।

डब्ल्यू पी 2 जलवायु परिवर्तन के दौर में खरपतवारों में परिवर्तन, प्रबंधन एवं खरपतवारनाशी प्रतिरोधक क्षमता

- जोरहट में, एसट्रेसी प्रजातियों *अक्मेला ब्राचीग्लोसा* और *अक्मेला अपोजिटीफोलिया* की पूरे देश में नई वर्गीकरणात्मक रिपोर्ट दर्ज की गई। इसके अतिरिक्त *अक्मेला रेडीकांस* एवं *अक्मेला यूलीजिनोसा* असम राज्य में नये खरपतवार दर्ज किये गये। खरपतवारों की ये चारों प्रजातियां दलदली फसलीय क्षेत्र, खेतों के किनारे नमी वाले क्षेत्र और सड़क किनारे कमोवेश रूप में दर्ज किये गये ।
- उदयपुर में मक्का में *रोटबोईलिया एक्जोलटाटा* को रेलमगरा तहसील में एक समस्याग्रस्त खरपतवार के रूप में दर्ज किया गया।
- *इथूलिया ग्रासीलिस,* एसट्रेसी फेमिली का एक नया आक्रमणकारी खरपतवार उत्तरी कर्नाटक के निप्पानी चिकोड़ी, बेलागवी क्षेत्र में पाया गया ।

through oxo-biodegradable plastic film mulching at par with the former. The yield loss due to weedy situation was around 84%. Green leaf yield of tea under organic management was found to be the highest at all the plucking stages in case of bio-degradable film mulching due to its effective management of weeds.

- Maximum seed yield (1.44 t/ha) of fennel was recorded with crop sown with treatment of soil solarization with plastic mulch, which was at par with plastic mulch with summer ploughing and stale seed bed. The highest net return (₹ 66,129/ha) and B: C (1.71) was recorded with stale seed bed with plastic mulch at Udaipur.
- At Thrissur, weed density at 45 and 90 DAS was not affected by various mulches treatments in a turmeric based cropping system. Mulching with polythene sheet best controlled weed growth and application of herbicide oxyfluorfen was on par with this. Highest B: C ratio was obtained with application of oxyfluorfen followed by polythene mulching.
- At Bengaluru in Foxtail millet, two hand weedings at 20 & 40 DAS recorded significantly higher grain yield (1.43 t/ha) which was on par with stale seed bed technique followed by intercultivation at 25 and 45 DAS (1.4 t/ha).
- At Bhubaneswar post-emergence application of tembotrione 100 g/ha or topramezone 25 g/ha recorded lowest weed index of 6.0% and highest maize cob yield 8 t/ha in the sweet corn.

WP 2 Weed dynamics and management under the regime of climate change and herbicide resistance

- At Jorhat, Asteraceae species *Acmella brachyglossa* and *Acmella oppositifolia* var. *opposifolia* were the new taxonomic report for the entire country, and in addition *Acmella radicans* var. *debilis* (HBK) R.K. Jansen and *Acmella uliginosa* were new record for the Assam state. All these four species have been found to more or less highly populated facultative weeds of marshy croplands, damp edges of crop fields and roadsides.
- At Udaipur, *Rottboellia exaltata* has become a serious weed of maize in Railmagra tehsil of Rajsamand.
- *Ethulia gracilis* Delile, Family Asteraceae-a new invasive weed was noticed in Nippani, Chikkodi, Belagavi, areas of Northern Karnataka.

- *एजेरेटम कोनीज्वाइड्स* भुवनेश्वर के लगभग सभी भाग में गंभीर समस्याकारी खरपतवार के रूप में उपस्थित पाया गया। यह खरपतवार ज्यादातर अपलेन्ड क्षेत्र में आक्रमणकारी है। उत्तर–पूर्वी घाट क्षेत्र में *कसकुटा चिनेनसिस* प्रमुख परजीवी खरपतवार नाईजर फसल में पाया गया ।
- महबुबनगर जिले के कोठुरमण्डल के कीडोर्चला गांव में *सोलेनम मेलोन्गाना* एक नये खरपतवार के रूप में पहचाना गया ।
- गुजरात के विभिन्न जिलों के क्षेत्रों में 2,4–डी एवं मेटसल्यूरॉन मिथाइल के लगातार प्रयोग से गेहूं की फसल में द्विपत्रीय खरपतवारों के प्रबंधन से एक बीजपत्रीय खरपतवारों की ओर विस्थापन पाया गया । एक बीजपत्रीय खरपतवार *कोमोलिना बेंगालेनसिस* कृषकों के और अनुसंधान प्रक्षेत्र में विभिन्न फसलों में नियंत्रण हेतु अनुंशंसित शाकनाशी का प्रयोग करने के पश्चात् भी नियंत्रण से बच गये ।
- रायपुर में, धान–गेहूं–लोबिया फसल चक्र में संरक्षित कृषि एवं खरपतवार नियंत्रण के प्रयोग के तीन वर्ष के पश्चात् एक वर्षीय घास कुल और चौड़ी पत्ती वाले खरपतवारों के स्थान पर बहुवर्षीय खरपतवार *साइनोडान डेक्टीलान* में विस्थापन पाया गया । यह विस्थापन जेड टी (डीएसआर) –जेड टी + आर–जेड टी और जेड टी (डीएसआर) + आर– जेड टी + आर–जेड टी में अधिक पाया गया ।
- खरीफ में नया खरपतवार *ओल्डेनलेडिया कोरियमबोसा* और *यूफोरबिया जेनीकुलाटा* बाजरा के खेतों में ग्वालियर में पाया गया ।
- हिसार में, अंकुरण के पूर्व पेडीमीथेलिन+पायरोजोसल्फोन (रेडी मिक्स) 1500 + 102 ग्रा./हे., मीजोसल्फ्यूरॉन + आइडोसल्फयूरॉन (रेडी मिक्स) 14.4 ग्रा./हे. का बुवाई के 35 दिन पश्चात प्रयोग करने पर *फै. माइनर* के घनत्व पर सार्थक कमी के साथ इस पर 83–93% तक नियंत्रण पाया गया।

डब्ल्यू पी 3 फसलीय और गैर फसलीय क्षेत्रों में समस्याकारक खरपतवारों का जैव विज्ञान एवं प्रबंधन

- भुवनेश्वर में बैंगन की फसल में पेंडीमेथिलीन 1.0 कि.ग्रा./हे. रोपण के 3 दिनों बाद प्रयोग करने पर *औरोबैंकी* की प्रति पौधो की संख्या और न्यूनतम खरपतवार घनत्व रोपण के 60 और 90 दिनों बाद दर्ज किये गये ।
- हिसार में टमाटर में इंजीप्सियन ब्रूमरेप के नियंत्रण हेतु अंकुरण पूर्व सल्फोसल्फयूरान और इथाक्सीसल्फयूरान का प्रयोग अनुपचारित की तुलना में 79–86% तक नियंत्रण पाया गया। सल्फोसल्फयूरान 50 ग्रा./हे. रोपने के 60 और 90 दिनों बाद प्रयोग करने पर अनुगामी फसल सोरघम पर प्रतिकूल प्रभाव पाया गया ।

- At Bhubaneswar, *Ageratum conyzoides* was observed to be a severe problem in almost all parts of the state. The weed is invading mostly the upland areas. *Cuscuta chinensis* was found to be a major parasitic weed in the niger crop in the North eastern ghat zone.
- In Kodicherla village of Kothur mandal of Mahabubnagar district a new weed species was identified as *Solanum melongena* var. *insanum*.
- In many areas of different districts of Gujarat, weed flora shifted towards monocot weeds in wheat crop fields due to continuous use of 2,4-D or metsulfuron-methyl to manage dicot weeds. Escape incidence of monocot weed *Commelina benghalensis* after application of recommended herbicides in different crops were observed at farmers and research farms.
- After completion of three cycles of weed management in rice-wheat-cowpea cropping system under conservation agriculture there was weed shift of annual grassy and broad leaf weeds to perennial weed like *Cynodon dectylon* specially under ZT (DSR) -ZT + R-ZT and ZT (DSR) + R - ZT + R -ZT system at Raipur.
- In *Kharif*, new weeds *Oldenlandia corymbosa* and *Euphorbia geniculata* were observed in pearlmillet field at Gwalior.
- Pre-emergence application of pendimethalin + pyroxasulfone (RM) at 1500+102 g/ha either alone or followed by sequential use of pinoxaden 60 g/ha, mesosulfuron + iodosulfuron (RM) 14.4 g/ha at 35 DAS caused significant reduction in density of *P. minor* and provided 83-93% control of *P. minor* at Hisar.

WP 3 Biology and management of problem weeds in cropped and non-cropped areas

- At Bhubaneswar, application of pendimethalin 1.0 kg/ha as pre-emergence 3 DAP recorded the lowest number of *Orobanche*/plant, lowest total weed density at 60 and 90 DAP in brinjal.
- In tomato, 79-86% control of Egyptian broomrape was obtained with PoE treatments of sulfosulfuron and ethoxysulfuron when compared with non treated control. Residues of sulfosulfuron at 50 g/ha at 60 and 90 DAP caused adverse effect on succeeding sorghum crop at Hisar.

- पंतनगर में, विभिन्न उपचारों में से ग्लाइफोसेट (1.0 कि.ग्रा. / हे), मेट्रीब्यूजिन (0.25 कि.ग्रा. / हे) और मेटसल्फ्यूरॉन (0.004 ग्रा. / हे) का अंकुरण पूर्व अनुप्रयोग से *सिरशियम आरवेंस* पर पूर्ण नियंत्रण पाया गया ।
- हैदराबाद में, त्रैमासिक अंतराल के सर्वेक्षण के दौरान माईलार्डदेवपल्ली तालाब में कीटों का प्रकोप पाया गया।
- उदयपुर में, *नियोकेटिना ब्रूची* भृंग में नवंबर माह तक गुणन पाया गया और लगभग 20–25% जलकुंभी पर नियंत्रण पाया गया औरे जलकुंभी की वृद्धि को भी रोक दिया ।
- कोयम्बटूर में *नियोकेटिना* भृंग कृषनामपाथी तालाब टीएनएयू के नमभूमि प्रक्षेत्र और लुधियाना जिले के बोपरिया कालन गांव में छोड़े गये । जलकुंभी पर इसका लक्षण मध्यम (रेटिंग–3) और फीडिग भी मध्यम पायी गयी। ग्वालियर में लगभग 85–90% (स्केल–1) जलकुंभी के पौधों में नष्ट होने के लक्षण पाये गये ।

डब्लू पी 4 पर्यावरण में प्रदूषकों एंव शॉकनाशी अवशेषो का अपघटन, निगरानी व शमन

- लुधियाना में, इमाजेथापायर का मृदा में अपघटन बाइफेजिक प्रथम क्रम काइनेटिक्स और अर्ध आयुकाल, 6.59 से 6.68 दिन प्रारम्भ में एवं अंतिम चरण में 93.7 से 118.6 दिनों तक होती है। लोमी रेती वाली मृदा में साइक्लोडेक्सट्रीन किटोसन तथा साइक्लोडेक्सट्रीन किटोसन बायो कम्पोसिट (एल.सी.डी.) से इमेजेथापायर का अपघटन बढ़ा है।
- ब्यूटाक्लोर, प्रेटीलाक्लोर, ऐनिलोफोस, क्लोडिनाफॉप, सल्फोसल्फ्यूरॉन, मेटसल्फ्यूरॉन एवं पेन्डीमेथिलीन का छिड़काव के बाद मृदा, पानी और फसलों के नमूने किसानो के खेतो से लिये गये। जिसमें इनके अवशेष आपेक्षित स्तर से कम पाये गये जबकि मेट्रीन्यूजिन के अवशेष 0.0063 से 0.0075 एवं 0.0061 से 0.0071 mg/g गेहूँ की फसल की मृदा लुधियाना में पाये गये। मेट्रीब्यूजिन के प्रयोग से काफी हद तक मिट्टी की डिहाइड्रीजिनेस और अल्कलाईन फास्फेट गतिविधि प्रभावित रहीं जबकि यूरेस गतिविधि अप्रभावित रही।
- पालमपुर में, फसलों की कटाई के समय आइसाप्रोटुरॉन एवं 2,4–डी का मृदा एवं गेहूँ के दानों में तथा पेन्डीमेथिलीन का मृदा एवं सोयाबीन में विभिन्न जुताई एवं अवशेष प्रबंधन की तकनीकों से अपशेषों की निर्धारित मात्रा से कम (<0.05 μg/g) प्राप्त हुई है।

- At Pantnagar, post-emergence application of glyphosate (1.0 kg /ha), metribuzin (0.25 kg/ha) and metsulfuron (0.004 kg/ha) completely controlled *Cirsium arvense*.
- At Hyderabad, in Mylardevpalli tank, most of the water hyacinth in the tank were severe by infested by weevils during a quarterly interval survey.
- At Udaipur *Neochetina bruchi* weevils could multiply up to the month of November and about 20-25% defoliation was observed on water hyacinth plants and also suppresses the growth of water hycianth.
- At Coimbatore, *Neochetina* beetles were released at Krishnampathy tank near Wetland farm of TNAU and Village water pond of village Boparia Kalan in district Ludhiana. Symptoms on water hyacinth plants were moderate (Rating-3) and feeding was medium. At Gwalior around 85-90% (scale-1) die back symptoms were observed on water hyacinth.

WP 4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment

- At Ludhiana, imazethapyr dissipation in soil followed biphasic first order kinetics and half-life varied from 6.59 to 6.68 days during initial and 93.7 to 118.6 days during final phase. In loamy sand soil, amended with β-cyclodextrin, chitosan and cyclodextrin-chitosan biocomposite (LCD), addition of amendment enhanced imazethypar dissipation.
- Residues of butachlor, pretilachlor, anilophos, clodinafop, sulfosulfuron, metsulfuron and pendimethalin in soil, water and crop samples collected from farmers' field were found below deletion limit while 0.0063 to 0.0075 and 0.0061 to 0.0071 μg/g residues of metribuzin were detected in soil and wheat crop, respectively at Ludhiana. Metribuzin application significantly affected soil dehydrogenase and alkaline phosphate activity while urease activity remained unaffected.
- At Palampur, residues of isoproturon and 2,4-D in soil and wheat grain and pendimethalin residues in soil and soybean under different tillage and residue management techniques were found to be below detectable limits (<0.05 μg/g) at the time of harvest.
- Residues of atrazine in the soil, maize grain and straw samples collected at the time of harvest were below the detectable limit of 0.05 ppm in aerobic and transplanted rice main treatments at Hyderabad.

- हैदराबाद में, एरोबिक एवं रोपित धान में एट्रॉजिन के अवशेष मक्का और पुआल के नमूनों में अपेक्षित मात्रा से कम पाये गये।
- यूरेस एन्जाइम की क्रिया सीधी बुबाई की धान से रोपित धान में कम पायी गयी। रबी में मक्का, शून्य जुताई के उपचार से यूरेस एक्टीविटी पारंपरिक जुताई उपचार से अधिक पायी गयी।
- भिण्डी में पेन्डीमेथलीन छिड़काव के बाद लिये गये नमूनों में पेन्डीमेथलीन के अवशेष आपेक्षित स्तर से कम पाये गये।
- संरक्षण खेती में मक्का – सूरजमुखी फसल चक्र में एट्राजिन और पेन्डीमेथलीन विभिन्न जुताई और खरपतवार प्रबंधन पद्धति से प्रभावित नही हुआ।

डब्लू पी 5 खरपतवार तकनीक का कृषक प्रक्षेत्र पर परीक्षण एंव प्रदर्शन तथा उनके प्रभावों का मूल्यांकन

- हरियाणा में धान गेहूँ उत्पादन क्षेत्रों के सात स्थानो में प्रक्षेत्र परीक्षण अनुसंधान में नए शाकनाशी *पाइरोजासल्फोन* 127.5 ग्रा./हे. अंकुरण पूर्व छिड़काव के उपयोग से बहुशाकनाशी प्रतियोगी *फैलेरिस माइनर* में 88.3% नियंत्रण प्राप्त हुआ साथ ही पेण्डिमेंथलीन 1.5 कि./हे. अंकुरण पूर्व तथा पाइरोजासल्यूरॉन बुआई के 35 दिन पर छिड़काव से *फैलेरिस माइनर* में 92.1% नियंत्रण प्राप्त हुआ तथा गेहूँ उत्पादन 5.39 टन/हे. प्राप्त हुआ जो कि पूर्व संस्तुत शाकनाशी पेन्डीमेथलीन 1.5 कि/हे. से 6.3% अधिक था।
- भुवनेश्वर में रबी 2017–18 में चार प्रक्षेत्र अनुसंधान हरे चने एंव मूंगफली में गजमारा गॉव में किये गये जिसमें हरे चने की अधिकतम उपज 1.02 टन/हे. तथा मूॅगफली की 1.8 टन/हे. प्राप्त हुयी जिसमें पेन्डीमेंथलीन 750 ग्रा./हे. का छिड़काव किया गया था। हरा चने की शुद्ध आय ₹ 5000/हे. तथा मूॅगफली की शुद्ध आय ₹ 6500/हे. प्राप्त हुई।
- हैदराबाद में नीम केक 200 किलो/हे. के पश्चात् ग्लाइफोसेट 50 ग्रा./हे. द्वारा *औरोबैंकी* को सफलता पूर्वक नियंत्रित किया गया पॉलीशीट के साथ मल्चिंग से *औरोबैंकी* के अंकुरण में विलंब तथा प्रकोप में कमी पाई गयी।
- ग्वालियर में एट्राजिन 0.5 कि./हे. + 2,4–0 0.5 कि./हे. (अंकुरण पश्चात) तथा पेण्डीमिथलिन 1.0 कि./हे. (अंकुरण के पूर्व उपचार) करने से बाजरा की अधिकतम उपज 2.39 टन/हे. प्राप्त हुयी जो कि किसानो की पद्धति से 49.3% और 41.5% अधिक थी। एट्राजिन 0.5 किलो/हे. + 2,4–0 0.5 किलो/हे. का अंकुरण के पश्चात् उपचार से सर्वाधिक लाभ लागत अनुपात 2.31 प्राप्त हुआ।

- Urease enzyme activity in the transplanted rice treatments was significantly inferior to the DSR treatments. In case of the *Rabi* maize, zero tillage maize treatments showed significantly higher urease activity compared to the conventional tillage treatments. Effect of herbicides on UA at the time of harvest was non-significant.
- Residues of pendimethalin in okra fruit samples collected from pendimethalin sprayed plots were below the detection limit of 0.05 mg/kg.
- In CA under maize-sunflower cropping system, the persistence of atrazine and pendimethalin was not influenced by different tillage and weed management practices with and without residues. At harvest, residues of both the herbicides were present below the detectable level of 0.01 mg/kg at Coimbatore.

WP 5 On-farm research (OFR) and front line demonstration (FLD)

- In on farm trials on use of new herbicide pyroxasulfone in wheat as pre-emergence whereas 127.5 g/ha demonstrated at 7 sites in rice -wheat growing areas of Haryana provided 88.3% control of multiple herbicide resistant *P. minor,* whereas integration of this herbicide with pendimethalin 1.5 kg/ha (PRE) and post-emergence herbicides at 35 DAS improved control of *P. minor* to 92% with grain yield of 5.39 t/ha which was 6.54 % higher than earlier recommended herbicide pendimethalin 1.5 kg/ha at Hisar.
- At Bhubaneswar four OFR were conducted on green gram and ground nut during *Rabi* 2017-18 at Gajamara village resulted in maximum yield of 1.02 t/ha in green gram and 1.8 t/ha in ground nut in the plot applied with pendimethalin 750 g/ha. A net saving of ₹ 5000/ha in green gram and ₹ 6500/ha in groundnut were obtained in the plots treated with herbicides.
- At Hyderabad, Neem cake 200 kg/ha *fb* glyphosate 50 g/ha was efficient in controlling *Orobanche* infestation. Mulching with polysheet delayed emergence and lowered the incidence of *Orobanche*.
- At Gwalior, the maximum yield of pearlmillet 2.39 t/ha was obtained with the application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (PoE) followed by pendimethalin 1.0 kg/ha (PE), which was 49.3% and 41.5% higher than farmers practice, respectively. The highest B:C ratio was also recorded with post-emergence application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (2.31).

- आनंद में कृषक प्रक्षेत्र प्रदर्शन में क्लोडीनाफॅप प्रोपारगिल+ मेटसल्यूरॉन–मिथाईल 64 ग्रा./हे. द्वारा कृषक पद्धति की तुलना मे लाभ : लागत अनुपात 2.48 प्राप्त हुआ।

- हिसार में मेंढेर, मीवा एवं हिसार जिलों 335 कृषक प्रक्षेत्र प्रदर्शन में ग्लाइफोसेट के उपचार से सरसों में *औरोबैंकी* में नियंत्रण पाया गया। अंकुरण के पश्चात् ग्लाइफोसेट 25 ग्रा./हे. बुआई के 30 दिन बाद खाद तदोपरांत बुआई के 50–60 दिनों बाद उपचार करने से 75–80% *औरोबैंकी* में नियंत्रण पाया गया तथा 51.9% अधिक उपज पायी गई।

- रायपुर में, पंक्ति में लगाये गये दन्तेश्वरी धान में रासायनिक शाकनाशियों द्वारा खरपतवार प्रबंधन पर चार अग्रिम पंक्ति प्रदर्शन किये गये। खरपतवार प्रबंधन की वैज्ञानिक विधि अपनाने से कृषक पद्धति एवं अनुसंशित पद्धति में धान की उपज क्रमशः 31.5 और 43.8 क्वि./हे. पाई गयी एवं अनुसंशित पद्धति अपनाने से कृषक पद्धति की तुलना में 39.3% की वृद्धि धान की खेती में प्राप्त की गई।

- उदयपुर में रबी में पाँच कृषक प्रक्षेत्र प्रदर्शन ग्राम श्यामपुरा तहसील शारदा में गेहूँ की फसल में किये गये। अंकुरण के पश्चात रेडी–मिक्स शाकनाशी सल्फोसल्यूरॉन+मेटसल्यूरॉन (30+2 ग्रा./हे.) बुआई के 35 दिन के पश्चात् उपचार करने से गेहूँ की फसल में 8.9% की वृद्धि कृषक पद्धति की तुलना (40.2 क्वि./हे.) में पायी गयी। खरीफ में एट्राजिन ततपश्चात् टेम्बोट्रिओन 500 ग्रा./हे. अंकुरण से पूर्व + 120 ग्रा./हे. करने से तीन से चार पत्ति की अवस्था में मक्का की फसल में 15.9% की वृद्धि कृषक पद्धति से प्राप्त (27 क्वि./हे.) की तुलना में प्राप्त हुई।

- तमिलनाडू में अंकुरण के पूर्व पेन्डीमेथलिन के उपचार से 1000 ग्रा/हे + हाथ द्वारा निंदाई के 30–35 दिन रोपण के पश्चात् करने से टमाटर की उपज 20.9 से 33.1% कृषकों की पद्धति से अधिक प्राप्त हुई।

- FLD conducted at farmer's field showed that B: C ratio of 2.48 achieved by application of clodinafop-propargyl + metsulfuron-methyl 64 g/ha PoE (RM) as compared to farmers practices at Anand.

- At Hisar, 335 FLDs were conducted on use of glyphosate for the control of *Orobanche* in mustard in Bhiwa, Hisar and Mahender Garh districts. Post-emergence application of glyphosate 25 g/ha at 30 DAS followed by its use at 50 g/ha at 50-60 DAS provided 75-85% control of *Orobanche* with 51.9% increase in yield over untreated check.

- At Raipur, four demonstrations were conducted on weed management in line sown rice by chemical weed control with rice cultivar Danteshwari. The average yield of farmers practice and recommended practice was 31.5 and 43.8 q/ha, respectively. However, percent increase under recommended practice over farmers practice was 39.35%.

- At Udaipur, five demonstrations on weed management in wheat were conducted at village - Shyampura tehsil - Sarada in *Rabi*. Post-emergence application of ready mix herbicide sulfosulfuron + metsulfuron (30 + 2 g/ha) at 35 DAS increased the wheat grain yield by 8.9% over farmers practice wheat yield (40.2 q/ha). During *Kharif*, application of atrazine *fb* tembotrion 500 g/ha as PE + 120 g/ha at 3-4 leaf stage (15 DAS) increased the maize grain yield by 15.9% over farmers practice maize yield (27 q/ha).

- Coimbatore FLD with improved weed management technology with PE pendimethalin 1000 g/ha + hand weeding on 30-35 DAT increased the tomato yields from 20.9 to 33.1 % over farmers practice (two hand weedings).

1. ORGANIZATION AND FUNCTIONING

1.1 Introduction

Systematic research work on weed management in the country started with the launching of All India Coordinated Research Project on Weed Management earlier known as All India Coordinated Research Project on Weed Control by the ICAR in collaboration with the United States Department of Agriculture (USDA) at six locations, *viz.* Punjab Agricultural University, Ludhiana (Punjab); University of Agricultural Sciences, Bangalore (Karnataka); Indian Institute of Technology, Kharagpur (West Bengal); Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.); Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (U.P.); and Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur (H.P.). The project came into operation in April, 1978 with the financial outlay of ₹ 42.97 lakhs for five years. The tenure of the project was, however, extended for one more year till March, 1984 with the savings. Further work was continued at these centres with the AP Cess fund of ICAR till the implementation of VII Plan in April, 1986.

The activities of the project were extended covering 7 more cooperating centres at Assam Agricultural University, Jorhat (Assam); Marathwada Agricultural University, Parbhani (Maharashtra); Gujarat Agricultural University, Anand (Gujarat); Narendra Dev University of Agriculture and Technology, Faizabad (U.P.); Indian Institute of Horticultural Research, Bangalore (Karnataka); Indian Grassland and Fodder Research Institute, Jhansi (U.P.) and Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) through a fresh negotiation between ICAR and FERRO, USDA with a sanctioned outlay of Rs 58.10 lakhs for five years. The work at these centres was effectively implemented from 1982-83 to 1986-87.

In the third phase, 9 more centres, *viz.* Birsa Agricultural University, Ranchi (Bihar); Haryana Agricultural University, Hisar (Haryana); Vishwa Bharati, Sriniketan (W.B.); Rajendra Agricultural University, Pusa (Bihar); Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.); Kerala Agricultural University, Thrissur (Kerala); Orissa University of Agriculture and Technology, Bhubaneswar (Orissa); Acharya N.G. Ranga Agricultural University, Hyderabad (Andhra Pradesh) and ICAR Research Complex, Barapani (Meghalaya) were initiated at total outlay of ₹ 63.85 lakhs for four years (1985-86 to 1989-90) with the assistance of USDA under USIF funds.

In the VIII Plan, 4 new centres, at Rajasthan Agricultural University, Bikaner; Indira Gandhi Krishi Vishva Vidyalaya, Raipur; Konkan Krishi Vidhya Peeth, Dapoli and University of Agricultural Sciences, Dharwad were initiated with total outlay of ₹ 16.41 lakhs. Seventy five percent of the total budget required by each centre was provided by the ICAR and the remaining 25% was met from the state department of agriculture as a state share. There was however, 100% funding by the ICAR to Visva Bharati, Sriniketan.

During IX Plan (1997-2002), X Plan (2002-2007), XI plan (2007-2012) and XII plan (2012-17), the total expenditure incurred under AICRP-WC was ₹ 823.79, 1696.57, 3548.78 and 4007.26 lakhs, respectively.

During XII Plan (2012-17), four AICRP on Weed management centres *viz.* University of Agricultural Sciences, Dharwad; Chandra Shekhar Azad University of Agriculture & Technology, Kanpur; Swami Keshwanand Rajasthan Agricultural University, Bikaner, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani and Visva-Bharati, Sriniketan were closed and new centers at Maharana Pratap University of Agriculture and Technology, Udaipur; University of Agricultural Sciencies, Raichur; Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola; Bidhan Chandra Krishi Viswavidyalaya, Kalyani; Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Central Agricultural University, Pasighat by redeployment of existing manpower were opened. As per the approval of SFC (2017-20), another six coordinating centres (NDUAT, Faizabad; CAU, Pasighat; RAU, Pusa; BAU, Ranchi;

DBSKKV, Dapoli and UAS, Raichur) were closed w.e.f. 1.4.2018.

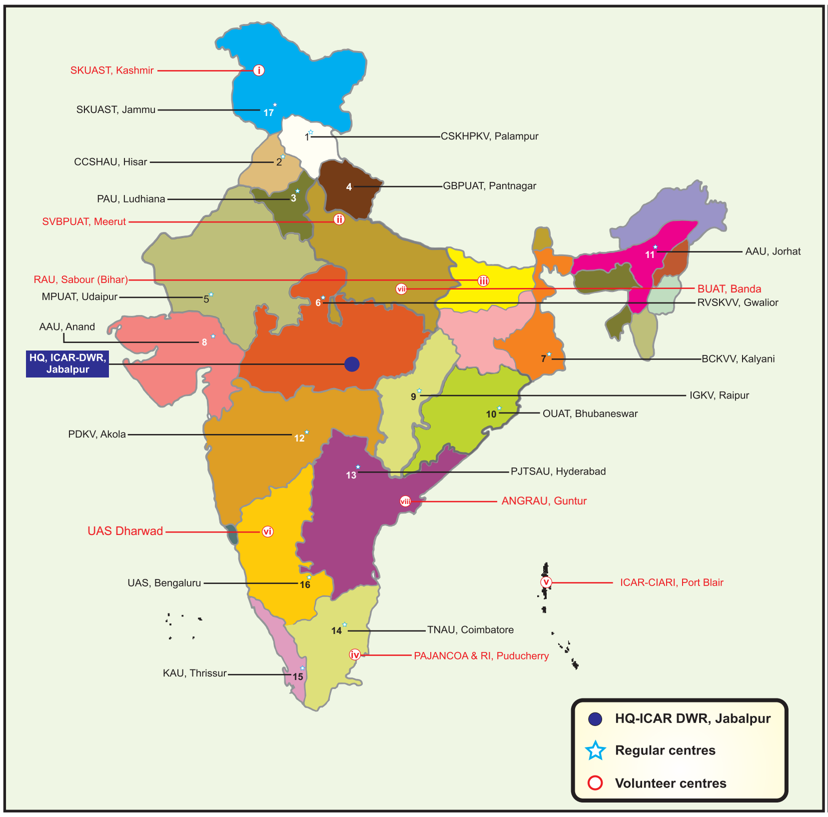
The coordinating unit of the project was located initially at Central Rice Research Institute, Cuttack, and shifted to National Research Centre for Weed Science in 1989. Later in 2009, NRC for Weed Science was upgraded to Directorate of Weed Science Research. During XII Plan (2012-17), it has renamed as "Directorate of Weed Research" and "AICRP on Weed Control" was renamed as "AICRP on Weed Management".

1.2 Mandate

- To conduct location-specific research for developing appropriate weeds management technologies.
- To demonstrate the weed management technologies through on-farm adaptive trials.

1.3 Objectives

- To survey and surveillance of weed flora, mapping their distribution, ecology and habitat.
- To evaluate new herbicides and working out the residual effect on non-targeted organisms.
- To work out effective and economic weed management modules for field and horticultural crops and in different aquatic situations.
- To study biology and control of problem weeds including aquatic and parasitic weeds.
- To study long-term residual and cumulative effects, if any, of herbicides.
- To standardize techniques for herbicide residues in soil, water and food chain.
- To carry out basic research at different centres having adequate laboratory facilities for rendering support to adaptive research.
- To test available tools/ implements for weed management under various agro-ecosystems.
- To transfer weed management technologies on farmers' fields through OFT and FLDs their impact assessment and training.



Regular Centre

1	CSKHPKV, Palampur
2	CCSHAU, Hisar
3	GBPUAT, Pantnagar
4	PAU, Ludhiana
5	MPUAT, Udaipur
6	RVSKVV, Gwalior
7	BCKV, Kalyani
8	AAU, Anand
9	IGKV, Raipur
10	OUAT, Bhubaneswar
11	AAU, Jorhat
12	PDKV, Akola
13	PJTSAU, Hyderabad
14	TNAU, Coimbatore
15	KAU, Thrissur
16	UAS, Bengaluru
17	SKUAST, Jammu

Volunteer Centres

i	SKUAST, Kashmir
ii	SVBPAUT, Meerut
iii	BAU, Sabour (Bihar)
iv	PAJNCOA & RI Punducherry
v	ICAR-CARI, Port Blair
vi	UAS, Dharwad
vii	BUAT, Banda
viii	ANGRAU, Guntur

2. STAFF POSITION AND EXPENDITURE

AICRP on Weed Management is presently under operation in 17 State Agricultural Universities in 17 different states of the country and represent diverse agro-ecological regions. Altogether, 34 scientists of different disciplines (Agronomy, Residue Chemistry and Taxonomy) are working in inter-disciplinary mode. Besides 17 main centres, 8 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2018-19 are as below:

Staff position at different coordinating centres during 2018-19

Centre	Scientific		Technical		Driver	
	Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled
PAU, Ludhiana	2	2	1	1	-	-
UAS, Bengaluru	2	2	1	1	1	1
RVSKVV, Gwalior	2	2	1	1	-	-
GBPUAT, Pantnagar	2	2	1	1	-	-
CSKHPKV, Palampur	2	2	1	1	1	1
AAU, Jorhat	2	2	1	1	1	1
AAU, Anand	2	2	1	1	1	1
TNAU, Coimbatore	2	2	1	1	1	1
KAU, Thrissur	2	1	1	1	1	1
OUAT, Bhubaneswar	2	2	1	1	1	1
PJTSAU, Hyderabad	2	2	1	-	1	-
CCSHAU, Hisar	2	2	1	-	-	-
IGKVV, Raipur	2	2	1	1	-	-
PDKV, Akola	2	2	1	1	-	-
MPUAT, Udaipur	2	2	1	-	-	-
SKUAST, Jammu	2	2	1	1	-	-
BCKV, Kalyani	2	2	1	1	-	-
Total	**34**	**33**	**17**	**14**	**08**	**07**

Funds released to different coordinating centres during the financial year 2018-19

(₹ in lakh)

S N	Centre name	Grant in aid Capital		Grant in aid Salary	Grant in aid General					Grant total ICAR share
		Capital	SCSP	Salary	TA	Recurring	Miscellaneous expense Other item	SCSP	Total	
1	PAU, Ludhiana	0.00	0.00	65.94	0.30	3.70	1.80	0.00	5.80	71.74
2	UAS, Bengaluru	0.00	0.00	68.13	0.30	3.64	1.80	0.00	5.74	73.87
3	RVSKVV, Gwalior	0.00	0.00	59.01	0.30	3.10	1.80	0.00	5.20	64.21
4	GBPUAT, Pantnagar	0.00	0.00	40.22	0.30	3.48	1.80	0.00	5.58	45.80
5	CSKHPKV, Palampur	0.00	2.54	124.11	0.65	3.23	1.80	2.53	8.21	134.86
6	AAU, Jorhat	0.00	2.53	87.79	0.30	3.90	1.80	2.53	8.53	98.85
7	AAU, Anand	0.00	0.00	49.02	0.30	3.59	1.80	0.00	5.69	54.71
8	TNAU, Coimbatore	0.00	0.00	106.42	0.30	3.05	1.80	0.00	5.15	111.57
9	KAU, Thrissur	0.00	0.00	114.50	0.30	3.74	1.80	0.00	5.84	120.34
10	OUAT, Bhubaneswar	0.00	0.00	59.73	0.37	3.87	1.80	0.00	6.04	65.77
11	PJTSAU, Hyderabad	0.00	0.00	78.51	0.30	4.47	2.30	0.00	7.07	85.58
12	CCSHAU, Hisar	0.00	0.00	42.96	0.49	3.61	1.80	0.00	5.90	48.86
13	IGKV, Raipur	0.00	0.00	66.54	0.47	1.90	1.80	0.00	4.17	70.71
14	PDKV, Akola	0.00	0.00	54.41	0.75	3.27	2.30	0.00	6.32	60.73
15	BCKV, Kalyani	0.00	2.53	29.01	0.37	3.37	2.30	2.52	8.56	40.10
16	MPUAT, Udaipur	0.00	0.00	30.05	0.51	3.86	1.80	0.00	6.17	36.22
17	SKUAST, Jammu	0.00	0.00	37.85	0.45	3.87	2.30	0.00	6.62	44.47
	UAS, Raichur *	0.00	0.00	17.33	0.00	0.00	0.00	0.00	0.00	17.33
	PC, Unit, Jabalpur	1.38	0.00	0.00	0.00	2.74	4.20	0.00	6.94	8.32
	Total ICAR share	**1.38**	**7.60**	**1131.53**	**6.76**	**62.39**	**36.80**	**7.58**	**113.53**	**1254.04**

* Closed w.e.f. 1st April, 2018

3. RESEACH ACHIEVEMENTS

WP 1 Development of sustainable weed management practices in diversified cropping systems

WP 1.1 Weed management in different cropping systems under conservation agriculture systems

WP 1.1.1 Weed management in rice-based cropping systems

Cooperating centres:

OUAT, Bhubaneswar; CCSHAU; Hisar; PJTSAU; Hyderabad; SKUAST; Jammu; PAU; Ludhiana, GBPUAT; Pantnagar; BCKV; Kalyani; AAU; Jorhat and UAS; Bengaluru.

Treatment details:

Treatments	*Kharif*	*Rabi*	Summer
Tillage and residue management			
T1	CT (Transplanted)	CT	-
T2	CT (Transplanted)	ZT	ZT
T3	CT (Direct-seeded)	CT	ZT
T4	ZT (Direct-seeded)	ZT	ZT
T5	ZT (Direct-seeded)+R	ZT+R	ZT
Weed management			
W1	Recommended herbicide		
W2	IWM (herbicide+manual weeding)		
W3	Weedy check or one hand weeding		

CT: Conventional tillage (3-4 harrowing/cultivation),
ZT: No-tillage, opening of the slice for placing seeds/fertilizers leaving inter-row undisturbed,
R: Previous crop residues, IWM: Integrated weed management

OUAT, Bhubaneswar

Weed management in rice- maize-cowpea under conservation agriculture systems

In rice, the weed flora during *Kharif* was comprised of *Echinochloa crus-galli, E. colona, Paspalum scorbiculatum, Cynodon dactylon,* among grassy weeds, Marsilea *quadrifolia*, *Alternanthera sessilis, Ludwigia parviflora* among broadleaved weed and *Cyperus difformis,* C. *iria,* C. *rotundus* and *Fimbristylis miliacea,* among sedges. At 60 DAP, ZT (direct seeded)-ZT-ZT system had recorded 45.5% higher weed dry biomass (47.2 g/m^2) over CT (transplanted)–CT system (32.5 g/m^2). Rest of the treatments had significantly lower weed dry biomass. However, their effect was less in relation to CT (transplanted)-CT system.

Among weed management practices, application of butachlor 1.5 kg/ha followed by one hand weeding (IWM) recorded fewer weeds, but dry biomass was lower in butachlor 1.5 kg/ha applied plots to the tune of 33% and IWM (29.6%) over one hand weeding (38.5 g/m^2). The grain yield and gross return were statistically at par with different tillage system. However, the highest grain yield (3.70 t/ha) and gross return (₹ 53 × 10^3/ha) were obtained with IWM followed by recommended herbicide and lowest grain yield and return obtained in one hand weeded plots. It was also noticed that the composition of the weed seed bank in ZT was dominated with grasses (60%) followed by broad-leaved weeds (24%) and sedges (16%) and the corresponding values in CT were 54, 32 and 14%, respectively.

In *Rabi* maize, experimental field was comprised with 60% grassy weeds (*Panicum repens, E. crus-galli, E. colona, Leptochloa chinensis, P. scrobiculatum* and *Dactyloctenium aegyptium)* followed by 25% broad-leaved weeds (*M. quadrifolia, A. sessilis*, *L. parviflora* and *Sphenoclea zeylanica)* and lowest by 15%

sedges (*C. difformis*, *C. iria* and *C. rotundus*). It was noticed that there was a decrease in different categories of weeds since the beginning of the experiment (i.e. 2013). At 60 DAS, ZT(DSR)+R-ZT+R-ZT recorded the lowest weed density (25.8 no./m^2) followed by ZT(DSR)-ZT+R-ZT (33.5 no./m^2), whereas the highest density recorded in CT(trans)-CT-ZT. It showed that the retention of crop residue significantly reduced the weed density thereof weed dry biomass. However, the grain yield was higher with CT (transplanting)-ZT-ZT system (4.52 t/ha) whereas, ZT(DSR)-ZT+R-ZT system resulted in the lowest grain yield and the yield reduction by 24.7% over CT-CT system. Among weed management practices, the IWM practice (pendimethalin 1.0 kg/ha with one manual weeding) recorded significantly the lowest weed density (17.9 no./m^2) and highest grain yield (4.12 t/ha) as compared to sole recommended herbicide application *i.e.* pendimethalin 1.0 kg/ha (34.1 no./m^2 and 3.93 t/ha, respectively) and one hand weeding (74.2 no./m^2 and 2.45 t/ha, respectively). The practice of IWM, however, reduced the weed density by 75.9% over one hand weeding.

In summer 2018, ZT(Direct)-ZT+R-ZT recorded the highest cowpea pod yield (42.3 t/ha) followed by ZT(Direct)+R-ZT+R-ZT+R (39.7 t/ha). The lowest yield recorded with CT-CT-ZT system (31.8 t/ha). At 60 DAS, recommended herbicides had the lowest weed density and dry biomass followed by IWM. The higher weed density and dry biomass were recorded with hand weeding. However, higher pod yield harvested with IWM (49.2 t/ha) followed by recommended herbicide (44.3 t/ha). The floristic composition of weed seed bank before the rice was dominated with grasses (56%) followed by broad-leaved weeds (32%) and sedges (12%). The dominant grasses were *E. colona*, *D. aegyptium*, *D. ciliaris*, *Eleusine indica* and *Sporobolus diander*. The major broadleaf weeds were *Ludwigia parviflora*, *Alternanthera sessilis,* and *Cleome viscosa*. Among sedges, *C. rotundus*, *C. iria* and *F. miliaceae* were dominated. The weed densities were conspicuously higher in hand weeding plots (217 and 245 no./m^2). Application of herbicides with manual weeding reduced the weed densities by 42.5% over sole herbicide application. The establishment method CT to rice and ZT+R in maize and ZT in cowpea produced the highest REY of 13.4 t/ha. But the application of butachlor + hand weeding (IWM) to rice and pendimethalin to maize of ZT+R with one hand weeding and ZT with cowpea recorded the highest B:C ratio (3.5).

CCSHAU, Hisar

Weed management in conservation agriculture systems in rice-wheat cropping system

During *Rabi* 2017-18, *Phalaris minor* was the

Table 1.1.1.1 Effect of conservation agriculture treatments in the rice-wheat system at RRS, Karnal (2015-16 to 2017-18)

Kharif (Rice)	*Rabi* (Wheat)	Density of weeds (No./m²)			Grain yield (t/ha)					
					2015-16		2016-17		2017-18	
		P. minor (wheat)	*E. crus-galli* (rice)	*D. aegyptium* (rice)	Rice (CSR30)	Wheat (HD2967)	Rice (CSR30)	Wheat (HD2967)	Rice (CSR30)	Wheat (WH1105)
ZT (DSR)+ residue	ZT+ residue	3.26(9.7)	3.20(9.3)	10.87(117.3)	3.38	5.40	2.17	5.51	2.72	6.49
ZT (DSR)	ZT+ residue	2.94(7.7)	2.75(6.7)	10.10(101.3)	3.37	5.42	2.18	5.48	2.64	6.26
CT (DSR)	CT	5.62(30.7)	7.45(54.7)	5.24(26.7)	3.33	5.35	2.16	5.40	2.80	6.41
CT (PTR)	ZT	4.04(15.3)	3.00(8.0)	1.00(0.0)	3.42	5.12	2.45	5.18	3.08	6.28
CT (PTR)	CT	4.51(19.3)	1.00(0.0)	1.00(0.0)	3.41	5.15	2.64	5.15	3.12	6.10
LSD (P=0.05)		0.54	0.54	0.91	NS	NS	0.17	0.23	0.16	NS

dominant weed in wheat. Under unweeded situations, the emergence of *P. minor* was low under ZT wheat with residues (7.7-9.7 no./m^2) as compared to ZT/CT wheat without residues (15.3-30.7 no./m^2). Grain yield of wheat after ZT/CT-DSR (6.27-6.50 t/ha) was higher than after conventional PTR (6.11-6.28 t/ha) **(Table 1.1.1.1)**. Based on three years of study, it may be concluded that *P. minor* was the dominant weed in wheat and *Echinochloa* in rice. The emergence of weeds in rice was higher under DSR than PTR. Grain yield of rice under DSR was similar/ lower than CT-PTR. However, system yields of DSR based rice-wheat were similar/ higher to PTR based rice-wheat system due to higher grain yield of wheat (0.2-0.3 t/ha) after ZT/CT-DSR than after conventional PTR. In another experiment initiated in 2018 under puddle transplanted rice-wheat cropping system, where rice grain yield was recorded by 6.3-6.4 t/ha.

PJTSAU, Hyderabad

Weed management in rice-maize-green manure cropping system under conservation agriculture

In *Kharif* 2018, the experimental area at 60 DAS was comprised with weed flora of *Alternanthera paranychioides, Digera arvensis, Cyanotis axillaris, Echinochloa colona, Corchorus tridens*, *Eclipta alba, Cyperus rotundus, Euphorbia geniculata, Dinebra retroflexa, Parthenium hysterophorus, Trianthema portulacastrum*, *Physalis minima, Merremia emarginata, Celosia argentia, E. cruss-galli, Paspalum* spp. In aerobic rice, a slight reddening of rice seedlings was noticed with the application of bispyribac-1 sodium at 25 g/ha on 15 DAS (2-3 weed leaf stage) but soon recovered.

The lowest weed density was observed with conventional transplanted rice (CT) and was followed by CT (DSR), ZT and ZT+R treatments sown under the aerobic system, inturn CT (DSR) treatment recorded lower weed density than ZT and ZT+R were on par with each other at all the stages. At 30 DAT/60 DAS, CT (transplanted) caused the lowest and at par dry biomass/m^2 at these days and were significantly superior compared to CT (DSR), ZT and ZT+R tillage practices and inturn CT (DSR), lower weed dry matter over ZT and ZT-R. A similar trend was observed at 60 DAS. IWM practice at 30 and 60 DAS recorded significantly lower weed dry biomass but inturn it were on par with chemical control and these two treatments significantly superior over unweeded control. At any of the crop growth stages interaction between tillage and weed management practice was not found significant.

More productive tillers, grains/panicle and test weight were noticed with CT transplanted and were significantly superior over CT, ZT and ZT+R treatments sown under the aerobic system (DSR) and were at par with each other, out of all the tillage. CT transplanted recorded more grain (5.54 t/ha), straw yield (8.66 t/ha) and B:C (2.2) which did not differ significantly with CT transplanted, and these were followed by CT, ZT and ZT+R sown under aerobic system (DSR) with on par grain and straw yield. Increased yield in CT transplanted was reflected in terms of lower weed index values. Significantly more grain and straw yield were obtained with IWM practice (3.84 and 5.60 t/ha, respectively) followed by chemical treatment. The lowest grain and straw yield recorded with unweeded control (1.83 and 2.54 t/ha, respectively).

In *Rabi* maize during 2017-18 at 30 DAS, the weed flora of experimental field consisted of *C. rotundus* among sedges, *D. retroflexa, E*. *crus-galli, E. colona, Cynodon dactylon* and *Paspalum distichum* among grasses and *P. hysterophorus, A. paranychioides, Melilotus alba, T. portulacastrum, D. muricata, Eclipta alba, Spilanthes acmella, Sonchus* sp. *Aeschynomene* sp. and *Cardiospermum helicacabum* among the broadleaved weeds. However, in addition to these weeds, *Amaranthus viridis, Amaranthus polygamus, Aacalypha indica* at 60 DAS, *Dactyloctenium aegyptium, Portulaca oleracea* at 90 DAS, *Euphorbia geniculata* and *Cyanotis axillaris* at harvest were recorded in *Rabi* maize.

Weed density at various stages showed no significant effect with respect to tillage and crop residue. However, significantly lower weed density observed with IWM practice at all the growth stages and was on par with the chemical method. At 30 DAS, significantly low weed dry biomass (4.42 g/m^2) was noticed in *Rabi* maize with CT compared to ZT under both systems of rice establishment (TPR & DSR) during *Kharif* were comparable with each other. This was followed by CT of

Rabi maize sown under ZT and inturn this was significantly superior over *Rabi* maize grown after DSR (10.91 g/m^2) during *Kharif*. A similar trend was recorded at 90 DAS, whereas, at 60 DAS there was no significant difference observed. Weed management practices were significant only at 60 and 90 DAS, IWM recorded the lowest weed dry biomass over unweeded control.

The effect of tillage was significant on cob length, cob girth and test weight. ZT proved better as it increased cob length and cob girth significantly over CT irrespective of the system of rice establishment in *Kharif*. Residue management had no significant effect under any of the tillage. But test weight was significantly higher in CT than ZT. However, more grain yield was obtained with CT under DSR (6.17 t/ha) condition and was on par with CT sown under TPR (6.01 t/ha) followed by ZT. The stover yield was not influenced by tillage practices. Among weed management, IWM (atrazine 1000 g/ha + paraquat 600 g/ha *fb* HW at 40 DAS) was significantly superior in producing better yield attributes and yield (6.21t/ha) but it was on par with chemical method of weed control (atrazine 1000 g/ha + paraquat 600 g/ha *fb* 2, 4-D 1000 g/ha at 20-25 DAS). The economic parameters are presented in **Table 1.1.1.2**. The highest rice equivalent yield of rice-maize cropping system was recorded under CT-CT (11.9 t/ha) followed by ZT (11.2 t/ha), even though more cost of cultivation incurred towards CT, due to the realization of more yield under conventional system over direct seeded aerobic rice. Among weed management, IWM recorded 10.27 t/ha followed by chemical weed management (9.48 t/ha).

Table 1.1.1.2 Influence of tillage and weed management practices on weed dry biomass, yield and economics of *rabi* maize in rice – maize-green manure cropping system (*Rabi,* 2017-18)

Treatment	Weed dry biomass (g/m²) at 90 DAS	Grain yield (t/ha)	Straw yield (t/ha)	COC (₹/ha)	GR (₹/ha)	NR (₹/ha)	B:C ratio
Tillage							
CT (Transplanted)-CT	3.52(11.3)	6.22	7.61	37,250	1,13,356	76,106	3.04
CT (Transplanted) ZT	3.45(10.9)	5.53	6.13	33,640	1,00,266	66,626	2.98
CT (Direct seeded) CT	3.60(11.9)	6.37	8.83	37,255	1,17,198	79,943	3.15
ZT (Direct seeded) ZT	3.35(10.2)	4.27	6.70	33,645	79,441	45,796	2.36
ZT(Direct seeded) + R^{-1} ZT+R	3.81(13.5)	5 38	7.46	33,642	99,042	64,500	2.94
LSD (P=0.05)	3.68	1.09	2.22				
Weed management							
Chemical	9.39(87.1)	5.92	7.67	34 565	1,08,409	73,844	3.14
IWM	8.53(71.7)	6.41	8.45	35,460	1,17,470	82,010	3.31
Unweeded control	14.11 (197.9)	4.34	6.22	31,464	80,019	4,855	2.54
LSD (P=0.05)	2.01	0.65	1.17				

Figures in parenthesis are orginal value, WC: cost of cultivation GR: Gross return, NR: nutrition.

SKUAST, Jammu

Weed management in rice-wheat-green gram cropping system under conservation agriculture

During *Rabi* 2017-18, the wheat field was comprised of *Phalaris minor, Medicago* spp., *Rumex* spp., *Ranunculus arvensis*, *Anagalis arvensis*, *Melilotus indica* and *Vicia* spp. There was significantly lower grassy, broad-leaved, total weed density and weed biomass recorded in ZT-wheat+residue plots as compared to CT-wheat and ZT-wheat. The density of *Phalaris minor, Rumex* spp., *Ranunculus arvensis*, *Anagallis arvensis*, *Melilotus indica* and other weeds were lower in ZT-wheat+residue plots as compared to CT-wheat and ZT-wheat. However, density of *Medicago* spp. significantly lower in CT-wheat as compared to ZT-wheat (with and without residue). The highest grain and straw yields were recorded in ZT+R (4.2 and 6.1 t/ha, respectively); however, lowest grain yield and straw yields were recorded with ZT-wheat without residue (3.8 and 5.4 t/ha, respectively). The highest B:C ratio was recorded in ZT-wheat+R.

Among the weed management treatments, all the weed management treatments recorded significantly lower weed density and weed biomass as compared to weedy check. The IWM (sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS *fb* HW at 45 DAS) recorded significantly lowest density and biomass of weeds as compared to weedy check and herbicidal treatment (sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS). The significant interactions were found between tillage and weed management treatments with respect to weed density and weed biomass at 60 DAS and at harvest (**Table 1.1.1.3**).

The integrated weed management (sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS *fb* HW at 45 DAS) recorded significantly higher panicles spikes (488/m^2), grain and straw yields (4.6 and 6.7 t/ha, respectively) of wheat as compared to weedy check and herbicidal treatment (sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS). The highest B: C ratio was recorded in integrated weed management (sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS *fb* HW at 45 DAS). The non-significant interaction was found between tillage and weed management treatments with respect to growth, yield attributes and yield of wheat.

Table 1.1.1.3 Effect of tillage and weed management practices on weed biomass in wheat (*Rabi*-2017-18)

Treatments	Weed biomass (g/m²) at 60 DAS				Weed biomass (g/m²) at harvest				Grain yield (t/ha)
	Grassy	BLWs	Total	WCE	Grassy	BLWs	Total	WCE	
Tillage and residue management									
TRM 1	4.48 (19.1)	5.98 (34.8)	7.41 (53.9)	58.5	7.20 (50.9)	8.33 (68.3)	10.9 (119.2)	59.9	4.0
TRM 2	4.28 (17.3)	6.52 (41.4)	7.73 (58.8)	58.7	6.99 (47.9)	8.89 (78.0)	11.2 (125.9)	60.2	3.8
TRM 3	4.41 (18.4)	5.78 (32.4)	7.20 (50.8)	58.6	7.02 (48.3)	7.94 (62.0)	10.5 (110.3)	60.1	4.1
TRM 4	3.21 (9.3)	4.70 (21.0)	5.60 (30.3)	60.7	5.30 (27.0)	6.82 (45.4)	8.5 (72.5)	60.7	4.2
TRM 5	3.16 (8.9)	4.54 (19.6)	5.44 (28.6)	61.0	5.20 (26.0)	6.36 (39.3)	8.1 (65.4)	60.4	4.2
SEm ±	0.07	0.11	0.08		0.10	0.11	0.11		0.1
LSD (p=0.05)	0.22	0.35	0.26	81.7	0.33	0.37	0.35	83.0	NS
Weed management									
Herbicide	2.78 (6.7)	3.83 (13.6)	4.63 (20.3)	0.0	4.69 (20.9)	4.68 (20.9)	6.55 (41.9)	0.0	4.3
IWM	1.49 (1.21)	1.91 (2.6)	2.20 (3.8)	58.5	1.75 (2.0)	2.20 (3.8)	2.63 (5.9)	59.9	4.6
Weedy	6.08 (35.9)	8.62 (73.3)	10.5 (109.3)	58.7	9.90 (97.0)	12.3 (151.2)	15.7 (248.3)	60.2	3.29
SEm ±	0.05	0.04	0.05		0.08	0.07	0.08		0.06
LSD (P=0.05)	0.14	0.12	0.13		0.24	0.19	0.24		0.19
Interaction	S	S	S		S	S	S		NS

TRM 1 CT (transplanted)-CT (wheat), **TRM 2** CT (transplant)- ZT (wheat-ZT (greengram), **TRM 3** CT(direct-seeded)-CT-wheat-ZT (greengram,**TRM 4** ZT (direct-seeded)-ZT (wheat)+R-ZT (greengram),**TRM 5** ZT (direct-seeded)+R-ZT+R (wheat)-ZT(greengram) R Crop residue).

Data were subjected to square root transformation $\sqrt{X+1}$. Original values are in parenthesis

During *Kharif* 2018, the study area was comprised of *Echinochloa* spp., *Cynodon dactylon* and *Digitaria sanguinalis* amongst grassy weeds; *Alternanthera philoxeroides, Caesulia axilaris, Phyllanthus niruri* and *Physalis minima* amongst broad-leaved weeds and *Cyperus* spp. were mainly infested in rice. Other weeds like *Dactyloctenium aegyptium*, *Ammannia baccifera* and *Commelina benghalensis* were also recorded.

Among the tillage and residue management treatments significantly lower grassy, broad-leaved, sedges, total weed density and weed biomass were recorded in transplanted rice as compared to ZT-DSR+residue, ZT-DSR and CT-DSR. *Alternanthera philoxeroides* and *Caesulia axillaris* were significantly higher in transplanted rice as compared to DSR either under ZT and CT. However, density of *Phyllanthus niruri* and *Physalis minima* were significantly higher in DSR either under ZT and CT as compared to transplanted rice. A significantly higher number of panicles, grain and straw yield were recorded in transplanted rice as compared to ZT-DSR+R, ZT-DSR, and CT-DSR (**Table 1.1.1.4**). The number of grains/panicle and test weight were found to be non-significant among different tillage and residue management treatments.

Among the weed management treatments, all the weed management treatments recorded significantly lower weed density and weed biomass as compared to weedy check. The IWM (herbicide + one hand weeding) recorded significantly lowest density and biomass of weeds as compared to weedy check and herbicidal treatment. The significant interaction was found between tillage and weed management treatments with respect to weed density and weed biomass. IWM (herbicide+one hand weeding) recorded significantly higher panicles/m^2 and grain and straw yield of rice as compared to weedy check and herbicidal treatment.

Amongst all the tillage and residue and weed management combinations, highest net returns and B: C ratio was recorded in ZT-DSR+R and IWM treatment combination.

Table 1.1.1.4 Effect of tillage and weed management practices on weed biomass in rice (*Kharif*-2018)

Treatment	Weed biomass (g/m2) at 60 DAS/DAT				WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)	B:C
	Grassy	BLWs	Sedges	Total				
Tillage								
TRM 1	3.96 (14.7)	2.98 (7.8)	2.97 (7.8)	5.61 (30.4)	53.5	4.11	5.26	1.93
TRM 2	4.03 (15.3)	3.08 (8.5)	2.99 (7.97)	5.72 (31.7)	52.9	4.02	5.07	1.86
TRM 3	6.52 (41.5)	3.95 (14.5)	4.37 (18.1)	8.68 (74.2)	56.7	3.30	4.24	1.50
TRM 4	6.84 (45.7)	3.99 (14.9)	4.89 (22.9)	9.20 (83.6)	56.3	2.87	3.65	1.30
TRM 5	6.04 (35.5)	3.46 (10.9)	4.12 (15.4)	7.96 (62.4)	58.5	3.48	4.52	1.76
SEm ±	0.13	0.02	0.07	0.11		0.12	0.22	
LSD (P=0.05)	0.42	0.08	0.24	0.37		0.39	0.72	
Weed management								
Herbicide	4.75 (21.6)	2.71 (6.3)	2.72 (6.4)	5.94 (34.3)	71.6	4.12	5.26	2.14
IWM	2.07 (3.3)	1.07 (0.1)	1.86 (2.4)	2.62 (5.8)	95.1	4.49	5.81	2.19
Weedy	8.23 (66.8)	5.35 (27.6)	5.99 (34.8)	11.41 (129.3)	0.00	2.01	2.57	0.69
SEm ±	0.06	0.04	0.04	0.06		0.07	0.12	
LSD (P=0.05)	0.18	0.12	0.13	0.17		0.21	0.37	
Interaction	S	S	S	S		S	S	

Data were subjected to square root transformation $\sqrt{}$ X+1. Original values are in parenthesis

PAU, Ludhiana

Weed management in rice-wheat-green manure cropping system under conservation agriculture

During *Rabi* 2017-18 in wheat, study area was comprised more with *Phalaris minor* and *Rumex dentatus*, whereas less number of *Avena ludoviciana, Coronopus didymus, Anagallis arvensis, Chenopodium album* and *Medicago denticulata* were recorded. Among tillage and residue management, CT-wheat following CT-DSR recorded significantly more density and biomass of *P. minor* than all other tillage and residue management treatments at 30 and 60 DAS. *A. ludoviciana* was observed in wheat grown in continuation with DSR. ZT wheat with residue retention, following ZT-DSR, recorded the lowest density of all weed plants. Among weed control, recommended herbicide and IWM significantly reduced weed density and biomass than weedy check.

Interaction effects of tillage, residues and weed management were significant for seed bank of *P. minor*, *R. dentatus* and *P. annua*. This year, the highest numbers of *P. annua* were observed in ZT wheat plus where residues of only wheat were retained (**Table 1.1.1.5**). Tillage and residue management exhibited a non-significant effect on weed seed bank of *A. arvensis* and *C. album.* Recommended herbicides and IWM recorded significantly lower weed seed numbers than weedy check. Lowest numbers of *A. arvensis* and *P. annua* seeds were observed in wheat sown with CT following transplanted rice.

Tillage and residue management treatments gave statistically similar wheat grain yield and yield attributes; ZT+R, following DSR+R, gave the highest net returns and B:C ratio (**Table 1.1.1.6**). Among weed control, IWM and herbicides recorded significantly higher wheat grain yield and economic returns compared to unweeded control; IWM recorded significantly higher wheat grain yield while highest economic returns were recorded with recommended herbicides. At harvest residues of metribuzin and clodinafop-propargyl, under recommended herbicide and IWM treatments were below detectable limit (<0.05 μg/g) in soil and wheat grains.

Table 1.1.1.5 Effect of tillage, residue and weed management on weed seed bank in wheat (*Rabi* 2017-18)

Treatment	No. of seeds/m² up to the depth of 15 cm				
	P. minor	*R. dentatus*	*A. arvensis*	*C. album*	*P. annua*
Tillage and residue management					
TRM1	22.8 (552)	19.4 (381)	13.7 (198)	13.9 (198)	19.1 (368)
TRM2	18.6 (368)	22.3 (566)	15.4 (240)	1.0 (0)	28.6 (990)
TRM3	20.3 (425)	18.6 (354)	16.2 (269)	13.9 (201)	30.6 (1117)
TRM4	16.8 (314)	24.5 (622)	15.4 (240)	12.6(162)	44.2 (2602)
TRM5	22.3 (537)	23.3(566)	17.6 (325)	14.7 (226)	34.1 (1230)
SEm±	0.41	0.33	0.34	0.83	0.46
LSD (P=0.05)	1.34	1.08	1.11	2.70	1.49
Weed management					
W1	18.3 (340)	20.6 (433)	15.5 (246)	10.7 (139)	25.3 (679)
W2	15.1 (231)	17.0 (290)	12.9 (170)	10.5 (138)	20.2 (416)
W3	27.2 (747)	27.4 (770)	18.6 (348)	12.5 (195)	48.4 (2690)
SEm±	0.29	0.29	0.42	0.56	0.31
LSD (P=0.05)	1.50	1.39	1.24	NS	0.70
Interaction LSD(P=0.05)	S	S	NS	NS	S

TRM 1- Puddled transplanted rice - Conventional till (CT) Wheat-ZT (green manure), **TRM 2-** Puddled transplanted rice - CT (wheat) with rice residue - ZT (green manure), **TRM 3 -** Puddled transplanted rice - ZT (wheat) with rice residue on surface - ZT (green manure), **TRM 4-** ZT (transplanted) - ZT + R (Wheat) - ZT (Green manure), **TRM 5 -** ZT (direct-seeded) + R - ZT (wheat) + R - ZT (green manure).

Data subject to square root transformation; Figure in parentheses are means of original values.

Table1.1.1.6 Effect of tillage, residue and weed management on growth, yield and yield attributes of wheat and economics of different treatments (*Rabi* 2017-18).

Treatment	Effective tillers (No./m^2)	Spike length (cm)	Wheat grain yield (t/ha)	Biolo-gical yield (t/ha)	Nutrient depletion at harvest (kg/ha)			Variable cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ration
					N	P	K				
Tillage and residue management											
TRM1	305.9	12.4	3.39	8.9	6.0	0.8	9.1	39,431	55,984	16,554	1.4
TRM2	296.0	12.4	3.23	8.6	8.3	1.1	12.6	34,618	53,377	18,760	1.5
TRM3	318.1	12.6	3.97	10.4	4.8	0.6	7.3	39,431	65,637	26,206	1.7
TRM4	319.6	12.5	4.03	10.5	5.3	0.7	8.0	34,618	66,561	31,943	1.9
TRM5	327.0	12.5	4.21	10.9	3.8	0.5	5.7	34,618	69,547	34,930	2.0
Sem ±	6.1	0.1	0.17	0.40	-	-	-	-	-	-	-
LSD(P=0.05)	20.0	NS	0.56	1.31	-	-	-	-	-	-	-
Weed management											
W1	341.0	12.5	4.57	12.5	1.5	0.2	2.2	32,985	74,327	41,343	2.2
W2	353.7	12.6	4.71	12.5	0.3	0	0.4	44,723	76,683	31,961	1.7
W3	245.3	12.4	2.02	5.5	15.2	2.0	23.0	31,923	32,841	918	1.0
SEm ±	6.3	0.1	0.07	0.6	-	-	-	-	-	-	-
LSD(P=0.05)	24.7	NS	0.27	0.2	-	-	-	-	-	-	-
Interaction LSD	NS	NS	NS	NS	-	-	-	-	-	-	-

In rice during *Kharif* 2018, *Echinochloa colona* and *E. crus-galli* amongst grassy weeds and *Eclipta alba* and *Digera arvensis* amongst broadleaf weeds infested the crop. In transplanted rice of establishment method, tillage and residue management, statistically similar population and biomass of grasses and broadleaf weeds were observed at 60 DAT and at harvest. Among weed control, IWM recorded significantly lower population and dry biomass of grasses and broadleaved weeds as compared to recommended herbicides and unweeded control. Among six weeds i.e. *E. crus-galli*, *E. colona, Dactyloctenium aegyptiacum, Trianthema portulacastrum* were major weeds and *Ischaemum* and *Cyperus* were added in weed seed bank during *Kharif* 2018 (**Table 1.1.1.7**). Lower numbers of weed seeds were observed in both weed control treatments as compared to unweeded control (**Table 1.1.1.8**).

All the yield attributes and grain yield in PTR were statistically similar. Rice crop growth, yield attributes and grain yield under both weed control treatments were significantly better than unsprayed control. At harvest residues of pendimethalin and bispyribac-sodium in soil and rice grains were below the detectable limit. DHA activity decreased significantly after 15 days of treatment as compared to unsprayed control.

Table 1.1.1.7 Effect of tillage, residue and weed management on weed density, biomass and nutrient depletion at harvest in rice (*Kharif* 2018).

Treatment	Weed population at harvest (No./m²)*				Weed biomass (g/m²) at harvest*		Yield attributes at harvest			Grain yield (t/ha)	Biological yield (t/ha)
	E. colona	*E. crus-galli*	*E. alba*	*D. arvensis*	Grasses	Broadleaves	Plant height (cm)	Effective tillers (No./m²)	Panicle length (cm)		
Tillage and residue management											
TRM1	2.1 (4)	1.5 (1)	1.5 (1)	1.1 (0)	11.7 (237)	3.1 (11)	76.2	247.7	22.2	4.53	11.3
TRM2	1.9 (4)	1.4 (1)	1.5 (1)	1.1 (0)	11.6 (236)	3.1 (11)	76.4	246.7	22.1	4.46	11.2
TRM3	2.2 (5)	1.5 (1)	1.5 (1)	1.1 (0)	11.6 (236)	3.1 (12)	76.6	247.2	22.1	4.49	11.3
TRM4	2.1 (4)	1.5 (1)	1.5 (1)	1.1 (0)	11.6 (236)	3.1 (12)	76.3	247.2	22.1	4.54	11.2
SEm ±	0.07	0.1	0.07	0.06	0.3	0.1	1.4	10.5	0.6	0.11	0.53
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management											
W1	3.4 (11)	1.9 (3)	1.9 (3)	1.2 (1)	25.2 (634)	5.1 (25)	73.6	206.7	22.2	3.68	9.4
W2	1.8 (3)	1.4 (1)	1.5 (1)	1.0 (0)	8.7 (75)	3.2 (9)	77.1	265.4	22.5	4.87	12.1
W3	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	78.5	268.8	22.7	4.97	12.3
SEm ±	0.1	0.04	0.04	0.04	0.4	0.1	1.1	10.8	0.3	0.15	0.10
LSD (P=0.05)	0.6	0.2	0.1	0.2	1.5	0.3	NS	42.3	1.1	0.59	0.41
Interaction LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Data subjected to square root transformation. Figures in parenthesis are means of original values.

Table 1.1.1.8 Effect of tillage, residue and weed management on weed seed bank in rice (*Kharif* 2018)

Treatment	No. of seeds/m² up to the depth of 15 cm					
	C. rotundus	*E. colona*	*D. aegyptium*	*T. portulacastrum*	*E. crus-galli*	*I. rugosum*
Tillage and residue management						
TRM1	604	188	327	171	335	114
TRM2	252	138	563	58	268	104
TRM3	339	115	600	188	338	148
TRM4	401	145	468	87	331	131
SEm±	15.6	12.3	24.1	8.7	7.4	5.9
LSD (P=0.05)	12.3	20.5	13.5	19.9	7.7	13.2
Weed management						
W1	274	151	281	112	190	128
W2	365	112	462	129	272	87
W3	496	276	865	154	407	186
SEm±	19.2	7.9	11.6	6.6	11.5	9.7
LSD (P=0.05)	19.7	17.1	8.4	19.5	15.3	28.2
Interaction LSD (P=0.05)	NS	NS	NS	NS	NS	NS

GBPUAT, Pantnagar

Weed management in rice-wheat-*Sesbania* cropping system under conservation agriculture

In wheat (2017-18) weed composition of experimental plots were *Pholaris minor, Medicago denticulata, Polygonum plebeium, Cornopus didymus, Melilotus indica, Chenopodium album, Vicia sativa, Rumex acetosella,* and *C. rotundus* at 60 DAS and among them dominant weed species were *M. denticulata* (47.7%), *P. minor* (32.7%) and *R. acetosella* (9.5%).

CT with or without *Sesbania* as well as TPR-ZT along with *Sesbania* recorded minimum density of weeds. Higher *P. minor* density was observed in the conventional system while significantly reduced in ZT-DSR-wheat system along with *Sesbania*. Whereas, *M. denticulata* and *R. acetosella* density were found lowest under CT DSR-wheat system along with *Sesbania*. *P. plebejium*, *M. indica* and *C. rotundus* density were completely eliminated under CT and ZT-TPR-wheat system along with *Sesbania* and *C. rotundus* and *M. indica* also got eliminated under ZT-DSR-wheat system with *Sesbania*. Among establishment systems, the highest number of spikes/m^2 and grain yield was achieved with CT-DSR-wheat system along with *Sesbania* (ZT). The straw yield was observed comparable to each other but numerically highest straw yield (6.3 t/ha) was achieved in conventional tillage DSR-wheat system along with *Sesbania* (ZT) (**Table 1.1.1.9**).

The minimum population of all weed species was obtained under IWM approach (recommended herbicide *fb* one hand weeding) followed by ready-mix herbicide (clodinafop + metsulfuron methyl) and both the treatments reduced the population of weed species over the weedy situation. IWM totally controlled the density of all broad-leaved weeds, except *M. denticulata* and *R. acetosella* and whereas, recommended herbicide (clodinafop + MSM) completely controlled *M. indica* and *C. rotundus*. Among weed management practices, IWM practice obtained the highest number of spikes/m^2, number of grains/spike, 1000 grain weight, grain yield, and straw yield and significantly superior to rest of the practices. Among different establishment methods, the highest net return and benefit-cost ratio of ₹65,434 and 3.0, respectively was recorded in the plots, where, wheat was sown in the DSR(CT)-wheat (CT)-*Sesbania* (ZT) incorporated as green manure system and TPR (CT)-wheat (ZT) along with sesbania, while, within weed management practices, integrated weed management (Recommended herbicide *fb* one HW) recorded the highest net return (₹ 72,469), while recommended herbicide recorded the highest B:C ratio (3.2).

Table 1.1.1.9 Effect of establishment methods and weed management on weed dry weight at 60 DAS in wheat crop in the rice-wheat cropping system.

Treatment	Weed dry weight (g/m)			Grain yield (t/ha)	Straw yield (t/ha)	B:C
	Grassy	BLWs	Sedges			
Establishment System						
TPR (CT)-Wheat (CT)	2.8(9.7)	1.8(2.7)	1.0(0.0)	4.6	5.7	2.9
TPR (CT)-Wheat (ZT)- *Sesbania* (ZT)	2.4(6.1)	1.6(2.0)	1.1(0.3)	4.0	5.3	3.0
DSR (CT)-Wheat (CT)- *Sesbania* (ZT)	2.9(10.4)	1.5(1.6)	1.2(0.4)	4.6	6.3	3.0
DSR (ZT)-Wheat (ZT)- *Sesbania* (ZT)	1.8(3.1)	2.3(5.6)	1.0(0.0)	4.0	5.2	2.9
DSR (ZT)+R-Wheat (ZT)+R- *Sesbania* (ZT)	3.3(11.7)	2.2(4.8)	1.0(0.1)	4.0	5.2	2.6
SEm±	0.07	0.03	0.01	0.19	0.12	-
LSD (P=0.05)	0.2	0.1	0.04	NS	0.14	-
Weed management						
Rec.herb. (Clodinafop + MSM 60+4 g/ha)	2.0(3.2)	1.5(1.4)	1.0(0.0)	4.2	5.9	3.2
IWM (Rec. herbicide + one hand weeding)	1.5(1.2)	1.1(0.3)	1.0(0.0)	5.1	6.5	3.1
Unweeded	4.5(20.2)	3.0(8.4)	1.2(0.5)	2.9	4.3	2.2
SEm±	0.05	0.3	0.1	0.15	0.42	-
LSD (P=0.05)	0.1	0.08	0.03	0.45	0.43	-

DSR: direct seeded rice; TPR- transplanted rice; CT- conventional tillage, ZT- zero tillage, R- residue retention; (Value in parentheses are original and transformed to square root $\sqrt{X+1}$ for analysis)

In rice during *Kharif* 2018 the experimental field was comprised with *Echinochloa colona*, *E. crus-galli*, *Leptochloa chinensis, Alternanthera sessilis*, *Cyanotis axillaris, Ammania baccifera, Cyperus rotundus*, *C. iria,* and *C. difformis* and among them the dominant weed species recorded were *L. chinensis* (13.1%), *A. sessilis* (8.7%), *A. baccifera* (12.02%) and *C. iria* (51.4%). At 60 DAS/T, among tillage and residue management, CTT-PR as well as ZT rice along with residue retention and *Sesbania*, attained a lowest total density of grassy and sedge weeds, while in case of broad leaf weeds, it was recorded with conventional tillage (TPR) rice-wheat along with *Sesbania* and residue retention. The total dry biomass of grassy weeds was obtained minimum with CTT-PR along with ZT rice with the inclusion of residue retention and *Sesbania*, while total dry biomass of broad leaf and sedges were obtained minimum under CTT-PR-wheat with the incorporation of residue retention and *Sesbania*. CT-TPR with residue recorded maximum number of tillers/m^2, grain and straw yield (5.7 and 12.5 t/ha, respectively). The highest grains/panicle was recorded in CT-TPR which was comparable to CT-TPR with the inclusion of residue retention. CT-DSR recorded the highest test weight which was found comparable to CT-TPR with the inclusion of residue.

Among weed management practices IWM achieved minimum total weed density and weed dry biomass of all grassy and non grassy weeds (**Table 1.1.1.10**). Lowered density and dry biomass resulted in better yield attributes and yield of rice which was significantly superior to recommended herbicide practice.

Table 1.1.1.10. Effect of establishment methods and weed management practices on total weed density and weed dry weight at 60 DAS/DAT in rice crop in the rice-wheat cropping system.

Treatments	Grassy		BLWs		Sedges		Grain yield (t/ha)	Straw yield (t/ha)
	Density (no./m²)	Dry weight (g/m²)	Density (no./m²)	Dry weight (g/m²)	Density (no./m²)	Dry weight (g/m²)		
Tillage and residue management								
TPR (CT)-Wheat (CT)	3.0 (10.7)	4.6 (32.8)	2.8 (8.0)	1.7 (2.3)	2.8 (12.9)	3.7 (26.9)	4.9	11.4
TPR (CT) + R- Wheat (CT)+R-*Sesbenia*	2.3(7.8)	3.8 (29.4)	2.3 (5.1)	1.5 (1.6)	2.5 (8.0)	3.7 (25.1)	5.3	12.0
TPR (CT) + R- Wheat (ZT)+R-*Sesbenia*	2.2(5.3)	3.7(28.0)	3.0 (9.8)	1.7 (1.9)	2.4 (8.4)	3.8 (29.3)	5.7	12.5
DSR (CT) -wheat (CT)	2.8 (11.1)	3.7 (16.8)	2.5 (5.3)	2.3 (6.8)	4.6 (27.1)	5.2 (37.8)	3.6	11.0
DSR (CT) + R-wheat (CT)+R-*Sesbenia*	3.4 (14.0)	4.2 (21.5)	2.5 (5.3)	1.9 (2.7)	2.9 (15.3)	3.9 (30.6)	3.7	9.0
DSR (CT) + R- wheat (ZT)+R-*Sesbenia*	3.1 (10.7)	3.7 (14.8)	3.8 (14.4)	2.8 (8.9)	4.1 (25.3)	4.4 (34.9)	3.7	8.8
SEm±	0.06	0.32	0.07	0.04	0.07	0.13	0.12	1.09
LSD (P=0.05)	0.2	NS	0.2	1.1	0.2	0.4	0.38	NS
Weed management								
Rec.herb. (Penoxsulam+ cyhalofop –butyl 135 g/ha (15-20 DAS/DAT)	2.1 (3.7)	2.8 (8.5)	2.5 (5.4)	1.5 (1.4)	1.7 (2.7)	1.6 (2.3)	5.1	11.5
IWM (Rec. herbicide *fb* one hand weeding at 45 DAS/DAT)	1.3 (0.8)	1.4 (1.1)	2.0 (3.3)	1.3 (0.8)	1.3 (0.9)	1.3 (1.0)	5.5	12.2
Unweeded	5.1 (25.3)	7.7(62.1)	3.9 (15.2)	3.1 (9.9)	6.6 (45.0)	9.5 (89.1)	3.1	8.3
SEm±	0.4	0.3	0.1	0.03	0.05	0.09	0.05	0.73
LSD (P=0.05)	0.13	0.7	0.1	0.1	0.2	0.3	0.13	2.14

DSR: direct seeded rice; TPR- transplanted rice; CT- conventional tillage, ZT- zero tillage, R residue retention, Value in parentheses are original and transformed to square root $\sqrt{}$X+1 for analysis

BCKV, Kalyani

Weed management in rice- rapeseed- greengram cropping system under conservation agriculture

In *Rabi* 2017-18, experimental plots in rapeseed comprised of dominant weed species like *Amaranthus viridis, Digera arvensis, Trianthema portulacastrum, Phyllanthus niruri* among broad-leaved weeds and in grassy weeds *Dactyloctenium aegyptium, Digitaria sanguinalis, Cynodon dactylon, Chloris barbata* were observed where as *Cyperus rotundus, Cyperus difformis* were present. Among sedges CT followed by MT recorded lower weed density at 30, 60 DAS and at harvest. However, retention of residue provided better management on weed with a lower number and biomass of weed flora throughout the crop growth period. Broad-leaved weed showed their dominance over grasses and sedges. Weed control efficiency was found the highest (58.2%) at 60 DAS with CT-TP-CT followed by CT-DSR-CT. Similarly, CT-TP-CT recorded maximum seed yield (1.08 t/ha) followed by CT-DSR-CT while the minimum was observed with MT-MT. The highest net return of ₹36,572/ha was recorded under CT-TP-CT while B:C ratio was highest with MT+R-MT+R (**Table 1.1.1.11**).

Application of pendimethalin 1.0 kg/ha PRE along with mechanical weeding at 30 DAS showed the best performance with lower number and biomass of weeds with higher WCE (71.5%) followed by the application of pendimethalin 1.0 kg/ha PRE. Pendimethalin 1.0 kg/ha PRE + mechanical weeding at 30 DAS recorded highest yield attributes, seed yield (0.95 t/ha), net return (₹ 33,510/ha) and was followed by application of pendimethalin 1.0 kg/ha PRE with better B: C (1.69).

In rice during *Kharif* 2018, the experimental field was dominated by *Echinochloa crus-galli, E. colona* among grasses, *Cyperus iria, C. difformis, C. rotundus, Fimbritylis miliaceae* among sedges, *Marsilea quadrifolia, Alternanthera sessilis, Ammannia baccifera, Commelina benghalensis* and *Monochoria vaginalis* amongst broad-leaved weeds. CT- transplanted plots recorded lower weed population and biomass compared to CT-DSR at 30, 60 DAS and at harvest with 55.1% WCE (at 60 DAT). Similarly, CT- transplanted recorded maximum grain (2.3 t/ha) and straw yield (5.3 t/ha) and found superior with highest net return (₹ 1,22.464.3/ha) and B:C ratio (1.10). Between DSR, CT-DSR recorded lower weed density and biomass over MT-DSR at all three dates of observation.

Among weed management practices application of pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT recorded the lowest weed density and weed biomass with higher WCE to the tune of 84.7, 87.6 and 76.5% at 30, 60 DAS and at harvest, respectively with highest grain (1.9 t/ha), straw yield (5.0 t/ha), net return (₹ 94,743 /ha) and B:C ratio (0.91) followed by pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT. CT- transplanted in combination with the application of pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT showed best performance with least weed density, weed biomass and WCE.

CT- transplanted rice integrated with pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT was found superior with the highest grain yield (2.35 t/ha) and net return (₹ 1,27,815/ha) to rest of the treatment combinations. However, maximum B:C ratio was observed with the treatment combination receiving CT- transplanted along with pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT.

AAU, Jorhat

Weed management in rice-mustard-green manure cropping system under conservation agriculture

In rice, a field comprised of *Ageratum houstonianum, A. conyzoides* and *Polygonum glabrum* broad-leaved weeds; *Cynodon dactylon, Digitaria setigera, Echinochloa crus-galli, Eleusine indica* and *Panicum repens* were grasses and *Cyperus rotundus* was predominant sedge in the DSR. However, in transplanted rice, *Cyperus iria, Fimbristylis littoralis* and *Scirpus juncoides* were the most prevalent sedges; *Monochoria vaginalis, Sagittaria guayanensis* and *Sphenoclea zeylanica* were amongst the broadleaved weeds and *E. crus-galli, Leersia hexandra* and *Sacciolepis interrupta* were the dominant grassy weeds.

Under CT in DSR weed density and dry

Table 1.1.1.11 Effect of tillage, residue and weed management practices on yield attributes, yield and economics of rapeseed in *Rabi*, 2017.

Treatments	Plant height (cm)	Siliqua/ plant	Seeds/ siliqua	Test weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
Main plot: Tillage and residue management										
CTTP-CT	117.3	110.7	20.1	2.95	1.08	3.90	23,011	59,583	36,572	1.59
CT-MT	111.3	101.3	14.4	2.95	0.90	3.75	18,960	49,683	30,723	1.62
CTDSR-CT	116.7	108.7	18.5	2.94	1.07	3.86	23,011	59,033	36,022	1.56
MT-MT	108.1	99.6	12.9	2.91	0.86	3.72	18,960	47,483	28,523	1.51
MT+R-MT+R	113.4	106.0	16.4	2.93	0.97	3.80	20,245	53,167	32,921	1.63
SEm±	0.11	0.20	0.12	0.005	0.03	0.001	-	-	-	-
LSD (P=0.05)	0.35	0.67	0.40	0.017	0.10	0.003	-	-	-	-
Sub plot: Weed management										
Pendimethalin 1.0 kg/ha PRE	112.2	104.2	14.8	2.92	0.92	3.77	18,825	50,710	31,884	1.69
Pendimethalin 1.0 kg/ha PRE + mechanical weeding at 30 DAS	100.4	95.9	20.0	2.97	0.95	3.30	18,740	52,250	33,510	1.49
One hand weeding at 30 DAS	106.8	96.5	10.6	2.92	0.87	3.69	21,199	47,960	26,761	1.26
SEm±	0.08	0.14	0.09	0.004	0.02	0.003	-	-	-	-
LSD (P=0.05)	0.25	0.43	0.26	0.011	0.06	0.005				

Table 1.1.1.12 Effect of tillage practices and weed management on the number of panicles/m^2, number of grains/panicle and grain yield of *Sali* rice.

Treatment	Rice			Mustard	
	Panicle (no./m^2)	Filled grains (no./panicle)	Grain yield (t/ha)	Number of siliqua/plants	Seed yield (no./plant)
Tillage practices					
CT(S)-CT(TR)-CT(IM)	292.0	107.1	3.35	152.7	1.07
MT(S)-CT(TR)-MT(IM)	300.0	113.5	3.62	156.7	1.11
MT(S)-CT(DSR)-CT(IM)	207.0	102.9	2.87	210.5	1.25
MT(S)-MT(DSR)-MT+R(IM)	289.7	110.8	3.50	212.6	1.34
MT(S)-MT(DSR)-MT(IM)	288.5	111.3	3.40	210.1	1.27
SEm±	7.24	3.4	0.13	5.5	0.03
LSD (P=0.05)	23.6	NS	0.41	18.2	0.12
Weed management					
Pretilachlor 0.75 kg/ha pre-em	258.4	114.4	3.35	191.0	1.03
Pretilachlor 0.75 kg/ha pre-em +hand weeding 30 DAS	326.2	123.9	3.95	232.4	1.43
Hand weeding 20 and 40 DAS	327.4	122.9	4.06	230.8	1.46
Weedy check	189.8	75.1	2.04	100.0	0.92
SEm±	8.33	1.98	0.08	3.89	0.03
LSD (P=0.05)	24.1	5.73	0.25	11.2	0.09
Interaction (T X W)					
SEm±	18.6	4.43	0.19	8.69	0.07
LSD (P=0.05)	53.8	12.8	0.55	25.1	0.21

S: Summer; TR: Transplanted rice ; IM: Indian mustard; DSR: Direct seeded rice.

biomass were significantly higher than other tillage practices over both in TR and DSR. Yield attributes a number of panicles/m^2 and grain yield of rice significantly higher under MT (DSR) and CT (TR) as compared to CT (DSR) (**Table 1.1.1.12**). However, all other tillage practices were found statistically at par for grain yield both for DRS and TR.

Among the weed management treatments, the lowest weed density and dry biomass at 20 DAS/DAT, while a number of panicles/m^2, filled grains/panicle and grain yield were recorded higher in pretilachlor 0.75 kg/ha *fb* hand weeding at 30 DAS which was closely followed by recommended herbicide pretilachlor 0.75 kg/ha.

In *Rabi* 2017-18, the main weeds in Indian mustard crop were *Acmella calva, Vicia sativa, Vicia hirsuta, Polygonum viscosum, Polygonum hydropiper, Gynura bicolor, Sphaeranthus indicus, Pseudognaphalium luteoalbum.*

Under CT system weed density and weed dry biomass were significantly higher than other tillage practices, whereas, yield attributes like the number of siliqua/plants and seed yield of mustard were significantly increased under MT(DSR)- MT+R (IM) as compared to CT(TR)-CT(IM) and CT(TR)-MT(IM) treatments. However, other treatments are on par with the best treatment. Among the weed management treatments, the lowest weed density and dry matter at 25 DAS were observed in pendimethalin 0.75 kg/ha *fb* hand weeding 25 DAS, whereas, number of siliquae/plants and seed yield were highest which was closely followed by recommended herbicide pendimethalin 0.75 kg/ha.

UAS, Bengaluru

Weed management in rice-green gram-rice cropping system under conservation agriculture

Rice field comprised with *Cyperus difformis, C. iria* (sedges) *Echinochloa colona, Paspalum distichum, Panicum repens* (grasses); *Ludwigia parviflora, Alternanthera sessilis, Monochoria vaginalis, Marsilea quadrifolia, Spilanthes acmella* (BLW). Among the weed species, the densities of *C. difformis, C. iria* (sedge), *Echinochloa colona* (grass) and *A. sessilis*, *Spilanthes acmella* and *Monochoria vaginalis* (BLW) were higher than other weed species, indicating their dominance at 60 DAP/S. Adopting CT for transplanted rice (3.03 to 4.10 t/ha) or DSR (2.98 t/ha) gave significantly higher yields than ZT with DSR (2.83 to 2.97 t/ha). These yield differences were due to differences in weed emergence being low under CT.

Pyrazosulfuron-ethyl 25 g/ha at 3 DAS/P alone or *fb* passing cono-weeder (45 DAS/P) recorded lower weed density and weed dry biomass over control. This help to harvest 4.87 t/ha in IWM followed by 4.48 t/ha of grain yield in pyrazosulfuron-ethyl 25 g/ha at 3 DAP/S over control. Unweeded control lowered the yield by 70% as a result of the severe competition of weeds particularly sedges and broad leaf weeds. The higher B:C ratio (2.39) was noticed in conventional tillage + integrated weed management and it was least (1.18) in the unweeded control.

WP 1.1.2 Weed management in maize-based cropping systems

Cooperating centres: TNAU, Coimbatore, CSKHPKV, Palampur, MPUAT, Udaipur, UAS, Bengaluru

TNAU, Coimbatore

Weed management in maize–sunflower–dhaincha (*Sesbania aculeata*) based conservation agriculture system

In sunflower, the experimental field was mainly infested with broad-leaved weeds like *Amaranthus viridis, Cleome viscosa* and *Parthenium hysterophorus*. The grassy weeds like *Cynodon dactylon, Setaria verticiliata* and *Chloris barbata;* and *Cyperus rotundus* was the only sedge present. Among tillage and residue management, significantly lower total weed density and dry biomass (5.0/m^2 and 1.57 g/m^2, respectively) were recorded in ZT-ZT+R system at 30 DAS resulted in higher WCE of 81.4% at 45 DAS. Better weed suppression recorded significantly higher plant height (166.7 cm), dry matter production (5.7 t/ha), higher seed yield (1.14 t/ha), higher net return (₹ 8,746/ha) and B: C ratio of 1.34.

Among weed management practices, PE pendimethalin at 1.0 kg/ha, recorded lower weed density and dry biomass (68.3/m^2 and 18.9 g/m^2, espectively) and higher WCE (70.9%), it was followed by PE pendimethalin at 1.0 kg/ha + HW on 45 DAS in sunflower (**Table 1.1.1.2.1**). However, PE pendimethalin at 1.0 kg/ha *fb* HW on 45 DAS recorded significantly taller plants (162.3 cm), higher DMP (6.67 t/ha) at 60 DAS and seed yield (1.21 t/ha) whereas, PE pendimethalin at 1.0 kg/ha recorded with higher net return (₹ 14,080/ha) and B:C ratio (1.75) in sunflower.

In maize, among tillages, at 30 DAS, significantly lower total weed density and dry biomass (44.3/m^2 and 22.7 g/m^2 respectively) were recorded in CT in ZT+R-ZT+R system. However, at 45 DAS, higher WCE of 89.4% was recorded in ZT in ZT+R-ZT+R system led to significantly taller plant (241.6 cm), higher dry matter production (6.35 t/ha), higher grain yield (5.96 t/ha), higher net return (₹39, 992/ha) and B: C ratio (2.01).

Among weed management practices, PE atrazine at 0.5 kg/ha *fb* HW on 45 DAS recorded lower weed density and dry biomass (47.4/m^2 and 19.2 g/ m^2 respectively) with higher WCE (68.8%). This resulted in taller plants (241.7 cm) and higher dry matter production (6.92 t/ha) at 60 DAS and seed yield (6.97 t/ha). However, PE atrazine at 0.5 kg/ha recorded with better economics *viz.* higher net return (₹ 43,530/ha) and B:C ratio (2.09).

Table 1.1.1.2.1 Effect of conservation tillage and weed management practices on weed density, weed dry weight, WCE and of sunflower and maize (45 DAS)

Treatment	Sunflower (*Rabi* 2017-18)			Maize (*Kharif* 2018)		
	Total weed density (no./m^2)	Total weed dry weight (g/m^2)	WCE (%)	Total weed density (no./m^2)	Total weed dry weight (g/m^2)	WCE (%)
Tillage methods						
T1(CT-CT)	13.67 (185.0)	8.32 (67.3)	47.4	11.2 (125.0)	6.94 (46.2)	25.1
T2(CT-ZT)	14.2 (200.3)	8.58 (71.6)	38.1	14.8 (217.0)	8.59 (71.7)	31.6
T3(ZT+R-ZT)	10.82 (115.0)	7.01 (47.2)	40.3	10.6 (111.0)	6.30 (37.7)	79.9
T4(ZT-ZT+R)	8.60 (72.0)	7.53 (54.7)	77.1	10.6 (112.3)	7.66 (56.7)	61.4
T5(ZT+R-ZT+R)	8.39 (68.3)	4.57 (18.9)	81.4	12.6 (158.0)	6.48 (39.9)	89.4
SEd	0.09	0.02	-	0.15	0.07	-
CD(P=0.05)	0.21	0.05	-	0.35	0.16	-
Weed management methods						
Recommended herbicides	8.45 (69.4)	5.31 (26.2)	70.9	10.1 (100.9)	6.53 (40.6)	51.9
Integrated weed management	10.1 (100.0)	6.46 (41.8)	55.8	9.25 (83.6)	5.33 (26.4)	68.8
Unweeded control	14.73 (215.0)	9.59 (91.8)	-	15.8 (249.4)	9.30 (84.4)	-
SEd	0.08	0.06	-	0.13	0.05	-
CD(P=0.05)	0.17	0.13	-	0.29	0.11	-

CSKHPKV, Palampur

Weed management in maize-wheat cropping system under conservation agriculture (year of commencement *Kharif* 2013)

Tillage treatment CT-ZT had significantly lower weed dry biomass followed by ZT-ZT-R and CT-CT, whereas, ZT-ZT resulted in the highest weed dry matter accumulation of weeds. The yield level realized was, therefore, very low and thus tillage and weed control treatments could not bring about significant variation in grain and straw yield of wheat. In the case of intercrop i.e. sarson ZT-ZT-R resulted in highest intercrop seed yield which remains statistically at par with CT-CT and CT-ZT. Whereas straw yield of intercrop was maximum in ZT- ZTR followed by ZT-R-ZT-R, CT-CT, and CT-ZT. Weed control treatments brought about significant variation in the grain as well as straw yield of intercrop sarson. However, it was recorded that there was no significant variation in gross returns and wheat grain equivalent yield due to tillage and weed management treatments. Among weed management, herbicide-herbicide resulted in superior control of weeds followed by IWM-IWM but was comparable in response to weed dry matter accumulation of weeds. The grain and straw yield did not influence by weed management practices in wheat.

In maize, higher weed density and weed dry biomass significantly influenced the seed yield during 2017-18. The cob yield of maize was affected significantly due to tillage but there was no significant variation in straw yield. There was significant variation in seed and straw of intercrop planted in additive series in maize due to tillage. CT-CT resulted in highest intercrop seed yield which remains at par with CT-ZT. However, CT-CT was recorded highest straw yield comparable to ZT-ZT-R and ZT-R-ZT-R. Among weed management, herbicide – herbicide system resulted in superior control of weeds followed by IWM-IWM. Hand weeding – hand weeding system recorded the maximum dry weight of weeds among weed management. Weed management practices did not bring about significant variation in the cob and straw yield of maize but significantly affected the intercrop grain and straw yield. The wheat equivalent yield and economics of maize-wheat cropping system are presented in (**Table 1.1.1.2.2**).

Table 1.1.1.2.2 Effect of weed control treatments on wheat grain equivalent yield , gross returns, net returns and cost of cultivation in the wheat-maize cropping system

Treatment (Maize – wheat)	Wheat grain equivalent yield (kg/ha/year)	Gross return (₹ /ha/year)	Cost of cultivation (₹ /ha/year)	Net returns (₹/ ha/year)
Tillage				
CT-CT	8,061	3,08,969	1,14,615	1,94,354
CT-ZT	8,278	3,24,917	1,07,487	2,17,431
ZT-ZT	8,056	3,06,873	1,00,224	2,06,649
ZT-ZTR	7,955	2,99,990	1,08,662	1,91,328
ZTR-ZTR	8,000	2,90,001	1,15,434	1,74,567
SEm±	505	10,011	1148	9,893
LSD (P=0.05)	NS	NS	2649	2,2815
Weed management				
H-H	7,387	2,98,964	86,847	2,12,117
IWM-IWM	9,112	3,30,676	1,13,293	2,17,383
HW-HW	7,711	2,88,810	1,27,714	1,61,097
SEm±	625.6	18,392	2,118	17,105
LSD (P=0.05)	NS	NS	5,879	NS

CT, conventional tillage; ZT, zero tillage; R, residues; H, herbicide; IWM-IWM, integrated weed management; HW, hand weeding;

MPUAT, Udaipur

Weed management in maize-wheat cropping system under conservation agriculture systems

In wheat, the major monocot weeds observed in the experimental fields were *Avena ludoviciana* and *Phalaris minor* where as the dicot weeds were *Chenopodium album*, *C. murale*, *Fumaria parviflora*, *Melilotus indica*, *Convolvulus arvensis* and *Malwa parviflora*. At 60 DAS and at harvest, broad-leaved weeds were dominant (90.6%), where *C. album* and *C. murale* consisted of 60% and grassy weeds were only 9.4%. The highest weed density was recorded with maize (CT)-wheat (ZT)- greengram (ZT) and lowest in maize (ZT+R)-wheat (ZT+R)- greengram (ZT). Dry biomass of broad leaf weeds was maximum in maize

(CT)-wheat (ZT)- greengram (ZT), while the grassy weeds were more in maize (ZT)-wheat (ZT)- greengram (ZT). Grain, stover yield and harvest index of maize was comparable with tillage and residue management practices. Similarly, maximum net return (₹ 65,144/ha) and B: C ratio (2.28) were recorded with maize (ZT)-wheat (ZT)- greengram (ZT).

Among weed management practices, sulfosulfuron + metsulfuron 30 + 2 g/ha at 30 DAS *fb* hand weeding at 50-55 DAS recorded lower weed density and dry biomass followed by sulfosulfuron + metsulfuron 30 + 2 g/ha at 30 DAS over the weedy cheek. IWM resulted in significant enhancement of plant height, gains/spike, 1000 seed weight, highest grain yield (4.25 t/ha) and stover yield (5.88 t/ha) over the weedy check.

In maize, study area comprised with *Echinochloa colona* (32.9%), *Dinebra retroflexa* (15.4%), *Commelina benghalensis* (13.8%), *Digera arvenris* (12.8%), *Trianthema partulacastrum* (16.8%) and *Corchorus olitorious* (8.2%). Among tillage and residue management treatments, total weed density at 60 DAS and at harvest attained highest in the treatment maize (ZT)-wheat (ZT)- greengram (ZT) and the lowest in maize (ZT+R)-wheat (ZT+R)- greengram (ZT+R). Weed species *Echinochloa colona, Dinebra retroflexa,* and *Corchorus olitorius* were not affected by different tillage and residues management practices. However, broad-leaved weeds were recorded highest in maize (ZT)-wheat (ZT)- greengram (ZT), while the weed dry biomass of monocot weeds was almost the same with different establishment methods. The density and dry biomass of weeds were lowest when previous crop residues were retained in the ZT system. However, yield attributes (length, cob girth, cob weight and 1000 seed weight) and yield (grain and stover) were comparable with tillage and residue management. The economic parameters were maximum net return (₹ 44,547 /ha) and B:C (2.35) were recorded with maize (ZT)-wheat (ZT)- greengram (ZT).

Among weed management practices, minimum number and dry biomass of grassy and broadleaf weeds were observed at 60 DAS and at harvest by application of atrazine 500 g/ha *fb* hand weeding at 30-35 DAS treatment. All the yield attributes except test weight and yield of maize were significant with weed management practices. Application of atrazine 500 g/ha *fb* hand weeding (IWM) and atrazine 500 g/ha *fb* tembotrione 120 g/ha resulted in better cob length, cob girth, cob weight, 1000 seed weight, grain and stover yield of maize over the weedy check. IWM recorded highest grain yield (3.40 t/ha) and stover yield (5.99 t/ha) this was comparable with the application of atrazine 500 g/ha *fb* temotrione 120 g/ha. IWM recorded maximum net return (₹ 47,964/ha), whereas B:C (2.35) with application of atrazine 500 g/ha PE *fb* tembotrione 120 g/ha PoE.

UAS, Bengaluru

Weed management in maize-based cropping system in conservation agriculture

Major weed flora in the experimental plots consistsed of *Cyperus rotundus* (sedges), *Cynodon dactylon, Setaria glauca* (grasses) and *Ageratum conyzoides, Alternanthera sessilis, Argemone mexicana, Borreria hispida, Commelina benghalensis*, *Euphorbia hirita* (broad-leaved weeds). In ZT, *Cyperus rotundus* (sedge) and grass species density was the lowest compared to other tillage treatments. Broad leaf weed flora was least and sedges were the highest in a permanent bed. *Ageratum conyzoides* was dominant over other weeds. Among tillage practices ZT had slightly lower weeds density and dry biomass of weeds followed by the permanent bed at all stages and the difference is at 60 and 90 DAS, perhaps due to the growth of weeds. Permanent beds plots recorded better establishment, high seedling vigour and superior growth over others.

At 60 DAS, IWM (pendimethalin 750 g/ha *fb* hand weeding at 30 DAS) recorded significantly lower weed density and dry weight of sedges, grasses and broad leaf weeds followed by pendimethalin 750 g/ha *fb* tembotrione 120 g/ha + atrazine 500 g/ha as compared to weedy plots. IWM plots had recorded superior growth and growth attributes over others.

WP 1.1.3 Weed management in soybean-based cropping systems

PDKV, Akola

Weed management in soybean-chickpea cropping system under conservation agriculture

The major weed flora during *Kharif* and *Rabi* seasons in soybean–chickpea crop sequence in the selected area were composed of *Xanthium strumarium, Celosia argentea, Tridax procumbens, Phyllanthus niruri, Portulaca oleracea, Lagascea mollis, Euphorbia geniculata, Euphorbia hirta, Phyllanthus niruri*, *Abutilon indicum, Abelmoschus moschatus, Boerhavia diffusa*, *Calotropis gigantea*, *Ageratum conyzoides*, *Bidens pilosa*, *Mimosa pudica*, *Alternanthera triandra, Parthenium hysterophorus, Digera arvensis, Cynodon dactylon, Cyperus rotundus, Amaranthus viridis, Dinebra arabica, Panicum* spp., *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Ischaemum pilosum*, *Digitaria sanguinalis, Dinebra retroflexa, Poa annua, Cyanotis axillaris,* etc. Both broad and narrow-leaved weeds were observed.

In soybean, CT+R recoded the lowest weed density and weed dry biomass (28.3 no./m^2 and 66.7 g/m^2, respectively) at 60 DAS and highest with ZT (40.0 no./m^2 and 92.0 g/m^2, respectively), whereas, treatments MTR, CT and MT being statistically at par (30.1, 32.8 and 33.4 no./m^2 and 71.7, 73.2 and 90.8 g/m^2 respectively). A similar trend was recorded in another stage of the crop, this resulted in the highest WCE in CT+R (57%) followed by MTR (54%). The yield attributes were better with CT+R followed by CT, resulting in the higher grain and straw yield in CT+R (1.94 and 2.33 t/ha, respectively), whereas, the lowest yield recorded with ZT (1.70 and 1.79 t/ha, respectively) (**Table 1.1.1.3.1**).

Among weed management practices, at 60 DAS, IWM recorded least weed density and the biomass (10.7 no./m^2 and 31.3 g/m^2, respectively) and conversely the unweeded check recorded significantly highest total number of weeds and dry biomass (86.9 no./m^2 and 161.1 g/m^2, respectively). This resulted in highest WCE in IWM (79%) followed by recommended herbicides (71%) over control. The yield attributes were better with IWM followed by recommended herbicide, resulting in the higher grain and straw yield in IWM (2.30 and 2.15 t/ha, respectively), whereas, the lowest yield recorded with control (1.52 and 1.86 t/ha, respectively).

Table 1.1.1.3.1 Total weed parameters (at 60 DAS) and yield attributes as influenced by weed control treatments in soybean.

Treatment	Weed density (no./m²)	Weed dry biomass (g/m²)	WCE	Grain yield (t/ha)	Straw yield (t/ha)
A) Tillage and residue management					
CT	5.77 (32.7)	8.58 (73.1)	53	1.93	2.20
CTR	5.36 (28.2)	8.20 (66.7)	57	1.94	2.33
MT	5.82 (33.4)	9.56 (90.8)	42	1.80	1.93
MTR	5.53 (30.1)	8.50 (71.6)	54	1.82	2.05
ZT	6.37 (40.0)	9.62 (92.0)	42	1.67	1.72
ZTR	6.19 (37.8)	8.88 (78.3)	50	1.70	1.79
SE (m) +	0.043	0.06		0.02	0.02
LSD (P= 0.05)	0.12	0.17		0.05	0.05
B) Weed management					
Recomended herbicide	4.61 (20.7)	6.66 (43.9)	71	1.9	2.02
IWM	3.25 (10.0)	5.64 (31.3)	79	2.03	2.15
Unweeded	9.35 (86.9)	12.7 (161.1)	-	1.52	1.86
SE (m) +	0.03	0.05		0.01	0.01
CD P= 0.05	0.10	0.14		0.03	0.04
Int (A x B)					
SE (m) ±	0.09	0.06		0.05	0.05
LSD (P= 0.05)	NS	NS		NS	NS

Figures in parenthesis are original value.

In chickpea, at 60 DAS, the lowest weed density and dry biomass of weed was recorded under CT+R (29.0 no./m^2 and 62.3 g/m^2, respectively) and highest with ZT (40.0 no./m^2 and 92.0 g/m^2, respectively), rest of the treatments were between the above treatments. A similar trend of weed density and dry biomass was recorded in other stage of the crop, this resulted in highest WCE in CT+R (59%) followed by MTR (56%). The yield attributes were better with CT+R followed by CT, resulted in the higher seed and haulm yield in CT+R (1.26 and 1.40 t/ha, respectively), whereas, the lowest yield recorded with ZT (1.01 and 1.16 t/ha, respectively). Among tillage and residue management, the economic parameters (gross and net return and B:C ratio) were better with CT followed by MT and CT+R.

Among weed management practices, at 60 DAS, IWM recorded least weed density and dry biomass (6.6 no./m^2 and 26.8 g/m^2, respectively) and conversely the unweeded check recorded significantly the highest weed parameter (83.5 no./m^2 and 156.6 g/m^2, respectively). This resulted the highest WCE in IWM (81%) followed by recommended herbicides (73%) over control. The yield attributes were better with IWM followed by recommended herbicide, resulting in higher seed and haulm yield in IWM (1.33 and 1.49 t/ha, respectively), whereas, the lowest yield recorded with control (0.83 and 0.98 t/ha, respectively) (**Table 1.1.1.3.2**). IWM recorded the better economic parameters (gross and net return and B:C ratio) followed by recommended herbicides over weedy check.

Table 1.1.1.3.2 Total weed parameters (at 60 DAS) and yield attributes as influenced by weed control treatments

Treatment	Weed density (no./m²)	Weed dry biomass (g/m²)	WCE (%)	Seed yield (t/ha)	Haulm yield (t/ha)
A) Tillage and residue management					
CT	5.87(33.9)	8.32(68.7)	55	1.24	1.37
CTR	5.43(29.0)	7.92(62.2)	59	1.26	1.40
MT	5.92(34.5)	9.32(86.4)	44	1.11	1.26
MTR	5.61(31.0)	8.23(67.2)	56	1.16	1.28
ZT	6.50(41.6)	9.39(87.6)	43	1.01	1.16
ZTR	6.31(39.3)	8.63(73.9)	52	1.04	1.18
SE (m)±	0.03	0.06		0.009	0.028
LSD (P= 0.05)	0.09	0.18		0.026	0.084
B) Weed management					
RH	4.11(17.3)	6.32(39.3)	73	1.21	1.36
HHW	2.48(6.6)	5.23(26.8)	81	1.33	1.49
UW	9.11(83.4)	12.5(156.6)	-	0.83	0.98
SE (m) ±	0.04	0.05		0.007	0.007
CD P= 0.05	0.12	0.15		0.020	0.021
Int (A x B)					
SE (m) ±	0.09	0.07		0.017	0.019
LSD (P= 0.05)	NS	NS		NS	NS

UAS, Dharwad

Weed management in soybean-chickpea cropping system under conservation agriculture (Year of commencement: *Kharif* 2017)

The dominant weeds in soybean were *Digera arvensis, Commelina benghalensis, Knoxia mollis* among BLWs; *Dinebra retroflexa, Digitaria sanguinalis, Panicum isachne*. *Cynodon dactylon*, *Cyperus rotundus* among grasses and sedge respectively. Among the tillage practices, the plot received two harrowings by tyne cultivator + one harrowing by blade harrow + planking + residue recorded least weed dry biomass at 30 and 60 DAS (4.38 and 4.88 g/m^2, respectively). ZT recorded the highest weed dry biomass at 30 and 60 days (11.3 and 6.5 g/m^2, respectively). This helped to harvest higher soybean grain yield in twice harrowing followed by tyne cultivator + one harrowing by blade harrow + planking+ residue (5.65 t/ha), which was on par with yield levels received from the plot received without incorporation of residue (5.12 t/ha). Among the various tillage practices, CT+R incorporation recorded maximum soil enzyme activity at 30 and 60 DAS.

Among the weed management practics the plots received diclosulam 30 g/ha PE *fb* imazethapyr 75-100 g/ha POE + one HW at 20 DAS recorded least weed dry biomass over the herbicide alone (10.33 g/m^2). IWM recorded higher soybean seed yield compared with the herbicide alone (5.12 and 4.90 t/ha respectively). The highest dehydrogenase activity was recorded with the plots received no herbicides, followed with HW and least was recorded with RH (14.5, 12.1 and 10.5 TPF formed/g soil/day, respectively) at 30 days. However, on 60 DAS highest dehydrogenase activity was recorded with RH (25.2). Similar results were recorded with phosphatase activity at 30 DAS.

WP 1.1.4 Weed management in pearl millet-based cropping systems

RVSKVV, Gwalior

Weed management in pearlmillet– mustard–cowpea cropping system under conservation agriculture (year of commencement: *Kharif* 2014)

In mustard, an experimental area comprised of *Phalaris minor, Spergula arvensis* and *Cynodon dactylon* as grasses; whereas *Chenopodium album, Anagallis arvensis Convolvulus arvensis* and *Medicago hispida* were observed as major broad-leaved weeds. *Cyperus rotundus* was the most dominating sedges weed among all. Two weeds *i.e. Medicago hispida* and *Cynodon dactylon* were recently observed in the experimental field during 2017 -18. The significantly lowest weed density and dry biomass of weeds at 30 and 60 DAS were reported in CT–CT. The highest WCE was recorded in ZT+R – ZT – R-ZT (81.7%) *fb* ZT-ZT-ZT (80.8%) and the lowest in CT-CT (71.6%). The highest values of all growth and yield attributes were recorded under CT-CT followed by CT–ZT–ZT.

Table 1.1.1.4.1 Effect of conservation tillage practices and different weed management on yield and economics in mustard under pearlmillet based cropping system (2017-18).

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
Tillage and residue management						
Conventional tillage (CT-CT)	1.97	7.96	20,400	80,923	60,523	3.97
Zero Tillage (CT-ZT-ZT)	1.68	6.94	17,700	68,884	51,184	3.89
Zero tillage ((ZT-ZT-ZT))	1.53	6.48	17,700	62,960	45,260	3.56
Zero tillage + Crop residue (ZT-ZT+R-ZT)	1.70	6.69	17,700	69,454	51,754	3.92
Zero tillage + Crop residue (ZT+R-ZT+R-ZT)	1.65	6.68	17,700	67,645	49,945	3.82
SEm (±)	0.03	0.25		-	-	-
LSD (P=0.05)	0.10	0.81		-	-	-
Weed management						
Pendimethalin PE	1.78	6.96	19,100	72,811	53,711	3.81
Oxyflourfen PE + 1 HW	1.92	7.37	21,200	78,431	57,231	3.70
Weedy check	1.42	6.53	16′300	58′678	42′378	3.60
SEm (±)	0.02	0.27				
LSD (P=0.05)	0.07	1.08				

The significantly highest seed yield of mustard (1.97 t/ha) was obtained with CT-CT and was followed by CT–ZT–ZT. The maximum net return obtained in CT-CT (₹ 60,523/ha) followed by CT-ZT-ZT. Similarly, B:C ratio was higher with CT-CT (3.97) followed by ZT-ZT+R-ZT (**Table 1.1.1.4.1**).

The highest weed population and dry biomass were recorded in weedy check while the lowest was recorded with oxyfluorfen 0.23 kg/ha PE *fb* one hand weeding. The weed control efficiency was maximum under integrated weed management practices (85.3%) followed by application of pendimethalin 1.0 kg/ha (71.6%) at 60 DAS. Maximum yield attributes and yield were recorded in IWM (oxyfluorfen 0.23 kg/ha *fb* one hand weeding) followed by pendimethalin 1.0 kg/ha. A similar trend was also recorded for store straw yield of mustard IWM recorded higher net return (₹ 57,231/ha) B:C ratio was higher in pendimethalin 1.0 kg/ha (3.81) followed by IWM practices (oxyfluorfen 0.23 kg/ha + 1 HW) (3.70).

In cowpea, the weed flora observed in the experimental field was *Cyperus rotundus, Dactyloctenium aegyptium, Cynodon dactylon, Echinochloa crus-galli* and *Acrachne racemosa* as narrow-leaved weeds (NLW), *Commelina benghalensis, Convolvulus arvensis, Digera arvensis* and *Trianthema monogyna* as broad-leaved weeds (BLW) and *Cyperus rotundus* as sedge. The population of NLWs was higher as compared to BLW's on the experimental site in the summer season.

At 40 DAS, the highest weed density and weed dry biomass was recorded in ZT-ZT-ZT followed by ZT-ZT+R-ZT and CT-ZT-ZT, whereas, the lower weed values and higher WCE recorded in ZT+R-ZT+R-ZT. This help to obtained highest plant height, number of branches/plant, number of pods/plant, pod length and number of seeds/pod in ZT+R–ZT+R – ZT this helped to harvest the highest cowpea yield (762 kg/ha) followed by CT-ZT-ZT and ZT-ZT+R-ZT. The maximum gross returns and B:C ratio was recorded under ZT+R – ZT+R – ZT system.

The lowest density and dry biomass of weeds were recorded in IWM (pendimethalin + imazethapyr +*fb* one HW) followed by imazethapyr + imazamox 80 g/ha PoE. The WCE at harvest was maximum of 87.9% under IWM followed by imazethapyr + imazamox (70.3%). Lower weed parameters and higher WCE helped to achieve the highest plant height, no. of branches/plant, no. of pods/plant, pod length and no. of seeds/pod in IWM followed by imazethapyr + imazamox 80 g/ha. There was yield advantage of 94 and 32%, respectively was found due to pendimethalin + imazethapyr + 1 HW and imazethapyr + imazamox as compared to weedy check. IWM gave maximum gross return and B:C ratio (₹ 52,005/ha and 2.53, respectively) which was followed by imazethapyr + imazamox 80 g/ha PoE (**Table 1.1.1.4.2**).

Table 1.1.1.4.2 Effect of different treatments on yield and economics of cowpea under pearlmillet based cropping system under conservation agriculture (2018)

Treatment	Seed yield (kg/ha)	Stover yield (t/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
Tillage and residue management						
Zero tillage (CT-ZT-ZT)	725	2.57	17,930	52,284	343,54	2.92
Zero tillage(ZT-ZT-ZT)	487	3.44	17,930	38,545	20,615	2.15
Zero tillage (ZT-ZT+R-ZT)	655	2 78	17,930	48,133	30,203	2.68
Zero tillage (ZT+R-ZT+R-ZT)	762	3.10	17,930	55,759	37,829	3.11
LSD (P=0.05)	191	1.33				
Weed management						
Imazethapyr+imazamox PoE	490	2.31	19,130	36,442	17,312	1.90
Pendimethalin+imazethapyr *fb* 1 HW	718	2.66	20,590	52,004	31,414	2.53
Weedy check	370	2.17	17,930	28,386	10,456	1.58
LSD (P=0.05)	287	1.28				

In pearlmillet, the weeds observed in the experimental field were *Echinochloa crus-galli, Celosia argentea, Acrachne racemosa, Leptochloa panicea, Cynodon dactylon, Phyllanthus niruri, Setaria glauca* and *Brachiaria reptans* as narrow-leaved weeds, *Digera arvensis* and *Commelina benghalensis* as broad-leaved weeds and *Cyperus rotundus* as sedges. Under pearlmillet based cropping system, the lowest weed density and weed dry biomass were recorded in CT-ZT-ZT followed by CT-CT. Although the dry biomass of weeds was recorded very less as compared to the last four years. Conservation tillage practices recorded the highest grain yield CT-ZT (3.01 t/ha) followed by CT-CT (2.97 t/ha) while B:C ratio was higher in CT-ZT-ZT (2.58) followed by CT-CT (2.38).

Among weed management practices, IWM practices (atrazine 500 g/ha PE *fb* 1 HW) significantly reduced the weed density and dry biomass of weeds and resulted in significantly highest pearlmillet yield (3.58 t/ha), net returns (₹ 34,531/ha) and B:C ratio (2.38) it was followed by atrazine + 2,4-D (2.65 t/ha, ₹ 25,764/ha and 2.31, respectively).

WP 1.1.5 Weed management in cotton-based cropping systems

AAU, Anand

Weed management in cotton-green gram cropping system under conservation agriculture

In cotton, at 60 DAS, significantly lower density and dry biomass of monocot were recorded under CT

Table 1.1.1.5.1 Growth attributes as influenced by tillage & weed managementt practices in cotton under conservation agriculture.

Treatments	Plant stand at 15 DAS (No./m²)	Plant height (cm)				Seed cotton yield (t/ha)	Stalk yield (t/ha)	Seed cotton equivalent yield (t/ha)
		30 DAS	60 DAS	90 DAS	At harvest			
Tillage and crop residue management (T)								
CT - CT	34.6	30.8	86.3	103	124	1.66	3.27	2.46
CT - ZT	34.7	30.6	85.6	102	122	1.52	3.18	2.35
ZT - ZT	34.9	30.1	82.7	101	122	1.40	2.87	2.18
ZT - ZR+R	34.9	31.6	89.3	106	125	1.66	3.32	2.61
ZT+R - ZT+R	34.8	31.8	94.8	112	133	1.81	3.56	2.96
S. Em. ±	0.25	0.67	3.44	0.81	1.81	0.04	0.14	0.05
LSD (P=0.05)	NS	NS	NS	2.54	5.66	0.12	NS	0.14
CV %	2.2	6.5	11.8	2.3	4.3	7.4	12.9	5.5
Weed management practices in cotton (W)								
Pendimethalin 900 g/ha PE *fb* IC+HW at 30 & 60 DAS	34.7	31.5	86.3	102	126	1.65	3.34	2.73
Quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS	34.4	30.6	86.4	98	121	1.48	2.89	2.13
IC + HW at 15, 30 and 45 DAS	35.1	30.9	90.5	114	130	1.70	3.48	2.67
S. Em. ±	0.29	0.54	1.64	3.70	1.16	0.02	0.14	0.03
LSD (P=0.05)	NS	NS	NS	NS	4.57	0.08	NS	0.13
CV %	3.2	6.8	7.3	13.7	3.6	4.9	17.3	5.0
Interaction TxW	NS	NS	NS	NS	NS	NS	NS	NS
CV %	4.2	6.6	7.8	9.1	2.7	7.7	10.2	6.3

(6.89 no./m^2 and 6.46 g/m^2, respectively). While lower density and dry biomass of dicot weeds (3.71 no./m^2 and 2.43 g/m^2) and sedges (3.67 no./m^2 and 3.89 g/m^2) were recorded under ZT and ZTR, respectively. Total weed density was comparable with tillage practices, but total weed dry biomass was significantly higher under ZT (11.4 g/m^2). At 90 DAS and harvest, ZT+R recorded the highest plant height (112 and 133 cm, respectively) and seed cotton yield (1.81 t/ha). Further, CT and ZT practices recorded equal seed cotton yield (1.66 t/ha) and found to be significantly superior over other tillage practices.

Among the weed management practices, at 60 DAS, density and dry biomass of monocot, dicot, sedges, and total weeds were recorded significantly the lowest under IC + HW at 15, 30 and 45 DAS followed by quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS. However, density and dry biomass of sedges (5.04 no./m^2 and 5.08 g/m^2) were registered significantly higher under pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS. IWM recorded taller plants (130 cm) over quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS. Seed cotton yield was comparable with IWM (IC+ HW at 15, 30 and 45 DAS) and pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS but found significant over quizalofop-ethyl 50 g/ha PoE *fb* IC+ HW at 30 DAS (**Table 1.1.1.5.1**).

In greengram, at 30 DAS, density and dry biomass of monocot (4.96 no./m^2 and 4.27 g/m^2 respectively), dicot (2.97 no./m^2 and 2.26 g/m^2), sedges (2.80 no./m^2 and 1.88 g/m^2 respectively) and total weeds (6.42 no./m^2 and 5.19 g/m^2 respectively) was recorded significantly lower under CT. Further, it was observed that significantly higher density and dry biomass of total weeds was recorded under ZT followed by ZT+R and ZT system. These helped to harvest significantly the highest seed yield (793 kg/ha) was achieved under ZT+R, while, significantly lower seed yield was recorded under ZT over others except CT. Significantly higher (984 kg/ha) haulm yield was observed under ZT+R as compared to the rest of the treatment except ZT (918 kg/ha).

Among weed management practices, significantly the highest density and dry biomass of monocot (9.24 no./m^2 and 6.40 g/m^2, respectively) and total weeds (10.2 no./m^2 and 7.62 g/m^2, respectively) was recorded under imazethapyr 75 g/ha PoE *fb* IC + HW at 30 DAS. While significantly the lowest density and dry biomass of monocot, dicot, sedges and total weeds were recorded under IC + HW at 20 and 40 DAS. Application of pendimethalin 500 g/ha PE *fb* IC+HW at 30 DAS recorded significantly the highest seed and haulm yield (742 and 1047 kg/ha, respectively) while the lowest seed and haulm yield (445 and 665 kg/ha, respectively) were recorded under imazethapyr 75 g/ha PoE *fb* IC + HW at 30 DAS (**Table 1.1.1.5.2**).

In cotton-greengram cropping system, the highest seed cotton equivalent yield, gross return, net return, and B: C were recorded with ZT+R (2.96 t/ha, ₹ 1,18,992 and 33,096/ha, and 1.3, respectively) and the lowest under ZT. Among weed management practices, significantly higher seed cotton equivalent yield, higher gross return (₹1,09,746/ha), net return (₹32,546/ha) and benefit-cost ratio (1.42) were achieved under pendimethalin (900+500 g/ha) PE *fb* IC+HW at 30 & 60 DAS in cotton and 500 g/ha PEFB IC+HW at 30 DAS in greengram crop.

The physicochemical properties of soil were non-significant with respect to tillage and residue management except organic carbon. Among weed management, except P all other parameters were non-significant. However, second-year onwards there was an improvement in physicochemical and microbial properties with ZT + R – ZT + R followed by ZT- ZR + R. Similarly, among weed management options IC+HW at 15, 30 and 45 DAS recorded superior results in comparison to other treatments. Regarding different weed management practices, total bacterial population and soil dehydrogenase activity were significantly influenced, while total fungal, actinobacterial, diazotrophic and PSM population were not influenced significantly at harvest. Moreover, there was not any adverse effect recorded of different weed management practices on microbial properties of soil. Significantly highest improvement in soil microbial properties was recorded in ZT+R.

Table 1.1.1.5.2 Growth attributes as influenced by weed management practices in greengram

Treatments	Plant stand at 15 DAS (No./m)	Plant height (cm)		Seed yield (kg/ha)	Haulm (kg/ha)
		30 DAS	60 DAS		
Tillage and crop residue management practices in greengram (T)					
CT - CT	10.4	20.6	38.1	548	827
CT - ZT	10.3	20.0	37.8	563	846
ZT - ZT	10.1	19.3	37.0	533	804
ZT - ZT+R	10.4	20.0	38.8	648	918
ZT+R - ZT+R	10.8	23.8	45.5	793	984
S. Em. ±	0.33	0.37	0.87	23.6	30.2
LSD (P=0.05)	NS	1.17	2.72	73.5	94.3
CV %	9.6	5.4	6.6	11.5	10.4
Weed management practices in greengram (W)					
Pendimethalin 500 g/ha PE *fb* IC+HW at 30 DAS	10.3	20.7	41.4	742	1047
Imazethapyr 75 g/ha PoE *fb* IC+HW at 30 DAS	10.3	19.3	37.1	445	665
IC + HW at 20 & 40 DAS	10.6	22.2	39.7	664	915
S. Em. ±	0.13	0.52	0.38	18.2	28.7
LSD (P=0.05)	NS	2.06	1.53	71.5	113
CV %	4.9	9.8	3.8	11.4	21.7
Interaction TxW	NS	NS	NS	NS	68.9
CV %	7.9	6.1	7.5	7.9	4.5

WP 1.2 Weed management in organic based cropping systems

AAU, Anand

WP 1.2.1 Weed management under organic based fennel and cropping system summer greengram

Objectives:

1. To monitor weed dynamics and crop productivity by weed management practices under organic fennel-greengram cropping system
2. To study the effect of organic sources and weed management practices on quality of produce
3. To study changes in physico-chemical and biological properties of soil

Treatments:

(A) Organic manure (Main plot)

M_1 Farm yard manure 20 t/ha

M_2 Vermi compost 8.0 t/ha

(B) Weed management practices (Sub plot)

W_1 Paddy straw mulch 5 t/ha *fb* HW at 30, 60 DATP

W_2 Paddy straw mulch 10 t/ha *fb* HW at 30, 60 DATP

W_3 IC + HW at 30 and 60 DATP *fb* earthing-up at 75 DATP

W_4 Pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DATP

W_5 Weedy check

Fennel

In general, dominancy of dicot weed (62.6 %) was observed during the experimental period. Major weeds observed in the experimental field were *Eleusine indica* (20.6 %), *Dactyloctenium aegyptium* (23.3 %), *Commelina benghalensis* (4.9 %), *Eragrostis major* (5.1 %)

in monocot weeds category whereas, *Oldenlandia umbellata* (13.9 %), *Phyllanthus niruri* (14.2 %), *Boerhavia diffusa* (4.6 %) and *Digera arvensis* (2.2 %) were found in dicot weed category.

Significantly the highest density of monocot weeds was recorded under vermicompost 8.0 t/ha treatment at 90 DAP. Same trend was also observed for recording dicot and total weeds at 90 DAP. Among weed management practices, minimum density of monocot, dicot and total weeds was recorded under IC + HW at 30 and 60 DAP *fb* earthing-up at 75 DAP, while the highest density of monocot, dicot and total weeds was recorded under weedy check treatment at 90 DAP.

Pooled data (2016-18) indicated that significantly the highest seed yield of fennel was achieved under vermicompost 8.0 t/ha (2.09 t/ha). Among weed management practices, paddy straw mulch 10 t/ha *fb* HW at 30 and 60 DAP recorded significantly higher seed yield (2.88 t/ha) as compared to pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DAP (1.90 t/ha). Significantly the lowest seed yield was recorded under weedy check treatment (0.49 t/ha).

Greengram

Weed dry biomass of monocot, dicot and total weeds recorded at 60 DAS was found to be non-significant due to organic manure treatments while it was significant due to weed management practices. Significantly lower dry biomass of monocot, dicot and total weeds was recorded under paddy straw mulch 10 t/ha *fb* HW at 30, 60 DAS while the highest dry biomass of monocot, dicot and total weeds was recorded under weedy check treatment at 60 DAS.

Seed yield of greengram showed non significant results due to different organic sources whereas, weed management practices showed significant influence during 2016-17 and in pooled analysis. Though the results were non significant, but numerically higher seed yield was recorded under vermicompost 8.0 t/ha (577 kg/ha). Among weed management practices, paddy straw mulch 5 t/ha *fb* HW at 30, 60 DAS recorded significantly higher seed yield as compared to rest of the treatment except pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DAS and weedy check. Significantly the lowest seed yield was recorded under weedy check (498 kg/ha).

Fennel equivalent yield and economics

The fennel equivalent yield (2.43 t/ha) and gross return (₹ 2,43,000/ha) was recorded higher under vermicompost 8.0 t/ha, while net return (₹ 1,38,220/ha) and benefit cost ratio (2.56) was recorded under farm yard manure treatment. Among weed management practices application paddy straw mulch 10 t/ha *fb* HW at 30, 60 DAS recorded higher fennel equivalent yield (3.24 t/ha), gross return (₹2,19,816/ha), net return (₹ 2,41,976/ha) and benefit cost ratio (3.11) as compared to rest of the treatment. The lowest fennel equivalent yield, gross return, net return and benefit cost ratio was recorded under weedy check treatment.

Treatments

	Kharif **(Rice)**	***Rabi*** **(tomato)**	**Summer (Okra)**
T_1	50% RDF + 50%N as FYM (8 t/ha)	50% RDF + 50%N as FYM (8 t/ha)	50% RDF + 50%N as FYM (8 t/ha)
T_2	Different organic sources equivalent to 1/3 of recommended N (1/3 N as FYM 5.5 t/ha, 1/3N as *Dhaincha*, 1/3 N as NEO)	Different organic sources equivalent to 1/3 of recommended N (1/3 N as FYM 5.5 t/ha, 1/3N as vermicompost, 1/3 N as NEO)	Different organic sources equivalent to 1/3 of recommended N (1/3 N as FYM 5.5 t/ha, 1/3N as vermicompost, 1/3 N as NEO)
T_3	T_2 +*Azospirillum* + PSB	T_2 +*Azotobacter* + PSB	T2 + *Azotobacter* + PSB
T_4	T_2 + agronomic practice for weed and pest control (No chemical pesticides)	T_2 + manual weed control + biopesticide	T_2 + manual weed control + biopesticide
T_5	T_2 + residue recycling	T_2 + residue recycling	T_2 + residue recycling
T_6 (Observation strip)	Recommended herbicide (pretilachlor 1.0 kg/ha pre - emergence)	Recommended herbicide (pendimethalin 1.0 kg/ha pre - emergence)	Recommended herbicide (pendimethalin 1.0 kg/ha pre - emergence)

OUAT, Bhubaneswar

WP.1.2.2 Weed management in organic based rice-tomato-okra cropping system

Objectives

1. To develop suitable weed management technique under organic packages for system based high value crops
2. To assess soil health condition due to organic packages and weed management practices

Application of 1/3 recommended dose of N each through FYM, *Dhaincha* and neemcake alongwith *Azospirillum* + PSB to rice followed by same proportion of organics through FYM, Vermicompost and Neem cake + *Azotobacter* + PSB (T_3) to tomato and okra in rice-tomato- okra system resulted in the maximum grain yield of rice (4.57 t/ha), fruit yield of tomato (17.7 t/ha) and okra (7.20 t/ha) with REY of 23.6 t/ha/year followed by T_1 and T_4 with REY of 21.5 and 21.4 t/ha/year respectively. The higher yield of T_3 over other organic combinations was supported by favorable yield attributing characters of the crops in the treatment. But the same treatment (T_3) with the highest gross returns of ₹2,89,217/ha/year fetched NMR of only ₹ 1,24,340/ha/year with BCR of 0.75 as compared to corresponding values of ₹ 2,56,301/ha/year and 0.77 in inorganic treatment (T_6). Uptake of nutrients by rice (77.8 kg N, 23.7 kg P and 89.7 kg K/ha), tomato (56.33 kg N, 7.07 kg P and 94.3 kg K/ha), okra (156.6 kg N, 34.9 kg P and 210.8 kg K/ha) and the system as a whole (292.80 kg N, 65.7 kg P and 394.9 kg K/ha) were the highest in T_3. Nutrient status of the soil improved with respect to organic carbon, N, P and K values in all the treatments except T_6 at the end of the cropping cycle.

RVSKVV, Gwalior

WP 1.2.3 (i) Weed management in organic based greengram - potato cropping system

Objective

1. To work out the best weed management practice in organic greengram - potato cropping system.

Treatments

1 White plastic mulch
2 Black plastic mulch
3 Straw mulch 5 t/ha at 5 DAS
4 One HW at 20 DAS + straw mulch 5 t/ha at 25 DAS
5 Two hand weedings at 20 & 40 DAS
6 One hand hoeing at 20 DAS
7 Hoeing at 20 DAS + hand weeding at 40 DAS
8 Recommended herbicide (metribuzin 0.5 kg/ha)
9 Recommended herbicide + one HW at 40 DAS
10 Weedy check

The major weed flora of experimental site during *Rabi* 2017-18 was *Cyperus rotundus* as sedge, *Spergula arvensis,* and *Polypogon monspeliensis* as grasses and *Medicago hispida, Phalaris minor, Chenopodium album, Convolvulus arvensis,* and *Anagallis arvensis* were observed as major broad-leaved weeds. *Cynodon dactylon* and *Rumex dentatus* were not seen in 2017-18 although they were present during *Rabi* 2016-17 in the field of potato. Similarly, *Avena fatua, Medicago hispida Polypogon monspeliensis* and *Anagallis arvensis* were observed at 60 DAP of potato crop. The sedge *Cyperus rotundus* was most dominating among all the weeds in potato field.

The narrow - leaved weeds population was effectively controlled by two hand weedings and it was *fb* one HW at 20 DAP + straw mulching 5 t/ha at 25 DAP, black plastic mulch and one hand hoeing at 20 DAP treatments. The minimum population of narrow leaved weeds was recorded in one HW at 20 DAP + hoeing at 40 DAP *fb* black plastic mulch, one HW at 20 DAP with straw mulching 5 t/ha at 25 DAP and straw mulching 5 t/ha at 25 DAP. While the minimum broad leaved weeds were recorded in two hand weeding at 20 and 40 DAP *fb* recommended herbicide + one hand weeding treatment. At 30 DAP, among all cultural practices the total weeds were significantly controlled with the application of straw mulch 5 t/ha at 5 DAP *fb* black plastic mulch, one HW at 20 DAP + straw mulching 5 t/ha at 25 DAP and white plastic mulch. At 60 DAP one hand hoeing *fb* one hand weeding resulted in better weed control. Although the recommended herbicide (metribuzine 0.5 kg/ha) with one hand weeding effectively controlled the broad leaved weeds at 60 DAP.

Dry weight of weeds was affected significantly by different treatments. At 30 DAP the minimum weed dry weight was found under one HW at 20 DAP with straw mulching 5 t/ha at 25 DAP *fb* straw mulching 5 t/ha at 5 DAP and black plastic mulch. The total minimum dry weight at 60 DAP was found with hoeing at 20 DAP with one hand weeding at 40 DAP *fb* one HW at 20 DAP with straw mulching 5 t/ha at 25 DAP. Therefore, the maximum weed control efficiency (100%) was recorded in two hand weeding at 20 & 40 DAP *fb* one HW at 20 DAP + hoeing at 40 DAP and one HW at 20 DAP + straw mulching 5 t/ha at 25 DAP. The tuber yield of potato was highest (34.7 t/ha) under two hand weeding at 20 & 40 DAP treatment *fb* one HW at 20 DAP with straw mulching 5 t/ha at 25 DAP (30.2 t/ha) and straw mulching 5 t/ha at 5 DAP (29.0 t/ha). The lowest tuber yield (18.6 t/ha) was obtained in unweeded control plot.

Application of two hand weeding at 20 and 40 DAP fetched significantly highest net returns (₹2,45,052/ha) *fb* one HW at 20 DAP with straw mulching 5 t/ha at 25 DAP (₹ 1,95,289/ha) and straw mulching 5 t/ha at 5 DAP (₹ 1,87,353/ha). Similarly, the highest B:C ratio of 2.39 was also recorded with two hand weedings at 20 and 40 DAP. One HW at 20 DAP with straw mulching 5 t/ha at 25 DAS resulted in higher B:C ratio (1.83) which was at par with straw mulching 5 t/ha at 5 DAP (1.82), recommended herbicide (metribuzin 0.5 kg/ha)+one hand weeding (1.82) and recommended herbicide (metribuzin 0.5 kg/ha) (1.81) application. The minimum net returns ₹ 90,388/ha were recorded with white plastic mulch with poor B:C ratio of 0.94. It was due to the high cost of white and black plastic mulch which resulted in poor net returns and B:C ratio.

In conclusion, two hand weedings at 20 and 40 DAP resulted in better control of weeds with 100% efficiency of weed control, and highest tuber yield (34.7 t/ha) *fb* one HW at 20 DAP + straw mulch application 5 t/ha at 25 DAP (30.2 t/ha) and also fetched highest net returns & B:C ratio.

View of potato field with black plastic mulch

View of potato field with one HW *fb* straw mulch

WP 1.2.3 (ii) Weed management in organic based maize (sweet corn) – potato – greengram (as a green manure) cropping system (Revised experiment)

Objectives

1. To work out the best weed management practice in organic maize based cropping system
2. To workout the economics of weed management in organic maize based cropping system

The major weed flora observed at experimental site during *Kharif* 2018 was *Setaria glauca, Acrachne racemosa, Echinochloa crus-galli* and *Celosia argentea* were found

Treatments:

	Maize	Potato
T_1	Black plastic mulch (25μ)	Black plastic mulch (25μ)
T_2	Soil solarization *fb* plastic mulch (25μ)	Soil solarization *fb* plastic mulch (25μ)
T_3	Soil solarization *fb* one HW at 40 DAS	Soil solarization *fb* one HW at 40 DAS
T_4	Intercrop (Maize+green gram)	Intercrop (Potato+chickpea))
T_5	Stale seed bed *fb* one HW at 40 DAS	Stale seed bed *fb* one HW at 40 DAS
T_6	Hoeing at 20 & 40 DAS	Earthing up at 20 & 40 DAS
T_7	Weedy check	Weedy check
T_8	RDF + Recommended herbicide (Atrazine 750 g/ha PoE)	RDF + Recommended herbicide (Metribuzin 500 g/ha PoE)

seen as narrow leaved weeds (NLW's), and *Commelina benghalensis* and *Digera arvensis* were observed as major broad-leaved weeds (BLW's). The sedge *Cyperus rotundus* was the most problematic weed in the experimental site during the year of study.

Weed population and dry weight of all weeds were significantly affected by weed management practices. When crop was 30 days old the significantly lowest weed population and dry weight was recorded in black plastic mulch which was at par with soil solarization *fb* plastic mulch as compared to other treatments. But at 60 DAS the population of narrow leaved weeds was significantly lowest in treatment where green gram was intercropped with maize *fb* hoeing at 20 and 40 DAS, however broad leaved weeds were not present in these two treatments at this stage. But the lowest population of BLW's were recorded in soil solarization *fb* one hand weeding at 40 DAS. The significantly lowest dry matter at 60 DAS was recorded where greengram was intercropped with maize *fb* hoeing at 20 and 40 DAS. Similarly, the highest weed control efficiency (86.4%) was also recorded with the same treatment (86.5%) hoeing at 20 & 40 DAS (85.2%) and soil solarization *fb* plastic mulch (79.4%).

All the growth and yield attributing parameters *i.e.* plant height, no. of leaves/plant, number of cobs/ plant, yield of cobs and yield of green fodder were significantly influenced by all weed management practices. At 60 DAS the highest plant height and number of leaves were recorded in RDF + recommended dose of herbicide *fb* soil solarization with one HW at 40 DAS. However the lowest plant height was recorded in weedy check. The maximum yield of cobs (7.31 t/ha) was recorded under RDF + recommended dose of herbicide. But under organic weed management practices the highest yield of cobs (7.27 t/ha) was recorded in intercropping treatment *fb* hoeing at 20 & 40 DAS (6.44 t/ha). Similarly, the highest yield of green fodder was recorded under RDF + recommended dose of herbicide (25.6 t/ha) application *fb* hoeing at 20 and 40 DAS.

Application of recommended dose of fertilizer + herbicide (atrazine 750 g/ha POE) fetched highest net returns (₹2,66,572/ha) *fb* greengram + maize intercropping treatment (₹ 2,27,766/ha) and hoeing at 20 and 40 DAS (₹ 2,21,266/ha). However, the highest B:C ratio of 4.45 was recorded with application of recommended dose of fertilizer + herbicide (atrazine 750 g/ha POE) *fb* hoeing at 20 and 40 DAS (3.85) and maize+green gram intercropping (3.74). The minimum net returns ₹ 19,762/ha were recorded with black plastic mulch with poor B:C Ratio of 1.13 *fb* soil solarization *fb* plastic mulch with B:C of 0.87. It was due to the high cost incurred in purchase of white and black plastic resulted in poor net returns and B:C ratio.

In conclusion, application of recommended dose of fertilizer + herbicide (atrazine 750 g/ha POE) gave highest yield (7.31 t/ha) with B:C ratio 4.45. But among the organic methods of weed control, intercrop maize+greengram intercropping gave maximum seed yield (7.27 t/ha) *fb* hoeing at 20 & 40 DAS (6.44 t/ha). Among all organic weed management practices application of white and black plastic mulch was not economically feasible.

Treatments:

Kharif (okra)	*Rabi* (carrot)
Live mulch with *dhaincha*	Mulching with rice husk 3t/ha
Stale seed bed *fb* HW at 20 & 40 DAS	Stale seed bed *fb* HW at 20 and 40DAS
Polymulch + interrow weeding at 30 DAS	Polymulch + interrow weeding at 30 DAS
Straw mulch 5t /ha *fb* intra row HW at 30 DAS	Straw mulch 5t /ha *fb* intra row HW at 30 DAS
Mechanical weeding (MW at 20 and 40 DAS *fb* HW)	Mechanical weeding (MW at 20 and 40 DAS *fb* HW)
Pendimethalin 1000g / ha *fb* HW at 30 DAS	Pendimethalin 1000g /ha *fb* HW at 30 DAS
Intercrop green leaf vegetable *fb* MW at 40 DAS	Intercrop green leaf vegetable *fb* MW at 40 DAS
Unweeded control	Unweeded control

PJTSAU, Hyderabad

WP 1.2.4 Weed management in organic based okra-carrot cropping system

Objectives

1. To monitor weed dynamics and crop productivity in okra and carrot due to non-chemical weed management
2. To monitor physical and chemical properties
3. To work out the economics

Okra

The weed flora infesting the experimental field comprised of *Cyperus rotundus* among sedges; *Rottboellia* spp, *Cynodon dactylon* and *Dactyloctenium aegyptium* among grasses; and *Commelina benghalensis*, *Parthenium hysterophorus*, *Trianthema portulacastrum*, *Digera arvensis* and *Celosia argentea* among the broad leaved weeds.

At 30 DAS, significantly lowest weed dry matter (2.3 g/m^2) and highest weed control efficiency (97.6%) was recorded with mulching with polysheet (25 microns)+ HW in the inter row and it was followed by cultural practice involving MW at 20 & 40 DAS (7.2g/m^2) and SSB preparation *fb* HW at 20 & 40 (7.6g/m^2 & 92.3%) which were at par with. Green mulches involving *Daincha*, did not show influence on weed dry matter significantly highest weed dry matter (98.7 g/m^2) was recorded with unweeded control. The same trend was followed at 60 DAS. Among all the treatments, significantly higher fruit yield was recorded with mulching with polysheet (25 microns) + HW in the inter row at 30 DAS, proved effective (3.63 t /ha) followed by cultural practice involving MW at 20 & 40 DAS and SSB preparation *fb* HW at 20 and 40 DAS. Lowest fruit yield (820 kg/ha) was recorded with unweeded control.

It can be concluded that, mulching with polysheet (25 m)+ HW in the inter row at 30 DAS proved effective followed by cultural practice involving MW at 20 & 40 DAS (2.6 t/ha) and SSB preparation *fb* HW at 20 and 40 (2.51 t/ha) or pendimethalin 1000g/ha *fb* HW at 30 DAS can be recommended for efficient weed control and higher yield in okra. Straw mulch 5t/ha *fb* intra row HW at 30 DAS is also better options in terms of cost effectiveness in view of non availability of labour during critical periods and high cost of labour coupled with poor efficiency.

Carrot

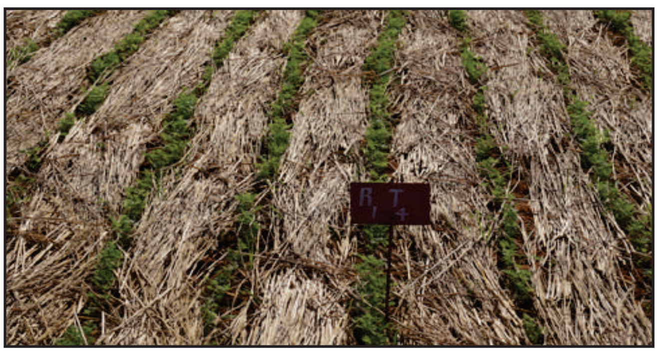
The weed flora observed during crop growing season comprised of *Cyperus rotundus*, *Parthenium hysterophorus, Alternanthera paronychioides, Melilotus alba*, *Digera arvensis, Blumea* sp, *Sonchus* sp., at 30 DAS. However in addition to these weeds, *Amaranthus viridis, Amaranthus polygamus, Aacalypha indica* at 60 DAS, *Dactyloctenium aegyptium, Portulaca oleracea* at 90 DAS, *Euphorbia geniculata* and *Cyanotis axillaris* at harvest were also recorded.

At 30 DAS, significantly lowest weed dry matter (5.3 g/m^2) were also recorded with hand weeding at 21 DAS. Cultural practice (hand weeding at 15 and 45 DAS) or hoeing (twice) at 15 DAS & 30 DAS or hand weeding at 15 DAS *fb* straw mulch 3 t/ha or pendimethalin 1000 g/ha *fb* HW at 30 DAS recorded lower weed dry matter. Significantly highest weed dry matter (42.0 g/m^2) was recorded with unweeded control.

Highest root yield (2.34 t/ha) among cultural treatments was recorded with mechanical weeding

(MW at 20 and 40 DAS *fb* HW). Pendimethalin 1000 g/ha *fb* HW at 30 DAS also recorded higher root yield (2.55 t/ha). Lowest root yield of carrot were recorded by unweeded control (0.66 t/ha). It can be concluded that cultural practice (Hand weeding at 15 and 45 DAS) or hoeing (twice) at 15 DAS & 30 DAS proved effective and can be recommended for efficient weed control and higher yield root yield of carrot. Straw mulch at 3.0 t/ha or power weeding twice are also better option in terms of cost effectiveness in view of non availability of labour during critical periods and high cost of labour coupled with poor efficiency.

ORGANIC WEED MANAGEMENT IN OKRA - CARROT CROPPING SYSTEM



SKUAST, Jammu

WP 1.2.5 Weed management in organic based basmati rice-broccoli-sesbania (green manure) cropping system under

Objective

1. To find out suitable organic weed management practices for basmati rice based cropping system

Treatments

S. No	Basmati rice	Broccoli	Green manure
1.	Stale seedbed	Paddy straw mulch (4 t/ha)	*Sesbania* green manure
2.	Stale seedbed + one hand weeding at 30 DAT	Paddy straw mulch (4 t/ha) + one hand weeding at 30 DAT	*Sesbania* green manure
3.	Stale seedbed *fb* one mechanical weeding at 30 DAT	Paddy straw mulch (6 t/ha)	*Sesbania* green manure
4.	Soil solarisation	Paddy straw mulch (6 t/ha) + one hand weeding at 30 DAT	*Sesbania* green manure
5.	Soil solarisation *fb* one mechanical weeding at 30 DAT	Plastic mulch (Black colour and 7 micron thickness)	*Sesbania* green manure
6.	Weed free (Hand weeding at 20, 40, 60 & 80 DAT)	Weed free (Hand weeding at 20, 40, 60 & 80 DAT)	*Sesbania* green manure
7.	Weedy check	Weedy check	*Sesbania* green manure
8.*	Bispyribac-sodium 25 g/ha at 25 DAT	Oxyfluorfen 200 g/ha before transplanting	*Sesbania* green manure

*Treatment number 8 was conducted separately and was not randomized.

Rice

The experimental field was dominated by *Echinochloa* spp. amongst grassy weeds; *Alternanthera philoxeroides* and *Ammannia baccifera* amongst broad-leaved and among sedges *Cyperus* spp. Besides these major weeds *Caesulia axillaris* and *Commelina benghalensis* were recorded as other weeds. The different weed management treatments had significant effect on weed density and weed biomass at 30 and 60 days after transplanting and at harvest. At 30 days after transplanting, soil solarised plots recorded significantly lowest weed density than other treatments. At 60 and harvest, stale seedbed + one hand weeding at 30 DAT recorded lowest weed density and weed biomass followed by soil solarisation *fb* one mechanical weeding at 30 DAT and stale seedbed *fb* one mechanical weeding at 30 DAT.

The highest grain yield and straw yield were recorded with soil solarisation *fb* one mechanical weeding at 30 DAT (2.75 t/ha) which was statistically at par with stale seedbed +one hand weeding at 30 DAT and stale seedbed *fb* one mechanical weeding at 30 DAT. Highest B.C ratio was recorded in stale seedbed *fb* one mechanical weeding at 30 DAT (1.35) followed by stale seedbed +one hand weeding at 30 DAT (1.27).

AAU, Jorhat

WP 1.2.6 Weed management in organic tea (in collaboration with Department of Tea Husbandry & Technology, AAU, Jorhat)

Objectives

1. To find an effective and economic weed management practice for organic tea cultivation
2. To study moisture conservation due to weed management practices

Treatments

T_1 Biodegradable film
T_2 Citronella leaf mulching
T_3 Guatemala mulch
T_4 Straw mulch pretreated with 3-4% urea
T_5 Chilling twice
T_6 Chilling twice and application of vermicompost after each chilling
T_7 Brush cutter thrice
T_8 Sickling thrice

Chromolaena odorata, Mikania micrantha, Scoparia dulcis, Spermacocce spp., *Axonopus compressus, Digitaria setigera, Ischaemum* sp., *Dichanthium* sp., and *Oplismenus burmanii* were the major weeds observed in the experimental plot. Bio-degradable film mulching (T_1) at all stages of observation resulted in the lowest dry weight of weeds in tea although in case of observations during March, May and June; barring brush cutting(T_7) and sickling(T_8) the rest were statistically similar to T_1 in this respect. The observations of April and July, showed that T_1 was the best treatment in this regard. In the month of August, chilling followed by vermicompost application (twice, T_6) was at par with T_1.

Green leaf yield of tea was found to be the highest at all the plucking stages in case of bio-degradable film mulching - T_1 (97.2 – 1373.2 kg/ha). In the 1st and 2nd plucking stages, citronella and lemon glass mulching (T_2) yielded similarly with T_1. During the 3rd, 4th and 5th 6th and 7th and 10th plucking stages, T_1 was the best yielder of green tea leaves. In case of the 8th plucking, Guatemala mulching (T_3) and chilling followed by vermicompost application (twice, T_6) produced similarly with T_1. In case of 9th plucking, T_1, T_2 and T_3 and T_7 yielded at par. During 12th plucking, T_1 and T_3 resulted in statistically similar yield of fresh tea leaves.

PAU, Ludhiana

WP 1.2.7 Weed management in organic based basmati rice-durum wheat cropping system

Objective

1. To develop effective weed management approaches for organic based basmati rice-durum wheat- green manure cropping system

Treatments

	Basmati rice (puddle transplanted)	Durum wheat
T1	GM 50 kg/ha + unweeded	Unweeded
T2	GM 50 kg/ha + weed free	Weed free
T3	GM 50 kg /ha + 25 % higher plant density + one hand pulling	50% higher plant density + one hoeing
T4	DT+GM 50 kg/ha + 25% higher plant density + one hand pulling	50% higher plant density+ straw mulch (6t/ha)
T5	GM 75 kg/ha + 25% high plant density + one hand pulling	DT + 50% higher plant density + one hoeing
T6	DT+GM 75 kg /ha + 25% higher plant density + one hand pulling	DT+ 50% higher plant density + Straw mulch (6 t/ha)
T7	GM 100 kg/ha + 25% higher plant density + one hand pulling	ZT with residues + 50% higher plant density
T8	DT + GM 100 kg /ha + 25% higher plant density + one hand pulling	ZT without residues +50% higher plant density
T9	DT + GM 100 kg/ha + Normal plant density + one hand pulling	Bed planting + 25% higher plant density + one hoeing
T10	Conventional agriculture (weedfree for both rice and wheat)	

GM = Green manuring (with *Sesbania aculeata*) DT= Deep tillage; ZT-Zero tillage

Durum wheat

Wheat crop was infested mainly with broadleaf weeds and major weeds were *Anagallis arvensis, Coronopus didymus* and *Chenopodium album*. Other weeds present in field in small densities included *Rumex dentatus*, *Medicago denticulata*. ZT with or without residue, CT and deep tillage along with paddy straw mulch, all integrated with 50% higher crop density resulted in no change in density and biomass of weeds at 30 and 60 DAS. Soil weed seed bank consisted of five weed spp. *P. minor*, *R. dentatus, A. arvensis, P. annua,* e.g., however, *P. annua* and *C. album* were new weeds observed in the seed bank. There was an increase in the seed bank of *P. minor*, *R. dentatus A. arvensis* as compared to last year; highest increase was in case of *A. arvensis* followed by *R. dentatus.* All weed control treatments did not show any significant influence on wheat crop growth, grain yield and yield attributes as compared to unweeded control.

Basmati rice

Basmati rice crop was infested with *Echinochloa colona, Eclipta alba* and *Alternanthera philoxeroides*. Soil weed seed bank consisted of four weed spp. *Echinochloa colona, Cyperus compressus, Dactyloctenium aegyptium, Trianthema portulacastrum*; these weed species were also recorded in the previous season. Soil seed bank results under different weed control treatments were inconsistent. All weed control practices involving seed rate of green manure crop, planting density of rice crop and tillage treatments did not significantly influence basmati rice growth, grain yield and yield attributes as compared to unweeded control.

CSKHPKV, Palampur

WP 1.2.8 Weed management in organic based maize-garlic cropping system

Objectives

1. To study weed floristic diversity under organic crop production system,
2. To evolve viable weed management practices in organic crop production system and
3. To study the effect of organic weed management practices on soil quality.

Treatments

	Kharif	*Rabi*	Remarks/short title
	Maize (Green cob)	Gralic	
T_1	Hoeing followed by earthing up at knee high stage	Hoeing at 15 DAS and 45 DAS	Hoeing
T_2	Stale seed bed (SSB) + hoeing + earthing up	SSB + hoeing + HW	SSB + hoeing
T_3	Raised stale seed bed (RSSB)+ hoeing + earthing up	RSSB + hoeing + HW	RSSB + hoeing
T_4	Mulch (Lantana) 5t/ha	Mulch 5 t/ha	Mulch
T_5	SSB + mulch 5t/ha	SSB + mulch 5t/ha	SSB + mulch
T_6	RSSB + mulch 5t/ha	RSSB + mulch 5t/ha	RSSB + mulch
T_7	Intercropping (Soybean) + hoeing	Intercropping (Coriander) + hoeing	Intercropping
T_8	*Maize/Soybean + hoeing+ earthing up	*Garlic/Pea + hoeing+ HW	Crop rotation
T_9	Mulch + manual weeding *fb* autumn crop of coriander	Mulch + manual weeding fb summer crop of green manure	Intensive cropping
T_{10}	Chemical check	Chemical check	Chemical check

*In *Kharif*, maize/ soybean and in *Rabi* garlic/pea as alternate crop

Maize

Weed flora of *Kharif* 2018 was dominated by *Commelina* sp. (21%), *Galinsoga parviflora* (18.9%), *Ageratum* sp. (9.4%), *Cyperus* sp. (9.0%), *Digitaria sanguinalis* (7.0%), *Paspalum* sp., (6.3%), *Polygonum alatum* (5.3%), *Phyllanthus niruri* (4.5%), *Panicum dichotomiflorum* (4.1%), *Bidens pilosa* (4%) and *Aeschynomene indica* (2.9%). *Alternenthera philoxeroides* also invaded the field but with a low proportion (0.3%) and may be a potential future threat. All treatments were comparable in influencing green fodder yield of maize during the *Kharif* 2017 but varied widely in the next year for green cob yield of maize.

Garlic

In winter, *Daucas carota* (21.5%) was most dominant followed by *Phalaris minor* (18.4%), *Anagallis arvensis* (15.5%), *Poa annua* (9.6%), *Asphodelus tenuifolius* (7.0%), *Euphorbia geniculata* (7.8%), *Vicia* sp. (5.9%) and *Stellaria media* (4.9%). Raised stale seed bed + mulch resulted in significantly higher bulb yield of garlic as compared to other weed control treatments. Bulb yield ranged from 1.27 to 3.36 t/ha in the first year and 1.47 to 3.47 t/ha in the second year under different treatments. Due to higher bulb yield of garlic, garlic equivalent yield was higher under raised stale seed bed + mulch or hoeing, intensive cropping and intercropping treatments applied both in maize and garlic.

GBPUAT, Pantnagar

WP 1.2.9 Weed management options in organic based rice-wheat cropping system

Objective

1. To study the performance of organic weed management practices against the complex weed flora in rice-wheat cropping system over herbicidal treatments.

Treatments

	Rabi (2017-18) Crop: Wheat		*Kharif* (2018) Crop: Rice
T1	Rice (TPR) - Summer ploughing + stale bed 10 days standing water+ one MW (20 DAT) + one HW (40 DAT) wheat (Convt.) stale bed + one MW (30 DAS)	T1	Rice (TPR) - Summer ploughing + stale bed + one MW (20 DAT)+ one HW (40 DAT) wheat (Convt.) stale bed + one MW (30 DAS)
T2	Rice (TPR) - stale bed + one MW (20 DAT) + one HW (40 DAT) wheat (Convt.) stale bed + one HW (30 DAS)	T2	Rice (TPR) - stale bed + one MW (20 DAT) + one HW (40 DAT) wheat (Convt.) stale bed+ one HW (30 DAS)
T3	Rice (TPR)-soil solarization + (40 HW (40 DAT) wheat (ZT) with rice straw + one HW	T3	Rice (TPR)- one HW (40 DAT) wheat (ZT) with rice straw + one HW
T4	Rice (FIRB DSR)-stale seed bed + soybean on bed) + (40 Hoeing at 20 DAS + one HW at 40 DAS wheat (FIRB) two rows wheat on bed + mentha in furrows + one HW (30 DAS)	T4	Rice (FIRB DSR)-stale seed bed + soybean on bed) + one hoeing (20 DAS) + one HW at 40 DAS wheat (FIRB) two rows wheat on bed + mentha in furrows + one HW (30 DAS)
T5	Rice (DSR) + *Sesbania* + MW (25 DAS) + HW (40 DAS) wheat (CTW) + stale bed + one HW (30 DAS)	T5	Rice (DSR) + *Sesbania* + MW (25 DAS) + HW (40 DAS) wheat (CTW)+ stale bed + one HW(30 DAS)
T6	Rice (DSR) soil solarization + one HW (25 DAS) wheat (ZT) with rice straw + one HW(30 DAS)	T6	Rice (DSR) soil solarization + one HW (25 DAS) wheat (ZT) with rice straw + one HW (30 DAS)
T7	Rice (TPR) + pre-em *fb* post-em herbicide (Control) wheat (Convt.) + Post-emergence herbicide (Control)	T7	Rice (TPR)+pre-emergence *fb* post-emergence herbicide (Control) wheat (Convt.) + post-emergence herbicide (Control)
T8	Rice (DSR) + pre-emergence *fb* post-emergence (Control) wheat (ZT) + post-emergence herbicide (Control)	T8	Rice (DSR) + pre-em. *fb* post-em. (Control) Wheat (ZT) + post-em. herbicide (Control)

Rice

Density and dry matter accumulation of weeds at 60 DAS/DAT was significantly influenced due to different treatments. Under organic mode, amongst the recorded weed species *Ammania baccifera* was dominant which was completely controlled under rice (DSR) with *Sesbania fb* one MW then HW; wheat (CTW) on stale bed *fb* one HW, being at par to the direct seeded rice; zero till wheat (control) and was found to be the significantly superior to rest of the treatments including organic mode of control practices. Transplanted rice with one hand weeding; zero-till wheat along with rice straw *fb* one HW completely controlled *E. colona, E. indica, P. maximum, D. aegyptium, M. stricta* and *C. rotundus,* being at par to control measures of rice (TPR) as well as wheat (conventional). However, *E. indica*, *D. aegyptium* and *C. rotundus* was also got eliminated under transplanted rice with summer ploughing on stale bed technique with one days standing water *fb* one MW then one HW; conventional wheat on stale bed *fb* one MW, rice (TPR) on stale bed technique *fb* one MW than one HW; wheat (conventional) on stale bed *fb* one HW, rice (DSR) incorporated with *Sesbania fb* one MW then one HW; wheat (CTW) on stale bed *fb* one HW, transplanted rice; conventional wheat (control) and direct seeded rice; zero-till wheat (control) in case of *E. indica* only. *M. stricta*, *C. iria* and *C. rotundus* were not observed under rice (TPR) on stale bed *fb* one MW then one HW; wheat (CTW) on stale bed then HW, rice (FIRB DSR) on stale bed with soybean *fb* one hoeing then one HW; wheat (FIRB) with mentha *fb* one HW; being at par to control measures of rice (TPR) as well as wheat (CTW). However, *M. stricta* and *C. iria* also got eliminated with rice (DSR) along with *Sesbania fb* one MW then HW; wheat (CTW) on stale bed *fb* one HW and also with rice (DSR) with soil solarization *fb* one HW; wheat (ZT) with rice straw *fb* one HW in case of *M. stricta* and *P. maximum*.

Total density and dry matter accumulation of all grassy and non grassy weeds were recorded least with direct seeded rice incorporated with *Sesbania fb* one mechanical and one hand weeding; conventional wheat stale bed *fb* one HW and was comparable to transplanted rice on stale bed technique *fb* one MW then one HW; conventional wheat stale bed *fb* one HW and rice (FIRB DSR) on stale bed technique with soybean *fb* one hoeing then one HW; wheat (FIRB) with mentha *fb* one HW.

Under organic mode, grain and straw yield were comparable to each other but numerically highest grain and straw yield of rice (3.5 and 6.6 t/ha), respectively, was achieved under direct seeding with FIRB with stale seed bed and soybean bed along with one hoeing *fb* one hand weeding; wheat with FIRB along with mentha *fb* one HW because rice equivalent yield of soybean was computed and added to sole rice yield in this treatment. While, rice (DSR) with soil solarization *fb* one HW; wheat (ZT) with rice straw *fb* one HW and control measures of rice (DSR) as well as wheat (ZT) recorded lowest grain and straw yield.

Wheat

Among different herbicidal treatments, density of all recorded weed species including *P. minor*, *M. indica*, *F. parviflora*, *C. album* and *C. rotundus* was completely controlled and reduced. *C. didymus* and *M. stricta* were completely eliminated under transplanted rice with soil solarization *fb* one HW; zero tillage wheat with rice straw *fb* one HW and was significantly superior to rest of the treatments. Also, the density of *P. minor* was completely controlled under all the treatments except transplanted rice on stale-bed technique *fb* one MW then HW; conventional wheat on stale bed technique *fb* one HW and FIRB-DSR on stale-bed technique with soybean on-bed *fb* one hoeing then one HW. The density of dominant weed species *P. hysterophorus* reduced under transplanted rice with summer ploughing on stale bed *fb* one MW then one HW; conventional wheat on stale bed *fb* one MW, while, *M. stricta* got eliminated under direct seeded rice (FIRB) on stale-bed with soybean *fb* one hoeing and one HW; wheat (FIRB) with mentha *fb* one HW. The density of *C. rotundus* completely eliminated under both conventional and zero till rice-wheat system (TPR and DSR) along with soil solarization and *Sesbania* or rice straw with or without stale-bed technique as well as transplanted rice and conventional wheat under control measures.

Total density of all grassy and non grassy weeds was minimum under direct seeded rice with soil solarization *fb* one HW; zero-till wheat with rice straw *fb* one HW which was comparable to rice (TPR) with summer ploughing on stale bed *fb* one MW then one HW; wheat (CTW) on stale bed *fb* one MW and rice (TPR) with soil solarization *fb* one HW; wheat (ZT) with rice straw *fb* one HW. Total dry matter accumulation was obtained minimum with transplanted rice with summer ploughing on stale bed technique *fb* one MW then one HW; conventional wheat with stale bed technique *fb* one HW being at par to the transplanted rice with soil solarization fb one HW; zero tillage wheat with rice straw *fb* one HW.

The highest grain yield (6.2 t/ha) was achieved with rice (FIRB DSR) on stale bed technique *fb* one hoeing then one HW; wheat (FIRB) with mentha in furrows *fb* one HW, because rice equivalent yield of soybean was computed and added to sole rice yield in this treatment, while in other treatments it was comparable to each other. Whereas, highest straw yield (6.5 t/ha) was achieved in control measures of direct seeded rice; zero till wheat, being at par to rest of the treatments.

MPUAT, Udaipur

WP 1.2.10 Organic weed management inorganic based fennel /sweet corn crop

(This trial was taken in collaboration with Network Project on Organic Farming-NPOF)

Objectives

1. To study the non-chemical methods of weed control fennel / sweet corn
2. To study their effect on growth and yield of fennel / sweet corn

Treatments

1. Summer ploughing+one hand weeding at 20 DAS
2. Summer ploughing + straw mulch (5 t/ha) at 20 DAS + one hand weeding at 40 DAS
3. Summer ploughing + plastic mulch at sowing
4. Stale seed bed preparation + one hand weeding at 20DAS
5. Stale seed bed preparation + straw mulch (5 t/ha) at 20 DAS + one hand weeding at 40 DAS
6. Stale seed bed preparation + plastic mulch at sowing

7. Soil solarization + one hand weeding
8. Soil solarization + straw mulch (5 t/ha) at 20 DAS+one hand weeding at 40 DAS
9. Soil solarization + plastic mulch at sowing
10. *Sesbania* as smothering crop in between rows and used same *Sesbaina* as mulch after 30 days + one HW at 40 DAS
11. Pendimethalin 1000 g /atrazine 500g *fb* straw mulching (5 t/ha) at 20 DAS
12. Weedy check

Sweet corn

The major broadleaf weeds in the experimental fields were *Digera arvensis, Trianthema portulacastrum, Physalis minima, Setaria glauca* and *Commelina benghalensis.* The grassy weeds were *Echinochloa colona* and *Dinebra retroflexa.* Weed density of monocots and dicot were recorded significantly lower in plastic mulch either with summer ploughing, sowing after stale seed bed preparation or soil solarization. All these treatments of plastic mulch were at par and significantly superior over other treatments like soil solarization with one hand weeding either with or without straw mulch (5 t/ha), *Sesbania* as smothering crop with hand weeding or pre-emergence application of herbicide with straw mulch (5 t/ha), summer ploughing and stale seed bed with one hand weeding at 20 DAS.

All the three treatments of plastic mulch either with soil solarization, summer ploughing and stale seed bed techniques proved equally effective in reduction of weed dry matter. Plastic mulch in different combinations proved most effective and recorded 95-100 % percent reduction in total weed dry matter at 60 DAS and at harvest, in comparison to weedy check. Maximum weed control efficiency was recorded with crop sown with treatment of soil solarization with plastic mulch, which was at par with plastic mulch with stale seed bed + plastic mulch and summer ploughing + plastic mulch.

Among different organic weed management treatments, maximum values of seed yield (4.11 t/ha) of sweet corn was recorded with crop sown with treatment of stale seed bed with plastic mulch, which was at par with plastic mulch with soil solarization + plastic mulch and summer ploughing + plastic mulch. Application of plastic mulch with stale seed bed, summer ploughing, and soil solarization recorded 211.3, 205.3 and 200 % respectively, increase in yield over weedy check (1.32 t/ha). A similar trend of superiority of plastic mulch with different agronomic practices was observed in straw yield of sweet corn. All the organic weed management treatments proved statistically superior over weedy check.

Among organic weed management practices, highest net return (₹ 62,746/ha) B: C (1.62) was recorded with stale seed bed with plastic mulch.

Fennel

The major broadleaf weeds in the experimental fields were *Chenopodium album, Chenopodium murale, Fumaria parviflora, Convolvulus arvensis, Melilotus alba* and *Malwa parviflora.* The grassy weed and sedges were *Phalaris minor* and *Cyperus rotundus.* Weed density recorded at 60 DAS and at harvest of fennel was significantly lower in plastic mulch either with soil solarization, summer ploughing and sowing after stale seed bed preparation or. All these treatments of plastic mulch were at par and significantly superior over other treatments like soil solarization with one hand weeding either with or without straw mulch (5 t/ha), *Sesbania* as smothering crop with hand weeding or pre-emergence application of herbicide with straw mulch (5 t/ha), summer ploughing and stale seed bed with one hand weeding at 20 DAS.

All the three treatments of plastic mulch either with soil solarization, summer ploughing and stale seed bed techniques proved equally effective in reduction of weed dry matter. Plastic mulch in different combinations proved most effective and recorded 95-100 % reduction in total weed dry matter at 60 DAS and at harvest, in comparison to weedy check.

Among different organic weed management treatments, maximum seed yield (1.43 t/ha) of fennel was recorded with crop sown with treatment of soil solarization with plastic mulch, which was at par with plastic mulch with summer ploughing and stale seed bed. Application of plastic mulch with soil solarization, stale seed bed and summer ploughing resulted in 241.9, 233.8 and 231.4 %, respectively, increase in yield over weedy check (0.420 kg/ha). A similar trend of superiority of plastic mulch with different agronomic practices was observed in straw yield of fennel. All the organic weed management treatments proved statistically superior over weedy check. Among organic weed management practices, highest net return (₹ 66,129/ha) and B: C ratio (1.71) was recorded with stale seed bed with plastic mulch.

BCKV, Kalyani

WP 1.2.12 Weed management in rice-capsicum system under organic cropping

Objective

1. To study the effect of weed control measures on weeds, crop growth, yield and economics in organic rice- capsicum cropping system

Treatments

	Kharif (Rice)	*Rabi* (Capsicum)
T_1	Closer spacing (20X15cm) *fb* one hand weeding at 30 DAT	Closer spacing (60X30cm) *fb* one hand weeding at 30 DAT
T_2	Green manuring 50 kg/ha before transplanting *fb* one hand weeding at 30 DAT	Black polythene mulch
T_3	*Sesbania* intercrop 25 kg/ha up to 30 DAS *fb* mechanical incorporation *fb* one hand weeding at 40 DAT	*Sesbania* intercrop 25 kg/ha up to 30 DAS *fb* mechanical incorporation *fb* one hand weeding at 45 DAT
T_4	Summer deep tillage *fb* one hand weeding at 30 DAT	Paddy straw mulch 7.5 t/ha *fb* one hand weeding at 30 DAT
T_5	Two mechanical weeding by paddy weeder at 20 & 40 DAT	Two mechanical weeding at 20 & 40 DAT
T_6	Two hand weeding at 20 & 40 DAT	Two hand weeding at 20 & 40 DAT
T_7	Weedy	Weedy
T_8	RDF + pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT	RDF + pendimethalin1 kg/ha

Major weed flora observed during *Kharif* 2018 was *Echinochloa crusgalli, E. colona, Chloris barbata* among grasses, *Cyperus iria, C. rotundus, Fimbritylis miliacea* among sedges, *Marsilea quadrifolia, Monochoria vaginalis, Alternanthera sessilis, Ludwigia parviflora, Ammannia baccifera,* and *Commelina benghalensis* amongst broad leaved weeds.

At 30 DAS, significantly lower total weed (21.7/m^2) and dry weed biomass (9.49 g/m^2) were noticed as compared to 60 DAS (44/ m^2 and 28.4 g/m^2, respectively) and at harvest (72.3/ m^2 and 33.3 g/m^2, respectively) with the treatment receiving RDF + pretilachlor 750 g/ha *fb* bispyribac /Na 25 g/ha at 25 DAT. The second best performance was observed with the application of two hand weedings at 20 & 40 DAT followed by the treatment receiving two mechanical weeding by paddy weeder at 20 & 40 DAT and then treatment *Sesbania* intercrop 25 kg/ha up to 30 DAS *fb* mechanical incorporation *fb* one hand weeding at 40 DAT. Treatment with closer spacing (20X15cm) *fb* one hand weeding at 30 DAT resulted in better in response to weed management with lower number and dry weed biomass in comparison to green manuring 50 kg/ha before transplanting *fb* one hand weeding at 30 DAT treatment.

Weed control efficiency was 87, 82.9 and 82.6% at 30, 60 DAS and at harvest, respectively when the crop was treated with RDF + pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT. Among different weed management practices, application of RDF + pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT found superior towards recording highest yield attributing characters *viz.,* panicle/m^2 (442.6), grains/panicle (82.3),test wt.(20.8 g) and yield *viz.,* grain (5.12 t/ha), straw yield (6.41 t/ha). This helped in realizing highest net return (₹ 27,920 /ha) and B:C ratio (0.33). Next highest grain (4.90 t/ha), straw yield (6.33 t/ha) and net return (₹ 20,785 /ha) were recorded with two hand weeding at 20 & 40 DAT followed by two mechanical weeding by paddy weeder at 20 & 40 DAT. The lowest yield (4.20 t grain/ha and 5.66 t straw/ha) and net return (₹ 13,455/ha) were recorded in weedy treatment.

KAU, Thrissur

WP 1.2.13 Weed management in organic based turmeric - cowpea cropping system

Objective

1. To evaluate the effect of different organic mulches on weed control in turmeric based cropping system.

Treatments

1. Mulching with *Eichhornia crassipes* 15 t/ha (fresh weight) + one HW at 50 DAP *fb* earthing up
2. Mulching with coir pith 15 t/ha (fresh weight) + one HW at 50 DAP *fb* earthing up
3. Mulching with coconut fronds, 20 t/ha (fresh weight) + one HW at 50 DAP *fb* earthing up
4. Mulching with grass clippings 15 t/ha (fresh weight) + one HW at 50 DAP *fb* earthing up
5. Mulching with jack leaves 15 t/ha (fresh weight) + one HW at 50 DAP *fb* earthing up
6. Oxyfluorfen 0.15 kg/ha + one HW at 50 DAP *fb* earthing up
7. Unweeded control

Broad leaf weeds were dominated the area, and the major species were *Borreria hispida*, *Alternanthera bettzickiana, Ludwigia perennis, Ageratum conyzoides*, *Emilia sonchifolia*, *Cleome rutidosperma*, etc. Major grassy weeds were *Paspalam conjugatum* and *Eleusine indica*, while, *Kyllinga monocephala* was the major sedge.

At 45 days, next to unmulched control, density of *Borreria hispida* was highest in *Eichhornia crassipes* mulched plots. All other treatments were on par. With regard to *Alternanthera bettzickiana*, mulching with polythene sheet significantly reduced the density; and this treatment was on par with plots mulched with coir pith, coconut fronds, grass clippings and those treated with oxyfluorfen. The remaining treatments were significantly inferior. *Kyllinga monocephala* was not affected by treatments, except by coir pith mulching and oxyfluorfen application. At 45 and 90 DAS, weed density was not affected by treatments. However, at 135 DAS, density of *Borreria hispida* was seen to be significantly lower when mulched with grass clippings. However, this treatment was on par with mulching with coir pith, *Eichhornia crassipes* and polythene sheet, and also in unmulched control. Significantly higher density was observed on mulching with coconut fronds and jack leaves, and application of oxyfluorfen.

Mulching with different materials had significant effect on plant height of turmeric. At 60 DAP, mulching with polythene sheet resulted in greatest height of plants. However, plant height in oxyfluorfen treated plot and in plots mulched with jack leaves and grass clippings were on par. Highest rhizome yield of 47 t/ha was obtained on mulching with polythene sheet. Mulching with jack leaves and coconut fronds produced yields on par with this treatment. Lowest yields were recorded with unmulched control. Analysis of economics of cultivation revealed that highest BC ratio was obtained with oxyfluorfen application (5.48), followed by polythene mulching (5.12).

UAS, Bengaluru

WP 1.2.14 Evaluation of weed management in organic based *kharif* - foxtail millet (*Setaria italica* (L.) P. Beauv.*)* – *Rabi*- greengram cropping system

Objectives

1. To evaluate the effective non- chemical methods of weed control on growth and yield of foxtail millet – greengram cropping system
2. To study the effect of non -chemical methods of weed control measures on weed intensity and weed control efficiency
3. To work out the economics

Treatments

	Kharif- Foxtail millet (June- Aug)	*Rabi*-Greengram (Oct)
T_1	*Stale seed bed technique	*Stale seed bed technique
T_2	Inter cultivation twice at 25 + one hand weeding at 45 DAS	Inter cultivation twice at 25 + one hand weeding at 45 DAS
T_3	Stale seed bed technique + intercultivation twice at 25 & 45DAS	Stale seed bed technique + intercultiva tion twice at 25 & 45 DAS
T_4	Straw mulching 5 t/ha at 10-15 DAS	Straw mulching 5 t/ha at 10-15 DAS
T_5	Bio-mulching (Seed of cowpea was sown in between two rows of fox tail millet). The cover crops cowpea was mulched between rows at 30 (DAS) + one interculturation at 40 DAS	*Sesbania* as bio mulching smothering crop in between two rows of cowpea,.greengram and used as mulch after 30 DAS + 1 intercultivation at 40 DAS
T_6	Hand weeding at 20 & 40 DAS	Hand weeding at 20 & 40 DAS
T_7	Bio-mulching (Seed of coriander was sown in between two rows of fox tail millet). The cover crops cowpea will be mulched between rows at 30 (DAS) + one interculturation at 40 DAS	Bio-mulching (Seed of coriander is sown in between two rows of fox tail millet). The cover crops cowpea was mulched between rows at 30 (DAS) + one interculturation at 40 DAS
T_8	Unweeded control	Unweeded control
T_9	**PE- pendimethalin 1.0 kg/ha + intercultivation 30 DAS	**PE- pendimethalin 1.0 kg / ha + intercultivation 30 DAS

* Stale seed bed treatment was initiated 15 days before sowing of the crop. One irrigation was given to stale seed bed plots and weeds were allowed to germinate. The germinated weeds were removed by passing cultivator cris-cross one day before sowing of the crop.

** Chemical treatment was laid out away from the non- chemical treatment plots.

** In organic experiments it was suggested to test the recommended practice (chemical based) in separate strip just for comparison, however, it would not be included for statistical analysis and also suggested to specify the source of plant nutrients supplying to the crop

Foxtail millet

Application of pendimethalin 0.5 & 1.0 kg/ha was found toxic to foxtail millet and inhibited germination.

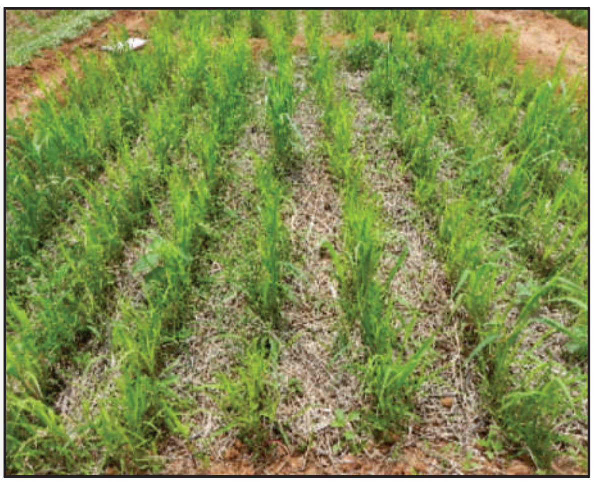
Major weed flora observed in the experimental plots was *Cyperus rotundus* (among sedges), *Cynodon dactylon, Digitaria marginata Echinochloa crus-galli, Echinochloa colona, Eleusine indica* (among grasses). Whereas, among broad leaf weeds, major weeds were *Acanthospermum hispidum, Ageratum conyzoides, Boerhavia diffusa, Cleome viscosa, Commelina benghalensis* at 60 DAS. Among the weed species, the density of were higher than other weed species, indicated their dominance from the beginning of the crop cycle.

Weed density and weed dry weight at 60 DAS among the weed flora sedges were not observed only grasses and broad leaf weeds were noticed. In unweeded control the density and dry weight of grasses were higher followed by broad leaf weeds (BLW). At 60 DAS, hand weedings at 20 and 40 DAS recorded significantly lower weed density and weed dry weight compared to other non chemical method of weed control due to completed removal of weeds by employing manual labour .Although it is costly, labour intensive and tedious job. Among other non chemical methods stale seed bed technique followed by inter cultivation at 25 at 45 DAS, following inter cultivation 25 DAS and one hand weeding at 45 DAS reduced the weeds' density and dry weight significantly over other treatments, which was comparable to hand weeding at 20 and 40 DAS.

At harvest, the total weed density was significantly lower in hand weeding at 20 and 40 DAS and was on par with stale seed bed technique followed by inter cultivation at 25 at 45 DAS, following inter cultivation 25 DAS and one hand weeding at 45 DAS. All weed management treatments recorded significantly lower total weed density at harvest except stale seed bed technique, Bio mulching with coriander and straw mulching were on par with unweeded control.

Two hand weedings (20 & 40 DAS) recorded significantly higher grain yield (1.4 t/ha) which was on par with stale seed bed technique followed by inter cultivation at 25 at 45 DAS (1.3 t/ha) followed by inter cultivation 25 DAS and one hand weeding at 45 DAS (1.2 t/ha). This higher yield might be due to better control of weeds at tillering stage of the crop which is crucial for fox tail millet. Unweeded control resulted in the lowest grain yield (0.6 t/ha) owing to severe weed competition. The lower grain yield was also recorded where only stale seed bed technique (0.88 t/ha) and straw mulching (1.0 t/ha) was practiced. This reduction in the yield might be due to severe weed competition with the foxtail millet throughout the crop growth period. The weed index was higher in stale seed bed technique (63.1%) followed by straw mulching (34.7%) owing to the fact that it produced less yield indicting the percent yield loss varied from 34 to 60% compared to hand weeding.

Higher gross return (₹ 28,601 /ha) was obtained in hand weeding twice at 20 and 40 DAS followed by stale seed bed technique combine with inter cultivation at 25 and 45 DAS (₹ 27,275 /ha). Highest net return was obtained in stale seed bed technique combined with inter cultivation at 25 and 45 DAS (₹ 10,900 /ha) followed by hand weeding twice at 20 and 40 DAS (₹ 10,726 /ha) and inter cultivation at 25 DAS and one hand weeding at 45 DAS (₹ 10,158 /ha). Whereas the B:C ratio was higher in stale seed bed technique combined with inter cultivation at 25 and 45 DAS (1.67) due to its lower cost of cultivation than hand weeding twice treatment. Hand weeding twice at 20 and 40 DAS produced the highest gross and net return but B:C ratio was lower as compared to other treatments (1.60). However, lowest B:C ratio of 1.03 was noticed in unweeded control.



T_4- Straw mulching at 40 DAS

T_5- Bio- mulching – cowpea at 30 DAS

T_3- Stale seed bed technique + Intercultivation at 25 + 45 DAS

T_8- Unweeded Control

Plate 3 Non-chemical methods of weed management in foxtail millet

WP 1.3 Herbicidal control of weeds in crops and cropping systems

WP 1.3.1 Weed management in rice, and rice-based cropping systems

TNAU, Coimbatore

WP 1.3.1.1 Long-term herbicide trial in transplanted lowland rice-rice cropping system

During *Rabi,* 2017-18 at 60 DAT, lower total weed density and dry weight was recorded in herbicide treatments than hand weeding **(Table 1.1.3.1)**. The application of pyrasosulfuron-ethyl (PE) *fb* hand weeding recorded lower total weed dry weight at 60 DAT and this treatment also produced higher number of productive tillers and rice grain yield. During *Kharif,* 2018 at 60 DAT, lower total weed density and dry weight was also recorded in herbicide treatments than hand weeding. Significantly lower total weed density and dry weight at 60 DAT was recorded with PE pyrasosulfuron-ethyl (PE) *fb* hand weeding. Among the treatments, significantly higher grain yield of 7.45 t/ha was recorded with hand weeding followed by pyrasosulfuron-ethyl (PE) *fb* bispyribac-sodium (PoE). Significantly lower grain yield was recorded with unweeded check. Residues of all the studied herbicides in the soil and rice grains at harvest from both *Rabi* 2017-18 and *Kharif* 18 were found below the detection limit of 0.01 mg/kg. Soil nutrients status was also unaffected significantly by the herbicidal weed management practices.

Table 1.1.3.1 Total weed density and weed dry weight at 60 DAT and productive tillers, grain yield and economics as influenced by long term herbicide trial in transplanted lowland rice-rice cropping system

Treatment	Dose (g/ha)	DAT	*Rabi* 2017-18				*Kharif* 2018			
			Total weed density (no./m^2) at 60 DAT	Total weed dry weight (g/m^2) at 60 DAT	Productive tillers (no./m^2)	Grain yield (t/ha)	Total weed density (no./m^2) at 60 DAT	Total weed dry weight (g/m^2) at 60 DAT	Productive tillers (no./m^2)	Grain yield (t/ha)
Pyrasosulfuron-ethyl (PE) *fb* hand weeding (K & R)	20	3 *fb* 30	2.93	1.41	518	6.73	5.97	2.90	304	6.46
Pyrasosulfuron-ethyl (PE) *fb* hand weeding (K); and bensulfuron-methyl + pretilachlor *fb* hand weeding (R)	20 +660	3 *fb* 30 (K and R)	3.98	2.07	438	6.09	6.78	3.42	272	6.29
Pyrasosulfuron-ethyl (PE) *fb* bispyribac sodium (PoE) (K & R)	20 *fb* 25	3 *fb* 30	2.30	2.24	506	6.64	5.98	3.49	240	5.02
Pyrasosulfuron-ethyl (PE) *fb* (PoE) bispyribac-sodium (K); and bensulfuron-methyl + pretilachlor *fb* bispyribac-sodium (PoE)(R)	20 *fb* 25 + 660 *fb* 25	3 *fb* 30 (K and R)	3.27	2.88	406	5.37	6.75	3.86	288	6.24
Hand weeding twice	-	15 and 30	4.16	3.21	464	6.63	8.21	3.62	336	7.48
Unweeded check	-	-	9.40	5.70	136	2.30	11.4	6.75	112	3.50
SEm$\pm$			0.10	0.11	11	0.15	0.17	0.30	5	0.16
LSD (P=0.05)			0.24	0.24	23	0.33	0.38	0.67	12	0.37

Note: K –*Kharif* ; R -*Rabi* , DAT : Days after transplanting; PE- Pre-emergence; PoE- Post-emergence

AAU, Jorhat

WP 1.3.1.2 (i) Long-term herbicidal trial in rice-rice cropping sequence

Among the various nutrient and weed management practices, farmers practice (pretilachlor 0.750 kg/ha + NPK fertilizer) recorded the highest weed density in both the seasons and maximum dry weight of weeds in autumn season (**Table 1.3.1.2(i)**). Among other weed management treatments, pyrazosulfuron 25g/ha + 2,4-D 0.5 kg/ha rotated with pretilachlor 0.750 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source) significantly reduced the weed density and dry biomass accumulation and subsequently enhanced the number of panicles, grain yield and straw yield of rice during autumn season. During winter season, the lowest weed dry biomass recorded with the application of pyrazosulfuron + 2, 4-D rotated with pretilachlor (100% nutrient through fertilizers); whereas minimal value of weed density was observed from pyrazosulfuron 25g/ha + 2,4-D 0.5 kg/ha rotated with pretilachlor 0.750 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source) applied plots. During this season also the maximum number of panicles, grain yield and straw yield of rice was noticed with pyrazosulfuron 25g/ha + 2, 4-D 0.5 kg/ha rotated with pretilachlor 0.750 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source) treatment.

WP 1.3.1.2 (ii) Integrated weed management in ginger

Throughout the cropping period, *Panicum repens* was the most dominant perennial grassy

Table 1.3.1.2 (i) Long term effect of different nutrient and weed management practices on weed growth and crop yield in rice-rice cropping system

Treatment	Autumn rice					Winter rice				
	Total weed density (no./m^2) at 60 DAT	Total weed dry weight (g/m2) at 60 DAT	No. of panicles /m^2	Grain yield (t/ha)	Straw yield (t/ha)	Total weed density (no./m2) at 60 DAT	Total weed dry weight (g/m^2) at 60 DAT	No. of panicles /m^2	Grain yield (q/ha)	Straw yield (t/ha)
Farmers practice (pretilachlor 0.750 kg/ha as PE + NPK fertilizer)	136.3	31.5	39.5	2.50	233.3	136.3	8.91	186.2	4.68	8.5.6
Pyrazosulfuron 25 g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT (100% nutrient through fertilizers)	104.0	30.8	41.7	3.08	241.7	104.0	8.30	196.2	5.06	10.3
Pyrazosulfuron 25 g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT (75% nutrient through fertilizers + 25% nutrient through organic source)	98.6	29.6	38.7	4.00	266.7	98.7	9.57	187.0	4.30	9.75
Pyrazosulfuron 25g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT rotated with pretilachlor 0.750 kg/ha (75% nutrient throughfertilizers + 25% nutrient through organic source)	65.6	23.7	42.0	4.83	291.7	65.7	10.0	245.0	5.75	13.6
Pyrazosulfuron 25 g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT rotated with pretilachlor (100% nutrient through fertilizers)	82.3	26.8	34.4	3.33	258.3	82.3	7.78	213.2	5.18	10.3
LSD (P=0.05)	23.1	3.09	NS	0.08	NS	23.1	0.90	23.3	0.53	1.39

Note: PE-Pre-emergence; DAT-Days after transplanting; *fb*- Followed by weed in the experimental site. *Cynodon dactylon*, *Digitaria setigera* and *Eleusine indica* were the other common weeds showed dominance during summer period. The lowest weed density and weed dry weight at 60 days after planting (DAP) were achieved under glyphosate 0.80 kg/ha + oxyfluorfen 0.2 kg/ha applied plots just before emergence of sprouts of ginger, and the highest number of tillers was also recorded in the same treatment (**Table 1.3.1.2(ii))**. However, pendimethalin 1.5 kg/ha after planting but before mulching resulted in the best yield of ginger followed by oxyfluorfen 0.20 kg/ha after planting but before mulching. Glyphosate 0.80 kg/ha just before emergence of sprouts of ginger also registered good rhizome production of ginger.

Table 1.3.1.2 (ii) Effect of different weed management practices on weed growth and rhizome yield in ginger

Treatment	Total weed density (no./m^2) at 60 DAT	Total weed dry weight (g/m^2) at 60 DAT	No. of tillers/ m	Rhizome length (cm)	Rhizome girth (cm)	Rhizome yield (kg/ha)
Pendimethalin1.5 kg/ha after planting but before mulching	12.1 (150.7)	7.33 (54.7)	21.2	9.87	7.93	361.1
Oxyfluorfen 0.20 kg/ha after planting but before mulching	10.9 (120.0)	6.49 (42.7)	20.7	9.20	7.93	354.1
Pendimethalin1.5 kg/ha *fb* hand weeding at 30-35 DAP after planting but before mulching	11.2 (128.0)	5.48 (30.7)	20.4	8.93	7.73	194.4
Oxyfluorfen 0.20 kg/ha *fb* hand weeding after DAS after planting but before mulching	10.1 (104.0)	6.09 (37.3)	20.2	4.53	4.60	229.1
Glyphosate 0.80 kg/ha just before emergence of sprouts of ginger	8.44 (72.0)	6.34 (40.0)	22.0	8.33	8.13	305.6
Glyphosate0.80 kg/ha + pendimethalin1.5 kg/ha just before emergence of sprouts of ginger	9.39 (88.0)	5.41 (29.3)	21.6	6.73	5.80	159.7
Glyphosate 0.80 kg/ha + oxyfluorfen 0.2 kg/ha just before emergence of sprouts of ginger	8.40 (70.7)	5.32 (29.3)	24.3	8.07	7.07	222.2
Hand weeding at 30 and 60 DAP	11.9 (142.7)	6.36 (40.0)	16.9	7.33	6.40	161.1
Un-weeded control	14.1 (200.0)	8.56 (73.3)	14.8	2.53	2.80	111.1
LSD (P=0.05)	2.39	1.88	4.30	1.48	1.47	26.2

Note: DAP-Days after planting; (Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis).

KAU, Thrissur

WP 1.3.1.3 Weed management and soil enrichment by concurrent growing of daincha in rice-rice-vegetable cropping system

Under this experimentation, 45 DAS, significantly lower weed density of *Isachne miliacea* was observed in the hand weeded treatment and in rice-Daincha concurrent system in which Daincha was incorporated manually, *fb* hand weeding at 45 DAS **(Table 1.3.1.3)**. The lower total dry biomass accumulation of weeds and higher weed control efficiency (WCE) at 45 DAS was also found with the rice-*Daincha* concurrent system in which *Daincha* was incorporated manually, *fb* hand weeding. But just after 45 DAS, very heavy rains and unpredicted flood occurred and the field was completely submerged for about a week, resulting in a completely different trend of weed dry matter production at 65 DAS. Hand weeding again recorded lowest value of dry matter, but the other treatments which were best at 45 DAS showed a reverse trend. Comparing weed density at 45 and 65 DAS, it was observed that at 65 DAS, there was a significant reduction in density of all species except that of *Isachne miliacea* and *Ludwigia perennis*, which probably could overcome complete prolonged submergence and survived. Data on effect of treatments on grain yield showed that all treatments were on par except in the case of rice-daincha concurrent system with *Daincha* incorporated manually and unweeded control, which registered significantly lower yields. Effect of treatments on straw yield was non-significant.

Table 1.3.1.3 Effect of different weed management practices on weed growth, crop yield and economics in rice-rice-vegetable cropping system (*Kharif*, 2018)

Treatmments	Weed density (no./m²) at 45 DAS		Weed dry weight (kg/ha) at 45 DAS	Weed control efficiency (%) at 45 DAS	Grain yield (t/m²)	Straw yield (t/m²)	B : C ratio
	I. mileacea	*M. vaginalis*					
Rice-*Daincha, Daincha* brown manured by 2,4-D at 25 DAS	2.99 (9.33)	1.48 (5.33)	66.0 (47.7)	35.6	2.22	2.72	1.06
Rice- *Daincha, Daincha* brown manured by 2,4-D *fb* cyahalofop butyl at 25 DAS	5.30 (28)	0.22 (0)	56.9 (32.4)	44.5	2.05	2.20	0.89
Rice- *Daincha, Daincha* brown manured by 2,4-D *fb* hand weeding at 45 DAS	3.26 (10.6)	0.22 (0)	32.0 (10.7)	68.7	2.41	2.66	0.85
Rice- *Daincha, Daincha* incorporated manually at 25 DAS	6.29 (40)	2.91 (13.3)	79.5 (66)	22.5	1.42	1.81	0.62
Rice- *Daincha, Daincha* incorporated manually at 25 DAS *fb* bispyribac sodium	6.68 (45.3)	0.22 (0)	96.7 (100.1)	5.8	2.58	2.75	1.00
Rice- *Daincha, Daincha* incorporated manually at 25 DAS *fb* hand weeding at 45 DAS	2.77 (8.00)	1.10 (2.67)	24.2 (6.1)	76.4	2.50	2.72	0.80
Rice - hand weeded at 25 and 45 DAS	2.29 (5.33)	0.82 (1.33)	30.2 (9.7)	70.5	2.33	2.43	0.66
Unweeded control	6.63 (45.3)	2.36 (8.00)	102.7 (109.3)	-	1.92	2.87	1.02
CD (P=0.05)	1.42	NS	3.38		0.56	NS	

Note: Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis

WP 1.3.2 Weed management in maize-based cropping system

PDKV, Akola

WP 1.3.2.1 Efficacy of pre and post emergence herbicides in maize

The weed control treatments significantly reduced the weed density and weed biomass when compared with unweeded control **(Table 1.3.2.1)**. Among the different weed management treatment, early post-emergence (EPoE) application of tembotrione +atrazine (120+500 g/ha) *fb* IC + HW at 40 DAS and topramezone +atrazine (25.2+500 g/ha) *fb* IC + HW at 40 DAS proved better in controlling weed density and dry matter accumulation at 60 DAS in maize. Maximum grain and straw yield at harvest was found in conventional practice i.e. IC + HW at 20 and 40 DAS, which was at par with atrazine 1.0 kg/ha *fb* HW at 40 DAS and post-emergence herbicides *fb* IC+ HW at 40 DAS IWM treatment. The net return was found maximum under conventional practice followed by atrazine 1.0 Kg/ha (PE) *fb* HW at 40 DAS and tembotrione +atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40 DAS. Whereas, the maximum B:C ratio (3.12) was found with atrazine 1.0 Kg/ha PE *fb* HW at 40 DAS and tembotrione +atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40 DAS and which closely followed by topramezone +atrazine (25.2+500 g/ha) EPoE *fb* IC + HW at 40 DAS (3.11).

Table 1.3.2.1 Effect of different weed management treatments on weed growth, crop yield and economics in maize

Treatment	Total weed density (No/m²) at 60 DAS	Total weed dry weight (g/m²) at 60 DAS	Grain yield (t/ha)	Straw yield (t/ha)	NMR (₹ /ha)	B:C Ratio
Atrazine 1.0 Kg/ha PE *fb* HW at 40 DAS	3.47 (11.6)	3.59 (12.3)	4.63	7.00	49,970	3.12
Atrazine + pendimethalin (0.50+0.25 Kg/ha) PE	6.24 (38.4)	5.06 (25.2)	2.98	6.15	28,635	2.37
Atrazine 1.0 Kg/ha PE *fb* 2,4-D 1.0 kg /ha LPoE	4.71 (21.7)	4.64 (21.1)	3.53	6.41	35,970	2.69
Atrazine + pendimethalin (0.50+0.25 Kg/ha) PE *fb* 2,4-D 1.0 kg /ha LPoE	5.19 (26.4)	4.93 (23.9)	3.48	6.37	35,218	2.65
Topramezone 25.2 g/ha EPoE	5.42 (29.0)	5.18 (26.3)	3.38	6.26	33,454	2.57
Tembotrione 120g /ha EPoE	5.75 (32.5)	5.57 (30.5)	3.40	6.28	33,616	2.58
Topramezone 25.2 g/ha EPoE *fb* IC +HW at 40 DAS	3.22 (9.89)	2.49 (5.71)	4.21	6.50	43,024	2.83
Tembotrione 120g /ha EPoE *fb* IC +HW at 40 DAS	2.97 (8.35)	2.49 (5.69)	4.07	6.70	41,243	2.74
Topramezone +atrazine (25.2+500g/ha) EPoE *fb* IC + HW at 40 DAS	2.61 (6.34)	2.29 (4.75)	4.38	6.86	44,976	3.11
Tembotrione +atrazine (120+500g/ha) EPoE *fb* IC + HW at 40 DAS	2.76 (7.11)	2.35 (5.01)	4.58	6.98	47,655	3.12
IC+HW at 20 and 40 DAS	2.34 (5.03)	2.10 (3.94)	4.87	7.30	50,852	2.75
Weedy check	13.28 (176.0)	12.5 (157.1)	1.99	5.64	15,863	1.81
SE m ±	0.21	0.18	0.25	0.23	3,160	--
LSD (P= 0.05)	0.58	0.54	0.72	0.69	8,468	--

Note: PE: Pre-emergence; PoE: Post-emergence; EPoE: Early post-emergence; LPoE: Late post-emergence; IC: Intercultural operation; HW: Hand weeding; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

MPUAT, Udaipur

Evaluation of new post-emergent herbicides for weed control in maize

The most dominating weed species in experimental plot were *Echinochloa colona* and *Setaria viridi.* Weed density of monocot weeds were higher than dicot weeds. At 60 DAS, the lowest weed density and dry weight was recorded with pre-emergence application of atrazine 750 g/ha *fb* tembotrione 120 g/ha at 20 DAS over other treatments **(Table 1.3.2.2)**. The maximum grain yield (5.24 t/ha) was recorded with pre-emergence application of atrazine 500 g/ha ha *fb* tembotrione 120 g/ha at 20 DAS which was statistically at par with two manual weeding at 15 & 35 DAS (5.21 t/ha). Atrazine 750 g/ha *fb* topramezone 25.2 g/ha at 20 DAS, atrazine 500 g/ha *fb* tembotrione 120 g/ha at 15-20 DAS, atrazine 500 g/ha *fb* topramezone 25.2 g/ha at 15-20 DAS and atrazine 500 g/ha *fb* + 2,4-D 800 g/ha statistically at par with each other in terms of grain yield. The maximum straw yield was recorded in pre-emergence application of atrazine 500 g/ha ha *fb* tembotrione 120 g/ha at 20 DAS over other treatments. The highest net returns (₹ 70,515/ha) and B:C ratio (2.51) were realized with pre-emergence application of atrazine 500 g/ha ha *fb* tembotrione 120 g/ha at 20 DAS.

Table 1.3.2.2 Effect of different weed management treatments on weed growth, crop yield and economics in maize

Treatment	*E. colona* density at 60 DAS	*S. viridis* density at 60 DAS	Total weed dry weight (No/m^2) at 60 DAS	Grain yield (t/ha)	Straw yield (t/ha)	Net return (₹/ha)	B:C ratio
Atrazine 750 g/ha as PE	3.10 (9.10)	1.43 (9.10)	18.6	3.82	5.02	48,651	1.99
2,4-D sodium salt 1000 g/ha at 15-20 DAS	6.91 (47.2)	1.42 (47.2)	49.0	3.23	4.96	38,362	1.55
Tembotrione 120 g/ha at 15-20 DAS	3.10 (9.12)	2.33 (9.12)	15.0	3.19	5.27	36,111	1.33
Topramezone 25.2 g/ha at 15-20 DAS	3.12 (9.25)	1.28 (9.25)	14.4	3.29	4.95	37,028	1.36
Atrazine 750 g/ha PE *fb* 2,4-D sodium-salt 1000 g/ha at 15-20 DAS	3.04 (8.72)	0.78 (8.72)	12.5	3.82	5.07	47,511	1.85
Atrazine 750 g/ha PE *fb* tembotrione 120 g/ha at 15-20 DAS	1.47 (1.67)	0.74 (1.67)	2.85	5.24	6.05	70,515	2.51
Atrazine 750 g/ha PE *fb* topramezone 25.2 g/ha at 15-20 DAS	1.58 (2.00)	0.74 (2.00)	3.35	4.96	5.70	65,195	2.32
Atrazine 500 g/ha PE *fb* 2,4-D sodium salt 800 g/ha at 15-20 DAS	5.21 (26.7)	1.06 (26.7)	31.51	4.60	5.05	60,290	2.35
Atrazine 500 g/ha PE *fb* + tembotrione 120 g/ha at 15-20 DAS	1.78 (2.67)	1.17 (2.67)	5.16	4.83	5.54	62,704	2.24
Atrazine 500 g/ha PE *fb* + topramezone 25.2 g/ha at 15-20 DAS	1.96 (3.33)	1.05 (3.33)	6.56	4.64	5.38	59,206	2.11
Manual weeding at 15 and 35 DAS	2.41 (5.33)	0.77 (5.33)	9.29	5.21	5.21	52,023	1.17
Weedy check	7.33 (53.3)	3.66 (53.3)	82.1	2.37	4.01	23,970	1.04
SE m ±	0.12	0.02	0.69	0.24	0.26	-	-
LSD (P= 0.05)	0.35	0.05	2.03	0.70	0.75	-	-

Note: PE: Pre-emergence; DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

OUAT, Bhubaneswar

Weed management with new generation herbicides in maize (sweet corn)

In sweet corn, at 45 DAS, treatments like pre emergence application of pendimethalin (1.0 kg/ha) *fb* tembotrione (115 g/ha) and pre emergence application of pendimethalin (1.0 kg/ha) *fb* topramezone (25 g/ha) reported lowest weed population which differ significantly from remaining treatments in decreasing total weed population **(Table 1.3.2.3)**. Whereas, at the same stage of maize crop, pre-emergence application of pendimethalin (1.0 kg/ha) *fb* tembotrione (115 g/ha) at 40 DAS, pre-emergence application of pendimethalin (1.0 kg/ha) *fb* topramezone (25 g/ha) at 40 DAS gave minimum weed dry weight. Both the treatments are significantly superior over the remaining treatments. Fresh kernel yield of sweet corn was significantly influenced due to different weed control treatments. All the weed control treatments recorded significantly higher cob yield than weedy check. Pre-emergence application of pendimethalin (1.0 kg/ha) *fb* topramezone (25 g/ha) at 40 DAS recorded higher fresh kernel yield (16.4 t/ha) over rest of the treatments. However, pre-emergence application of pendimethalin (1.0 kg /ha) *fb* tembotrione (115 g/ha) at 40 DAS (15.8 t/ha), pre-emergence application of pendimethalin (.0 kg/ha) *fb* 1.0 HW at 40 DAS (14.8 t/ha), pre-emergence application of atrazine (1.0 kg/ha) *fb* 1.0 HW at 40 DAS (14.3 t/ha) recorded higher yield which were at par with pendimethalin (1.0 kg/ha) *fb* topramezone (25 g/ha) at 40 DAS.

Table 1.3.2.3 Effect of different weed management treatments on weed growth, crop yield and economics in maize (sweet corn)

Treatment	Total weed density (no./m^2) at 45 DAS	Total weed dry weight (no./m^2) at 45 DAS	Fresh kernel yield (t/ha)	Fresh cob yield (t/ha)	Green fodder yield (t/ha)
Atrazine 1.0 kg/ha PE *fb* HW at 40 DAS	8.67(74.6)	5.13(25.8)	9.4	20.5	38.6
Atrazine + pendimethalin (0.50 + 0.25 kg/ha) PE (tank mix)	8.17(66.2)	4.83(22.8)	10.2	22.7	39.2
Atrazine 1.0 kg/ha PE *fb* 2,4-D 1.0 kg/ha LPoE	4.97(24.2)	3.93(14.7)	11.0	24.4	40.4
Atrazine + pendimethaline (0.50 + 0.25 kg/ha) PE *fb* 2,4-D 1.0 kg/ha LPoE	5.53(30.0)	3.90(14.7)	11.0	24.5	40.7
Topramezone 25 g/ha EPoE	2.01(3.5)	1.42(1.54)	14.2	31.7	45.3
Tembotrione 100 g/ha EPoE	1.97(3.4)	1.26(1.33)	14.8	32.9	45.8
Topramezone 25 g/ha EPoE *fb* IC	1.48(1.7)	0.91(0.33)	15.8	35.2	47.3
Tembotrione 100 g/ha EPoE *fb* IC	1.63(1.4)	0.84(0.22)	16.4	36.2	47.9
Topramezone + atrazine (25 + 250 g/ha) EPoE *fb* IC	2.08(3.8)	1.43(1.54)	12.0	28.4	42.5
Tembotrione + atrazine (100+ 250 g/ha) EPoE *fb* IC + HW at 30 DAS	15.2(230.5)	10.9(119.8)	5.45	12.1	23.4
IC + HW at 20 and 40 DAS	2.01(3.57)	0.84(0.22)			
Weedy check	32.4 (102.4)	14.3(15.4)			
SEm±	0.22	0.08	1.75	1.89	1.70
LSD(P=0.05)	0.53	0.19	4.30	4.63	4.17

Note: PE: Pre-emergence; PoE: Post-emergence; EPoE: Early post-emergence; LPoE: Late post-emergence; IC: Intercultural operation; HW: Hand weeding; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis

WP1.3.3 Weed management in other cropping system

CCSHAU, Hisar

WP 1.3.3.1 (i) Herbicidal weed management in green gram

Experimental field was infested with *Trianthema portulacastrum* and *Cyperus rotundus*. All pre-emergence herbicide treatments proved effective control against predominant weed *T. portulacastrum* but not against *C. rotundus* **(Table 1.3.3.1(i))**. Post-emergence application of aciflourfen + clodinafop at all the rates proved very effective control against *T. portulacastrum* but its efficacy against *C. rotundus* was poor. Pyroxasulfone alone at 127.5 and 150 g/ha and its combination with pendimethalin proved effective control against all weeds. Maximum plant dry matter accumulation and number of pods /plant were recorded under weed free treatment which was at par with aciflourfen + clodinafop at all rates and imazethapyr + pendimethalin at 1000 g/ha. Presence of weeds throughout the season caused 76 % reduction in seed yield of greengram. Seed yield was maximum (1.29 t/ha) with use of aciflourfen + clodinafop at 370 g/ha which was significantly at par with its lower dose, pyroxasulfone 150 g/ha, pyroxasulfone + pendimethalin, imazethapyr + pendimethalin at 1000 g/ha and weed free but significantly higher than all other treatments.

Residual effect of different herbicides applied in greengram on succeeding mustard crop

Residual effect of different herbicides applied in greengram on succeeding mustard crop was very much apparent in some treatments. Crop toxicity in treatments involving imazethapyr ranged from 52.8-82.8 at 15 DAS and 43.9-72.8% at 30 DAS **(Table 1.3.3.1(ii))**. Toxicity was more in imazethapyr than its combination with imazamox. Similarly plant dry weight was significantly less in treatments involving imazethapyr as compared to other herbicides. New ready-mix herbicide aciflourfen + clodinafop and pyroxasulfone did not show any

Table 1.3.3.1 (i) Effect of different weed management practices on weed density, dry weight, crop growth and seed yield in greengram

Treatment	Dose (g/ha)	Time of application	Weed density (no./m²) at 40 DAS		Total weed dry weight at 40 DAS	Plant dry weight at 40 DAS	No. of pods/ plant	Seed yield (t/ha)
			T. portulacastrum	*C.rotundus*				
Aciflourfen + clodinafop (RM)	245	3-4 leaf stage	4.27(2.0)	3.13(2.7)	4.9	33.2	35	1.19
Aciflourfen + clodinafop (RM)	305	3-4 leaf stage	3.68(2.3)	2.54(2.9)	4.2	34.1	37	1.24
Aciflourfen + clodinafop (RM)	370	3-4 leaf stage	2.92(2.5)	1.71(1.6)	4	34.0	38	1.29
Pyroxasulfone	127.5	PE	1.54(5.4)	1.79(2.3)	6.4	30.8	32	1.12
Pyroxasulfone	150	PE	1.41(4.1)	1.98(1.4)	6.8	30.3	36	1.29
Pyroxasulfone + pendimethalin (TM)	106 + 1000	PE	1.13(1.3)	1.91(0)	6.2	24.7	35	1.18
Quizalofop	60	3-4 leaf stage	1.80(1.9)	1.80(1.9)	49.5	21.6	21	0.73
Imazethapyr	70	3-4 leaf stage	1.60(1.9)	1.68(2.8)	29	26.3	32	1.00
Imazethapyr +quizalofop(TM)	70 + 60	3-4 leaf stage	2.89(3.9)	1.47(2.9)	32.8	28.2	32	1.02
Imazethapyr +imazamox (RM)	70	PE	1.88(2.5)	4.87(3.6)	30.7	27.8	32	1.06
Pendimethalin *fb* quizalofop	1000	PE	1.79(2.3)	1.60(1.9)	38.4	26.2	29	0.83
Imazethapyr + pendimethalin (TM)	1000	PoE	1.48(4.8)	2.13(2.1)	10.2	34.4	36	1.25
Two hand weeding	-	20 & 40 DAS	1.0(0)	1.0(0)	6.52	27.1	38	1.24
Weedy check	-	-	3.58(16)	2.89(3.9)	53.2	23.8	19	0.31
Weed free	-	-	1.0(0)	1.0(0)	0	35.4	39	1.26
SEm±			0.50	0.23	0.78	1.06	1.2	0.03
LSD (P=0.05)			1.47	0.67	2.26	3.07	3.4	0.11

Note: RM: Ready mix; TM: Tank mix; DAS: Days after sowing; PE: Pre-emergence; PoE: Post-emergence; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis.

residual toxicity in mustard. Significantly less number of leaves /plant and seed yield was observed with treatments of imazethapyr alone and imazethapyr and imazamox as compared to untreated check and other herbicides. It can be concluded that imazethapyr and its combination with imazamox should not be used for weed control in greengram if mustard is to be planted as succeeding crop. In such situation ready-mix of aciflourfen + clodinafop and pyroxasulfone at 127.5-150 g/ha can be used safely without any toxic effect.

WP 1.3.3.1 (ii) Integrated management of complex weed flora in vegetable peas and residual effect on succeeding crops

CCSHAU, Hisar

In the experimental field, most dominating weeds were *Fumaria parviflora* and *Coronopus didymus* having relative density of 71 % and 13 %, respectively at 30 DAS. All the weed control treatments except

Table 1.3.3.1(ii) Effect of different treatments on dry matter of plant, phyto-toxicity, plant height and yield attributes on succeeding mustard crop

Treatments	Dose (g/ha)	Time of application	Crop dry weight (g/plant) at 30 DAS	Phyto-toxicity on crop (%) at 30 DAS	Plant height (cm) at 30 DAS	No. of plants/ m at 20 DAS	No. of leaves /plant at 30 DAS	Seed yield (t/ha)
Aciflourfen + clodinafop (RM)	245	-4 leaf stage	0.81	0	19.2	9.2	7	1.92
Aciflourfen + clodinafop (RM)	305	-4 leaf stage	0.83	0	19.9	9.3	6.20	1.95
Aciflourfen + clodinafop (RM)	370	-4 leaf stage	0.82	0	18.5	9.63	6.43	1.94
Pyroxasulfone	127.5	PE	0.66	0	19.4	8.63	5.76	1.78
Pyroxasulfone	150	PE	1.07	0	16.6	11.1	5.76	1.79
Pyroxasulfone + pendimethalin (TM)	106 + 1000	PE	1.42	0	20.9	10.1	6.86	1.80
Quizalofop	60	-4 leaf stage	0.60	0	18.0	9.83	6.63	1.79
Imazethapyr	70	-4 leaf stage	0.15	72.8	3.33	9.06	3.83	1.47
Imazethapyr +quizalofop(TM)	70 + 60	-4 leaf stage	0.25	64.7	4.16	8.5	4.01	1.49
Imazethapyr +imazamox (RM)	70	PE	0.26	43.9	5.63	9.1	4.36	1.67
Pendimethalin *fb* quizalofop	1000	PE	0.98	0	18.8	8.86	5.76	1.78
Imazethapyr + pendimethalin (TM)	1000	PoE	0.98	0	17.5	8.96	6.53	1.94
Two hand weeding	-	20 & 40 DAS	1.03	0	16.6	9	6.03	1.91
Weedy check	-	-	0.93	0	18.0	9.96	6.20	1.89
Weed free	-	-	1.23	0	17.7	8.73	6.10	1.88
SEm±			0.10		0.58	0.32	0.20	0.06
CD(P=0.05)			0.31		1.69	0.94	0.59	0.18

Note: RM: Ready mix; TM: Tank mix; DAS: Days after sowing; PE: Pre-emergence; PoE: Post-emergence; Original figures in parentheses were subjected to square-root transformation $\sqrt{(X+0.5)}$ before statistical analysis.

clodinafop and pinoxaden significantly reduced the density and dry matter of weeds in field pea and gave higher yield in comparison to the weedy check **(Table 1.3.3.1(iii))**. Pre-emergence application of pendimethalin + imazethapyr (Ready-mix) at 1250 g/ha provided excellent control of *C. didymus, A. arvensis* and *C. album* causing weed free conditions throughout the season, thus gave the highest yield (1.79 t/ha) among the herbicidal treatments. The maximum weed control efficiency of 91.7 % at 30 DAS and 83.3 % at 90 DAS was recorded with pre-emergence application of pendimethalin + imazethapyr at 1250 g/ha which was closely followed by pre-emergence application of pendimethalin + imazethapyr (RM) at 800 and 1000 g/ha, respectively. Post-emergence (2-4 leaf stage) application of imazethapyr alone and its ready mix combination with imazamox at 60-80 g/ha provided 86-94 % control of weeds at 60 DAS but phyto-toxicity in the range of 5-10 % was also visually observed in field pea at 30 DAS which was mitigated within two weeks after application. Phyto-toxicity suppressed the crop growth though up to some extent and caused yield penalty. The maximum plant dry matter, yield and yield attributes were recorded in weed free treatment which was statistically at par with pre-emergence application of pendimethalin + imazethapyr (RM) at 1250 g/ha. Highest B: C (2.36) was obtained with pre-emergence application of pendimethalin + imazethapyr (RM) at 1250 g/ha, followed by pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 and 800 g/ha, respectively. As per the findings of this experiment, it can be inferred that pre-emergence application of pendimethalin + imazethapyr (RM) at 1250 g/ha provides an effective and economical control of weeds in field pea without any phyto-toxicity on the crop.

Table 1.3.3.1(iii) Effect of different weed control practices on weed growth, crop yield and economics in vegetable peas

Treatment	Dose (g/ha)	Time of application	Density (no./m^2) at 60 DAS		Weed control efficiency at 90 DAS	Weed index (%)	Visual phyto-toxicity (%) 30 DAS	Seed yield (t/ha)	B:C
			Fumaria parviflora	*Coronopus didymus*					
Clodinafop	60	35 DAS	8.67 (74.3)	4.82 (22.7)	1.6	45.0	0.00 (0)	0.99	1.42
Pinoxaden	50	35 DAS	8.69 (74.7)	4.97 (24.0)	2.4	46.7	0.00 (0)	0.94	1.35
Pendimethalin	1000	PE	8.01 (63.3)	4.28 (17.7)	35.9	26.5	0.00 (0)	1.33	1.87
Pendimethalin + imazethapyr (RM)	800	PE	6.90 (46.7)	1.24 (0.7)	70.0	8.7	0.00 (0)	1.65	2.26
Pendimethalin + imazethapyr (RM)	1000	PE	6.79 (45.3)	1.24 (0.7)	75.8	6.6	0.00 (0)	1.68	2.27
Pendimethalin + imazethapyr (RM)	1250	PE	6.77 (45.0)	1.00 (0)	83.3	5.5	0.00 (0)	1.79	2.36
Imazethapyr	70	PE	7.47 (55.0)	1.41 (1.3)	44.8	23.3	0.00 (0)	1.38	1.95
Imazethapyr	60	2-4 leaf stage	7.72 (59.0)	2.44 (5.0)	72.7	14.7	12.8 (5)	1.50	2.20
Imazethapyr	70	2-4 leaf stage	7.48 (55.0)	2.30 (4.3)	75.9	11.3	12.8 (5)	1.50	2.13
Imazethapyr	80	2-4 leaf stage	6.89 (46.7)	2.23 (4.0)	80.1	10.0	12.8 (5)	1.53	2.15
Imazethapyr + imazamox (RM)	60	2-4 leaf stage	7.69 (58.3)	2.41 (5.0)	67.1	14.8	12.8 (5)	1.54	2.10
Imazethapyr + imazamox (RM)	70	2-4 leaf stage	7.65 (57.7)	1.99 (3.0)	73.8	11.0	18.4 (10)	1.61	2.17
Imazethapyr + imazamox (RM)	80	2-4 leaf stage	7.91 (61.7)	1.90 (2.7)	80.3	10.4	18.3 (10)	1.62	2.16
Weedy check	-		8.69 (74.7)	5.74 (32.7)	0.0	50.2	0.00 (0)	0.90	1.33
Weed free	-		1.00 (0)	1.00 (0)	100.0	0.0	0.00 (0)	1.81	1.38
SE (m) ±			0.28	0.30			0.51	0.005	
LSD (P=0.05)			0.82	0.87			1.50	0.15	

Note: RM: Ready mix; PE: Pre-emergence; DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis.

Residual effect on succeeding crops:

Clodinafop 60 g/ha, pinoxaden 50 g/ha, pendimethalin alone at 1000 g/ha alone or its pre mix combination with imazethapyr 800-1000 g/ha (PE) did not cause any residual toxicity on any of the succeeding crop planted after harvest of peas **(Table 1.3.3.1(iv))**. Imazethapyr and its pre mix combination with imazamox caused severe toxicity on muskmelon, ridge gourd and bottle gourd as is evident from number of leaves/plant, fresh weight/plant and plant height in all these treatments was significantly less than untreated check. .Toxicity was more in imazethapyr as compared to it mixture with imazamox. **(Table 1.3.3.1 (iv))**. So it can be concluded that ridge gourd, muskmelon and bottle guard should not be planted after using imidazolinone herbicides in vegetable peas.

Table 1.3.3.1(iv) Residual effect of different herbicides on number of leaves/plant, fresh weight/plant and plant height of different crops grown after harvest of pea

Treatments	Weight		No. of leaves/plant			Plant height (cm)			Fresh weight(g)/plant		
	Dose (g/ha)	Time of application	Muskmelon	Ridge gourd	Bottle gourd	Musk melon	Ridge gourd	Bottle gourd	Muskmelon	Ridge gourd	Bottle gourd
Clodinafop	60	35 DAS	19.7	25.2	17.2	105	230	121	169	168	212
Pinoxaden	50	35 DAS	17.9	23.5	17.8	107	255	126	170	172	215
Pendimethalin	1000	PE	18.0	22.5	17.0	110	221	123	217	175	211
Pendimethalin + imazethapyr RM)	800	PE	18.5	22.5	18.0	107	217	132	173	177	226
Pendimethalin + imazethapyr RM)	1000	PE	20.4	22.3	17.4	107	219	120	173	180	223
Pendimethalin + imazethapyr RM)	1250	PE	18.6	26.4	14.8	102	226	117	173	180	221
Imazethapyr	70	PE	14.8	17.1	14.6	92	198	96	120	180	150
Imazethapyr	60	2-4 leaf stage	14.8	19.3	15.8	93	205	103	80	133	165
Imazethapyr	70	2-4 leaf stage	15.6	16.2	14.0	92	189	94	103	143	110
Imazethapyr	80	2-4 leaf stage	15.3	16.6	14.3	97	180	103	83	137	118
Imazethapyr + imazamox (RM)	60	2-4 leaf stage	15.6	17.8	14.9	97	204	108	100	147	170
Imazethapyr + imazamox (RM)	70	2-4 leaf stage	16.6	17.2	14.6	93	201	108	100	147	110
Imazethapyr + imazamox (RM)	80	2-4 leaf stage	16.7	20.0	14.8	96	203	110	93	133	150
Weed free	-	-	19.2	26.5	17.2	104	236	126	177	173	219
Weedy check	-	-	20.2	24.4	17.7	107	247	123	173	167	213
LSD(P=0.05)			2.32	4.58	2.66	11	27	17	48	18	22

Note: RM: Ready mix; PE: Pre-emergence; DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

WP 1.3.3.2 Integrated weed management in turmeric

PDKV, Akola

In the experimental field, both broad and narrow leaved weeds were observed but dominance of broad leaved weeds was observed in entire field. The weed control treatments significantly reduced the weed population and weed biomass when compared with unweeded control **(Table 1.3.2.2)**. At 60 DAS, hand weeding (25, 45 & 75 DAP) recorded significantly lower weed count and dry matter accumulation followed by glyphosate *fb* 2 HW (45 & 75 DAP), pendimethalin 1.0 kg/ha (0-5 DAP) *fb* straw mulch 10 t/ha (10 DAP) *fb* one HW (75 DAP) and metribuzin 0.7 kg/ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP). At 60 DAS highest weed control efficiency (WCE) was recorded under metribuzin 0.7 kg / ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP) followed by post-emergence application of glyphosate *fb* 2 HW (45 & 75 DAP) followed by pendimethalin 1.0 kg/ha (0-5 DAP) *fb* straw mulch 10 t/ha (10 DAP) *fb* one HW (75 DAP). Number of leaves recorded more or less similar in most of the treatment while maximum number found with those treatments performed better in managing weeds. Maximum rhizome yield was observed in weed free treatment (23.8 t/ha) while among the IWM treatments application of pendimethalin 1.0 kg/ha (0-5 DAP) *fb* straw mulch 10 t/ha (10 DAP) *fb* one HW (75 DAP) recorded higher rhizome yield (22.7 t/ha) which was closely followed by metribuzin 0.7 kg/ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP). The higher net return and B:C ratio was also observed with these treatments.

Table 1.3.3.2 Effect of different weed management practices on weed growth, crop yield and economics in turmeric

Treatments	Weed density (no./m^2) at 60 DAS	Weed dry weight (g/m^2) at 60 DAS	Weed control efficiency at 60 DAS	weight of rhizomes at harvest (t)	Net return (₹/ha)	B:C Ratio
Metribuzin 0.7 kg/ha (0-5 DAP) *fb* 2 hand weeding (45 & 75 DAP)	4.80 (22.7)	5.49 (29.7)	63.3	20.4	2,53,575	3.80
Metribuzin 0.7 kg / ha (0-5 DAP) *fb* fenoxaprop + metsulfuron (67+ 4 g / ha) 45 DAP.	4.65 (21.1)	5.70 (32.0)	60.5	17.9	2,06,078	3.35
Metribuzin 0.7 kg / ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP)	4.80 (22.6)	3.90 (14.8)	81.6	22.4	2,87,309	4.19
Pendimethalin 1 kg / ha (0-5 DAP) *fb* 2 HW (45 &75 DAP)	3.70 (13.1)	6.39 (40.3)	50.2	17.3	2,04,032	3.34
Pendimethalin 1 kg / ha (0-5 DAP) *fb* fenoxaprop + metsulfuron (67+ 4 g / ha) 45 DAP	5.98 (35.4)	6.27 (38.8)	52.1	17.1	2,04,439	3.46
Pendimethalin 1 kg/ha (0-5 DAP) *fb* straw mulch 10 t / ha (10 DAP) *fb* one HW (75 DAP).	3.66 (12.9)	4.58 (20.5)	74.7	22.7	2,93,468	4.33
Atrazine 0.75 kg/ha (0-5 DAP) *fb* two HW (45 & 75 DAP).	5.47 (29.5)	6.12 (36.9)	54.4	18.2	2,21,650	3.59
Atrazine 0.75 kg/ha (0-5 DAP) *fb* fenoxaprop+ metsulfuron (67+ 4 g / ha) 45 DAP.	6.10 (36.9)	6.05 (36.1)	55.5	18.3	2,25,600	3.72
Atrazine 0.75 kg/ha (0-5 DAP) *fb* straw mulch 10 t/ha (10DAP) *fb* one HW (75DAP).	3.73 (13.5)	5.21 (26.7)	67.1	22.2	2,86,462	4.25
Oxyfluorfen *fb* two HW (45 & 75 DAP).	4.72 (21.8)	5.55 (30.2)	62.7	17.9	2,16,284	3.56
Oxadiargyl 0.25 kg/ha (0-5 DAP) *fb* two HW (45 & 75 DAP).	5.67 (31.6)	5.53 (30.1)	62.9	17.0	2,01,910	3.37
Glyphosate 2 kg/ha (directed spray) fb 2HW (45 & 75 DAP)	3.73 (13.6)	4.79 (22.5)	72.2	17.6	2 12 340	3.51
Hand weeding (25, 45 & 75 DAP).	1.94 (3.27)	1.98 (3.44)	95.7	23.8	2,87,785	3.54
Unweeded check.	9.65 (92.6)	9.02 (81.1)	0.00	9.18	75,623	1.96
SE m ±	0.18	0.17		1.05	17,638	--
LSD (P= 0.05)	0.55	0.50		3.05	51,274	--

Note: DAP: Days after planting; *fb*: followed by; HW: Hand weeding; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x + 0.5)}$ before statistical analysis.

WP 1.3.4.1 (i) Rice residue management to standardize the succeeding wheat crop

GBPUAT, Pantnagar

Present study envisaged the management of rice residue in a combine harvested field and its impact on wheat performance. Rice was harvested very close to the surface at 30 and 50 cm by combine and in all cases, loose straw left by combine was removed from the field (simulating as conditions created by Baler). In conventional tillage, double harrow + planking + rotavator + double harrow + planking and in reduced tillage harrow + planking + rotavator + harrow + planking were done to prepare land. In zero tillage, sowing was done at about 70% of field capacity moisture. The day on which sowing was done in zero tillage; the field preparation was started in other tillage systems. In the first year, grain yield was not influenced significantly by tillage systems and was comparable in all the tillage systems **(Table 1.3.4.1(i))**. Numerically, reduced tillage managed to record maximum grain yield. Whereas, straw yield and harvest index both were influenced significantly by tillage systems. Reduced tillage recorded maximum straw yield and harvest index, which was comparable in all the tillage systems. Residue load did not influence grain and straw yield and harvest index. Reduced tillage attained maximum yield due to better rhizospheric environment.

Table 1.3.4.1(i) Effect of tillage and residue management strategies on grain, straw yield and harvest index of wheat

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Tillage system			
CT	4.6	7.5	38.2
RT	4.8	7.8	38.3
ZT	4.7	7.4	39.0
SEm±	54.4	87.7	0.05
LSD (P=0.05%)	NS	343	0.20
Residue load			
No residue	4.7	7.6	38.5
30 cm	4.8	7.5	39.0
50 cm	4.7	7.7	37.9
SEm±	218.4	288.4	0.49
LSD (P=0.05%)	NS	NS	NS

Note: CT: Conventional tillage; RT: Reduced tillage; ZT: Zero-tillage

WP 1.3.4.1(ii) Weed management of complex weed flora in wheat under stale seed bed system

GBPUAT, Pantnagar

Among the different herbicidal treatments, density of *Phalaris minor*, *Medicago denticulata* and *Melilotus alba* was recorded minimum with application of clodinafop + metsulfuron-methyl (0.06+0.004 kg/ha) after 1st irrigation and was found superior to rest of the treatments **(Table 1.3.4.1(ii))**. Density of *Chenopodium album* and *Polygonum Plebeium* was completely controlled with stale seed bed system followed by glyphosate (1.0 kg/ha) and paraquat (0.5 kg/ha) application. Whereas, *Lathayrus aphaca* was completely control with clodinafop + metsulfuron-methyl (0.06+0.004 kg/ha) both before seeding as well as after 1st irrigation. Among different herbicidal treatments, total minimum dry matter accumulation was recorded with application of paraquat dichloride (at 5% germination) at 0.5 kg /ha with highest weed control efficiency (84.8%) and significantly proved to be superior among all the treatments. Among different weed control treatments, maximum yield and yield attributes were obtained with herbicidal treatments over the twice hand weeding and weedy check. The highest number of spikes/m^2, grain yield (3.4 t/ha) and straw yield (6.4 t/ha) was obtained with paraquat dichloride (at 5% germination) at 0.5 kg/ha, with highest increased 126.6% in yield over weedy check. However, grains/spike was achieved maximum with twice hand weeding which was at par to paraquat dichloride (at 5% germination) at 0.5 kg/ha, while, 1000 grain weight (43.8 g) was found highest with clodinafop + metsulfuron methyl (0.06+0.004 kg/ha) at before seeding among different herbicidal treatments.

Table 1.3.4.1(ii) Effect of different weed management practices on weed density, dry weight , grain yield and straw yield in wheat

Treatments	Dose (kg ai/ha)	Time of application (DAS)	Weed density (no./m²) at 60 DAS		Total weed dry weight (g/m²)	Weed control efficiency (%)	Grain yield (t/ha)	Straw yield (t/ha)	% increase in yield over weedy check
			P. minor	*M. alba*					
Glyphosate	1.0	Before seeding	5.1 (25.3)	2.6 (6.0)	5.4 (27.9)	77.9	3.2	5.6	113.3
Paraquat dicloride	0.5	Before seeding	6.6 (42.7)	2.5 (5.3)	4.6 (20.7)	83.6	3.0	4.9	10.0
Glyphosate	1.0	At 5% germination	5.1 (25.3)	3.2 (9.3)	6.3 (39.1)	69.2	3.1	5.3	106.6
Paraquat dichloride	0.5	At 5% germination	5.2 (26.7)	3.2 (9.3)	4.5 (19.3)	84.8	3.4	6.4	126.6
Clodinafop+metsulfuron -methyl	0.06+0.004	Before seeding	8.0 (64.0)	2.5 (5.3)	5.4 (28.1)	77.8	2.3	4.6	53.3
Clodinafop+metsulfuron -methyl	0.06+0.004	After 1st irrigation	4.1 (16.0)	2.2 (4.0)	4.8 (22.5)	82.2	2.9	5.3	93.3
Hand weeding	twice	Before seeding and 30 DAS	4.9 (22.7)	4.4 (18.7)	4.9 (23.9)	81.2	2.7	4.3	80.0
Weedy	-	-	10.0 (100.0)	6.2 (37.3)	11.1 (126.8)	-	1.5	3.0	-
SEm±	-	-	0.29	0.21	0.49	-	0.12	0.23	-
LSD(P=0.05)	-	-	0.90	0.63	1.5	-	0.38	0.71	-

Note: DAS- Days after sowing

WP 1.3.5.1 (i) Management of complex weed flora in summer greengram

PAU, Ludhiana

Major weed flora in the field included *Trianthema portulacastrum, Dactyloctenium aegyptium, Digitaria sanguinalis* and *Cleome viscosa*. Application of sodium-acifluorfen + clodinafop-propargyl at 245 and 306 g/ha gave effective control of all weeds species which was significantly better than use of sodium acifluorfen, clodinafop-propargyl or pendimethalin alone **(Table 1.3.5.1(i))**. All weed control treatments gave significantly higher seed yield of greengram than unsprayed weedy check. Sodium-acifluorfen + clodinafop-propargyl at 245 and 306 g/ha gave the highest seed yield of greengram which was at par to weed free treatment.

WP 1.3.5.1(ii) Management of complex weed flora in rapeseed & mustard crops

PAU, Ludhiana

Cyperus rotundus was the major weed in the experimental field. Other weeds included *Eleusine indica, Digitaria sanguinalis, Eragrostis tenella, Anagallis arvensis, Trianthema portulacastrum, Phylanthus niruri*. Pre-emergence application of napropamide at 1125 and 1406 g/ha significantly reduced the density of all the weeds as compared to unsprayed check **(Table 1.3.5.1(ii))**. Napropamide at all doses significantly reduced biomass of grasses, broadleaves and sedges than weedy check; there was significant decrease in weed biomass with every increment of napropamide rate. The height and

Table 1.3.5.1(i) Effect of different weed management practices on weed growth, crop yield and economics in summer greengram

Treatment	Dose (g/ha)	Weed density (No./m²) at 40 DAS				Wed biomass (g/m²) at 40 DAS		Pods (no./ plant)	Seed Yield (t/ha)
		T. portulacastrum	*D. aegyptium*	*D. sanguinalis*	*C. viscosa*	*Grasses*	Broadleaves		
Sodium-acifluorfen + clodinafop-propargyl as (PoE)	184	1.5 (1)	1.4 (1)	1.3 (1)	1.3 (1)	2.3 (5)	3.2 (10)	23.1	1.39
Sdium-acifluorfen + clodinafop-propargyl as (PoE)	245	1.2 (1)	1.2 (1)	1.0 (0)	1.0 (0)	1.4 (1)	1.8 (2)	26.4	1.65
Sodium-acifluorfen + clodinafop-propargyl as (PoE)	306	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	27.6	1.66
Sodium-acifluorfen (PoE)	165	1.1 (0)	2.0 (3)	2.1 (3)	1.2 (1)	3.7 (13)	2.8 (7)	23.7	1.29
Clodinafop-propargyl as (PoE)	80	2.3 (4)	1.2 (1)	1.3 (1)	2.4 (5)	1.6 (2)	6.4 (40)	22.4	1.28
Pendimethalin as (PE)	750	1.3 (1)	1.3 (1)	1.3 (1)	1.2 (1)	1.7 (2)	1.9 (3)	23.9	1.30
Weed free	HWs	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	26.9	1.62
Weedy check	-	2.3 (4)	2.2 (4)	2.3 (5)	2.5 (6)	4.4 (18)	6.4 (41)	13.3	0.79
SEm ±	-	0.1	0.1	0.1	0.1	0.1	0.1	0.9	0.05
LSD (P=0.05)		0.3	0.3	0.3	0.3	0.3	0.3	2.7	0.15

Note: PE: Pre-emergence; PoE: Post-emergence; DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+1.0)}$ before statistical analysis.

Table 1.3.5.1(ii) Effect of different weed management practices on weed growth and crop yield in rapeseed

Treatment	Dose (g/ha)	*C. rotundus* density (no./m²) at 40 DAS	Weed biomass (g/m²) at 40 DAS			Pods (No./plant)	Seed yield (q/ha)
			Grasses	Broadleaves	Sedges		
Napropamide	843.7	5.5 (29)	4.2 (17)	6.0 (36)	6.6 (43)	39.7	11.5
Napropamide	1125	3.8 (14)	2.7 (6)	3.9 (14)	4.7 (22)	43.7	13.7
Napropamide	1406.2	3.3 (10)	1.0 (0)	1.0 (0)	4.1 (16)	42.4	14.3
Weed free	Hand weedings	1.3 (1)	1.0 (0)	1.0 (0)	1.0 (0)	41.8	14.8
Weedy check	-	6.3 (39)	8.4 (70)	6.4 (41)	7.3 (52)	32.3	9.9
SEm ±		0.4	0.2	0.1	0.3	2.2	0.4
LSD (P=0.05)		1.1	0.5	0.3	0.9	7.3	1.4

Note: DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+1.0)}$ before statistical analysis.

branches of crop plants did not vary significantly among weed control treatments. Application of napropamide at all levels significantly increased seed yield of toria as compared to unsprayed check; seed yield with napropamide at 1125 and 1406 g/ha were at par to weed free treatment. Overall herbicide was safe to the crop at doses tested.

WP 1.3.6.1 Long term effect of continuous use of herbicides on shift in weed flora in transplanted rice-wheat rotation

CSKHPKV, Palampur

A comprehensive analysis on continuous use of herbicide for fourteen years on weed flora shift, crop and system yield was performed at Palampur. The data on grain yield of wheat based on five years moving average beginning in 2000-01 to 2017-18 have been presented in **Fig.1.3.6.1.1** Yield of wheat was higher during the middle years followed by latter and former years. All weed control treatments were superior to farmers' practice in increasing wheat grain yield. The pooled wheat grain yield has been shown in **(Table 1.3.6.1(i))** based on seventeen years pooled data, T_9 and T_7 remaining at par with T_5 resulted in significantly higher wheat grain yield over other treatments. Treatment T_9 had highest sustainable wheat yield index **(Table 1.3.6.1(ii))** In case of rice, the grain yield of rice based on five years moving average beginning in 2001 to 2017 have been given Rice grain yield showed increasing trend over the years. The fourteen years pooled yield of rice has been presented in Fig. 1.3.6.1.1d The highest sustainable rice yield index was observed with T_4 (0.780) followed by T_3 (0.769). Total grain productivity increased consistently until the middle years and then showed a decreasing trend irrespective of the treatment. In case of treatment T_9 where herbicides were applied in rotation in both the crops along with 25% N substitution through *Lantana* in rice had highest sustainable yield index (0.778) with highest total grain productivity of rice and wheat. This treatment also increased total grain productivity by 16.6% over the farmers practice.

Table 1.3.6.1(i) Weed management treatment

Treatment	Rice	Wheat
T1	Farmers' practice	Farmers' practice
T2	Butachlor 1.5 kg/ha *fb* 2,4 DEE 1.0 kg/ha (100% fert.)	Isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha
T3	Butachlor 1.5 kg/ha *fb* 2,4 DEE 1.0 kg/ha (100% fert.)	Clodinafop 75 g/ha /*isoproturon 1.0 kg/ha+2,4-D 0.75 kg/ha
T4	Butachlor 1.50 kg/ha *fb* 2,4 -DEE 1.0 kg/ha (75% N Fert. 25% N through *Lantana*	Isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha
T5	Butachlor *fb* 2,4 -DEE (75% N Fert._25% N through *Lantana*	Clodinafop 75 g/ha/*isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha
T6	Pretilachlor 0.75 kg/ha/butachlor 1.5 kg/ha*(100% Fert.)	Isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha
T7	Pretilachlor 0.75 kg/ha/butachlor 1.5 kg/ha*(100% Fert.)	Clodinafop 75 g/ha/*isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha
T8	Pretilachlor 0.75 kg/ha /butachlor 1.5 kg/ha*(75% N Fert. + 25% N *Lantana*	Isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha
T9	Pretilachlor 0.75 kg/ha/butachlor 1.5 kg/ha*(75% N Fert. + 25% N *Lantana*	Clodinafop 75 g/ha/*isoproturon 1.0 kg/ha +2,4-D 0.75 kg/ha

Table 1.3.6.1(ii) Effect of treatments on seventeen year's average yield and sustainable yield index

Treatment	Grain yield (t/ha)			Sustainable yield index (SYI)		
	Wheat	Rice	Wheat + rice	Wheat	Rice	Wheat + rice
T1	2.58±0.30	2.99±0.22	5.57±0.42	0.55	0.71	0.68
T2	2.69±0.31	2.87±0.37	5.57±0.58	0.58	0.64	0.66
T3	2.94±0.41	3.29±0.32	6.23±0.61	0.61	0.76	0.74
T4	3.07±0.48	3.39±0.38	6.47±0.73	0.63	0.78	0.76
T5	3.21±0.54	3.15±0.31	6.37±0.65	0.65	0.73	0.762
T6	2.98±0.38	3.16±0.45	6.14±0.75	0.63	0.70	0.71
T7	3.20±0.48	2.85±0.36	6.06±0.62	0.66	0.64	0.72
T8	3.15±0.44	3.22±0.47	6.39±0.88	0.66	0.71	0.73
T9	3.38±0.41	3.23±0.52	6.61±0.77	0.72	0.70	0.77
LSD (P=0.05)	0.13	97	0.18	-	-	-

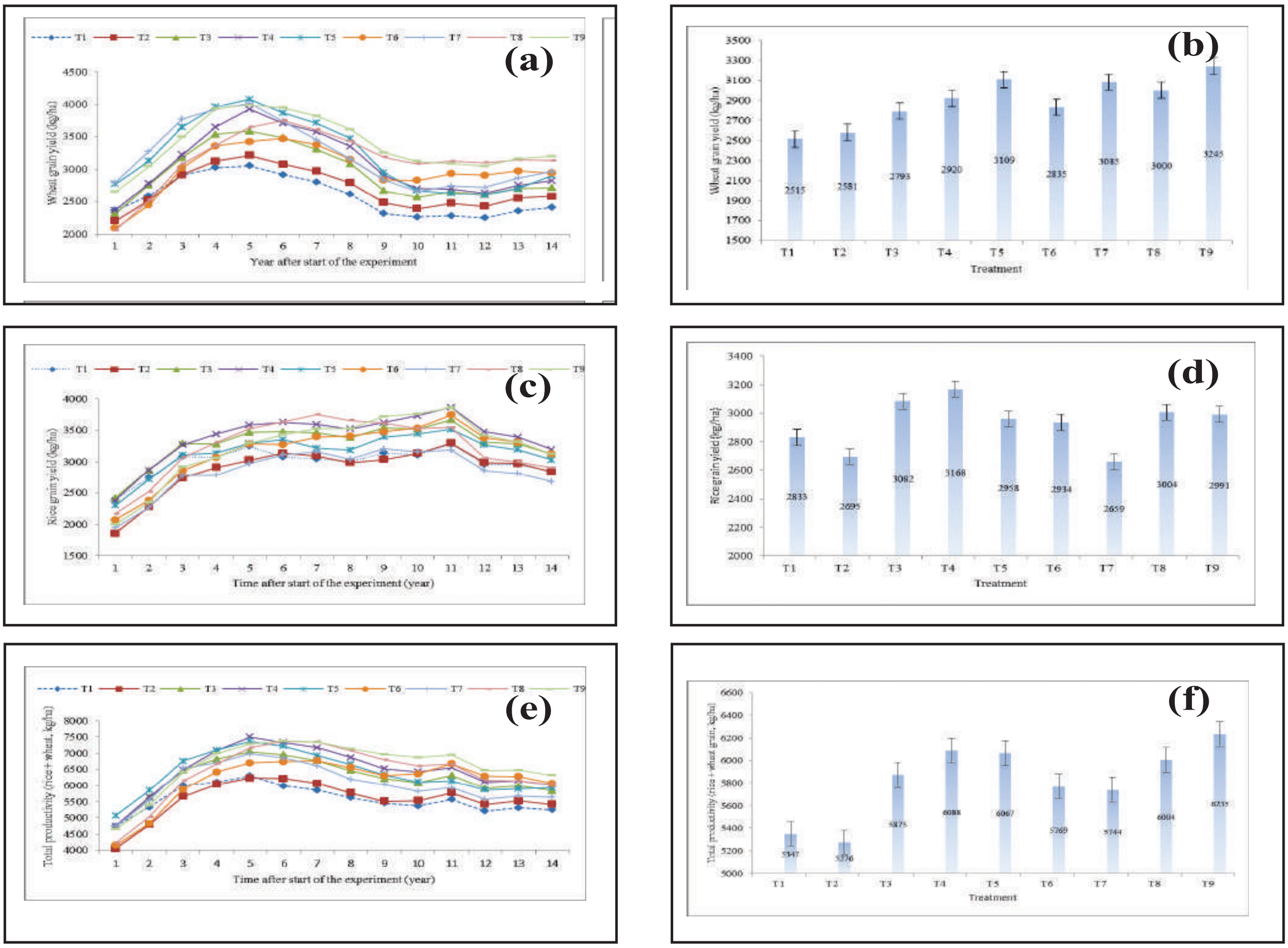


Fig:1.3.6.1.1 Effect of treatments on grain yield of wheat (a, b), rice (c, d) and system yield (e, f) based on five years moving average, beginning in 2000-01 and pooled for 14 years, error bars indicate standard error (n=8).

WP 1.3.7 Weed management in sugarcane

WP 1.3.7.1 Evaluation of different herbicides in spring planted sugarcane

CCSHAU, Hisar

Weed flora of experiment consisted of *Dactyloctenium aegyptium* and *Cynodon dactylon* (grassy), *Euphorbia microphylla* (broad leaved weed-BLW) and *Cyperus rotundus* (sedge). At 45 DAS, all weed control treatments were very effective against grasses and broadleaf weeds **(Table 1.3.7.1)**. Treatments consisted of halosulfuron proved very effective against *C. rotundus* as is evident from density of sedges at 45 DAS. Inspite of three hoeing, density of *Cyperus* was more due to regeneration in 3 days after hoeing. Sulfentrazone at 720 g/ha *fb* hoeing *fb* metsulfuron/2, 4-D was less effective in reducing density of total weeds particularly sedges. Similar trend in density of grassy, BLW and sedges was also observed at 60 DAS. Effect of halosulfuron in reducing density of *C. rotundus* remained consistent. None of the treatment affected the germination and not showed any phytotoxicity on sugarcane crop (data not given). Early post emergence (15 DAP) use of glyphosate 40% SL at 1860 g/ha + metribuzin was more effective than paraquat *fb* atrazine in reducing total weed count.

WP 1.3.7.1 (i) Weed management in spring planted sugarcane.

BCKV, Kalyani

The experiment was started during March, 2017. The most dominating weeds were *Cyperus rotundus* and *C. difformis* as sedge, *Cynodon dactylon* as grassy weed and *Alternanthera phyloxeroides, Physalis minima, Commelina benghalensis* and *Cucumis sativus* as broad leaved species. The minimum dominance of *C. rotundus* and *C. dactylon* was observed in the treatment having atrazine 1.0 kg/ha as PE *fb* hand weeding at 30

Table 1.3.7.1 Effect of different herbicides on weed density at 45 DAS in sugarcane

Treatment	Dose (g/ha)	Time of application	Grasses	BLW	Sedges	Total weeds
Metribuzin	1000	PE	2.03(3.10)	2.07(3.30)	11.18(124)	11.5(130)
Metribuzin + halosulfuron methyl (TM)	1000+ 67.5	PE	2.07(3.30)	2.07(3.30)	6.7(44)	7.2(50.6)
Atrazine	2000	PE	2.16(3.67)	2.17(3.70)	12.45(154)	12.7(161.4)
Atrazine + halosulfuron (TM)	2000+ 67.5	PE	2.15(3.63)	2.0(3.00)	7.67(58)	8.1(64.6)
Metribuzin + halosulfuron (TM)	1000+ 67.5	PoE 40 DAP	2.76(6.60)	3.11(8.70)	3(8.0)	4.9(23.3)
Atrazine + halosulfuron (TM)	2000+ 67.5	PoE40 DAP	2.76(6.60)	3.02(8.10)	3.16(9)	5.0(23.7)
Metribuzin *fb* halosulfuron	1000 & 67.5	PE *fb* 40 DAP-PoE	2.03(3.13)	2.19(3.80)	2.65(6)	3.7(12.9)
Atrazine *fb* halosulfuron	2000 & 67.5	PE *fb* 40 DAP-PoE	2.50(5.23)	2.15(3.60)	3.16(9)	4.3(17.8)
Sulfentrazone *fb* hoeing *fb*2,4-D	720 & 1000	PE *fb* 45 DAP *fb* 60 DAP-PoE	2.62(5.87)	3.08(8.47)	7(48)	8.0(62.3)
Sulfentrazone *fb* hoeing *fb*almix	720 & 4	PE *fb* 45 *DAP fb 60* DAP-PoE	2.73(6.43)	3.05(8.30)	6.78(45)	7.8(59.7)
Atrazine *fb* 2,4-D	2000 & 1000	PE *fb* 60 DAP-PoE	2.61(5.80)	2.46(5.0)	12.69(160)	13.1(170.9)
Hoeing after first irrigation *fb* atrazine	2000	PoE to Sugarcane	2.61(3.67)	2.03(3.1)	12.97(167)	13.2(174.1)
Glyphosate (41% SL) + metribuzin + surfactant	1860 + 1000	15 DAS-EPoE	2.38(4.70)	2.61(5.8)	8.72(75)	9.3(85.5)
Atrazine*fb* metsulfuron + carfentrazone (RM)	2000 & 25	PE *fb* PoE-60 DAP	2.18(3.77)	1.61(1.6)	12.69(160)	12.9((165.4)
Atrazine *fb* hoeing *fb* toparamezone	2000 & 25	PE *fb* 45 DAP *fb* 60 DAP-PoE	1.67(1.80)	1.64(1.7)	12.12(146)	12.3(149.5)
Paraquat *fb* atrazine	800 & 2000	15 DAS-EPoE *fb* 60 DAP-PoE	2.38(4.67)	2.95(7.7)	12.88(165)	13.4(130.3)
Three hoeing(30, 60 and 90 DAP)	-	30, 60 and 90 DAP	1.90(2.63)	2.07(3.3)	11.71(136)	12(50.7)
Unweeded (Control)	-	-	3.01(8.07)	3.42(10.7)	13.23(174)	14(161.3)
SEm ±			0.06	0.04	0.11	0.04
LSD (P=0.05)			017	011	0.32	0.1

Note: PE: Pre-emergence; PoE: Post-emergence; EPoE: Early post-emergence; RM: Ready mix; TM: Tank mix; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(X+0.5)}$ before statistical analysis.

DAS, and this treatment also reduced the total biomass of weeds to a greater extent **(Table 1.3.7.1(i)**. Regarding crop performance, highest value of biological yield was recorded in atrazine 1.0 kg/ha as PoE *fb* hand weeding at 30 DAS followed by *Sesbania* co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS and atrazine + pendimethalin (0.50 + 0.5 kg/ha) PoE *fb* hand weeding at 30 DAS. Yield components and yield as recorded in the experiment showed that the treatment atrazine 1.0 kg/ha as PoE *fb* hand weeding at 30 DAS was the best performer and the second best one was the treatment sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS. This threatments also gave higher net return and B:C ratio as compared to others treatments.

Table 1.3.7.1(i) Effect of different weed management practices on weed density, dry weight, crop yield and economic benefits in spring planted sugarcane.

Treatment	Density of *Cyperus rotundus* (g/m^2) at 50 DAS	Density of *Cynodon dactylon* (g/ m^2) at 50 DAS	Total weed dry weight (g /m) at 50 DAS	Number of millable cane (cane/m^2)	Cane yield (t/ha)	Net return (₹/ha)	B:C Ratio
Atrazine 1.0 kg/ha PE	11.90 (140.6)	6.17 (37.1)	14.38 (205.6)	8.23	40.4	76,035	0.62
Pendimethalin 750g/ha PE	11.15 (123.5)	5.98 (34.7)	14.43 (179.4)	9.21	61.5	1,60,235	1.28
Atrazine + pendimethalin (0.50 + 0.5 kg/ha) PE	11.4 (129.1)	5.78 (32.4)	13.60 (183.9)	9.30	58.8	1,56,057	1.30
Atrazine 1.0 kg/ha PE *fb* hand weeding at 30 DAS	7.59 (56.6)	3.98 (14.8)	9.22 (83.9)	10.3	82.4	2,32,790	1.85
Pendimethalin 750g/ha PE *fb* hand weeding at 30 DAS	10.94 (118.8)	5.50 (29.2)	13.01 (168.2)	10.1	70.5	1,90,930	1.52
Atrazine + pendimethalin (0.50 + 0.5 kg/ha) PE *fb* hand weeding at 30 DAS	9.40 (87.5)	4.18 (16.4)	11.07 (121.5)	10.0	73.8	2,03,285	1.62
Glyphosate 1.0 kg/ha at 30 DAS (Directed application)	11.84(139.3)	5.78 (32.4)	14.00 (194.8)	8.52	43.3	1,00,415	0.83
Sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS	9.11 (82.1)	4.07 (15.5)	10.69 (113.3)	10.0	74.8	2,28,752	1.87
Hand weeding at 30 DAS	11.9 (140.9)	5.78 (32.3)	14.08 (197.3)	8.4	41.4	93,520	0.77
Weedy check	14.9 (221.7)	8.96 (79.3)	20.90 (435.8)	7.3	31.2	31,022	0.27
SEm ±	0.01	0.02	0.21	0.17	2.59	-	-
LSD (P= 0.05)	0.03	0.06	0.51	0.51	6.31	-	-

Note: PE: Pre-emergence; *fb*: Followed by; DAS: Days after sowing; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

WP 1.3.8 Weed management in orchards

WP 1.3.8.1 Integrated weed management in established peach orchard

CSKHPKV, Palampur

The weed flora of the experimental field comprised of *Alternanthera philoxeroides*, *Ageratum* spp. *Cynodon dactylon*, *Artemisia*, spp. *Bidens pilosa*, *Trifolium repens*, *Plantago lanceolata*, *Setaria glauca* and *Polygonum* spp. In the month of March major weed flora comprised of *Ageratum*, spp. *C. dactylon*, *Artemisia*, spp. *T. repens* and *P. lanceolata*. The population of *Artemisia* spp. was highest followed by *P. lanceolata*, *C. dactylon*, *T. repens* and *Ageratum* spp. In the month of August major weed flora comprised of *A. philoxeroides*, *Ageratum*, *C. dactylon*, *Artemisia* spp. *B. pilosa*, *S. glauca* and *Polygonum* **(Table 3.8.1.1)**. The population of *Ageratum* was highest followed by *A. philoxeroides*, *B. pilosa*, *C. dactylon*, *Artemisia* spp. , *Polygonum* spp. and *S. glauca*. Results of the study revealed that maximum peach yield was recorded in legume intercropping treatment (7.74 t/ha) and which was at par with the manual weeding, fodder intercropping, application of glyphosate. While significantly lowest peach yield was recorded under unweeded situation due to abundance of weeds.

Table 3.8.1.1 Effect of different treatments on weed density and peach yield during 2018

Treatment	Density (no./m2) during March, 2018		Dry weight (no./m2) during March, 2018		Density (no./m2) during August, 2018		Dry weight (no./m2) during August, 2018		Peach yield (t/ha)
	Artemisia Spp.	*Plantago lanceolata*	*Artemisia* Spp.	*Plantago lanceolata*	*A. philoxeroides*	*Ageratum* Spp.	*A. philoxeroides*	*Ageratum* Spp.	
Legume intercropping*	3.49 (16.0)	2.94 (10.6)	2.00 (4.37)	1.87 (3.7)	4.06 (16.0)	4.61 (21.3)	2.50 (5.8)	2.73 (7.1)	7.74
Turmeric intercropping	6.54 (42.6)	6.48 (42.6)	3.57 (12.3)	3.68 (13.1)	6.12 (37.3)	8.34 (69.3)	5.00 (24.8)	3.96 (15.2)	6.60
Fodder intercropping$	5.15 (26.6)	5.15 (26.6)	2.79 (7.36)	2.98 (8.53)	6.12 (37.3)	6.54 (42.6)	4.15 (16.8)	3.20 (9.7)	7.34
Interculture basin area + sod culture	6.12 (37.3)	6.12 (37.3)	3.26 (10.2)	3.66 (12.9)	5.58 (32.0)	8.03 (64.0)	4.73 (22.4)	3.62 (12.6)	6.68
Glyphosate 2.0 kg/ha. (4 times)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	7.17
Paraquat 1.0 kg/ha. (4 times)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	12.43 (154.7)	12.6 (160.0)	8.90 (79.2)	4.26 (17.6)	6.53
Weed mulch (Lantana/Chromolaena; 3 times in a year)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	8.94 (80.0)	7.68 (58.67)	6.53 (42.6)	3.49 (11.7)	6.98
Manual weeding (3 times in a season)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	5.15 (26.7)	5.58 (32.00)	3.66 (13.3)	3.13 (9.4)	7.54
Weedy check	7.99 (64.0)	7.99 (64)	4.02 (15.7)	4.22 (17.3)	14.43 (208.0)	13.28 (176.0)	9.08 (82.6)	4.26 (17.6)	6.13
CD (P=0.05)	1.80	1.68	0.79	0.76	1.19	1.36	1.09	0.51	0.74

Note: *Soybean in May-June with recommended weed control i.e quizalofop 60g/ha + chlorimuron-ethyl 4g/ha and peas in October with recommended weed control i.e pendimethalin 1.5 kg /ha); #Planting in April-May with recommended weed control i.e pendimethalin 1.5 kg/ha; $ Pearl millet in *Kharif* and Oats in winter.

WP 1.3.9 Weed management in fenugreek

WP 1.3.9.1 Bioefficacy evaluation of different herbicides in fenugreek and their residual effect on succeeding crop

MPUAT, Udaipur

The prominent weed species in experimental field were *Chenopodium album, Chenopodium murale, Fumaria parviflora, Malwa parviflora, Melilotus indica, Convolvulus arvensis and Phalaris minor*.Weed density of broad leaf weeds were higher than grassy weeds at 60 DAS. The lowest weed density and total weed dry biomass accumulation at 60 DAS was recorded with PE application of oxadiargyl 100 g/ha *fb* one hoeing at 40 DAS **(Table 1.3.9.1)**. And the maximum weed control eficiency (WCE) (86.3%) was also recorded with the same treatment. Data indicated that the maximum seed yield (2.90 t/ha.) was recorded with weed free treatment. Among herbicidal treatments PRE application of oxadiargyl 100 g/ha *fb* one hoeing at 40 DAS recorded the maximum seed yield (2.82 t/ha) which was significantly higher to other treatments. The lowest seed yield was recorded in weedy check (1.05 t/ha). The increment in seed yield due to PE application of oxadiargyl 100 g/ha *fb* one hoeing at 40 DAS was 24.7 and 27.2 % higher over PE application of imazethapyr *fb* one hoeing at 40 DAS and PE application of oxadiargyl 100 g/ha. The highest net returns (₹ 98,158/ha) and B C ratio (2.63) were realized with PE application of oxadiargyl 100 g/ha *fb* one hoeing at 40 DAS.

Table 1.3.9.1 Effect of different weed management practices on weed growth, crop yield and economics in fenugreek

Treatments	Weed density (no./m^2) at 60 DAS			Weed dry matter (g/m^2) at 60 DAS	Seed yield (t/ ha)	Net return (₹/ha)	B:C Ratio
	C. album	*C. murale*	*F. parviflora*				
Imazethapyr 70 g/ha PE	3.36 (10.83)	2.48 (5.67)	2.25 (4.58)	123.5	1.89	61,715	1.94
Imazethapyr 70 g/ha PE *fb* hoeing at 40DAS	2.66 (6.58)	2..00 (3.50)	1.99 (3.50)	69.7	2.26	73,940	2.04
Imazethapyr 50 g/ha PE	2.72 (6.92)	1.95 (3.33)	1.82 (2.84)	98.1	2.13	73,487	2.36
Imazethapyr + imazamox (RM) 50 g/ha PoE	3.53 (12.0)	2.60 (6.25)	2.11 (3.96)	132.7	2.10	70,756	2.23
Imazethapyr + imazamox (RM) 60 g/ha PoE	3.37 (10.9)	2.25 (4.58)	2.28 (4.75)	121.9	2.16	71,689	2.24
Pendimethalin 750 g/ha PE	2.69 (6.75)	2.41 (5.33)	2.18 (4.25)	117.0	2.00	64,196	1.87
Oxyfluorfen 120 g/ha PE	4.56 (20.3)	2.57 (6.08)	2.34 (5.00)	168.1	1.84	57,710	1.87
Oxyfluorfen 150 g/ha PE	4.11 (16.4)	2.10 (3.92)	2.33 (4.97)	129.3	1.97	63,010	2.02
Oxyfluorfen 120 g/ha PE *fb* hoeing at 40DAS	3.33 (10.5)	1.98 (3.42)	1.66 (2.29)	78.3	2.11	66,421	1.85
Oxadiargyl 100 g/ha PE	2.61 (6.32)	2.81 (7.43)	2.37 (5.17)	90.0	2.22	74,352	2.30
Oxadiargyl 100 g/ha PE *fb* hoeing at 40DAS	2.00 (3.50)	1.85 (2.92)	1.87 (3.00)	54.2	2.82	98,158	2.63
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.0	2.91	96,532	2.19
Weedy check	8.98 (80.0)	7.90 (61.9)	5.20 (26.5)	395.9	1.05	21,774	0.87
SEm ±	0.02	0.02	0.02	1.86	0.031	-	-
LSD (P = 0.05)	0.05	0.05	0.05	5.74	0.095	-	-

Note: PE: Pre-emergence; PoE: Post-emergence; RM: Ready mix; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

Residual effect of herbicide on succeeding fodder maize

During fodder maize cultivation, major weeds observed in the experimental field were *Echinochloa colona, Commelina bengalensis, Trianthama portulacastrum, Digera arvensis, Parthenium hysterophorus* and *Cyperus rotundus*. There was no residual phytotoxic effect of herbicides applied in fenugreekon succeeding fodder maize **(Table 1.3.9.1(i))**. All the weed control treatments adopted in preceding fenugreek crop had no significant impact in respect to dry matter accumulation of maize crop plant at 30 DAS and final green fodder yield.

Table 1.3.9.1 (i) Visual phytotoxicity of herbicide scoring at different growth stages and green fodder yield of maize

Treatment	Dry matter at 30 DAS	Green fodder yield (t/ha)
Imazethapyr 70 g/ha PE	24.2	44.5
Imazethapyr 70 g/ha PE *fb* hoeing at 40DAS	23.7	44.1
Imazethapyr 50 g/ha PE	23.6	45.3
Imazethapyr + imazamox (RM) 50 g/ha PoE	23.3	45.1
Imazethapyr + imazamox (RM) 60 g/ha PoE	24.3	45.2
Pendimethalin 750 g/ha PE	22.9	45.4
Oxyfluorfen 120 g/ha PE	24.3	43.9
Oxyfluorfen 150 g/ha PE	23.7	43.6
Oxyfluorfen 120 g/ha PE *fb* hoeing at 40DAS	23.3	44.4
Oxadiargyl 100 g/ha PE	24.7	45.0
Oxadiargyl 100 g/ha PE *fb* hoeing at 40DAS	25.7	45.1
Weed free	24.2	45.6
Weedy check	23.8	44.2
SEm ±	0.35	0.65
LSD (P = 0.05)		NS

Note: PE: Pre-emergence; PoE: Post-emergence; RM: Ready mix; DAHA: Days after herbicide application; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

WP 1.3.10 Weed management in vegetable pea

WP 1.3.10.1 Management of complex weed flora in vegetable peas and residual effect on succeeding cucurbit crops

SKUAST, Jammu

The most dominant weed species found in experimental field during crop growth period were mainly *Vicia sativa, Anagallis arvensis, Melilotus indica* and *Medicago denticulata* amongst broad leaved weeds and *Phalaris mionr* and *Cynodon dactylon* amongst grassy weeds. The weed management treatments had significant effect on weed density and weed biomass at 50 DAS **(Table 1.3.10.1)**. Among the herbicidal treatments lower grassy, broad-leaved, total weed density and weed biomass were recorded in pendimethalin+imazethapyr 1250 g/ha as pre-emergence followed by pendimethalin+imazethapyr 1000 g/ha as pre-emergencee. Different weed management treatments had significant effect on growth, yield and yield attributes as compared weedy check as compared to weedy check. All the weed management practices recorded significantly higher plant height, plant dry matter, nodules number of pods and green pod yield . Among the herbicidal treatments, highest green pod yield was recorded with pendimethalin + imazethapyr 1250 g/ha as pre-emergencee followed by pendimethalin + imazethapyr 1000 g/ha. The highest net returns and B:C ratio was recorded with pendimethalin + imazethapyr 1000 g/ha treatment. There was no residual phytotoxicity of herbicides applied in vegetable pea on succeeding cucurbit crops (Cucumber and Round Gourd).

WP 1.3.11 Weed management in direct-seeded rice and wheat

WP 1.3.11.1 Effect of irrigation methods and weed management on weed flora dynamics in direct- seeded rice and wheat

SKUAST, Jammu

During winter the main dominating weed flora was *Phalaris minor* and *Avena* spp. amongst grassy weeds; *Rumex* spp., *Anagalis arvensis* and *Melilotus indica* amongst broad-leaved weeds. Different irrigation treatments had no significant effect on weed density and weed biomass at 60 DAS and harvest **(Table 1.3.11.1)**. However, lower weed density and weed biomass were recorded in flooding irrigation as compared to sprinkler and sprinkler with VSD. Among the weed management treatments, all the weed management treatments recorded significantly lower weed density and weed biomass as compared to weed check. At 60 DAS, significantly lowest total weed density and biomass were recorded in sulfosulfuron +

Table 1.3.10.1 Effect of different weed management practices on weed growth, green pod yield and economics in vegetable pea

Treatment	Weed density (no.m^2)at 50 DAS		Weed biomass (g/m^2) at 50 DAS		Plant dry matter (g/m^2) at 50 DAS	Number of pods/ plant	Green pod yield (t/ha)	Net returns (₹/ ha)	B: C ratio
	Broad leaved weeds	Grassy weeds	Broad leaved weeds	Grassy weeds					
Clodinafop 60 g/ha	6.01 (35.2)	2.54 5.47)	9.99 (99.0)	4.10 (15.8)	2.75	14.2	6.93	91,264	1.93
Pinoxaden 50 g/ha	6.07 (35.9)	2.47 (5.10)	10.0 (100.9)	3.96 (14.7)	2.78	13.5	6.90	89,485	1.84
Pendimethalin at 1.0 kg/ha PE	3.05 (8.40)	3.85 (13.8)	4.98 (24.0)	6.49 (41.20)	2.79	16.2	7.18	95,215	1.96
Pendimethalin + imazethapyr at 800 g/ha PE	2.55 (5.53)	3.43 (10.7)	4.04 (15.4)	5.67 (31.2)	2.74	15.8	7.20	95,460	1.96
Pendimethalin + imazethapyr at 1000 g/ha PE	2.21 (3.90)	3.13 (8.80)	3.39 (10.5)	5.14 (25.5)	2.70	17.8	7.47	1,00,40	2.10
Pendimethalin + imazethapyr at 1250 g/ha PE	1.75 (2.06)	3.00 (8.07)	2.58 (5.69)	4.93 (23.4)	2.63	18.5	7.53	1,01,03	2.00
Imazethapyr at 70 g/ha PE	3.49 (11.2)	3.51 (11.4)	5.69 (31.4)	5.82 (33.1)	2.66	16.4	7.13	94,503	1.96
Imazethapyr at 60 g/ha at 2-LS	4.72 (21.4)	3.80 (13.4)	7.79 (60.1)	6.47 (40.9)	2.65	13.7	7.03	92,703	1.93
Imazethapyr at 70 g/ha at 2-LS	5.01 (24.3)	3.53 (11.4)	8.30 (68.3)	5.84 (33.2)	2.66	15.5	7.07	93,303	1.93
Imazethapyr 80 g /ha at 2-4 LS	3.91 (14.3)	3.57 (11.8)	6.42 (40.3)	6.04 (35.5)	2.63	16.0	7.10	93,379	1.92
Imazethapyr+ imazamox 60 g/ha at 2-4 LS	4.91 (23.2)	3.46 (11.1)	8.12 (65.1)	5.73 (32.3)	2.92	15.8	7.09	93,459	1.93
Imazethapyr+ imazamox 70 g/ha at 2-4 LS	5.68 (31.3)	3.52 (11.5)	9.43 (87.9)	5.84 (33.2)	2.12	14.1	6.99	91,183	1.87
Imazethapyr+ imazamox 80 g/ha at 2-4 LS	5.87 (33.5)	3.37 (10.4)	9.75 (94.2)	5.57 (30.2)	2.55	13.9	6.94	89,916	1.83
Weed free	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.81	19.5	7.79	83,423	1.15
Weedy check	8.44 (70.3)	3.92 (14.4)	11.0 (120.3)	6.73 (44.3)	2.18	11.1	4.89	51,423	1.10
SEm ±	0.18	0.14	0.43	0.23	0.04	0.73	0.14	-	-
LSD (P=0.05)	0.53	0.40	1.24	0.67	0.12	2.11	0.41	-	-

Note: PE: Pre-emergence; LS: Leaf stage; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

carfentrazone (25 + 20 g/ha) which was statistically at par with clodinafop-propargyl + metsulfuron (60 +4 g/ha) and significantly lower than other herbicidal treatments. Different irrigation treatments had non-significant effect on growth, yield attributes and grain and straw yield of wheat. However, higher growth, yield attributes, grain yield and straw yield of wheat were recorded in flooding irrigation as compared to sprinkler and sprinkler with VSD. All the weed management treatments recorded significantly higher growth parameters, yield attributes, grain and straw yield of wheat compared to weedy check. The higher grain yield and straw yield were recorded in clodinafop-propargyl+metsulfuron (60 +4 g/ha) which was statistically at par with sulfosulfuron+ carfentrazone (25+20 g/ha) and clodinafop-propargyl +metribuzin (60+210 g/ha). The higher B: C ratio was recorded with flood irrigation as compared to sprinkle

Table 1.3.11.1 Effect of different weed management practices on weed growth, crop yield and economics in wheat

Treatment	Weed density(no./m^2)		Weed dry (kg/m^2) weight 60	Tillers/m² at 60 DAS	Grain yield (t/ha)	Net returns (₹/ha)	B: C
	30 DAS	60 DAS					
Irrigation method							
Flooding	8.80 (76.4)	5.51 (34.0)	8.02 (63.3)	462	4.13	58,441	2.28
Sprinkler	8.77 (75.9)	5.68 (35.9)	8.18 (65.9)	454	4.08	56,058	2.11
Sprinkle with VSD*	8.73 (75.3)	5.91 (38.4)	8.27 (67.4)	449	4.05	55,407	2.08
SEm ±	0.07	0.08	0.07	12	0.08		
LSD (P=0.05)	NS	NS	NS	NS	NS		
Weed management							
Clodinafop-propargyl+metsulfuron (60 +4 g/ha)	8.76 (75.9)	4.26 (17.2)	5.46 (28.9)	502	4.49	64,935	2.47
Clodinafop-propargyl+metribuzin (60+210 g/ha)	8.80 (76.4)	4.76 (21.7)	5.96 (34.4)	488	4.38	62,184	2.34
Sulfosulfuron+carfentrazone (25 + 20 g/ha)	8.73 (75.2)	4.09 (15.8)	5.20 (26.1)	496	4.42	62,883	2.36
Clodinafop -propargyl + carfentrazone (60 + 20 g/ha)	8.80 (76.4)	5.51 (29.4)	7.29 (52.2)	449	4.17	57,674	2.17
Weedy check	8.75 (75.6)	9.87 (96.6)	13.6 (186.1)	340	2.99	35,501	1.45
SEm ±	0.09	0.06	0.08	13	0.09		
LSD (P=0.05)	NS	0.17	0.23	38	0.27		
Interaction	NS	NS	NS	NS	NS		

Note: DAS: Days after sowing * VSD: Variable speed drive check work on the basis of soil in filtration rate.

irrigation and sprinkler with VSD. However, highest water use efficiency was recorded with sprinkler with VSD as compared to sprinkler and flood irrigation. Amongst the weed management treatments highest B: C ration and water use efficiency were recorded with clodinafop-propargyl+metsulfuron (60 + 4 g/ha) followed by sulfosulfuron+carfentrazone (25 + 20 g/ha) in wheat.

WP 1.3.12 Weed management in maize

WP 1.3.12.1 Weed management with new generation herbicides in maize and its residual effect on succeeding wheat

UAS, Dharwad

The major weed flora recorded during the present investigation was *Dinebra retroflexa, Panicum isachne, Digera arvensis, Ageratum conyzoides, Commelina benghalensis, Cyanotis* spp., *Corchorus olitorius* were dominant in maize during *Kharif*. The higher weed density other than weedy check was recorded with non chemical treatment i.e. IC + HW at 20 and 40 DAS **(Table 1.3.12.1)**. Among the herbicidal approach application of topramezone + atrazine (25.2 + 500 g/ha) as EPoE *fb* IC + HW at 30 DAS reduced the weed density, followed in the plots received tembotrione 120 g/ha as EPoE. Similar trend was also noticed with weed dry matter. Among the herbicides, the plots received atrazine 1.0 kg/ha PE *fb* HW at 40 DAS recorded maximum weed density and weed dry matter at 30 and 60 DAS. The highest maize yields were recorded with the plots received topramezone + atrazine (25.2 + 500 g/ha) as EPoE *fb* IC + HW at 30 DAS (5.49 t/ha), followed with tembotrione 120 g/ha EPoE (5.32 t/ha). However, the results obtained were statistically on par with each other. Among the herbicides, atrazine 1.0 kg/ha PE *fb* HW at 40 DAS resulted in the lowest yield compared to the rest of the chemical herbicides (2.67 t/ha). The highest B:C ratio was recorded with topramezone + atrazine (25.2 + 500 g/ha) EPoE *fb* IC + HW at 30 DAS. Highest dehydrogenase activity was recorded with the plots, were herbicides were not applied. However, among the herbicide applied plots topramezone + atrazine (25.2 + 500 g/ha) EPoE *fb* IC + HW at 30 DAS recorded highest dehydrogenase activity at 30 and 60 DAS (3.98 and 6.37 µg TPF formed/g soil/day, respectively).

Table 1.3.12.1 Effect of herbicides on total weed density , weed dry matter, yield and economics in maize under maize-wheat cropping sequence:

Treatments	Weed density (no./m^2)		Weed dry matter (g/m^2)		Yield (t/ ha)	Gross returns ₹/ha	Net returns ₹/ha	B:C ratio
	30 DAS	60 DAS	30 DAS	60 DAS				
Atrazine 1.0 kg/ha PE *fb* HW at 40 DAS	10.3	9.67	5.67	10.6	2.66	42,000	18,670	1.80
Atrazine + pendimethaline (0.50 + 0.25 kg/ha) PE	6.67	9.00	4.40	10.1	4.54	44,216	17,600	1.66
Atrazine 1.0 kg/ha PE *fb* 2,4-D 1.0 kg/ha LpoE	4.33	3.33	3.97	3.77	4.66	44,000	21,400	1.94
Atrazine + pendimethaline (0.50 + 0.25 kg/ha) PE *fb* 2,4-D 1.0 kg/ha LPoE	5.67	3.00	3.10	3.33	4.97	41,000	14,205	1.53
Topramezone 25.2 g/ha EPoE	6.33	2.67	3.97	3.17	3.49	45,565	14,490	1.46
Tembotrione 120 g/ha EPoE	3.67	3.00	3.5	3.00	5.32	42,740	21,700	2.03
Topramezone 25.2 g/ha EPoE *fb* IC + HW at 30 DAS	7.0	6.67	3.63	4.37	5.15	41,450	17,765	1.75
Tembotrione 120 g/ha EPoE *fb* IC + HW at 30 DAS	8.33	11.3	3.5	3.33	4.86	43,885	18,450	1.72
Topramezone + atrazine (25.2 + 500 g/ha) EPoE *fb* IC + HW at 30 DAS	2.67	3.33	2.7	2.90	5.49	20,505	14,650	3.50
Tembotrione + atrazine (105 + 250 g/ha) EPoE *fb* IC + HW at 30 DAS	8.0	5.67	5.17	4.33	2.46	24,625	15,640	2.74
IC + HW at 20 and 40 DAS	52.0	22.7	5.93	10.8	376	21,000	14,660	3.31
Weedy check	79.7	71.0	7.87	10.2	1.66	21,000	7,720	1.58
LSD (P=0.05)	4.2	3.98	1.89	1.76				

Note: PE: Pre-emergence; PoE: Post-emergence; EPoE: Early post-emergence; LPoE: Late post-emergence; IC: Intercultural operation; HW: Hand weeding; DAS: Days after sowing; *fb*: Followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{(x+0.5)}$ before statistical analysis.

WP 1.5 Station trials on weed management

WP 1.5.1 Herbicides combinations for control of complex weed flora in wheat (2017-18)

PDKV, Akola

A trial was conducted to assess the efficacy of pre-emergence and post-emergence herbicides for control of complex weed flora in wheat. The major weed flora during *Rabi* 2017-18 in wheat crop composed of *Parthenium hysterophorus, Chenopodium album, Chenopodium murale, Melilotus indica, Portulaca oleracea, Euphorbia hirta, Euphorbia geniculata, Mimosa pudica*, *Alternanthera triandra, Cynodon dactylon, Cyperus rotundus, Amaranthus viridis, Dinebra arabica, Panicum* spp, *Digitaria sanguinalis, Dinebra retroflexa, Poa annua, etc.* Both broad and narrow leaved weeds were observed but dominance of broad-leaved weeds was observed in entire field.

Significantly lower weed density and dry matter were recorded in hand weeding treatment followed by treatment where pre-emergence herbicides like pendimethalin 1.0 kg/ha, metribuzin 0.21 kg/ha and pendimethalin + metribuzin (1.0 + 0.175 kg/ha) were applied. At 60 DAS, lowest weed density and weed dry matter were noticed in hand weeding carried out at 30 and 60 DAS followed by pendimethalin *fb* sulfosulfuron (1.0 + 0.018 kg/ha), pinoxaden + metsulfuron (0.06 + 0.004 kg/ha) pre-mix at 35 DAS, sulfosulfuron 0.025 kg/ha PoE at 35 DAS, mesosulfuron + iodosulfuron (0.012 + 0.0024 kg/ha) at 35 DAS. Similar trend was also recorded at harvest stage. It was observed that 30 days onwards different post-emergence herbicides were found very effective in controlling broad-leaved weeds and thereby decreasing the weed density and weed dry biomass.

At 60 DAS and at harvest stage of crop growth, the highest weed control efficiency (WCE) was observed in two hand weeding (30 and 60 DAS) treatment. At both the satges, among herbicidal treatments, highest WCE (91%) was recorded where pendimethalin *fb* sulfosulfuron (1.0 + 0.018 kg/ha) followed by pinoxaden + metsulfuron (0.06 + 0.004 kg/ha) at 35 DAS and treatment mesosulfuron + iodosulfuron (0.012 + 0.0024 kg/ha). Maximum grain yield was observed in two hand weeding treatment (4.41 t/ha) closely followed by pendimethalin *fb* sulfosulfuron (4.31 t/ha). Maximum net returns of ₹ 56,120 /ha and highest B: C ratio (3.20) was observed in clodinafop + metsulfuron (Premix) (0.06 + 0.004 kg/ha) at 35 DAS. The next best economical treatment was pinoxaden + metsulfuron (Premix) (0.06 + 0.004 kg/ha) at 35 DAS with B: C ratio of 3.12.

WP 1.5.1 (i) Efficacy of post-emergence herbicides in *Kharif* groundnut

The experiment on efficacy of post-emergence herbicides in *Kharif* groundnut was conducted for three years as a station trial based on the farmers feedback and recommendation in the Joint Agresco 2018. The post-emergence application of imazethapyr + imazomox 0.07 kg/ha at 20 DAS found to be the most remunerative and effective herbicide for controlling the weed flora and getting higher yield and economic returns in groundnut.

WP 1.5.2 Management of complex weed flora in garlic (*Allium sativum* L.)

AAU, Anand

To study the bio-efficacy of different herbicides against weeds in garlic, a field experiment was conducted during *Rabi* 2016-17. During the experimental period, the overall dominance of dicot and monocot weeds was 83.1 and 16.9%, respectively. Major weeds observed in the experimental field were *Eleusine indica* (8.9%), *Asphodelus tenuifolius* (3.0 %), *Setaria gluaca* (0.92%) and *Digitaria sanguinalis* (0.92%) in monocot weeds category and *Chenopodium murale* (60.6%), *Chenopodium album* (15.5%) and *Melilotus indica* (5.2%) in dicot weed category.

Application of oxyfluorfen 240 g/ha PoE and pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank-mix) showed phytotoxic symptoms of necrosis at 10 days after herbicide application but recovered after 20 DAHA. At 40 DAP, minimum density and dry biomass of monocot, dicot and total weeds was recorded under paddy straw mulch 5.0 t/ha. Among various weed management practices, pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank-mix) and hand weeding at 30 and 60 DAP both were remain at par with each other and recorded significantly lower density and dry biomass of dicot and total weeds as compared to rest of the treatments. Similar line of results was also observed for density of monocot weeds recorded at 40 DAP. Among all the weed management practices, higher weed control index was recorded under application of pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank-mix) followed by twice hand weeding and oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP.

Among weed management practices, significantly lower density of total weeds was recorded under oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP as compared to pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank Mix) and weedy check. Though the result was non-significant but similar trend was also noticed for density of monocot and dicot weeds recorded at 90 DAP. Similarly, dry biomass of dicot and total weeds was recorded significantly lower under oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP as compared to rest of the treatments except pendimethalin 500 g/ha PE *fb* HW at 60 DAP, oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP and twice hand weeding at 30 and 60 DAP. Similar trend was observed for dry biomass of monocot weeds.

At harvest, significantly lower dry biomass of dicot and total weeds was recorded under oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP as compared to pendimethalin 1000 g/ha PE, pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank Mix) and weedy check. Among all the weed management practices, maximum weed control index was recorded under oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP which was followed by pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank Mix), twice hand weeding at 30 and 60 DAP and oxyfluorfen 240 g/ha PoE *fb* HW at 60 DAP.

Significantly higher bulb weight and bulb yield of garlic (6.15 t/ha) were recorded under paddy straw mulch 5 t/ha. Further, it was observed that among all weed management treatments, oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP recorded significantly higher bulb weight and bulb yield (7.44 t/ha) than other treatments. Thus, application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP with paddy straw mulch 5.0 t/ha recorded higher bulb yield, gross return, net return and benefit cost ratio which was closely followed by pendimethalin 500 g/ha + oxyfluorfen 120 g/ha EPoE (Tank Mix) and pendimethalin 500 g/ha + oxyfluorfen 120 g/ha PE (Tank mix).

WP 1.5.3 Studies of weed management in Ajwain (*Trachyspermum ammi*)

MPUAT, Udaipur

To study the bio-efficacy of combination of herbicides against weed complex in Ajwain, a field experiment was conducted in *Rabi* 2017-18. Prominent weed species in experimental plot were *Chenopodium album, Chenopodium murale, Fumaria parviflora, Convolvulus arvensis, Malwa parviflora, Melilotus indica* and *Phalaris minor*. Pre-emergence application of oxadiargyl 100 g/ha + one hand weeding at 50 DAS recorded minimum total weed density followed by other treatments. The lowest monocot, dicot and total weeds dry matter at 60 DAS and at harvest was observed by management practice of two hand weeding at 25 and 50 DAS. Among herbicidal traetments, pre-emergence application of oxadiargyl 100 g/ha + one hand weeding at 50 DAS reduced

Table 1.5.3.1 Effect of treatments on weed dry matter and weed control efficiency (WCE) of ajwain

Treatments	Dose (kg /ha)	Application stage (DAS)	Weed dry matter			Weed control efficiency (WCE)			Seed yield (kg/ha)	Straw yield (kg/ha)	Net return (₹/ha)	B:C ratio
			Monocot	Dicot	Total	Monocot	Dicot	Total				
Pendimethalin + 1 HW 50 DAS	1000	PE	6.03	141.3	147.3	89.0	83.0	83.6	564	1.12	39,765	1.23
Pendimethalin *fb* quizalofop-ethyl	750 + 40	PE & PoE (3-4 leaf stage)	18.0	253.7	271.7	66.0	71.0	70.4	587	1.18	46,694	1.64
Oxadiargyl + 1 HW at 50 DAS	100	PE	0.00	139.7	139.7	100.0	84.0	84.6	678	1.34	58,350	2.03
Oxadiargyl *fb* quizalofop-ethyl	75+ 40	PE & PoE (3-4 leaf stage)	12.0	155.3	167.3	78.0	83.0	82.9	646	1.32	57,353	2.22
Oxyfluorfen + 1 HW at 50 DAS	100	PE	6.03	212.3	218.3	89.0	74.0	75.3	591	1.14	47,955	1.73
Oxyfluorfen *fb* quizalofop-ethyl	75+40	PE & PoE (3-4 leaf stage)	18.1	288.5	306.5	66.0	67.0	66.9	575	1.17	48,426	1.94
One hoeing at 25	--	25 DAS	30.0	328.1	358.1	44.0	61.0	59.7	585	1.18	48,995	1.87
Two hoeing (2)	--	25 DAS & 50 DAS	0.00	71.0	71.0	100.0	91.0	91.6	697	1.42	59,353	1.96
Weedy check	--	--	54.1	844.3	898.3	0.0	0.0	0.0	241	0.49	8,757	0.39
SEm ±	-	-	0.43	7.40	7.73	-	-	-	21	0.05	-	-
LSD (P = 0.05)	-	-	1.28	22.2	23.2	-	-	-	64	0.17	-	-

maximum dry matter of monocot, dicot and total weeds (0.00, 139.70 and 139.70 g/ha) followed by pendimethalin 100 g/ha as pre-emergence + one hand weeding at 50 DAS. At 60 DAS and harvest, maximum weed control efficiency recorded by management practice with two hand weeding at 25 and 50 DAS was 100% and 91%, respectively by monocot, dicot and total weeds. However, among herbicidal treatments, maximum weed control efficiency was recorded by pre-emergence application of oxadiargyl 100 g/ha + one hand weeding at 50 DAS followed by pendimethalin 100 g/ha as pre-emergence + one hand weeding at 50 DAS. Highest plant height (125.6 cm), number of branches per plant (71.9) and number of umbels per plant (72.3) were recorded with pre-emergence application of oxadiargyl 100 g/ha + one hand weeding at 50 DAS followed by pendimethalin 100 g/ha as pre-emergence + one hand weeding at 50 DAS.

The maximum seed yield (697 kg/ha) was recorded with weed free treatment. Among herbicidal treatments, pre-emergence application of oxadiargyl 100 g/ha + one hand weeding at 50 DAS recorded the maximum seed yield (678 kg/ha) significantly over rest of the treatments except oxadiargyl 75 g/ha + quizalofop-ethyl 40 g/ha. The highest net returns (₹ 58,350/ha) was realized with pre-emergence application of oxadiargyl 100 g/ha + one hoeing at 50 DAS.

WP 1.5. 4 (i) Weed management in kinnow basins

SKUAST, Jammu

To study different weed management options in kinnow, an experiment was conducted during 2017-18. The most dominant weeds in the experimental fields during *Rabi* were *Anagallis arvensis, Medicago denticulata, Vicia sativa, Melilotus indica, Rumex* spp. and *Cynodon dactylon*; in summer, *Solanum nigrum, Physalis minima, Amaranthus viridis, Imperata cylindrica. Cynodon dactylon*, *Alternanthera philoxeroides, Cirsium arvensis, Erigeron* spp., *Phyllanthus niruri, Digitaria sanguinalis, Imperata cylindrica* and *Paspalum* spp. in *Kharif* season.

In *Rabi* and *Kharif* seasons, lower density and biomass of broad-leaved, grassy weeds and maximum weed control efficiency were recorded in polythene mulch followed by atrazine 2.0 kg/ha + paddy straw muching *fb* glyphosate 1.0% and pendimethalin 1.0 kg/ha + paddy straw muching *fb* glyphosate 1.0%. In summer, lowest weed density, biomass and maximum WEC were recorded in polythene mulch followed by application of paraquat 0.5% and glyphosate 1.0%. Among the weed management treatments, polythene mulch gave significantly higher number of fruits, fruit size and fruit yield followed by atrazine 2.0 kg/ha + paddy straw muching *fb* glyphosate 1.0% and pendimethalin 1.0 kg/ha + paddy straw muching *fb* glyphosate 1.0%. However, highest net return and benefit cost ratio was recorded in these herbicidal treatments, whereas lowest in polythene mulch.

WP 1.5.4 (ii) Effect of pre- and post-emergence herbicides on weed flora and yield of direct-seeded rice

A field experiment was conducted to study the effect of pre- and post-emergence herbicidal weed management in direct-seeded rice during *Kharif* 2018. The experimental field was dominated by *Echinochloa* spp. and *Digitaria sanguinalis* amongst grassy weeds; *Phyllanthus niruri* and *Physalis minima* amongst broad-leaved weeds and *Cyperus* spp. Besides these major weeds, *Commelina benghalensis, Cucumis* spp. *Caesulia axillaris, Euphorbia* spp. and *Dactyloctenium aegyptium* were recorded as other weeds.

At 30 DAS, significantly lowest weed density was recorded with oxyflourfen 175 g/ha as pre-emergence than other treatments, whereas, at 60 DAS and harvest, oxyflourfen 175 g/ha *fb* fenoxaprop-p-ethyl + 2-4-DEE (60+500 g/ha) at 25 DAS or pendimethalin 1000 g/ha *fb* bispyribac-sodium 25 g/ha at 25 DAS recorded significantly lowest total density of weeds and weed biomass than other treatments. The highest number of panicles/m^2 and number of grains/panicle were recorded with pendimethalin 1000 g/ha *fb* bispyribac-sodium 25 g/ha at 25 DAS which was statistically at par with pretilachlor 600 g/ha *fb* penoxsulam + cyhalofop-butyl 150 g/ha at 25 DAS. The highest grain yield and straw were recorded in pendimethalin 1000 g/ha (PE) *fb* bispyribac-sodium 25 g/ha at 25 DAS which was statistically at par with pretilachlor 600 g/ha *fb* penoxsulam + cyhalofop-butyl 150 g/ha at 25 DAS and significantly higher than all other herbicidal treatments. The highest B: C ratio was recorded in pendimethalin 1000 g/ha (PE) *fb* bispyribac-sodium 25 g/ha at 25 DAS followed by pretilachlor 600 g/ha *fb* penoxsulam + cyhalofop-butyl 150 g/ha at 25 DAS.

WP 1.5.4 (iii) Monitoring of weeds dynamics in different cropping system under assured irrigated conditions of Jammu region

An experiment was conducted to study weed dynamics in different cropping systems. The experimental field was dominated by *Echinochloa* spp. and *Cynodon dactylon* among grassy weeds; *Alternanthera philoxeroides* among broad-leaved weeds and *Cyperus* spp. The lowest density of *Echinochloa* spp. was recorded in rice-berseem-berseem (seed) and rice-cauliflower-cucumber cropping sustems which were statistically at par with rice-knol khol-cowpea. However, highest density of *Echinochloa* spp. was recorded in rice-wheat followed by rice-broccoli-blackgram. The lowest density of *Cyperus* spp. was recorded in rice-knol, khol-cowpea while highest in

Table 1.5.4.1(ii) Effect of weed management treatments on weed density, weed biomass, grain yield and straw yield in direct-seeded rice during *Kharif* 2018

Treatment	Total weed density (No./m²)			Total weed biomass (g/m²)		Grain yield (t/ha)	Straw yield (t/ha)	B: C ratio
	30 DAS	60 DAS	At harvest	60 DAS	At harvest			
Pendimethalin 1000 g/ha	7.23 (51.3)	8.26 (67.3)	7.83 (60.3)	7.42 (54.0)	9.17 (83.0)	1.94	3.84	2.00
Pretilachlor 600 g/ha	8.06 (64.0)	9.18 (83.3)	8.75 (75.7)	8.27 (67.5)	10.44 (108.0)	1.65	3.32	1.64
Oxyflourfen 175 g/ha	6.16 (37.0)	7.33 (52.7)	7.14 (50.0)	6.46 (40.8)	8.17 (65.7)	1.58	3.12	1.43
Bispyribac-sodium 25 g/ha at 25 DAS	10.7(114.0)	6.60 (42.7)	6.27 (38.3)	5.66 (31.0)	7.59 (56.6)	2.12	4.31	2.24
Penoxsulam + cyhalofop-butyl 150 g/ha at 25 DAS	10.8 (115.7)	6.76 (44.7)	6.32 (39.0)	6.07 (35.9)	8.16 (65.6)	1.60	3.23	1.45
Fenoxaprop-p-ethyl + 2-4-D -EE (60+500 g/ha) at 25 DAS	10.7 (114.3)	6.65 (43.3)	6.29 (38.7)	5.50 (29.3)	6.92 (46.9)	1.80	3.53	1.70
Pendimethalin1000 g/ha *fb* bispyribac-sodium 25 g/ha at 25 DAS	7.18 (50.7)	4.20 (16.7)	3.95 (14.7)	3.69 (12.6)	4.61 (20.3)	2.67	5.53	2.78
Pretilachlor 600 g/ha *fb* penoxsulam + cyhalofop-butyl 150 g/ha at 25 DAS	8.10 (64.7)	5.03 (24.3)	4.65 (20.7)	4.51 (19.5)	5.52 (29.5)	2.45	4.91	2.50
Oxyflourfen 175 g/ha *fb* fenoxaprop-p-ethyl + 2-4-D -EE (60+500 g/ha) at 25 DAS	6.38 (39.7)	4.35 (18.0)	4.07 (15.7)	3.55 (11.61)	4.07 (15.6)	2.08	3.85	1.84
Control	10.9 (117.7)	11.53 (132.0)	11.06 (121.3)	10.76 (114.9)	14.06 (196.7)	1.11	2.09	0.87
SEm ±	0.13	0.14	0.12	0.17	0.16	0.11	0.23	-
LSD (P=0.05)	0.38	0.41	0.35	0.50	0.49	0.314	0.692	-

Data was subjected to square root transformation $\sqrt{x+1}$ Original values are in parenthesis rice-pea-bottle gourd and rice-potato-okra. The highest density of *Alternanthera philoxeroides* was recorded in rice-knol khol-cowpea and lowest in rice-oat-oat (seed). The lowest density of *Cynodon dactylon* was recorded in rice-potato-okra.

Table 1.5.4 (iii) Weed density and total weed biomass in different cropping systems under assured irrigated conditions at 40 DAT (After 9 years)

Cropping System	*Echinochloa* spp. (No./m²)	*Cyperus* spp. (No./m²)	*Alternanthera philoxeroides* (No./m²)	*Cynodon dactylon* (No./m²)	Total weed density (No./m²)	Total weed dry weight (g/m²)
Rice -wheat	3.30 (10)	1.62 (2)	2.24 (4)	1.98 (3)	4.47 (19)	5.09 (25.0)
Rice -wheat-green manure (daincha)	2.62 (6)	1.31 (1)	1.62 (2)	1.73 (2)	3.43 (11)	4.13 (16.1)
Rice - berseem- berseem (seed)	1.93 (3)	1.93 (3)	1.62 (2)	1.98 (3)	3.43 (11)	3.98 (14.9)
Rice - knol khol- cowpea	2.24 (4)	1.00 (0)	2.63 (6)	1.68 (2)	3.58 (12)	4.13 (16.2)
Rice - pea- bottle gourd	2.43 (5)	2.24 (4)	2.43 (5)	1.68 (2)	4.11 (16)	4.69 (21.1)
Rice - cauliflower- cucumber	1.93 (3)	1.31 (1)	1.73 (2)	1.68 (2)	3.00 (8)	3.45 (10.9)
Rice - barley+chickpea-greengram	2.43 (5)	1.31 (1)	1.93 (3)	1.68 (2)	3.45 (11)	4.09 (15.7)
Rice - broccoli- blackgram	3.09 (9)	1.62 (2)	2.43 (5)	1.68 (2)	4.35 (18)	4.83 (22.5)
Rice - oat- oat (seed)	2.82 (8)	1.62 (2)	1.37 (1)	1.98 (3)	3.85 (14)	4.47 (19.2)
Rice - potato- okra	2.81 (7)	2.24 (4)	1.73 (2)	1.00 (0)	3.71 (13)	4.38 (18.3)
SEm±	0.15	0.25	0.22	0.20	0.19	0.16
LSD (P = 0.05)	0.45	0.74	0.66	0.58	0.58	0.48

Data are subjected to square root transformation ($\sqrt{X+1}$); Original values are in parenthesis

WP 1.5.5 Weed management in jute

BCKV, Kalyani

A field experiment was conducted to study the effect of chemical and cultural practices in controlling weeds in jute. The experimental findings revealed that the treatment with nail weeder- 1st at 5-6 DAE and 2nd at 10 DAE + one hand weeding (within the row) at 15 DAE effectively suppressed the weed biomass and recorded the highest plant height (354.6 cm) and fibre yield (3.92 t/ha). Greengram (*var*. Pant Mung 5) intercropped with jute suppressed the weeds effectively and recorded the

Table 1.5.5.1 Jute yield, weed biomass production and economics as affected in different treatments of weed management

Treatment	Jute fibre equivalent yield (q/ha)		Weed biomass production(q/ha) at DAE: 15 DAE		35 DAE		45 DAE		WCE (%)		B:C ratio	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1	38.0	37.1	0.09	0.14	0.13	0.82	0.67	0.95	66.6	64.4	1.75	1.72
T_2	40.1	39.2	0.05	0.09	0.08	0.78	0.57	0.87	71.3	67.5	1.83	1.80
T_3	34.8	32.7	0.58	0.32	0.15	0.45	0.55	0.55	72.2	75.4	1.52	1.50
T_4	33.9	33.3	0.55	0.39	0.11	0.41	0.50	0.60	74.8	73.9	1.55	1.54
T_5	18.2	17.3	0.78	0.89	1.43	2.15	2.03	2.33	0.0	0.0	0.45	0.40
T_6	36.0	35.1	0.56	0.50	0.22	0.42	0.54	0.64	72.7	70.9	1.51	1.48
SEm±	0.75	0.75	0.06	0.06	0.05	0.05	0.05	0.04	--	--	--	--
LSD (P=0.05)	2.25	2.35	0.18	0.17	0.15	0.25	0.15	0.15	--	--	--	--

T_1= Pretilachlor 50 % EC 900ml/ha at 45-48 hours of sowing with irrigation + one hand weeding (15 DAE)T_2 =Nail weeder- 1st at 5-6 DAE and 2nd at 10 DAE + one hand weeding (within the row) at 15 DAE; T_3 =Jute + Green gram (Pant Mung 5) (1:1 replacement series); T_4 =Jute + Green gram (TMB 37) (1:1 replacement series); T_5 =Unweeded check; T_6 =Two hand weeding (HW) at 15-20 DAE and at 35-40 DAE highest weed control efficiency but gave significantly lower jute fibre equivalent yield as compared to sole crop of jute. However, in 2017, treatment with greengram (*var*. TMB 37) was found superior over other varieties. The highest cost of cultivation was incurred in two hand weedings at 15-20 DAE and at 35-40 DAE while highest net return was recorded with nail weeder- 1st at 5-6 DAE and 2nd at 10 DAE + one hand weeding (within the row) at 15 DAE.

From economic point of view, treatment with greengram *var.* TMB 37 was more promising one than variety *Pant Mung 5* , based on two years' data, it may be concluded that treatment having use of nail weeder- 1st at 5-6 DAE and 2nd at 10 DAE + one hand weeding (within the row) at 15 DAE can be a very good option of weed management in jute.

WP 1.5.6 Effect of shading on growth, development and reproductive biology of seven major weed species of winter season

GBPUAT, Pantnagar

The experiment was conducted in the winter 2017-18 to evaluate the effects of shading on growth, development and reproductive biology of seven major weed species of winter season viz. *Phalaris minor, Polypogon monspeliensis*, *Melilotus indica, Medicago denticulata, Lathyrus aphaca, Vicia sativa,* and *Solanum nigrum.* It was reported that the total duration was delayed by more than two weeks under 55% shading while it was delayed by as much as four weeks under 75% shading **(Table 1.5.6.1)**.

Table 1.5.6.1 Changes in total duration of weed species under different shading

Weed species	Total duration (days)		
	Full sunlight	55% shading	75% shading
Phalaris minor	144	157	171
Polypogon monspeliensis	131	143	172
Melilotus indica	118	137	151
Medicago denticulata	126	143	158
Lathyrus aphaca	118	128	140
Vicia sativa	140	138	156
Solanum nigrum	134	151	174

However, on an average, plant height increased by more than 40 cm under shading for all the seven weed species under study. More than 75% decrease in dry matter production was observed in shading. In case of grassy weeds *Phalaris* and *Polypogon*, total above ground dry matter decreased by 67-78% under 55% shading and by 84-95% under 75% shading. Broad-leaved weeds with the exception of *Solanum* exhibited a 60-72% reduction in dry matter accumulation under 55% shading while at 75% shading the values ranged from 78-91%. In case of *Solanum,* percentage reduction in dry matter was relatively low as compared to other dicot weeds. It was about 49% under 55% shading, and 70% under 75% shading in *Solanum*. Net Assimilatory Rate (NAR) was halved on an average in weed species under shade. The lowest reduction in NAR was noted in *Polypogon* spp. among grasses and for *Solanum* spp. among dicot weeds. The reduction in maximum NAR of the order of 65-71% was noted in case of 55% shading for all the weed species under study, while under 75%, percentage reduction in maximum NAR ranged from 87-95% for all weeds under study.

The number of reproductive structures was highly reduced under shade. Under shading, the number of fruits per plant **(Table 1.5.6.2**) and seeds per plant **(Table 1.5.6.3**) were reduced by more than 60% and 75% approximately. Although, the number of seeds per fruit was fairly constant, 100 seed weight decreased by 15-25% for all the seven weeds species under study. Under shade, the resource partitioning towards reproductive organs was declined and there is a species dependent delay in onset of flowering. Both of these together lead to reduced number of flowers per plant and in turn reduced number of fruits per plant.

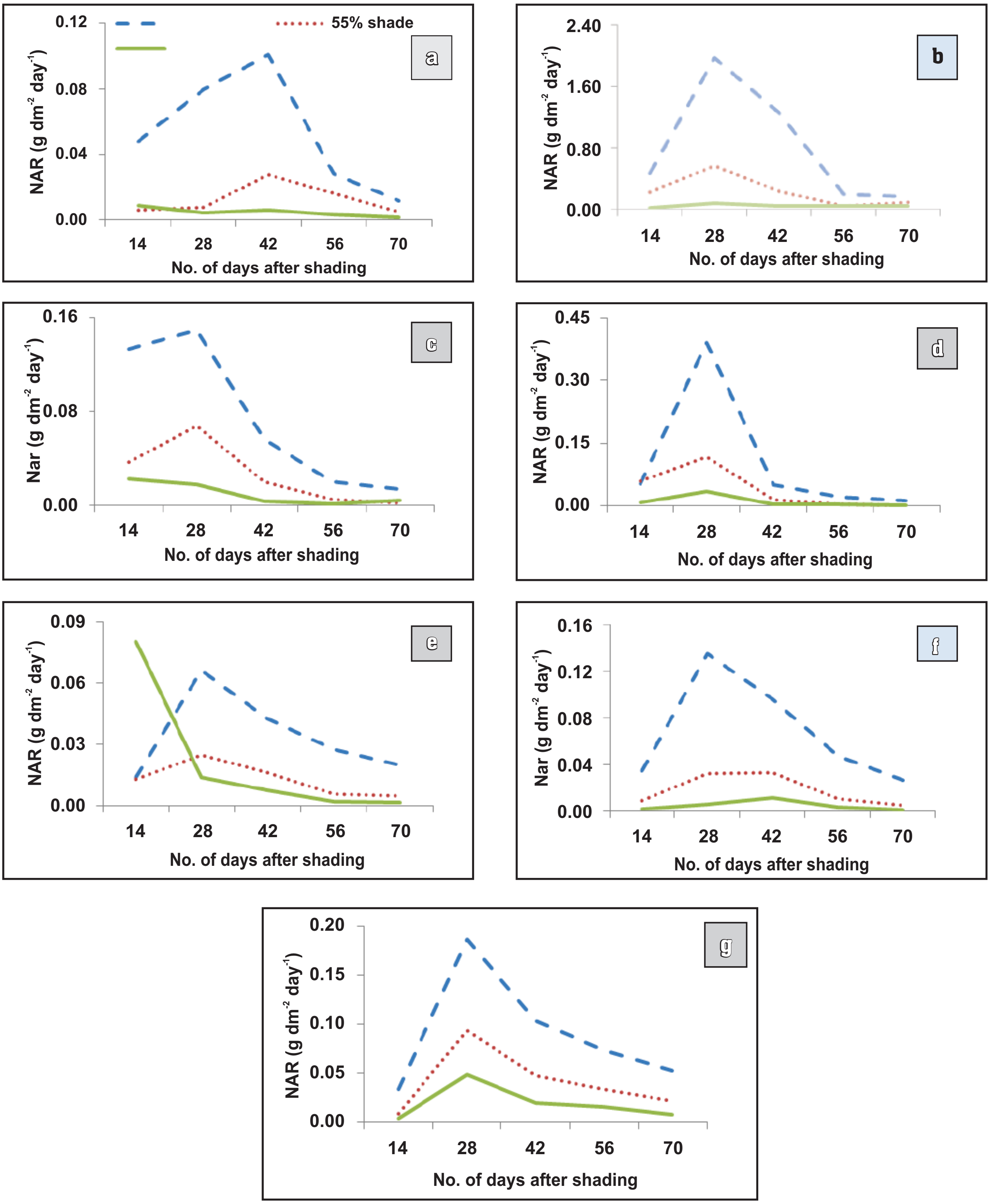


Fig. 3 NAR at different intervals of shading in *Phalaris minor* (a), *Polypogon* sp. (b), *Melilotus alba* (c), *Medicago sativa* (d), *Lathyrus aphaca* (e), *Vicia sativa* (f), and *Solanum nigrum* (g)

Table 1.5.6.2 No. of fruits/plant for various dicot weeds under full sunlight and shading

	No. of fruits/plant				
Weed species	**Full sunlight**	**55% shade**	**75% shade**	**CD**	**SE(m)**
M. denticulata	1056	375	152	1.2	0.3
L. aphaca	68	18	12	9.4	2.3
V. sativa	49	19	10	5.9	1.4
S. nigrum	575	338	179	3.4	0.7

Table 1.5.6.3 Total number of seeds per plant for all seven weeds species under study

	No. of seeds per plant				
Weed Species	**Full sunlight**	**55% shade**	**75% shade**	**CD**	**SE(m)**
P. minor	3911	1482	727	7.2	1.87
M. indica	1261	814	381	1.4	0.36
M. denticulata	4614	1919	558	8.14	2.02
L. aphaca	362	90	61	2.6	0.6
V. sativa	572	209	108	2.02	0.5
S. nigrum	39520	22238	11464	38.6	9.57

WP 1.5.7 Weed management in millets

WP 1.5.7.1 Integrated weed management in little millet (*Panicum sumatrense)*

UAS, Bengaluru

A field experiment was conducted during *Kharif* 2018 to study the effect of weed control methods on growth, yield and quality of little millet and weed control efficiency. Treatments were (i) PE-pendimethalin 1.0 kg/ha *fb* intercultivation at 30 DAS (ii) PE- oxyfluorfen 0.5 kg/ha + intercultivation at 30 DAS (iii) PE- oxadiargyl 70 g /ha + intercultivation at 30 DAS (iv) PE- bensulfuron + pretilachlor 660 g/ha (RM) + intercultivation at 30 DAS (v) PE-pendimethalin 1.0 kg/ha + POE 2,4-D Na salt 0.5 kg/ha (vi) PE- pendimethalin 1.0 kg/ha + POE byspyribac Na 100 ml/ha (vii) PE oxyfluorfen 0.5 kg/ha + POE 2, 4-D Na salt 0.5 kg/ha (viii) PE-oxyfluorfen 0.5 kg/ha + POE byspyribac - Na 100 ml/ha (ix) PE oxadiargyl 70 g /ha + POE 2,4-D Na salt 0.5 kg/ha (x) PE -oxadiargyl 70 g /ha + POE byspyribac - Na 100 ml/ha (xi) PE -bensulfuron + pretilachlor 660 g/ha (RM) + POE 2,4-D Na salt 0.5 kg/ha (xii) inter cultivation twice at 20 and 40 DAS (xiii) hand weeding at 20 & 40 DAS (xiv) unweeded control.

Results revealed that despite applying pre-emergence herbicides there was complete failure of germination of seeds when herbicides were sprayed and in the intercultivation and hand weeding treatments 100% germination was recorded. The result indicted that the herbicide dosage that was tested caused phytotoxicity. However, in the second stage, dosage of herbicides as per the treatement was reduced to 50% and sprayed on the re-sown plots of little millet by dividing each of the plots. In this attempt also, the plots applied with 50% of the tested dose of herbicides, there was complete failure of germination, while unsprayed plot recoded 100% germination.

WP 1.5.8 Management of mixed weed flora in potato

PAU, Ludhiana

An experiment was conducted during autumn 2017-18 to study the effect of post-emergence application of pre-mix of clodinafop and metribuzin on weeds and tuber yield of potato. The major weed flora in the experimental field was *Eleusine indica* among grass and *Anagallis arvensis, Rumex dentatus, Medicago denticulata,* and *Coronopus didymus* among broad-leaved weeds. Post-emergence application of pre-mix of clodinafop and metribuzin at 260 and 325 g/ha had 100% weed control at 14 days after application. Clodinafop alone controlled grass weed only. Pre-mix of clodinafop and metribuzin at all doses recorded significantly lower biomass of grass and broad-leaf weeds as compared to unsprayed control. Pre-mix of clodinafop and metribuzin at 325 g/ha recorded the highest potato tuber yield and it was statistically similar to its lower doses 195 and 260 g/ha and weed free check. All weed control treatments except clodinafop 60 g/ha gave significantly higher potato tuber yield than unsprayed check.

Table 1.5.8.1 Effect of weed control treatments on biomass of crop and weeds, yield attributes and yield of potato during autumn 2017-18

Treatment	Weed biomass at 30 DAS (g/m^2)			Crop biomass at 30 DAS (g/plant)	Weed biomass at harvest (g/ha)	Tubers (No./ plant)	Tuber weight (kg/plant)	Tuber yield (t/ha)
	Grasses	Broadleaved weeds	Sedges					
Weedy check	2.5 (5)	5.0 (24)	3.6 (12)	20.9	11.2 (125)	7.5	0.25	14.5
Weed free	1.0 (0)	1.0 (0)	1.0 (0)	35.5	1.0 (0)	12.2	0.50	29.0
Metribuzin (Pre) 350 g/ha	1.4 (1)	1.3 (1)	2.6 (6)	24.8	10.1 (100)	11.4	0.36	21.6
Metribuzin (Post) 350 g/ha	2.1 (3)	2.4 (5)	3.3 10)	24.7	7.6 (57)	11.1	0.45	25.6
Clodinafop 60 g/ha	2.1 (3)	5.1 (26)	3.0 (9)	20.9	11.3 (131)	9.2	0.28	14.7
Clodinafop+ metribuzin 195 g/ha	1.9 (3)	2.6 (6)	3.2 (9)	28.5	5.7 (31)	11.1	0.49	28.6
Clodinafop+ metribuzin 260 g/ha	1.4 (1)	2.0 (3)	2.9 (7)	30.3	4.6 (20)	11.3	0.50	30.9
Clodinafop+ metribuzin 325 g/ha	1.3 (1)	1.8 (2)	2.4 (5)	34.7	4.1 (16)	11.3	0.51	31.1
SEm ±	0.06	0.1	0.3	2.3	0.5	0.6	0.02	0.49
LSD (P=0.05)	0.2	0.4	0.8	8.5	1.6	1.9	0.05	1.47

Data is subjected to square root transformation. Figures within parenthesis are means of original values.

WP 1.5.9 (i) Integrated weed management in turmeric

CSKHPKV, Palampur

Twelve integrated weed control treatments were evaluated to study the effect of treatments on the productivity of turmeric. During 2018, the last years experiment was continued after estimating the yield. During the off-season, general weed control measures were adopted i.e. spray of glyphosate and general cleaning. The treatments consisted of metribuzin 0.7 kg/ha *fb* two handweeding, metribuzin 0.7 kg/ha *fb* straw mulch 5 t/ha *fb* one hand weeding, pendimethalin 1.0 kg/ha *fb* two hoeings, pendimethalin 0.7 kg/ha *fb* straw mulch 5 t/ha *fb* one hand weedings, atrazine 0.75 kg/ha *fb* two hand weeding, atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* one hand weeding, pendimethalin 0.5 kg/ha + atrazine 0.375 kg/ha *fb* hand weeding twice, imazethapyr 75 g/ha *fb* hand weeding twice, imazethapyr 100 g/ha *fb* hand weeding twice, hand weeding thrice, organic weed management (mulch twice + hand weeding) and weedy check.

In the month of October, 2017; weeds, *viz. Echinochloa colona, Digitaria sanguinalis, Commelina benghalensis, Cyperus iria, Cynodon dactylon, Paspalum dilatatum, Alternanthera philoxeroides, Ageratum conyzoides, Pennisetum clandestinum, Setaria glauca, Bidens pilosa* and *Aeschynomene indica* were found growing in turmeric. *A. philoxeroides* was the most important weed with highest density, abundance and frequency followed by *C. dactylon*, *C. iria* and *D. sanguinalis*. However, during 2018, the weed flora shifted to *Ageratum* sp. (67%), *Cyperus* sp. (5.8%), *Echinochloa* sp. (3.1%), *Commelina* sp. (4.3%), *A. philoxeroides* (15.8%), *Polygonum alatum* (3.1%) and *Bidens pilosa* (0.9%).

Weed control treatments significantly affected the number of *Ageratum* and *Cyperus* sp. at all the stages of observation and on the mean basis. These weeds were significantly lower in treatments where mulch was applied **(Table 1.5.9.1)**. Total count of other weeds viz. *Echinochloa* sp., *Commelina* sp., *Alternanthera* sp., *Polygonum* sp. and *Bidens* sp. were not significantly affected. However, there was significant variation in the total weed count due to treatments.

Table 1.5.9.1 Effect of treatments on count (No./m^2) of weeds in turmeric

Treatment	*Ageratum*	*Cyperus*	*Echin-ochloa*	*Comm-elina*	*Altern-anthera*	*Polyg-onum*	*Bidens*	Total weed count
Metribuzin 0.70 kg/ha *fb* hand weeding (HW) twice	21.1 (444.0)	7.0 (50.7)	2.8 (9.3)	4.2 (17.8)	5.7 (37.3)	2.9 (10.7)	0.7 (0.0)	23.8 (569.8)
Metribuzin *fb* straw mulch *fb* HW	8.8 (88.5)	3.2 (9.8)	2.1 (8.0)	5.7 (32.9)	9.3 (88.0)	2.9 (10.7)	1.4 (2.7)	15.4 (240.5)
Pendimethalin 1.0 kg/ha *fb* HW twice	18.1 (329.3)	4.2 (21.3)	1.2 (1.3)	1.6 (2.7)	7.2 (65.8)	2.6 (8.0)	0.7 (0.0)	20.6 (428.5)
Pendimethalin *fb* straw mulch *fb* HW	6.2 (41.1)	3.0 (8.9)	0.7 (0.0)	3.1 (12.4)	5.3 (34.7)	1.8 (5.3)	2.1 (8.0)	10.2 (110.4)
Atrazine 0.75 kg/ha *fb* HW twice	15.2 (231.7)	3.2 (15.1)	3.6 (20.0)	2.9 (10.0)	7.3 (65.3)	5.4 (29.3)	1.4 (2.7)	19.3 (374.1)
Atrazine *fb* straw mulch *fb* HW	9.5 (91.3)	2.4 (7.1)	2.6 (8.0)	3.7 (15.1)	8.4 (72.0)	1.8 (5.3)	2.2 (5.3)	14.3 (204.2)
Pendimethalin 0.5 + atrazine 0.375 kg/ha *fb* HW twice	12.9 (198.7)	3.5 (14.2)	0.7 (0.0)	6.2 (45.3)	6.9 (54.7)	1.4 (2.7)	2.1 (8.0)	17.4 (323.6)
Imezethapyr 75 g/ha *fb* HW twice	17.1 (304.7)	3.7 (13.3)	3.4 (16.0)	2.6 (6.2)	9.1 (92.0)	3.5 (16.0)	1.4 (2.7)	21.0 (450.9)
Imazethapyr 100 g/ha *fb* HW twice	18.0 (323.8)	7.0 (50.7)	4.7 (26.7)	2.8 (9.8)	4.7 (30.0)	4.6 (29.3)	1.4 (2.7)	21.7 (472.9)
Hand weeding thrice	17.1 (298.0)	5.4 (31.1)	4.1 (18.7)	2.6 (7.1)	2.1 (4.7)	0.7 (0.0)	0.7 (0.0)	18.8 (359.6)
Organic weed management (Mulch + HW)	8.8 (94.7)	2.2 (8.9)	1.4 (2.7)	2.9 (8.0)	9.4 (88.7)	2.9 (10.7)	0.7 (0.0)	14.2 (213.6)
Un-weeded check	19.9 (412.7)	3.8 (16.0)	4.0 (21.3)	3.3 (14.2)	5.3 (38.7)	1.8 (5.3)	2.1 (8.0)	22.4 (516.2)
SEm±	1.8	1.0	1.2	1.0	1.6	1.1	0.8	1.5
LSD (P=0.05)	5.4	3.1	NS	NS	NS	NS	NS	4.5

Mean of all observations during 2018 ; Data transformed to square root transformation; Values in bracket are the mean of original value

WP1.5.9 (i) Evaluation of herbicide combinations for weed management in okra

Twelve treatment combinations namely pendimethalin (pre) 1500 g/ha, pendimethalin (pre) 1000 g/ha *fb* imazethapyr (post) 100 g/ha, imazethapyr (pre) 100 g/ha *fb* imazethapyr (post) 100 g/ha, imazethapyr + pendimethalin (pre) 1200 g/ha, imazethapyr + pendimethalin (pre) 1500 g/ha, imazethapyr + pendimethalin (pre) 1000 g/ha *fb* imazethapyr (post) 100 g/ha, imazethapyr + imazamox (post) 60 g/ha, imazethapyr + imazamox (post) 90 g/ha, pendimethalin (pre) 1000 g/ha *fb* imazethapyr + imazamox (post) 60 g/ha, pendimethalin (pre) 1000 g/ha *fb* HW (30 DAS), hand weedings (30 and 45 DAS) and weedy check were evaluated in a randomized block design with three replications.

The major weed flora of the experiment field was comprised of *Cyperus rotundus* (34.6%), *Commelina benghalensis* (27.1%), *Galinsoga parviflora* (14.1%), *Panicum dichotomiflorum* (13.1%), *Echinochloa colona* (7.4%) and other minor weeds. Pendimethalin (pre) 1000 g/ha *fb* hand weeding (30 DAS), pendimethalin (pre) 1500 g/ha alone and hand weeding twice (30 and 45 DAS) resulted in significantly lower total weed count and dry weight than most of the other weed control treatments. However, hand weeding twice (30 and 45 DAS) resulted in highest WCE followed by pendimethalin (pre) 1000 g/ha *fb* hand weeding (30 DAS) and pendimethalin (pre) 1500 g/ha alone. Hand weeding twice (30 and 45 DAS), pendimethalin (pre) 1500 g/ha alone and pendimethalin (pre) 1000 g/ha *fb* imazethapyr (post) 100 g/ha had higher final plant population than other treatments. Phytotoxicity induced by imazethapyr resulted in significantly lower final plant stand in the treatments constituting of it. Treatments like pendimethalin (pre) 1500 g/ha alone, hand weeding twice (30 and 45 DAS), pendimethalin (pre) 1000 g/ha *fb* imazethapyr (post) 100 g/ha, imazethapyr + imazamox (post) 90 g/ha, imazethapyr + pendimethalin (pre) 1500 g/ha, imazethapyr (pre) 100 g/ha *fb* imazethepyr (post) 100 g/ha produced fruits with increased fruit length. However, pendimethalin (pre) 1000 g/ha *fb* hand weeding (30 DAS) and pendimethalin (pre) 1500 g/ha alone had more number of fruits/plant than other treatments. Pendimethalin (pre) 1000 g/ha *fb* hand weeding (30 DAS) remaining at par with imazethapyr + pendimethalin (pre) 1200 g/ha and pendimethalin (pre) 1500 g/ha alone resulted in significantly higher fresh fruit yield/plant and fruit yield per hectare over the other weed control treatments. As far as montery returns is concerned, pendimethalin (pre) 1000 g/ha *fb* hand weeding (30 DAS) resulted in higher net returns due to weed control followed by imazethapyr + pendimethalin (pre) 1200 g/ha and pendimethalin (pre) 1500 g/ha alone. Thus, overall the combination of herbicides viz. imazethapyr + pendimethalin (pre) 1200 g/ha is the better option for the control of mixed weed flora to obtain higher fruit yield of okra.

WP 1.5.10 (i) Long-term effect of continuous or rotational use of herbicides with or without green manuring in rice-wheat sequence (Permanent trial)

CCSHAU, Hisar

A field experiment was initiated on a permanent plot at CCS Haryana Agricultural University, Regional Research Station, Karnal during *Kharif* 1999 to study the effect of green manuring and continuous or rotational use of herbicides in rice and wheat on their weed control efficacy, shift in weed flora, development of resistance, growth and productivity of rice and wheat compared to rotation of herbicides and weedy check. The herbicidal treatments included fix herbicide (clodinafop 60 g/ha), rotational herbicide (clodinafop 60 g/ha *fb* sulfosulfuron 25 g/ha *fb* pinoxaden 50 g/ha) along with weed free and weedy check. Sulfosulfuron was the rotational herbicide in *Rabi* 2017-18.

During *Rabi* 2017-18, infestation of *Phalaris minor* under herbicide treated or weedy check plots was almost similar under green manuring (1.5-68.7 g/m^2) and non-green manuring (2.5-60.6 g/m^2), however, broadleaf weeds were more under green manuring (5.7-37.5 g/m^2) than non-green manuring (0.6-17.0 g/m^2) (Table 15.10.1). Grain yield of wheat under different treatments was more under green manuring (44.7-67.5 q/ha) plots than without green manuring (40.5-64.3 q/ha). There were no signs of development of resistance in *P. minor* against continuously/ rotationally used herbicides till now. During *Kharif* 2018, *Echinochloa crus-galli* was the dominant weed. The continuous or rotational use of butachlor provided effective control of weeds under both the situations of green manuring. Under weedy checks, dry weight of *Echinochloa* was similar under green manuring (257 g/m^2) and non-green manuring (240 g/m^2), while BLW and sedges were slightly higher under green manuring (26.1 & 16.9 g/m^2) than non-green manuring (9.7 & 3.0 g/m^2). Grain yield of rice under herbicide treated plots was significantly higher than weedy plots. Grain yield of rice under different treatments was significantly higher (4.00-6.15 t/ha) under green manuring than non-green manuring (3.62-5.61 t/ha).

Weed seed bank studies in long-term trial on green manuring and continuous or rotational use of herbicides

In *Rabi* 2017-18, there was emergence of *Phalaris minor, Melilotus indica, Coronopus didymus, Anagallis arvensis, Rumex dentatus* and other broadleaf weeds from the petri-pots filled with soil from different treatment plots. Emergence of *Phalaris minor* under different treatments was slightly higher under green manuring (3.0-24.3/pot) than non-green manuring (2.0-3.0/pot). Emergence of broadleaf weeds was also more under green manuring (57-75/pot) as compared to non-green manuring (42-63/pot). In *Kharif* 2018, *Echinochloa crus-galli* and *E. colona* among grasses; and *Trianthema monogyna* among broadleaf weeds were recorded in soil from different treatments **(Table 1.5.10.1)**. Under herbicide treated plots, emergence of *Echinochloa crus-*

galli was similar under green manuring and non-green manuring, while under weedy check plots, emergence of *E. crus-galli* was more under green manuring. In general, emergence of *Trianthema monogyna* was less under green manuring. There was no difference in emergence of *E. colona* and *Cyperus rotundus* under different treatments.

Table 1.5.10.1 Emergence of weeds under pot culture (No./pot)* during *Rabi* season in soil from long-term trial on continuous or rotational use of herbicides with or without green manuring in rice-wheat system

Treatment	*Rabi* 2017-18			*Kharif* 2018			
	Phalaris minor	Total BLW	Total weeds	*Echinochloa crus-galli*	*Echinochloa colona*	*Trianthema monogyna*	*Cyperus rotundus*
With green manuring							
Fix herbicide	1.99 (3.0)	8.69 (74.7)	8.86 (77.7)	4.66 (21.7)	1.28 (0.7)	1.14 (0.3)	1.14 (0.3)
Rotational herbicide	2.50 (5.3)	7.63 (57.3)	7.97 (62.7)	2.66 (6.3)	1.00 (0.0)	1.14 (0.3)	1.00 (0.0)
Weed free	3.03 (8.3)	8.82 (77.0)	9.28 (85.3)	1.58 (1.7)	1.14 (0.3)	1.00 (0.0)	1.14 (0.3)
Weedy check	5.02 (24.3)	8.31(68.3)	9.66 (92.7)	4.56 (20.0)	1.14 (0.3)	1.41 (1.3)	1.00 (0.0)
Without green manuring							
Fix herbicide	1.82 (2.3)	7.06 (49.0)	7.23 (51.3)	4.64 (20.7)	1.28 (0.7)	1.79 (2.3)	1.14 (0.3)
Rotational herbicide	1.72 (2.0)	6.55 (42.3)	6.70 (44.3)	1.38 (1.0)	1.00 (0.0)	1.41 (1.0)	1.00 (0.0)
Weed free	1.72 (2.0)	7.37 (53.3)	7.50 (55.3)	1.52 (1.3)	1.00 (0.0)	1.75 (2.3)	1.00 (0.0)
Weedy check	1.99 (3.0)	7.98 (62.7)	8.16 (65.7)	3.36 (10.3)	1.38 (1.0)	2.99 (8.0)	1.14 (0.3)
SEm ±	0.19	0.29	0.30	0.34	0.12	0.23	0.10
LSD (P=0.05)	0.57	0.86	0.88	1.01	NS	0.70	NS

*Original figures in parenthesis were subjected to square root transformation ($\sqrt{X+1}$) before statistical analysis

WP 1.5.10 (v) Evaluation of pendimethalin (applied 1 day before sowing) in sequence with other recommended herbicides for management of *Phalaris minor* in zero-till sown wheat

A field experiment was laid out during *Rabi* 2017-18 at CCS Haryana Agricultural University Regional Research Station, Karnal. The treatments included sequential application of pendimethalin 1500 g/ha (one day before sowing) alone and in sequence with POE herbicides clodinafop 60 g/ha, sulfosulfuron 25 g/ha, sulfosulfuron+ metsulfuron (ready-mix) 32 g/ha, mesosulfuron + iodosulfuron (ready-mix) 14.4 g/ha and pinoxaden 50 g/ha along with alone application of POT herbicides, weed free and weedy check. Results revealed that sequential application of pendimethalin 1000 g/ha *fb* post-em herbicides (clodinafop, sulfosulfuron, pinoxaden or mesosulfuron + iodosulfuron (RM)) provided effective control of *Phalaris minor* in zero-till wheat with lower dry weight of *P. minor* (2.1-9.3 g/m^2) as compared to alone applications of POE herbicides (22.0-37.9 g/m^2) and weedy check (116.7 g/m^2). However, there was phytotoxicity of 23-28% at 30 DAS which lowered to 15-20% at 45 DAS. The grain yields of wheat (5.26-5.66 t/ha) were lower under sequential treatments than weed free check (6.35 t/ha) due to phytotoxicity. This needs further confirmation with early application of pendimethalin (one week before sowing). The experiment will continue with application of pendimethalin 1 week before sowing (WBS).

WP 1.5.11 Weed management in Onion

OUAT, Bhubaneswar

To study the effect of weed control measures against weeds and on growth as well as yield of onion, an experiment was conducted during 2017-18 with treatments *viz*. pendimethalin 0.750 kg/ha at two DAP (Pre), oxyfluorfen 0.250 kg/ha at two DAP (Pre), quizalofop–p-ethyl 0.050 kg/ha at 20 DAP, pendimethalin *fb* quizalofop –p-ethyl 0.750 kg/ha *fb* 0.050 kg/ha at two DAP (Pre) *fb* 20 DAP, oxyfluorfen *fb* hand weeding 0.250 kg/ha *fb* 0.050 kg/ha at 2 DAP (Pre) *fb* 20 DAP, weed free (HW) 20,40 & 60 DAP and Un-weeded control.

Table1.5.11.1 Effect of different herbicides combinations on weed density, weed biomass, yield and economics in onion (*Rabi* 2017-18)

Treatment	Weed density (m-2)			Weed biomass (gm-2)			Fresh yield (t/ha)	Net profit (₹/ha)	B:C
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
Pendimethalin	5.5 (19.9)	5.2 (26.5)	6.7 (44.5)	3.1 (9.3)	3.6 (12.5)	5.7 (31.5)	18.8	45,630	2.49
Oxyfluorfen	5.3 (17.7)	4.8 (22.7)	6.4 (40.3)	2.9 (7.8)	3.0 (8.6)	5.3 (27.5)	21.2	54,263	2.20
Quizalofop –p-ethyl	24.3 (10.7)	13.9 (14.7)	5.5 (29.7)	4.1 (2.9)	3.5 (5.8)	5.1 (25.7)	21.0	54,258	2.19
Pendimethalin *fb* Quizalofop –p-ethyl	4.0 (9.3)	3.1 (5.3)	16.1 (36.7)	2.7 (6.7)	2.8 (7.2)	5.2 (26.8)	23.4	71,523	2.59
Oxyfluorfen *fb* hand weeding	6.4 (5.3)	3.3 (10.3)	6.2 (38.3)	1.8 (3.9)	2.1 (3.8)	4.5 (19.9)	21.9	65,236	2.32
Weedy free (HW)	3.8 (18.2)	4.9 (23.8)	6.5 (42.3)	2.9 (7.7)	3.1 (9.5)	5.3 (27.5)	27.2	85,426	2.62
Un-weeded control	12.9 (38.4)	24.0 (45.0)	36.6 (42.5)	13.0 (8.5)	23.2 (9.8)	25.3 (28.0)	6.7	15,423	1.66
SE(m)±	0.11	0.19	0.11	0.08	0.11	0.08	0.25	-	-
C.D (0.05)	0.34	0.55	0.33	0.24	0.31	0.24	0.84	-	-

WP 1.5.12 Bioefficacy of new generation herbicides for weed management in maize

PJTSAU, Hyderabad

An experiment was conducted to test the bioefficacy of tank-mix combinations of atrazine with new hydroxy-phenyl pyruvate dioxygenase (4-HPPD) inhibiting herbicides with and without adjuvants in maize during *Kharif* 2018. The treatments comprised of atrazine (1.0 kg/ha) as PE *fb* intercultivation at 30 DAS, topramezone (25.2 g/ha) + MSO (adjuvant) as PoE at 15-20 DAS; tembotrione (105 g/ha) + stefesmero (adjuvant) as PoE at 15-20 DAS; topramezone + atrazine (25.2+250 g/ha) + MSO (adjuvant) tank mix as PoE at 15-20 DAS; tembotrione + atrazine- (105+250 g/ha) + stefesmero (adjuvant) tank mix as PoE at 15-20 DAS; tembotrione (105 g/ha) as PoE at 15-20 DAS; intercropping of maize with cowpea and application of pendimethalin (1.0 kg/ha) as PE, hand weeding at 20 and 40 DAS; intercultivation at 20 and 40 DAS and unweeded control.

The predominant weed species observed in experimental site were *Cynodon dactylon*, *Digitaria sanguinalis, Dactyloctenium aegyptium*, *Echinochloa* spp. and *Rottboellia exaltata* among grasses; *Parthenium hysterophorus*, *Commelina benghalensis*, *Amaranthus viridis, Euphorbia geniculata*, *Digera arvensis* and *Trianthema portulacastrum* among the broadleaved weeds and *Cyperus rotundus* among sedges. Dry matter production of weeds varied significantly due to different weed control treatments at all growth stages. At 20 DAS, topramezone + atrazine 25.2 + 250 g/ha + MSO as PoE recorded significantly lower weed dry matter (16.7 g/m^2) which was on par with tembotrione + atrazine 105 + 250 g/ha + stefes mero as PoE (18.2 g/m^2), intercropping with cowpea and pendimethalin 1.0 kg/ha as PE (18.9 g/m^2) and atrazine 1.0 kg/ha as PE *fb* IC at 30 DAS (20.3 g/m^2) and these three treatments were significantly superior to other treatments.

At 40 DAS, HW at 20 and 40 DAS recorded lowest weed dry matter (11.0 g/m^2) which was significantly superior to other treatments. Application of atrazine 1.0 kg/ha as PE *fb* intercultivation at 30 DAS recorded lower (16.4 g/m^2) weed dry matter which was on par with intercultivation at 20 and 40 DAS (18.5 g/m^2). These findings revealed that pre-emergence application of herbicides followed by hand weeding once was effective in controlling the complex weed flora. At 60 DAS, HW at 20 and 40 DAS recorded significantly lower weed dry matter (12.0 g/m^2) over other treatments. This might be due to effective control of weeds by hand weeding at 40 DAS which resulted in lower weed dry matter. Intercultivation (IC) at 20 and

40 DAS recorded significantly lowest weed dry matter (24.4 g/m^2) followed by PoE application of topramezone + atrazine 25.2 +250 g/ha + MSO (51.4 g/m^2). At harvest, among the different weed management practices, HW at 20 and 40 DAS recorded lower weed dry matter (42.8 g/m^2) followed by IC at 20 and 40 DAS (60.5 g/m^2). At 60 DAS, highest WCE was recorded in HW at 20 and 40 DAS followed by IC at 20 and 40 DAS and was closely followed by topramezone or tembotrione tank mixed with atrazine + adjuvants. At harvest, higher WCE was recorded in HW at 20 and 40 DAS, IC at 20 and 40 DAS, PoE application of topramezone + atrazine 25.2 + 250 g/ha + MSO (75.0%) and tembotrione + atrazine 105 + 250 g/ha compared to other treatments.

Highest grain yield was recorded in hand weeding at 20 and 40 DAS with 60.5% increase over the unweeded control which was on par with topramezone + atrazine 25.2 + 250 g/ha + MSO (6.44 t/ha) and tembotrione + atrazine 105 + 250 g/ha + stefes-mero with 59.6% and 58.7%, respectively over the unweeded control. Among the other treatments, atrazine 1.0 kg/ha as PE *fb* IC at 30 DAS recorded higher grain yield, which was on par with intercultivation at 20 and 40 DAS. Highest stover yield (8.04 t/ha) was recorded in HW at 20 and 40 DAS which was significantly superior to all other treatments, which may be due to the continuous removal of weeds. Among the other treatments topramezone + atrazine 25.2 + 250 g/ha + MSO as PoE recorded higher stover yield (7.60 t/ha) which was on par with tembotrione + atrazine 105 + 250 g/ha + stefes mero as PoE (7.50 t/ha).

Higher net returns (₹ 62,608/ha) and B: C ratio (3.17) were realized in topramezone + atrazine 25.2 + 250 g/ha + MSO as PoE which was on par with tembotrione + atrazine 105 + 250 g/ha + stefes-mero (₹ 60,181 t/ha). It may be concluded that tank-mix of topramezone 25.2 g/ha or tembotrione 105 g/ha with atrazine 250 g/ha and adjuvant or atrazine as pre-emergence 1.0 kg/ha followed by intercultivation can be recommended for efficient weed control in maize without any phytotoxic effect on maize where there is labour scarcity and high cost of labour for hand weeding.

WP 1.5.13 Field evaluation of mycorrhizal consortium in the management of *Striga* in sugarcane (Under farmers field)

UAS, Dharwad

Application of mycorrhizal consortium reduced the *Striga* emergence compared to UIC. At 90 DAP, the highest number of *Striga* was recorded with UIC (10.5/m^2). However, *Striga* was almost suppressed in the treatment received AMF consortium i.e. 2.5/m^2. In the AMF treated plot at 90 DAP plant height of 150.7 cm and in uninoculated plot of AMF 89.2 cm found. Spad reading of 35.4 was obtained in AMF treated plot at 90 days of planting. And, in uninoculated plot of AMF we obtained less spad reading i.e 25.5. At 180 days of planting in AMF treated plot we obtained very less emergence of striaga i.e 4/m^2 compared to uninoculated AMF plot (14/m^2). Plant height of 180.7cm and 125.2 cm was obtained in AMF treated plot and uninoculated AMF plot, respectively. High chlorophyll content i.e 40.4 (SPAD) was obtained in AMF treated plot. And, in uninoculated plot SPAD value was 30.5.

WP 1.5.14 Effect of weed management practices on complex weed flora and soil microflora in aerobic rice under rainfed condition of Bihar

BAU, Sabour (Bihar)

A field experiment was conducted to evaluate the bio-efficiency of combination of herbicides against complex weed flora, microbial population and their effect on growth and yield of aerobic rice at BAU, farm, Sabour in Randomized Block Design replicated thrice during *Kharif* 2018. The experimental field was infested with *Echinochloa crus-galli, E. colona, Digitaria sanguinalis, Dactyloctenium aegyptium, Cynodon dactylon* among grasses; *Cyperus rotundus, Cyperus difformis, Cyperus iria* and *Fimbristylis milliacea* among sedges and *Caesulia axillaris, Lippia nodiflora, Amaranthus spinosus, Oxalis acetosella, Commelina benghalensis, Eleusine indica, Amaranthus viridis, Eclipta alba, Phyllanthus niruri* and *Monochoria vaginalis* among broad-leaved weeds.

The lowest weed population and weed dry weight were recorded in weed free plots which were significantly superior over rest of the treatments. Similarly, highest grain yield of rice (4.01 t/ha) was also recorded in the weed free plot which was statistically at par with pyrazosulfuron *fb* one hand weeding (3.92 t/ha), pyrazosulfuron *fb* bispyribac-Na(3.88 t/ha), bispyribac-sodium (3.82 t/ha), pyrazosulfuron + ethoxysulfuron (3.62 t/ha) and halosulfuron + azimsulfuron (3.50 t/ha). The highest weed control efficiency (100%) was recorded under the weed free condition which was followed by pyrazosulfuron *fb* one hand weeding (86%), pyrazosulfuron *fb* bispyribac-Na (84.8%), bispyribac - Na (83.1%). Halosulfuron caused some phytotoxic effects at early stage on rice crop. Highest net return (₹ 37,335/ha) was recorded by the treatment pyrazosulfuron *fb* one hand weeding which was found superior over rest of the treatments. The highest B: C ratio (2.22) was recorded by pyrazosulfuron which was statistically at par with bispyribac-sodium (2.20), pyrazosulfuron *fb* one hand weeding (2.19) and pyrazosulfuron + ethoxysulfuron (2.14). All these were significantly superior over rest of the treatments.

WP 1.5.15 Effect of biosynthesized zinc nanoparticle from medicinal weed *Tridax procumbens* on the germination potential of blackgram (Jan-March 2018)

PJNCA&RI, Karaikal

A lab study was conducted during Jan-March 2018 to study the effect of biosynthesized zinc nanoparticle from medicinal weed *Tridax procumbens* on the germination potential of blackgram *(Vigna mungo).* zinc nanoparticles (ZnO) suspension at various concentrations (0.250, 0.750, 1.00, 1.25, 1.75, 2.0 along with untreated control were considered as different treatments. Seed germination and vigour of treated blackgram seeds was significantly influenced by biogenic zinc nanoparticles **(Table 1.5.15.1)**. Higher germination (100%) and vigour index (738.0) was observed with zinc nanoparticles 1.0 g/L concentration. It is because germination is normally known as a physiological process beginning with water imbibition by seeds and culminating in the emergence of rootlet zinc NP's is a constituent of an enzyme which influences the secretion of IAA and result in positive response in seed germination.

However, improved root germination was observed with lower concentration of zinc rather than the higher concentration. More pronouncing effect in reduction was noticed with 2.0 g/L concentration. It is because of the toxicant effect of zinc at higher concentration. Roots are in direct contact with NPs and accumulation in the root tissue or on root surface is cause of shorter root length.

Table 1.5.15.1 Effect of biogenic zinc nanoparticles (ppm) on seed germination and vigour index of blackgram

Treatments (g/L)	Germination (%)	Seedling length (cm)	Vigour index
0.250	96.7	7.1	683.7
0.750	96.7	7.3	702.7
1.000	100.0	7.4	738.0
1.250	100.0	6.9	689.0
1.750	100.0	6.6	658.8
2.000	96.7	6.2	601.7
Untreated control	86.7	5.9	512.6
LSD (P=0.05)	7.88	0.80	90.34

WP 2 Weed dynamics and maangementy under the regime of climate change and herbicide resistence

WP 2.1 Monitoring of appearance of new weed species

AAU, Anand

During survey, high weed intensity of *Argemone mexicana* infestation was observed in different parts of Gujarat. Due to thorny nature and high seed production potentiality, it is spreading very fast in cultivated fields. After harvesting of *Rabi* crops, this weed flourishes and enters in new cultivated fields.

AAU, Jorhat

Following two weed genera have been identified during survey- 2018.

1. *Nicandra physaloides* (L.) Gaertn. belongs to family Solanaceae and is also commonly known as apple of Peru and shoo fly plant. It is an annual erect herb; leaves were simple, alternate, ovate and bell-shaped. Flowers were light blue-violet, 5-merous, solitary. Fruit were many seeded, spherical berry within a balloon formed by papery calyx. This species was first recorded at Sadiya and Tinsukia sub-divisions of Tinsukia district, Assam during 2014-15, which has extended to Jorhat district. This weed was recorded in the summer vegetable fields of North West Developmental Block of Jorhat district during 2018.

***Nicandra physaloides* in Brinjal at Upor Deuri village of Jorhat**

2. *Acmella* spp. belongs to family Asteraceae and commonly known as toothache plants. As many as 10 taxa belonging to eight species have been identified. Out of the 10 taxa, *Acmella brachyglossa* Cassini and *Acmella oppositifolia* (Lamarck) R K Jansen var. *opposifolia* were the new taxonomic report for the entire country and in addition *Acmella radicans* var. *debilis* (HBK) R. K. Jansen and *Acmella uliginosa* (Swartz) Cassini were new record for the state Assam. All these four species have been found to more or less highly populated facultative weeds of marshy croplands, damp edges of crop fields and roadsides.

***Acmella oppositifolia* var. oppositifolia**

Acmella unliginosa

CCSHAU, Hisar

During survey in berseem, *Coronopus didymus* and *Cuscuta* sp. were emerging as new major weeds causing losses in Kaithal, Kurukshetra, Ambala and Yamuna Nagar areas of state. Ratoon sugarcane crop mulched with sugarcane trash was heavily infested with *Ipomoea* spp., *Parthenium* and *Ageratum conyzoides* causing huge losses in Yamuna Nagar, Palwal, Ambala and some parts of Karnal and Kurukshetra districts.

Weed surveillance studies conducted in *Kharif* crops revealed that new broadleaf weed *Oenothera laciniata* was observed to infest guava and ber orchards in sandy soils of RRS, Bawal. *C. didymus* (Pithpapra), *Anagallis arvensis* (Krishanneel) and *Polypogon monspeliensis* (Loomar ghas) and *Lephochloa phleoides* (Lallu ghas) were on the rise in wheat. Pea crop in north-eastern districts of state severely infested with grassy as well as broadleaf weeds, *viz. Phalaris minor*, *Poa annua, P. monspliensis*, *C. didymus, Malwa parviflora, Medicago denticulata* etc. Tomato and brinjal crops were severely infested with parasitic weed *Orobanche aegyptiaca* in Nuh, Punnahana, Meoli areas of Mewat. Spring maize was infested both by *Rabi* and *Kharif* weeds, *viz. Rumex dentatus M. denticualta*, *Chenopodium album*, *Anagallis arvensis*, *Melilotus indica*, *Physalllis minima*, *C. didymus*, *Digitaria sangunallis* and *Echinochloa colona*. Spring urdbean is found to infest with *Amarnthus viridus, Cyperus rotundus*, *Trianthema portulacastrum*, *M. indica* and *P. minima*. Based on the observations recorded from farmers' interviews and experiments being conducted at farmers' fields, greenhouse bioassay studies, it was found that *P. minor* has developed cross resistance against clodinafop-propargyl, sulfosulfuron and pinoxaden not only in north-eastern but also south-western and central districts of the state. To control resistance problem against these herbicides at farmers fields, use of tank mixtures of pendimethalin + metribuzin (2000 + 120 g/ha) *fb* sequential use of mesosulfuron + iodosulfuron (RM) 14.4 g/ha, sulfosulfuron + metsulfuron (RM) at 40 g/ha and pinoxaden at 70 g/ha did not provide satisfactory control (less than 50%) of *P. minor*. Potency or efficacy of metsulfuron against *Rumex dentatus* and *R. spinosus* in wheat crop has decreased and use of metsulfuron + carfentrazone (TM) have been found effective against it at farmers' fields.

CSKHPKV, Palampur

Increased infestation of *Fumaria parviflora*, *Alternanthera pheloxeroides* and *Artemisia* sp. was found in different farming situations. *Erodium cicutarium* infestation was found to be increased in wheat. *Erigeron canadensis*, a weed of non-cropped lands was recorded in wheat. There was intense population of *Ranunculus* sp. in berseem.

***Erigeron canedensis* invading wheat**

Infestation of *Ranunculus* sp. in berseem

UAS, Bengaluru

A new weed *Ethulia gracilis* Delile belonging to family Asteraceae has been reported in Nippani, Belagavi district, Karnataka, India. It is an annual, erect herb, up to 60 cm tall. Stems erect, branched towards upper part, striate, adpressed puberulent. Leaves subsessile to sessile, narrowly lanceolate, 4–10 × 1–2 cm, narrowly cuneate at base, obscurely or sparsely dentate at margin, acute at apex, midrib distinct with 10–15 pairs of secondary veins adpressed puberulent, white beneath. Heads homogamous on terminal panicles, peduncles 1–7 mm; involucre hemispheric to globose; phyllaries 3-seriate. Florets 10–25; corolla pale lilac to mauve-purple, tubular, 2-2.5 mm, corolla 5-lobed, sparsely hairy on margin and outside, tube curved in the middle; stamens 5, syngenesious, 1-1.5 mm; style 2-3 mm long sparsely hairy, stigma 2-fid. Achenes subcylindric, 0.8–1.5 mm, 4-6 ribbed, with glands in 1-3 rows between ribs; pappus absent.

***Ethulia gracilis* Delile : A new invasive weed spotted in Karnataka**

RVSKVV, Gwalior

Weed surveillance was carried out to find appearance of any new weed/weeds in nearby area of public distribution systems, procurement centres, FCI godowns, garbage areas. These places were visited 2 – 3 times. No new weeds were found in these areas.

PJTSAU, Hyderabad

During 2018 weed survey was conducted at fixed point and with GPS data, no new weed species were identified. However following weeds were recorded during the survey.

OUAT, Bhubaneswar

During *Rabi* 2017-18, the weed survey has been conducted in the rainfed tracts along the state highway number 1 from Khurda to Nayagarh under East and South Eastern Coastal Plain agro-climatic zone of the state in crop and non-crop areas. The covered locations were Baghamari, Pichukuli of Khurda district and Bolagarh of Nayagarh district. Whereas, during *Kharif*, 2018, the weed survey has been conducted in the irrigated tracts along the national highway no.203 from Bhubaneswar to Puri under East and South Eastern Coastal Plain agro-climatic zone of the state in crop and non-crop areas. The covered locations were Siula of Khurda district and Kanas of Puri district. However, no new weed species was observed.

MPUAT, Udaipur

Periodical weed surveillance and monitoring carried out to monitor the appearance of new weed species in hot spots of Udaipur district during *Rabi* 2017-18 and *Kharif* 2018. Different areas and hot spots like different FCI godowns of the zone, railway yard and krishi upaj mandi of Udaipur and Rajsamand were visited twice in a season; similarly the areas near PDS shops situated in outer skirt of Udaipur and Rajsamand city and rural areas of different tehsils were surveyed. No new weed flora was observed in these areas.

SKUAST, Jammu

There were no any new weed species found in *Kharif* 2018 and *Rabi* 2017-18 at high risks places (*i.e.* nearby area of public distribution system, procurement centres, FCI godowns, garbage area and other spots) as compared to bench mark survey of *Kahrif* 2016 and *Rabi* 2015-16. However, density of grassy weed increased in *Kharif* 2018 as compared to *Kahrif* 2016. In the farmer's field, moderate infestation of *Marsilea quadrifolia* was noticed in transplanted rice in R.S. Pura block of Jammu region. Low to moderate infestation of *Cuscuta* in berseem was noticed in Kathua district. In late sown wheat low to moderate infestation of *Lolium* sp., was also noticed in R.S. Pura block of Jammu district.

PJANCOA & RI, Karaikal

A weed survey was taken up in order to study the occurrence of major aquatic weeds during October 2017 to February 2018. The distribution of aquatic weeds was recorded in different village of Karaikal **(Table 2.1.1)**.

Table 2.1.1 Occurrence of aquatic weed species in various revenue villages of Karaikal

Name of the village	Water hyacinth	Water lily	Cape-pond weed	Morning glory	Water cabbage
1. Ambagarathur	√	√	√		
2. Nallazhundur	√		√	√	
3. Sethur	√	√			
4. Thennankudy	√				
5. Devamapuram	√				
6. Sorakudy	√				√
7. Sellur	-	√			
8. Pettai	√				
9. Thirunallar	√	√			
10. Subrayapuram	√	√			
11. Keezhavoor	√				

WP 2.3 Management of cross resistance in *P. minor* against recommended herbicides in wheat

AAU, Jorhat

Taxonomic and phyto-geographic assessment of invasive and other problem weeds

In the year 2018, the genus *Acmella* L.C Richard (1807) belonging to the family *Asteraceae* was taken in to account for this study. Most of the species of this genus occurring in India are weeds in crop fields as well as in crop fallow lands. Many a times the genus is confused with another Asteraceaen herbaceous genus *Spilanthes.* Looking towards the existing difficulties in recognizing *Acmella* species in the field. The present study was undertaken to review the taxa and record their phytogeographic distribution in the country.

Acmella* v/s *Spilanthes : The members of *Acmella* were characterized by the presence of shallow rooted decumbent (or erect) broadleaved herbaceous habit, opposite and petiolated leaves, capitula with usually yellow (rarely white) flowers and dimorphic cypsela (fruit) with or without bristle like pappus. The differences between *Acmella* and *Spilanthes* as per the most recent taxonomic revisionary works are as follows-

	Spilanthes	*Acmella*
Leaves	Sessile	Petiolate
Capitula	Discoid	Radiate & discoid
Corolla	White to purplish white	Yellow (rarely white)
Cypsela	Monomorphic; rhombic in cross section; with a massive, stramineous cork-like margin at maturity	Dimorphic- ray cypsela triangular and disc cypsella 2 angular in cross section; with or without a stramineous cork-like margin at maturity
Pappus	Stiff awns	Soft bristles or lacking

Enumeration and phyto-grographic distribution

Altogether ten taxa of species and variety ranks have been recognized so far in the country, out of which only one species (*Acmella oleracea*) is known only under cultivation state and rarely in escaping state from cultivation in certain location and around Haflong of Dima Hasa district of Assam. Rest of the taxa has been found as facultative weed of a member of field crops. Phytogeographic distribution of seven interesting taxa are also shown in (**Fig. 2.3.1.**)

The list of the recognized taxa is given below:-

1. *Acmella brachyglossa* Cassini, Dict. Sci. Nat. 50: 258.1827.

Synonyms: *Spilanthes caespitosa* DC; *Ceratocephalus caespitosus* (DC) Kuntze; *Spilanthes arrayana* Gardner; *Spilanthes eggersii* Hieronymus; *Spilanthes limonica* A. H. Moore; *Spilanthes ocymifolia* f.

radiifera A. H. Moore. A South American herb newly migrated to India. An erect herbaceous facultative weed grows in marshy croplands of Jorhat and Majuli districts of Assam. It is also known to occur in Kerala.

2. *Acmella calva* (DC in wight) R.K.Jansen, Syst. Bot. Monog. 8:41. 1885.

Synonyms: *Spilanthes calva* DC in Wight; *Spilanthes acmella* var. *calva* (DC in Wight) Clarke ex Hook. f.; *Spilanthes rugosa* Blume ex DC; *Spilanthes javanica* Schultz-Bipontinus ex Miquel; *Spilanthes rugosa* var. *truncata* Miquel; *Spilanthes callimorpha* A.H.Moore; *Colobogyne langbianensis* Gangnepain; *Spilanthes langbianensis* (Gagnepain) Stuessy. A native to Indian subcontinent grows in moist places; common along the hilly tracts from NE India to South India.

3. *Acmella ciliata* (Humboldt, Bonpland & Kunth) Cassini, Dict. Sci. Nat. 24: 331.1822.

Synonyms: *Spilanthes ciliata* Humboldt, Bonpland & Kunth; *Ceratocephalus ciliatus* (Humboldt, Bonpland & Kunth) Kuntze; *Spilanthes fimbriata* Humboldt, Bonpland & Kunth; *Acmella fimbriata* (Humboldt, Bonpland & Kunth) Cassini; *Ceratocephalus fimbriatus* (Humboldt, Bonpland & Kunth) Kuntze; *Spilanthes poeppigii* DC; *Ceratocephalus poeppigii* (DC) Kuntze; *Spilanthes melampodioides* Gardner; *Spilanthes popayanensis* Hieronymus. A weed of fertile soil, occurs both in croplnd and crop fallow land situations. Native to South America, appreared as one of the most common weeds in India, mostly along the rice belt of the country.

4. *Acmella oleracea* (Linnaeus) R.K.Jansen, Syst. Bot. Monog. 8:65. 1885.

Synonyms: *Spilanthus oleracea* Linnaeus; *Spilanthes acmella* var. *oleracea* (Linnaeus) C. B. Clarke ex Hooker f.; *Ctula pyrethraria* Linnaeus; *Isocarpha pyrethraria* (Linnaeeus) Cassini; *Bidens fusca* Lamarck; *Spilanthes fusca* Lamarck; *Spilanthes radicans* Schrader ex DC. Nativity is unknown. Commonly cultivated as ornamental and medicinal herb; however, escaped and naturalized elsewhere including the Dima Hasao district of Assam.

5. *Acmella oppositifolla* (Lamarck) R. K. Jansen, Syst. Bot. Monog. 8:30. 1985. var. oppositifolla.

Synonyms: *Spilanthes beccabunga* DC; *Spilanthus beccabunga* G. Gomez; *Spilanthes subhirsuta* DC; *Spilanthes diffusa* Poeppig & Endlicher; *Ceratocephalus diffusus* (Poeppig & Endlicher) Kuntze; *Spilanthes ciliata* var. *diffusa* (Poeppig & Endlicher) A.H. Moore. A Latin American species, recorded for the first time in India from Assam as a newly introduced cropland weed of upland situations.

6. *Acmella oppositifolia* var. ***repens*** (Walter) R.K.Jansen, Syst. Bot. Monog. 8:34. 1885.

Synonyms: *Anthemis repens* Walter; *Spilanthes repens* (Walter) Michaux; *Ceratocephalus repens* (Walter) Kuntze; *Spilanthes americana* var. repens (Walter) A.H.Moore; *Acmella occidentalis* Nuttall; *Acmella nuttaliana* Rafinesque; *Spilanthes nuttalli* Torrey & Gray. A weed of Southern United States nativity. It was first recorded from Andhara Pradesh in 1999 in India and now extended towards the eastern Ghat.

7. *Acmella paniculata* (Wall. ex DC) R. K. Jansen, Syst. Bot. Monog. 8:67. 1885.

Synonyms: *Spilanthes paniculata* Wall. ex DC; *Spilanthes acmella* var. *paniculata* (Wall. ex DC) C. B. Clarke ex Hooker f.; *Spilanthes grandifolia* Miquel; *Spilanthes acmella* var. *albescentifolia* A.H.Moore; *Spilanthes paniculata* f. *bicolor* Koster. A native to SE Asia; commonly grows in forest edges, roadsides and west places as well as a facultative weed in upland crops. Common in Kerala, MP, Andhra Pradsh to NE India.

8. *Acmella radicans* (Jacquin) R. K. Jansen, Syst. Bot. Monog. 8:69. 1885.

Synonyms: *Spilanthus radicans* Jacquin; *Spilanthes exasperatus* Jacquin. A Central American weed, distributed to Kerala, Eastern Ghat to West Bengal.

9. *Acmella radicans* var. ***debilis*** (Humboldt, Bonpland & Kunth) R. K. Jansen, Syst. Bot. Monog. 8:72. 1885. Synonyms: *Spilanthes debilis* Humboldt; *Acmella debilis* (Humboldt, Bonpland & Kunth) Cassini; *Ceratocephalus debilis* (Humboldt, Bonpland & Kunth) Kuntze. A native to Central America; in India it was first reported in 2015 and known to occur in Maharastra, Karnataka and MP. The present investigation has confirmed its presence in Assam and Arunachal Pradesh since a long past, as the species is commonly used as vegetable by Mishing and Adi tribes. A naturalized herbaceous species ith weedy nature in NE India.

10. ***Acmella uliginosa*** (Swartz) Cassini, Dict. Sci. Nat. 24: 331.1822.

Synonyms: *Spilanthes uliginosa* Swartz; *Jaegeria uliginosa* (Swartz) Sprengel; *Spilanthes acmella* var. uliginosa (Swartz) Baker in Martius; *Ceratocephalus acmella* var. *uliginosa* (Swartz) Kuntze; *Coreopsis acmella* var. *uliginosa* (Swartz) K. Krause; *Spilanthes lundii* DeCandolle; *Spilanthes salzmanni* DC; *Ceratocephalus acmella* var. *depauperata* Kuntze; *Spilanthes iabadicensis* A.H. Moore; *Spilanthes charitopis* A.H. Moore; *Spilanthes uliginosa* var. *discoidea* Aristeguieta.A Pan-tropical species and a common cropland weed of upland and marshland situations almost throughout the country.

A dichotomous key for identification is constructed for the Indian taxa with slight modification of Jansen's (1985) work.

Key for identification of taxa belonged to *Acmella*:

1a. Head discoid:

2a. Corolla white, greenish white or with purple tinge. (Pappus of 2 or 3 sub-equal bristles; cypsela moderately to densely ciliate with hairs having straight tips; leaves attenuate at base; erect annuals) … ..… ***A. radicans* var. *radicans***

2b. Corolla pale yellow, yellow, or orange-yellow:

3a. Pappus absent; cypsela usually glabrous or if ciliate hairs having strongly recurved tips; perennials; stems decumbent or repent and rooting at nodes ……......................... … ***A. calva***

3b. Pappus of 2 or 3 sub- or unequal bristles; cypsela moderately to densely ciliate with hairs having straight tips; annuals or perennials; stems erect and usually lacking nodal roots:

4a. Mature cypsela with evident cork-like margins, surfaces sparsely to densely tuberculate ..……........................***A. paniculata***

4b. Mature cypsela without cork-like margins, surfaces not tuberculate:

5a. Corolla 4-merous; phyllaries 5-6, uniseriate; heads 5.7-8.1mm high, 4-6mm in diameter; receptacle 3-6mm high ....……… ***A. uliginosa***

5b. Corolla 5-merous; phyllaries 8-18, biseriate to triseriate; leaves broadly ovate to deltate, truncate to short attenuate at the base; known only from cultivation …… ….… … ***A. oleracea***

1b. Heads radiate:

6a. Ray florets slightly shorter to only slightly exceeding the phyllaries, often inconspicuous:

7a. Cypsela glabrous and epappose …. ……. … … ....***A. oppositifolia*** var. ***oppositifolia***

7b. Cypsela moderately to densely ciliate, usually with a well developed pappus of 2 or 3 bristles:

8a. Mature cypsela with evident, straminous, cork-like margins:

9a. Corolla orange-yellow; disc corollas 5-merous; perennials with stem rooting at nodes …….. …… ….. ………...................................… ***A. ciliata***

9b. Corolla white or greenish white; disc corolla 4-merous; erect annuals .... ***A. radicans*** var. ***debilis***

8b. Mature cypsela lacking evident, straminous, cork-like margins:

10a. Phyllaries 7-11, biseriate; leaves ovate; corollas pale yellow, 4-5-merous; disc florets 107-222; cypsela 1.8-2.3mm long, 0.5-0.9mm wide … … …... ***A. brachyglossa***

10b. Phyllaries 5-6, uniseriate; leaves lanceolate to narrowly ovate; corollas yellow to orange-yellow, 4-merous; disc florests 68-148; disc cypsela 1.2-1.8mm long, 0.4-0.6mm wide ….. ….. …………. … …. …..... … ..…. ***A. uliginosa***

6b. Ray florets 3-10 times longer than the phyllaries, conspicuous. (Leaves narrowly or broadly ovate, never linear-lanceolate) :

11a. Cypsella with pappus of bristles and moderately to densely ciliate …… ……… ……….…... ***A. oppositifolia*** var. ***oppositifolia***

11b. Cypsela epappose or pappose poorly developed and then the cypsela glabrous:

12a. Phyllaries lanceolate, acuminate at apex; cypsela sparsely to densely ciliate with very short straight-tipped hairs; pappus absent …. …............................***A. oppositifolia*** var. ***repens***

12b. Phyllaries narrowly to broadly ovate, rounded to acute at apex; cypsella glabrous to densely ciliate with long straight-tipped hairs ....… ....***A. oppositifolia*** var. ***oppositifolia***

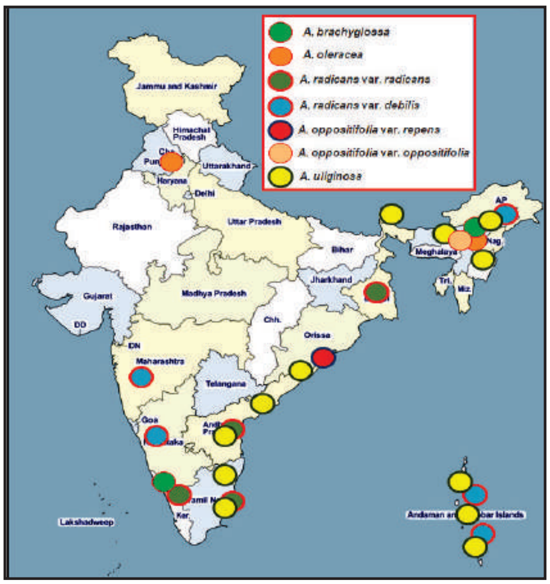


Fig. 2.3.1 Phyto-geographic distribution of some species of *Acmella* in India (Map is not in scale)

HAU, Hisar

Management of cross resistance in *P. minor* against recommended herbicides in wheat through use of pre and post emergence herbicides used

Phalaris minor is the dominant and troublesome grass weed of wheat in rice-wheat cropping system in the north-western Indo-Gangetic plains of India. To study the efficacy of different herbicides against *P. minor* with poor control by clodinafop, sulfosulfuron and pinoxaden since last 3-4 years, a field experiment was conducted during *Rabi* 2017-18 in a randomized block design. Herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using water volume of 375 L/ha. Phyto-toxicity in terms of chlorosis, stunting, leaf burning and epinasty was recorded at 10 and 20 DAT (days after treatment).

All herbicide treatments caused significant reduction in density of *P. minor* at 30 and 60 DAT **(Table 2.3.1).** Pre-emergence application of pendimethalin or metribuzin was not much effective against resistant population of *P.minor* with only 33-35% control. Although pre-emergence application of pendimethalin + metribuzin (TM) at 1500+175 g/ha increased control of *P. minor* but was not sufficient to control second flush of weeds appeared after first irrigation to satisfactory level with only 53.3 % control. Pre-emergence application of pendimethalin + pyroxasulfone (RM) at 1500 + 102 g/ha either alone or followed by sequential use of pinoxaden 60 g/ha meso + iodosulfuron(RM) 14.4 g/ha at 35 DAS caused significant reduction in density of *P. minor* and provided 83-93% control. Pre-emergence use of pendimethalin + metribuzin in conjunction with post emergence herbicides provided 60-68.3% control. None of herbicide treatment except tank mixture of pinoxaden and metribuzin at 50 + 120/150 g/ha and pendimethalin + metribuzin (before sowing) at 1500 + 175 g/ha caused any phytotoxicity on wheat. Toxicity up to 5% in form of chlorosis and yellowing was observed with tank mixture of pinoxaden and metribuzin at 50 + 120/150 g/ha up to 10 DAT which mitigated up to 20 DAT and this mixture was not much effective with only 51.7% control of *P. minor*. Pre-emergence application of pendimethalin + metribuzin (before sowing) at 1500 +175 g/ha (before sowing) caused 5.0% reduction in wheat germination affecting no. of tillers/m^2 and significant reduction in grain yield. WCE also varied among treatments due to varying control of *P. minor*. Maximum WCE (83-93% at 30 DAT and 87-88% at 60 DAT) was obtained with pyroxasulfone treatments which had a reflection on number of tillers/m^2 and grain yield of wheat. Recommended herbicide pinoxaden and meso + iodosulfuron at 14.4 g/ha provided only 51.7% control of weeds at 60 DAT. Effect of different treatments on weed density, dry weight of weeds, visual control and grain yield of wheat was also evaluated **(Table 2.3.2)**. Maximum grain yield (5.82 t/ha) was obtained with pendimethalin + pyroxasulfone at 1500+102 g/ha *fb* sequential use of pinoxaden 60 g/ha with 88.7% control of *P. minor* which was at par with weed free check, pendimethalin + pyroxasulfone at 1500+102 g/ha *fb* sequential use of meso + iodosulfuron (14.4 g/ha) and pendimethalin + pyroxasulfone at 1500+102 g/ha alone.

Table 2.3.1 Effect of different treatments on density (No./m^2) of different weeds in wheat

Treatment	Dose (g/ha)	Time of application	*P. minor*		*Rumex dentatus*		*Chenopodium album*	
			30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
Pendimethalin	1500	PRE	5.62 (31.3)	9.35 (86.7)	1.38 (1.0)	1.00 (0)	1.66 (2.0)	1.24 (0.67)
Metribuzin	210	PRE	5.42 (28.7)	9.32 (86.0)	1.14 (0.33)	1.0 (0)	1.66 (2.0)	1.24 (0.67)
Pendimethalin + metribuzin (TM)	1500+175	PRE	4.19 (17.0)	8.67 (78.7)	1.0 (0)	1.14 (0.3)	1.0 (0)	1.0 (0)
Pendimethalin + metribuzin (TM) *fb* pinoxaden	1000+ 175 *fb* 60	PRE *fb* PoE	4.43 (19.3)	8.34 (68.7)	1.0 (0)	1.0 (0)	1.52 (1.3)	1.0 (0)
Pendimethalin + metribuzin (TM) *fb* mesosulfuron + iodosulfuron (RM)	1000+175 *fb* 14.4	PRE *fb* PoE	3.99 (15.3)	7.52 (57.3)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
T6- Pendimethalin + pyroxasulfone (TM)	1500+102	PRE	2.56 (7.3)	5.08 (26.7)	1.0 (0)	1.0 (0)	1.14 (0.3)	1.14 (0.3)
Pendimethalin + pyroxasulfone (TM)*fb* pinoxaden	1500+102 *fb* 60	PRE *fb* PoE	2.24 (4.3)	4.54 (20.0)	1.0 (0)	1.0 (0)	1.3 (1.0)	1.0 (0)
Pendimethalin + pyroxasulfone(TM) *fb* mesosulfuron + iodosulfuron (RM)	1500+102 *fb* 14.4	PRE *fb* PoE	2.24 (4.3)	4.58 (20.0)	1.0 (0)	1.0 (0)	1.14 (0.3)	1.0 (0)
Pendimethalin + metribuzin (TM) *fb* pinoxaden	1500+175 *fb* 60	Before sowing *fb* PoE	5.02 (24.3)	7.35 (66.7)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Sulfosulfuron *fb* pinoxaden	25 *fb* 60	BI *fb* PoE	5.43 (28.7)	10.8 (118.7)	1.88 (3.0)	1.0 (0)	1.52 (1.3)	1.0 (0)
Pinoxaden	60	PoE	4.55 (21.0)	11.2 (126.7)	2.44 (5.00)	1.52 (1.3)	2.99 (8.3)	1.73 (2.0)
Pinoxaden+ metribuzin(TM)	50+120	PoE	4.51 (19.7)	9.32 (86.7)	1.14 (0.33)	1.0 (0)	1.0 (0)	1.0 (0)
Pinoxaden+ metribuzin(TM)	50+150	PoE	3.98 (15.7)	8.50 (72.0)	1.14 (0.33)	1.0 (0)	1.0 (0)	1.0 (0)
Mesosulfuron+iodosulfuron(RM)	14.4	PoE	4.63 (22.3)	9.03 (82.7)	1.14 (0.33)	1.14 (0.3)	1.0 (0)	1.0 (0)
Weedy check	-		6.17 (38.3)	12.5 (157.3)	2.3 (6.0)	1.1 (0.3)	3.6 (12.0)	1.41 (1.3)
Weed free	-		1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
SE(m)±			0.62	1.08	0.25	0.06	0.27	0.14
LSD(P=0.05)			1.79	3.14	0.75	0.17	0.77	0.39

Monitoring and management of herbicide resistance to different herbicides in *P. minor* biotypes from farmers' fields (Pot-culture)

The seeds of uncontrolled *P. minor* were collected from farmers' fields in different districts of Haryana during *Rabi* 2016-17. Twelve such biotypes were collected from different parts of Haryana. The herbicidal treatments along with untreated check were laid out in completely randomized block design (CRD) with three replications. The observations on control of weeds were taken at 30 days after herbicide application **(Table 2.3.3)**.

The pot-culture studies with 12 populations of *P. minor, viz.* P_1 Hisar (HAU), P_2. Khedar (Hisar), P_3. Khedi (Kaithal), P_4 Keorak (Kaithal), P_5 Kalwan (Jind), P_6 Rasidan (Hisar), P_7 Ludas (Hisar), P_8 Lamba Kheri (Kaithal), P_9 Dhos (Kaithal) and P_{10} Ujhana (Jind), P_{11} Lehrawali Dhani (Sirsa), P_{12} Nangla (Fatehabad) from different parts of Haryana indicated the decrease in efficacy of one or two out of 12 populations of *P. minor* evaluated; 10 populations were resistant to recommended dose of clodinafop, 9 populations to sulfosulfuron and 7 populations to meso + iodosulfuron (RM) and pinoxaden each. Even 10 populations (P_1, P_3,

Table 2.3.2 Effect of different treatments on weed density, dry weight of weeds, visual control and grain yield of wheat.

Treatment	Dose (g/ha)	Time of application	Dry weight of weeds (g/m²)		WCE (%)		Visual control of *P.minor* (%)	Crop phytotoxicity (%)		No of tillers /m²	Yield (t/ha)
			30 DAT	60 DAT	30 DAT	60 DAT		10 DAT	20 DAT		
Pendimethalin	1500	PRE	4.12 (16.0)	19.4 (401.6)	56.3	49.6	5.99 (35.0)	0	0	396	4.86
Metribuzin	210	PRE	4.64 (20.6)	20.4 (418.7)	43.9	47.4	5.84 (33.)	0	0	396	4.80
Pendimethalin + metribuzin (TM)	1500+175	PRE	3.94 (14.8)	19.2 (372.9)	59.7	53.2	7.36 (53.3)	0	0	404	5.06
Pendimethalin+metribuzin (TM) *fb* pinoxaden	1000+175 *fb* 60	PRE *fb* PoE	3.64 (12.2)	18.1 (328.7)	66.7	52.4	7.79 (60.0)	0	0	407	5.100
Pendimethalin + metribuzin (TM) *fb* mesosulfuron + iodosulfuron (RM)	1000+175 *fb* 14.4	PRE *fb* PoE	3.37 (10.4)	15.8 (257.1)	71.7	67.4	8.32 (68.3)	0	0	410	5.412
Pendimethalin + pyroxasulfone (TM)	1500+102	PRE	1.70 (2.3)	9.57 (94.7)	93.5	88.1	9.53 (90.0)	0	0	432	5.80
Pendimethalin +pyroxasulfone (TM) *fb* pinoxaden	1500+102 *fb* 60	PRE *fb* PoE	2.35 (4.6)	9.51 (89.6)	87.5	88.7	9.71 (93.0)	0	0	436	5.82
Pendimethalin +pyroxasulfone (TM) *fb* mesosulfuron + iodosulfuron RM)	1500+102 *fb* 14.4	PRE *fb* PoE	2.48 (5.9)	9.99 (98.8)	83.8	87.6	9.18 (83.0)	0	0	431	5.80
Pendimethalin + metribuzin (TM) *fb* pinoxaden	1500+175 *fb* 60	Before sowing *fb* PoE	4.25 (17.1)	21.80 (476.8)	53.5	40.1	6.53 (41.7)	5	5	386	4.42
Sulfosulfuron *fb* pinoxaden	25 *fb* 60	BI *fb* PoE	4.34 (17.9)	22.3 (498.3)	51.3	28.6	6.26 (38.3)	0	0	399	5.00
Pinoxaden	60	PoE	3.89 (14.2)	19.6 (383.8)	61.3	51.7	6.37 (40.0)	0	0	396	4.80
Pinoxaden + metribuzin (TM)	50+120	PoE	3.63 (12.2)	18.6 (349.2)	66.7	56.2	7.23 (51.7)	5	0	400	5.00
Pinoxaden+ metribuzin (TM)	50+150	PoE	3.37 (10.4)	17.9 329.1)	71.7	58.7	7.23 (51.7)	5	0	401	5.05
T14-Mesosulfuron + iodosulfuron (RM)	14.4	PoE	3.91 (14.3)	19.6 (384.5)	61.0	51.7	6.59 (43.3)	0	0	401	4.92
Weedy check		-	6.10 (36.8)	28.2 (797.1)	0	0	1.0 (0)	0	0	370	3.64
Weed free		-	1.0(0)	1(0)	100	100	10.05 (100.0)	0	0	435	5.80
SE(m)±			0.39	1.91			0.29	-	-	9.7	0.04
LSD (P=0.05)			1.15	5.55			0.84	-	-	28.1	0.12

P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{12}) were found tolerant to 2X dose of clodinafop. Populations from P_1, P_3, P_4, P_5, P_6, P_7, P_8 P_9, and P_{12} were resistant to 2X dose of sulfosulfuron. Biotypes P_3, P_4, P_5, P_6, P_8, P_{10}, P_{12} were not controlled satisfactorily by recommended dose of pinoxaden. Less than 50% control of populations P_6, P_7, P_8 and P_9 was achieved when treated with 2X dose of sulfosulfuron. Two populations P_6 (50% control)) and P_8 (65% control) have poor control when treated with 2 X dose of meso + iodosulfuron (RM) at 28.8 g/ha. Only 20% control of population P_6 was achieved when treated with 2X dose of pinoxaden **(Fig. 2.3.2)**.

Development of cross-resistance against clodinafop in majority of areas was observed (**Fig. 2.3.3**). Pinoxaden and mesosulfruon + iodosulfuron (RM) could also play an important role in management of resistant populations.

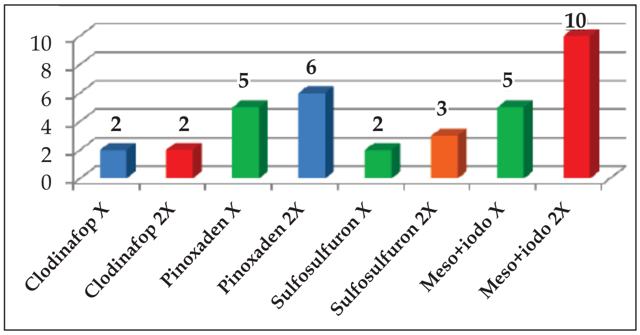


Fig. 2.3.2 Efficacy (⩾80%) of different herbicides against *P. minor* biotypes in pot studies

Fig. 2.3.3 Resistant populations of *P. minor* treated with different doses of clodinafop

Table 2.3.3 Efficacy (% control) of herbicides in pot-studies against biotypes of *P. minor* obtained from farmers' fields in Haryana (*Rabi* 2017-18)

	(Biotyps 1% control)											
Treatments	**BT1**	**BT2**	**BT3**	**BT4**	**BT5**	**BT6**	**BT7**	**BT8**	**BT9**	**BT10**	**BT11**	**BT12**
Clodinafop 30 g/ha	0	80	0	0	0	0	0	0	0	0	100	30
Clodinafop 60 g/ha	15	100	30	0	0	0	30	30	35	30	100	60
Clodinafop 120 g/ha	60	100	0	30	10	0	30	20	50	0	100	30
Sulfosulfuron -12.5 g/ha	0	85	30	25	20	20	20	15	15	40	95	30
Sulfosulfuron 25 g/ha	60	98	35	30	25	30	20	20	20	70	100	65
Sulfosulfuron 50 g/ha	75	98	70	50	50	35	35	0	15	95	98	75
Mesosulfuron + iodosulfuron(RM)7.2 g/ha	70	85	50	55	55	25	80	30	70	85	100	60
Mesosulfuron + iodosulfuron(RM)14.4g	75	90	70	70	70	40	90	70	80	85	95	75
Mesosulfuron + iodosulfuron(RM) 28.8 g/ha	90	95	90	85	85	50	85	65	85	95	100	95
Pinoxaden 25g/ha	70	80	20	15	15	0	60	50	55	20	100	30
Pinoxaden 50g/ha	95	95	60	55	55	0	80	70	90	70	100	50
Pinoxaden 100g/ha	95	95	50	70	70	20	95	90	100	100	100	75
Untreated check		0		0	0				0			

Populations : P_1Hisar (HAU), P_2. Khedar(Hisar), P_3. Khedi (Kaithal), P_4. Keorak(Kaithal), P_5. Kalwan(Jind), P_6. Rasidan (Hisar), P_7. Ludas (Hisar), P_8. Lamba Kheri (Kaithal), P_9. Dhos (Kaithal), P_{10}. Ujhana (Jind), P_{11}. Lehrawali Dhani (Sirsa) , P_{12}. Nangla (Fatehabad)

Survey on status of herbicide resistance in *Phalaris minor* in wheat at farmers' fields of Haryana

Information about spray pattern

An extensive survey with systematic approach was conducted in *Rabi* 2018 in five districts (Yamunanagar, Kaithal, Karnal, Fatehabad and Rohtak) of Haryana. Two blocks were selected from each district and three villages from each block and a total of 300 farmers were covered from 30 villages involving 10 farmers from each village.

Farmers are mainly using knapsack sprayer for herbicides application but recently have also started using the power sprayer to reduce the drudgery. Overall 76.3% farmers use knapsack sprayer and 23.7% use power sprayer in surveyed districts. Almost all famers reported that they use single nozzle and apply the herbicides in clear weather. In case of nozzle 49.3% farmer use flood jet/cut nozzle followed by hollow cone nozzle by 45.3% farmers; only 6.3% famers use the flat fan nozzle. Farmers in the Karnal, Kaithal and Bilaspur block of Yamunagar district mainly use the cut nozzle it is mainly rice-wheat growing area. Farmers in Fatehabad, Rohtak and Radaur block use the hollow cone nozzle in this belt diversification is there farmers also take cotton, sugarcane, sorghum and pear millet along with rice in *Kharif*. Very few farmers are using flat fan nozzle for herbicides application. Farmers are not using right nozzle for herbicides application due to ignorance, casual approach (same nozzle for other pesticides and herbicides) and flat fan nozzle takes more time than other nozzle. In case of water volume used for herbicides spray less than <2% use the standard recommended amount of water 200 L acre. Around 90% farmers are using water volume from 90-120 L acre (51.7 and 39.3% using 120 and 90 L acre, respectively)

Maximum numbers of farmers 48.3% go for first herbicide application at 2-3 leaf stage (40-45 DAS), only <2% farmers apply herbicides at recommended time 30-35 DAS. Nowadays farmers have started using pre and post emergence herbicides combination to get desirable control and few farmers also reported that application of sulfosulfuron at 20 DAS before first irrigation in dry field also gave satisfactory control, in table it is showing that 20% farmers applying first spray up to 25 DAS. Overall three-fourth farmers 74.6% are applying first herbicides after 35 DAS. In case of second spray highest number of farmers is applying herbicides >50 DAS (71.8%), almost all farmers go for second spray after 40 DAS **(Table 2.3.4)**. Field takes time to come in wapsa condition is the one of the prime reason for delay in herbicides application other than this some farmers also have perception that application of herbicides at later stage 4-5 leaf stage of *P. minor* gives better control. Farmers also have tendency to apply fertilizers (mainly urea) and irrigation within one week of herbicides application.

Table 2.3.4 Time of spray and *P. minor* growth stage

	Time of spray	H_1 (First spray)	H_2 (Second spray)
0 DAS	Pre emergence	14 (4.7%)	0 (0%)
20-25 DAS	Not germinated	50 (16.7%)	1 (0.7%)
25-30 DAS	Germination <50%	5 (1.7%)	0 (0%)
30-35 DAS	Germination >50%	5 (1.7%)	0 (0%)
35-40 DAS	1-2 leaf stage	29 (9.7%)	1 (0.7%)
40-45 DAS	2-3 leaf stage	145 (48.3%)	13 (9.1%)
45-50 DAS	3-4 leaf stage	37 (12.3%)	25 (17.6%)
>50 DAS	>4 leaf stage	13 (4.3%)	102 (71.8%)

In 2017-18 overall farmers applied 2.91 X-dose of total herbicides to control *P. minor,* highest in case of Karnal district with 4.13% and lowest in Rohtak, 1.80 X-dose. Still only get, 69.1 to 80.8% control. Lowest control was observed in Karnal and highest in Yamuna Nagar district. Overall 23.6% regeneration reported lowest in Yamuna Nagar (19.1%) and highest in Karnal (27.7%). Farmers accept that clodinafop is not showing any result but still it is contributing about half (48.48%) of the total herbicide use. Whereas, sulfosulfuron and pinoxaden contributed one-fifth 21.62 and 19.23%, respectively of the total herbicide use. Mesosulfuron + iodosulfuron (ready-mix) contributed very less (<5%) to total herbicide use.

Management of herbicide resistant *Rumex dentatus* population from Panipat (Pot culture)

There have been reports of poor efficacy of herbicides particularly metsulfuron against *Rumex dentatus* population from KVK, Panipat. A pot experiment was conducted at RRS, Karnal. The seeds of *Rumex dentatus* population were collected from KVK, Panipat during *Rabi* 2016-17. Seeds of this biotype were sown in pots (7" diameter) during *Rabi* 2017-18. Spray of graded doses (1/4X, 1/2X, X, 2X and 4X) of herbicides (metsulfuron-methyl, carfentrazone and 2, 4-D) was done at 2-4 leaf stage. The experiment was laid out in completely randomized block design (CRD) with three replications. The observations on control of weeds were taken at 30 days after herbicide application.

At recommended doses, metsulfuron 4.0 g/ha provided no control (0%) of *Rumex* population from KVK, Panipat; however, efficacy of 2,4-D 600 g/ha (90%) and carfentrazone 20 g/ha (78.3%) was satisfactory **(Fig.2.3.4)** It indicated towards development of herbicide resistance in *Rumex* against metsulfuron-methyl.

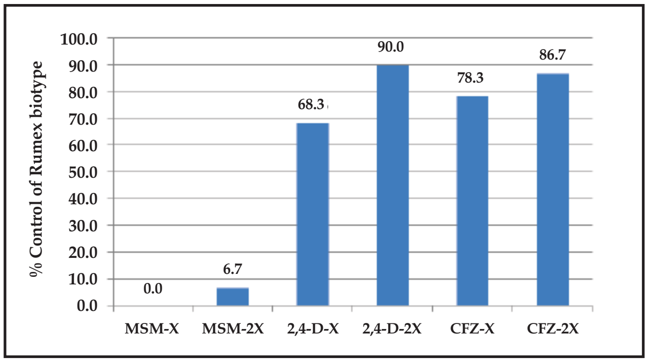


Fig 2.3.4 Efficacy of different herbicides at X and 2X doses against *Rumex* biotype from Panipat

GBPUAT, Pantnagar

Management of cross resistance in *P. minor* against recommended herbicides in wheat

An experiment was conducted to mange cross resistance in *P. minor* against recommended herbicides in wheat. The experiment was laid out in RBD with three replications. Data on weed density and biomass as well as yield and yield attributes of wheat were recorded. Weed density of *P. minor* was recorded at 30, 60 and 90 DAS. At 30 DAS, the density was highest in Weedy plot (134.67/m^2) followed by clodinafop + metsulfuron-methyl (102.7/m^2) and mesosulfuron + idosulfuron (64 /m^2). There was no weed recorded in pendimethalin followed by clodinafop-propargyl treatment at 60 DAS. At 90 DAS, the density was highest in weedy plot (249.3 /m^2) followed by mesosulfuron + idosulfuron (70.67/m^2) and pendimethalin (25.3/m^2) treatment (**Fig 2.3.5**).

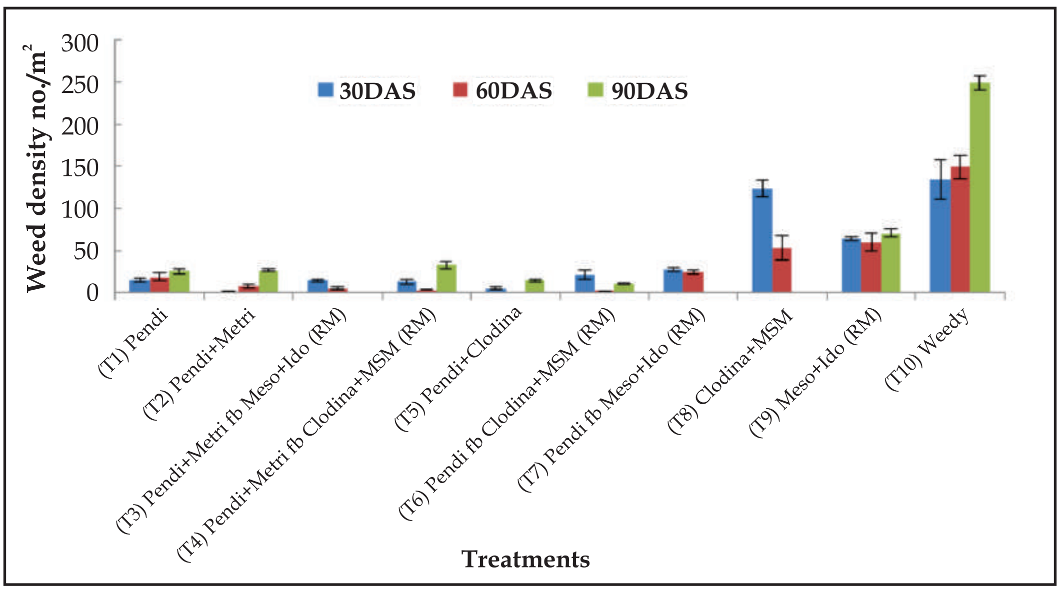


Fig. 2.3.5 Effect of herbicides on *P. minor* density at 30, 60 and 90 DAS

Whereas weed biomass was recorded at different growth stages, *viz.* 30, 60 and 90 DAS. At 30 DAS, weed biomass was maximum in weedy plot (3.60g/m^2) followed by clodinafop + metsulfuron-methyl (3.50g/m^2) and mesosulfuron + idosulfuron (2.12 g/m^2) treatment. The biomass was gradually increased in weedy plot and mesosulfuron + idosulfuron till 90 DAS. At 90 DAS, weed biomass was maximum in weedy plot (201.6 g/m^2) followed by pendimethalin (21.4 g/m^2). The few herbicide treatments, pendimethalin + metribuzin, pendimethalin + metribuzin followed by mesosulfuron + idosulfuron, pendimethalin + metribuzin followed by clodinafop + metsulfuron-methyl, pendimethalin followed by clodinafop-propargyl, pendimethalin followed by mesosulfuron + idosulfuron) and clodinafop + metsulfuron-methyl were effective to control the weed successfully **(Fig. 2.3.6)**.

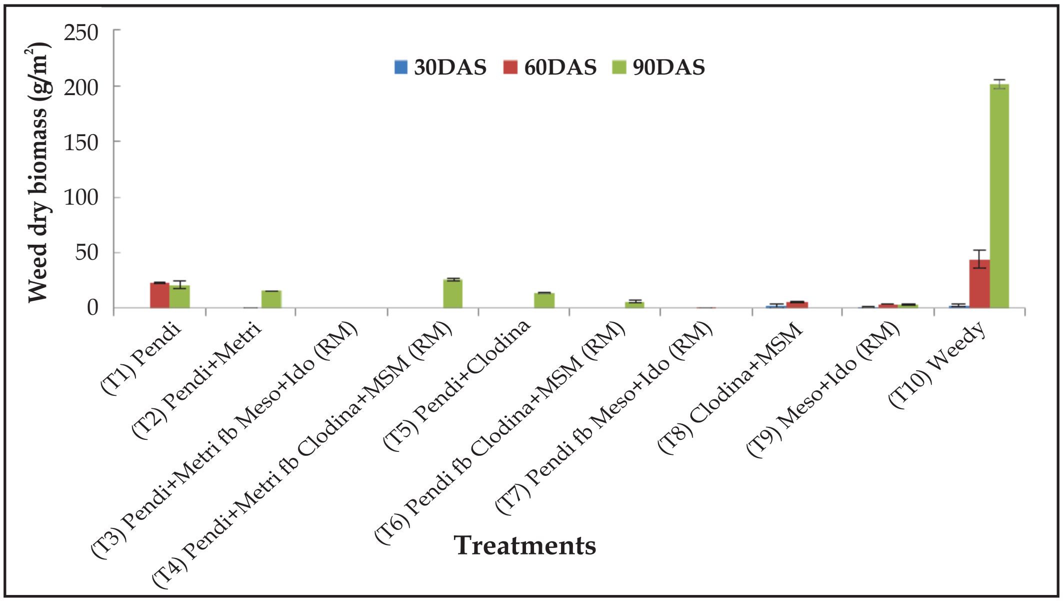


Fig. 2.3.6 Effect of herbicides on biomass of *P. minor* at 30, 60 and 90 DAS

Number of shoots was recorded at 30 and 60 DAS. There was no significant difference in number of shoots at different growth stages. At 30 DAS, pendimethalin followed by clodinafop-propargyl and pendimethalin + metribuzin followed by mesosulfuron + idosulfuron treatment had highest number of tillers whereas, lowest in weedy plot. At 60 DAS, the herbicides treatments pendimethalin, endimethalin + metribuzin, pendimethalin + metribuzin followed by mesosulfuron + idosulfuron and clodinafop + metsulfuron-methyl had comparable number of shoots.

The biological yield (kg/m^2) of wheat was maximum in pendimethalin + metribuzin followed by clodinafop + metsulfuron-methyl treatment (1.48 kg/m^2) whereas, lowest biological yield was found in weedy plot (1.2 kg/m^2). The biological yield of pendimethalin followed by clodinafop-propargyl was at par with clodinafop + metsulfuron-methyl treatment.

Grain yield was also highest in pendimethalin + metribuzin followed by clodinafop + metsulfuron-methyl treatment (0.53 kg/m^2) whereas, lowest grain yield was achieved in weedy condition (0.30 kg/m^2) **(Table 2.3.5)**.

Table 2.3.5 Biological yield and grain yield of wheat (kg/m^2)

Treatments	Biological yield (kg/m^2)	Grain yield (kg/m^2)
Pendimethalin (38.7%)	1.23	0.44
Pendimethalin+metribuzin	1.36	0.52
Pendimethalin+metribuzin *fb* mesosulfuron+idosulfuron (RM)	1.35	0.49
Pendimethalin+metribuzin *fb* clodinafop+metsulfuron -methyl (RM)	1.48	0.53
Pendimethalin *fb* clodinafoppropargyl	1.25	0.47
Pendimethalin *fb* clodinafop+metsulfuron -methyl (RM)	1.27	0.51
Pendimethalin *fb* mesosulfuron+idosulfuron (RM)	1.29	0.49
Clodinafop+metsulfuron-methyl (RM)	1.25	0.49
Mesosulfuron+idosulfuron (RM)	1.30	0.49
Weedy	1.20	0.30
S.Em±	0.05	0.01
CD at 5%	0.14	0.04

PAU, Ludhiana

To study the bio-efficacy of combination of herbicides against cross resistant *P. minor*, a study was carried out as per details given below:

Treatment	Dose (g/ha)	Application time
Pendimethalin	750	PRE
Pendimethalin + metribuzin	750 + 210	PRE
Pendimethalin + metribuzin *fb* mesosulfuron + iodosulfuron (RM)	750 + 210 *fb* 12 + 2.4	PRE *fb* POST
Pendimethalin + metribuzin *fb* clodinafop-propargyl + metsulfuron-methyl (RM)	750+210 *fb* 60+4	PRE *fb* POST
Pendimethalin + pyroxasulfone (TM)	750+102	PRE
Pendimethalin + pyroxasulfone (TM) *fb* clodinafop-propargyl + metsulfuron-methyl (RM)	750+102 *fb* 60+4	PRE *fb* POST
Pendimethalin + pyroxasulfone (TM) *fb* mesosulfuron + iodosulfuron(RM)	750+102 *fb* 12 + 2.4	PRE *fb* POST
Clodinafop-propargyl + metsulfuron-methyl (RM)	60+4	POST
Mesosulfuron + iodosulfuron(RM)	12 + 2.4	POST
Weedy	-	-
*Pendimethalin		

Table 2.3.6 Effect of different weed control treatments on density and biomass of *Phalaris minor* (*Rabi* 2017-18).

Treatments	Dose (g/ha)	*P. minor* population (No./m^2)		Weed biomass (g/m^2)		Weed Control Efficiency (%)	
		40 DAS	90 DAS	40 DAS	90 DAS	40 DAS	90 DAS
Pendimethalin	750	5.1 (26)	6.1 (36)	4.3 (17)	13.6 (185)	69.7	50.6
Pendimethalin + metribuzin	750 + 210	4.2 (17)	5.6 (30)	3.7 (12)	13.1 (171)	78.2	54.1
Pendimethalin + metribuzin *fb* mesosulfuron + iodosulfuron (RM)	750 + 210 *fb* 12 + 2.4	4.4 (19)	2.9(7)	2.4 (5)	8.8 (78)	91.4	79.1
Pendimethalin + metribuzin *fb* clodinafop-propargyl + metsulfuron-methyl (RM)	750+210 *fb* 60+4	4.8 (22)	2.6 (6)	5.5 (5)	9.4 (87)	90.6	76.7
Pendimethalin + pyroxasulfone (TM)	750+102	2.0 (4)	2.6 (6)	2.4 (5)	6.6 (43)	91.2	88.6
Pendimethalin + pyroxasulfone (TM) *fb* clodinafop-propargyl + metsulfuron-methyl (RM)	*fb* 60+4	2.0 (4)	2.0 (3)	2.0 (3)	5.5 (29)	94.7	92.1
Pendimethalin + pyroxasulfone (TM) *fb* mesosulfuron + iodosulfuron(RM)	750+102 *fb* 12 + 2.4	1.5 (2)	1.7 (2)	1.7 (2)	4.7(21)	96.5	94.4
Clodinafop-propargyl + metsulfuron-methyl (RM)	60+4	10.1 (102)	4.5 (19)	3.8 (13)	10.8 (115)	76.5	69.2
Mesosulfuron + iodosulfuron(RM)	12 + 2.4	9.2 (84)	3.4 (11)	3.5 (11)	9.8 (95)	80.0	74.6
Weedy check	-	15.6(243)	15.6 (243)	7.6 (57)	19.3 (373)	-	-
SEm±		0.5	0.1	0.1	0.4	-	-
LSD (P=0.05)		1.6	0.3	0.3	1.1	-	-

Data is subjected to square root transformation. Figures within parenthesis are means of original values

As compared to unsprayed control pre-emergence application of pendimethalin 750 g/ha and tank-mix of pendimethalin 750 g + metribuzin 210 g/ha significantly (>75%) reduced *P. minor* density at 20 DAS **(Table 2.3.6).** Whereas, at 40 and 90 DAS, all weed control treatments significantly reduced *P. minor* density and biomass as compared to unsprayed control. Pendimethalin + pyroxasulfone herbicide resulted in weed control after first irrigation and sequential application of pendimethalin 750 g/ha + pyroxasulfone 102 g/ha as pre-emergence followed by either clodinafop propargyl 60 g/ha + metsuflruon methyl 4.0 g/ha or mesosulfuron 12 g/ha + iodosulfuron 2.4 g/ha as post-emergence gave >90% control of *P. minor* **(Table 2.3.6)**. All herbicides did not show any significant influence on crop plant height, tiller production and biomass indicating safety of these chemical combinations for wheat. All weed control treatments gave significantly higher wheat grain yield than unsprayed check and were at par among each other. Weed control with these chemicals increased net returns from wheat by ₹ 19000 to ₹ 24000 /ha as compared to unsprayed check **(Table 2.3.7)**.

Table 2.3.7 Wheat growth at 40 DAS, yield attributes at harvest and yields under different weed control treatments (*Rabi* 2017-18).

Treatments	Dose (g/ha)	Plant height (cm)	Tillers (No./m²)	Crop biomass (g/m²)	Effective tillers (No./m²)	Final plant height (cm)	Grain yield (t/ha)	Biological yield (t/ha)
Pendimethalin	750	48.4	605.0	303.3	293.3	84.8	5.08	12.3
Pendimethalin + metribuzin	750 + 210	48.1	605.0	306.7	302.0	86.3	5.37	12.6
Pendimethalin + metribuzin *fb* mesosulfuron + iodosulfuron (RM)	750 + 210 *fb* 12 + 2.4	48.6	608.3	308.3	305.0	86.0	5.79	13.5
Pendimethalin + metribuzin *fb* clodinafop + metsulfuron (RM)	750+210 *fb* 60+4	48.2	608.3	311.7	305.0	86.3	5.72	13.5
Pendimethalin + pyroxasulfone (TM)	750+102	48.0	609.0	310.0	300.0	86.0	5.58	13.0
Pendimethalin + pyroxasulfone (TM) *fb* clodinafop + metsulfuron (RM)	750+102 *fb* 60+4	48.3	610.0	311.5	309.0	86.3	5.74	13.7
Pendimethalin + pyroxasulfone (TM) *fb* mesosulfuron + iodosulfuron(RM)	750+102 *fb* 12 + 2.4	47.0	608.3	311.3	306.0	86.3	5.797	13.7
Clodinafop-propargyl + metsulfuron-methyl (RM)	60+4	48.7	600.0	301.7	293.3	86.1	5.59	12.6
Mesosulfuron + iodosulfuron(RM)	12 + 2.4	47.9	608.3	304.6	301.7	86.0	5.60	13.1
Weedy		47.4	535.0	200.0	225.0	83.4	4.00	9.93
SEm±		0.8	9.5	8.0	4.7	0.9	0.07	0.45
LSD (P=0.05)		NS	28.3	23.7	14.0	NS	0.27	1.43

WP 2.4 Threshold of *Phalaris minor* in wheat PAU, Ludhiana

In wheat threshold level of *P. minor* was studied in variety PBW 677. Seven densities, *viz.* 0, 1, 2, 4, 6, 8 and 10 plants per m^2 were maintained in wheat field. The weeds other than *P. minor* were uprooted at weekly intervals. The yield and yield attributes of all treatments were at par indicating that *P. minor* at densities upto 10 plants /m^2 were not competitive with wheat **(Tables 2.4.1 and 2.4.2)**.

Table 2.4.1 Phenological stages of wheat and *P. minor*

Phenological stage of rice	Days after transplanting (DAT)
Tillering	52
Jointing	71
Anthesis	100
Physiological maturity	150
Harvest maturity	164
Phenological stage of *P. minor*	
Flowering initiation	78
Completion of flowering	96
Maturity	128

Table 2.4.2 Effect of *P. minor* density (No./m^2) on yield and yield attributes of rice

Density of *P. minor* (No./m ^{2})	Plant height (cm)	Effective tillers (No./m ^{2})	Biological yield (t/ha)	Grain yield (t/ha)
0	113	409	15.1	5.41
1	115	416	15.1	5.53
2	116	416	15.2	5.47
4	112	408	15.4	5.46
6	111	411	15.3	5.49
8	114	398	15.0	5.51
10	112	407	14.9	5.47
SEm±	1.7	10.5	0.20	0.13
LSD (P=0.05)	NS	NS	NS	NS

WP 3 Biology and management of problem weeds in cropped and non-cropped areas

WP 3.1 Management of problematic weeds

3.1.1 (a) *Orobanche* management in brinjal

Egyptian broomrape (*Orobanche aegyptiaca* Pers.) locally known as Margoja/ Rukhri/ Khumbhi / Gulli is an achlorophyllous, phanerogamic troublesome root parasite that depends completely on host to complete its life cycle. This parasitic plant causes economic damage in field crops and vegetable production worldwide. The conventional method of weed control by hoeing is not possible for the control of *Orobanche* due to repeated emergence throughout the crop growth period. Present investigation was done to assess the efficacy of various sulfonylurea herbicides against *Orobanche aegyptiaca* in brinjal

A field trial was conducted by OUAT, Bhubaneswar as OFT in brinjal crop infested with *Orobanche* at Talabasta village in Cuttack district during September, 2017. Some of the biological parameters recorded have been presented in **Table 3.1.1.** The emergence of the shoot took around 49 days and there were average 5.2 shoots per brinjal plant. The shoot of *Orobanche* grew up to a height of 14.3 cm. The parasite produces around 4500 seeds/floret and there may be 40.0 florets per shoot.

Application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT recorded significantly lowest number of *Orobanche*/plant (9.2) at 30 DAT. However, the practice of two hand weeding at 35 and 55 DAT recorded significantly the lower density (10.2) at harvest and the reduction in density was in the tune of 25% over application of sulfosulfuron 50 g/ha at 60 DAT. Among weed management practices, hand weeding twice recoded the highest yield (34.7 t/ha), which was at par with application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT (34.3 t/ha). The lowest yield of 11.6 t/ha was obtained from the control plot.

Experiment was also conducted by CCHAU, Hisar in village of tehsil Nuh of distrct Mewat (Haryana). Brinjal hybrid 707 was planted on August,16 2017. Observations on number of broom rape spikes/m^2 by different treatments and broom rape visual control (0-100 scale) was recorded at 120 DAP. Number of fruits/plant was recorded from five tagged plants and averaged to compute values /plant. Brinjal fruits picked in four flushes were weighed and thus total yield/plot was computed. These observations were subjected to ANOVA and means were compared with appropriate Fisher's protected LSD test at 5% level of probability. Crop phyto-toxicity due to different treatments was assessed at 120 DAP on a scale of 0-100, where 0 means no injury and 100 = complete mortality of tomato plant. Injury data were arc sin transformed prior to ANOVA but was also expressed in their original form for clarity.

Broom rape panicles did not appear in any of the treatment up to 60 DAT. Application of neem cake at sowing in combination with pendimethalin followed by soil drenching of metalaxyl MZ 0.2 % at 20 DAT did not cause any inhibition in broom rape emergence as evident from density of broom rape at 120 DAP (**Table 3.1.2**). Although excellent control of *Orobanche* was obtained with bort or pre plus bort treatments of sulfosulfuron and ethoxysulfuron when compared with non treated controls, but proved phytotoxic to brinjal crop. *Orobanche* stalks to the tune of 1.7-3.0 panicles/m^2 appeared in all sulfosulfuron and ethoxysulfuron treatments, which was significantly less than untreated control. Broom rape spikes which emerged in ethoxysulfuron and sulfosulfuron treatments were very weak and small sized.

Treatment of ethoxysulfuron 20 g/ha at transplanting were more phytotoxic than sulfosulfuron and brinjal exhibited 80% growth reduction under this treatment. Only 70% suppression on brinjal plant was recorded with use of post- emergence application of sulfosulfuron at 25 g/ha at 25 and 45 DAP **(Table 3.1.2).** Crop suppression with use of 25 g/ha sulfosulfuron had reflection on plant height, number of fruits/plant and

Table 3.1.1 Biology of *Orobanche* in brinjal

Parameter		Range	Mean
Days to emergence of shoot above ground (from date of planting)		43 – 56	49
No. of shoots of parasite / plant		3 - 7.4	5.2
Shoot height (cm)		11.3 – 17.0	14.3
Days to flowering (from the date of planting)		50-60	55
Days to drying of shoot (from the date of emergence)		35-41	38
Dry weight / plant	Stem	1.1 – 4.5	3.0
	Florets	0.5-2.0	1.4
	Seeds	0.30-1.36	0.76
	Total	1.90 – 7.86	5.16
No. of florets / shoot		26 – 95	40.0
No. of seeds / floret		3,500 – 5,700	4,500
No. of seeds / inflorescence		96,400 - 5,50,200	2,80,000

total fruit yield of brinjal. Maximum fruit yield (21.8 t/ha) was recorded from untreated check, which was at par with sulfosulfuron 25 g/ha at 25 and 45 DAP (20.8 tones/ha) and neem cake *fb* pendimethalin and metalyxyl, but significantly higher than ethoxysulfuron and sulfosulfuron application at 2-3 days after transplanting.

Table 3.1.2 Effect of different weed control measures on broom rape *(Orobanche)* population visual control, crop toxicity and fruit yield of brinjal

Treatment	Number of broom rape spikes/m² (120 DAS)	Visual control (%) (120 DAS)	Visual phytotoxicity (%) on crop 120 DAP	Fruit yield (t/ha)
Neem cake 200 kg/ha at sowing *fb* pendimethalin 1.0 kg/ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2 % at 20 DAT	5.13(25.4)	0(0)	0(0)	21.2
Ethoxysulfuron 20 g/ha (PRE) and at 45 DAT	1.41(1.0)	63.5(80.0)	56.7(70)	12.4
Sulfosulfuron 25 g/ha at 25 and 45 DAT	2.0(3)	56.7(70.0)	33.1(30.0)	20.8
Sulfosulfuron 25 g/ha at sowing and 45 DAT	1.41(1.0)	73.5(88.3)	36.5(35.0)	15.6
Weedy check	5.29(27.0)	0(0)	0(0)	21.8
S Em +	0.15	0.90	0.65	0.82
LSD (P=0.05)	0.46	3.01	2.18	2.6

*Original figures in parenthesis related to broom rape density were subjected to square root transformation $\sqrt{(X+1)}$ and broom rape control were subjected to arc $\sin^{-1}$ transformation before statistical analysis

3.1.1 (b) *Orobanche* management in tomato

During survey of weed flora in tomato fields in Haryana, crop was found badly infested with *Orobanche aegyptiaca* in Nuh, Ferozepur Jhirka, Nagina, Taoru areas of Mewat, Charkhi Dadri of district Bhiwani. Farmers reported 40-75% loss in fruit yield due to its infestation in tomato crop depending on intensity of infestation. A continuous increase in *Orobanche* infestation in these areas has forced farmers to abandon tomato cultivation and switch over to non-profitable crops.

A field experiment was conducted by CCHAU, Hissar in tomato field. Hybrid '2853' was planted on November 11, 2017 at Farm of Abaas of village Rehna, tehsil Nuh Distt. Mewat (Haryana). Crop was grown as per university recommended package of practices for tomato except herbicide treatments. Post-emergence herbicides were applied at various stages as per treatment using 375 litres of water/ha. Observations on number of broom rape spikes/m^2 and broom rape visual control (0-100 scale) by different treatments was recorded at 60, 90, 120 DAP and at harvest. Data on plant height, were recorded at 120 DAP. Number of fruits/plant was recorded from five tagged plants at 90,120 DAT and harvest which were averaged to compute values /plant. Tomato fruits picked in four flushes were weighed and thus total yield/plot was computed. These observations were subjected to ANOVA and means were compared with appropriate Fisher's protected LSD test at 5% level of probability. Crop phyto-toxicity due to different treatments was assessed at 10, 30 DAT and harvest on a scale of 0-100, where 0 means no injury and 100 = complete mortality of tomato plant. Foliar necrosis, yellowing, stunting, necrosis and wilting were the main symptoms considered while making visual estimate of visual injury on tomato plants. Injury data were arc sin transformed prior to ANOVA but was also expressed in their original form for clarity.

Study showed that broom rape panicles did not appear in any of the treatment even up to 60 DAS and number of panicles emerged above ground were few even at 90 DAS. Excellent control was obtained with post-emergence treatments of sulfosulfuron and ethoxysulfuron when compared with non treated

Table 3.1.3 Effect of different weed control measures on broom rape *(Orobanche)* population, visual control, plant height, crop toxicity and fruit yield of tomato 2017-18

Treatment	Number of broom rape spikes/m²				Visual phytotoxicity (%) on crop	Visual broom rape control (%)		No. of fruits/ plant	Fruit yield (t/ha)	B:C
	60 DAP	90 DAP	120 DAP	Harvest	10 DAT	120 DAP	Harvest			
Ethoxysulfuron 50 g/ha at 60 and 90 DAT	0	1.14 (0.40)	1.49 (1.33)	1.99 (3.00)	14.0(6)	73.5 (88.3)	62.9 (79.3)	35.0	25.4	4.9
Sulfosulfuron 25 g/ha at 60 DAT *fb* 50 g/ha 90 DAT	0	1.24 (0.60)	1.58 (1.67)	1.73 (2.33)	0(0)	71.1 (85.0)	72.4 (86.7)	35.7	24.9	5.0
Sulfosulfuron 50 g/ha at 60 and 90 DAT	0	1(0)	1.63 (1.67)	1.72 (2.00)	15.2(7)	90 (100)	67.4 (85.0)	34.3	24.4	4.6
Hand pulling (FP)	0	2.76 (6.20)	2.70 (6.33)	2.52 (5.6)	0(0)	37.2 (36.7)	33.1 (30.0)	27.3	16.7	2.7
Weedy check	0	3.21 (9.40)	3.93 (14.6)	4.50 (19.3)	0(0)	0.0 (0.0)	0.0 (0.0)	25.0	13.0	3.0
S Em ±		0.16	0.22	0.32	0.78	6.0	4.5	0.8	0.4	-
LSD (P=0.05)		0.52	0.74	1.05	2.59	20.0	14.9	2.6	1.4	-

*Original figures in parenthesis related to broom rape density were subjected to square root transformation $\sqrt{(X+1)}$ and visual toxicity to arc sin transformation before statistical analysis

controls. At harvest, *Orobanche* stalks to the tune of 2-3 panicles/m^2 appeared in various herbicide treatments, which was significantly less than 19.3/m^2 in untreated control. Toxicity to tomato crop due to post- emergence use of ethoxysulfuron and sulfosulfuron 50 g/ha at 60 and 90 DAT varied from 6-7 % at 10 DAT but it mitigated after 30 DAT and did not translate into any yield reduction**.**

At harvest, visual *Orobanche* control in various herbicide treatments varied from 79-86%. Plant height and number of fruits per plant varied significantly due to various herbicide treatments. Maximum plant height (51.7-52 cms) was recorded in post-emergence treatments of sulfosulfuron and ethoxysulfuron, which was significantly higher than all other treatments. Number of tomato fruits/plant were maximum (35.7) with use of sulfosulfuron 25 g/ha at 60 DAP and 50 g/ha at 90 DAP, which were at par among all herbicide treatments, but significantly higher than weedy check and hand pulling. Maximum fruit yield (25.4 t/ha) was recorded from use of ethoxysulfuron 50 g/ha at 60 and 90 DAP, which was at par with sulfosulfuron treatments and significantly higher than weedy check with 48.8% increase over untreated check. Maximum B:C ratio (5.0) was obtained with post emergence use of sulfosulfuron 25 g/ha at 60 DAP and 50 g/ha at 90 DAP and minimum (2.7 & 3.0) with hand pulling and weedy check treatments (**Table 3.1.3**).

MPUAT, Udaipur surveyed the area for *Orobanche* infestation in tomato growing field. Infestation was observed in about 2000 ha area of Salumber and Sarada tehsil of Udaipur district.

3.1.1 (c) *Cuscuta*

Cuscuta chinensis- a dreaded parasitic weed is a serious threat in onion growing area of Chitradugrga district of Karnataka. In order to find the suitable and economic weed management practice for onion in these area, UAS Bengaluru conducted an experiment in Onion crop for the management of *Cuscuta* in a plot size of 3.9 X 2.8 m at farmers' field. Onion was sown on 5-11-2018 and pre-emergent herbicide was applied on 7-11-2018. These treatments combinations were replicated thrice in RCBD. The pre-emergence herbicides were applied using spray volume of 750 litres/ha with Knapsack sprayer having WFN nozzle. No germination of C*uscuta* was observed in plots where pre-emergent application of herbicide was imposed. However, *Cuscuta* emergence was noticed at 15 DAT where imazethapyr 75 g/ha as post-em, 20 DAS was imposed.

On the 5th day after spray, phtotoxicity on onion crop and *Cuscuta* was noticed.

WP 3.1.1 (d) Biology and management of *Sacciolepis interrupta* in rice

a) Biology of *Sacciolepis interrupta*

KAU, Thrissur conducted experiment on problematic weed *Sacciolepis* in rice. Nodes are glabrous. Culm length ranges from 25-90 cm, and the plant has erect, creeping or geniculate, spongy and floating habitat. Leaves range in length from 5 to 30 cm, and breadth from 0.3 to 2 cm. Leaf shape is lanceolate or base rounded, and apex was acute or acuminate. Length of the panicle ranges from 4 to 25 cm, with spiceform and interrupted shape. Spikelets are ovate and lanceolate in shape, and were 3 to 5 mm long.

Plant phenophases

Sowing to emergence (DAS)	Emergence to tillering (DAS)	Tillering to panicle initiation (DAS)	Panicle initiation to booting (DAS)	Heading to flowering (DAS)	Flowering to grain filling (DAS)	Milky stage (DAS)	Dough stage (DAS)	Maturity (DAS)
0-9 (9)	10-26 (17)	27-44 (18)	45- 56 (12)	57-63 (7)	64-75 (12)	76-77 (2)	78-80 (3)	81-86 (6)

The period from sowing to emergence of *Sacciolepis interrupta* was 9 days, and it took another 17 days for tillering of the plant. After tillering, another 37 days elapsed before flowering, and the seeds were mature in another 23 days. Total mean duration of the plant was 86 days.

Tillering in *Sacciolepis interrupta*

Spikelets of *Sacciolepis interrupta*

b) Integrated management of *Sacciolepis interrupta*

The trial was conducted at farmers' field in Chithali in Palakkad district of Kerala. Dry sowing was done on 29-06-2018 and the crop was harvested on 27-09-18. The major weeds in the field were *Sacciolepis interrupta*, *Cyperus iria*, *Paspalum conjugatum* and *Cyanotis axillaris*. Weedy rice was also present in the experimental plot. At 30 DAS, significant effect of treatments was observed only on the weeds *Sacciolepis interrupta* and *Cyanotis axillaris*. *Cyanotis axillaris* was comparatively a minor weed, and significantly higher density was noticed only in the unweeded control treatment. Though values of weed control were higher, all treatments except unweeded control were at par with *Sacciolepis interrupta* also. Unweeded control recorded significantly higher value (**Table 3.1.4**). At 60 DAS, *Sacciolepis interrupta* was the only dominant weed in rice. Combinations of pre- and post-emergence were effective in significantly reducing density of the weed. These treatments were followed by the hand weeding and pyrazosulfuron-ethyl *fb* hand weeding. Highest values of density of *Sacciolepis interrupta* was recorded in the unweeded control

Various treatments had significant effect, with highest values recorded in un-weeded control, both at 30 and 60 DAS. At 30 DAS, all herbicidal treatments were significantly superior to hand weeding. At 60 DAS, hand weeding was at par with all herbicidal treatments, except for pyrazosulfuron-ethyl *fb* hand weeding (T_1), which recorded significantly higher value of weed dry matter production. Unweeded control recorded highest values of weed dry matter production at both stages.

Table 3.1.4 Effect of treatments on *Sacciolepis interrupta* dry matter production at 30 and 60 DAS

Treatment		Weed dry matter production (kg/ha)	
		30 DAS	60 DAS
T1	Pyrazosulfuron-ethyl *fb* hand weeding	2.24 c** (0)*	48.62 b (34.8)
T2	Cyhalofop-butyl + penoxsulam *fb* hand weeding	21.0 bc (11.5)	2.24 c (0)
T3	Pyrazosulfuron-ethyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	2.24 c (0)	2.24 c (0)
T4	Pretilachlor + bensulfuron-methyl *fb* hand weeding	2.24 c (0)	2.24 c (0)
T5	Pretilachlor + bensulfuron- methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	16.56bc (6.8)	2.24 c (0)
T6	Hand weeding	35.3 b (18.1)	24.50bc (15.9)
T7	Unweeded control	81.4 a (67.5)	112.1 a (127)
	LSD (P=0.05)	32.5	36.5
	SEm	1.05	1.18

* Original values are given in parentheses ** Values followed by same alphabet do not differ significantly in DMRT

Weed control efficiency at 30 DAS was more than 95% for the treatments pyrazosulfuron-ethyl *fb* hand weeding, pyrazosulfuron-ethyl *fb* cyhalofop-butyl + penoxsulam *fb h*and weeding and pretilachlor + bensulfuron-methyl *fb* hand weeding. At 60 DAS, all herbicidal treatments except pyrazosulfuromethyl *fb* hand weeding registered 98% WCE, indicating very good control of weeds. Effect of treatments on grain yield was found to be significant, with highest yield (4.44 t/ha) in pretilachlor + bensulfuron-methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding. Treatment pyrazosulfuron-ethyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding came next with a grain yield of 3.78 t/ha. All other herbicidal treatments and hand weeding registered lower yields. The lowest grain yield of 2.11 t/ha was observed in unweeded control. Significantly higher straw yields ranging from 4.83 to 5.01 t/ha were recorded in treatments T_3, T_4 and T_5. All other herbicidal treatments and hand weeding resulted in lower straw yields, which were at par. Unweeded control recorded lowest straw yield of 2.11 t/ha.

Table 3.1.5 Effect of treatments on grain and straw yields of rice

Treatment		Yield (t/ha)	
		Grain	Straw
T1	Pyrazosulfuron-ethyl *fb* hand weeding	3.24 c**	4.10 b
T2	Cyhalofop-butyl + penoxsulam *fb* hand weeding	3.42bc	4.09b
T3	Pyrazosulfuron-ethyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	3.78b	5.01a
T4	Pretilachlor + bensulfuron-methyl *fb* hand weeding	3.06c	4.83 a
T5	Pretilachlor + bensulfuron-methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	4.44a	4.83a
T6	Hand weeding	3.42bc	4.10 b
T7	Unweeded control	2.11 d	2.11 c
	CD (0.05)	0.44	0.40
	SEm	0.14	0.13

** Values followed by same alphabet do not differ significantly in DMRT

Highest BC ratio of 1.53 was obtained with the treatment pretilachlor + bensulfuron-methyl *fb* hand weeding (**Table 3.1.6**). Next higher ratio of 1.4 was obtained when pyrazosulfuron-methyl was followed by cyhalofop-butyl + penoxsulam and hand weeding. Ratios ranging from 1.22 to 1.26 were obtained with other herbicide treatments.

Table 3.1.6 Effect of treatments on economics of cultivation of rice

Treatments	Cost of cultivation (other than weed control) (₹/ha)	Cost of weed control (₹/ha)	Total cost (₹/ha)	Returns (Rs.)		Total returns (t/ha)	B : C ratio
				Grain	Straw		
Pyrazosulfuron -ethyl *fb* hand weeding	72,000	27,125	99,125	76,271	45,141	1,21,413	1.22
Cyhalofop- butyl + penoxsulam *fb* hand weeding	72,000	27,250	99,250	80,412	45,054	1,25,467	1.26
Pyrazosulfuron- ethyl *fb* cyhalofop butyl + penoxsulam *fb* hand weeding	72,000	30,375	1,02,375	88,888	55,189	1,44,078	1.41
Pretilachlor + bensulfuron- methyl *fb* hand weeding	72,000	27,825	99,825	71,933	53,172	1,25,106	1.25
Pretilachlor + bensulfuron-methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	72,000	31,075	103075	1,04,389	53,165	1,57,554	1.53
Hand weeding	72,000	48,000	1,20,000	80,549	45,197	1,25,746	1.05
Unweeded control	72,000	0	72,000	49,724	23,288	73,012	1.01

Analysis of dehydrogenase enzyme activity revealed that there was only a slight change in microbial population in soil due to herbicidal effect. Initial soil dehydrogenase activity was 2 µg TPF h/g soil, while after the experiment, the mean value was 2.12 µg TPF h/g soil.

WP 3.2.2 Management of problem weeds in *Kharif* season like *Leptochloa chinensis* and *Alternanthera* spp. in rice

GBPUAT, Pantnagar conducted experiment to determine the best weed management practices for control of problematic weeds like *Leptochloa chinensis*, *Alternanthera* spp. and *Eragrostis japonica*. Density of *L. chinensis* was completely controlled under the treatment of penoxsulam+cyhalofop at 135 g/ha, which was also effective for reducing the density of *A. sessilis* at 60 DAS and found to be the significantly superior to rest of the treatment, being at par to the weed free. *L. chinensis* also got eliminated with cyhalofop-butyl at 80 g/ha (**Table 3.2.2a**). Similarly, the lowest dry biomass (g/m^2) of *L. chinensis* and *A. sessilis* was also observed with penoxsulam+cyhalofop 6% at 135 g/ha and cyhalofop-butyl at 80 g/ha also in case of *L. chinensis*, which was at par to weed free (**Table 3.2.2b**).

Table 3.2.2a Effect of treatment on weed density (No./m^2) at 60Days after transplanting in rice

Treatment	*Leptochloa chinensis*	*Alternanthera Sessilis*
Pretilachlor 750 g/ha	1.5(1.3)	3.1(8.7)
Bispyribac- sodium 20 g/ha	2.3(4.7)	2.5(5.3)
Fenoxaprop-p-ethyl 56.25 g/ha	1.6(1.7)	3.2(9.3)
Cyhalofop-butyl 80 g/ha	1.0(0.0)	3.2(9.3)
Penoxsulam+ cyhalofop 135g/ha	1.0(0.0)	1.5(1.3)
Penoxsulam 22.5 g/ha	2.4(4.7)	1.9(2.7)
Metsulfuron-methyl 4.0 g/ha	2.5(5.3)	1.9(2.7)
2,4-D ethyl ester 850g/ha	2.2(4.0)	1.9(2.7)
Weed free	1.0(0.0)	1.0(0.0)
Weedy	2.8(6.7)	3.4(10.7)
SEm±	0.10	0.14
LSD(P=0.05)	0.29	0.42

DAS: Days after sowing; Value in parentheses was original and transformed to square root$\sqrt{X+1}$ for analysis

Table 3.2.2b Effect of treatment on weed density (g/m^2) at 60Days after transplanting in rice

Treatment	*Leptochloa chinensis*	*Alternanthera Sessilis*
Pretilachlor 750g/ha	1.9(2.7)	2.6(5.8)
Bispyribac-sodium 20g/ha	2.5(5.6)	2.2(3.9)
Fenoxaprop-p-ethyl 56.25 g/ha	1.9(2.7)	2.7(6.5)
Cyhalofop-butyl 80g/ha	1.0(0.0)	2.7(6.6)
Penoxsulam+ cyhalofop 135g/ha	1.0(0.0)	1.4(0.9)
Penoxsulam 22.5 g/ha	2.7(6.3)	1.7(2.1)
Metsulfuron-methyl 4.0 g/ha	2.7(6.3)	1.4(0.9)
2,4-D Ethyl Ester 850g/ha	2.7(6.7)	1.4(0.9)
Weed free	1.0(0.0)	1.0(0.0)
Weedy	2.9(7.3)	2.7(6.3)
SEm+	0.06	0.06
LSD(P=0.05)	0.19	0.17

DAS: Days after sowing; Value in parentheses was original and transformed to square root$\sqrt{X+1}$ for analysis

Data of yield and yield attributing characters in transplanted rice showed that the highest plant height was recorded in fenoxaprop-p-ethyl at 56.2 g/ha, while, highest number of panicles/m^2, 1000-grain weight (g) and straw yield (9.30 t/ha) were recorded with penoxsulam+cyhalofop at 135 g/ha. Highest grains/panicle was achieved with penoxsulam, whereas, the highest grain yield (5.4 t/ha) was obtained with weed free which was comparable to penoxsulam+cyhalofop at 135 g/ha (**Table 3.2.2c**).

Table-3.2.2c Effect of treatment on yield and yield attributes characters in transplanted rice

Treatment	Plant height (cm)	Panicle (No./m²)	Grain/ panicle	1000 grain wt.(g)	Grain yield (t/ha)	Straw yield (t/ha)
Pretilachlor 750 g/ha	127	151	178	28.8	4.30	8.08
Bispyribac-sodium 20 g/ha	128	140	200	29.0	4.92	8.42
Fenoxaprop-p-ethyl 56.25 g/ha	132	161	186	29.8	5.00	8.72
Cyhalofop-butyl 80 g/ha	129	139	184	29.7	5.23	8.43
Penoxsulam+ cyhalofop 135g/ha	130	157	176	31.5	5.44	930
Penoxsulam 22.5 g/ha	130	139	218	28.2	5.08	7.95
Metsulfuron-methyl 4.0 g/ha	130	143	198	29.0	4.72	8.38
2,4-D Ethyl Ester 850 g/ha	130	154	165	29.2	4.48	8.29
Weed- free	129	141	187	28.7	5.45	9.12
Weedy	130	125	141	27.2	4.30	8.90
SEm+	0.8	4.1	9.5	0.3	0.19	0.28
LSD(P=0.05)	2.5	12.2	28.5	1.0	0.56	0.85

WP 3.4.1 Control of *Cirsium arvensis*

For the control of *Cirsium arvense*, an experiment was conducted at GBPAUT, Pantnagar to test the bio-efficacy of different herbicides during the winter season 2017-18. The experiment was laid out in a randomized block design with three replications. For establishment of *C. arvense*, cuttings of stem were sown in the plots. Different post -emergence herbicides were applied when the new plants emerged. Metribuzin was also applied as pre-emergence. The biomass of plants was 1.83 kg/plot in the control plots. Among the treatments, glyphosate application (1.0 kg /ha) recorded the lowest biomass followed by post-emergence application of metribuzin (0.25 kg/ha), metsulfuron-methyl (0.004 kg/ha) and 2,4-D, which significantly reduced the biomass. However, in the carfentrazone and metribuzin (pre-emergence application) treatments, the biomass was similar to the control plots. This showed that among the herbicides, glyphosate is most effective in controlling *C. arvense* followed by metrubuzin (post-emergence) and metsulfuron-methyl (**Figure 3.4.1**).

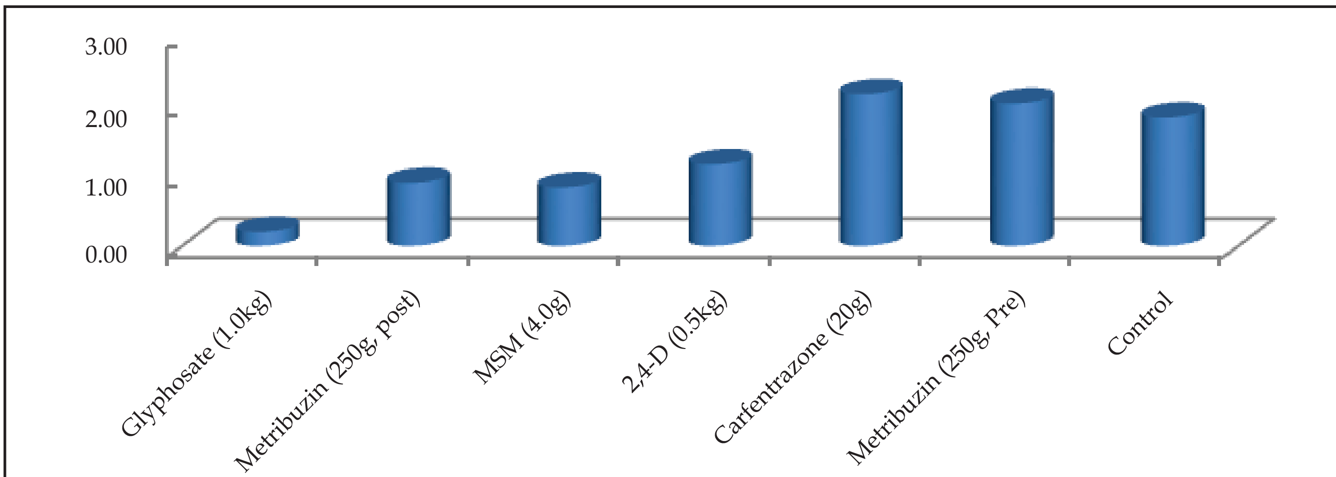


Fig. 3.4.1 Effect of different herbicides on biomass production of *C. arvense*

WP 3.4.2 Management of *Argemone mexicana, Solanum nigrum* and *Polygonum plebeium* in wheat crop

For evaluation of the bio-efficacy of some pre- and post- emergence herbicides for the management of three weed species, *viz. Argemone maxicana, Solanum nigrum* and *Polygonum plebeium* in wheat crop, an experiment was carried out in the winter season of 2017-18 at farm of GBPUAT, Pantnagar. It was laid out in a Randomized Block Design with 12 treatments and three replications. Wheat variety '*HD 2967*' was sown in the plots with a row to row spacing of 20 cm.

Argemone mexicana: *Argemone mexicana* was not observed in any of the treatments till 45 DAS **(Fig 3.4.2.1).** At 60 DAS, metsulfuron-methyl, sulfosulfuron+ MSM and carfentrazone+ sulfosulfuron treatments recorded higher density of *Argemone maxicana* than other treatments. Its density decreased at 75 DAS as compared to that 60 DAS in these treatments.

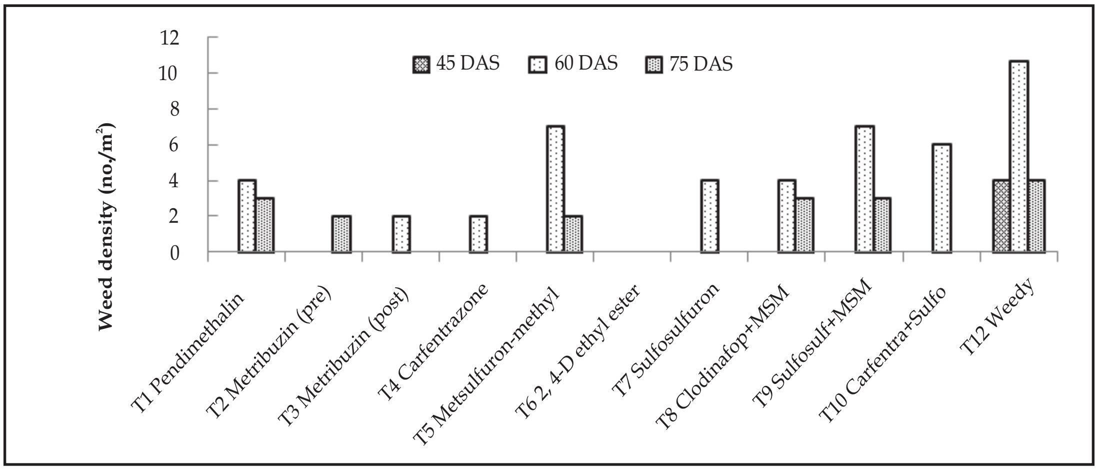


Fig 3.4.2.1 Effect of herbicides on density (no./m^2) of *Argemone maxicana*

Higher weed biomass of *Argemone maxicana* was recorded in weedy plot at all the stages (The treatments, metribuzin (PoE), carfentrazone, pendimethalin (PE) and carfentrazone+ sulfosulfuron recorded lower biomass at 60 DAS.

***Solanum nigrum*:** The density of *Solanum nigrum* ranged between 10-12.0/m^2 in the weedy plot at all the stages **(Fig. 3.4.2.2).** It was totally absent in the treatments of pendimethalin (PE) and carfentrazone + sulfosulfuron . At 45 DAS, this species was observed in the treatments metsulfuron-methyl, sulfosulfuron , clodinafop+MSM and sulfosulfuron+MSM , where its density was lower than weedy plot. At 75 DAS, its density decreased in these treatments.

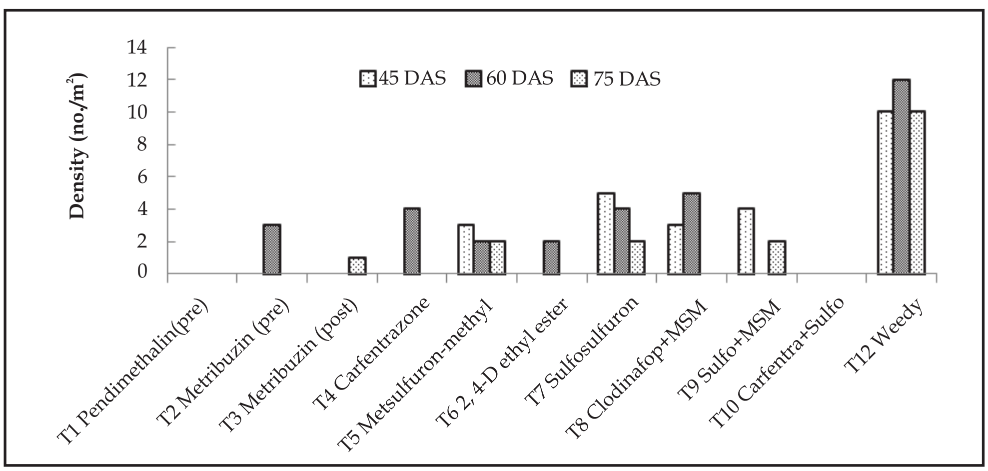


Fig. 3.4.2.2 Effect of herbicides on density (no./m^2) of *Solanum nigrum*

The biomass of *Solanum nigrum* was 0.68 g /m^2 in the weedy plot at 45 DAS, which increased to 1.32 g/m2 at 60 DAS. In the treatments, metsulfuron-methyl, sulfosulfuron, clodinafop + MSM and sulfosulfuron + MSM biomass was lower than weedy plot. At 75 DAS, its biomass decreased in these

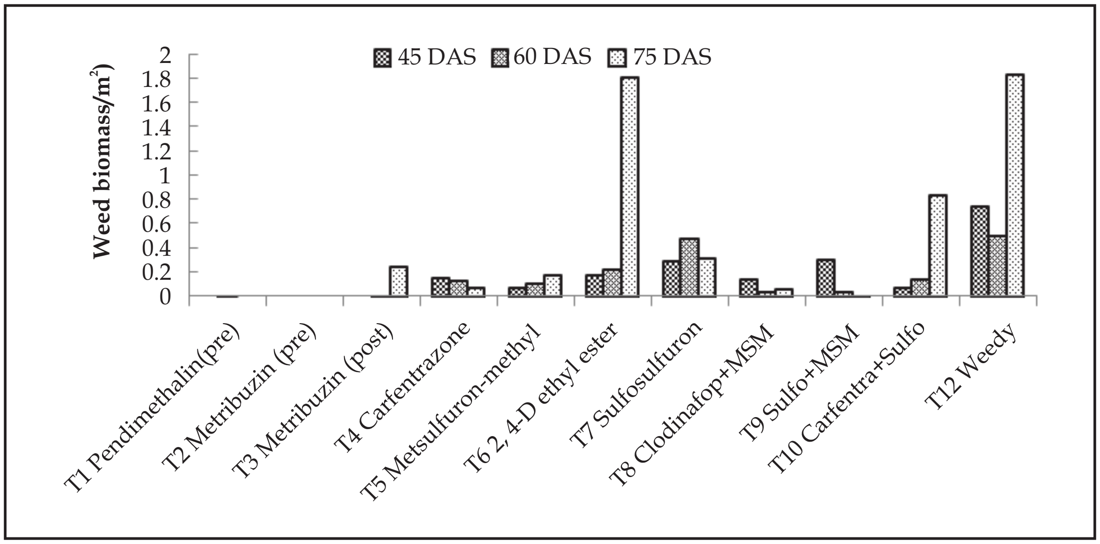


Fig 3.4.2.3 Effect of herbicides on biomass (g/m^2) of *Polygonum plebeium*

treatments. The density of *Polygonum plebeium* in weedy plot was 34.0/m^2 at 45 DAS, which increased to 65.0/m^2 at 75 DAS. This species was not observed in the treatment metribuzin (PE) at any stage. However, 2,4-D ethyl-ester, sulfosulfuron and carfentrazone+ sulfosulfuron treatments recorded higher density as compared to other treatments, but it was lower than the weedy plot.

Polygonum plebeium: Biomass of *Polygonum plebeium* was 0.74 g/m^2 at 45 DAS, which increased to 1.826 g/m^2 at 75 DAS in weedy plot (**3.4.2.3**).). In treatments, 2,4-D, ethyl-ester, sulfosulfuron and carfentrazone + sulfosulfuron, higher biomass was recorded as compared to other treatments, but was lower than weedy plot.

Effect of herbicides on number of panicles /m^2 in wheat crop

Maximum numbers of panicles were recorded in weed free followed by pendimethalin (PE) and sulfosulfuron + MSM treatments while minimum number of panicles was observed in clodinafop + MSM followed by carfentrazone+sulfosulfuron and sulfosulfuron . In the treatments, metsulfuron-methyl, carfentrazone, metribuzin (both pre and post-emergence), it ranged between 302-342 /m² (**Fig 3.4.2.4)**.

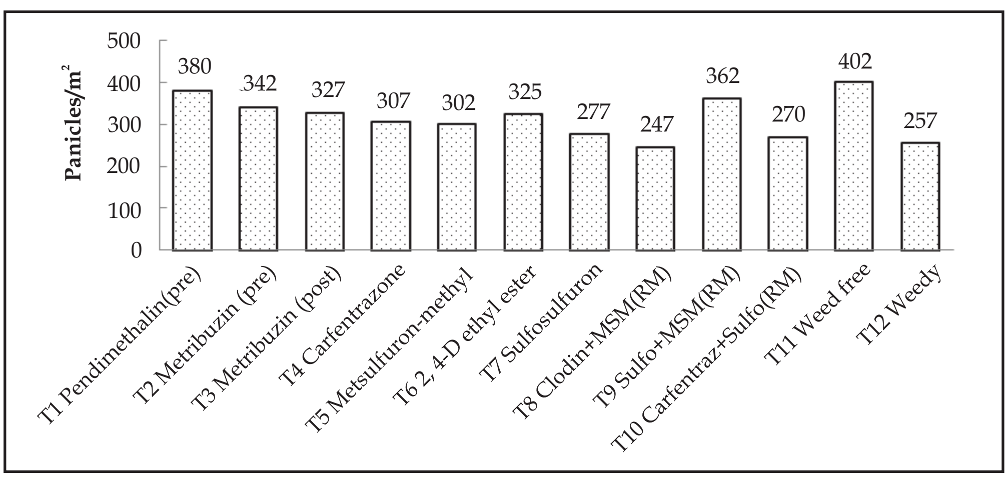


Fig 3.4.2.4 Effect of herbicides on number of panicles/m2 in wheat crop

Effect of herbicides on total biological yield (kg/m^2) and grain yield of wheat crop

There was no significant difference in biological yield among treatments, which ranged between 1.1-1.4 kg/m^2. Weedy plot as well as clodinafop+MSM treted plots recorded lowest biological yield (1.1 kg/m^2). There was not much difference in grain yield/m^2 of wheat among treatments, which ranged between 0.36-0.49 kg/m^2. Lower grain yield (0.36 kg/m^2) was recorded in weedy plot as well as in carfentrazone+sulfosulfuron (**Fig. 3.4.2.5**).

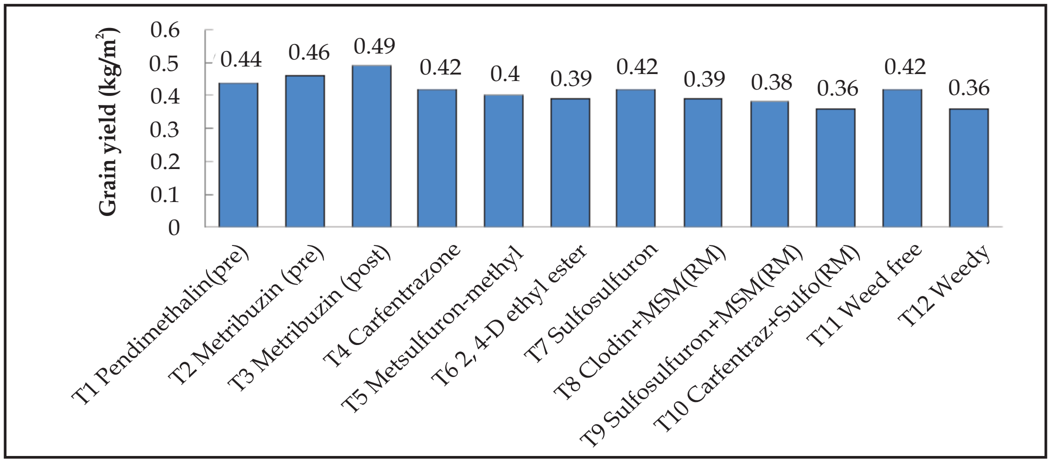


Fig 3.4.2.5 Effect of herbicides on grain yield/m^2 in wheat crop

WP 4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment

WP 4.1 Study herbicide residues in the long-term conservation agriculture experiment

CSKHPKV, Palampur

Persistence of herbicides may vary under different tillage and residue management techniques. Persistence of isoproturon and 2,4-D in wheat (*Rabi* 2017-18); and atrazine in maize and pendimethalin in soybean (*Kharif* 2018) under different tillage and residue management techniques was studied at Palampur. Soil samples were collected immediately after herbicide application and at crop harvest. Crop produce samples were taken at harvest. The treatment and other details are given in **Table 4.1.1.**

Table 4.1.1 Weed management in conservation agriculture system in maize–wheat cropping system

Treatment	*Kharif* (Maize)	*Rabi* (Wheat)
A. Tillage and residue management-T		
1	CT	CT
2	CT	ZT
3	ZT	ZT
4	ZT	ZT+R
5	ZT+R	ZT+R
B .Weed Management- W		
1	Recommended herbicide (Atrazine 1. 5 kg/ha	Recommended herbicide (Isoproturon 1.25 kg/ha +2,4-D 0.75 Kg/ha)
2	Integrated Weed management (Herbicide+ HW+intercrop) Pendimethalin 1.0 kg/ha	Integrated Weed Management (Herbicide +HW + intercrop) Isoproturon 1.00 kg/ha
3	Hand weeding	Hand weeding

CT-Conventional tillage ,ZT-Zero tillage, R-Residues.

In *Rabi* (2017-18), residues of isoproturon and 2,4-D under different tillage and residue management techniques were studied in soil (0-15 cm) at zero day after herbicide application and at harvest; and wheat grain samples at harvest. Residues of isoproturon (35 DAS) applied at 1.25 and 1.0 kg/ha in treatments CT-CT (T_1), CT-ZT (T_2), ZT-ZT (T_3), ZT- ZT +R (T_4) and ZT+R -ZT+R (T_5) are given in Table (4.1.2). In soil and wheat grain under different tillage and residue management techniques isoproturon residues were below detectable limits at the time of harvest. Initial residues of 2,4-D (35 DAS) applied at 0.75 kg/ha in treatments CT-CT (T_1), CT-ZT (T_2), ZT-ZT (T_3), ZT- ZT +R (T_4) and ZT+R -ZT+R (T_5) were 0.23, 0.25, 0.21,0.18 and 0.20 µg /g respectively. The residues of 2,4-D in soil and grain samples collected at harvest were below detectable level.

Table 4.1.2 Residues (µg/g) of isoproturon in soil under different planting pattern

Treatment		Residues(µg/g)			
		W_1 Isoproturon1.25 Kg/ha		W_2 Isoproturon 1.0 Kg/ha	
Maize	Wheat	Initial soil	Harvest soil	Initial soil	Harvest soil
CT	CT	0.450	<0.01	0.374	<0.01
CT	ZT	0.463	<0.01	0.368	<0.01
ZT	ZT	0.456	<0.01	0.364	<0.01
ZT	ZT+R	0.407	<0.01	0.354	<0.01
ZT+R	ZT+R	0.381	<0.01	0.348	<0.01

Table 4.1.3 Residues (µg/g) of atrazine in maize cropped soil under different planting pattern

Treatment W_1		Atrazine 1.5 Kg/ha Residues(µg/g)	
Maize	Wheat	Initial soil	Harvest soil
CT	CT	0.625	<0.01
CT	ZT	0.635	<0.01
ZT	ZT	0.597	<0.01
ZT	ZT+R	0.553	<0.01
ZT+R	ZT+R	0.528	<0.01

LOD–0.005 ppm&LOQ–0.01 ppm

PAU, Ludhiana

Pendimethalin and bispyribac-sodium from soil/rice grain samples was extracted by matrix solid phase dispersion (MSPD) method. The residues were analyzed using Waters HPLC system. The retention time of pendimethalin and bispyribac-sodium was 5.73 and 7.14 min, respectively. The LOD and LOQ of pendimethalin were 0.003 and 0.01 µg/g, respectively. The LOD and LOQ of bispyribac-sodium were 0.02 and 0.05 µg/g, respectively. Initial residues of pendimethalin in the soil ranged from 0.304 to 0.324 µg/g in different treatments and the residues were below the detectable limit (<0.01 µg/g) in the soil and rice grain at the harvest of crop. Initial residues of bispyribac-sodium in soil ranged from 0.162 to 0.191 µg/g in different treatments and residues were below detectable limit (0.05 µg/g) in soil and rice grain at the time of harvest.

In Durum wheat (2017-18), metribuzin and clodinafop-propargyl from soil and wheat grain samples were extracted by MSPD and analyzed by HPLC with the LOD and LOQ of 0.02 and 0.05 µg/g, respectively. Initial residues of metribuzin ranged from 0.123 to 0.129 µg/g in different treatments, and the residues were below the detectable limit (0.05 µg/g) in soil and wheat grain at the harvest of crop. The residues of clodinafop-propargyl in soil and wheat grain at harvest under recommended herbicide and IWM treatments were below detectable limit (<0.05 µg/g).

TNAU, Coimbatore

Soil characteristics					
Soil type	:	Sandy clay loam	Soil pH	:	7.78 - 8.32
Soil EC (dS m^{-1})	:	1.5 -1.71	Available N	:	128 -164 kg/ha
Available P	:	14.2 – 15.5 kg ha^{-1}	Available K	:	484 - 621 kg/ha

During *Rabi* 2017-18 and *Kharif* 2018, sunflower and maize were grown, respectively as test crops which received pendimethalin and atrazine as pre emergence herbicide, respectively to control weeds. Soil and crop produce samples were collected from the herbicides application on 0, 15, 45 and at harvest stages and were subjected to residue analysis to in soil as influenced by the tillage practices. Atrazine and pendimethalin residues were determined by HPLC with LOD and LOQ of 0.01 and 0.05 mg/kg (**Table 4.1.4 and 4.1.5)**.

The dissipation of both the molecules was found to follow first order reaction kinetics (R^2> 0.90) irrespective of tillage practices under both the weed control methods with the half life of 14.8 – 20.0 days and 16.0 – 25.7 days for pendimethalin and atrazine respectively. Irrespective of tillage practices and weed management methods, >80 % of both the herbicides were dissipated from the soil.

Table 4.1.4 Influence of conservation tillage and weed management practices on pendimethalin (mg/kg) residue in soil with sunflower (*Rabi* 2017-18) in maize –sunflower system

Treatments	W (Pendimethalin 1.0 kg/ha)				W_2 (Pendimethalin 1.0 kg/ha + HW on 45 DAS)			
	0 day	15 day	45 day	Harvest	0 day	15 day	45 day	Harvest
T_1 (CT-CT)	0.499	0.142	0.061	BDL	0.456	0.174	0.061	BDL
T_2 (CT-ZT)	0.498	0.173	0.063	BDL	0.419	0.169	0.067	BDL
T_3 (ZT+R - ZT)	0.482	0.179	0.065	BDL	0.419	0.185	0.074	BDL
T_4 (ZT – ZT+R)	0.471	0.201	0.091	BDL	0.461	0.201	0.084	BDL
T_5 (ZT+R – ZT+R)	0.48	0.207	0.098	BDL	0.479	0.208	0.101	BDL

BDL - Below deletion limit.

Table 4.1.5 Influence of conservation tillage and weed management practices on residues of atrazine(mg/kg) in soil with maize (*Kharif* 18) in maize –sunflower system

Treatments	W_1 (Atrazine 0.5 kg/ha)				W_2 (Atrazine 0.5 kg/ha + HW on 45 DAS)			
	0 day	15 day	45day	Harvest	0 day	15 day	45 day	Harvest
T_1 (CT-CT)	0.252	0.142	0.075	BDL	0.268	0.158	0.062	BDL
T_2 (CT-ZT)	0.286	0.151	0.081	BDL	0.290	0.171	0.083	BDL
T_3 (ZT+R - ZT)	0.225	0.103	0.062	BDL	0.232	0.135	0.054	BDL
T_4 (ZT – ZT+R)	0.233	0.097	0.055	BDL	0.254	0.102	0.050	BDL
T_5 (ZT+R – ZT+R)	0.249	0.075	0.048	BDL	0.261	0.079	0.040	BDL

The residues of atrazine and pendimethalin in soil, maize grain and straw from different plots were below 0.01 mg/kg irrespective of the tillage management practices followed for weed control.

PJTSAU, Hyderabad

A field study was conducted at college farm, Rajendranagar, Hyderabad on conservation agriculture in rice (*Kharif, 2018*) – maize (*Rabi 2017-18*) – green manure (Summer) cropping system to study the influence of herbicides on different soil properties and also to assess the carryover of the herbicide residues. Pendimethalin, pretilachlor, bispyribac-sodium (rice) and atrazine (maize) were studied in this experiment. Along with the herbicide persistence, impact of different methods of rice establishment/ tillage and weed management were studied. Initial soil samples before transplanting/ sowing of rice were collected from different herbicide treatments for analysis of soil physico-chemical properties and nutrient status analysis **(Table 4.1.6).** For residue analysis, soil samples were collected at four hours after herbicide application and at harvest. Rice grain, and straw samples (rice and maize), were collected at harvest.

Pretilachlor, pendimethalin and atarzine residues were determined by GC. Quantification bispyribac-sodium was done using a HPLC. The experimental soil was very dark greyish brown in colour. Bulk density and particle density of the soil were 1.38 and 2.59 Mg/m^3 respectively. Soils were moderately alkaline in reaction, non-saline with a CEC of 23.12 cmol (p$^+$) /kg. Organic carbon content of the soil was medium. Soil of the experiment site was low in available nitrogen, high in available phosphorus and medium in available potassium. Dehydrogenase, urease and phosphatase activities were assayed by the standard methods.

Table 4.1.6 Soil properties after harvest of maize crop (*Rabi* 2017-18)

Treatments		pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Main Plots							
T_1	CT (Transplanted)	8.08	0.580	0.60	189.6	36.52	220.7
T_2	CT (Transplanted)	8.07	0.51	0.64	188.6	36.92	218.6
T_3	CT (Direct seeded)	8.12	0.48	0.60	191.9	35.50	223.2
T_4	ZT (Direct seeded)	8.09	0.48	0.60	201.6	38.15	218.1
T_5	ZT(Direct seeded) + R	8.16	0.49	0.69	196.5	37.54	216.0
LSD (P=0.05)		NS	NS	0.078	NS	NS	NS
Sub Plots							
W_1	Chemical	8.1	0.41	0.63	194.7	36.52	218.1
W_2	IWM	8.13	0.54	0.63	193.9	36.92	222.4
W_3	Unweeded	8.09	0.49	0.64	190.8	37.33	217.4
LSD (P=0.05)		NS	NS	NS	NS	NS	NS

Influence of CA treatments on soil properties after harvest of rice *(Kharif*, 2018)

After completion of three years, there were no significant changes in physico-chemical (pH, EC) and fertility properties of the soil (Available N, P_2O_5 and K_2O) due to different treatments after harvest of the rice crop in different methods of establishment. However, significant changes in organic carbon content of the soil was observed as influenced by method of establishment of rice. The organic carbon content in the aerobic rice soils after three years was significantly higher than that of the transplanted rice treatments and the rice (rice) - maize (ZT) + residues and green manure plots have shown significantly higher organic carbon content compared to all other treatments. However, the method of weed management (IWM, Chemical or control) did not significantly influence the organic carbon status of the soils.

Table 4.1.7 Urease and dehydrogenase enzyme activity in conservation agriculture soils (*Rabi* 2017-18)

Treatment	Urease activity ($\mu g\ NH_4^+$/ g/ day)		Dehydrogenase (μg TPF/ g/ day)	
	Flowering	Harvest	Flowering	Harvest
T_1	25.9	14.9	6.8	3.5
T_2	26.9	15.6	7.1	3.8
T_3	25.8	14.9	5.9	3.3
T_4	27.1	14.8	5.9	3.4
T_5	28.3	15.6	6.4	3.7
CD	1.8	NS	0.4	NS
W_1	25.8	14.8	6.1	3.4
W_2	27.7	15.7	6.7	3.7
W_3	27.0	15.0	6.4	3.5
LSD (P=0.05)	NS	NS	NS	NS

NS : Non significant

Different methods of establishment of rice (transplanted and DSR) and residue retention had shown significant influence on the urease activity of the soil. However, the weed management treatments impact on urease activity was not-significant. Different weed management treatments did not have influence on urease activity at the time of flowering and at the time of harvest of rice crop. In case of the *Rabi* maize, the zero tillage maize treatments showed higher urease activity compared to the conventional tillage treatments. Effect of weed management treatments on urease activity at the time of harvest and flowering stages was non-significant. In general, higher urease activity was noticed at the time of flowering compared to harvest time urease activity. Highest urease activity (28.33 $\mu g\ NH_4^+$/ g/ day) was recorded in T_5 main treatment (ZT +R - ZT+R – ZT) which was significant superior over conventional tillage treatments (T_1 and T_3) (**Table 4.1.7**).

In *Kharif* rice, the weed management treatments impact on dehydrogenase enzyme activity was not-significant. Among the DSR treatments (T_3, T_4, T_5), residue retention treatments recorded higher dehydrogenase enzyme activity compared to the conventional tillage treatment (T_3). In T5, (ZT +R - ZT+R – ZT), DHA was significant higher as compared to the other two DSR treatments. Highest DHA among all the treatments at the time of flowering was recorded in CT-ZT-ZT (T_2) treatment which was significantly over all other treatments. Dehydrogenase enzyme activity recorded at the time of harvest was significantly lower in case of all the treatments. Effect of weed management methods on dehydrogenase enzyme activity at the time of harvest was non-significant.

Initial residues of pretilachlor at 24 hours after application were 0.282 and 0.256 mg/kg in T_1W_1 and T_2W_1 treatments, respectively. The residues of pretilachlor in soil, rice grain and straw collected at harvest were below detectable level (0.05 mg/kg). In transplanted rice soils, the initial detected amount (IDA) of bispyribac-sodium varied from 0.014 to 0.017 mg/kg. In aerobic rice soils, the IDA varied from 0.015 to 0.019 mg/kg. The variation in the initial soil concentration of the bispyribac-sodium is due to the presence of large quantity of the weeds and green manure residue on the surface. Residues of bispyribac-sodium in the soil samples, rice grain and rice straw samples collected at the time of harvest were below the detectable limit of 0.010 mg/kg in aerobic and transplanted rice treatments. Residues of pendimethalin in aerobic rice soils varied from 0.411, 0.212 and 0.181 mg/kg on 0 DAA (at four hours after application of the herbicide) in T_3, T_4 and T_5 respectively, presence of the green manure and weed biomass might have resulted in lower initial concentration of pendimethalin in soil. In all the treatments residues of pendimethalin were below detection limit of 0.05 mg/kg in rice grain, plant and soil at the time of harvest. Initial concentration of atrazine in soil applied to maize as pre-emergence herbicide varied from 0.341 to 0.468 mg/kg. Higher concentration of atrazine was recorded in T_1 and T_3 and lowest concentration was recorded in

T_5. Residues of atrazine in the soil samples, maize grain and straw samples collected at the time of harvest were below the detectable limit of 0.05 mg/kg in aerobic and transplanted rice main treatments.

AAU, Jorhat

Pretilachlor was used as pre-emergence weed control in rice whereas pendimethalin was used as pre - emergence in mustard under rice – mustard cropping sequence in the conservation agriculture experiment. The experiment was initiated during the year 2016 in the soils acidic in reaction. Representative surface sandy loam soil samples at 0 – 15 cm depth were collected after 4 hours of herbicide application and at harvest of winter rice crop. Pretilachlor residues were detected by GC. The dissipation of pretilachlor and pendimethalin in soil followed a pseudo first order equation. The pretilachlor residues level ranged 0.334–0.386 µg/g on the day of application of pretilachlor and observed up to the ranged 0.008–0.124 µg/g on the 30th day of application of pretilachlor. In case of minimum tillage, the pretilachlor residue level was observed at BDL from 60th day of application of pretilachlor. However, lowest level of pretilachlor residue were resulted from the combination treatments of minimum tillage with direct seeding rice and residues were incorporation (**Table 4.1.8 and 4.1.9**).

Table 4.1.8 Persistance of pretilachlor (soil) in rice crop in rice – mustard sequence during 2018 winter season

Treatment	Pretilachlor residue in soil (µg/g) in days after application (DAA)									Half life
	0	3	7	15	21	30	45	60	Harv.	
CT + Transplantd	0.386	0.396	0.295	0.198	0.134	0.124	0.086	0.005	BDL	9.56
CT+Direct seeded	0.348	0.388	0.264	0.162	0.116	0.085	0.036	0.002	BDL	8.05
MT+Direct seeded	0.334	0.324	0.175	0.135	0.087	0.026	0.006	BDL	BDL	7.75
MT+Direct seeded+R	0.382	0.310	0.146	0.102	0.058	0.008	BDL	BDL	BDL	5.37

BDL: 0.016 mg/kg based on signal noise ratio.

The pendimethalin residue level in soil samples ranged 0.936 – 0.992 µg/g on the day of application of pendimethalin and observed upto the ranged 0.008 – 0.075 µg/g on the 30th day of application of pendimethalin. The pendimethalin residue level was observed at BDL in case of minimum tillage from 45th day of application of pendimethalin. However, lower level of pendimethalin residue was resulted from the combination treatments of minimum tillage with residue incorporation.

Table 4.1.9 Persistance of pendimethalin (soil) in mustard crop in rice – mustard sequence during *Rabi* 2018.

Treatment	Pendimethalin residue in soil (µg/g) in days after application (DAA)								Half life
	0 DAA	3DAA	7DAA	15DAA	21DAA	30 DAA	45 DAA	60 DAA	At harvest	
CT	0.936	0.864	0.485	0.268	0.164	0.075	0.026	0.004	BDL	7.54
MT	0.988	0632	0.318	0.216	0.116	0.024	0.003	BDL	BDL	5.37
MT+ R	0.992	0.465	0.284	0.112	0.083	0.008	BDL	BDL	BDL	4.31

CT – Conventional Tillage MT – Minimum Tillage R – Residue Incorporation. Lower half lives is recorded with treatment comprised of MT+Direct seeded+Residue in rice and MT + R in mustard.

OUAT, Bhubaneswar

The application of herbicides did not have any significant effect on BD, pH, organic carbon and other available indices except available P and S. There was substantial increase in P & S levels and slight decrease in N & K levels with herbicide treatment in rice. Lower urease activity and higher phosphate activity with herbicide application in rice strongly support this result. Application of herbicides to rice significantly reduced some of the microbial attributes like fungal and bacterial population by 6.0 - 9.0 % and 7.0 - 9.0 %, respectively. However, the available nutrients status of the soils showed an increasing trend over the years in treatments with organic matter i.e. the crop residues which degrade in to the soil itself within one or one and half month which justifies the role of organic amendments in stabilizing soil properties. The microbial population of treatments were in order: zerotillage > pretilacholor 0.75 kg /ha, hand weeding (twice).

WP 4.2 Herbicide residues in high-value crops

At PAU, Ludhiana, metsulfuron-methyl from soil and wheat grain samples was extracted by MSPD (Liang et al. 2013). The residues were quantified using LCMS/MS. The precursor ion was obtained at m/z 382.11 ($M+H^+$). The LOD and LOQ of metsulfuron -methyl were 0.003 and 0.01 µg/g, respectively. The mean percent recoveries of metsulfuron-methyl from soil and wheat grain samples ranged from 80.7-98.2 and 90.1-95.0%, respectively. The residues of metsulfuron -methyl in soil and wheat grain at harvest were below detectable limit. In Basmati rice, the residues of pendimethalin in soil were found to be 0.271 µg/g and residues in soil and crop produce at harvest were below the detectable limit.

At CSKHPKV, Palampur, atrazine applied at 1.5 kg/ha residues in soil and green cob, and pendimethalin applied at 1.5 kg/ha in garlic under high-value crops/organic farming system were evaluated for determination of terminal residues. HPLC analysis of samples revealed that atrazine (BDL >0.01 µg/g) and pendimethalin (>0.01 µg/g) residues in soil and crop produce were below the detectable levels.

At TNAU, Coimbatore, field experiment was conducted at Devarayapuram village, to estimate the harvest time residues of oxyfluorfen in/on onion and soil. A single preemergence application of oxyfluorfen was done at different doses (T_1 - 200 g/ha and T_2 - 400 g/ha). Soil and plant samples taken up at harvest and analysed for residues by HPLC-DAD. After the application of oxyfluorfen, residues of 0.162 and 0.278 mg/kg were found with the applied dose of 200 and 400 g/ha respectively. At harvest the residues of oxyfluorfen were not detected in soil as well as in onion plant top whereas in onion bulb the residue of 0.018 mg/ kg was recorded however it was below the MRL of 0.05 mg/kg which was fixed by FSSAI -2018.

At Hyderabad, an experiment was formulated to assess the impact of organic weed management practices on soil properties and herbicide persistence in okra (okra) and carrot cropping system in Alfisols of Southern Telangana Zone of Telangana state. Initial soil samples before sowing of okra were collected for analysis of soil physico-chemical properties and nutrient status analysis. For residue analysis, soil samples were collected at 4 hours after pendimethalin application and at harvest. Okra frits were collected randomly from all the pendimethalin sprayed plots at harvest time and analyzed for residues by GLC. Pendimethalin residues were below the detection limit of 0.05 mg/kg in all the soil and okra fruit samples collected at the time of harvest. In carrot crop, at flowering, highest urease activity (UA) was recorded in straw mulch treatment (T4) which was significantly superior over all other treatments followed by the intercropping with greenleafy vegetable treatment (T_7). Lowest urease activity, at flowering was recorded in hand weeding treatment. No adverse effect of pendimethalin spray was detected on urease activity at both flowering and harvest stages.

AAU, Jorhat

A field trial was conducted with tomato as the test crop and metribuzin at 250, 500 and 1000 g/ha was applied as weed control measure. Composite surface soil samples (0 – 15 cm) were collected after 4 hours of herbicide application and periodically from after harvesting of winter rice for residue estimation. Metribuzin residues were below detection limit (0.01 mg/kg) from 75[th] and 90th DAA of metribuzin at half and recommended dose of application **(Table 4.2.1**).

Table 4.2.1 Persistance of metribuzine (soil) in tomato field during 2017 - 18

Days	Residue (µg/g)		
	Rates of metribuzine application (kg/ha)		
	0.25	0.50	1.00
0	0.194	0.334	0.672
3	0.136	0.252	0.588
7	0.108	0.186	0.430
10	0.086	0.158	0.293
20	0.031	0.069	0.187
30	0.026	0.041	0.120
45	0.018	0.026	0.058
60	0.009	0.010	0.026
75	BDL	0.004	0.015
90	BDL	BDL	0.006
T ½ (Days)	13.54	11.74	13.21

BDL : Below deletion limit

WP 4.3 Degradation of selected persisting herbicides

PAU, Ludhiana

The dissipation behaviour of imazethapyr was evaluated in loamy sand and sandy loam soil under laboratory conditions. The physico-chemical characteristics of soil samples are presented in **Table 4.3.1.**

Table 4.3.1 Physico-chemical properties of soil samples

Texture class	Sand (%)	Silt (%)	Clay (%)	pH	EC (dS/m)	OC (%)	OM (%)
Loamy sand	86.20	11.00	2.80	8.80	0.21	0.24	0.41
Sandy loam	56.60	29.60	13.80	8.00	0.24	0.39	0.67

Commercially available formulation of imazethapyr was applied at 300 mL/acre and 600 mL /acre. The soil samples from imazethapyr treated pots were collected at 0 (3 h), 3, 7, 10, 15, 21, 30, 45, 60 and 90 days after treatment (DAT). Imazethapyr was extracted by MSPD and LC-MS/MS was used to quantify the residues in soil at different time interval. Imazethapyr eluted at 4.21 min **(Fig. 4.3.1)** and showed a precursor ion at m/z 290.50 $[M+H^+]$. The LOD and LOQ were 0.001 and be 0.003 µg/g, respectively.

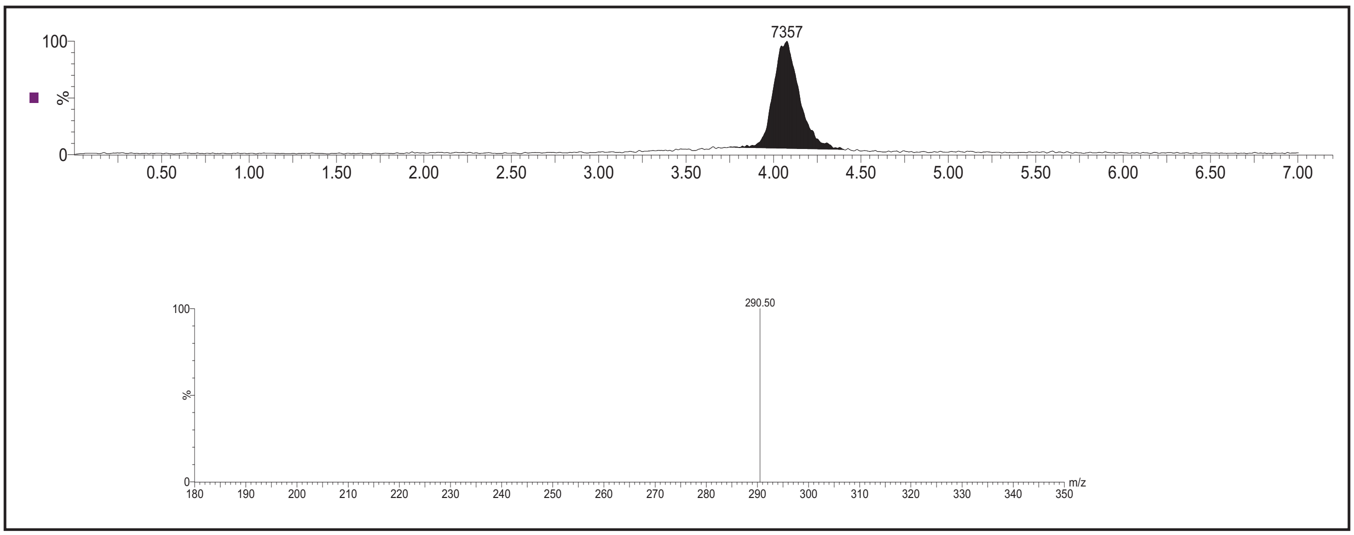


Fig 4.3.1 LC-MS/MS (a) chromatogram (b) spectrum of imazethapyr (0.1 µg/mL)

After the application of imazethapyr, the residues were found to vary with the applied concentration and soil type. The initial residues of imazethapyr varied from 0.751 ± 1.335 to 1.488 ± 2.715 and 0.784 ± 4.775 to 1.574 ± 2.549 µg/g in loamy sand and sandy loam soil, respectively **(Fig. 4.3.2 and 4.3.3)**.The soil samples collected 90 day after the application of imazethapyr showed residues of 0.032 ± 3.125 and 0.071 ± 3.527 µg/g at 300 mL/acre and 600 mL/acre, respectively in loamy sand soil however, the residues were found to be 0.041 ± 4.878 and 0.092 ± 4.347 µg/g in sandy loam soil at 300 mL/acre and 600 mL/acre, respectively.

Disappearance parameters for imazethapyr residues were calculated on the basis of both SFOK and BFOK using first order equation. R^2 values obtained for SFOK were lower than BFOK **(Table 4.3.2)**, for both soils indicating a biphasic rate of dissipation **(Fig. 4.3.2)**. DT_{50} was in the range of 6.57 to 6.68 days for the initial phase and 93.74 to 108.63 days for the final phase in both the treatments in loamy sand soil. However, dissipation was comparatively slower in sandy loam soil and the observed DT_{50} for the initial and final phase were in the range of 6.59 to 6.72 and 102.21 to 118.66 days, respectively in both the treatments.

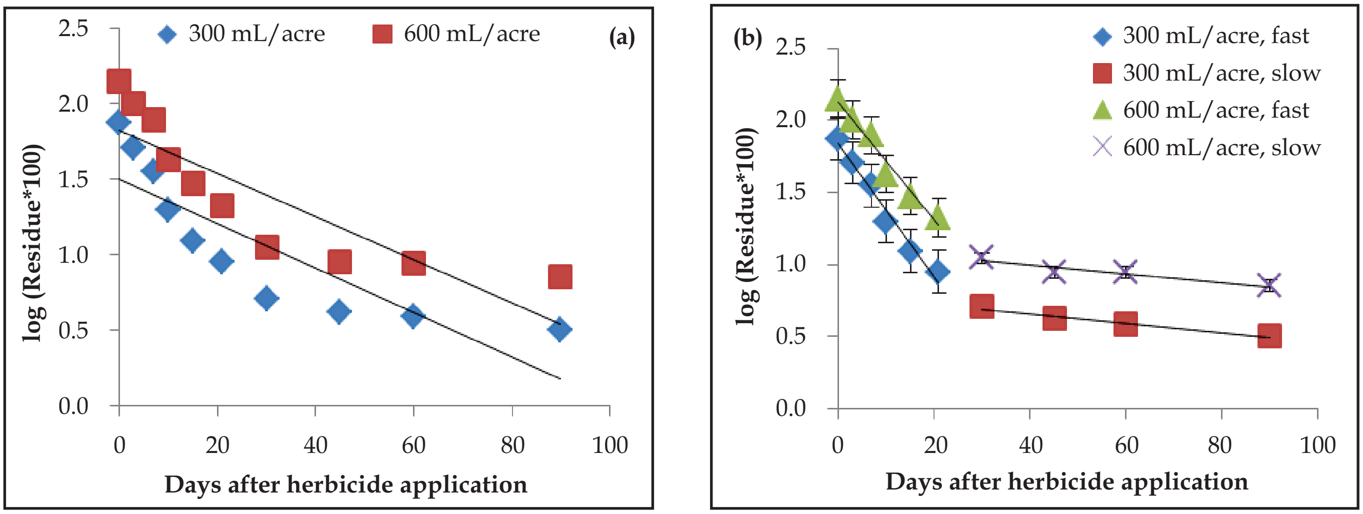


Fig. 4.3.2 Imazethapyr dissipation in loamy sand soil (a) SFOK (b) BFOK.

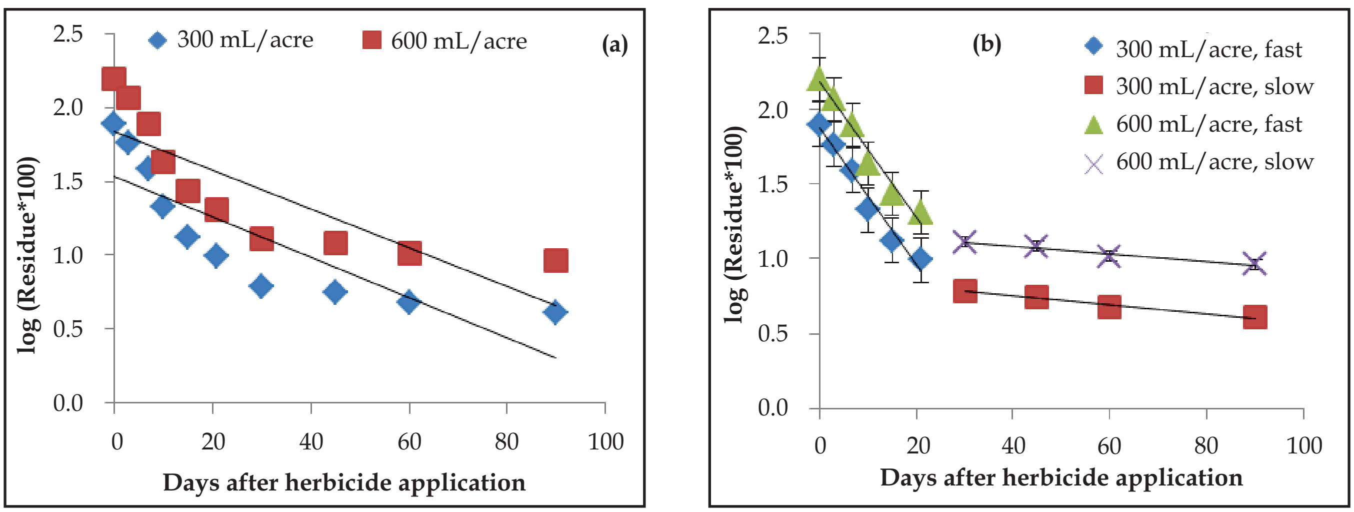


Fig. 4.3.3 Imazethapyr dissipation in sandy loam soil (a) SFOK (b) BFOK.

Table 4.3.2 Half- lives and statistical parameters for imazethapyr dissipation in loamy sand and sandy loam soil

Soil	Application rate (mL/acre)	SFOK			BFOK					
		-90 days			Initial fast phase			Final slow phase		
		k	R^2	DT_{50}	k	R^2	DT_{50}	k	R^2	DT_{50}
Loamy sand	300	0.033	0.46	20.5	0.105	0.97	6.57	0.007	0.96	93.7
	600	0.032	0.50	21.4	0.103	0.92	6.68	0.006	0.88	108.6
Sandy loam	300	0.031	0.46	22.0	0.105	0.97	6.59	0.006	0.98	102.2
	600	0.031	0.46	23.0	0.103	0.96	6.72	0.005	0.97	118.6

CSKHPKV, Palampur

A field investigation consisting of four treatments *viz*. tembotrione 60, 120 and 240 g/ha and control replicated five times in a randomized block design (RBD) during *Kharif 2018* to determine dissipation of tembotrione in soil. Samples of soil at 0-15 cm depth at weekly interval were collected. The residues of tembotrione in extracts were quantified on HPLC.

Table 4.3.3 Residues of tembotrione in soil applied at different doses

Days after herbicide application	Residue (µg/g)		
	Rate of tembotrione (g/ha)		
	60	120	240
0	0.056	0.086	0.114
7	0.036	0.060	0.106
15	0.017	0.023	0.037

Initial residues of tembotrione in soil immediately after application of tembotrione applied at 60, 120 and 240 g/ha were 0.056, 0.086 and 0.114 µg/g respectively. In all three applied tembotrione treatments i.e. 60 g/ha, 120 g/ha and 240 g/ha, more than 70% applied herbicide in soil dissipated within 15 days after herbicide application (**Table 4.3.3**).

TNAU, Coimbatore

The surface (0-15 cm) soil samples were collected from pesticide free zone was used for studying the degradation of oxyfluorfen under X (200 g / ha) and 2X (400 g / ha) doses in lab under controlled condition in sandy clay loam with pH of 8.01, EC of 0.46 dS/m and OC of 0.37%. After the application of oxyfluorfen, the residues were found to vary with the applied concentration (**Table 4.3.4.**) from 0.011 to 0.320 mg/kg in soil and 0.024 to 0.527 mg/kg in soil for 200 and 400 g/ha application of oxyfluorfen, respectively. The oxyfluorfen in soil declined sharply and persisted up to 45 days after application.

Table 4.3.4 Persistence, half- lives and statistical parameters for oxyfluorfen dissipation insoil

Dose	Days after quizalofop application (mg/kg)							k	R^2	DT_{50} (days)
	0	3	7	10	15	30	45			
200 g /ha	0.320	0.243	0.162	0.074	0.033	0.018	0.011	0.102	0.903	6.83
400 g/ ha	0.527	0.414	0.268	0.154	0.092	0.039	0.024	0.089	0.957	8.75

WP 4.4 Mitigation of herbicides residues

PAU, Ludhiana

Dissipation of imazethapyr in amended soils under laboratory conditions

The dissipation behavior of imazethapyr was evaluated after amendment of loamy sand soil with β-cyclodextrin, chitosan and β-cyclodextrin-chitosan biocomposite (LCD) under laboratory conditions.

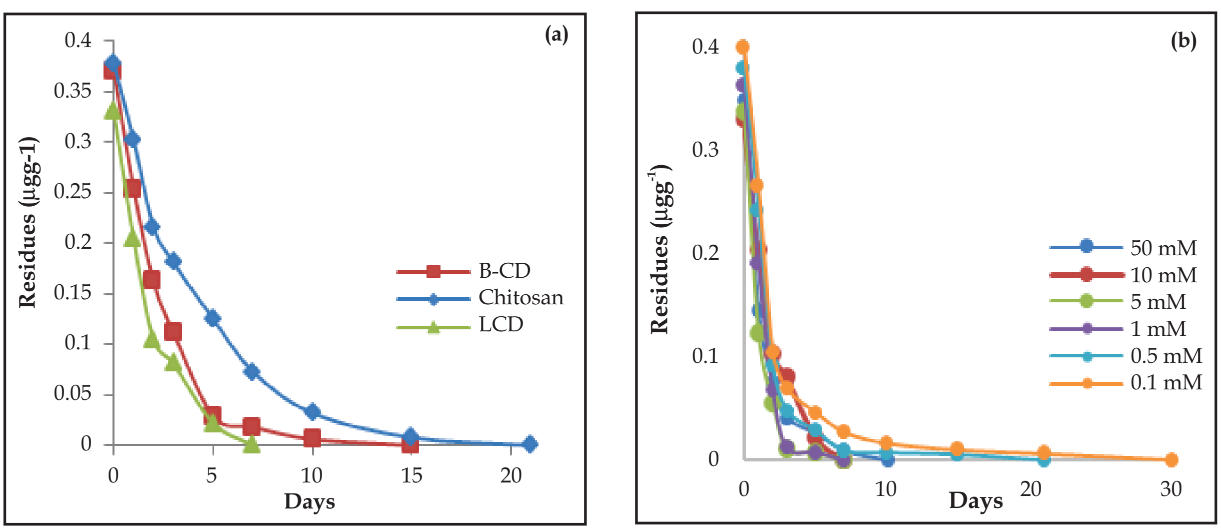


Fig. 4.4.1

Commercially available formulation of imazethapyr was applied at 0.01, 0.05, 0.5 and 1.0 µg/g and pots were incubated at 30°C. The soil samples were collected at 0 (5 h), 3, 7, 10, 15, 21, 30 days after treatment (DAT). Imazethapyr was extracted by MSPD method and LC-MS/MS was used to quantify the residues in soil at different time interval. The LOD and LOQ were 0.001 and be 0.003 µg/g, respectively.

The effect of type of extractant solution and its concentration and liquid to soil ratio on dissipation of imazethapyr was optimized. The effect of β-cyclodextrin, chitosan and LCD on the dissipation of imazethapyr is shown in **Figure 4.4.1**. Different soil amendments showed variation in dissipation rater and the residues of imazethapyr were below the detectable limit within 10 to 15, 15 to 21 and 5 to 7 days in loamy sand soil amended with β-cyclodextrin, chitosan and LCD, respectively.

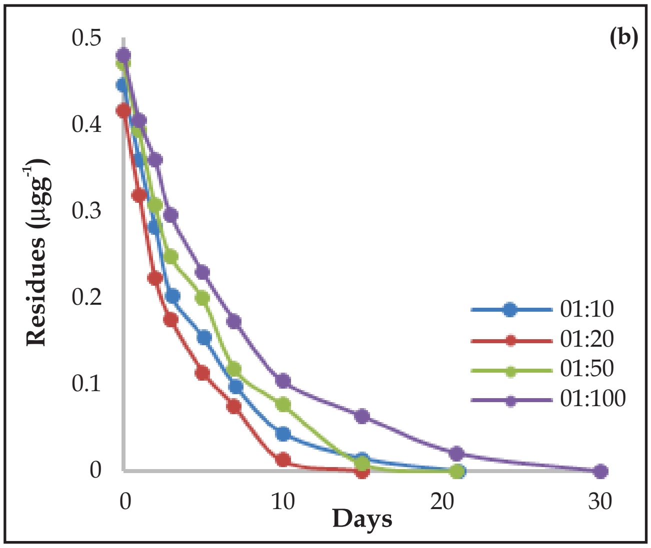


Figure 4.4.1 Effect of (a) different extractants (b) concentration of LCD (c) liquid to soil (1 mMLCD) ratio on residues of imazethapyr in loamy sand soil

Considering highest dissipation rate of imazethapyr in LCD amended loamy sand soil, different concentration of LCD (0.1 to 50 mM) were optimized to know the minimum LCD concentration required to provoke efficient degradation. Increase in concentration of LCD from 0.1 to 1 mM enhanced the dissipation but further increase in concentration from 1 to 50 mM decreased the dissipation of imazethapyr. The influence of liquid to soil ratio viz. 1:10, 1:20, 1:50 and 1:100 was studied and 1:20 liquid to soil ratio resulted in maximum dissipation of herbicide using 1 mM LCD. Under the optimum conditions, the residues of imazethapyr applied at 0.01, 0.05, 0.5 and 1.0 µg/g were below the quantification limit within 5 to 7 days (**Figure 4.3.1**).

The phytotoxicity of imazethapyr on indicator plants was evaluated using cucumber, gobhi sarso, raya, sorghum and spinach **(Figure 4.3.2, Table 4.3.2)**. With the increase in concentration of imazethapyr from 0.001 to 1.0 µg/g, growth inhibition increased and herbicidal toxicity was more pronounced at 1.0 µg/g than the other concentrations. Raya was most sensitive species to imazethapyr (GR_{50}= 0.440 µg/g) whereas gobhi sarso, spinach, cucumber and sorghum were comparatively less sensitive to imazethapyr with GR_{50} of 0.529, 0.833, 1.019 and 1.323 µg/g, respectively.

Table 4.4.1 Linear regression equation and relative parameters of the sensitivity plants

Test plant	Equation	R^2	GR_{50}
Raya	y= 91.979x + 9.545	0.972	0.440
Gobhi sarso	y= 78.089x + 8.672	0.971	0.529
Spinach	y= 53.341x + 5.586	0.963	0.833
Cucumber	y= 44.070x + 5.075	0.972	1.019
Sorghum	y= 35.163x + 3.472	0.976	1.323

Taking into consideration the results obtained from the chemical assay, the seeds of raya were sown at 5, 7 and 10 days after the application of biocomposite to artificially contaminated soil. Germination count and plant height of seedlings were recorded on 7 and 15th day after sowing, respectively. It was observed that the germination percent and plant height decreased in herbicide treated soils (SH) as compared to control indicating the adverse effect of imazethapyr on the growth of raya (**Figure 4.3.3, Table 4.4.2**). The phytotoxicity symptoms like chlorosis, leaf curling and stunted growth of raya was also visualized at all application rates. After the amendment of soil with biocomposite (SHB), the growth inhibition decreased as compared to SH treatments and phytotoxicity symptoms on raya were not observed in treatments.

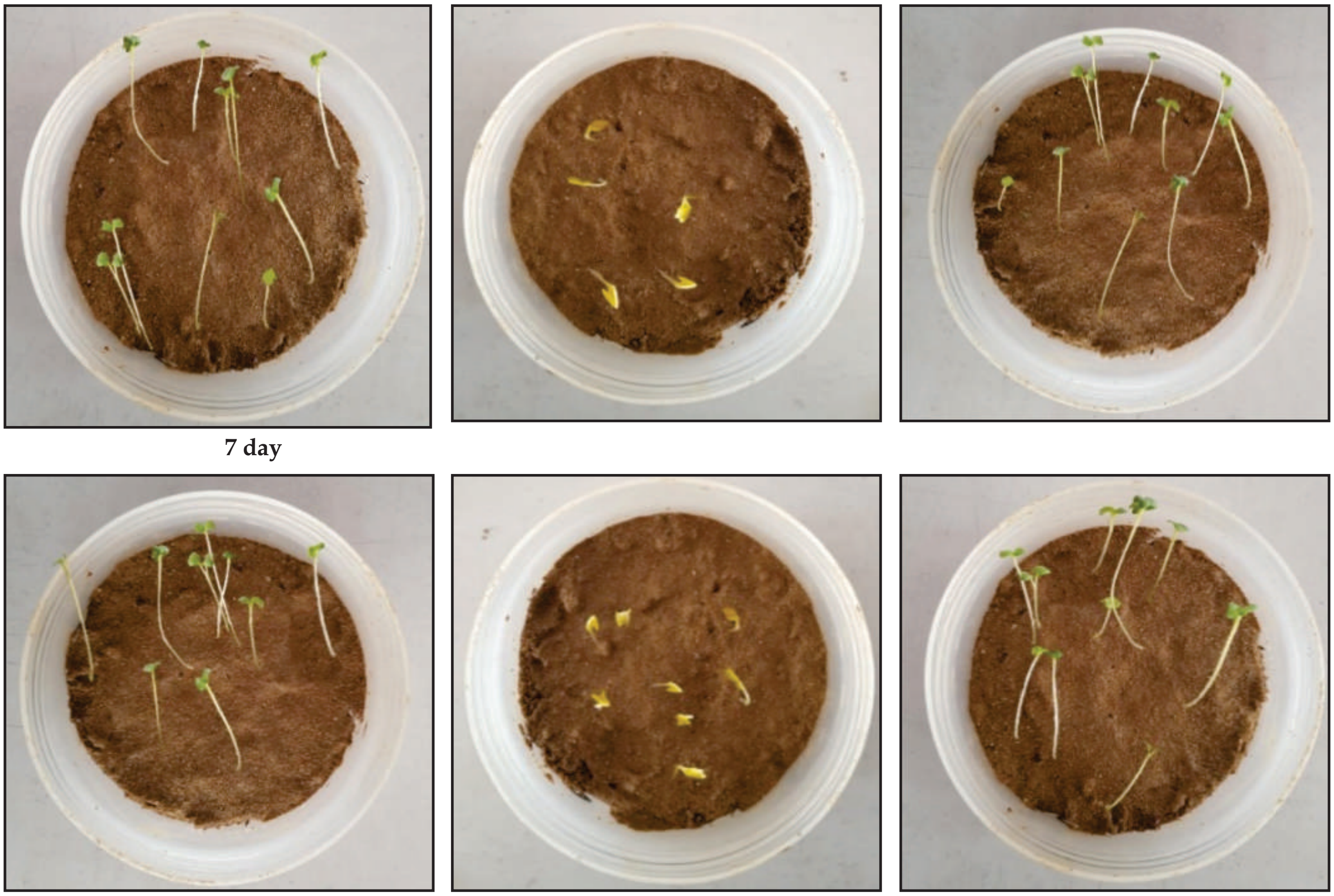


Figure 4.4.3 Effect of LCD on amelioration of imazethapyr (applied at 0.5 µg/g) toxicity on growth of raya (*Brassica juncea* L).

TNAU, Coimbatore

Mitigation of commonly used pendimethalin in the soil grown with greengram

Sandy clay loam samples were collected for the pot study. Treatments were imposed 3 days before sowing of greengram (Co 8). On 3rd day after greengram sowing, the pendimethalin was applied to each pot 1.0 kg/ha along with mitigation measure (T_1 to T_{10}). Soil samples were collected from a depth of 0-15 cm on 0, 1, 3, 5,10, 15, 30 and 45 DAA and analysed for pendimethalin residues by HPLC pendimethalin.

Treatments

T_1	FYM 10 t/ha	T_6	Vesicular-Arbuscular mycorrhiza culture 10kg /ha
T_2	Vermicompost 5 t/ha	T_7	Pseudomonas 10 kg / ha
T_3	Biochar 5 t /ha	T_8	Urea 100 kg /ha
T_4	Phosphobacteria 10 kg /ha	T_9	Crop residue incorporation 5 t /ha
T_5	Trichoderma 10 kg /ha	T_{10}	Control (no manure/bioagents)

The soil used for the study was sandy clay loam in texture having pH 7.92, EC 1.7 dS/m, OC 0.46 %, available N,P,K of 166.8, 17.2 and 674 kg/ha. Irrespective of the treatments the pendimethalin residues persisted upto 45 DAS.

Table 4.4.3 Persistence of pendimethalin in soil as influenced by the organic sources and microbial application under pot study

Treatments		Pendimethalin residues (mg/kg) in soil							
		0 day	1 day	3 day	5day	10 day	15 day	30 day	45 day
T_1	FYM 10 t/ha	0.465	0.442	0.364	0.268	0.136	0.080	0.033	0.013
T_2	Vermicompost 5 t/ha	0.543	0.381	0.311	0.222	0.123	0.076	0.042	0.012
T_3	Biochar 5 t /ha	0.633	0.498	0.398	0.226	0.196	0.097	0.037	0.023
T_4	Phosphobacteria 10 kg/ha	0.620	0.459	0.355	0.272	0.142	0.082	0.046	0.028
T_5	Trichoderma 10 kg /ha	0.574	0.492	0.405	0.329	0.211	0.108	0.062	0.035
T_6	VAM 10 kg /ha	0.558	0.453	0.329	0.215	0.124	0.093	0.046	0.021
T_7	Pseudomonas 10 kg/ha	0.606	0.541	0.395	0.292	0.165	0.086	0.054	0.024
T_8	Urea 100 kg/ha	0.744	0.616	0.445	0.296	0.172	0.103	0.057	0.034
T_9	Crop residue (maize straw) incorporation 5 t/ha	0.588	0.389	0.348	0.294	0.196	0.115	0.069	0.035
T_{10}	Control (no manure/bioagents)	0.793	0.622	0.479	0.346	0.229	0.118	0.064	0.039

It was found that the dissipation was faster under FYM, VAM and biochar applied treatments and the slowest degradation was noticed in control. The lowest half life of 8.57 days was observed in FYM treatment **(Table 4.4.4)**. Irrespective of mitigation measures followed, the atrazine persisted upto 45 DAS.

Table 4.4.4 Pendimethalin dissipation equation, correlation coefficient and half lives in soil

	Treatments	Regression equation	R^2	Half life (days)
T_1	FYM 10 t/ha	y = -0.0809x + 0.920	0.970	8.57
T_2	Vermicompost 5 t/ha	y = -0.0782x + 0.997	0.958	8.86
T_3	Biochar 5 t /ha	y = -0.0747x + 0.824	0.931	9.28
T_4	Phosphobacteria 10 kg/ha	y = -0.0669x + 0.925	0.903	10.36
T_5	Trichoderma 10 kg /ha	y = -0.062x + 0.800	0.940	11.18
T_6	VAM 10 kg /ha	y = -0.0691x + 0.986	0.931	10.03
T_7	Pseudomonas 10 kg/ha	y = -0.0704x + 0.812	0.930	9.85
T_8	Urea 100 kg/ha	y = -0.0418x + 0.735	0.886	10.66
T_9	Crop residue (maize straw) incorporation 5 t/ha	y = -0.0475x + 0.886	0.956	11.46
T_{10}	Control (no manure/bioagents)	y = -0.0657x + 0.618	0.920	10.55

Based on the present results it was found that the FYM 10 t /ha or vermicompost 5/ha or biochar 5 t/ha is efficient in reducing the residual concentration of pendimethalin in greengram grown soil. This could be due to the enhanced adsorption of the compounds by these sources.

AAU, Jorhat

A laboratory pot culture study was conducted by incorporating bacterial consortium on the pot containing to reveal the affect of microbes on the degradation behaviour and persistence extent of quizalofop-ethyl in the soil and the environment.

GPS based survey of five different degraded soil ecosystems of Assam, *viz*., coal, petroleum oil, brick, paper and cement industry have been carried out in both summer and winter season **(Table 4.4.5)**. Random soil samples (6 nos.) were collected from each polluted site up to a constant depth of 10 cm (from surface). All together 26 bacterial cultures were isolated, out of which 4 from coal, 8 from petroleum oil, 3 from brick, 5 from cement and 6 from paper polluted soil. DNA of the respective bacterial isolates were isolated and PCR amplification of 16S rRNA gene was done for each of the isolated DNA using the bacterial primers (8F and 1406R). Identity of the bacterial isolates was done by sequencing of 16SrRNA and phylogenetic tree for all the 26 bacterial isolates were also prepared **(Fig.4.4.3)**.

Table 4.4.5 Characterization of isolated Microbes from polluted sites

Sample name (Type of colony)	Strain
Coal 34 (white)	*Fictibacillus barbaricus* strain N7
Coal 24 (yellow)	*Acinetobacter calcoaceticus* strain MTCC:9488
Coal 24 (white)	*Bacillus megaterium* strain NJAUR1
C3 (yellow)	*Sphingomonas mucosissima*
Oil 35 (white)	*Ensifer adhaerens* strain CCNWSX1647(also known as *Sinorhizobium*)
Oil 34 (rhizoides spreading)	*Bacillus mycoides* strain BGSC1
Oil 14 (white)	*Gordonia rubripertincta* strain BAA1
Oil 14 (yellow)	*Ralstonia pickettii* strain C2
Oil 24 (white)	*Cupriavidus sp*. JJ2
Oil 14 (creamy type)	*Bacillus cereus* ATCC 109867 strain
Oil 14 (wavy colony)	*Bacillus luciferensis* strain F30
Oil 14 (rhizoetes white)	*Bacillus pseudomycoides* strain IHB B 7147
Brick 15 (gummy)	*Bacillus licheniformis* strain HQB243
Brick 25 (yellow)	*Bacillus infantis* strain HQB248
B15 (white)	*Burkholderia cepacia* ATCC 25416
Cement 34 (spreading type)	*Bacillus megaterium* strain NJAUR1
Cement 15 (small circular) yellow	*Acinetobacter calcoaceticus* strain culture collection MTCC:9488
Cement-2 (watery)	*Pseudomonas* sp. Strain XT
Cement 14 (yellow circular)	*Chryseobacterium bernardetii* strain G229
Cement -2 (watery)	*Pseudomonas sp. XT-28*
Paper 14 (yellow circular)	*Bacillus aquimaris* strain LB23
Paper 24 (creamy circular)	*Bacillus arsenicus* strain B3
Paper 34 (yellow circular)	*Bacillus cibi* strain BDH3
Paper 35 (white circular)	*Pseudomonas sp.* KHg3
Paper 15 (yellow circular)	*Bacillus indicus*
Paper 34 (creamy white circular)	*Pseudomonas oryzae* strain WM-3

Treatment : T1 –Quizalofop-ethyl 50g/ha **;** T2 – Quizalofop-ethyl 50g/ha +Vermicompost 2 ton/ha**;** T3 – Quizalofop-ethyl 50g/ha + Bacterial consortia 10 ml /6 kg soil**;** T4 – Quizalofop-ethyl 50 g/ha + Vermicompost 2 ton/ha + Bacterial consortia 10 ml /6 kg soil; Replication - 4 nos; Experimental design-CRD

Two kg of air-dried soil with vermicompost 2.0 ton/ha was put in each pot and 30 % moisture level was maintained by sprinkling water frequently to the pot. Vermicompost was prepared from weed biomass viz. *Ipomoea carnea, Eichhornia crassipes,* banana plant and rice straw using screened earth worm spp. *viz. Aminthes diffringens, Eudrillus euginiae* and *Paryonix excavatus*. Hericides were applied to the pots at recommended (X) and double the recommended (2X) rate of application. Bacterial consortia were applied to the pots 10 ml per 6 kg soil with the range of dilution CFU of (52.32 – 782.4)x10^6 CFU/g soil were collected periodically from the day of application of herbicide (after four hour of application) till 45th day of application. The soil samples were processed and stored in polythene bags.

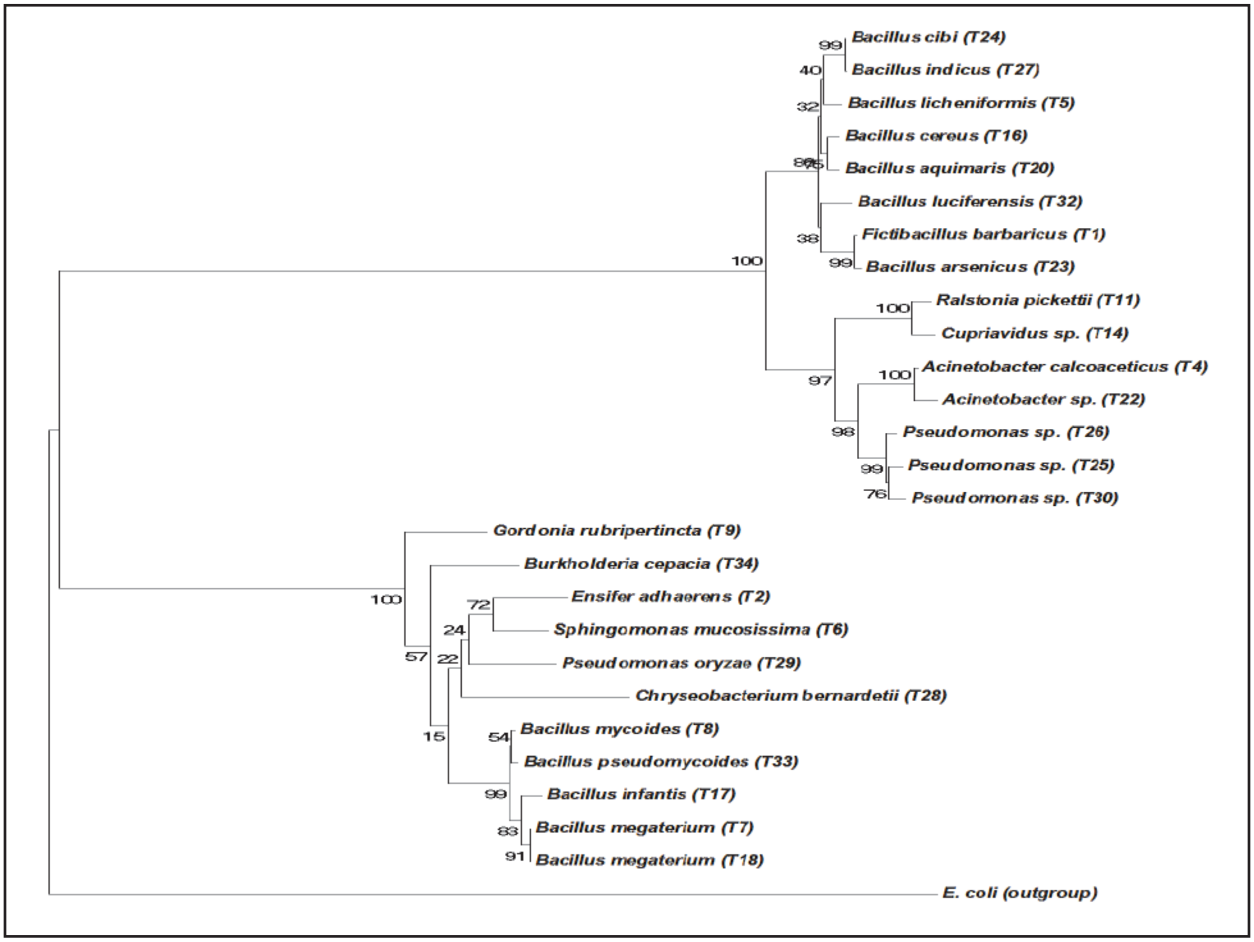


Fig.4.4.3 Phylogenetic tree of the bacterial isolates

The degradation of quizalofop-ethyl followed a first order equation. The treatment with only quizalofop-ethyl at recommended dose recorded residue to 60th DAA (0.018 µg/g) and below detection limit (BDL) at 90th DAA. The treatment with quizalofop-ethyl, vermicompost and bacterial consortia at recommended dose recorded residue to 21st DAA (0.005 µg/g) and BDL at 30th DAA (**Table 4.4.6**).

Table.4.4.6 Bioremediation of quizalofop ethyl with application of effective microorganisms (Laboratory study)

Treatment	Residue(µg/g)in days after application (DAA)										Half-life
	0	1	3	7	15	21	30	45	60	90	
T_1	0.746	0.618	0.526	0.416	0.292	0.216	0.163	0.085	0.018	BDL	11.18
T_2	0.765	0.596	0.454	0.375	0.185	0.132	0.012	BDL	BDL	BDL	5.0
T_3	0.790	0.524	0.370	0.215	0.128	0.080	0.002	BDL	BDL	BDL	3.48
T_4	0.792	0.425	0.246	0.128	0.065	0.005	BDL	BDL	BDL	BDL	2.87

WP 4.5 Testing of persistence of herbicides in the farmers' field (soil, water and crop produce)

PAU, Ludhiana, soil, water and crop samples were collected at harvest from farmer's fields from Ludhiana, Moga, Kapurthala, Fazilka and Sangrur districts of Punjab in rice-wheat cropping system. The soil, water and crop samples were extracted by standard methodologies and residues of pretilachlor, butachlor, anilophos, clodinafop-propargyl, sulfosulfuron, metsulfuron-methyl, pinoxaden and pendimethalin in the samples were estimated using HPLC. The residue of these herbicides in soil, water and crop produce were below detectable limit (<0.01 µg/g). Samples of soil and wheat crop were also collected from farmer fields where sencor was applied at higher application rate. Metribuzin from soil was extracted by the matrix solid phase dispersion (MSPD) and quantified using LCMS/MS. The retention time of metribuzin was found to be 3.98 minutes. The LOQ and LOD were 0.006 and 0.002 µg/g, respectively. The residues of metribuzin in soil and wheat crop samples ranged from were 0.0063 to 0.0075 and 0.0061 to 0.0071 µg/g, respectively **(Table 4.5.1)** and were below the maximum residue limit (0.75 µg/g) set by EPA.

Table 4.5.1 Residues of metribuzin in farmer field samples

Application rate (g/acre)	Metribuzin residue (µg/g)	
	Soil	Wheat grain
70 + 120	0.0063	0.0061
70 + 140	0.0067	0.0065
100	<0.006	<0.006
150 + 200	0.0073	0.0068
150 + 200	0.0075	0.0071

CSKHPKV, Palampur

Soil and wheat grain samples were collected from the 2, 4-D and clodinafop-propagryl treated fields of eight farmers of Kangra district at the harvest of the crop and were analyzed for residues by HPLC. Residues in soil and grain samples were below detectable levels. Samples (soil and rice grain) from butachlor 1.5 kg/ha and bispyribac-sodium treated rice field and atarzine treated maize samples of five farmers of Kangra district farmers were collected at harvest of the crop. The soil taken for study was 0-15 cm and the texture of soil was silty clay loam type. The analysis revealed that no residues of butachlor, bispyribac sodium and atarzine were detectable (0.01 µg/g) in the farmer field at the time of harvest in soil and rice grain. At TNAU, Coimbatore, soil and plant samples were collected at the time of harvest from the tomato and onion grown fields of different farmers from Devarayapuram village of Coimbatore district that received atrazine, pendimethalin, 2,4-D, quizalofop-ethyl and oxyfluorfen. The collected soils were sandy loam, sandy clay loam in texture and the organic carbon content ranged from 0.46 to 0.52%, pH and EC rangedfrom 6.80 to 7.12 and 0.18 to 0.19 dS/m respectively. NPK were supplied as per the state recommendation to the particular crop. They were analyzed in HPLC-DAD for their residue content at the time of harvest in soil and plant produce. None of the applied herbicides were detected in the different plant matrices and soil. This showed that they have been degraded from the soil before the harvest of the crop.

At PJTSAU, Hyderabad, atrazine and 2,4 D are the most commonly used herbicides in grass fodder crops gown by the famers.. Four fodder maize and soil samples were collected from different farmers at the time of harvest in various villages located in fodder growing areas. In all the fodder maize and soil samples collected, atrazine residues were below the detection limit of 0.05 mg/kg. At AAU, Jorhat, soil samples at (0-15 cm), grain and straw were collected after harvest of winter rice and mustard in Rabi from farmers' field growing with pretilachlor and pendimethalin application respectively as weed control and analyzed for the herbicide residue by GC. The pendimethalin residue at 1.5 kg/ha in soil, seed and straw after harvest of winter rice were found at below detectable limit (BDL).

WP 5 On-farm research trials and front line demonstration

WP 5.1 On-farm research trials

At Ludhiana, four on-farm research **(**OFR) trials were conducted in wheat during *Rabi* 2017-18 and four in cotton during *Kharif* 2018. New herbicide pre-mix combination of pendimethalin and metribuzin 962 g/ha was tested against pendimethalin 1125 g/ha.

Combination of herbicide recorded effective control of *P. minor* in wheat and increased wheat grain yield and economic returns as compared to unsprayed control and was at par with pendimethalin. New post-emergence herbicide pre-mix of pyrithiobac-sodium and quizalofop-p-ethyl 1.25 l/ha was compared with paraquat 1.25 l/ha and control in cotton. Results revealed that pre-mix of pyrithiobac-sodium and quizalofop-p-ethyl recorded effective control of grasses, broadleaf and sedges and was equally or more effective than already recommended post-directed herbicide paraquat.

At Gwalior, ten OFR trials were conducted at farmers' fields during *Rabi* 2017-18 in wheat crop. Post-emergence application of sulfosulfuron 25 g/ha, metsulfuron 4 g/ha, 2, 4-D 500 g/ha and metsulfuron + sulfosulfuron 16 g/ha were tested for chemical control of weeds and compared with farmers' practices at 10 locations of Gwalior district. It was observed that all the chemical weed management practices gave lower weed population and higher seed yield over farmers' practices. The maximum yield of 4.44 t/ha was obtained with the application of metsulfuron + sulfosulfuron 16 g/ha *fb* sulfosulfuron 25 g/ha PoE (4.32 t/ha), 2,4-D 0.5 kg/ha (4.20 t/ha) and clodinafop-propargyl 60 g/ha (4.15 t/ha) which was 17.8, 14.5, 11.5 and 10.0% higher over farmers practice (3.89 t/ha). The B:C ratio was found as 2.44 to 2.33 in these weed management practices as compared to 2.26 in farmer's field. Four OFR trials were conducted on pearl millet and black gram each at farmer's fields of three locations in Gwalior district during *Kharif* 2018. Atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha and pendimethalin 1.0 kg/ha (PE) were tested on pearlmillet and compared with farmers practice. All chemical weed management practices gave higher grain yield over farmers practice. The maximum yield of pearlmillet (2.4 t/ha) was obtained with the application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (PoE) *fb* pendimethalin 1.0 kg/ha (PE) (2.27 t/ha), which was 49.3%, and 41.5% higher than farmers practice. Highest B:C ratio of 2.31 was also recorded in atrazine 0.5 kg/ha + 2,4-D 0.5 kg/ha (PoE). On the other hand, imazethapyr + imazamox (RM) 80 g/ha as PoE and pendimethalin + imazethapyr (RM) 750 g/ha as PE were tested on blackgram and compared with farmers practice. Maximum yield of 0.89 t/ha was recorded with the application of imazethapyr + imazamox (RM) 80 g/ha PoE *fb* pendimethalin + imazethapyr (RM) 750 g/ha PE (0.81 t/ha), which was 43.4%, and 30.3% higher than farmers practice. Highest B:C ratio was also (2.40) recorded in imazethapyr + imazamox (RM) 80 g/ha PoE.

At Pantnagar, two OFR trials in wheat crop were conducted in farmers' field of two different locations of Tarai area in the Distt. U.S. Nagar during *Rabi* 2017-18. Treatments were comprised of ready mix combination of clodinafop-propargyl + metsulfuron methyl 60 + 4 g/ha, sulfosulfuron + metsulfuron-methyl 30 + 2 g/ha applied at 30-35 DAS as recommended practices, whereas, clodinafop-propargyl 60 g/ha as farmers' practice. These three treatments were compared with weedy check for yield loss estimation. An average increase in grain yield in recommended practice was 13.9% higher than farmer's practice. Among the herbicidal treatments, highest weed control efficiency (85.5%) was recorded with recommended practice clodinafop-propargyl + metsulfuron-methyl *fb* sulfosulfuron + metsulfuron-methyl (75.6%) and farmer's practice (66.2%). Application of clodinafop-propargyl + metsulfuron-methyl recorded highest grain yield of 5.1 t/ha, gross return ₹ 88,485/ha, net return ₹ 51,244/ha and B:C ratio of 2.38 followed by sulfosulfuron + MSM with grain yield 4.7 t/ha, gross return ₹ 81,545/ha, net return ₹ 44,481/ha and B:C ratio 2.2, whereas farmer's practice recorded wheat grain yield of 4.3 t/ha, gross return ₹ 74,605/ha, net return ₹ 37,620/ha and B:C ratio 2.0. In Bhabar area, two sets of on farm research trials on wheat crop were conducted at two locations of farmer's field of Distt. Nainital during *Rabi* season of 2017-18. The treatments were comprised of ready mix combination of clodinafop-propargyl + MSM 60+4 g/ha, sulfosulfuron +MSM 30+2 g/ha both were applied at 30-35 DAS under recommended practice, whereas, MSM 4 g/ha was taken as farmer's practice. An increase in grain yield due to application of clodinafop-propargyl + MSM 60 + 4g/ha was 36.1%, 25% in sulfosulfuron + MSM 30+2 g/ha and 16.7% in farmers' practice as compared to weedy check. An average increase in grain yield in recommended practice was 11.9% higher than farmer's practice. Among weed control treatments, highest weed control efficiency was recorded with recommended practice (85.1% and 78.7%) followed by farmer's practice (65.1%). Clodinafop-propargyl + MSM 60+4g/ha recorded the highest grain yield (4.9 t/ha), gross return ₹ 85,015/ha, net return ₹ 47,774/ha and B: C ratio 2.3. During *Kharif* 2018, two sets of on farm research trials were conducted at different locations of farmer's field in Distt. Udham Singh Nagar, Uttarakhand in transplanted rice. The treatments were consisted of bispyribac-sodium 20 g/ha and pretilachlor 750 g/ha under recommended/ improved practice, whereas butachlor 1000 g/ha under farmer's practice and weedy check as uncontrolled condition. An increase in grain yield with bispyribac-Na 20g/ha was found as 32%, with pretilachlor 28% and in farmer's practice 20% over weedy check. Among different weed management treatments, highest grain yield 6.6 t/ha, gross return ₹ 1,02,300/ha, net return ₹ 63,732/ha and B:C ratio 2.65 were achieved with bispyribac-Na at 20 g/ha which was closely followed by pretilachlor 750 g/ha. In Bhabar area, two sets of OFR on soybean were conducted at farmers' field during *Kharif* 2018 in Distt. Nainital. The treatments were comprised of imazethapyr 100 g/ha (EPOE), pendimethalin + imazethapyr 750+50 g/ha and imazethapyr +imazamox 70 g/ha (PoE) under recommended practice, whereas, propaquizafop 100 g/ha (PoE) was applied by the farmers. An increase in grain yield with imazethapyr + imazamox 70 g/ha was found as 63.6% followed by pendimethalin + imazethapyr 750 + 50 g/ha (54.5%) followed by imazethapyr 100 g/ha (45.5%) and farmers' practice propaquizafop 100 g/ha (36.4%) over weedy check. The highest grain yield 1.8 t/ha, gross return ₹ 54,900/ha, net return ₹ 27,098/ha and B:C ratio 1.97 was recorded with imazethapyr + imazamox 70 g/ha.

At Jorhat, on farm trials were conducted on black gram and green gram in the Golaghat district wherein four farmers participated. The treatments comprised of pendimethalin 750 g/ha pre-em and farmers practice (2 hand weeding). Application of pendimethalin 750 g/ha pre-em showed superiority over farmers' practice (2 hand weeding) in terms of weed control and seed yield of the crop. The treatment increased seed yield by 1.74 q/ha in greengram and 1.79 q/ha in blackgram over farmers' practice.

At Anand, two OFR trials were conducted in wheat during *Rabi* 2017-18. IC *fb* hand weeding at 20 and 40 DAS (farmers practice) was more effective for weed management in wheat as compared to other treatments. However, in terms of yield and net return, application of clodinafop propargyl + metsulfuron-methyl performed better as compared to this treatment. As far as B: C ratio is concerned, highest value was observed in clodinafop propargyl + metsulfuron-methyl followed by sulfosulfuron + metsulfuron-methyl (PM). Results of two OFR trials conducted at the centre in soybean during *Kharif* 2018 revealed that IC *fb* HW at 20 and 40 DAS (farmers practice) was more effective for weed management in soybean as compared to other herbicidal treatments quizalofop *fb* HW at 30 DAS and imazethapyr *fb* IC + HW at 30 DAS.

At Coimbatore, OFT was conducted at Devarayapuram village of Thondamuthur block at five farmers' fields to demonstrate the integrated weed management in aggergatum onion CO 4 during *Kharif* 2018. PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAP, PE pendimethalin 1000 g/ha + hand weeding on 25-30 DAP were compared with hand weeding twice as farmers practice. Total weed density and weed dry weight were considerably lower with application of PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAP in all five locations and it was higher than farmers practice. Two hand weeding induced the emergence of new weeds and regrowth of present weed seeds which ultimately resulted in higher weed density and weed dry weight in farmers practice. PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAP recorded higher bulb yield (12.5 to 13.4 t/ ha) along with net return (₹ 1.72 – 1.94 lakh/ha). Effective control of early and late emerged weeds was the reason for higher yield of onion and economic returns in PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAPS. OFT was also conducted on farmers' fields in soybean during *Kharif* 2018. Application of imazethapyr 100 g/ha PoE was found most effective for weed management with higher B:C ratio (2.37) as compared to post-emergence application of quizalofop-ethyl and IC *fb* HW at 20 and 40 DAS (FP) in soybean crop.

At Bhubaneswar, four OFTs on transplanted rice were conducted during *Rabi* 2017-18 at Rout pada, Begunia and Khurda districts. Pretilachlor (0.75 kg/ha), oxadiargyl (75 g/ha) were compared with farmers practice (hand weeding at 25 and 40 DAP). Maximum yield of 3.65 t/ha was recorded in the plot applied with pretilachlor 0.75 kg/ha followed by oxadiargyl 75 g/ha (3.47 t/ha). A net saving of ₹ 2450 - 2550/ha was obtained in the plots treated with herbicides. Four OFTs on rice were also conducted during *Kharif* 2018 in Bhubasuni Patna, Baghamari, Khurda area. In the trials, pretilachlor (800 g/ha), bispyribac- Na (20 g/ha) were compared with farmers practice (two hand weeding at 25 and 40 DAT). Highest yield was obtained in the treatment bispyribac- Na 20 g/ha (4.5 t/ha) followed by penoxsulam 23.5 g/ha (4.3 t/ha). Net saving in weeding cost over farmers practice was in the tune of ₹ 2600 - 2950/ha in herbisidal treatments.

At Hyderabad, OFR was conducted during *Rabi* 2017-18 for the management of *Orobanche* in tomato and solanaceous (Brinjal) crops. Treatments were imposed in farmers fields at Chenvelly village of Chevella Mandal in Vikarabad District. Application of neem cake 200 kg/ha *fb* glyphosate 30 g/ha at 25 and 55 days after transplanting was effective in controlling *Orobanche* infestation while mulching with polysheet UV resistant mulch of 25 mm thickness before planting delayed emergence and lowered the incidence of Orobanche resulting higher plant spread, average fruit weight, dry weight per plant and higher fruit yield. On the other hand, application of neem cake 200 kg/ha at sowing *fb* application of higher doses of glyphosate either 50 g/ha or 40 g/ha at 25 and 55 days after transplanting recorded phototoxic symptoms on eggplant.

At Hisar, OFR trials were conducted in wheat during *Rabi* 2017-18. Pre-emergence use of pendimethalin 1.5 kg/ha alone or in combination with metribuzin *fb* sequential use of post-emergence herbicides at 35 DAS was demonstrated at 10 locations in rice-wheat growing regions of Haryana. Pendimethalin integrated with post-emergence herbicides provided 73.3% control of resistant *P. minor* whereas its ready mixture with metribuzin gave 83.6% control resulted in 18 kg/ha yield increase over clodinafop + metribuzin (TM) as pre-emergence. Although, post-emergence use of clodinafop + metribuzin (RM) gave 84% control of *P. minor* but 5-10% toxicity to wheat crop was also observed at 6 locations. OFR trials were also conducted on use of new herbicide pyroxasulfone in wheat during the season. Pre-emergence use of pyroxasulfone at 127.5 g/ha demonstrated at 7 sites in rice –wheat growing areas of Haryana provided 88.3 % control of multiple herbicide resistant *P. minor*, whereas, integration of this herbicide with pendimethalin at 1.5 kg/ha (PRE) and post-emergence herbicides at 35 DAS improved control of *P. minor* to 92% with grain yield of 5.39 t/ha which was 6.54% higher than earlier recommended herbicide pendimethalin at 1.5 kg/ha.

At Akola, an OFT was conducted in soybean in two farmers' fields during *Kharif* 2018. In these trials, farmers practice (2 hoeing) was compared with improved practice pre-emergence herbicide diclosulam 22 g/ha *fb* post-emergence use of imazethapyr + imazamox 100 g/ha at 20-25 DAS. Use of pre- and post-emergence herbicides provided better weed control along with higher grain yield (2.38 t/ha) as compared to the farmers' practice (1.83 t/ha).

At Jammu, on farm research trial was conducted at 5 farmers' field at Nagrota block of Jammu region in maize under rainfed condition during *Kharif* 2018 in collaboration with KVK, Jammu. The lowest weed density and weed biomass were recorded in tembotrione 100 g/ha + atrazine 500 g/ha as post-emergence followed by atrazine 1000 g/ha as pre-emergence *fb* tembotrione 100 g/ha as post-emergence. Highest grain yield, straw yield and B: C ratio were recorded in tembotrione 100 g/ha + atrazine 500 g/ha as post-emergence followed by atrazine 1000 g/ha as pre-emergence *fb* tembotrione 100 g/ha as post-emergence.

At Kalyani, on-farm research trials were conducted in cowpea in four farmers field at Panchkahania village of Haringhata block of Nadia district during *Kharif* 2018. Two weed management practices were tested against farmers practice (Two hand weeding at 15 & 30 DAS). Among the weed management treatments, application of pendimethalin 0.75 kg/ha at 0-3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS recorded lower weed density, dry weight and higher weed control efficiency over other treatments.

Highest green pod yield (8.7 t/ha), net return (₹ 91,585/ha) and B: C ratio of 3.03 were observed with the treatment pendimethalin 0.75 kg/ha at 0-3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS. The next best performance was observed by the application of pendimethalin 0.75 kg/ha at 0-3 DAS *fb* one hand weeding at 30 DAS with green pod yield (8.1 t/ha), net return (₹ 75,914/ha) and B:C ratio of 2.03 and was followed by the farmers' practice (Two hand weedings at 15 and 30 DAS).

Four on-farm trials were conducted in cabbage at Panchkahania village, of Haringhata block of Nadia District, West Bengal during *Rabi,* 2018. Farmers' practice (two hand weeding at 20 & 40 DAT) was compared with other two weed management practices. Application of fluchloralin 1.0 kg/ha as pre- plant incorporation *fb* irrigation *fb* hand weeding at 20 DAT showed superiority over other two practices in terms of better weed control and seed yield. This treatment recorded minimum weed density and biomass throughout the crop growth period and maintained highest WCE of 81.4 and 80.1% at 30 DAS and at harvest, respectively. Highest head yield 46.6 t/ha, net return of ₹ 1,84,249/ha and B:C ratio 2.86 were also recorded in this treatment which was closely followed by the farmers' practice (two hand weeding at 20 & 40 DAT). Fluchloralin 1.0 kg/ha as pre-plant incorporation *fb* irrigation produced head yield 37.3 t/ha, net return of ₹ 1,41,985 t/ha. Five on-farm trials were also conducted in transplanted rice at Matiagacha village of Habra-II block of North 24 Parganas District, West Bengal during *Kharif,* 2018. The treatment having pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT has been found to be the best treatment considering weed control efficiency, yield and economics of the trial.

WP 5.2 Front line demonstration

At Ludhiana, control of *Phalaris minor* in wheat with pre-mix of clodinafop + metribuzin (a new post-emergence herbicide mixture) was demonstrated through front-line demonstrations during *Rabi* 2017-18. Total of eight demonstrations were conducted in the farmers' fields. Farmers practice include use of different herbicides such as pinoxaden 50 g/ha, clodianfop 60 g/ha, sulfosulfuron 25 g/ha and clodinafop 120 g/ha. Demonstrations showed superiority of new herbicide (clodinafop + metribuzin) for effective control of *P. minor* in wheat as compared to herbicides. With farmers practice, 40-75% control of *P. minor* was observed, however, 95% control was observed with new pre-mix herbicide. New herbicide also gave 10-14% increase in grain yield of wheat. Six FLDs were also conducted for weed control in maize with post-emergence herbicide tembotrione 110 g/ha in Hoshiarpur, SBS nagar and Pathankot districts during 2018. Farmers practice include the use of atrazine 1.0 kg/ha or interculture operation. The effective weed control was observed with this herbicide and farmers were happy to get new window to control weeds with herbicide. A yield increase of 31.4% was observed with the use of herbicide over farmers practice.

At Gwalior, two FLDs were conducted on pearlmillet and two were on blackgram crops at farmer's fields in two locations in the villages of Gwalior district. Atrazine 500 g/ha + 2,4-D 500 g/ha were tested on pearlmillet as first FLD and second FLD were conducted to test the herbicide atrazine 0.5 kg/ha (PoE) and compared it with the farmer's practice. In pearlmillet it was observed that all the chemical weed management practices gave higher grain yield over farmers practice. Maximum yield of 2.45 t/ha was obtained with the application of atrazine 500 g/ha + 2,4-D 500g/ha (PoE) *fb* atrazine 500 g/ha, which was 58%, and 48% higher than farmers practice. Similarly, highest B:C ratio of 2.29 was recorded in atrazine 500g/ha+ 2,4-D 500g/ha (PoE). In blackgram maximum yield of 0.89 kg/ha was obtained with the application of imazethapyr + imazamox (RM) 80 g/ha PoE *fb* quizalofop-p-ethyl 75 g/ha PoE, which was 43.32%, and 36% higher than farmers practice. The highest B: C ratio of 1.40 was also recorded in imazethapyr + imazamox (RM) 80 g/ha PoE.

At Pantnagar, three sets of front line demonstrations were conducted to evaluate the competitive bio-efficacy of herbicides at farmer's field in wheat during *Rabi* 2017-18 in various villages of Distt- Nainital, Uttarakhand in Bhabar area. The experiment was consisted of clodinafop-propargyl + metsulfuron-methyl 60+4 g/ha applied at 30 - 35 DAS as recommended practice, whereas, under farmer's practice MSM 4g/ha was applied. An increase of 11.4%

grain yield was recorded with improved practice over farmer's practice. The higher grain yield 4.9 t/ha, gross return ₹ 85015/ha, net return ₹ 47,774/ha, B:C ratio 2.28 and weed control efficiency of 88.9% was recorded with improved practice which was higher than farmer's practice.

To compare the performance of improved vis-a-vis farmer's practice in transplanted rice, three sets of front line demonstrations were conducted at farmer's field in Distt. U.S. Nagar, Uttarakhand in Tarai area during *Kharif* 2018. The trials comprised of bispyribac-Na 20 g/ha applied at 20 DAT under improved practice, whereas, butachlor 1000 g/ha was applied by the farmer's within 3 days of transplanting. An increase of 12% higher grain yield was recorded in improved practice as compared to farmer's practice. The highest grain yield 6.5 t/ha, net return ₹ 62,182/ha and B: C ratio 2.9 and weed control efficiency of 80.8% was recorded with improved practice which were higher than farmer's practice. Total two sets of front line demonstrations on soybean were conducted at different farmer's fields during *Kharif* of 2018 in Distt. Naninital, Uttarakhand in Bhabar area**.** The treatments comprised of imazethapyr 100g/ha (EPOE) under improved technology and propaquizafop 100 g/ha was taken as farmer's practice. Application of imazethapyr 100 g/ha under improved practice increase the 14.3% higher grain yield over farmer's practice which recorded 1.6 t/ha grain yield, ₹ 48,800/ha gross return, ₹ 19,950/ha net return and 1.69 B:C ratio and 66.9% weed control efficiency which were higher than farmer's practice.

At Palampur, twenty demonstrations (11 in rice, 5 in maize and 6 in wheat) were conducted during 2017-18. In rice, bispyribac-Na 20 g/ha was tested against butachlor 1.5 kg/ha as farmers practice; whereas, in maize, tembotrione 120 g/ha was tested against hoeing 20 DAS or earthing up 45 DAS and in wheat, clodinafop-propargyl 60 g/ha + metsulfuron-methyl against isoproturon 1.25 kg/ha. These demonstrations were conducted on maize, wheat and rice in Dharer, Deol and Sehal Panchayats of the Baijnath block in collaboration with FPP project. The results revealed 33.5% of yield increase and 2.79 B:C ratio in maize (Hybrid: F1 KH 517) with technological intervention involving chemical weed control along with introduction of improved variety, improved method of sowing and balanced fertilization. Front line demonstrations on rice (Variety: F1 Raja 369) showed 9-32.7% increase in yield in different areas of demonstrations. Whereas, front line demonstrations on wheat (HPW 155, HPW 368, HPW 349) during 2017-18 under FPP project with technological intervention involving chemical weed control along with improved practices in different Panchayats like Dharer, Deol and Sehal gave yield increase of 17.2-33% over farmers practice.

At Anand, four FLDs were conducted in maize during *Kharif*, 2018. In the demonstrations, atrazine *fb* topramezone 336 g/L was tested against IC *fb* HW at 20 and 40 DAS as farmers practice. Herbicide provided 4% yield increase, net return of ₹ 26,567/ha and 1.88 as compared to farmers practice (net return ₹ 22,455/ha and B:C ratio 1.69). On the other hand, clodinafop + metsulfuron-methyl 64.0 g/ha was tested against metsulfuron-methyl 4.0 g/ha (Farmers Practice) in 5 demonstrations in wheat during *Rabi* 2017-18. Improved practice (herbicide) provided 12% yield increase, net return of ₹ 47,939/ha and 2.48 B.C. ratio as compared to farmers practice (net return ₹40,854/ha and B: C ratio 2.30) in wheat.

At Coimbatore, front line demonstrations were conducted in tomato at five farmer's field of Devarayapuram village, Thondamuthur block of Coimbatore District. In these demonstrations, PE pendimethalin 1000 g/ha + hand weeding on 30-35 DAT was tested against hand weeding twice (25 and 50 DAT) as farmers practice. Due to adoption of improved weed management technology (PE pendimethalin 1000 g/ha), average tomato yields increases ranging from 21-33% than farmers practice (two hand weeding). Higher income was also obtained by improved practice over farmers practice.

At Thrissur, management of weedy rice with weed wiper was demonstrated in farmers fields. FLDs were done in 5 locations of Alathur, Venkitangu and Chazhur Panchayats. Almost 80-92% control of weedy rice through wiper was observed in farmers' fields.

At Bhubaneswar, 10 FLDs were conducted in rice during *Kharif*, 2018. In these demonstrations, application of bispyribac-Na 200 ml/ha was demonstrated against farmers practice. Yield increase of

32% and B:C ratio 2.45 were observed from demonstrated technology over farmers practice. The study on impact analysis on weed management was also carried out in Munida village of Sakhigopal block of Puri district. The farmers have mostly marginal holding size with medium family size. The dominant cropping systems practiced are rice - pulses / groundnut, rice - vegetables and rice - rice (irrigated patch - 20%). The major production constraints are lack of exposures, unavailability of inputs in time, weed menace and uncertainty of monsoon. The yields of the crops were low in 60% of the areas and the farmers were spending ₹ 1500-2150/ha more in manual weeding. Most of the farmers are not satisfied with the traditional method of weed management.

At Hyderabad, eight front line demonstrations were conducted in rice during *Kharif* 2018 to popularize the integrated weed management technology in Chityal village, Parigi mandal of Vikarabad district and Anthvelli village of Medchal mandal district, respectively, with the technology generated at AICRP on Weed Management. The results from FLDs on rice during *Kharif*, 2018 at Chityal village showed that IWM involving post-emergence application of penoxulam + cyhalofop – butyl *fb* hand weeding resulted in efficient weed control and increase in yield ranged from 5.3 to 11.6 %. Mean reduction of 13-15 % was observed in the cost of cultivation of improved practice over the farmer's practice due to usage of herbicide for one time by avoiding manual weeding.

At Hisar, five FLDs were conducted in different villages of Panchkula district. Tembotrione provided effective control of weeds (85-95%) which are not being controlled by use of atrazine used by farmers. Yield data showed that economics is in favour of use of tembotrione at all locations. B: C ratio with use of tembotrione varied 2.62-2.89 against 2.34-2.67 in farmer's practice. During *Kharif*, 15 demonstrations on bio efficacy of a ready mix combination of pretilachlor + pyrazosulfuron against complex weed flora in transplanted rice were conducted in various parts of state and compared with earlier recommended herbicide pretilachlor. On an average ready mix combination of pretilachlor + pyrazosulfuron had an edge over pretilachlor as it provided more than 94% control of complex weed flora as against 82% by use of pretilachlor with yield increase of 7.28% over FP (pretilachlor). It also showed excellent efficacy against broad leaf weeds and sedges such *Scirpus tuberosus* and *C. rotundus* not being controlled by pretilachlor alone. 325 demonstrations in Bhiwani, Hisar and Mahender Garh districts were also conducted on use of glyphosate for the control of *Orobanche* in mustard. Post-emergence application of glyphosate 25 g/ha at 30 DAS followed by its use at 50 g/ha at 50-60 DAS provided 75-85% control of *Orobanche* in mustard with 51.9% increase in yield over untreated check.

At Akola, 2 FLDs were conducted in cotton to test the bio efficacy of pre-emergence application of pendimethalin 1.0 kg/ha *fb* directed spray (by using protective shield) of non-selective herbicide paraquat 0.6 kg/ha at 45 DAS after sowing against farmers practice (3-4 hoeing + 2-3 weeding). The higher yield was recorded in farmers practice, however the B: C ratio was more in the demonstrated technology on weed management in cotton.

At Udaipur, during *Rabi*, 2017-18, five FLDs on broad spectrum weed control in wheat with premix application of sulfosulfuron + metsulfuron (30 + 2 g/ha) at 35 DAS were conducted at Shayampura, and Maudi village of Sarada Tehsil. The farmer's field was infested with *Phalaris minor* among the monocots. *Chenopodium album*, *Chenopodium murale, Convolvulus arvensis, Fumaria parviflora* and *Melilotus indica* were among dicots. Post-emergence application of ready mix herbicide increased the wheat grain yield by 8.93% over farmers practice (4.03 t/ha). During *Kharif* 2018, five demonstrations on weed management in maize through herbicide was conducted at Shayampura, and Maudi village of Sarada Tehsil. The recommended herbicide (atrazine *fb* tembotrione 500 g/ha as PE + 120 g/ha at 3-4 leaf stage (15 DAS)) was compared with farmers practice. Application of atrazine *fb* tembotrione in maize provided higher yield as compared to farmer practice. Minimum density of total weeds was recorded under the atrazine *fb* tembotrione (3.3/m^2). It also showed mild phyto-toxicity symptoms on crop but crop recovered after some days. Application of tembotrione increased the maize grain yield by 15.9% over farmers practice (2.7 t/ha). During *Kharif*, 2018 five demonstrations on weed management in soybean through herbicide imazethapyr + propaquizafop 75 + 75 g/ha PoE at 21 DAS (tank mix) was conducted at Shayampura, and Maudi village of Sarada Tehsil. Application of imazethapyr + propaquizafop in soybean gave higher yield as compared to farmer practice. Minimum density of total weeds was also recorded under the effect of imazethapyr + propaquizafop. It also showed mild phyto-toxicity symptoms on crop and check growth of the crop plant but crop recovered after some days. Application of imazethapyar + propaquizafop increased the soybean grain yield by 47% over farmers practice.

Overall extention activities are summaried in (**Table 5.1.**).

Table 5.1 Extension activities undertaken by coordinating centres.

Centres	**Training imparted**	**Radio talks**	**TV programmes**	**Kisan melas/Kisan Day**	**Handouts/folders/pamphlets**	**Bulletins/booklet**	**Training participated**	**On-farm trials**	**Frontline demonstrations**	**Parthenium awareness**
PAU, Ludhiana	4	-	3	-	2	-	-	8	14	✓
UAS, Bengaluru	1	1	2	-	-	-	3	29	-	✓
RVSKVV, Gwalior	-	-	-	-	-	1	-	4	2	✓
GBPUAT, Pantnagar	3	7	-	2	-	-	-	8	11	✓
CSKHPKV, Palampur	6	1	-	-	-	1	-	17	17	✓
AAU, Jorhat	-	2	-	-	-	-	-	-	-	✓
AAU, Anand	9	1	1	3	-	-	-	4	9	✓
TNAU, Coimbatore		1	-	-	-	-	-	5	5	✓
KAU, Thrissur	-	-	-	-	-	2	-	2	5	✓
OUAT, Bhubaneshwar	2	-	-	-	-	-	-	8	2	✓
PJTSAU, Hyderabad		-	12	-	-	1	-	1	8	✓
CCSHAU, Hisar	11	3	-	5	-	1	-	17	355	✓
IGKV, Raipur	-	1	-	-	-	-	-	9	4	✓
PDKV, Akola		1	-	1	5	-	1	2	2	✓
BCKV, Kalyani	1	-	-	1	-	-	1	9	-	✓
MPUAT, Udaipur	3	-	-	1	-	3	-	-	15	✓
SKUAST, Jammu	-	-	-	-	-	1	-	5	-	-
Total	**40**	**18**	**18**	**13**	**7**	**10**	**5**	**124**	**449**	

4. RECOMMENDATIONS FOR PACKAGE OF PRACTICES

AAU, Anand

- Weed flora shifted towards monocot weeds in wheat fields due to continuous use of 2, 4-D or metsulfuron-methyl. Herbicide mixtures were found more effective to manage complex weed flora in wheat crop.
- Escape incidence of monocot weed *Commelina benghalensis* after application of recommended herbicides in different crops were observed at farmers and research farms. Escape of dicot weed *Digera arvensis* and *Phyllanthus niruri* were observed in the research farm as a result of pre-emergence application of pendimethalin.
- Application of oxyfluorfen 240 g/ha PE *fb* HW at 60 DAP along with paddy straw mulch 5 t/ha was found more effective to manage weeds and produce higher garlic bulb yield.
- In maize based cropping system application of atrazine + pendimethalin (500 + 250 g/ha) PE (tank mix) *fb* 2, 4-D 1000 g/ha PoE found effective weed management practices. Adverse effect of herbicides on succeeding wheat crop was not observed.
- The highest seed cotton equivalent yield was achieved under zero tillage with residue treatment. Application of pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS recorded significantly higher seed cotton equivalent yield as compared to quizalofop- ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS in cotton-green gram cropping system under conservation agriculture.
- Fennel equivalent yield and gross return was recorded higher under vermicompost 8.0 t/ha, while net return and benefit cost ratio was recorded under farm yard manure treatment. Paddy straw mulch 10 t/ha *fb* HW at 30, 60 DAS recorded higher fennel equivalent yield, gross return, net return and benefit cost ratio.

CCSHAU, Hisar

- Application of penoxsulam+ cyhalofop 900 ml/acre at 15-20 days after transplanting as spray in 120 liter water to control complex weed flora in transplanted rice is recommended. There should be no standing water one day before and one day after herbicide application.
- Application of penoxsulam 360 ml/acre at 15-20 days after transplanting as spray in 120 liter water to control complex weed flora in transplanted rice. There should be no standing water one day before and one day after herbicide application.
- To control resistant population of *P. minor, A. ludoviciana* and broadleaf weeds in wheat, a ready mix combination of clodinafop+metribuzin 200 ml per acre along with surfactant (500 ml) should be sprayed at 35 DAS using 120 litres of water.

CSKHPKV, Palmpur

- For higher productivity of maize-wheat system, zero tillage with or without residues followed by IWM (herbicide + mechanical weeding + intercropping) in both crops was found to be the effective treatment.
- Under organically managed maize – garlic cropping system, raised stale seed bed + mulch or hoeing; intercropping and intensive cropping may be an effective mean of suppressing weeds and increasing garlic bulb equivalent yield.
- Pre-emergence application of metribuzin 0.7 kg/ha or pendimethalin1.0 kg/ha *fb* mulch (2-5 DAP) *fb* hoeing (75 DAP) could be an effective integrated weed management strategy in turmeric.
- Mixture of indaziflam 125 g/ha + glufosinate ammonium 1000 g/ha during the month of January and then again in the month of July gave selective control of weeds in tea. However, indaziflam 62.5 g/ha + glufosinate ammonium 1500 g/ha gave higher net returns.
- Pre-emergence application of the imazethapyr + pendimethalin at 1200 g/ha may be the better option for managing mixed weed flora and obtaining higher fruit yield of okra.

GBPUAT, Pantnagar

- In maize crop minimum two hand weeding at 20 & 35 DAS are required. Apply atrazine 2.5 kg /ha pre emergence *fb* tembotrione 120 g/ha post emergence or alachlor 2 kg/ ha as pre –emergence were found able to control of grass, broadleaf weeds and sedges.
- In rice crop application of anilofos 0.4 kg/ha or thiobencarb 1.0 kg/ha when first leaf of rice has turned green is recommended. Application of butachlor 1.5 kg/ha or anilofos 400 g/ha or pretilachlor 1.0 kg/ha as pre-emergence after transplanting is recommneded. Application of bispyribac-sodium 25 g/ha or almix 4 g/ha as post-emergence to control grassy, sedges and broad leaf weeds is recommneded. Application of penosulam 20-22 g/ha as early post emergence or penoxsulam w/w+ cyhalofop-butyl w/w 120-135 g/ha as early post emergence in DSR and TPR is recommneded.
- Application of atrazine 1.0 kg/ha as pre-emergence in sorghum was effective to control grassy and broadleaf weeds.
- For control of grassy, broadleaf and sedges in soybean crop application of pendimethalin + imazethapyr 750+50 g/ha as pre emergence is recommnended. Alternatively, imazethapyr 100 g/ha or alachlor 2.0 kg/ha or metolachlorr 1.0 kg/ha as pre-emergence or fluchloralin 1.0 kg/ha as pre-plant incorporation or metribuzin 350 g/ha as pre-emergence *fb* one hand weeding at 30-35 DAS is recommneded.
- For control of grassy, broad leaf and sedges weeds in sugarcane, irrigate the field at 40-45 days of crop stage and do hoeing at this stage *fb* atrazine 2.0 kg/ha within 3-4 days after hoeing or metribuzin 1.0 kg/ha or pendimethalin 1.0 kg/ha as pre-emergemnce. Apply 2,4-D 0.5 kg/ha for control of *Ipomea* spp. spray hexazinone + diuron 1.2 kg/ha as pre emergence or post emergence.
- In wheat crop for control of grassy, broad leaf weeds and sedges, application of clodinafop-propargyl 0.06 kg/ha or sulfosulfuron 0.025 kg/ha *fb* one hand weeding at 60 DAS is recommended. Apply clodinafop propargyl+ metsulfuron-methyl 60+4 g/ha at 30-35 days stage or sulfosulfuron + metsulfuron-methyl 3.0+2.0 kg/ha at 25-30 days stage for control of broad leaved weeds and grasses.
- In potato for control of grassy, broadleaf weeds and sedges, apply paraquat 500 g/ha when weeds have been emerged but potato emergence is not more than 5 % *fb* earthing up. Pendimethalin 1.0 kg/ha or metribuzin 350 g/ha as pre-emergence fb one hand weeding and earthing up at appropriate stage.
- In urd, moong, cowpea and pigeonpea for control of grassy, broadleaf and sedges application of alachlor 2.5 kg/ha or metribuzin 0.35 kg/ha as pre-emergence or fluchloralin 1.0 kg/ha as pre-plant incorporation is recommended.
- In gram, pea, lentil for control of grassy, broad leaf weeds and sedges, application of pendimethalin 1.0 kg/ha or alachlor 2.0 kg/ha as pre-emergence or fluchloralin 1.0 kg/ha as pre-plant incorporation found effective.

IGKV, Raipur

- Application of oxadiargyl 80 g /ha *fb* post-emergence bispyribac – Na 25 g/ha or oxadiargyl 80 g /ha *fb* post-emergence pinoxsulam 22.5 g/ha in direct seeded rice is recommended for effective weed control.

OUAT, Bhubaneswar

- Pre emergence application of pendimethalin 750 g/ha followed by either post emergence of tembotrione 100 g/ha or topramezone 25 g/ha at 0-2 DAS *fb* 25 DAS is recommended for control of weeds in maize.
- In blackgram/greengram preemergence application of pendimethalin 750 g/ha following one manual weeding at 0-2 DAS *fb* 30 DAS is recommended for control of weeds.

PDKV, Akola

- Post emergence application of imazethapyr + imazamox 0.070 kg/ha PoE 15 DAS was the most remunerative and effective herbicide for controlling the weed flora and getting higher yield and economic returns in soybean.
- In cotton, preemergence application of pendimethalin 1.0 kg/ha followed by directed spray (by using protective shield) of non-selective herbicide paraquat 0.60 kg/ha at 45 days after

sowing is recommended for controlling weeds and higher yield and monetary returns.

- The post emergence application of imazethapyr+ imazomox 0.07 kg/ha at 20 DAS was the most remunerative and effective herbicide for controlling the weed flora and getting higher yield and economic returns in groundnut.

TNAU, Coimbatore

- PE bensulfuron methyl + pretilachlor 660 g/ha *fb* hand weeding on 30 DAT during *Rabi* and PE pyrasosulfuron-ethyl 20 g/ha *fb* hand weeding on 30 DAT during *Kharif* for higher grain yield and income in transplanted rice-rice cropping system is recommended.
- Conventional tillage (disc ploughing + two harrowing) with PE application of atrazine 0.5 kg /ha for maize and pendimethalin 1.0 kg/ha for sunflower + hand weeding on 45 DAS was effective in maize - sunflower.
- Pre-emergence application of oxyflourfen at 200 g /ha on 3 DAP followed by hand weeding on 25-30 DAP for broad spectrum weed control and higher bulb yield and economic returns in onion is recommended.
- Pre-emergence application of pendimethalin 1000 g /ha on 3 DAT followed by hand weeding on 35 - 40 DAT is recommended for broad spectrum weed control, higher fruit yield and economic returns in tomato.
- Post emergence application of glyphosate 1.5 kg/ha + 2, 4-D Na salt 1.25 kg/ha + wetting agent 2 ml litre of water was found to be effective in reducing density and dry weight of *Solanum elagaenifolium* in fallow fields and with no regeneration even after 60 days after herbicide application.

UAS, Bengaluru

- Alachlor 800 ml/ acre or pendimethalin 1000 ml/acre within 3 DAS followed by imazethapyr 250 ml/acre at 20-25 days after sowing in field bean (*Dolichos lablab)* is recommended.
- Alachlor 800 ml/acre or pendimethalin 1000 ml/acre within 3 DAS followed by imazethapyr 250 ml/acre at 20-25 days after sowing in cowpea (*Vigna unguiculata*) is recommended.

PAU, Ludhiana

- Lucky seed drill with automatic spraying system for direct sowing of rice and simultaneous spraying of pre-emergence herbicide significantly reduced weed density and increased rice grain yield as compared to manual spray of herbicide on the same day of sowing.
- Pre-emergence application of pendimethalin at 1.25 kg/ha significantly reduced resistant *P. minor* density and biomass and gave higher wheat grain yield than earlier recommended dose (750 g/ha) of pendimethalin and has been approved for ad-hoc recommendation and for conduct of adaptive research trials.
- Uniform spreading of paddy straw mulch at 10 t/ha immediately after planting of poplar cuttings provides long term control of diverse weed flora in poplar nursery plantations.
- Complete production technology- including optimum sowing time, crop geometry, fertilization, irrigation, weed control - for sugarbeet has been developed for Punjab conditions through series of research experimentation at PAU Ludhiana and different KVKs and Regional Research Stations. It has been advised that before cultivation of sugarbeet, the farmers should ensure marketing of the produce, by contacting sugarmills or other stakeholder, beforehand.
- Post-emergence spray of ready-mix of clodinafop and metribuizn at 174 g/ha provided effective control of *Phalaris minor* and broadleaf weeds in wheat and has approved for ad-hoc recommendation and for conduct of adaptive research trials.

PJTSAU, Hyderabad

- Application of penoxsulam + cyhalofop-p-butyl at 150 g (25 g + 125 g)/ha as post emergence at 20-25 DAT can be recommended to provide effective control of weeds and higher net returns in transplanted rice.

5. LINKAGES AND COLLABORATION

All India Coordinated Research Project on Weed Management has effective collaboration with state agriculture universities, ICAR institutes such as IIPR, Kanpur, IISS, Bhopal, IVRI, Izatnagar, IIFSR, Modipuram, and other AICRP's such as AICRP-IFS and Network Project on Organic farming (NIOF), IIFSR, Modipuram. Following collaborative research work was carried out during the year.

CSKHPKV, Palampur

Weed flora association in rice varieties at varying fertility levels in Himachal Pradesh (AICRP – Rice)

Weeds infestation is greatly responsible for reduction in potential rice crop yield. The genotype and fertility status of the soil mainly influence weed flora association and their diversity in a cropping system. Weed flora associated with rice under varying fertility treatments and variety was therefore investigated during *Kharif,* 2018. Five fertility levels viz. F_1 (50% of recommended dose of fertilizer (RDF) (45:20:20), F_2 (100% of RDF (90:40:40), F_3(150 % of RDF (135:60:60), F_4 (F_1 + Azolla at 10 DAT), F_5 (F_2 + Azolla at 10 DAT) and four varieties of rice V_1 (Vivekdhan 65),V_2 (HPR 2143), V_3 (HPR 2720), V_4 (AZ 6508) (Table 18.1) were evaluated at Rice and wheat Research centre, Malan during the *Kharif* season of 2018.

Rice crop was found invaded by *Alternanthera philoxeroides* (34.1%), *Cyperus* sp. (*C. iria* and *C. difformis* (21.5%), *Echinochloa colona* (20.6%), *Panicum dichotomiflorum* (7.5%), *Digitaria sanguinalis* (5.2%), *Monochoria vaginalis* (5.2%), *Phyllanthus niruri* (2.6%), *Aeschynomene indica* (2.6%) and *Paspalum* sp. (0.7%). The overall average weed density was about 98 weeds/m^2. Fertility treatments brought about significantly variation in the count of *Cyperus* sp. 50% NPK remaining at par with 50% NPK + Azolla gave significantly lower count of *Cyperus* sp. over other treatments. Fifty percent NPK + Azolla could not reduce the count of *Cyperus* over 100% NPK + Azolla and was superior to 100% NPK and 150% NPK. The count of *Echinochloa colona* was lower in 50% NPK being at par with 50% NPK + Azolla and 100% NPK + Azolla over other treatments. In case of *Digitaria sanguinalis,* treatment 50% NPK + Azolla recorded minimum count which remained statistically at par with treatment 50% NPK, 100% NPK + Azolla and 150% NPK. Count of *Monochoria vaginalis* was significantly lower due to 100% NPK + Azolla followed by 50% NPK + Azolla, 150% NPK and 50% NPK. Count of *Alternanthera philoxeroides*, *Panicum dichotomiflorum*, *Phyllanthus niruri*, *Aeschynomene indica*, *Paspalum* sp. was not affected by fertility treatments. Total weed count was significantly lower due to the treatment 50% NPK + Azolla which remains at par with 50% NPK.

Varieties did not significantly influence species-wise weed count but total weed count was significantly affected. AZ 6508 and HPR 2143 remaining at par with HPR 2720 gave significantly lower total weed count over Vivekdhan 65. However, Vivekdhan 65 was at par with HPR 2720.

Cropping system's influence on weeds floristic diversity

Eight cropping systems, *viz.*C_1: rice – wheat, C_2: rice – pea – summer squash, C_3: okra – radish – onion, C_4: turmeric – pea – summer squash, C_5: rice – lettuce – potato, C_6: rice – palak – cucumber, C_7: rice –broccoli – radish, and C_8: colocasia – pea + coriander are being evaluated for their production potential from *Kharif* 2014. An appraisal of weed species associated with different cropping systems has been made monthwise during 2016-17.

Monochoria vaginalis, *Cyprus* sp., *Ageratum* sp., *Echinochloa* sp., *Cynodon dactylon* and *Polygonum hydropiper* were major weeds in *Kharif*. *Brassica sp.*, *Fimbristylis* sp., *Artemisia argyi* and *Trifolium repens* were observed few times in a season. *Polygonum alatum* had sporadic appearance in some months in some crops. *Scirpus juncoides*, *Eleocharissp.* and *Phyllanthus niruri* were found only in September. Whereas, *Commelina benghalensis* was prevalent in September and August only. *Lathyrus aphaca*, *Ageratum sp.*, *Cynodon dactylon*, *Polygonum hydropiper*, *Fimbristylis* sp., *Phalaris minor*, *Spergulla arvensis*, *Vicia sativa*, *Polygonum alatum*, *Trifolium repens* were prevalent throughout the *Rabi* season. *Bidens pilosa* and *Avena ludoviciana* have shown their occurrence at later stages of crop growth.

Ageratum sp. contributed about 28% of total weed flora *in Kharif*. *Cynodon dactylon* and *Commelina benghalensis* were next in dominance constituting 20% and 19% of total weed flora respectively. In *Rabi*, *Phalaris minor* was the most dominating weed contributed 63% to total weed flora. Other weeds prevalent were *Fimbristylis* sp. (10%), *Spergulla arvensis* (6%), *Ageratum* sp. (4%), *Trifoliumrepens* (3%), *Cynodondactylon* (3%) and *Polygonum* sp. (4%). The present investigation clearly indicate that weeds are dynamic in nature and are greatly influenced by crops, seasons and management practices being carried out from time to time.

Weed count

During *Kharif* the total weed count was maximum in September in okra, turmeric and colocasia but in rice it was uniform throughout the season probably due to standing water. Weed count in rice-based cropping systems varied from 80 to 200/m^2 but count in other cropping systems was higher than 200/m^2 at all the observations and varied from 200 to 650/m^2. In *Kharif,* count of *Cyprus* sp., *Polygonum alatum*, *Trifolium repens*, *Monochoria vaginalis* and *Polygonum hydropiper* was at peak in August. The count of *Brassica* sp. was highest in starting and termination of season i.e. July and October. Populations of *Cyprus* sp., *Trifolium repens*, *Monochoria vaginalis*, *Cynodon dactylon*, *Polygonum alatum* and *Echinochloa* decreased as the season advanced. But a reverse trend was seen in *Commelina benghalensis* and *Ageratum* sp. *Polygonum hydropiper* population was uniform throughout the season.

There were contrasting differences in the count of *Monochoria vaginalis* and *Ageratum* sp. in different cropping systems. Populations of *Cyprus*, *Polygonum alatum* and *Fimbristylis* sp., were also differing significantly in different cropping systems in *Kharif*. *Monochoria vaginalis* typically a weed of lowland situations was found growing in rice-based cropping systems only. Highest density of *Monochoria vaginalis* was found in rice-pea-summer squash followed by rice-wheat, rice-broccoli-radish, rice-palak-cucumber and rice-lettuce-potato. It was absent in okra under okra-radish-onion, turmeric under turmeric-pea-summer squash and colocasia under colocasia-pea + coriander cropping sequence. Therefore, the population of *Monochoria vaginalis* was significantly affected due to cropping systems. On the other hand *Ageratum*, a weed of upland situations was significantly higher under okra-radish-onion, colocasia-pea + coriander and turmeric-pea-summer squash cropping systems where upland crops viz. okra, colocasia and turmeric, respectively, occupied the land. It invaded rice at a later part of the season, when the field dried out. Highest density of *Ageratum* sp. was noted in okra-radish-onion followed by colocasia-pea + coriander and turmeric-pea-summer squash.

Cyprus sp. was found in highest amount in association with rice-palak-cucumber being at par with okra-radish-onion, rice-pea-summer squash, colocasia-pea + coriander and turmeric-pea-summer squash. Rice-wheat, rice-lettuce-potato and rice-broccoli-radish were next in order. Population of *Polygonum alatum* was in negligible and was absent in rice-wheat, rice-pea-summer squash, rice-lettuce-potato, rice-palak-cucumber and rice-broccoli-radish. *Cynodon dactylon* had higher populations in the experimental field. However, the variation in its population in different cropping systems was not significant. The highest population was found in turmeric-pea-summer squash followed by okra-radish-onion, rice-lettuce-potato, colocasia-pea + coriander, rice-broccoli-radish, rice-palak-cucumber, rice-pea-summer squash and rice-wheat. *Commelina benghalensis* was another weed that was found in higher amounts in the field but cropping systems did not significantly affected its population. *Eleocharis* sp., *Phyllanthus ninuri*, *Scirpus juncoides, Polygonum alatum* and *Echinochloa* sp. had sporadic appearance in the season.

Population of *Phalaris minor* and *Spergulla arvensis* was highest in December and decreased as the season advanced. Population of *Trifolium repens*, *Stellaria media*, *Polygonum alatum*, *Viciasativa* and *Polygonum hydropiper* was highest in March. Whereas *Commelina benghalensis* was seen growing in March. Count of *Ageratum* sp. and *Cynodon dactylon* was higher at termination of season i.e. April and May. But, both weeds had peak population in May.

Phalaris minor was most dominating weed in each cropping sequence, still the count was significantly affected by different cropping systems. Highest population of *Phalaris minor* was found in rice-palak-cucumber being at par with turmeric-pea-summer squash. Rice-broccoli-radish, rice-wheat, colocasia-pea + coriander and rice-pea-summer squash were next in order. In okra-radish-onion and rice-lettuce-potato the populations were lower. Count of *Spergulla arvensis* was highest in okra-radish-onion followed by rice-pea-summer squash and colocasia-pea + coriander. Whereas, population of *Trifolium repens* was maximum in colocasia-pea + coriander followed by okra-radish-onion, rice-palak-cucumber, turmeric-pea-summer squash, rice-pea-summer squash, rice-wheat, rice-broccoli-radish and rice-lettuce-potato. **(Table 5.1)**

Population of *Fimbristylis* sp. was also highest in colocasia-pea + coriander followed by okra-radish-onion, rice-pea-summer squash , rice-lettuce-potato turmeric-pea-summer squash, rice-palak-cucumber, rice-wheat and colocasia-pea + coriander.

Table 5.1 Effect of treatments on count (No/m^2) of weeds in wheat during 2017-18: mean of all observations (data transformed to square root transformation)

	Artemisia	*Anagallis*	*Avena*	*Coronopus*	*Gnaphalium*	*Vicia*	*Phalaris*	*Polygonum*	*Poa*	*Plantago*
T1	1.8	4.5	1.3	0.7	2.3	1.6(2.3)	5.4	8.6	1.4	2.2
	(4.0)	(28.3)	(1.7)	(0.0)	(6.0)		(29.3)	(88.9)	(1.7)	(4.3)
T2	1.0	1.0	1.1	1.2	1.3	1.2(1.0)	2.7	20.1	0.9	0.9
	(0.7)	(0.7)	(0.7)	(1.3)	(1.3)		(8.0)	(482.4)	(0.3)	(0.3)
T3	0.7	1.0	1.1	0.7	1.6	0.9(0.3)	2.4	14.8	0.7	2.7
	(0.0)	(0.7)	(1.0)	(0.0)	(2.7)		(6.7)	(222.9)	(0.0)	(9.0)
T4	1.1	0.7	1.5	2.8	1.7	1.0(0.7)	3.4	20.3	1.1	0.7
	(1.0)	(0.0)	(2.0)	(8.0)	(4.7)		(11.0)	(503.6)	(0.7)	(0.0)
T5	0.7	1.4	1.5	0.7	0.7	1.2(1.0)	2.1	23.4	1.0	1.8
	(0.0)	(1.7)	(2.3)	(0.0)	(0.0)		(4.7)	(607.7)	(0.7)	(5.0)
T6	1.1	0.9	1.2	1.6	1.3	0.9(0.3)	2.1	18.6	0.9	1.9
	(1.0)	(0.3)	(1.0)	(2.7)	(1.3)		(4.3)	(394.4)	(0.3)	(3.7)
T7	0.9	0.7	0.9	1.2	0.7	1.2(1.0)	1.7	22.5	1.3	0.7
	(0.3)	(0.0)	(0.3)	(1.3)	(0.0)		(3.7)	(518.5)	(2.0)	(0.0)
T8	1.1	1.4	1.4	0.7	1.8	1.4(1.7)	4.3	6.2	1.3	0.9
	(1.0)	(1.7)	(1.7)	(0.0)	(3.0)		(19.7)	(43.5)	(1.3)	(0.3)
T9	0.7	1.4	1.4	1.2	0.9	1.1(0.7)	3.2	9.8	1.3	1.4
	(0.0)	(1.7)	(2.0)	(1.3)	(0.3)		(10.0)	(100.8)	(1.7)	(1.7)
T10	0.7	4.2	2.1	1.4	1.9	1.9(3.3)	2.7	9.2	0.7	1.3
	(0.0)	(17.7)	(4.0)	(2.7)	(4.3)		(7.0)	(125.0)	(0.0)	(1.7)
T11	0.7	8.6	1.0	0.7	0.9	1.1(1.0)	3.2	11.4	0.7	1.1
	(0.0)	(89.0)	(0.7)	(0.0)	(0.3)		(13.7)	(152.8)	(0.0)	(1.0)
SE(m±)	0.3	1.0	0.3	0.4	0.5	0.2	0.6	3.1	0.3	0.5
LSD (P=0.05)	NS	3.0	NS	NS	NS	0.6	1.8	9.2	NS	NS

Values in parentheses are the means of original value

Influence of long-term application of fertilizers on weed floristic diversity in maize – wheat cropping system

Long-term repetitive application of same nutrients year after year brings about conditions conducive for the growth of specific weed flora. That is why fertility treatments gave significant variation in the count of weeds. *Anagallis arvensis*, *Vicia* sp., *Phalaris minor* and *Polygonum* sp., counts were significantly varied due to fertility treatments. *Polygonum plebezium* (89.6%) was most dominant weed during *Rabi* 2017-18 and was followed by *Anagallis arvensis* (3.9%) and *Phalaris minor* (3.3%). *Artimissia* sp., *Avena ludoviciana, Coronopus didymus, Gnaphalium, Vicia* sp., *Poa annua* and *Plantago lanceolata* were the other minor weeds.

During *Kharif* 2018, *Digitaria sanguinalis* (50%) was the most dominant weed followed by *Ageratum* sp., *Eragrostis* sp. and *Cyperus* sp., *Brachiaria, Commelina, Eleusine* sp., and *Paspalum* sp. were the other minor weeds. Fertility treatments resulted in significant variation in the count of *Digitaria sanguinalis, Ageratum* sp., *Cyperus* sp. and *Eragrostis* sp. (**Table 5.2**).

Table 5.2 Effect of treatments on count (No/m^2) of weeds maize: mean of all observations (data transformed to square root transformation

	Doigitaria	*Brachiaria*	*Commelina*	*Eleusine*	*Paspalum*	*Ageratum*	*Cyperus*	*Eragrostis*
T1	6.1	1.3	1.4	2.1	1.4	11.2	4.9	3.1
	(39)	(1.7)	(1.7)	(4.3)	(1.7)	(125)	(24.7)	(9.3)
T2	8.0	2.5	1.9	1.4	1.8	6.9	1.6	3.7
	(67)	(7.7)	(3.3)	(2.3)	(3.3)	(49)	(2.3)	(15.0)
T3	8.4	1.2	1.3	1.6	0.7	5.1	1.5	3.9
	(78)	(1.3)	(1.3)	(2.7)	(0.0)	(29)	(2.0)	(16.7)
T4	10.4	0.7	1.1	1.5	1.7	7.0	1.7	3.1
	(107)	(0.0)	(0.7)	(2.3)	(4.3)	(50)	(2.7)	(9.3)
T5	10.6	0.9	1.4	1.0	1.0	9.7	2.3	3.3
	(116)	(0.3)	(1.7)	(0.7)	(0.7)	(97)	(5.0)	(10.7)
T6	7.2	1.3	1.1	1.1	1.0	6.8	2.1	4.3
	(57)	(1.7)	(0.7)	(1.0)	(0.7)	(48)	(5.0)	(19.0)
T7	12.7	0.7	0.7	1.0	1.0	4.0	2.8	1.2
	(161)	(0.0)	(0.0)	(0.7)	(0.7)	(18)	(8.3)	(1.0)
T8	7.9	2.2	1.8	2.5	1.7	9.2	4.3	2.0
	(63)	(7.0)	(3.3)	(6.0)	(2.7)	(85)	(19.7)	(4.0)
T9	9.1	1.4	1.2	1.3	1.5	6.8	2.5	3.9
	(85)	(2.0)	(1.3)	(1.3)	(3.0)	(48)	(7.3)	(14.7)
T10	9.1	0.7	1.6	1.1	0.9	6.2	3.2	1.3
	(84)	(0.0)	(2.7)	(0.7)	(0.3)	(39)	(9.7)	(2.0)
T11	6.8	2.0	0.7	1.6	0.7	6.0	2.3	2.2
	(51)	(5.3)	(0.0)	(2.7)	(0.0)	(35)	(6.0)	(5.0)
SE(m±)	1.2	0.6	0.4	0.5	0.5	0.9	0.5	0.5
LSD (P=0.05)	3.5	NS	NS	NS	NS	2.6	1.4	1.4

Values in parentheses are the means of original value

It may be conclusively inferred that fertility treatments could significantly influence weed flora shifts owing to conditions altered by them particularly of the soil environment. However, there need to be a comprehensive appraisal of the associated weed flora during the cropping seasons as well to devise means for their control. To minimize fertility depletions there is need of off-season weed management and the management tactics may be differing depending upon the weed flora associated with them.

TNAU, Coimbatore

Airside vegetation management at Lal Bahadur Shastri International Airport, Varanasi

Lal Bahadur Sasthiri International Airport, Varanasi was visited in 2018 to survey prevalent vegetation and propose suitable management options to mitigate bird menace in the airport area. The vast area of land was infested predominantly with grassy weeds and to some extent broad leaved weeds, shrubs and small trees. The following weeds were infesting predominantly in the airport area.

Table 5.3 Major weeds found in the airport area.

S.No.	Common name	Scientific name	Group
A.	**Terrestrial vegetation**		
1.	Black spear grass	*Andropogon contortus*	Grass
2.	Johnson grass	*Sorghum halapens*	Grass
3.	Creeping panic grass	*Brachiaria reptans*	Grass
4.	Bermuda grass	*Cynodon dactylon*	Grass
5.	Quack grass/dog-tooth grass	*Panicum repens*	Grass
6.	Yellow foxtail grass	*Setaria glauca*	Grass
7.	Mauritian grass	*Apluda mutica*	Grass
8.	Spear grass	*Heteropogon contortus*	Grass
9.	Purple chloris	*Chloris barbata*	Grass
10.	Egyptian crowfoot grass	*Dactyloctenium aegyptium*	Grass
11.	Shrub Verbenas	*Lantana camera*	Broad leaved weed/Shrub
12.	Wild ivy guard	*Coccinia indica*	Broad leaved weed
13.	Wild Jute	*Corchorus trilocularis*	Broad leaved weed
14.	Jute mallow	*Corchorus olitorius*	Broad leaved weed
15.	Kapok bush	*Aerva tomentosa*	Broad leaved weed
16.	Indian Mallow	*Abutilon indicum*	Broad leaved weed
17.	Gigantic swallow wort	*Calotropis gigantean*	Broad leaved weed
18.	Milk weed	*Euphorbia geneculata*	Broad leaved weed
19.	Dwarf copper leaf	*Alternanthera sessillis*	Broad leaved weed
20.	Indian Joint Vetch	*Aeschynomene indica*	Broad leaved weed
21.	Coral vine	*Antigonon leptopus*	Broad leaved weed
22.	Tiger foot morning glory	*Iopomoea pes-tigridis*	Broad leaved weed
23.	Coat buttons	*Tridax procumbens*	Broad leaved weed
24.	Field bindweed	*Convolvulus arvensis*	Broad leaved weed
25.	Madras leaf-flower	*Phyllanthus madraspatensis*	Broad leaved weed
26.	Stonebreaker	*Phyllanthus niruri*	Broad leaved weed
27.	Crown flower	*Calotropis gigantea*	Broad leaved weed
28.	Pink node flower	*Caesulia axillaries*	Broad leaved weed
29.	Asthma herb	*Euphorbia hirta*	Broad leaved weed
30.	Castor	*Ricinus communis*	Broad leaved weed
31.	Subabul	*Leucaena leucocephala*	Broad leaved weed
32.	Airy Bachelor Buttons	*Gomphrena decumbens*	Broad leaved weed
33.	Madras Thorn	*Pithecellobium dulce*	Shrub
B.	**Aquatic vegetation**		
1.	Narrow leaf cattail	*Typha angustifolia*	Aquatic grass
2.	Cattail	*Typha latifolia*	Aquatic grass
3.	Common reed	*Phragmites australis*	Broad leaved weed
4.	Water lilly	*Nymphaea sp.*	Broad leaved weed

Habitats attractive to birds/wild life within airports

Vast, open and flat area of an airport is very attractive to the birds and reptiles. Birds are not afraid of aircraft because they do not identify them as predators. They view the airport as a safe place for resting, bathing, gathering in flocks, or hiding from predators. The airport can then become the only open and relatively safe area in the region, where birds can find peace.

Grasses and broad leaved weeds are to be managed by spraying tank mix of glyphosate 15 ml + wetting agent 2 ml per litre of water using tractor mounted sprayer fitted with multi herbicide nozzles followed by mowing with tractor drawn mower. The

spraying have to be repeated as and when the grass and broad leaf weeds are at 6 inches to 1 foot height. As the soil of the airport area is heavily loaded with weed seeds the repetition of spraying may be frequent in the early period and during the monsoon seasons. Subsequently the number of spraying will get reduced (2 to 3 spraying per year). Weed vegetation has to be continuously monitored and managed to prevent resting and movement of all type of wild life's. The grass mower can be employed to cut the dried portions of the weeds after 25-30 days after spraying of above herbicide. The grass mower has to run without leaving any strips of vegetation while in operation. This can be addressed when the mower run in overlap cutting.

AAU, Anand

MOA on management of unwanted vegetation / weeds on road side of runway and surrounding to control bird hit issues at Ahemdabad airport is under progress between airport authority of India and AICRP-weed management, AAU, Anand.

6. PUBLICATIONS

AAU, Anand

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RVSKVV, Gwalior

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Table 6.1 Publications by the coordinating centres

Centres	Research paper	Popular articles	Paper presented seminars/ symposia /conferences	Books	Book Chapter	Lecture delivered during training	Student guided	
							M.Sc.	Ph.D.
PAU, Ludhiana	7	8	10	-	4	6	4	3
UAS, Bengaluru	5	2	5	-	-	-	1	-
RVSKVV, Gwalior	4	2	6	-	4	-	4	1
GBPUAT, Pantnagar	2	3	22	-	3	4	7	3
CSKHPKV, Palampur	12	-	16	3	-	21	3	-
AAU, Jorhat	3	-	10	-	-	9	5	1
AAU, Anand	4	1	5	-	4	21	-	3
TNAU, Coimbatore	19	1	6	3	15	7	1	2
KAU, Thrissur	3	-	2	-	-	-	8	6
OUAT, Bhubaneswar	-	-	2	-	1	-	3	-
PJTSAU, Hyderabad	14	3	11	-	2	12	3	1
CCSHAU, Hisar	10	10	7	-	3	-	2	4
IGKV, Raipur	4	-	2	-	-	5	2	2
PDKV, Akola	4	7	12	-	-	3	4	-
BCKV, Kalyani	3	2	2	-	1	4	5	3
MPUAT, Udaipur	6	8	9	-	6	4	4	2
SKUAST, Jammu	1	-	10	3	-	6	2	-
Total	**101**	**47**	**137**	**9**	**43**	**102**	**58**	**31**

7. AWARDS AND RECOGNITIONS

AAU, Anand

- Dr. B. D. Patel was awarded with prestigious Indian Society of Weed Science Fellow Award for the year 2017. (ISWS Fellow-2017) for his significant contributions in weed science.

PJTSAU, Hyderabad

- AICRP-WM, PJTSAV, Centre Hydrabad received ICAR – Best Centre Award-2017-2018 during Annual Review Meeting of AICRP on Weed Management held at GB Pant University of Agriculture and Technology, Pantnagar during 7^{th}-8^{th} June, 2018
- Dr.T. Ramprakash Awarded with PG Krishna Memorial Gold Medal on the occasion of 4^{th} University Foundation day celebrations for 2018

RVSKKV, Gwalior

- Appreciation award has received by Dr. Deep Sing Sasode, and Dr. Varsha Gupta for best research and teaching on the occasion of teacher's day by *"Jan Utthan Nyaas Society Gwalior"* on 5^{th} September, 2018.

8. RECOMMENDATIONS OF XXV ANNUAL REVIEW MEETING

Recommendations of XXV Annual Review Meeting of All India Coordinated Research Project on Weed Management held at Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) during 7-8 June 2018 are given below:

- It was suggested to take good quality field/lab photographs and mention date and time.
- All data provided in report/presentation should be statistically presented and verified properly.
- Follow prescribed guidelines while preparing annual report and presentation.
- Compile data on dominant cropping systems of all centers under CA experiment as 3-4 years/cycles completed.
- Pay intensive effort on organic weed management to all the centers of the project.
- Bring out quality publications.
- Develop Mobile App in regional languages
- Timely supply required data/information.
- Gwalior, Bhubaneswar, Bengaluru, Palampur, Hisar and Jorhat centres were advised to improve publication record.
- Pantnagar, Palampur, Ludhiana, Jammu, Gwalior and Coimbatore centres were instructed to submit RFD report in time to the PC Unit.
- Annual reports of Gwalior, Bhubaneswar, Bengaluru and Hyderabad were not prepared as per prescribed guidelines.
- Changes in weed seed bank dynamics in long-term experiments should be observed and reported by Gwalior centre
- All centres were instructed to select best treatment for FLDs in various crops.
- At Anand, high dose of vermicompost is included in the experiment than recommended, check it for suitability.

9. NEW INITIATIVES

- Research themes were reorganized and technical program was made in tune with the research programmes of the Directorate based on the emerging challenges in weed management.
- Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency and herbicide use in cropping systems were reorganized.
- All AICRP-WM centres were visited by the monitoring team to monitor research and extension activities.
- Collaboration with other AICRPs at the university like integrated framing systems, dryland agriculture, organic farming, pesticide residues, and others dealing with crops like rice, wheat, maize, soybean, sugarcane, pulses etc. was strengthened.
- Initiatives were taken to provide additional manpower in the form of skilled staff.
- Review of AICRP-WM centres by QRT team was undertaken.
- Evaluation of the centers based on score card and 'Best Centre Award' were continued. Additional grants and incentives were given to the better performing centre and winner of the Best Centre Award.
- Greater emphasis was given on publication of the research data generated over the years and bringing out quality publications in reputed journals.
- Salient achievements and happenings of the Directorate were presented and shared with the scientists of AICRP-Weed Management during the Annual Review Meeting. It was desired that all scientists of the project should attend the meeting every year.
- An initiative to maintain '*Parthenium*-free campus' was taken with the involvement of students and other staff of the University.

10. STATUS OF EXPERMENTS

Sl. No.	Centres	WP 1 Development of sustainable weed management practices in diversified cropping systems	WP 2 Weed dynamics and management under the regime of climate change and herbicide resistance	WP 3 Biology and management of problem weeds in cropped and non cropped areas	WP 4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment	WP 5 On-farm research and demonstration of weed management technologies, their adoption and impact assessment
1.	PAU, Ludhiana	WP 1.1.1.5, WP1.2.7, WP1.5.9*	WP2.1*, WP2.2, WP 2.3.2(i)*, WP 2.3.2(ii),	WP3.1.1(e) WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4 WP4.5	WP5.1, WP5.2
2.	UAS, Bengaluru	WP 1.1.2.4 WP1.2.14 WP1.5.8.1(i), WP 1.5.8(ii)	WP2.1 WP2.2*	WP3.1.1(b), WP3.1.1(e),	-	WP5.1
3.	RVSKKV, Gwalior	WP 1.1.3.1, WP1.2.3,	WP2.1, WP2.2	WP3.1.1(b)*, WP3.1.1(e), WP3.4.1	-	WP5.1 WP5.2
4.	GBPUAT, Pantnagar	WP 1.1.1.6, WP1.2.9, WP1.3.7.1* WP1.5.6(i) WP1.5.6(ii)	WP2.1*, WP2.2	WP3.1.1(c), WP3.1.1(e),	-	WP5.1 WP5.2
5.	CSKHPKV, Palampur	WP 1.1.2.2, WP1.2.8, WP1.3.8.1 WP1.5.11	WP2.1 WP2.2	WP3.1.1(e),	WP4.1, WP4.2, WP4.3 WP4.5	WP5.1 WP5.2
6.	AAU, Jorhat	WP 1.1.1.8, WP1.2.6, WP1.3.1.2, WP1.5.7(i)*, WP1.5.7(ii)*, WP1.5.7(iii)	WP2.1, WP2.2, WP 2.3.3.	WP3.1.1(e),	-	WP5.1, WP5.2*
7.	AAU, Anand	WP 1.1.5.1, WP1.2.1, WP1.5.2*	WP2.1, WP2.2	WP3.1.1(a)*, WP3.1.1(b)*, WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2
8.	TNAU, Coimbatore	WP 1.1.2.1, WP1.3.1.1	WP2.1*, WP2.2*	WP3.1.1(e) WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4 WP4.5	WP5.1, WP5.2
9.	KAU, Thrissur	WP1.2.13 WP1.3.1.3	WP2.1*, WP2.2*	WP3.1.1(d), WP3.1.1(e)	-	WP5.1, WP5.2
10.	OUAT, Bhubaneshw ar	WP 1.1.1.1, WP1.2.2(i), WP1.2.2(ii)	WP2.1, WP2.2	WP3.1.1(a) WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2

Table Contd...

11.	PJTSAU, Hyderabad	WP 1.1.1.3, WP1.2.4	WP2.1, WP2.2 WP2.3.4	WP3.1.1(a), WP3.1.1(e), WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4* WP4.5	WP5.1, WP5.2
12.	CCSHAU, Hisar	WP 1.1.1.2, WP1.3.4.1 WP1.3.71	WP2.1, WP2.2, WP2.3.1(i), WP2.3.1(ii),	WP3.1.1(a), WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2
13.	IGKVV, Raipur	WP1.1.1.9 WP1.2.11(i) WP1.2.11(ii) WP1.5.10	WP2.1, WP2.2, WP2.3.4	WP3.1.1(b)* WP3.1.1(c) WP3.1.1(e), WP3.4.1	-	WP5.1, WP5.2
14.	SKUAST, Jammu	WP 1.1.1.4, WP1.2.5, WP1.5.4(i), WP1.5.4(ii) WP1.5.4(iii) WP1.5.4(iv)	WP2.1, WP2.2	WP3.1.1(b), WP3.1.1(e), WP3.4.1,	-	WP5.1 WP5.2
15.	MPUAT, Udaipur	WP1.1.2.3, WP1.2.10, WP1.3.2.1, WP1.5.3(i)*, WP1.5.3(ii)*	WP2.1, WP2.2	WP3.1.1(a), WP3.1.1(e), WP3.4.1	-	WP5.1, WP5.2
16.	PDKV, Akola	WP1.1.4.1, WP1.3.2.1, WP1.3.3.1, WP 1.3.6.1, WP 1.5.1	WP2.1, WP2.2	WP3.1.1(e) WP3.4.1*	-	WP5.1, WP5.2
17.	BCKV, Kalyani	WP 1.1.1.7, WP1.2.12(i), WP1.2.12(ii), WP1.3.2.1, WP1.3.7.1, WP1.3.7.1(i), WP1.5.5	WP2.1*, WP2.2*	WP3.1.1(e), WP3.4.1	-	WP5.1

* Not reported

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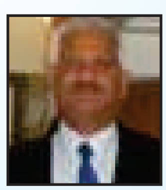

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12. STATUS OF SUBMISSION OF ANNUAL REPORT -2018-19

Sl No.	Centre's name	Received	
		Before due date (15.01.2019)	After due date
Regular centres			
1.	PAU, Ludhiana	15.1.2019	-
2.	UAS, Bengaluru	10.1.2019	-
3.	RVS KVV, Gwalior	10.1.2019	-
4.	GBPUAT, Pantnagar	15.1.2019	-
5.	CSKHPKVV, Palampur	15.1.2019	-
6.	AAU, Jorhat	15.1.2019	-
7.	AAU, Anand	10.1.2019	-
8.	TNAU, Coimbatore	12.1.2019	-
9.	KAU, Thrissur	13.1.2019	-
10.	OUAT, Bhubaneswar	15.1.2019	-
11.	PJTSAU, Hyderabad	-	18.1.2019
12.	CCSHAU, Hisar	8.1.2019	-
13.	IGKVV, Raipur	-	4.2.2019
14.	SKUAST-Jammu	-	16.1.2019
15.	PDKV, Akola	14.1.2019	-
16.	MPUAT, Udaipur	-	24.1.2019
17.	BCKV, Kalyani	15.1.2019	-
Volunteer centres			
1.	SVBPUAT, Meerut	-	-
2.	SKUAST-Kashmir	-	-
3.	PJNCA&RI, Karaikal	-	21.1.2019
4.	BAU, Sabour	13.1.2019	-
5.	ICAR-CIAS, Port Blair	-	-
6.	UAS, Dharwad	15.1.2019	-

ACRONYMS

B:C	Benefit cost ratio
BCR	Benefit cost ratio
BD	Bulk density
BDL	Below detectable limit
BLW	Broad leaf weeds
CT	Conventional tillage
CT-DSR	Conventional tilled direct seeded rice
CT-TPR	Conventional tillage after transplanted rice
DAD	Days after disappearance
DAP	Days after planting
DAS	Days after sowing/spraying
DAT	Days after transplanting
DB	Development blocks
DHA	De-hydrogenese activity
DSR	Direct-seeded rice
DSR+R	Direct seeded rice+Residue
EPoE	Early post emergence
FYM	Farm yard manure
GA	Gibberellic acid
HHW	Hand hoeing weeding
HW	Hand weeding
IC	Inter cultivation/culture
IM	Indian mustard
IWM	Integrated weed management
K	Potassium
LPoE	Late post emergence
MBC	Microbial biomass carbon
MRL	Maximum residue limit
MT	Minimum tillage
MW	Mechanical weeding
N	Nitrogen
Na	Sodium
P	Phosphorus

PE	Pre-emergence
PM	Poultry manure
PSB	Phosphorus solubilizing bacteria
PTR	Puddled transplanted rice
RD	Recommended dose
RM	Ready mix
SMBC	Soil microbial biomass carbon
SSB	Sulfer solubilizing bacteria
SVI	Seedling vigour index
TM	Tank mixed
TPR	Transplanted rice
TPR	Transplanted residue
TPR	Transplanted puddled rice
VSD	Variable speed drive
ZT	Zero tillage
ZT+R	Zero tillage + Residue

8. RECOMMENDATIONS OF XXV ANNUAL REVIEW MEETING

Recommendations of XXV Annual Review Meeting of All India Coordinated Research Project on Weed Management held at Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) during 7-8 June 2018 are given below:

- It was suggested to take good quality field/lab photographs and mention date and time.
- All data provided in report/presentation should be statistically presented and verified properly.
- Follow prescribed guidelines while preparing annual report and presentation.
- Compile data on dominant cropping systems of all centers under CA experiment as 3-4 years/cycles completed.
- Pay intensive effort on organic weed management to all the centers of the project.
- Bring out quality publications.
- Develop Mobile App in regional languages
- Timely supply required data/information.
- Gwalior, Bhubaneswar, Bengaluru, Palampur, Hisar and Jorhat centres were advised to improve publication record.
- Pantnagar, Palampur, Ludhiana, Jammu, Gwalior and Coimbatore centres were instructed to submit RFD report in time to the PC Unit.
- Annual reports of Gwalior, Bhubaneswar, Bengaluru and Hyderabad were not prepared as per prescribed guidelines.
- Changes in weed seed bank dynamics in long-term experiments should be observed and reported by Gwalior centre
- All centres were instructed to select best treatment for FLDs in various crops.
- At Anand, high dose of vermicompost is included in the experiment than recommended, check it for suitability.

9. NEW INITIATIVES

- Research themes were reorganized and technical program was made in tune with the research programmes of the Directorate based on the emerging challenges in weed management.
- Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency and herbicide use in cropping systems were reorganized.
- All AICRP-WM centres were visited by the monitoring team to monitor research and extension activities.
- Collaboration with other AICRPs at the university like integrated framing systems, dryland agriculture, organic farming, pesticide residues, and others dealing with crops like rice, wheat, maize, soybean, sugarcane, pulses etc. was strengthened.
- Initiatives were taken to provide additional manpower in the form of skilled staff.
- Review of AICRP-WM centres by QRT team was undertaken.
- Evaluation of the centers based on score card and 'Best Centre Award' were continued. Additional grants and incentives were given to the better performing centre and winner of the Best Centre Award.
- Greater emphasis was given on publication of the research data generated over the years and bringing out quality publications in reputed journals.
- Salient achievements and happenings of the Directorate were presented and shared with the scientists of AICRP-Weed Management during the Annual Review Meeting. It was desired that all scientists of the project should attend the meeting every year.
- An initiative to maintain '*Parthenium*-free campus' was taken with the involvement of students and other staff of the University.

10. STATUS OF EXPERMENTS

Sl. No.	Centres	WP 1 Development of sustainable weed management practices in diversified cropping systems	WP 2 Weed dynamics and management under the regime of climate change and herbicide resistance	WP 3 Biology and management of problem weeds in cropped and non cropped areas	WP 4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment	WP 5 On-farm research and demonstration of weed management technologies, their adoption and impact assessment
1.	PAU, Ludhiana	WP 1.1.1.5, WP1.2.7, WP1.5.9*	WP2.1*, WP2.2, WP 2.3.2(i)*, WP 2.3.2(ii),	WP3.1.1(e) WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4 WP4.5	WP5.1, WP5.2
2.	UAS, Bengaluru	WP 1.1.2.4 WP1.2.14 WP1.5.8.1(i), WP 1.5.8(ii)	WP2.1 WP2.2*	WP3.1.1(b), WP3.1.1(e),	-	WP5.1
3.	RVSKKV, Gwalior	WP 1.1.3.1, WP1.2.3,	WP2.1, WP2.2	WP3.1.1(b)*, WP3.1.1(e), WP3.4.1	-	WP5.1 WP5.2
4.	GBPUAT, Pantnagar	WP 1.1.1.6, WP1.2.9, WP1.3.7.1* WP1.5.6(i) WP1.5.6(ii)	WP2.1*, WP2.2	WP3.1.1(c), WP3.1.1(e),	-	WP5.1 WP5.2
5.	CSKHPKV, Palampur	WP 1.1.2.2, WP1.2.8, WP1.3.8.1 WP1.5.11	WP2.1 WP2.2	WP3.1.1(e),	WP4.1, WP4.2, WP4.3 WP4.5	WP5.1 WP5.2
6.	AAU, Jorhat	WP 1.1.1.8, WP1.2.6, WP1.3.1.2, WP1.5.7(i)*, WP1.5.7(ii)*, WP1.5.7(iii)	WP2.1, WP2.2, WP 2.3.3.	WP3.1.1(e),	-	WP5.1, WP5.2*
7.	AAU, Anand	WP 1.1.5.1, WP1.2.1, WP1.5.2*	WP2.1, WP2.2	WP3.1.1(a)*, WP3.1.1(b)*, WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2
8.	TNAU, Coimbatore	WP 1.1.2.1, WP1.3.1.1	WP2.1*, WP2.2*	WP3.1.1(e) WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4 WP4.5	WP5.1, WP5.2
9.	KAU, Thrissur	WP1.2.13 WP1.3.1.3	WP2.1*, WP2.2*	WP3.1.1(d), WP3.1.1(e)	-	WP5.1, WP5.2
10.	OUAT, Bhubaneshw ar	WP 1.1.1.1, WP1.2.2(i), WP1.2.2(ii)	WP2.1, WP2.2	WP3.1.1(a) WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2

Table Contd...

11.	PJTSAU, Hyderabad	WP 1.1.1.3, WP1.2.4	WP2.1, WP2.2 WP2.3.4	WP3.1.1(a), WP3.1.1(e), WP3.4.1	WP4.1, WP4.2, WP4.3 WP4.4* WP4.5	WP5.1, WP5.2
12.	CCSHAU, Hisar	WP 1.1.1.2, WP1.3.4.1 WP1.3.71	WP2.1, WP2.2, WP2.3.1(i), WP2.3.1(ii),	WP3.1.1(a), WP3.1.1(e), WP3.4.1*	-	WP5.1, WP5.2
13.	IGKVV, Raipur	WP1.1.1.9 WP1.2.11(i) WP1.2.11(ii) WP1.5.10	WP2.1, WP2.2, WP2.3.4	WP3.1.1(b)* WP3.1.1(c) WP3.1.1(e), WP3.4.1	-	WP5.1, WP5.2
14.	SKUAST, Jammu	WP 1.1.1.4, WP1.2.5, WP1.5.4(i), WP1.5.4(ii) WP1.5.4(iii) WP1.5.4(iv)	WP2.1, WP2.2	WP3.1.1(b), WP3.1.1(e), WP3.4.1,	-	WP5.1 WP5.2
15.	MPUAT, Udaipur	WP1.1.2.3, WP1.2.10, WP1.3.2.1, WP1.5.3(i)*, WP1.5.3(ii)*	WP2.1, WP2.2	WP3.1.1(a), WP3.1.1(e), WP3.4.1	-	WP5.1, WP5.2
16.	PDKV, Akola	WP1.1.4.1, WP1.3.2.1, WP1.3.3.1, WP 1.3.6.1, WP 1.5.1	WP2.1, WP2.2	WP3.1.1(e) WP3.4.1*	-	WP5.1, WP5.2
17.	BCKV, Kalyani	WP 1.1.1.7, WP1.2.12(i), WP1.2.12(ii), WP1.3.2.1, WP1.3.7.1, WP1.3.7.1(i), WP1.5.5	WP2.1*, WP2.2*	WP3.1.1(e), WP3.4.1	-	WP5.1

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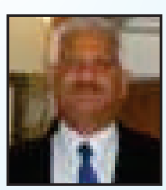

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12. STATUS OF SUBMISSION OF ANNUAL REPORT -2018-19

Sl No.	Centre's name	Received	
		Before due date (15.01.2019)	After due date
Regular centres			
1.	PAU, Ludhiana	15.1.2019	-
2.	UAS, Bengaluru	10.1.2019	-
3.	RVS KVV, Gwalior	10.1.2019	-
4.	GBPUAT, Pantnagar	15.1.2019	-
5.	CSKHPKVV, Palampur	15.1.2019	-
6.	AAU, Jorhat	15.1.2019	-
7.	AAU, Anand	10.1.2019	-
8.	TNAU, Coimbatore	12.1.2019	-
9.	KAU, Thrissur	13.1.2019	-
10.	OUAT, Bhubaneswar	15.1.2019	-
11.	PJTSAU, Hyderabad	-	18.1.2019
12.	CCSHAU, Hisar	8.1.2019	-
13.	IGKVV, Raipur	-	4.2.2019
14.	SKUAST-Jammu	-	16.1.2019
15.	PDKV, Akola	14.1.2019	-
16.	MPUAT, Udaipur	-	24.1.2019
17.	BCKV, Kalyani	15.1.2019	-
Volunteer centres			
1.	SVBPUAT, Meerut	-	-
2.	SKUAST-Kashmir	-	-
3.	PJNCA&RI, Karaikal	-	21.1.2019
4.	BAU, Sabour	13.1.2019	-
5.	ICAR-CIAS, Port Blair	-	-
6.	UAS, Dharwad	15.1.2019	-

ACRONYMS

B:C	Benefit cost ratio
BCR	Benefit cost ratio
BD	Bulk density
BDL	Below detectable limit
BLW	Broad leaf weeds
CT	Conventional tillage
CT-DSR	Conventional tilled direct seeded rice
CT-TPR	Conventional tillage after transplanted rice
DAD	Days after disappearance
DAP	Days after planting
DAS	Days after sowing/spraying
DAT	Days after transplanting
DB	Development blocks
DHA	De-hydrogenese activity
DSR	Direct-seeded rice
DSR+R	Direct seeded rice+Residue
EPoE	Early post emergence
FYM	Farm yard manure
GA	Gibberellic acid
HHW	Hand hoeing weeding
HW	Hand weeding
IC	Inter cultivation/culture
IM	Indian mustard
IWM	Integrated weed management
K	Potassium
LPoE	Late post emergence
MBC	Microbial biomass carbon
MRL	Maximum residue limit
MT	Minimum tillage
MW	Mechanical weeding
N	Nitrogen
Na	Sodium
P	Phosphorus

PE	Pre-emergence
PM	Poultry manure
PSB	Phosphorus solubilizing bacteria
PTR	Puddled transplanted rice
RD	Recommended dose
RM	Ready mix
SMBC	Soil microbial biomass carbon
SSB	Sulfer solubilizing bacteria
SVI	Seedling vigour index
TM	Tank mixed
TPR	Transplanted rice
TPR	Transplanted residue
TPR	Transplanted puddled rice
VSD	Variable speed drive
ZT	Zero tillage
ZT+R	Zero tillage + Residue


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June 7-8, 2018
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INDIA COORDINATED RESEARCH PROJECT ON WEED MANAGEMENT
June 7-8, 2018
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All India Coordinated Research Project on Weed Management
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कांग्रेस घास भगायें
पर्यावरण बचायें
गाजर घास (पर्थेनियम हिस्टेरोफोरस)
जागरुकता एवं
प्रबंधन सप्ताह
Professor Jayashankar Telangana State Agricultural University
AICRP on Weed Management
Parthenium Awareness Week
16-22 August, 2018


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MPUAT, Udaipur
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