अखिल भारतीय समन्वित खरपतवार प्रबंधन अनुसंधान परियोजना

All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन
ANNUAL REPORT 2019-20

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ICAR - Directorate of Weed Research, Jabalpur

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स्वास्थ्य के लिए गाजर घास खतरनाक

कृषि विश्वविद्यालय में मना गाजर घास जागरूकता सप्ताह

नवभारत रिपोर्टर। रायपुर.

जहां तहां उगने वाले गाजर घास से दमा एलर्जी एवं चर्म रोग की शिकायतें बढ़ जाती है यह स्वास्थ्य के लिए खतरनाक है. यह जानकारी इंदिरा गांधी कृषि विश्वविद्यालय में गत दिवस गाजर घास जागरूकता सप्ताह के दौरान दी गई. इस दौरान विश्वविद्यालय के अधीन विभिन्न कृषि महाविद्यालयों और कृषि विज्ञान केन्द्रों और शालाओं में कार्यक्रम आयोजित कर महाविद्यालयीन विद्यार्थियों, किसानों एवं शालेय छात्रों को खतरनाक खरपतवार गाजर घास के दुष्प्रभावों और उससे मानव स्वास्थ्य को होने वाले नुकसान से अवगत कराया गया तथा बचाव के उपाय बताये गए. विद्यार्थियों को गाजर घास के पौधे की पहचान कराई गई तथा यांत्रिक, रासायनिक एवं जैविक तरीकों से उसके उन्मूलन की जानकारी भी दी गई.

इंदिरा गांधी कृषि विश्वविद्यालय रायपुर में संचालित अखिल भारतीय समन्वित अनुसंधान परियोजना खरपतवार प्रबंधन के तत्वावधान में आयोजित गाजर घास उन्मूलन सप्ताह का प्रारंभ इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर के अनुसंधान सह अनुदेशक प्रक्षेत्र से किया गया. इसमें एन.सी.सी. एवं एन.एस.एस. के विद्यार्थियों की उल्लेखनीय सहभागिता रही. कृषि महाविद्यालय, रायपुर में अध्ययनरत विद्यार्थियों को गाजर घास से मनुष्यों, पशुओं एवं पर्यावरण को होने वाले नुकसान के बारे में विस्तार से जानकारी दी गई.

कार्यशाला में किसानों ने सीखा पराली प्रबंधन

संस, पंतनगर : गोविंद वल्लभ पंत कृषि विश्वविद्यालय में प्रौद्योगिक महाविद्यालय के फार्म मशीनरी एवं पावर इंजीनियरिंग विभाग एवं फसल अनुसंधान केंद्र के तत्वाधान में आयोजित कार्यशाला में किसानों को खेतों में पड़े पराली के प्रबंधन के बारे में विस्तार से बताया गया। साथ ही सुपर सीडर द्वारा गेहूं की बुवाई की विधि बताई गई।

पंत विवि में आयोजित कार्यशाला में बुधवार को कृषि वैज्ञानिकों ने कहा कि धान की कटाई के बाद पराली बच जाती है तो इसे सुपर सीडर मशीन से मिट्टी में मिलाते हुए गेहूं की बुवाई की जा सकती है। इससे पराली से ग्रीन खाद बनेगी और मृदा की उर्वरा शक्ति भी बढ़ेगी। इस विधि से उत्पादन लागत कम होगा और उत्पाद में बढ़ोतरी होगी। कार्यशाला में काशीपुर, सितारगंज, किच्छा एवं रुद्रपुर के 50 किसानों ने हिस्सा लिया। किसानों को प्रैक्टिकल तौर पर खड़ी पराली के खेत में गेहूं की बुवाई करते हुए सुपर सीडर मशीन के बारे में बताया गया। डाक्टर टीपी सिंह व डा. जयंत सिंह ने कहा कि सुपर सीडर मशीन में रोटावेटर, रोलर व फर्टिसीडड्रिल साथ में लगे होते हैं। ट्रैक्टर के साथ 12 से 18 इंच खड़ी पराली के खेत में जुताई करने के साथ रोटावेटर पराली को मिट्टी में दबाने, रोलर समतल करने व फर्टिसीडड्रिल खाद के साथ बीज की बुवाई करने का काम करता है। दो से तीन इंच गहरे में बुवाई होती है। डा.वीपी सिंह, डा सुभाष चंद्रा ने बताया कि पराली जलाने से मृदा की ऊपरी सतह जलने से जीवाश्म, जिंक, कार्बन आदि सूक्ष्म तत्व जल जाते हैं।

दैनिक भास्कर 18-Aug-2018 डबरा Page 2

शिविर — ग्राम निकोड़ी में आयोजित जागरूकता शिविर में किसानों ने गाजर घास के बचाव के लिए बताए उपाय

फसल के साथ जानवरों के लिए भी नुकसानदायक:डॉ. दीप

भास्कर संवाददाता | भितरवार

खेतों के आस-पास उगी गाजर घास न केवल इंसानों को नुकसान पहुंचाती है, बल्कि दूसरी फसलों को भी। यह खरपतवारों में सबसे विनाशकारी खरपतवार है क्योंकि यह कई तरह की समस्याएं पैदा करता है। इसकी वजह से फसलों की पैदावार 30-40 प्रतिशत कम हो जाती है इसलिए इसका नियंत्रण बहुत जरूरी है। यह पशुओं के साथ ही इंसानों के लिए भी घातक है.इस खरपतवार के संपर्क में आने से एग्जिमा, एलर्जी, बुखार, दमा व नजला जैसी घातक बीमारियां हो जाती हैं। यह बात कृषि वैज्ञानिक डॉ.दीप सिंह रावत ने कही।

भारतीय कृषि अनुसंधान परिषद के अंतर्गत ग्राम निकोड़ी में शुक्रवार को गाजरघास उन्मूलन शिविर आयोजित किया गया। इस शिविर में डॉ. दीप सिंह ने किसानों को गाजर घास के बारे में जानकारी देकर उससे बचाव के उपाय बताए साथ ही इस खरपतवार से होने वाली हानियां भी बताई। उन्होंने कहा कि गाजर घास खरपतवार में सेस्क्यूटरपिन लेक्टोन नामक विषाक्त पदार्थ पाया जाता है, जो फसलों की अंकुरण क्षमता और विकास पर विपरीत असर डालता है। इसके परागकण, पर-परागित फसलों के मादा जनन अंगों में एकत्रित हो जाते हैं जिससे उनकी संवेदनशीलता खत्म हो जाती है और बीज नहीं बन पाते हैं।

यह दलहनी फसलों में नाइट्रोजन स्थिरीकरण करने वाले जीवाणुओं की क्रियाशीलता को भी कम करता है। इसे खाने से पशुओं में कई रोग हो जाते हैं। अगर गाय या भैंस इसे खा लेती हैं तो उनके थनों में सूजन आ जाती है और वे मर भी सकती हैं।

ऐसे बचें गाजर घास से: कृषि वैज्ञानिक डॉ. वर्षा गुप्ता ने गाजर घास बचाव की जानकारी देते हुए कहा कि इस खरपतवार को फूल आने से पहले उखाड़ कर जला देना चाहिए ताकि इसके बीज न बन पाएं और न फैल पाएं। खरपतवार को उखाड़ते समय दस्तानों और सुरक्षात्मक कपड़े पहनने चाहिए। गाजर घास के ऊपर 20 प्रतिशत साधारण नमक का घोल बनाकर छिड़काव करें। हर्बीसाइड जैसे 000000 रसायनों में ग्लाइफोसेट, 2, 4-डी, मेट्रीब्यूजिन, एट्राजीन, सिमेजिन, एलाक्लोर और डाइयूरान आदि प्रमुख हैं।

'ଗାଜର ଘାସ ନିର୍ମୂଳ କର'

வேளாண்மை பல்கலை.யில் பார்த்தீனியம் விழிப்புணர்வு வாரம்

వయ్యారిభామతో పంటలకు తీవ్ర నష్టం

Kisanganj 22 Aug 2019 — www.jagran.com

इंसान व पशुओं के स्वास्थ्य पर बुरा असर डालती है गाजर घास

'ಮೂಲದಲ್ಲಿಯೇ ಪಾರ್ಥೇನಿಯಂ ನಿಯಂತ್ರಿಸಿ'

गांव-गांव जाकर बताई गाजर घास से हानियां

SKUAST Jammu imparts awareness on Parthenium management

STATE TIMES NEWS

R S PURA: Krishi Vigyan Kendra (KVK), R. S. Pura and AICRP Weed Management, Division of Agronomy, SKUAST-Jammu initiated awareness campaign against parthenium weed on 16th of August, 2019 at Government Middle School Khepar, Miran Sahib, R.S. Pura, on the directions of Vice Chancellor SKUAST-J Dr. K.S Risam, which is being organised simultaneously on national level from 16-22 August, 2019.

Dr. Rakesh Sharma, Senior Scientist and Incharge Head KVK Jammu started with introduction about aggressive and poisonous nature of Parthenium weed which have posed a serious threat to crops, human health and livestock health and biodiversity. Dr. B. R. Bazaya, PI and Incharge AICRP Weed Management, delivered a talk to students and highlighted various harmful effects of Parthenium.

Dr. Punit Choudhary Senior Scientist (Agroforestry) explained about cultural practices to mange parthenium weed. Dr. Prem Kumar Scientist KVK Jammu explained that parthenium infestation is serious issues in the surrounding area of the village and proper management is needed. A student rally was also organised in the village carrying cards displaying slogan regarding awareness and control of parthenium. During this awareness programme, more than 70 participants including school teachers Chander Prabha, Sunil Singh, Sanjay Kumar, Pawan Kumar, Gaganjot Kour, students and university staff Supneet Kour, Ashiana Javed, took part in programme. The campaign ended with vote of thanks by Poonam Abrol, Programme Assistant (Trainings) KVK, SKUAST Jammu.

PAU Experts Push For Direct-Seeded Rice

Times News Network

Chandigarh: As a part of its ongoing efforts to promote direct seeded rice (DSR) for the forthcoming kharif (summer) season, experts of the Punjab Agricultural University (PAU) at Ludhiana have issued a set of recommendations for farmers. Here is what they have to say:

SUITABLE SOILS

DSR is suitable for medium and heavy textured soils only. Do not go for direct seeding in light textured soils

FIELD PREPARATION

Level the field with laser land leveler and do 'rauni' (pre-sowing irrigation). When it comes to 'tar-wattar' (good soil moisture) condition with two cultivations (with cultivator) followed by two planking, sow immediately

SUITABLE VARIETIES AND SOWING TIME

Short and medium duration varieties are most suitable. First fortnight of June is optimum for direct sowing of parmal rice varieties, like PR 126, PR 114, PR 121, PR 120, PR 127 and, second fortnight of June is optimum for basmati rice varieties, like Pusa Basmati 1121, Pusa Basmati 1509 and Pusa Basmati 1718

SOWING METHOD

Prefer 'Lucky Seed Drill', which does sowing and spray of herbicide simultaneously, or use inclined plate rice seed drill and spray herbicide immediately after sowing. If these machines are not available, modify zero till drill or happy seeder by partially closing the pistols of fertiliser box or by replacing the gear of fertiliser box having double or more number of teeth and set the lever in a position that 16-20 seed falls in one meter row.

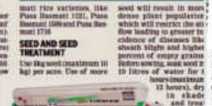
IRRIGATION

Apply first irrigation at 21 days after sowing

For more details, farmers may contact Makhan Singh Bhullar (98728 11360) and Janvir Singh Gill (79861 88120) of the PAU agronomy department

SEED AND SEED TREATMENT

Use 8kg seed (maximum 10 kg) per acre. Use of more seed will result in more dense plant population which will restrict the air flow leading to greater incidence of diseases like sheath blight and higher percent of empty grains. Before sowing, soak seed in 10 litres of water for 8 hours (maximum 12 hours), dry in shade and treat with fungicide



डॉ. चौधरी ने पेश किया अनुसंधान

उदयपुर. मलेशिया में एशियन पेसिफिक वीड सांइस सोसायटी की 27वीं अंतरराष्ट्रीय संगोष्ठी में एमपीयूएटी की सहायक आचार्य डॉ. रोशन चौधरी ने जैविक स्वीट कॉर्न में तीन दिवसीय जैविक खरपतवार प्रबंधन की तकनीकी व अनुसंधान पेश किए। सोसायटी की ओर से उन्हें सम्मानित किया गया।

AAU to help airport tackle bird menace

Malvya.ReggieThomas @timesgroup.com

Surat: Surat airport authorities have approached Anand Agricultural University (AAU) for expert guidance on battling bird menace.

Airports Authority of India (AAI) officials said AAU experts will provide them with guidance in controlling wild grass and insect problem in the airport premises to help reduce bird-hit incidents.

According to data from the airport, there have been four bird-hit incidents from January-July 2019. The bird-hit did not damage aircraft or forced the pilot to ground the flight.

Problem of wild vegetation and elephant grass is serious as they bring in various kinds of insects that attract birds to the airport

Surat's international airport spread over in 312 hectares at Magdalla is second largest in Gujarat after Ahmedabad.

Official sources said given the huge area of the airport, problem of wild vegetation and elephant grass is serious as they bring in various kinds of insects. The insects attract the winged visitors at the airport.

Airport director Sanjay Kumar Panigrahi told TOI, "We have been facing the problem of grassland insects. The birds get attracted to the insects in the wild vegetation. We have sought expert guidance of AAU experts."

At present, airport authorities use zone guns to create a loud shot-like sound to scare away the birds in the airport premises. A total of two guns have been installed on the side of the runway.

Panigrahi said, "The bird-hit incidents are under control due to these guns. But, we want to completely stop the bird-hit incidents at the airport by keeping the area clean of grass and insects."

એરપોર્ટ વિસ્તારના ઘાસને નિયંત્રણમાં રાખવા નિર્દેશ કરાયા છે : ડો. બી.ડી.પટેલ

આણંદ કૃષિ યુનિ.ની સંશોધક ટીમ દ્વારા એરપોર્ટ વિસ્તારમાં ઊગી નીકળતા ઘાસ, નિંદણના નિયંત્રણ માટે ઓથોરીટીને સરળ રીત દર્શાવી છે. જેમાં ઘાસ કાપવું, દવા છંટકાવ, ઉપરના ભાગેથી કપાયેલ ઘાસને એકતરફે એકત્ર કરવા સહિતનું જણાવાયાનું વિભાગ હેડ ડો.બી.ડી.પટેલે જણાવ્યું હતું. વધુમાં તેઓએ કહ્યું હતું કે, એરપોર્ટ વિસ્તાર એકદમ ખુલ્લો, ઘાસ રહિત કરી દેવાય તો જીવાતો નીકળવાની સંભાવના છે. જીવાતોનો શિકાર કરવા પક્ષીઓની એરપોર્ટ વિસ્તારમાં વધુ અવરજવર પણ થઇ શકે છે. આથી ઘાસના બીજનું ઉત્પાદન ન થાય તે માટેની અસરકારક રીત અખત્યાર કરવાનો નિર્દેશ પણ કરાયો છે.

Noxious Parthenium and its Management

Dr. Kaberi Mahanta
Scientist, Assam Agricultural University, Jorhat

कृषि विशेषज्ञ की सलाह

डॉ. वीरेंद्र प्रताप सिंह

जीरो टिलेज मशीन के प्रयोग से बढ़ेगी किसानों की आय

धान के खेतों में गेहूं की बुवाई देर से हो पाती है, जिससे उपज कम होती है। साथ ही इस खेत को तैयार करने के लिए किसान को 6 से 8 जुताई भी करनी पड़ती है। इससे विलंब और खर्च में भी बढ़ोतरी हो जाती है। धान कटाई के बाद बिना जुताई जीरो टिल फर्टी सीड ड्रिल अथवा हैप्पी सीडर मशीन से गेहूं की बुवाई कर किसान लाभ प्राप्त कर सकते हैं।

कैसे करें बुवाई-धान की कटाई के तुरंत बाद बची हुई नमी का उपयोग कर जीरो-टिलेज मशीन से बुवाई कर दी जाती है। यदि खेत में नमी की संभावना न हो तो धान कटाई से पहले और तुरंत बाद हल्की सिंचाई करें। यदि बुवाई करने में देरी हो रही है तो शुष्क खेत में ही बुवाई करें। एक हफ्ते बाद हल्की सिंचाई की जानी चाहिए। किसानों को बुवाई के लिए बीज दर 125 किग्रा प्रति हेक्टेयर रखनी चाहिए।

जागरूकता शिविर • कृषि विज्ञान केंद्र बड़ा में किसानों के लिए लगा जागरूकता शिविर

गाजरघास से पशुओं को होते हैं सांस, त्वचा रोग

वार्षिक प्रतिवेदन
Annual Report

2019 - 20

भाकृअनुप – खरपतवार अनुसंधान निदेशालय
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Cover page photographs
The first photographs shows releasing of *Neochetina bruchi* water hyacinth infested tank. Second picture shows the release of AICRP Weed Management Annual Report 2018-19 during XXVI Annual Review Meeting held at AAU, Jorhat during 15-16 October, 2019, third photographs shows the *Fumeria parviflora* infestation in wheat crop, fourth photographs shows *Orobanche* infestation in brinjal crop.

Preface

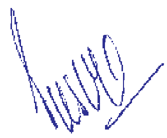
All India Coordinated Research Project on Weed Management (AICRP-WM) was launched in 1978 with the mandate to execute systematic research on weed management in the country. This project was started initially with 6 centres in different parts of the country, which later has been expanded to 23 centres in 2014 and at present, 17 regular and 6 volunteer centres are linked with each other under AICRP-Weed Management project. These centres are located almost in all the important Agricultural Universities of the country. In the last four decades, information on 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. Research and extension activities were undertaken as per the technical programme for 2019-20 on emerging challenges in weed management under five major research themes. Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency, weed dynamics and herbicide use in cropping systems, management of problematic weeds, monitoring, degradation and mitigation of herbicides were implemented. On-Farm Research and impact assessment of weed management technologies were also undertaken. Review of all AICRP-WM centres has been accomplished by the QRT team for the period of 2012-17 during 2018-19. Strict 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 for annual plan 2019-20 in terms of contingencies, staff restructuring and new research programmes have been worked out. Two new volunteer centres namely, BUAT, Banda and ANGRAU, Guntur have been linked with AICRP-WM.

I place on record my personal gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR; and Dr. S.K. Chaudhari, Deputy Director General (Agri. Engg. and NRM), for providing constant support 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 congratulate Dr. Shobha Sondhia, Incharge, AICRP-WM for consistently and judiciously pursuing the project activities. I sincerely acknowledge the support and cooperation received from Dr. Sushil Kumar, Dr. R.P. Dubey and Assistant Chief Technical Officer, Mr. Pankaj Shukla and Senior Technical Officer, Mr. O.N. Tiwari.

I have great pleasure in presenting the annual report of AICRP-Weed Management for the year 2019-20 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: 30.08.2020

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

Contents

विशिष्ट सारांश

निदेशालय के अर्न्तगत 17 नियमित और 6 स्वैच्छिक केन्द्र देश के विभिन्न राज्यों में स्थित कृषि विश्वद्यिालय के माध्यम से विभिन्न फसलों, फसल प्रणाली और गैर फसलीय क्षेत्रों में खरपतवार प्रबंधन हेतु अनुसंधान कार्य कर रहे है। वर्ष 2019–20 के दौरान दिये गये मुख्य अनुसंधानीय उपलब्धियाँ निम्नानुसार है :

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

- लुधियाना में विभिन्न जुताई और अवशेष प्रबंधन पद्धतियों के अर्न्तगत गेहूं में शून्य जुताई से *फेलेरिस माइनर* की संख्या और शुष्क भार फसल अवशेष के साथ और अवशेष के बिना अभिसामयिक भूपरिष्करण की तुलना में कम पायी गयी, जबकि चौड़ी पत्ती वाले खरपतवारों में इसके विपरीत पाया गया। धान–गेहूं फसल प्रणाली में मोलबोर्ड हल के साथ धान के अवशेष शामिल करने के बाद बोए गए गेहूं में *फेलेरिस माइनर* का धनत्व खरपतवार बीज बैंक में उच्चतम पाया गया।
- विभिन्न फसल पद्धतियों में से गेहूं की अधिकतम उपज और लाभ : लागत अनुपात (3.2) पारंपरिक परिपक्वन के बाद धान की सीधी बुबाई करने पर एवं *सिसबेनिया* के समावेश से पंतनगर में पायी गयी। जबकि धान की सार्थक उच्चतम उपज, लाभ : लागत अनुपात (2.0) और शुद्ध लाभ पारंपरिक परिष्करण रोपित धान में तदोपरान्त शून्य गेहूं में फसल अवशेष रखने के साथ *सिसबेनिया* के समावेश से पाया गया। खरपतवार प्रबंधन पद्धतियों से एकीकृत खरपतवार प्रबंधन करने पर धान की अधिकतम उपज एवं लाभ : लागत अनुपात पायी गयी।
- जोरहट मे संरक्षण खेती के अर्न्तगत धान–सरसो हरी खाद–फसल प्रणाली में, धान में पारंपरिक जुताई (सीधी बुवाई व धान) की तुलना में न्यूनतम जुताई (सीधी बुवाई व धान) और पांरपरिक जुताई (रोपित धाने) में धान की उपज में सार्थकता के साथ बढोत्तरी दर्ज की गई। न्यूनतम जुताई (सीधी बुवाई धान) में उच्च फास्फेट सॉल्यूबॉलिंग बेक्टीरिया, एजोटेबेक्टर और एजोस्पिरिलस की संख्या मे बढोत्तरी दर्ज की गई लेकिन रोपित धान की कटाई पर इनकी संख्या में गिरावट दर्ज की गई।
- मक्का–गेहूं–मूंग संरक्षित व कृषि के अर्न्तगत फसल प्रणाली में, उदयपुर में खरीफ मक्का में जुताई और अवशेष प्रबंधन उपचार द्वारा कुल खरपतवार धनत्व (बुवाई के 60 दिन पश्चात्) मक्का (शून्य जुताई)–गेहूं (शून्य जुताई)–मूंग (शून्य जुताई) में उच्चतम पाया गया और मक्का (पारंपरिक जुताई)–गेहूं (पारंपरिक जुताई)–परती में सबसे कम पाया गया। खरपतवार प्रबंधन उपचार द्वारा मक्के के दानों और भूसे मे सार्थक वृद्धि खरपतवारों के नियंत्रण के साथ अंकुरण पूर्व एट्राजिन 500 ग्रा./हे. तदोपरान्त टेम्बोट्रियोन 125 ग्रा/हे. बुवाई के 21 दिन बाद जो कि एट्राजिन 500 ग्रा/हे. (अंकुरण पूर्व) एवं हाथ द्वारा निंदाई समतुल्य दर्ज की गई। गेहूं में, जुताई एवं अवशेष प्रबंधन

This Directorate coordinates its network programme, through All India Coordinated Research Project on Weed Management (AICRP-WM) which has 17 regular centres at SAUs and 6 voluntary centres all over the India in different agro-climatic zones of the country. During 2019-20 main achievement were as follows:

WP 1 Development of sustainable weed management practices in diverfied cropping system

- Under different tillage and residue management practices in population density and dry weight of *P. minor* was lower in zero till wheat with or without residue compared to conventional tillage, while, it was reverse in case of broad leaved weeds. In rice-wheat system, the wheat sown after incorporation of rice residue with mouldboard plough had significantly lower density of *P. Minor* while wheat sown using CT after removing rice residues had highest density of *P. minor* in soil seed bank at Ludhiana
- Among the different establishment methods, wheat grain yield and B: C ratio (3.2) was highest under conventional wheat after direct seeding of rice without residue and *Sesbania* incorporation at Pantnagar. Whereas, significantly highest grain yield of rice was achieved under conventional transplanting of rice followed by zero tillage wheat along with residue and *Sesbania* incorporation by achieving highest net return as well as B:C ratio (2.0). Among weed management practices, IWM achieved maximum grain yield of rice and B:C ratio.
- The grain yield of rice of the system significantly increased under MT (DSR) and CT (TR) compared to CT (DSR) at Jorhat under rice-mustard-green manure cropping system under conservation agriculture. Higher phosphate solubilising bacteria, azotobacter and azospirillum population were observed under MT (DSR) and then there was an increasing trend in the population which declined at harvesting of transplanted rice.
- In maize-wheat-greengram cropping system under conservation, the tillage and residue management treatments, total weed density at 60 DAS attained highest with the treatment, maize (ZT)-wheat (ZT)-greengram (ZT) and lowest with maize (CT)-wheat (CT) – fallow at Udaipur in maize (*Kharif*). Significant increase in grain and stover yield of maize was recorded with weed management treatments. Highest grain yield and stover yield were obtained by controlling weeds with application of atrazine 500 g/ha PE *fb* tembotrione 125 g/ha PoE at 21 DAS which was at par with application of atrazine 500 g/ha as PE with hand weeding (IWM). In wheat, among tillage and residue

उपचारों से बुवाई के 60 दिन बाद कुल खरपतवार धनत्व मक्का (पांरपरिक जुताई)– गेहूं (शून्य जुताई)–मूंग (शून्य जुताई) से कम पाया गया।

- सोयाबीन–गेहूं–मूंग फसल चक्र में, दो बार हैरोइंग एक बार टाईन हैरो और एक बाद ब्लेड हैरो (पांरपरिक जुताई) के बदले में रोटो–टिल (न्यूनतम जुताई) और जीरो–टिल (शून्य जुताई) के संयोजन से अंकुरण पूर्व शाकनाशी तदोपरान्त अंकुरण पश्चात् शाकनाशी के प्रयोग से उपयोग करने से मृदा के भौतिक गुणधर्म फलस्वरूप फसल उत्पादकता में बढ़ोत्तरी के साथ आर्थिक सुरक्षा अकोला के कछारी भूमि में पायी गई।
- कपास की सार्थक उच्चतम बीच उपज के बराबर शून्य जुताई अवशेष के साथ पायी गई, जबकि कपास की सार्थक उच्चतर बीज उपज के बराबर हाथ द्वारा 20, 40 और 60 दिन (बुवाई के पश्चात्) पायी गई। यह पेंडीमीथेलिन 900 ग्रा./हे. तदोपरान्त क्विजालोफाप–इथाईल 50 ग्रा./हे.+पाइरीथियोबेक–सोडियम 62.5 ग्रा./हे. अंकुरण पश्चात् (टैंक मिक्स) तदोपरान्त हाथ द्वारा 60 दिन (बुवाई के पश्चात्) के समतुल्य पाई गई। मूंग की सार्थक उपज शून्य जुताई कपास–मूंग फसल चक्र में आंनद में पायी गई।
- भुवनेश्वर में 1/3 अनुसंशित नत्रजन मात्रा गोबर की खाद द्वारा, ढेंचा और नीमकेक एजोस्पीरिलयम+पी.एस.बी. तदोपरान्त जैविक खाद का एक ही अनुपात में गोबर की खाद, वर्मी कम्पोस्ट और नीम केक+एजोटोबेक्टर+पी.एस.बी. का उपयोग टमाटर और भिण्डी में धान–टमाटर–भिण्डी फसल कार्बनिक चक्र में धान, टमाटर के फलों और भिण्डी की अधिकतम उपज के साथ आरईवाई 28 टन/हे. प्रति वर्ष पायी गई।
- जैविक मक्का–आलू–मूंग फसल प्रणाली में मृदा सूर्यीकरण प्लास्टिक मल्च द्वारा तदोपरान्त हाथ द्वारा एक निराई करने पर आलू में खरपतवारों की संख्या कम पायी गई और 88% खरपतवार नियंत्रण दक्षता के साथ बेहतर खरपतवार नियंत्रण ग्वालियर में पाया गया।
- हैदराबाद में, पाली शीट (25 माइक्रोन्स) + अंतः पंक्ति में हाथ द्वारा बुवाई के 30 दिन बाद निराई या कल्चरल प्रेक्टिस यांत्रिक वीडिग बुवाई के 20 और 40 दिन पश्चात् और पुआल का मल्च (5 टन/हे.) तदोपरान्त अतः पंक्ति में निराई और स्टेल सीड बैड तदोपरान्त हाथ द्वारा बुवाई के 20 और 40 दिन बाद निराई करने पर भिण्डी में भिण्डी–गाजर जैविक फसल प्रणाली में खरपतवारों पर प्रभावशाली नियंत्रण पाया गया। गाजर में, पुआल मल्च (5 टन/हे.)+अंतः पंक्तियों में निराई बुवाई के 30 दिन बाद करने पर गाजर में खरपतवारों में प्रभावशाली नियंत्रण के साथ गाजर के कंदो की उच्चतर उपज दर्ज की गई।
- बासमती धान–ब्रोकोली–सिसबेनिया (हरीखाद) जैविक फसल प्रणाली में धान के पुआल का मल्च (6 ट./हे.) + एक बार रोपण

management treatment, total weed density at 60 DAS attained highest with the maize (CT)-wheat (ZT)-greengram (ZT) and lowest in maize (ZT+R)-wheat (ZT+R)- greengram (ZT).

- In soybean-wheat-greengram, use of two harrowing by tyne harrows and a blade harrow (CT) instead of roto-till (MT) and zero-till (ZT) in combination with pre-emergence herbicide *fb* post-emergence herbicide application (WM) not only improves the physical properties of soil but provide added productivity and economic security in vertisols at Akola.
- Significantly the highest seed cotton equivalent yield was achieved under zero tillage with residue whereas, significantly higher seed cotton equivalent yield was achieved under HW at 20, 40 and 60 DAS but it was at par with pendimethalin 900 g/ha PE *fb* quizalofop-ethyl 50 g/ha + pyrithiobac-sodium 62.5 g/ha PoE (tank mix) *fb* HW at 60 DAS. Significantly higher seed yield of greengram was achieved under zero tillage in cotton-greengram cropping system at Anand.
- 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 (T3) to tomato and lady's finger in rice-tomato-lady's finger system resulted in the maximum grain yield of rice, fruit yield of tomato and lady's finger with REY of 28 t/ha/yr in rice-tomato-okra system under organic cropping at Bhubaneswar.
- In organic maize -potato – greengram cropping system, the weeds population was less in soil solarization plots done with plastic mulch *fb* soil solarization with one hand weeding in potato and resulted better control of weeds with 88% WCE at Gwalior.
- At Hyderabad mulching with polysheet (25 microns) + HW in the inter row at 30 DAS proved effective followed by cultural practice involving mechanical weeding at 20 & 40 DAS and staw mulch (5t/ha) *fb* intra row weeding and SSB preparation *fb* HW at 20 & 40 in okra under okra-carrot under organic cropping system. In carrot, straw mulch 5 t/ha + intra row weeding at 30 DAS providedd effective weed control and higher root yield of carrot.
- The highest weed control efficiency (WCE) was recorded in paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT alongwith significantly higher curd

के 30 दिन पश्चात् ब्रोकोली की सार्थक उपज अन्य उपचारों की तुलना में उच्चतम खरपतवार नियंत्रण दक्षता के साथ जम्मू में दर्ज की गई। धान में स्टेल सीड बेड+रोपण के 30 दिन बाद हाथ द्वारा निराई करने पर उच्चतम खरपतवार नियंत्रण दक्षता के साथ लाभः लागत अनुपात खरपतवारों के नियंत्रण हेतु जैविक कृषि के लिये उपयुक्त पाया गया।

- जोरहट में कार्बनिक खेती के अन्तर्गत चाय के हरी पत्तियों की बायोडिग्रेडेबल फिल्म मल्चिंग से सभी प्लकिंग चरणो में खरपतवारों के नियंत्रण हेतु प्रभावकारी पायी गई।
- त्रिशूर में, हल्दी–लोबिया जैविक फसल प्रणाली में, पॉलीथीन शीट का मल्च करने पर खरपतवारों की वृद्धि पर प्रभावकारी नियंत्रण पाया गया। जैविक मल्चों में घास की कतरनों और नारियल के पत्तों द्वारा मल्च करने पर रोपण के 90 और 135 दिन पर खरपतवारों के शुष्क भार में बहुत ही ज्यादा कमी पायी गई। पॉलीथीन शीट का मल्च करने पर सबसे अधिक कंदो की उपज और लाभः लागत अनुपात पायी गयी।
- दो बार हाथ द्वारा निराई बुवाई के 20 और 40 दिन बाद करने पर फॉक्सटेल बाजरा की उच्चतर सार्थक उपज दर्ज की गई जो कि स्टेल सीड बेड+इन्टर कल्टीवेशन दो बार बुवाई के 25 और 45 दिन बाद या इन्टरकल्टीवेशन बुवाई के 25 दिन के बाद + एक बार बुवाई के 45 दिन बाद के समतुल्य बेंगलुरू मे पाया गया।
- उदयपुर में, मक्का में, द्विपत्रीय खरपतवारों का धनत्व और अधिकतम दानों की उपज एट्राजिन 500 ग्रा./हे. शीघ्र अंकुरण पश्चात् तदोपरान्त टेम्बोट्रायन 120 ग्रा./हे.+बुवाई के 40 दिन बाद हाथ द्वारा निराई करने पर सांख्यिकी रूप से एट्राजिन 500 ग्रा./हे. शीघ्र अंकुरण पश्चात् टोप्रामाजोन 25.2 ग्रा./हे. तदोपरान्त हाथ द्वारा बुवाई के 40 दिन बाद और मेनुअल वीडिग 15 और 35 दिन बुवाई के बाद के समतुल्य उदयपुर और भुवनेश्वर में पाया गया।

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

- गुजरात के विभिन्न भागों में *अर्जीमोन मेक्सीकाना* का तीव्र संक्रमण का अवलोकन किया गया। *फ्यूमेरिया पार्वीफ्लोरा* गेहूं में एक नया खरपतवार उत्तर गुजरात के क्षेत्रो में दर्ज किया गया।
- चौड़ी पत्ती वाला एक नया खरपतवार *निकान्ड्रा फाईसालोआइड्स* का विस्तार तिनसुकिया जिले के जोरहट तक बढ़ गया है। *एसट्रेसी फाकूटेटिव, अक्मेला ब्राचीग्लोसा* और *अक्मेला अपोजिटीफोलिया* की पूरे देश में नई वर्गीकणात्मक रिपोर्ट दर्ज की गई और *अक्मेला रेडीकांस* और *अक्मेला यूलीजिनोसा* असम राज्य में नये खरपतवार दर्ज किये गये।
- एक नया खरपतवार *फिनेक्ष हरटस/फिनेस अन्गसफोलियस* पालमपुर में सोयाबीन की फसल में पाया गया जो कि सम्भवतः

yield of broccoli than rest of treatments in basmati rice-broccoli-Sesbania (green manure) organic cropping system at Jammu. In rice, stale seedbed + one hand weeding at 30 DAT reecorded highest weed control efficiency along with highest benefit cost ratio thus found suitable for weed control in organic farming.

- At Jorhat, 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.
- Mulching with polythene sheet controlled weed growth effectively under turmeric- cowpea organic cropping system. Among organic mulches, mulching with grass clippings and coconut fronds reduced weed dry matter production to the greatest extent at 90 and 135 days after planting. Highest rhizome yield and B:C ratio were obtained on mulching with polythene sheet at Thrissur.
- Seed yield of foxtail millet was significantly higher in hand weeding at 20 and 40 DAS and on par with stale seed bed technique + intercultivation twice at 25 & 45 days after sowing and followed by intercultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing at Bengaluru.
- The lowest dicot weed density and maximum seed yield was recorded with early post emergence application of atrazine 500 g/ha *fb* tembotrione 120 g/ha + HW at 40 DAS in maize which was statistically at par with early post-emergence application of atrazine 500 g/ha with topramazone 25.2 g/ha *fb* hand weeding at 40 DAS (4.48 t/ha) and two manual weeding at 15 & 35 DAS at Udaipur and Bhubaneswar.

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

- High weed intensity of *Argemone mexicana* infestation was observed in different parts of Gujarat. *Fumeria parviflora* a new weed in wheat crop in north Gujarat zone was recorded during survey work.
- A newly appeared broad-leaved weed *Nicandra physaloides* has extended its distribution from Tinsukia district to Jorhat district. Asteraceae facultative, *Acmella brachyglossa* and *Acmella oppositifolia* var. opposifolia were the new taxonomic report for the entire country, and *Acmella radicans* var. debilis and *Acmella uliginosa* were new record for the state Assam.
- New weeds *Phenax hurtus*/*Phenax angustifolius* were found in soybean in Palampur owing to import of FYM

प्रायोगिक क्षेत्र में एफवाईएम लाये जाने के कारण पहुँचा। आडु के बाद में *अल्टरनेनथरा फिलोज्योराइड्स* और *असचीनोमीन इंडिका* और *फाइजेलिस मिनिमा* का सोयाबीन की फसल में अत्याधिक प्रकोप पाया गया।

- पूर्वी विदर्भ में *हायपटिस सुओवियोलेन्क* का प्रकोप रोड के किनारे देखा गया। पश्चिमी विदर्भ जिले में कसकुटा का भारी प्रकोप कृषको के कुछ खेतों में सोयाबीन और अरहर की फसलों में देखा गया, जिसकी प्रभावकारी खरपतवार प्रबंधन की आवश्यकता है।
- *इथूलिया ग्रासीलिस* पीरावड़ी गांव (निप्पानी से 8.5 कि.मी. चिकोडी की ओर) बेलगावी जिले में मक्का, मूंगफली और परती जगह पर 4 हेक्टेयर क्षेत्र में पाया गया।
- *सीलोसिया अर्जेन्शिया* की गंभीर समस्या ओड़ीसा में सभी क्षेत्र के अपलेन्ड क्षेत्रों में बढ़ रही है। *कसकुटा चिनेन्सिस* मुख्य परजीवी खरपतवार उत्तर पूर्वी घाट क्षेत्रो मे नाईजर की फसल में पाया गया।
- एक नये खरपतवार की प्रजाति *कोडीर्चला* महबूब नगर के काठुरमण्डल जिले में पायी गई और *सोलेनम मेलोन्गाना* के रूप में पहचाना गया।
- पंजाब में, *फेलेरिस माइनर* की संख्या कृषको के खेतो में मध्यम से उच्च स्तर तक की प्रतिरोधक *सल्फोसल्फ्यूरॉन, क्लोडीनाफॉप, पीनोक्साडेन* और *मीजोसल्फ्यूरॉन + आयोडोसल्फ्यूरॉन* के प्रति पायी गई यद्यपि *प्रीमिक्स क्लोडीनाफॉप + मेट्रीब्यूजिन* के प्रति प्रतिरोधकता नही पायी गयी। जीआर 50 वेल्यूस *फेलेरिस माइनर* की उच्च स्तर की प्रतिरोधकता गेहूं में आमतौर पर उपयोग दिये जाने वाले शाकनाशियों द्वारा खरपतवार नियंत्रण हेतु की गई।
- टेक्सोनामिक और फाइटो–जियोग्राफिक्स के मूल्यांकन के आधार पर *स्पीलान्थस* के 10 टेक्सा आठ प्रजातियों के रूप में भारत में पहचान किये गये जो कि *अक्मेला* से संबंधित है।

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

- भुवनेश्वर में, सल्फोसल्फ्यूरॉन 25 ग्रा./हे. रोपण के 30 दिन बाद तदोपरान्त 25 ग्रा./हे. रोपण के 60 दिन बाद *औरोबैंकी*/पौधो की सबसे कम संख्या और कुल खरपतवार घनत्व रोपण के 60 और 90 दिनों बाद दर्ज किया गया।
- हिसार में, टमाटर के फलो की अधिकतम उपज इथाक्सीसल्फ्यूरॉन 50 ग्रा./हे. रोपण के 60 और 90 दिनो के बाद करने पर *औरोबैंकी* के नियंत्रण के साथ दर्ज की गई जो कि सल्फोसल्फ्यूरॉन उपचार के समतुल्य पायी गयी।
- उदयपुर में, बैंगन में, इथाक्सीसल्फ्यूरॉन का दो बार प्रयोग 20 ग्रा./हे. रोपण के 45 दिन बाद तदोपरान्त 15 ग्रा./हे. रोपण के

in experimental field. Severe infestation of *Alternanthera philoxeroides* in peach orchard, *Aeschynomene indica* and *Phasalis minima* was also observed in soybean crop.

- At Akola, heavy infestation of *Hyptis suoveolenc* (Ran Tulas) was observed along the road sides in Eastern Vidarbha. Heavy infestation of Cuscuta was observed in some pocket on farmers field on soybean and pigeonpea crop particularly in western Vidarbh districts. which needs effective weed management technology.
- The *Ethulia gracilis* weed was noticed in Peerawadi village (8.5 km from Nippani towards Chikkodi) (16º24.213'N, 74º26.948'E 619m) Nippani, Belgavi district in maize and groundnut crop and fallow land in about 4 hectare areas.
- *Celosia argentea* is observed to be a severe problem in almost all parts of the state and invading mostly the upland areas at Bhubaneswar. *Cuscuta chinensis* was found to be a major parasitic weeds in the niger crop in the North eastern ghat zone.
- One new weed species found in Kodicherla village of Kothur mandal of Mahabubnagar district and identified as *Solanum melongena* var. insanum (L.).
- In Punjab, *Phalaris minor* populations from farmers' field showed moderate to higher level of resistance to sulfosulfuron, clodinafop, pinoxaden and/or mesosulfruon + iodosulfuron, however, no resistance to pre-mix of clodinafop plus metribuzin was recorded. GR_{50} values confirmed presence of high levels of resistance in *P. minor* to herbicides commonly used for its control in wheat.
- On the basis of taxonomic and phyto-geographic assessment, 10 taxa of *Spilanthes* under eight species have been recognized in India that belonged to *Acmella*.

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

- At Bhubaneswar, application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT recorded lowest number of Orobanche/plant and lowest total weed density at 60 and 90 DAP
- At Hisar, maximum fruit yield was recorded in tomato, with for control of *Orobanche*, with use of ethoxysulfuron 50 g/ha at 60 and 90 DAP, and it was at par with sulfosulfuron treatments.
- At, Udaipur, application of ethoxysulfuron twice i.e. 20 g/ha at 45 DAT followed by 15 g/ha at 90 DAT proved

90 दिन बाद करने पर *औरोबैंकी* का नियंत्रण पर प्रभावकारी पाया और बैंगन के उपज में 11.1% उपज कृषक पद्धति की तुलना में अधिक दर्ज की गई।

- हैदराबाद में, नीम केक 200 कि.ग्रा./हे. तदोपरान्त ग्लायफासेट 30 ग्रा./हे. औरोबेंकी के संक्रमण के नियंत्रण हेतु प्रभावी पाया गया। पॉलीथीन शीट की मल्चिंग से *औरोबैंकी* का अंकुरण देर से कम होना पाया गया।
- आंनद में, सल्फोसल्फ्यूरॉन 25 ग्रा./हे. रोपण के 45 दिन बाद तदोपरान्त 50 ग्रा./हे. रोपण के 90 दिन बाद और सल्फोसल्फ्यूरॉन 50 ग्रा./हे. रोपण के 60 दिन बाद प्रयोग से *औरोबैंकी* के प्ररोह में न्यूनतम वृद्धि के साथ टमाटर के फलों की संख्या उच्चतर दर्ज की गई।
- ग्वालियर में, बुवाई के बाद पेन्डीमीथेलिन 1.0 कि.ग्रा./हे. का शीघ्र प्रयोग करने से सबसे अधिक चारा की उपज तीन कटाई के साथ बीज उपज एवं इमेजाथापायर 40 ग्रा./हे. पहली कटाई के बाद+पुनः आखिरी कटाई के बाद प्रयोग करने पर *कसकुटा रिफलेक्सा* पर प्रभावी नियंत्रण पाया गया साथ ही चारा की कुल उपज 74 ट./हे. व बीज उत्पादन 248 कि.ग्रा./हे. प्राप्त हुआ सर्वाधिक लाभः लागत अनुपात पेन्डीमीथेलिन 1.0 कि.ग्रा./हे. के उपयोग से पाया गया।
- त्रिशूर में, प्रेटिलाक्लोर + बेनसल्फ्यूरॉन–मिथाईल तदोपरान्त सायहैलोफाफ व्यूटाइल+पेनुक्जालुम तदोपरान्त हाथ द्वारा निराई दोनो उपचार में बुवाई के 30 और 60 दिन पश्चात् करने पर *सेसिओलेपिस इन्ट्रप्टा* का शुष्क भार कम पाया गया और खरपतवार नियंत्रण दक्षता उच्चतम पायी गयी। इसके साथ ही दानों और चारे की उच्चतम उपज एवं लाभः लागत अनुपात प्राप्त किया गया।
- ग्वालियर में, दो बड़े तालाबो पिलुआ डैम और मुरैना ताल में *निओक्टिना ब्रूची* पर जलकुंभी पर नियंत्रण वर्ष 2016 से लगातार प्रयोग करने पर पाया गया।

डब्लू पी 4 पर्यावरण में प्रदूषकों एवं शाकनाशी अवशेषो का अपघटन, निगरानी व शमन

- लुधियाना में, इमाजेथापायर का अपघटन मृदा के पी.एच. और तापमान के साथ सकारात्मक रूप से और मृदा के कार्बनिक पदार्थो के साथ नकारात्मक रूप से सहसंबंधित पाया गया। सोखने की क्षमता के कारण एलएमडब्लूसीबी और टीआरएच जल से इमाजेथापायर और इमाजामाक्स के निष्कासन के लिए बेहतर पाये गये। बिसपायरीबेक–सोडियम की हाफ लाईफ धान की भूसी और इसके बायोचार संशोधित मृदा में कम पायी गयी और 23.1 से 28.6 और 7.5 से 18.4 दिनो तक अपरिवर्तित और संशोधित मृदा में पायी गयी।

effective in reducing the *Orobanche* infestation and increasing brinjal yield by 11.1 % over farmers practice.

- At Hyderabad, neem cake 200 kg/ha *fb* glyphosate 30 g/ha was effective in controlling *Orabanche* infestation. Mulching with polysheet delayed emergence and lowered the incidence of *Oranbanche*.
- At Anand, minimum *Orobanche* shoots and higher tomato yield was recorded under sulfosulfuron 25 g/ha at 45 DATP *fb* 50 g/ha at 90 DATP and sulfosulfuron 50 g/ha at 60 DATP fb 50 g/ha at 90 DATP.
- At Gwalior, early post emergence application of pendimethalin 1.0 kg/ha produced higher fodder yield with total three cuts and seed yield and application of imazethapyr 40 g/ha after 1st cut + again applied after last cut were also found effective to control the *Cuscutta reflexa* and other weeds with 74 t/ha fodder yield and 248 kg/ha seed yield. The B:C ratio was also high with the use of pendimethalin 1.0 kg/ha.
- At Thrissur, *Sacciolepis interrupta* dry matter production was lowest and weed control efficiency was highest with pretilachlor + bensulfuron-methyl followed by cyhalofop-butyl + penoxsulam followed by hand weeding at both 30 and 60 days after sowing. Highest grain and straw yields as well as B:C ratio were also obtained with this treatment.
- Gwalior *Neochetina bruchi* has controlled water hyacinth in two large ponds namely Pilua dam Morena and Taal (pond) of Morena after its introduction in 2016.

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

- At Ludhiana, dissipation of imazethapyr was positively correlated with soil pH and temperature and negatively correlated with soil organic matter. Amongst the studied adsorbents, LMWCB and TRH were superior for the removal of imazethapyr and imazamox from water in terms of adsorption and desorption capacity. Half-life of bispyribac-sodium decreased in rice husk and its biochar amended soils and ranged from 23.1 to 28.6 days and 7.5 to 18.4 days in unamended and amended soil.

- 75% से अधिक टेम्बोट्रायोन का मृदा में अपघटन 60,120 और 240 ग्रा./हे. की दर से प्रयोग करने के 15 दिनो में होना पाया गया। मेटसल्फ्यूरान के अवशेष धान में और क्लोडिनाफाप के अवशेष गेहूं में कांगड़ा जिले में कृषको के खेतो से फसल की कटाई के उपरान्त लिए गये नमूनो में शाकनाशी अवशेष आपेक्षित स्तर से कम पाये गये।
- बिसपायरीबेक–सोडियम का अवशेष मृदा, धान के दानों एवं धान के पुआल में कटाई उपरान्त लिये गये नमूनो में 0.01 पी.पी.एम. से नीचे हैदराबाद और पालमपुर में पाये गये।
- एट्राजिन का अवशेष मृदा के नमूनो, मक्का के दानो और भूसो को कटाई उपरान्त एकत्र कर जॉच उपरान्त आपेक्षित मात्रा से कम 0.05 पी.पी.एम. पाये गये।
- डिहाइड्रोजनेज एंजाइम एक्टीविटी (डी.एच.ए.) रोपित धान में पुष्पण के समय सीधी बुवाई धान से सार्थक रूप से उच्च पायी गयी। शाकनाशियों का प्रभाव डी.एच.ए. पर पुष्पन के समय या कटाई के समय नान–सिग्नीफिकेन्ट पाया गया।
- पेन्डीमीथेलिन के अवशेष भिण्डी में आपेक्षित मात्रा से कम 0.05 मि.ग्रा./कि.ग्रा. पाये गये।
- कोयंबटूर में, एट्राजिन और पेन्डीमीथेलिन के अवशेष मृदा और मक्का के दानो का निरक्षेप रूप से जुताई प्रबंधन पद्धति द्वारा खरपतवार नियंत्रण अलग–अलग प्लाटो से लिये गये नमूनो मे शाकनाशी अवशेष की आपेक्षित मात्रा से कम 0.01 कम मि.ग्रा./कि.ग्रा. पायी गयी। ऑक्सीफ्लोरफेन के अवशेष प्याज में एवं मृदा के नमूनों में नही पाये गये।

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

- हिसार और लूधियाना में, धान–गेहूं फसल चक्र उपजाने वाले पॉच क्षेत्रो पर पायरोजासल्फोन 127 ग्रा./हे. को अंकुरण पूर्व प्रदर्शित किया गया जिसमें *फेलेरिस माइनर* को विभिन्न प्रतिरोधकता पर 84% नियंत्रण पाया गया वही पेन्डीमीथेलिन 1.0 कि.ग्रा./हे. (अंकुरण पूर्व) और पेन्डीमीथेलिन का छिड़काव अंकुरण पश्चात् 35 दिन पर करने पर 92% नियंत्रण पाया गया जिससे 5532 कि.ग्रा./हे. उपज प्राप्त हुई जो कि पहले अनुशंसित शाकनाशी पेन्डीमीथेलिन 1.5 कि.ग्रा./हे. की तुलना में 9.32% अधिक था।
- पन्तनगर में, तराई और भाबर क्षेत्रो में, क्लोडिनाफॉप–प्रोपारजिल+मेटसल्फ्यूरॉन–मिथाईल (60+4 ग्रा./हे.) का रेडी मिक्स प्रयोग से उच्चतम गेहूं के दानों की उपज क्रमशः 5.2 ट./हे. और 4.5 ट./हे. दर्ज की गयी जबकि धान की उपज दोनो क्षेत्रो मे क्रमशः 6.6 और 4.4 ट./हे. बिसपायरीबेक सोडियम (20 ग्रा./हे.) के साथ अधिकतम लाभः लागत अनुपात कृषक पद्धति की तुलना में पाया गया।

- More than 75% applied tembotrione at 60, 120 and 240 g/ha dissipated from soil within 15 days after herbicide application. The residues of metsulfuron-methyl in rice and clodinafop in wheat were found BDL from the samples collected from farmers fields of Kangra district at the harvest of the crop.
- Residues of bispyribac-sodium in the soil samples, rice grain and rice straw samples at harvest were below the detectable limit of 0.010 ppm at Hyderabad and Palampur.
- 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 ppm.
- Dehydrogenase enzyme activity (DHA) in transplanted rice at the time of flowering was significantly higher in direct-seeded rice (DSR) treatments. Effect of herbicides on DHA at the time of flowering or harvest was non-significant.
- Residues of pendimethalin in okra fruit samples collected from pendimethalin sprayed plots was below the detection limit of 0.05 mg/kg.
- At Coimbatore, the residues of atrazine and pendimethalin in soil and maize grain from different plots were below 0.01 mg/kg irrespective of the tillage management practices followed for weed control. The harvest time residues of oxyfluorfen were not detected in soil as well as onion plant top.

WP 5.1 On Farm Research and Front Line Demonstrations

- At Hisar and Ludhiana, pre-emergence use of pyroxasulfone at 127.5 g/ha demonstrated at 5 locations in rice-wheat growing areas of Haryana provided 84 % control of multiple herbicide resistant *P. minor* whereas integration of this herbicide with pendimethalin at 1.5 kg/ha (PRE) and post mergence herbicides at 35 DAS improved control of *P. minor* to 92% with grain yield of 5532 kg/ha which was 9.32 % higher than earlier recommended herbicide pendimethalin at 1.5 kg/ha.
- At Pantnagar, ready mix application of clodinafop-propargyl +metsulfuron-methyl (60+4 g/ha) recorded the highest wheat grain yield of 5.2 t/ha and 4.55 t/ha in both Tarai and Bhabar region, respectively, whereas, yield of rice crop was achieved higher both in Tarai and Bhabar area (6.6 and 4.4 t/ha, respectively) with application of bispyribac-Na (20 g/ha) with maximum benefit cost ratio over farmers practice.

- कान्थोड़ा और बूटबासा गांव में मक्का की फसल में सात प्रदर्शन लगाये गये, जिसमें अंकुरण पूर्व एट्राजिन तदोपरान्त टेम्बोट्रियान 500 ग्रा./हे. अंकुरण पूर्व +120 ग्रा./हे. 3–4 पत्तियाँ आने पर अंकुरण के 15 दिन बाद उपयोग करने से कृषक पद्धति की तुलना में अधिकतम दानो और भूसे की उपज के साथ 10.5ः अधिक दानों की मक्का की उपज दर्ज की गयी।
- जम्मू में, मक्का में सबसे कम खरपतवार घनत्व और खरपतवार बायोमास अंकुरण पूर्व टेम्बोट्रीयोन 1000 ग्रा./हे.+एट्राजिन 500 ग्रा./हे. के प्रयोग से या अंकुरण एट्राजिन 1000 ग्रा./हे. या अंकुरण पूर्व टेम्बोट्रीयोन 100 ग्रा./हे. अंकुरण पश्चात् सभी स्थानों पर दर्ज किया गया। उच्चतम दानों, भूसे की उपज एवं लाभः लागत अनुपात टेम्बोट्रीयोन 100 ग्रा./हे.+एट्राजिन 500 ग्रा./हे. या अंकुरण पश्चात् एट्राजिन 1000 ग्रा./हे. अंकुरण पूर्व टेम्बोट्रायन 100 ग्रा./हे. के प्रयोग अंकुरण पश्चात् सभी स्थानों पर दर्ज किया गया।
- कोयंबटूर में, 5.5 कृषक प्रक्षेत्रो मे प्याज और टमाटर पर परीक्षण किये गये, जिसमें अंकुरण पूर्व ऑक्सीफ्लोरफिन 200 ग्रा./हे. +हाथ द्वारा निराई रोपण के 25–30 दिन पश्चात् प्याज की उच्चतर उपज (13.8–14.7 ट./हे.) और शुद्ध लाभ (₹ 1.90–2.10 लाख/हे.) पाया गया। औसतन टमाटर की पैदावार 21.3 से 38.9ः कृषक पद्धति (दो बार हाथ द्वारा निराई) करने पर अधिक पायी गयी।
- कल्याणी में, कृषक प्रक्षेत्र में लोबिया और पत्ता गोभी में परीक्षण किये गये। लोबिया में पेन्डीमीथेलिन 0.75 कि.ग्रा./हे. 0–3 दिन अंकुरण बाद तदोपरान्त क्विजालोफॉप–इथाइल 50 ग्रा. /हे. अंकुरण के 20 दिन बाद कम खरपतवार धनत्व, बायोमास और उच्चतम उपज दर्ज की गयी।
- भिवानी, हिसार, महेन्द्रगढ़ जिलो में लगभग 199 प्रदर्शनों को कृषक प्रक्षेत्रो में ग्लायफासेट द्वारा सरसो में *औरोबेंकी* के नियंत्रण हेतु प्रदर्शित किये गये। बुवाई के 30 दिन बाद ग्लायफासेट 25 ग्रा./हे. तदोपरान्त बुवाई के 50–60 दिन बाद 50 ग्रा./हे. के उपयोग से सरसों में 33.6% अधिक सरसो की उपज के साथ *औरोबेंकी* का 79.5% नियंत्रण पाया गया।
- रायपुर में ग्राम महुआभाटा (साजा), बेमेतरा जिले में अग्रिम पंक्ति प्रदर्शन पंक्तियों में बुवाई धान का रासायनिक विधियों से खरपतवार नियंत्रण का परीक्षण किया गया। खरपतवार प्रबंधन की वैज्ञानिक विधि अपनाने से कृषक पद्धति की तुलना में 15.4% की वृद्धि धान की खेती में प्राप्त की गई। कृषक पद्धति में धान की औसत उपज 36.5 और अनुसंशित पद्धति से औसत उपज 42 क्वि./हे. पायी गयी।
- भुवनेश्वर में, 10 अग्रिम पंक्ति प्रर्दशन रोपित धान और खरीफ मक्का में पुरी जिले के 3 गांवो में किये गये अंकुरण पूर्व उपयोग प्रेटिलाक्लोर या अंकुरण पश्चात् बिसपायरीबेक–सोडियम 200 ग्रा./हे. रोपण के 25 दिन बाद मक्का में करने पर कृषक पद्धति (एक बार हाथ द्वारा निराई) की तुलना में 20–30% तक उपज में वृद्धि पायी गयी।

- Seven demonstrations on weed management in maize through post-emergence application of tembotrione was conducted at village Kanthoda and Bootwas, Tehsil- Sarada and maximum value of grain and straw yield was obtained with the application of atrazine *fb* tembotrione 500 g/ha as PE + 120 g/ha at 3-4 leaf stage (15 DAS) by increasing 10.5% over farmers practice in respect of grain yield of maize.
- At Jammu, the lowest weed density and weed biomass were recorded in tembotrione 100 g/ha+atrazine 500 g/ha as post-emergence fowllowed by atrazine 1000 g/ha as pre-emergence *fb* tembotrione 100 g/ha as post-emergenc at all the locations. The 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-emergenc at all the locations.
- At Coimbatore, five on-farm research on in aggerigatum onion and five FLDs in tomato were carried out with PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAP recorded higher bulb yield (13.8 to 14.7 t/ ha) and net return were higher in the same treatment (₹ 1.90 – 2.10 lakh /ha). On an average, tomato yields increased upto 21.3 to 38.9% higher over farmers practice (two hand weeding). Higher income also obtained by improved practice over farmers practice has been demonstratedand popularized.
- At Kalyani, OFR trials conducted at farmers' field on vegetable cowpea and cabbage. In cowpea pendimethalin 0.75 kg/ha at 0-3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS maintained its superiority with less weed density and biomass and highest yield.
- Approximetly 199 demonstrations in Bhiwani, Hisar and Mahendergarh districts were 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 79.5% control of *Orobanche* in mustard with yield gain of 33.6% over untreated control.
- At Raipur, front line demonstrations were conducted in village Mauhabhata (Saja) district Bemetara on weed management in line sown rice by chemical weed. The average yield of farmers practice and recommended practice was 36.4 and 42.0 q/ha, respectively. However, percent increase under recommended practice over farmers practice was 15.4%.
- At Bhubaneswar, 10 frontline demonstration were conducted on transplanted rice and *Kharif* maize in three villages of puiri district resulted in 20- 30% yield increase with pre-emergence application of pretilachlor or post emergence application of bispyribac-sodium 200 g/ha at 25 DAT in maize over farmers' practice (One HW).

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, Punjab Agricultural University, Ludhiana (Punjab); University of Agricultural Sciences, Bangaluru (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 Rs. 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, 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, Bangaluru (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, 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 Rs. 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, 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-WM was Rs. 823.79, 1696.57, 3548.78 lakhs and 4007.26 lakhs, respectively. During XII Plan (2012-17), four AICRP on Weed Management centres, 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-eKashmir 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.

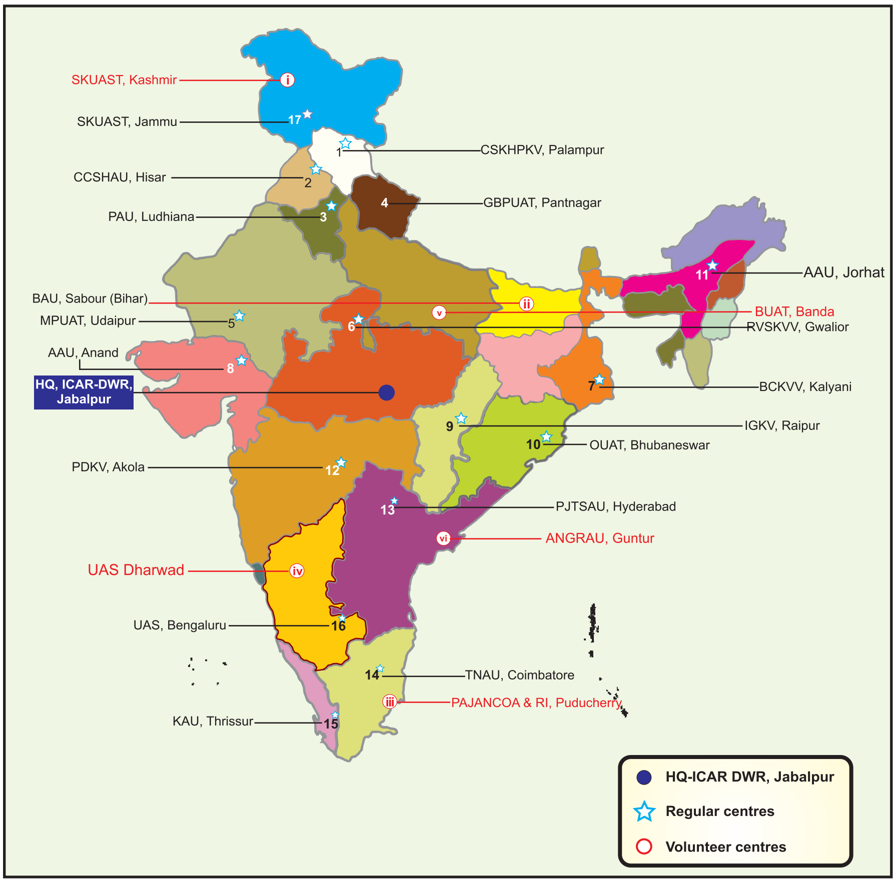
The coordinating unit of the project was located initially at Central Rice Research Institute, Cuttack, and shifted to National Research Centre for Weed Science in 1989. Later in 2009, NRC for Weed Science was upgraded to Directorate of Weed Science Research. During XII Plan (2012-17), it has renamed 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 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 PAU, Ludhiana
4 GBPUAT, Pantnagar
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 BAU, Sabour (Bihar)
iii PAJNCOA & RI Punducherry
iv UAS, Dharwad
v BUAT, Banda
vi 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, 6 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2019-20 are given below:

Staff position at different coordinating centres during 2019-20

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	2	1	1	1	1
OUAT, Bhu baneshwar	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**	**34**	**17**	**14**	**08**	**07**

Funds released to different coordinating centres during the financial year 2019-20

(₹ in lakh)

Sl. No.	Centre name	Grant in aid Capital		Grant in aid Salary	Grant in aid General					
		Other than NEH	SCSP	Salary	TA	Research Expenses	miscellaneous expense other item	SCSP	Total	ICAR Total
1	PAU, Ludhiana	0.94	-	35.66	0.64	2.80	0.93	0.00	4.37	40.97
2	UAS, Bengaluru	0.50	-	40.44	1.65	3.45	0.50	0.00	5.60	46.54
3	RVSKVV, Gwalior	0.00	-	25.16	0.80	3.92	0.57	1.88	7.17	32.33
4	GBPUAT, Pantnagar	0.50	-	33.23	0.40	3.48	0.73	0.00	4.61	38.34
5	CSKHPKV, Palampur	0.50	-	48.07	0.45	3.65	0.50	1.88	6.48	55.05
6	AAU, Jorhat	0.50	-	46.47	0.92	3.50	0.59	1.88	6.89	53.86
7	AAU, Anand	0.50	-	34.07	0.73	3.07	0.66	0.00	4.46	39.03
8	TNAU, Coimbatore	0.00	-	42.44	1.10	3.25	0.60	1.88	6.83	49.27
9	KAU, Thrissur	0.00	-	30.20	0.89	3.00	1.37	0.00	5.26	35.46
10	OUAT, Bhubaneshwar	0.23	0.20	39.73	1.00	3.75	0.50	1.88	7.13	47.29
11	PJTSAU, Hyderabad	0.50	-	40.17	0.89	3.25	0.70	1.88	6.72	47.39
12	CCSHAU, Hisar	0.00	-	30.81	0.60	4.90	0.50	0.00	6.00	36.81
13	IGKV, Raipur	0.00	0.00	32.40	0.60	3.13	0.50	1.95	6.18	38.58
14	PDKV, Akola	0.00	0.20	25.72	0.70	4.75	1.23	1.88	8.56	34.48
15	BCKV, Kalyani	1.00	0.20	22.50	0.80	3.05	0.50	1.88	6.23	29.93
16	MPUAT, Udaipur	0.00	0.20	29.50	0.62	3.00	1.12	1.88	6.62	36.32
17	SKUAST, Jammu	0.00	0.25	37.26	0.85	4.29	0.50	1.88	7.52	45.03
18	**PC, Unit, Jabalpur**	1.68	0.00	0.00	0.00	4.21	0.00	0.00	4.21	5.89
	Total	**6.85**	**1.05**	**593.83**	**13.64**	**64.45**	**12.00**	**20.75**	**110.84**	**712.57**

3. RESEARCH ACHIEVEMENTS

WP1 Development of sustainable weed management practices in diversified cropping systems

WP1.1 Weed management in different cropping systems under conservation agriculture systems

WP1.1.1 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 IGKVV, Raipur.

Treatment details:

Treatments	*Kharif*	*Rabi*	Summer
Tillage and residue management			
T_1	CT(Transplanted)	CT	-
T_2	CT (Transplanted)	ZT	ZT
T_3	CT (Direct-seeded)	CT	ZT
T_4	ZT (Direct-seeded)	ZT	ZT
T_5	ZT (Direct-seeded)+R	ZT+R	ZT+R
Weed management			
W_1	Recommended herbicide		
W_2	IWM (herbicide + manual weeding)		
W_3	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

Rice- maize-cowpea cropping system

OUAT, Bhubaneswar

In *Kharif* rice, the weed flora comprised of *E. crus-galli, E. colona, P. scorbiculatum* and *C. dactylon,* among grassy weeds, *M. quadrifolia*, *A. sessili, L.* and *parviflora* among broadleaf weeds and *C. difformis, C. iria, C. rotundus* and *F. miliacea* among sedges. At 60 DAP, conventional tillage (CT) plots had considerably lower weeds over zero tillage (ZT). In ZT (direct seeded)-ZT-ZT system had recorded 31.5% higher weed dry biomass (47.32 g/m^2) over zero tillage (CT) (transplanted)–CT system (33.0 g/m ^{2}) and 40% more than CT-ZT-ZT system. Rest of the treatments had significantly lower weed dry biomass, however, their effect was less in relation to CT (transplanted)-CT system. The grain yield and gross return were statistically differed among tillage system. However, the highest grain yield (4.3 t/ha) and B: C ratio (2.75) was recorded in CT-CT system.

Among weed management practices, application of pretilachlor 1.0 kg/ha followed by one hand weeding (IWM) recorded fewer weeds and lesser weed dry biomass followed by pretilachlor 1.0 kg/ha over weedy check (113.4/m^2). Lower weed density and dry biomass under IWM resulted in higher grain yield (4.28 t/ha) followed by pretilachlor 1.0 kg/ha (3.95 t/ha) and proved better than weedy check. However, pretilachlor 1.0 kg/ha obtained the highest B:C ratio (2.95) over weedy check (2.20). It was also noticed that the composition of the weed seed bank in ZT was dominated with grasses (60%) followed by broad-leaf 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 52% grassy weeds [*Panicum repens* (25%), *Echinochloa crus-galli* (18%) and *Echinochloa colona* (15%)] followed by 33% broad-leaf weeds [*Marselia quadrifolia* (10%), and *Alternanthera sessilis* (7%)] and lowest by 15% sedges [*Cyperus difformis* (9%) and *Cyperus iria* (3%)]. Other major weeds observed were *Ludwigia parviflora, Leptochloa chinensis*, *Sphenochloa zeylanica*, *Cyperus rotundus, Paspalum scrobiculatum* and *Dactyloctenium aegyptium*. At 60 DAS, the lowest weed density recorded in CT (transplanting)-ZT-ZT and ZT (DSR)-ZT+R-ZT of 33.5/m^2 and 43.9/m^2, respectively. Inclusion of CT in the tillage methods reduced the weed densities by 21.1, 19.6 and 28.1%, respectively and weed dry biomass by 16.2, 17.5 and 21.2%, respectively. 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 was 24.7% over CT-CT system. Weed index values were observed to be the maximum in ZT-ZT-ZT system (24.7%) and yield losses due to weeds were 47.5% in both the seasons. Among various tillage systems, CT (trans)-ZT-ZT recorded the highest B: C ratio of 3.5 in the entire rice-maize-cowpea system followed by CT(DSR)-CT-ZT method (2.8). The lowest value, however was observed in ZT (DSR)-ZT+R-ZT method (2.5). 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 (4.43 t/ha) as compared to sole recommended herbicide application *i.e.* pendimethalin 1.0 kg/ha. Use of pendimethalin 1.0 kg/ha with manual weeding produced better B: C ratio (2.78) as compared to sole herbicide application (2.57).

In summer, CT (trans)-ZT-ZT system of tillage recorded significantly higher grain yield (4.23 t /ha). Practice of ZT (DSR)-ZT+R-ZT system resulted in the lowest grain yield and 24.7% yield reduction as compared to CT-CT method in both the seasons. Among the weed management practices, IWM (herbicide +manual weeding) proved better than sole herbicide with yields of 4.42 t/ha. Weed index values were observed to be the maximum in ZT-ZT-ZT system (24.7%) and yield losses due to weeds were 47.5% in both the seasons. 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 application of pretilachlor + 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 of 3.5.

Rice-wheat cropping system

CCSHAU, Hisar

Under different tillage and residue management scenarios, population density and dry weight of *P. minor* was lower in case of ZT wheat with or without residue compared to CT, while, it was reverse in case of broad leaved weeds. Moreover, retention of residue halts the diurnal fluctuation in temperature compared to CT in wheat. Soil temperature was higher and lower (0.5-1.5^{0}C) during morning and afternoon in ZT with full rice residue retention under both the conditions i.e. with or without waste decomposer compared to CT wheat, respectively. This congenial environment also reflected in wheat yield and yield attributes as under ZT wheat (Happy seeder sown) with full residue load with/without waste decomposer (WD) resulted in significantly higher grain yield compared to other scenarios (retention of partial residue, anchored stubble and conventional sown wheat). Application of herbicide (mesosulfuron+iodosulfuron 12+2.4 g/ha) along with one hand weeding comprises as integrated weed management resulted in more grain yield as compared to alone application of the same herbicide, but both were statistically at par with each other **(Table 1.1.1.1)**.

In *Kharif*, 2019 rice was transplanted under conventional puddled conditions (CT-PTR). The grain yields of rice were similar amongst all the treatments (6.22-6.49 t/ha) mainly due to similar planting method of rice establishment.

Table 1.1.1.1 Effect of tillage and residue management treatments on yield and yield attributes of wheat

Treatments	Effective tillers/ mrl	Plant height (cm)	Spike length (cm)	1000-grain weight (gm)	Grain yield (t/ha)
Tillage and residue management					
ZTW + full residue (Happy seeder) + WD	98	108.7	10.9	40.7	6.54
ZTW + full residue (Happy seeder)	103	108.6	10.8	41.1	6.59
ZTW + partial residue (Happy seeder)	99	108.7	10.9	41.3	6.26
ZTW + anchored stubbles (Happy seeder)	100	108.9	10.7	40.9	6.16
CTW (Drill sown)	96	107.4	10.8	41.10	6.18
SE (m)±	0.7	0.2	0.1	0.18	0.32
CD 5%	2.6	0.79	NS	NS	0.10
Weed management					
Recommended herbicides	101	108.6	10.9	41.2	6.86
Integrated weed management	100	108.8	10.9	41.2	6.97
Weedy check	97	108.0	10.7	40.8	5.20
SE (m)±	0.6	0.3	0.2	0.1	0.23
LSD (P=0.05)	1.8	NS	NS	0.3	0.69

Rice-maize- *sesbania* cropping system

PJTSAU, Hyderabad

In *Rabi* maize during 2018-19, the weed flora observed during crop growing season consisted of *Cyperus rotundus* among sedges, *Dinebra retroflexa, E***.** *crussgalli, Cynodon dactylon, Eleucine indica* and *Paspalum scrobiculatum* among grasses and *Parthenium hysterophorus, Alternanthera sessilis***,** *Melilotus alba, Trianthema portulacastrum, Digeria arvensis, Eclipta alba,* and *Aeschynomene* spp. among the broadleaved weeds at 30 DAS. However, in addition to these weeds, *Amaranthus viridis, Amaranthus polygamus, Aacalypha indica* and *Physalis minima* at 60 DAS, *Dactyloctenium aegyptium* and *Portulaca oleracea* at 90 DAS, *Euphorbia geniculata* and *Cyanotis axillaris* at harvest were also recorded.

Among tillage practices at 60 DAS, significantly lowest weed density and dry biomass (155.1/m^2 and 28.1 g/m^2), respectively was recorded with CT (TPR) - CT (maize) followed by CT (TPR) - ZT (maize). With respect to weed management practices, significantly lowest weed density and dry biomass were recorded in IWM involving atrazine + paraquat as PE *fb* hand weeding. Among the tillage practices significantly highest number of grains/cob (461), test weight (24.3 g), cob length (17.2 cm), cob width (15.7) and number of rows per cob (15) was recorded in CT (TPR) - CT (maize). The lowest cob length was recorded with ZT (DSR) - ZT (maize) + residues (14.8 cm), lowest cob width and no. of rows/cob in CT (DSR) - CT (maize). Significantly superior yield attributes were recorded under IWM followed by recommended herbicides. This showed that higher grain yield, gross returns and BC ratio can be obtained in *Rabi* maize raised conventionally and zero tillage in sequence transplanted rice in *Kharif* season, respectively. Either PE application of atrazine 1000 g/ha + paraquat 600 g/ha *fb* HW at 40 DAS (IWM) or atrazine 1000 g/ha + paraquat 600 g/ha *fb* 2-4,D 1000 g/ha at 20-25 DAS as PoE was economical with higher grain yield, gross returns and net returns, respectively **(Table 1.1.1.2)**.

System productivity and economic analysis showed that, more system productivity, gross returns, net returns and BC ratio obtained under CT rice *Kharif* followed by maize under CT (10.84 t/ha, ₹ 1,96,837, ₹ 1,19,090 and 2.53), respectively and ZT practices, respectively (10652 kg/ha, ₹ 1,93,334, ₹ 1,15,587 and 2.49), even though more cost of cultivation incurred towards CT, due to realization of more yield under conventional system over direct seeded aerobic rice.

Regarding weed management practices, more system productivity, gross returns, net returns and BC ratio was obtained with IWM (9703 kg/ha, ₹ 1,76,109 for both *Kharif* rice and *Rabi* maize in sequence due to realization of higher yields. This was followed by practicing of chemical methods in sequence for *Kharif* rice and *Rabi* maize (8956 kg/ha, ₹ 1,62,551, ₹ 90,031 and 2.24), respectively.

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,* 2018-19)

Treatment	Weed dry biomass (kg/ha) at 60 DAS	Grain yield (t/ha)	Straw yield (t/ha)	COC (₹/ha)	GR (₹/ha)	NR (₹/ha)	B:C ratio
Tillage							
CT (Transplanted)-CT	6,829	5.61	6.949	39,705	1,02,425	62,720	2.5
CT (Transplanted)-ZT	6,631	5.58	6.777	39,705	1,01,690	60,986	2.5
CT (Direct -seeded)-CT	5,058	4.06	5.283	40,538	74,370	34,666	1.7
ZT (Direct -seeded)-ZT	5,236	4.26	5.595	42,538	78,067	34,529	1.8
ZT(Direct -seeded) + R-ZT+R	5,710	4.64	5.909	43,538	84,866	41,328	1.9
LSD (P=0.05)	225.4	0.70	0.331				
Weed management							
Chemical	6777.3	5.57	6.859	41,780	1,01,639	59,859	2.4
IWM	7411.8	6.02	7.415	44,680	1,09,897	65,217	2.5
Unweeded control	3489.0	2.89	4.034	37,853	53,314	15,461	1.4
LSD (P=0.05)	107.9	0.40	0.267				

In *Kharif* 2019, aerobic rice decrease in population density of *Aeschynomene indica* was noticed, where as occurrence of new weed species were noticed like *Dinebra retroflexa, Cardiospermum* spp. and *Spilanthes oleracea***.** Tillage and weed management practices exerted significant influence on weed density and dry matter production at various stages of crop growth. At 30 DAT/60DAS, CT (transplanted) showed the lowest and at par density and dry matter/m^2 with each other and were significantly superior compared to CT (directed seeded), ZT and ZT+R tillage practices and inturn CT (directed seeded), lower weed dry biomass over ZT and ZT-R. Similar trend was observed 60 DAS.

IWM practice at 30 and 60 recorded significantly lower weed dry biomass but in turn it was on par with chemical control and these two treatments significantly superior over unweeded control.

Growth and yield attributes were found to be higher and comparable in both the transplanted treatments whereas in direct seeded rice, CT - CT found to be superior and ZT systems with and without residue cover was inferior to all other treatments. In DSR, CT – CT was found to be superior over ZT with and without residue cover treatments. IWM was found to be significantly superior with highest grain and straw yields followed by chemical weed management. Higher gross returns and net returns were realized in TPR with CT – CT system comparable to CT - ZT system. The B: C ratio was also the maximum under transplanted rice. Among weed management practices IWM recorded higher gross returns (₹ 62,935/ha), net returns (₹ 31,129/ha) and B: C ratio (1.81) followed by chemical weed management.

Rice-wheat-greengram cropping system

SKUAST, Jammu

During *Rabi* 2018-19, the wheat field was infested with *Phalaris minor, Rumex* spp., *Anagalis arvesnsis*, *Medicago* spp., *Ranunculus arvensis, Melilotus* spp. and other weeds like *Vicia* spp**.** At 60 DAS, the density of *Phalaris minor* in ZT wheat was significantly lower than CT wheat. Among the tillage and residue management treatments, significantly lower grassy weed, broad-leaved weed, total weed density and weed biomass were recorded in ZTDSR/ZTDSR+residue-ZT wheat+residue plots as compared to CT-Wheat and ZT-wheat. The density of *Phalaris minor, Rumex* spp., *Ranunculus arvensis, Anagalis arvesnsis, Melilotus* spp. and other weeds were significantly lower in ZTDSR/ZTDSR + residue-ZT wheat+residue plots as compared to CT transplanted rice-CT wheat, CT transplanted rice-ZT wheat and CTDSR-CT wheat. However, significantly lower density of *Medicago* spp. was observed in CT transplanted rice-CT wheat as compared to ZTDSR/ZTDSR+residue-ZT wheat+residue and CT transplanted rice-ZT wheat and it was statistically at par with CTDSR-CT wheat. The integrated weed management (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 highest grain yield and straw yield were recorded in ZT-DSR+residue-ZT wheat+residue which was significantly higher than CT transplanted rice-ZT wheat without residue. The highest B: C ratio was also recorded in ZT-DSR+residue-ZT wheat+residue. Among the weed management treatments, the integrated weed management [sulfosulfuron + metsulfuron (30+2 g/ha) at 30 DAS *fb* HW at 45 DAS] recorded significantly higher panicles/m^2, grains/panicle, test weight, grain and straw yield 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].

During *Kharif* 2019, the study area comprised of *Echinochloa* spp., *Cynodon dactylon* and *Digitaria sanguinalis* amongst grassy weeds; *Alternanthera philoxeroides, Caesulia axilaris, Phyllanthus niruri* and *Physalis minima* amongst broad-leaf weeds and *Cyperus* spp. were in rice. *Dactyloctenium aegyptium, Ammannia baccifera* and *Commelina benghalensis* were recorded as other weeds. Among the tillage and residue

Table 1.1.1.3 Effect of tillage and weed management practices on weed biomass in wheat (*Rabi* 2018-19)

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	4.59 (20.1)	6.01 (35.1)	7.49 (55.1	58.4	7.27 (51.9)	8.14 (65.2)	10.8 (117.2)	59.9	3.98
TRM 2	3.86 (13.9)	6.83 (45.8)	7.79 (59.6)	58.3	6.32 (38.9)	9.16 (83.0)	11.09 (121.9)	59.8	3.78
TRM 3	4.45 (18.8)	5.84 (33.1)	7.28 (52.0)	58.2	7.08 (49.2)	7.84 (60.5)	10.52 (109.6)	59.7	4.06
TRM 4	3.03 (8.2)	4.57 (19.9)	5.39 (28.1)	61.5	4.90 (23.1)	6.74 (44.4)	8.27 (67.5)	61.4	4.26
TRM 5	3.00 (8.0)	4.49 (19.2)	5.31 (27.2)	61.4	4.72 (21.3)	6.50 (41.2)	7.97 (62.5)	61.2	4.31
SEm ±	0.07	0.11	0.08		0.11	0.15	0.09		0.10
LSD (P=0.05)	0.21	0.37	0.27		0.35	0.50	0.31		0.35
Weed management									
Herbicide	2.83 (7.0)	3.84 (13.8)	4.67 (20.8)	81.7	4.65 (20.6)	4.57 (19.9)	6.44 (40.5)	83.4	4.38
IWM	1.55 (1.4)	1.79 (2.2)	2.15 (3.6)	97.0	1.95 (2.8)	1.98 (2.9)	2.59 (5.7)	97.9	4.66
Weedy	5.83 (33.0)	8.76 (75.8)	10.4 (108.8)	0.00	9.39 (87.2)	12.44 (153.8)	15.5 (241.0)	0.00	3.20
SEm ±	0.06	0.06	0.07		0.08	0.08	0.09		0.07
LSD (P=0.05)	0.17	0.19	0.20		0.24	0.23	0.25		0.21
Interaction	S	S	S		S	S	S		NS

Data were subjected to square root transformation $\sqrt{X+1}$. Original values are in parenthesi, S: significant, NS: non significant 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. The *Alternanthera philoxeroide* and *Caesulia axillaris* were significantly higher in transplanted rice as compared to DSR either under ZT and CT. However, the 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 test weight was found to be non-significant among different tillage and residue management treatments.

The IWM (pendimethalin 1 kg/ha *fb* bispyribac-sodium 25 g/ha *fb* hand weeding in DSR and bispyribac-sodium 25 g/ha *fb* hand weeding in transplanted rice) recorded significantly lowest density and biomass of weeds as compared to weedy check and herbicidal treatment (pendimethalin 1 kg/ha). The significant interaction was found between tillage and weed management treatments with respect to weed density and weed biomass. Amongst all the tillage, residue and weed management combinations, the highest net returns and B: C ratio was recorded in ZT-DSR+R and IWM treatment combination.

Rice-wheat cropping system

PAU, Ludhiana

During *Rabi* 2018-19 in wheat, study area was comprised with *Phalaris minor, Rumex dentatus, Coronopus didymus, Anagallis arvensis* and *Medicago denticulata*. Among tillage and residue management, at 60 DAS, PTR-CT had the highest density of *P. minor, R. dentatus* and *A. arvensis*. PTR-CT wheat with MB plough had significantly lower density of *P. minor* than all other treatments. Similarly, PTR-CT wheat with MB plough had lowest biomass of grasses and broadleaf weeds; in case of grassy weeds, biomass was significantly lower than all other treatments. All tillage and residue management treatments gave statistically similar wheat grain yield however yield attributes like panicle density and crop biomass varied significantly (**Table 1.1.1.5**).

Among weed management, recommended herbicide and IWM had similar density and biomass of *P. minor* at 60 DAS, which were significantly lower than weedy check. In case of *R. dentatus* and *M. denticulata*,

Table 1.1.1.4 Effect of tillage and weed management practices on weed biomass in rice (*Kharif* 2019)

Treatment	Weed biomass (g/m^2) at 60 DAS/DAT				WCE	Grain yield (t/ha)	Straw yield (t/ha)	B:C ratio
	Grassy	BLWs	Sedges	Total				
Tillage and residue management								
TRM 1	4.11 (15.9)	3.11 (8.6)	3.12 (8.8)	5.86 (33.3)	54.1	3.93	5.06	2.65
TRM 2	4.17 (16.4)	3.15 (8.9)	3.18 (9.1)	5.95 (34.5)	53.4	3.88	4.88	2.61
TRM 3	6.70 (43.9)	4.14 (16.1)	4.53 (19.5)	8.97 (79.5)	56.9	2.95	4.03	2.12
TRM 4	7.09 (49.2)	4.08 (15.7)	5.02 (24.2)	9.49 (89.1)	56.4	2.62	3.43	2.00
TRM 5	5.93 (34.1)	3.54 (11.5)	4.23 (16.9)	7.97 (62.5)	58.7	3.16	4.15	2.46
SEm ±	0.11	0.05	0.07	0.09		0.13	0.21	
LSD (P=0.05)	0.35	0.17	0.24	0.31		0.44	0.70	
Weed management								
Herbicide	4.83 (22.4)	2.80 (6.9)	2.82 (6.9)	6.10 (36.2)	72.3	3.83	4.97	2.76
IWM	1.98 (2.9)	1.00 (0.00)	1.93 (2.7)	2.58 (5.6)	95.4	4.16	5.47	2.82
Weedy	8.45 (70.4)	5.54 (29.7)	6.20 (37.4)	11.77 (137.5)	0.00	1.93	2.49	1.52
SEm ±	0.07	0.04	0.04	0.06		0.08	0.11	
LSD (P=0.05)	0.22	0.13	0.13	0.18		0.25	0.33	
Interaction	S	S	S	S		S	S	

Data were subjected to square root transformation $\sqrt{X+1}$. Original values are in parenthesis, S: significant, WCE: weed control effectively.

recommended herbicide (RH) had significantly higher density than IWM and higher broadleaf biomass than RH and weedy check. IWM and herbicides recorded similar grain yield which was significantly higher than weedy check. Treatment combination of PTR-HS wheat with IWM gave the highest grain yield which was at par to combination of PTR-HS/PTR-MB under unsprayed check. *P. minor*, *R. dentatus*, *A. arvensis* and *Poa annua* were major weeds in soil weed seed bank. PTR-CT wheat had the highest density of all these weeds in weed seed bank which were significantly higher than all other residue and tillage treatments except PTR-HS wheat in case of *R. dentatus*.

At harvest residues of metribuzin and clodinafop-propargyl, under recommended herbicide and IWM treatments, were below the detectable limit (<0.05 µg/g) in the soil and wheat grains. Significantly higher DHA and urease activity was observed in ZT treatment (ZT MTR (rice) - ZT HS (wheat)) as compared to CT, both under RH and IWM treatments. Counts of bacteria, actinomycetes and fungi were also significantly higher in ZT MTR (rice) - ZT HS (wheat) treatment as compared to CT on different days after herbicide treatment (DAHT).

Table 1.1.1.5 Effect of tillage, residue and weed management on growth, yield and yield attributes of wheat (*Rabi* 2018-19).

Treatments	Plant height (cm)			Ear height (cm)	Tiller density (no./m²)		Crop biomass (g/m²)		Grain yield (t/ha)	Straw yield (t/ha)
	30DAS	60DAS	At harvest	At harvest	60DAS	At harvest	60DAS	At harvest		
Tillage and residue management										
PTR-CT	17.5	38.3	96.8	11.1	468	444	157.1	1707.7	4.60	6.47
PTR- CT (MB)	17.5	36.9	97.7	10.8	363	366	134.8	1519.8	4.69	5.97
PTR- ZT (HS)	17.3	38.5	97.4	11.6	440	449	158.6	1877.1	4.74	7.49
ZT - ZT (HS)	18.0	37.7	97.7	11.5	541	511	180.0	1988.8	4.78	6.76
PTR- CT (Rotavator)	18.0	40.4	99.1	11.1	504	501	176.8	1813.2	4.77	7.17
LSD (P=0.05)	NS	NS	NS	0.3	106	46	27.1	257.6	NS	0.83
Weed management										
Weedy check	17.9	37.1	96.1	10.9	432	424	148.9	1678.6	4.33	6.41
RH	17.2	39.0	97.8	11.2	475	460	166.9	1795.5	4.85	6.97
IWM	17.6	38.9	99.2	11.4	483	479	168.6	1870.0	4.95	6.93
LSD (P=0.05)	NS	NS	NS	0.2	NS	NS	NS	42.4	0.15	NS
Interaction LSD(P=0.05)	NS	NS	NS	NS	S	NS	S	NS	S	NS

During *Kharif* 2019, *Echinochloa colona* and *Echinochloa crus-galli* amongst grasses and *Cyperus iria* amongst sedge infested the rice crop. There was clear cut shift in weed flora, as there was more number of *E. colona* in 2019 and also recorded *C. iria* which was not present in 2018. Similarly, two broadleaf weeds (*Eclipta alba* and *Digera arvensis)* which were recorded in 2018 were not observed in 2019. Among tillage and residue management treatments, at 60 DAT, ZT rice had significantly higher density of *E. colona* and *C. iria* than all other treatments; it also had significant higher biomass of grass weeds than all other treatments however the broadleaf weed biomass was highest under PTR-HS treatment. PTR-ZT wheat recorded the highest rice grain yield (6.62 t/ha) which was at par to PTR-CT (MB) (6.52 t/ha) and significantly higher than PTR-CT and ZT-ZT treatments. Among weed control, IWM recorded significantly lower population and dry biomass of grass and sedge weeds as compared to recommended herbicides and unweeded control. IWM and RH gave statistically similar grain yield to weedy check .

Interaction effects of tillage, residues and weed management were significant for seed bank of *E. colona*, *E. crus-galli, D. aegypticum* and *C. rotundus.* Harvest time residues of penoxsulam and cyhalofop-butyl in soil and rice grains were below detectable limit. Significantly higher DHA and urease activity was observed in ZT treatment [ZT MTR (rice) - ZT HS (wheat)] as compared to CT, both under RH and IWM treatments. Irrespective of tillage and residue management treatments, increased enzyme activity was observed under IWM as compared to RH alone (**Table 1.1.1.6**).

Table 1.1.1.6 Effect of tillage, residue and weed management on weed seed bank in rice (*Kharif* 2019)

Treatment	No. of seeds/m² up to the depth of 15 cm			
	E. colona	*E. crus-galli*	*D. aegyptium*	*C. rotundus*
Tillage and residue management				
PTR-CT	14.2 (205)	18.4 (351)	17.4 (306)	22.8 (532)
PTR- CT (MB)	13.6 (188)	18.1 (331)	20.3 (414)	20.1 (435)
PTR- ZT (HS)	13.1 (175)	17.5 (326)	21.5 (482)	19.6 (393)
ZT - ZT (HS)	12.5 (157)	15.5 (274)	20.7 (432)	17.0 (287)
PTR- CT (Rotavator)	12.6 (162)	17.7 (319)	21.3 (455)	18.9 (357)
SEm±	0.24	0.20	0.40	0.33
LSD (P=0.05)	0.45	0.37	0.75	0.61
Weed management				
Weedy check	14.1 (200)	18.6 (363)	21.6 (473)	21.1 (478)
RH	13.5 (184)	16.8 (301)	20.9 (441)	19.6 (391)
IWM	12.1 (148)	16.8 (297)	18.2 (339)	18.2 (334)
SEm±	0.39	0.26	0.35	0.24
LSD (P=0.05)	0.50	0.34	0.45	0.32
Interaction LSD (P=0.05)	S	S	S	S

Data subjected to square root transformation; Figure in parentheses are means of original value.

Rice-wheat-sesbania cropping system

GBPUAT, Pantnagar

In wheat (2018-19), experimental plot comprised with *Phalaris minor, Chenopodium album, Coronopus didymus, Solanum nigrum, Rumex acetosella, Medicago denticulata, Melilotus indica, Melilotus alba, Fumaria parviflora,* and *Mollugo* spp. in which major weed species were *Phalaris minor* (18.3%), *Coronopus didymus* (15.8%), *Rumex acetosella* (13.8%), *Mollugo* spp. (11.6%) and *Chenopodium album* (10.1%) at 60 DAS.

Conventional TPR along with residue incorporation and ZT wheat + residue retention and *Sesbania* incorporation recorded minimum density of weeds amongst all the treatments. Majority of the grassy and broad-leaf weeds were controlled by conventional till system TPR as well as DSR with residue incorporation followed by ZT wheat + residue retention and *Sesbania* incorporation. However, complete removal of *Mollugo* spp. was observed under all the treatments except conventional till system TPR as well as DSR with incorporation of residue and ZT wheat + residue retention and *Sesbania* incorporation. Rice TPR with incorporation of residue and ZT wheat + residue retention and *Sesbania* incorporation attained lowest total weed density and total weed dry biomass grassy as well as broad leaf weeds. The highest plant height (97.8 cm), number of spikes per m^2 (319.4 no./m^2), grain yield (4.68 t/ha) and straw yield (7.18 t/ha) were achieved with rice DSR followed by CT wheat without residue and *Sesbania* incorporation. The highest net return and benefit cost ratio of ₹ 78,581 and 3.2 was recorded in the plots, where, wheat was sown in the rice (DSR) followed by CT wheat without incorporation of residue and *Sesbenia* (**Table 1.1.1.7**).

Among weed management practices, the minimum population of all weed species was obtained under IWM approach (clodinafop propargyl + MSM 60+4 g/ha as post emergence *fb* one hand weeding at 60 DAS) followed by clodinafop propargyl + MSM 60+4 g/ha as post emergence and both the treatments reduced the population of weed species over the weedy situation. However, IWM achieved lowest total weed density and weed dry weight of all grassy and broad leaf weeds leads to obtained highest grain yield (4.73

t/ha) and found significantly superior to rest of the practices. Clodinafop-propargyl + MSM 60+4 g/ha recorded the highest net return (₹ 52,385) and highest benefit cost ratio (2.7) which was similar to weedy check (**Table 1.1.1.9**).

Table 1.1.1.7 Effect of establishment methods and weed management on weed dry biomass at 60 DAS, yield and economics in wheat crop in the rice-wheat cropping system (*Rabi* 2018-19).

Treatment	Weed dry biomass (g/m^2)		Grain yield (t/ha)	Straw yield (t/ha)	Net return (₹/ha)	B:C ratio
	Grassy	BLWs				
Establishment method						
Rice (TPR)-Wheat (CTW)	1.4(1.4)	2.7(6.5)	4.42	6.63	71,488	2.9
Rice (TPR) + RC- Wheat (CTW)+R-*Sesbenia* (INC)	1.6(1.2)	2.9(7.9)	4.02	6.10	37,731	2.0
Rice (TPR) + RC- Wheat (ZTW)+RR-*Sesbenia* (INC)	1.2(0.4)	2.3(4.5)	4.59	6.84	53,990	2.8
Rice (DSR) -Wheat (CTW)	1.3(0.9)	2.8(7.3)	4.68	7.18	78,581	3.2
Rice (DSR) + R-Wheat (CTW)+R-*Sesbenia*(INC)	1.2(0.7)	2.6(6.0)	4.39	6.81	44,416	2.2
Rice (DSR) + R- Wheat (ZTW)+RR-*Sesbenia* (INC)	1.7(2.0)	3.4(14.1)	4.42	6.64	50,800	2.6
SEm±	0.06	0.04	0.08	0.15		
LSD (P=0.05)	0.18	0.14	0.27	0.47		
Weed management						
Rec.herb. (Clodinafop + MSM 60+4 g/ha)	1.2(0.6)	2.5(5.1)	4.44	6.62	57,181	2.7
IWM (Rec. herbicide + one hand weeding)	1.1(0.3)	1.9(2.5)	4.73	7.33	52,385	2.4
Unweeded	1.9(2.7)	3.9(15.6)	4.10	6.14	52,936	2.7
SEm±	0.04	0.05	0.03	0.08		
LSD (P=0.05)	0.12	0.16	0.09	0.24		

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

In rice during *Kharif* 2019, experimental field was comprised with *Echinochloa colona*, *Echinochloa crus-galli*, *Leptochloa chinensis*, *Alternanthera sessilis*, *Ischaemum rugosum*, *Panicum maximum*, *Caesulia axillaris*, *Ammania baccifera*, *Cyperus rotundus*, *Cyperus iria* and *Cyperus difformis* and the major weed species recorded were *Leptochloa chinensis* (11.8%), *Panicum maximum* (15.2%), *Ammania baccifera* (13%), *Cyperus iria* (20%) and *Cyperus difformis* (14%). At 60 DAS/T, among tillage methods, the lowest total weed density and total weed dry biomass of grassy weeds was observed with rice (TPR) incorporated with residue followed by ZT wheat + residue retention and *Sesbania* incorporation, whereas BLWs, rice (DSR) followed by CT wheat without incorporation of residue and *Sesbania*. However, the lowest sedges were observed with rice (TPR) with residue followed by ZT wheat along with residue retention and *Sesbania* incorporation. The highest grains per panicle, grain yield (5.1 t/ha) and straw yield (9.3 t/ha) of rice were achieved under rice (TPR) incorporated with residue and *Sesbania* followed by ZT wheat with residue retention and *Sesbania* the highest net return and benefit cost ratio of ₹ 44,305 and 2.0 followed by ZTW with residue retention (**Table 1.1.1.8**).

IWM (Rec. herbicide *fb* one hand weeding at 45 DAS/DAT) achieved lowest total weed density and total weed dry biomass of all grassy and non grassy weeds over the un-weeded situation. Similarly, IWM found superior towards recording highest yield attributing characters and yield of rice which was significantly superior to recommended herbicide practice and unweeded situation resulted in IWM recorded the highest net return (₹48,208) and highest benefit cost ratio (2.1).

Table 1.1.1.8 Effect of establishment methods and weed management practices on total weed density, dry biomass at 60 DAS/DAT and yield of rice in the rice-wheat cropping system

Treatments	Grassy		BLWs		Sedges		Grain yield (t/ha)	Straw yield (t/ha)
	Density (no./m2)	Dry biomass (g/m2)	Density (no./m2)	Dry biomass (g/m2)	Density (no./m2)	Dry biomass (g/m2)		
Tillage and residue management								
Rice (TPR)-Wheat (CTW)	4.8(28.0)	4.3(23.6)	4.5 (21.3)	2.2 (4.6)	2.9(13.3)	2.9(15.5)	4.24	7.8
Rice (TPR) + R- Wheat (CTW)+R-*Sesbenia* (INC)	5.0(28.9)	4.6(27.8)	5.0(25.7)	2.5 (5.8)	2.6(11.1)	2.5 (9.9)	5.05	9.1
Rice (TPR) + R- Wheat (ZTW)+RR-*Sesbenia* (INC)	3.9(19.1)	3.8(24.1)	5.3(28.4)	2.6 (6.0)	2.8(13.3)	3.8(28.7)	5.1	9.3
Rice (DSR) -Wheat (CTW)	5.5(36.4)	10.0(114.3)	1.4(1.3)	1.6(1.7)	4.5(29.2)	4.4(25.3)	3.45	6.0
Rice (DSR) + R-Wheat (CTW)+R-*Sesbenia* (INC)	5.5(40.0)	7.9(78.5)	2.6(8.9)	2.5 (7.3)	5.2(36.9)	4.6(30.9)	3.75	7.0
Rice (DSR) + R- Wheat (ZTW)+RR-*Sesbenia*(INC)	4.8(25.7)	6.8(69.6)	3.6(12.7)	3.2(10.8)	3.9 (40.8)	4.2(32.2)	3.65	6.8
SEm±	0.05	0.2	0.07	0.03	0.06	0.09	0.1	0.2
LSD (P=0.05)	0.15	0.6	0.2	0.08	0.20	0.3	0.4	0.5
Weed management								
Rec.herb. (Penoxsulam + cyhalofop – butyl 135 g/ha (15-20 DAS/DAT)	4.1(16.2)	4.7(29.6)	3.6(14.7)	2.2 (4.3)	2.9(10.4)	1.9 (3.9)	4.3	8.8
IWM (Rec. herbicide *fb* one hand weeding at 45 DAS/DAT)	2.5(5.1)	2.9(9.7)	2.5(6.5)	1.5 (1.5)	1.1(0.2)	1.2 (0.8)	5.3	9.8
Unweeded	8.2(67.7)	11.0(129.5)	5.2(28.0)	3.7(13.0)	7.8(61.7)	8.1(66.6)	2.5	4.5
SEm±	0.06	0.12	0.05	0.04	0.05	0.07	0.1	0.1
LSD (P=0.05)	0.17	0.4	0.14	0.1	0.14	0.2	0.2	0.4

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

Rice- rapeseed- greengram cropping system

BCKV, Kalyani

In greengram at 30 DAS, field comprised with *Cynodon dactylon, Digitaria sanguinalis* and *Dactyloctenium aegyptium* as major grassy weed, *Cyperus rotundus* as sedge, *Phylanthus niruri, Trianthema portulacastrum* and *Physalis minima* as broad-leaf weeds. CTTP-CT-CT recorded the lowest weed density and weed biomass (38.1 no./m^2 and 19.7 g/m^2, respectively) with higher WCE (46.8%) and highest density and dry biomass with MT-MT-MT (60.7 no./m^2 and 37.0 g/m^2, respectively). Similar trend was recorded at 60 DAS. CTTP-CT-CT recorded with better growth and more yield attributes thus resulted in higher grain and straw yield (1.19 and 2.80 t/ha, respectively), whereas the lowest yield recorded with MT-MT-MT treatment (0.97 and 1.97 t/ha, respectively). Similarly, the economic parameters *viz.*, net return and B: C were found highest with CTDSR-CT-MT (40728.3 ₹/ha and 1.85, respectively).

Among weed management practices, at 30 DAS, treatment receiving quizalofop-ethyl 50 g/ha at 20 DAS + mechanical weeding at 30 DAS recorded least weed density and weed biomass (22.7 no./m^2 and 9.8 g/m^2, respectively), resulted in highest WCE (75.86%) followed by the treatment receiving quizalofop-ethyl 50g/ha at 20 DAS (29.06%) over control. Quizalofop-ethyl 50 g/ha at 20 DAS + mechanical weeding at 30 DAS recorded better growth and yield attributes resulted in higher grain and straw yield (9.8 and 1.08 t/ha, respectively) with higher net returns and B:C (₹ 34,940.7 ₹/ha and 1.80, respectively). The lowest yield and return was recorded with one hand weeding at 30 DAS.

Kharif 2019, 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, Eclipta alba* and *Monochoria vaginalis* amongst broad leaved weeds. At 60 DAS, CT-TR worked better over CT-DSR and MT-DSR. MT-DSR + R showed less weed number (38.7/m^2) and biomass (8.8 g/m^2) than MT-DSR with weed number (62.2/m^2) and weed dry biomass (18.5 g/m^2). Reduction in density and dry biomass of weeds leads to maximum grain (2.37 t/ha) and straw yield (5.33 t/ha) with CT-TR followed by CT-DSR (2.34 and 5.27 t/ha, respectively) over MT-DSR + R (2.31 and 5.16 t/ha, respectively).

Among weed management practices, pretilachlor 0.75 kg/ha PRE followed by bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT showed least weed number (20.4/m^2) and weed dry biomass (5.5 g/m^2) as compared to other treatments. This resulted in higher yield attributes, grain and straw yield (2.40 and 5.40 t/ha, respectively), net return (₹ 1,22,414/ha) and B:C ratio (1.98).

Rice-mustard-green manure cropping system

AAU, Jorhat

In rice, field comprised of *Ageratum houstonianum* and *Polygonum glabrum* as broad-leaf weeds *Cynodon dactylon, Panicum repens, Digitaria setigera, Echinochloa crus-galli* and *Eleusine indica* as grasses and *Cyperus rotundus* was predominant sedge in the DSR. However, in the plots where rice was transplanted, weed flora was little different; *Fimbristylis littoralis, Cyperus iria,* and *Scirpus juncoides* were the most prevalent sedges. Moreover, *Monochoria vaginalis* and *Sagittaria guayanensis* amongst the broadleaf weeds and *Echinochloa crus-galli, Leersia hexandra* and *Sacciolepis interrupta* were the dominant grassy weeds. Under CT-DSR, weed density was significantly higher than any other tillage practice treatments. The grain and straw yield of rice increased under MT (DSR) (2.77 and 5.08 t/ha, respectively) followed by CT (TR) (2.51 and 4.33 t/ha, respectively) as compared to CT (DSR) and other tillage treatments. Among the weed management treatments, the lowest weed density and dry biomass at 60 DAS was observed in pretilachlor 0.75 kg/ha + hand weeding 30 DAS which was closely followed by recommended herbicide pretilachlor 0.75 kg/ha. Although, weed parameters were more in two hand weeding, still it could obtained the highest grain and straw yield (2.24 and 3.68 t/ha, respectively) followed by pretilachlor 0.75 kg/ha as well as weedy check.

In *Rabi* 2018-19, the main weeds observed in the field of Indian mustard crop were, *Acmella calva, Polygonum viscosum, Vicia sativa, Polygonum hydropiper, Grangea maderaspatana, Gynura bicolor, Sphaeranthus indicus, Pseudognaphalium luteoalbum etc.* It was revealed that under CT system weed density and weed dry matter were significantly higher than other tillage practices.

Under CT system, weed density and weed dry biomass were significantly higher than other tillage practices. The plant height and yield attributes like number of siliqua/plant and seed yield were significantly increased under MT(DSR)- MT+R (IM) as compared to CT(TR)-CT(IM) and CT(TR)-MT(IM) treatments. However, all other tillage practices were found statistically at par for seed yield. Among the weed management treatments, the lowest weed density and dry biomass at 25 DAS were observed in pendimethalin 0.75 kg/ha + hand weeding 25 DAS which was closely followed by pendimethalin 0.75 kg/ha. The plant height of mustard were significantly enhanced in pendimethalin 0.75 kg/ha pre-em + hand weeding 25 DAS and hand weeding 25 DAS as compared to other treatments. Better growth and yield attributes in pendimethalin 0.75 kg/ha pre-em + hand weeding 25 DAS and hand weeding 25 DAS resulted significantly the higher seed yield as compared to recommended herbicide (pendimethalin 0.75 kg/ha pre-em) as well as weedy check.

Rice-wheat-cowpea fodder cropping system IGKV, Raipur

In wheat 2018-19, the experimental field was heavily infested with *Medicago denticulata* followed by *Echinochloa colona* and *Chenopodium album*. The other weed flora was *Anagalis arvensis, Melilotus indica, Rumex dentatus,* etc. in lower number. The *Medicago denticulata* was the most serious weed. At 60 DAS, weed density and dry biomass was recorded lowest ZT (direct seeded) +R-ZT+R followed by ZT with residue as compared to CT-CT and CT-ZT. The higher grain yield (3.22 t/ha) was obtained under ZT(DSR)+R-ZT with residue compared to ZT(DSR)-ZT without residue tillage (3.17 t/ha). However, CT (TPR) – CT / ZT and CT (DSR) - CT comparable with each other, although it was significantly lower yield than that of ZT (DSR)+R-ZT+R. Similarly, the net returns and B:C ratio was also higher under ZT with residue.

Among weed management practices, weed density and dry biomass were recorded lowest under integrated weed management (clodinofop 0.06 kg/ha + metsulfuron 0.004 kg/ha PoE *fb* HW 40 DAS) over recommended herbicide (clodinofop 0.06 kg/ha + metsulfuron 0.004 kg/ha) and control. The higher grain yield was recorded under integrated weed management which was at par with recommended practice and both were significantly superior over control. Integrated weed management found more profitable in terms of net return as well as B: C ratio over recommended herbicide practice (**Table 1.1.1.9**).

Table 1.1.1.9 Weed biomass yield and economics as influenced by weed management practices in conservation agriculture in wheat in *Rabi* 2018-19

Treatments	Weed dry biomass (g/m^2)	Grain yield (t/ ha)	Net return (₹/ha)	B:C
Tillage				
CT (Transplanted) -CT-CT	5.28 (27.4)	2.90	33207	2.58
CT (Transplanted) -ZT-ZT	4.64(21.0)	2.98	37763	3.15
CT (Direct seeded)-CT-ZT	5.18(26.3)	2.97	34501	2.64
ZT (Direct seeded)-ZT+R-ZT	4.40(18.9)	3.17	41253	3.38
ZT (Direct seeded)+R - ZT+R-ZT+R	4.36(18.6)	3.22	42022	3.43
SEm±	0.19	0.08	-	-
LSD (P= 0.05)	0.40	0.23	-	-
Weed management				
Recommended (Clodinofop 0.06kg/ha+ metsulfuron 0.004 kg/ ha PoE)	3.48(11.6)	3.70	48675	3.34
Integrated (Clodinofop 0.06 kg/ha + metsulfuron 0.004 kg/ha PoE *fb* HW 40 DAS)	3.33(10.6)	3.93	52502	4.54
Weedy check	6.19(37.9)	1.52	12071	2.41
SEm±	0.17	0.14	-	-
LSD (P= 0.05)	0.52	0.39	-	-

In cowpea 2019, the experimental field was dominated by *Echinochloa colona* and *Cynodon dactylon* among grasses and *Alternanthera triandra* was found as major broad-leaf weed. Significantly lower weed dry biomass was recorded under ZT (DSR) + R-ZT+R-ZT+R than other crop establishment methods. Green fodder yield was remarkably higher under ZT with residue than CT/ZT without residue. The highest net return and benefit: cost ratio obtained under ZT (DSR) +R-ZT +R-ZT+R followed by ZT (DSR)-ZT+R-ZT. It was found that ZT+R had 17.4% higher resource use efficiency over CT, ZT with no residue had shown 4.7% higher efficiency over CT.

Application of pendimethalin 1.0 kg/ha as PE *fb* one hand weeding at 20 DAS leads to higher fodder yield. Similarly, highest net returns and benefit: cost ratio were under the IWM. The IWM recorded resource use efficiency by 161.3% followed by recommended herbicide 145.1% over unweeded.

In rice 2019, weed flora of the experimental field consisted of *Echinochloa colona* among grasses, *Cyperus iria* among sedges and *Alternanthera triandra* among broad-leaf weeds. Broadleaved and sedges were dominated over grasses. Other weeds like *Brachiaria ramosa*, *Sporobolus diander*, *Cynotis axillaris, Commelina benghalensis, Ludwigia parviflora,* etc. were also found in irregular and less number. *Cyanotis axillaris* and *Sporobolus diander* being late *Kharif* weeds dominated the weed flora during maturity of crop.

The lowest weed density and weed dry biomass were found under CT (Transplanted) over CT (DSR), ZT (DSR) and ZT (DSR) with residue at all the stages. However, in case of DSR, weed density and dry biomass was lower in ZT (DSR) with residue as compared to ZT alone, this might be due to retaining crop residues between rows. Lower weed parameters leads to better yield attributes resulted in higher seed and straw yield found under CT (Transplanted). The net income was higher under ZT (DSR)+R followed by ZT (DSR). While, highest B:C ratio (4.06) was also achieved in ZT(DSR) +R closely followed by ZT (DRS).

As regards to weed management the lower density and dry biomass of total weeds was less under IWM followed by recommended herbicide over control. Although, significant variation in grain yield was obtained and significantly, higher grain yield was recorded under IWM practices followed by pyrazosulfuron 0.02 kg/ha *fb* penoxsulam 0.225 kg/ha PoE. Both the weed management practices were significantly superior over untreated control. Lower weed parameters and higher yield resulted in higher net return and B:C ratio was oxadiargyl 0.08 kg/ha PE *fb* hand weeding at 25 DAT/S followed by pyrazosulfuron 0.02 kg/ha *fb* penoxsulam 0.225 kg/ha PoE (**Table 1.1.1.10**).

Table 1.1.1.10 Weed dry biomass, seed yield and economics of rice as influenced by weed management practices in conservation agriculture *Kharif* 2019.

Treatment	Weed dry biomass at 60 DAS/T (g/m)^2	Grain yield (t/ha)	Net income (₹/ha)	B:C Ratio
Crop establishment method				
CT (Transplanted)-CT-CT	3.55 (12.1)	5.78	65,173	2.87
CT (Transplanted)-ZT-ZT	4.07(16.1)	5.62	62,215	2.78
CT (Direct seeded) _CT_ZT	6.05(36.1)	4.95	59,496	3.33
ZT (Direct seeded) -ZT+R-ZT	6.22 (38.1)	5.09	65,496	3.99
ZT(Direct seeded)+ R-ZT+R-ZT+R	5.71(32.1)	5.17	67,088	4.06
SEm±	0.27	0.14	-	-
LSD (P= 0.05)	0.90	0.46	-	-
Weed management				
Recommended (pyrazosulfuron 0.02 kg/ha *fb* penoxsulam 0.225 kg/ha PoE	4.20(17.1)	5.95	65,925	3.12
Integrated weed management (oxadiargyl 0.08 kg PE *fb* hand weeding at 25 DAT/S	2.99(8.4)	6.51	80,094	3.96
Unweeded	8.17(66.3)	3.52	27,483	2.08
SEm±	0.20	0.18	-	-
LSD (P= 0.05)	0.59	0.54	-	-

WP 1.1.2 Weed management in maize-based cropping systems

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

Maize–sunflower–dhaincha (*Sesbania aculeata*) cropping system

TNAU, Coimbatore

Weed flora of the experimental field predominantly consisted of thirteen species of broad-leaf weeds, six species of grasses and a sedge weed. The predominant among broad-leaf weeds were *Amaranthus viridis, Cleome viscosa* and *Parthenium hysterophorus*. Among the grass weeds, *Cynodon dactylon, Setaria verticiliata* and *Chloris barbata* were the dominant ones. *Cyperus rotundus* was the only sedge weed present in the experimental field.

In sunflower, among tillage methods, significantly lower total weed density and dry weight (2.13/m^2 and 0.90 g/m^2), respectively were recorded in ZT in ZT+R-ZT+R system at 30 DAS resulted in higher WCE of 81.4% at 45 DAS. Better weed suppression recorded significantly higher plant height (168.4 cm), dry matter production (6.86 t/ha), higher seed yield (1.62 t/ha), higher net return (₹ 8,921/ha) and B:C ratio of 1.37. Among weed management practices, PE pendimethalin at 1.0 kg/ha, recorded lower weed density and dry biomass (12.10 / m^2 and 4.67 g / m^2) respectively with WCE (70.9%) it was followed by PE pendimethalin at 1.0 kg/ha + HW on 45 DAS. Better weed suppression recorded significantly higher plant height (163.9 cm), dry matter production (6738 kg/ha), higher seed yield (1.96t/ha), higher net return (₹14,362/ha) and B: C ratio of 1.45 (**Table 1.1.1.2.1**).

In maize, among tillages significantly lower total weed density and dry biomass was recorded in CT in ZT+R-ZT+R system at 30 DAS. However, at 45 DAS, higher WCE of 81.7% was recorded in ZT in ZT+R-ZT+R system led to significantly taller plant, higher dry matter production, higher grain yield, higher net return and B: C ratio.

Among weed management practices, PE atrazine at 0.5 kg/ha *fb* HW on 45 DAS recorded lower weed density and dry biomass (with higher WCE (73.9%). This resulted in taller plants (252 cm) and higher dry matter production at 60 DAS and seed yield.

Table 1.1.1.2.1 Effect of tillage and weed management practices on weed density, weed dry biomass and WCE in of sunflower and maize

Treatment	Sunflower (*Rabi*, 2018-19)			Maize (*Kharif*, 2019)		
	Total weed density (no./m ^{2})	Total weed dry biomass (g/m^2)	WCE (%)	Total weed density (no./m ^{2})	Total weed dry biomass (g/m^2)	WCE (%)
Tillage methods						
T1(CT-CT)	7.31(54.0)	4.62(20.4)	60.1	7.47(55.7)	6.17(38.0)	62.5
T2(CT-ZT)	5.43(31.0)	4.51(18.9)	63.8	9.12(80.2)	5.73(32.3)	53.2
T3(ZT+R-ZT)	7.01(48.0)	4.97(22.7)	65.2	9.69(93.8)	6.59(43.0)	62.1
T4(ZT-ZT+R)	2.65(5.0)	1.89(1.6)	70.3	6.84(45.3)	4.96(21.7)	73.1
T5(ZT+R-ZT+R)	1.89(2.13)	1.70(0.90)	76.3	8.48(70.3)	6.61(44.0)	55.8
SEd	0.03	0.037	-	0.09	0.10	-
CD(P=0.05)	0.09	0.08	-	0.21	0.25	-
Weed management						
Recommended herbicides	4.92(19.2)	3.5(9.43)	61.7	6.16(38.0)	4.02(17.6)	61.7
Integrated weed management	3.47(12.1)	2.17(4.7)	71.6	5.13(27.4)	3.39(12.2)	71.0
Unweeded control	7.52(56.0)	5.71(32.3)	-	10.9(118.2)	7.83(61.2)	-
SEd	0.07	0.03	-	0.09	0.08	-
CD(P=0.05)	0.14	0.06	-	0.19	0.16	-

Maize-wheat cropping system (year of commencement *Kharif* 2013)

CSKHPKV, Palampur

In wheat 2018-19, the population of *Lolium temulentum* was lowest under ZT-ZT which remained statistically at par with ZT-ZTR and CT-ZT. Population of *Avena* sp. and *Phalaris minor* was significantly lower under CT-ZT which was statistically alike with ZT-ZTR. The count of *Vicia sativa* was minimum under CT-CT followed by CT-ZT and ZT-ZT. The ZT-ZTR had lower population of C*ornopous* sp. which was at par with ZTR-ZTR. The CT-CT had lowest weed population of *Dacus carota* and *Poa annua* during 90 DAS of wheat crop. Tillage as well as weed management treatments significantly affected the grain and straw yield of wheat. CT-ZT had highest grain yield which was statistically at par with those under ZTR-ZTR and CT-CT. On the other hand, CT-CT resulted in significantly higher wheat straw yield which remained alike to ZTR-ZTR and CT-ZT. Tillage treatments did not significantly affect the intercrop grain and straw yield i.e. sarson grown in replacement series in integrated weed management treatment

In maize, tillage treatments resulted in significant variation in the population of *Cyprus* sp., *Commelina benghlensis, Digitaria* sp., *Ageratum* sp., *Echinochloa* sp. and *Polygonum alatum* at 60 DAS. *Panicum* sp., population was not significantly affected by the tillage treatments. ZTR-ZTR behaving statistically alike with ZT–ZT and ZT-ZTR resulted in significantly lower population of *Cyperus* sp. as compared to other treatments. In case of *Commelina benghalensis,* ZT-ZT remained at par with CT-ZT. The CT-ZT had lower population of *Digitaria* sp. as compared to other tillage treatments which remained statistically similar with CT-CT, ZT-ZT and ZTR-ZTR. The population of *Ageratum* sp. was significantly lower under ZTR-ZTR. The population of *Echinochloa* sp. was the minimum in ZTR-ZTR. ZT-ZTR had lowest population of *Polygonum alatum* at 60 DAS which was at par with ZT-ZT and ZTR-ZTR. The green cob yield, stover yield of maize and grain and straw yield of intercrop was influenced by intensity of tillage. The yield levels realized were satisfactory but below the potential yield levels. There was non-significant variation in seed and straw of intercrop planted in additive series in maize due to tillage. Among tillage treatments, CT-ZT behaving

Table 1.1.1.2.2 Effect of weed control treatments on wheat grain equivalent yield (kg/ha/annum), gross returns (₹/ha/annum) and net returns (₹/ha/annum), cost of cultivation (₹/ha/annum) in the wheat-maize cropping system

Treatment (Maize – wheat)	Wheat grain equivalent yield (t/ha)	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B: C ratio
Tillage					
CT-CT	9.9	114.6	327.5	212.9	2.9
CT-ZT	10.6	107.5	341.0	233.5	3.3
ZT-ZT	9.0	100.2	283.9	183.7	2.9
ZT-ZTR	9.4	108.7	301.7	193.0	2.9
ZTR-ZTR	10.9	115.4	348.7	233.3	3.1
SEm±	0.3	-	-	-	-
LSD (P=0.05)	0.9	-	-	-	-
Weed management					
H-H	10.5	86.8	343.9	257.1	4.0
IWM-IWM	8.2	113.3	271.4	158.2	2.4
HW-HW	11.0	127.7	346.3	218.6	2.7
SEm±	0.4	-	-	-	-
LSD (P=0.05)	1.4	-	-	-	-

CT, conventional tillage; **ZT,** zero tillage; R, residues; **H,** herbicide; **IWM-IWM,** integrated weed management; **HW,** hand weeding; figures with the same sign as superscript mean statistically similar statistically alike with ZTR-ZTR had significantly higher green cob yield as compared to other tillage practices, whereas ZTR-ZTR remaining at par with CT-ZT resulted in significant higher stover yield of maize. (**Table 1.1.1.2.2**).

MPUAT, Udaipur

In wheat, the major monocot weeds observed in the experimental fields were *Avena ludoviciana* (5.9%) and *Phalaris minor* (6.3%) where as the dicot weeds were *Chenopodium album* (38.5%), *Chenopodium murale* (24.7%), *Fumaria parviflora* (8.1%), *Melilotus indica* (8.2%), *Convolvulus arvensis* (4.8%) and *Malwa parviflora* (3.5%). At 60 DAS and at harvest, broad-leaf weeds were dominant (87.7%) where *Chenopodium album* and *Chenopodium murale* consisted of 60% and monocot weeds were only with 12.3%. The dry biomass accumulation of monocots as well as dicot weeds were recorded maximum in maize (CT)-wheat (ZT)-greengram (ZT). Minimum total weed dry biomass were observed under maize (ZT+R)-wheat (ZT+R)-greengram (ZT+R) establishment method. Grain, stover yield and harvest index of maize was comparable with tillage and residue management practices. Similarly, maximum net return (₹ 62,926/ha) and B: C ratio (2.42) 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 (IWM) recorded lower weed density and dry biomass followed by sulfosulfuron + metsulfuron 30 + 2 g/ha at 30 DAS over the weedy cheek. Lower weed parameters under IWM resulted in significant enhancement of plant height, grains/spike, 1000 seed weight, highest grain yield (4.45 t/ha) and stover yield (6.00 t/ha) which resulted to increase in yields of 34.8% and 18.1%, respectively, over weedy check. The maximum net return (₹ 57,570/ha) and B:C ratio (2.18) recorded with IWM.

In maize during *Kharif* 2019, dominant weed species in the experimental field were *Echinochloa colona* (31.9%), *Dinebra retroflexa* (16.4%), *Commelina benghalensis* (15.3%), *Digera arvenris* (14.3%), *Trianthema partulacastrum* (15.0%) and *Corchorus olitorious* (7.1%). Among tillage and residue management treatments, dry biomass accumulation of broad-leaf weeds were recorded maximum in maize (ZT)-wheat (ZT)-greengram (ZT), while the weed dry biomass of monocot weeds were almost same with different establishment methods. Minimum weed dry matter of monocot and dicot weeds were observed under maize (CT)-wheat (CT)- greengram (CT). The yield attributes like length and width of cobs, cob weight and 1000 seed weight show non-significant variation under different tillage and residue management. Similarly, grain and stover yield failed to record significant response with different tillage and residue management practices. The maximum net return (₹ 47,171 /ha) and BC ratio (2.49) was recorded with maize (ZT)-wheat (ZT)- greengram (ZT).

Minimum number of weeds was observed at 60 DAS and at harvest by application of atrazine 500 g/ha PE *fb* hand weeding at 30-35 DAS. Similar trend was observed by weed dry biomass both at 60 DAS and at harvest. Amongst different weed management practices, the highest grain yield (3.15 t/ha) and stover yield (4.66 t/ha) were obtained by controlling weeds with application of atrazine 500 g/ha PE *fb* tembotrione 125 g/ha PoE through IWM however, it was at par with application of atrazine 500 g/ha as PE with hand weeding (IWM). The magnitude of increase in grain and stover yield by this treatment was to the tune of 67.8% and 72.9%, respectively, over weedy check. The maximum net return (₹ 55,071/ha) was realized by atrazine 500 g/ha PE *fb* hand weeding at 30 DAS and B: C (2.74) with application of atrazine 500 g/ha PE *fb* tembotrione 125 g/ha PoE. Amongst different weed management practices, the highest grain yield (3.15 t/ha) and stover yield (4.66 t/ha) were obtained by controlling weeds with application of atrazine 500 g/ha PE *fb* tembotrione 125 g/ha PoE through IWM however, it was at par with application of atrazine 500 g/ha as PE with hand weeding (IWM). The magnitude of increase in grain and stover yield was 67.8 and 72.9%, respectively over weedy check. The maximum net return (₹ 55,071/ha) was realized by atrazine 500 g/ha PE *fb* hand weeding at 30 DAS and B: C (2.74) with application of atrazine 500 g/ha PE *fb* tembotrione 125 g/ha PoE.

Maize-greengram cropping system

UAS, Bengaluru

In greengram during *Rabi* 2018-19, major weed flora observed in the experimental plots was *Cyperus rotundus* (among sedges), *Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium,* (among grasses). Whereas, among broad-leaf weeds, major weeds were, *Euphorbia hirita, Commelina benghalensis*, *Boreria hispida, Alternanthera sessilis, Ageratum conyzoides* and *Spilanthes acmella.*

Total weed density did not differ significantly between tillage treatments. However, under permanent bed tillage system, overall density of sedges, grasses and broadleaf weeds were slightly lower than other tillage treatments. The higher B: C ratio (3.43) was noticed in permanent bed + IWM (pendimethalin 750 g/ha *fb* one hand weeding at 30 DAS). Among tillage treatments, combined with weed management practices, MT and unweeded control recorded lowest B: C ratio (1.23) compared to other tillage. At 60 DAS, pendimethalin 750 g/ha (pre) *fb* hand weeding at 30 DAS lowered the weed density and dry biomass over control. IWM effectively controlled weeds up to critical period of crop- weed competition, there by resulted in significantly superior yield and yield attributes over application of only herbicide alone and unweeded control.

In Summer maize 2019, major weed flora as *Cyperus rotundus* (sedge), *Cynodon dactylon, Digitaria marginata; Bracharia repens (*among grasses*)*. Whereas, among broad-leaf weeds, *Commelina benghalensis, Alternanthera sessilis, Euphorbia geniculata* and *Ageratum conyzoides,* were dominant broadleaf weeds. Among tillage practices, permanent bed recorded lowest weed density (56.5 no./m^2) and weed dry biomass (10.16 g/m^2) compared to other tillage practices. At 90 DAS, IWM (pendimethalin 750 g/ha pre *fb* hand weeding at 30 DAS) recorded significantly lower weed density (47.4 no./m^2) and weed dry biomass (6.68 g/m^2) over others. Whereas, unweeded recorded highest weed density (75.4 no./m^2) and dry biomass (17.39 g/m^2). The lower weed parameters leads in synthesizing more yield attributes resulted in significantly highest yield (2.83 t/ha) in IWM followed by pendimethalin 750g/ha *fb* tembotrione 120g/ha + atrazine 500g/ha (2.50 t/ha) compared to unweeded control (1.71 t/ha). The higher B:C ratio (1.72) was noticed in permanent bed tillage + IWM.

In *Kharif* 2019 maize, experimental field comprised with *Cyperus rotundus* (sedges), *Cynodon dactylon, Digitaria marginata; Bracharia repens* (among grasses). Whereas, *Commelina benghalensis, Alternanthera sessilis, Spillanthus acmella* and *Ageratum conyzoides* were dominant broad-leaf weeds. In ZT, *Cyperus rotundus* (sedge) and grass species density was lowest compared to other tillage treatments., whereas broad-leaf weeds was lowest in permanent bed. In all the tillage treatments, among the broad-leaf weeds species, the density of *Commelina benghalensis* was higher than other weed species. Whereas, *Alternanthera sessilis* dominance was observed from 60 DAS onwards.

Weed management practices significantly influenced the weed density and weed dry biomass, at 60 DAS-IWM (pendimethalin 750 g/ha *fb* hand weeding at 30 DAS) recorded significantly lower weed density and dry biomass of weeds compared to two other treatments. The crop after sowing was infested with fall armyworm twice and later, heavy rains retarded its growth, thus resulting in comparatively lower yield compared to earlier seasons. Among weed management practices, IWM recorded significantly highest grain yield (3.34 t/ha) compared to unweeded control (2.50 t/ha) and pendimethalin 750 g/ha *fb* tembotrione 120 g/ha + atrazine 500 g/ha (3.12 t/ha). The higher B:C ratio (1.56) was noticed in permanent bed tillage + IWM and lowest with unweeded control (1.31).

WP 1.1.3 Weed management in pearlmillet based cropping system Pearlmillet–mustard–cowpea cropping system

RVSKVV, Gwalior

In mustard, an experimental area comprised of *Phalaris minor, Spergula arvensis* and *Cynodon dactylon* as grasses and *Chenopodium album, Anagallis arvensis Convolvulus arvensis* and *Medicago hispida* as major broad-leaf weeds. 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 ZTR – ZTR-ZT (88%) *fb* ZT-ZTR-ZT (82%) and the lowest in ZT-ZT-ZT (73%). The highest values of all growth and yield attributes were recorded under CT-CT followed by CT–ZT–ZT. The significantly highest seed yield of mustard (1.94 t/ha) was obtained with CT-CT and was followed by ZTR–ZTR–ZT. The maximum net return (₹6,24,635/ha) was obtained with ZTR–ZTR–ZT followed by CT-CT. Similarly, the highest B:C ratio (4.20) was found in with ZTR–ZTR–ZT tillage practice (**Table 1.1.1.3.1**).

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 WCE was maximum under IWM practices (89.5%) followed by application of oxyfluorfen 0.23 kg/ha (72.9%) at 60 DAS. Maximum yield attributes and yield were recorded in IWM (2.01 t/ha) followed by oxyfluorfen 0.23 kg/ha. A similar trend was also recorded for straw yield of the mustard crop. IWM recorded higher net return (₹ 61,101/ha) B: C ratio was higher in oxyfluorfen 0.23 kg/ha (3.94) *fb* IWM practices (oxyfluorfen 0.23 kg/ha + 1 HW) (3.68).

Table 1.1.1.3.1 Effect of different weed management & conservation tillage practices on yield and economics in mustard under pearlmillet based cropping system (2017-18)

S.N.	Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Total cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C Ratio
Tillage							
T_1	Conventional tillage (CT-CT)	1.94	7.42	21,200	81,415	60,215	3.84
T_2	Zero tillage (CT -ZT-ZT)	1.64	5.77	18,500	68,409	49,909	3.70
T_3	Zero tillage ((ZT-ZT-ZT))	1.47	5.62	18,500	61,497	42,997	3.32
T_4	Zero tillage + crop residue (ZT-ZT+R-ZT)	1.81	6.51	19,500	75,474	55,974	3.87
T_5	Zero tillage + crop residue (ZT+R-ZT+R-ZTR)	1.95	7.95	19,500	81,963	62,463	4.20
	SEm (±)	0.06	0.22	-	-	-	-
	LSD (P=0.05)	0.21	0.71	-	-	-	-
Weed management							
W_1	Pendimethalin PE	1.92	7.07	20,400	80,456	60,056	3.94
W_2	Oxyflourfen PE + 1 HW	2.01	7.04	22,800	83,901	61,101	3.68
W_3	Weedy check	1.35	5.85	18,100	56,898	38,798	3.14
	SEm (±)	0.06	0.19	-	-	-	-
	LSD (P=0.05)	0.25	0.76	-	-	-	-

In cowpea, the weed flora observed in the experimental field was *Cyperus rotundus, Dactyloctenium aegyptium,* and *Cynodon dactylon* as narrow leaf weeds (NLW), and only *Trianthema monogyna* as broad-leaf weeds (BLW). The weed density and dry biomass were found significantly higher in ZT-ZT-ZT followed by ZT-ZT+R-ZT. Whereas, the lowest weed density and dry biomass was recorded in ZT+R–ZT+R–ZT+R. This resulted in highest WCE (83%) at 40 DAS and 93% at harvest stage. The highest seed yield of cowpea (677 kg/ha) and maximum net returns (₹ 34,627/ha) and B: C (2.93) was obtained from ZT+R – ZT+R – ZT+R. Among weed management practices, the lowest weed density and dry biomass was recorded in IWM (pendimethalin + imazethapyr 0.90 kg/ha PE *fb* one hand weeding) with the highest WCE (62%). The significantly higher seed yield of cowpea was recorded with IWM. An increase in yield 36% and 15%, respectively was found due to IWM and pendimethalin + imazethapyr 0.90 kg/ha as compared to weedy check. The maximum net returns (₹ 20,715/ha) and B:C ratio (2.01) was recorded under IWM over weedy check (1.77) (**Table 1.1.1.3.2**).

In pearlmillet, the weeds observed in the experimental field were *Echinochloa crus-galli, Celosia argentia, Acrachne racemosa, Leptochloa penicia, Cynodon dactylon, Phyllanthus niruri, Setaria glauca* and *Brachiaria reptans* as grassy weeds, *Digera arvensis* and *Commelina benghalensis* as broad-leaf weeds and *Cyperus rotundus* as sedges. Under pearlmillet based cropping system, the lowest weed density and weed dry biomass were recorded in ZTR-ZTR-ZTR followed by ZT-ZTR-ZT. Conservation tillage practices recorded the highest grain yield CT-ZT-ZT followed by ZTR-ZTR-ZTR while B: C ratio was higher in CT-ZT-ZT (2.37) followed by ZTR-ZTR-ZTR (2.11). Among weed management practices, IWM practices (atrazine 500 g/ha PE + 1 HW) significantly reduced the weed density and dry biomass of weeds and resulted in significantly highest

Table 1.1.1.3.2 Effect of different treatments on yield and economics of cowpea under pearlmillet based cropping system (2019)

S.N	Treatment	Grain yield (kg/ha)	Stover yield (t/ha)	Weed biomass at harvest (t/ha)	WCE (%) at harvest	Net return (₹/ha)	B:C Ratio
Tillage							
T_1	CT-CT-F	-	-	-	-	-	-
T_2	CT-ZT-ZT	613	3.90	3.18	85.3	-	-
T_3	ZT-ZT-ZT	416	4.11	2.93	77.0	29,744	2.66
T_4	ZT-ZT+R-ZT	583	4.41	3.30	83.4	17,356	1.97
T_5	ZT+R-ZT+R-ZT	677	4.28	3.52	93.0	28,801	2.61
	SEm (±)	22.9	0.24	0.24			
	LSD (P=0.05)	74.5	0.81	0.79			
Weed management							
W_1	Pendimethalin + imazethapyr 0.90 kg/ha (PE)	448	3.59	2.26	74.8	17,170	1.90
W_2	Pendimethalin + imazethapyr 0.90 kg/ha (PE) + 1 HW	533	3.33	3.09	93.4	20,715	2.01
W_3	Weedy check	393	3.10	2.40		13,814	1.77
	SEm (±)	16.7	0.16	0.31			
	LSD (P=0.05)	65.4	0.63	1.22			

pearlmillet yield, net returns and B: C ratio it was followed by atrazine + 2,4-D.

WP 1.1.4 Weed management in soybean-based cropping systems soybean-chickpea cropping system

PDKV, Akola

The major weed flora during *Kharif* and *Rabi* in soybean –chickpea cropping sequence in the selected area composed of *Xanthium strumarium, Celosia argentea, Tridax procumbens, Phyllanthus niruri, Portulaca oleracae, Lagasca mollis, Euphorbia geniculata, Euphorbia hirta, Phyllanthus niruri*, *Abutilon indicum*, *Abelmoschus moschatus, Boerhavia diffusa*, *Calotropis gigantea*, *Ageratum conyzoides*, *Bidens pilosa*, *Mimosa pudica etc.* Both broad and narrow leaf weeds were observed.

In soybean, CT recoded the lowest weed density and weed dry biomass at 60 DAS and highest with ZT. A similar trend was recorded in another stage of the crop, this resulted in highest WCE in CT (53.3%) followed by reduced tillage (RT, 40.3%). The yield attributes were better with CT followed by RT, resulting in the higher grain and straw yield in CT, whereas, the lowest yield recorded with ZT (**Table 1.1.1.4.1**). Among weed management practices, at 60 DAS, weed free recorded the lowest weed density and dry biomass followed by IWM and conversely the unweeded check recorded significantly highest total number of weeds. This resulting highest WCE in weed free (94.4%) followed by IWM (42.7%) over control. The yield attributes were better with weed free and IWM, resulting in the higher grain and straw yield in weed free, whereas, the lowest yield recorded with control.

In wheat at 60 DAS, the lowest weed density and dry biomass of weed was recorded under CT-MT and highest with ZTR-ZTR, 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-MT followed by RT-MT. The yield attributes were better with CT-MT followed by RT-MT, resulting in the higher grain and straw yield in CT-MT, whereas, the lowest yield recorded with ZTR-ZTR. Among weed management practices, at 60 DAS, weed free recorded least weed density and dry biomass resulting in highest WCE and conversely the unweeded check recorded significantly highest weed parameters. The yield attributes were better with weed free followed by IWM, resulting in the higher grain and straw yield in weed free, whereas, the lowest yield recorded with weedy check.

Table 1.1.1.4.1 Total weed parameters (at 60 DAS) and yield attributes as influenced by weed control treatments in wheat

Treatment	Weed density (no./m^2)	Weed dry biomass (g/m^2)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage and residue management					
T_1 : MT (1 Rototill)	4.43 (22.6)	5.81 (33.7)	66.8	3.98	8.13
T_2 : MT (1 Rototill)	5.40 (33.1)	6.06 (36.8)	64.5	3.46	7.05
T_3 : MT (1 Rototill)	5.87 (34.4)	5.97 (39.1)	62.5	3.29	6.78
T_4 : ZT + R	6.54 (45.0)	6.79 (46.2)	58.1	3.15	6.47
SE (m) ±	0.10	0.16		0.13	0.27
LSD (P=0.05)	0.28	0.46		0.45	0.95
Weed management					
W_1 : Sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS	5.70 (33.5)	5.50 (30.2)	73.9	3.63	7.42
W_2 : Mesosulfuron + iodosulfuron 12+2.4 g/ha at 30 DAS	5.11 (26.8)	4.80 (22.9)	78.1	3.53	7.82
W_3 : Clodinafop + metsulfuron 60+4 g/ha at 30 DAS	4.66 (22.6)	4.41 (20.1)	84.3	3.98	8.08
W_4 : Weed free	2.12 (4.1)	1.84 (4.0)	84.5	4.27	8.28
W_5 : Weedy check	9.31 (86.7)	10.27 (105.2)	-	1.93	3.94
SE (m) ±	0.12	0.14		0.77	0.18
LSD (P=0.05)	0.34	0.41		0.22	0.52

In greengram, CT-MT-MT recorded the lowest weed density and dry biomass resulting in the highest WCE. The lower values of weeds led to synthesizing more yield attributes resulted the highest seed (688 kg/ha) and haulm yield (1.40 t/ha). The highest weed parameters and lowest yield recorded with ZTR-ZTR-ZTR. Among weed management practices, weed free i.e. two hand weeding at 20 and 40 DAS recorded the lowest weed density and dry biomass followed by sequential application of herbicides i.e. pendimethalin 1 kg/ha *fb* imazethapyr+imazamox 0.07 kg/ha. This resulted in higher WCE over weedy check. Weed free recorded the highest seed (807 kg/ha) and haulm yield (1.64 t/ha) followed by sequential application of herbicides, whereas the lowest yield recorded under weedy check.

WP 1.1.5 Weed management in cotton-based cropping systems cotton-green gram cropping system

AAU, Anand

In cotton, at 60 DAS, significantly higher density and dry biomass of monocot weeds were recorded under ZTR-ZTR (49.3 no./m^2 and 16.9 g/m^2, respectively). While lower density and dry biomass of dicot weeds (26.2 no./m^2 and 8.5 g/m^2), recorded under ZT and ZTR, respectively. Total weed density was comparable with tillage practices but total weed dry biomass was significantly higher under CT-ZT (38.3 g/m^2). The CT-CT system recorded considerably higher seed cotton yield (1.37 t/ha) followed by ZTR-ZTR system (1.35 t/ha). Among the weed management practices, at 60 DAS, density of monocot weeds was lowest with pendimethalin 900 g/ha PE *fb* quizalofop ethyl 50 g/ha + pyrithiobac sodium 62.5 g/ha PoE (tank mix) *fb* HW at 60 DAS whereas, dicots weeds were lowest under thrice hand weeding, whereas total weed density was dramatically lowest under quizalofop-ethyl 50 g/ha + pyrithiobac sodium 62.5 g/ha PoE (tank mix) *fb* HW at 40 and 60 DAS. The dry biomass of monocot, dicot and total weeds were lowest under thrice hand weeding. The seed cotton yield was comparable with all weed management practices and ranged from 2.41-3.00 t/ha and higher value with thrice hand weeding.

In greengram density and dry biomass of monocot weeds (62.7 no./m^2 and 27.2 g/m^2, respectively) was recorded lowest at 30 DAS under ZTR-ZTR, whereas, the density of dicot weeds (30.2 no./m^2) was more with CT-CT and dry biomass was lowest with ZT-ZT (24.2 g/m^2) and total weeds was recorded lowest with ZTR-ZTR (132 no./m^2 and 63.4 g/m^2, respectively). These helped to harvest significantly the highest seed and haulm yield (604 and 732 kg/ha, respectively) under ZTR-ZTR, while, significantly lower seed yield was recorded under ZT-ZT system.

Among weed management practices, significantly the highest density and dry biomass of monocot weeds (178 no./m^2 and 53.5 g/m^2, respectively), dicot (77.3 no./m^2 and 46.7 g/m^2, respectively) and total weeds (255 no./m^2 and 100 g m^2, respectively) were 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 HW at 20 and 40 DAS. Imposition of twice hand weeding recorded the highest seed and haulm yield (608 and 740 g/ha, respectively) followed by imazethapyr 75 g/ha PoE *fb* HW at 30 DAS.

In cotton-greengram cropping system, the highest seed cotton equivalent yield, gross return, net return, and B: C were recorded with ZTR-ZTR (2.15 t/ha, ₹ 1,17,175 and 29415/ha, and 1.34, respectively) and the lowest under ZT-ZT system. Among weed management practices, the higher seed cotton equivalent yield (2.13 t/ha) and gross return (₹ 1,16,085/ha) obtained under thrice and twice hand weeding in system. Whereas, net returns (₹ 27,279/ha) and benefit-cost ratio (1.33) were achieved under pendimethalin 900 g/ha PE *fb* quizalofop-ethyl 50 g/ha +pyrithiobac sodium 62.5 g/ha PoE (tank mix) *fb* HW at 60 DAS and imazethapyr 75 g/ha PoE *fb* HW at 30 DAS.

WP 1.2 Weed management in organic cropping systems

WP 1.2.1 Weed management in turmeric under organic cropping system and its residual effect on succeeding summer greengram

AAU, Anand

Objectives:

1. To monitor weed dynamics in turmeric-greengram cropping system under organic cropping

Treatments:

Sr. No.	Treatment
T_1	Paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP
T_2	Wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP
T_3	IC + HW at 30 DAP + PSM 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP
T_4	IC + HW at 30 DAP + WSM 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP
T_5	Plastic mulch (0-3 DAP) *fb* HW at 20, 40 and 60 DAP
T_6	Plastic mulch (0-3 DAP) *fb* HW at 30 and 60 DAP
T_7	Turmeric + sunnhemp intercropping *fb* HW at 30 DAP *fb* HW + mulch of sunnhemp at 60 DAP *fb* HW at 90 DAP
T_8	IC *fb* HW at 20, 40, 60 and 80 DAP
T_9	Weedy check
*T_{10}	RDF + metribuzin 0.7 kg/ha PE (0 -3 DAP) *fb* quizalofop 75 g/ha PoE *fb* HW at 75 DAP (this has included only for comparison & it would not be included for statistical analysis)

2. To study the effect of integrated weed management practices on growth, yield and quality of turmeric under turmeric-greengram cropping
3. To study the residual effect on succeeding greengram by integrated weed management practices

In general, dominancy of monocot weed (59.0%) was observed during the experimental period. Major weeds observed in the experimental field were *Dactyloctenium aegyptium* (24.0%), *Eleusine indica* (15.1%), *Digitaria sanguinalis* (8.12%), *Commelina benghalensis* (6.64%) and *Eragrostis major* (2.95%) in monocot weeds category whereas, *Oldenlandia umbellat* (9.59%), *Digera arvensis* (8.49 %), *Phyllanthus niruri* (8.12%), *Trianthema monogyna* (4.43%) and *Mollugo nudicaulis* (3.69%) in dicot weed category and *Cyperus rotundus* (2.58) and *Cyperus iria* (1.35) in sedges category**).**

At 60 DAP, all the weed management practices recorded more than 80% weed control efficiency except plastic mulch (0-3 DAP) *fb* HW at 30 and 60 DAP, turmeric + sunnhemp intercropping *fb* HW at 30 DAP *fb* HW + mulch of sunnhemp at 60 DAP *fb* HW at 90 DAP which recorded weed control efficiency of 74.6 and 75%, respectively. However, maximum weed control efficiency was recorded under IC + HW at 30 DAP + wheat straw mulch 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP (88.4%). Among all the weed management practices, maximum weed control efficiency of 84.6% was recorded under wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP followed by paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP (79.4%) and IC + HW at 30 DAP + paddy straw mulch 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP (78.6%) at harvest.

Significantly higher rhizome yield of 24.2 t/ha was registered under wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP but it was at par with paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP which recorded rhizome yield of 23.4 t/ha. The next best treatment in line of recording higher rhizome yield was IC + HW at 30 DAP + wheat straw mulch 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP which recorded significantly higher rhizome yield of 19.5 t/ha as compared to rest of the treatment except IC + HW at 30 DAP + paddy straw mulch 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP. Significantly the lowest rhizome yield of 2.29 t/ha was recorded under weedy check treatment. Maximum rhizome yield (24.2 t/ha), gross return (₹ 3,63,000/ha), net return (₹1,93,890/ha) and benefit cost ratio of 2.15 was achieved under wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP which was closely followed by paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP which recorded 23.4 t/ha rhizome yield, ₹ 3,51,000/ha gross return, ₹ 1,81,000/ha net return and 2.06 benefit cost ratio.

WP.1.2.2 Weed management in rice-tomato-okra system under organic farming

Treatments OUAT, Bhubaneswar

Treatment	*Kharif*	*Rabi*	Summer
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

This experiment was conducted to develop suitable weed management technique under organic packages for system based high value crops and to assess soil health condition due to organic packages and weed management practices.

Rice

The weed flora observed in rice was *Echinochloa crusgalli, E. colona, Panicum repens, Paspalum scorbiculatum* among grasses, *Cyperus difformis, C.rotundus* and *Fimbristylis miliaceae* among sedges and *Marsilia quadrifolia, Alternanthera sessilis, Luduwigia parviflora* and *Monocharia Vaginalis* amog broad-leaf weeds. Both the weed population (no/m^2) and dry weight (g/ m^2) were found to be the minimum in chemical agriculture where all standard agriculture were practiced. However the application of application of 1/3 recommended dose of N each through FYM, *Dhaincha* and neemcake with *Azospirillum* + PSB to rice along with one manual weed + one mechanical weeding in rice resulted in reduction in weed population and dry weight and found to be at par with other chemical weed control practices.

Tomato

The floristic composition of the experiment in tomato was *Digitaria sanguinalis, Eleucrine indica, Elchenochloa colona, Panicum repens, Cynodon dactylon* among grasses, *Cyperus iria* and *C. rotundus* among sedges and *Chenopodium album, Amaranthus viridi, Eclipta alba, Trianthema portulacastrum, Oldenlandia corymbosa, Euphorbia hirta* and *Heliotropium indicum* among broad leaved weeds.

The application of 1/3 recommended dose of N each through FYM, vermicompost and neemcake with the bio-fertiliser of *Azotobacter* + PSB to tomato along with one manual weed + one mechanical weeding resulted in reduction in weed population and dry weight and it was found to be at par with other organic methods of weed control.

Okra

The floristic composition of the experiment in okra was *Elucine indica, Eleucine colona, Sorghum halepense, Brachiaria ramose, Cynodon dactylon* among grasses, *Cyperus diformis* and *C. rotundus* among sedges and *Digera arvense, Portulaca oleracea, Tridax procumbense, Physalis minima,* & *Euphorbia hirta* among broad leaved weeds. The organic treatments with manual weeding and manual + mechanical weeding were found to be best treatment with report to controlling weed population and dry weight in. However the practice of herbicide strip was observed to be the best in minimizing the weed population and dry weight in both the days of the observation. The application of application of 1/3 recommended dose of N each through FYM, vermicompost and neemcake with the bio-fertiliser of *Azotobacter* + PSB to okra along with one manual weeding + one mechanical weeding was well comparable to other organic treatments with report to weed control.

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 lady's finger in rice-tomato-lady's finger system resulted in the maximum grain yield of rice (4.57 t/ha), fruit yield of tomato (17.7 t/ha) and lady's finger (7.20 t/ha) with REY of 23.6 t/ha/yr followed by T_1 and T_4 with REY of 21.5 and 21.4 t/ha/yr, respectively. Uptake of nutrients by rice (77.8 kg N, 23.7 kg P and 89.7 kg K/ha), tomato (56.3 kg N, 7.07 kg P and 94.3 kg K/ha), lady's finger (156.6kg N, 34.9 kg P and 210.8 kg K/ha) and the system as a whole (292.8 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.

WP 1.2.3 Weed management in organic maize - potato – greengram (as green manuring) cropping system

RVSKVV, Gwalior

An experiment was conducted for weed management in organic maize -potato – greengram (as green manuring) cropping system with the following set of 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 DAP
T_4	Intercrop (Maize+greengram)	Intercrop (Potato+chickpea))
T_5	Stale seed bed *fb* one HW at 40 DAS	Stale seed bed *fb* one HW at 40 DAP
T_6	Hoeing at 20 & 40 DAS	Earthing up at 20 & 40 DAP
T_7	Weedy check	Weedy check
T_8	RDF + recommended herbicide (Atrazine 750 g/ha PoE)	RDF + recommended herbicide (Metribuzin 500 g/ha PoE)

Potato (*Rabi* 2018-19)

The major weed flora of experimental site comprised of *Cyperus rotundus, Phalaris minor, Spergula arvensis* and *Polypogon monspeliensis* as grasses and *Chenopodium album, Medicago hispida, Anagallis arvensis* and *Convolvulus arvensis* were observed as major broad-leaved weeds. *Cyperus rotundus* was the most dominating among all the weeds in potato field during entire crop growth period. Among all the weed management practices the weeds were effectively controlled by soil solarization with plastic mulch (25µ). The population of BLWs except *Chenopodium album,* NLWs except *Phalaris minor* and sedges *Cyperus rotundus* was signigficantly controlled by the application of soil solarization with plastic mulch (25µ) *fb* soil solarization with one hand weeding at 40 DAP and stale seed bed with one hand weeding at 40 DAP. The population of sedges was very high in the weedy check plot.

The maximum weed control efficiency (88%) was also recorded where soil solarization was applied with plastic mulch (25µ) *fb* soil solarization with one hand weeding at 40 DAP (83%) and stale seed bed with one hand weeding at 40 DAP (77%). The tuber yield of potato was also recorded maximum (28.25 t/ha) under soil solarization with plastic mulch (25µ) *fb* soil solarization with one hand weeding at 40 DAP (26.00 t/ha). But the yield under stale seed bed *fb* one HW at 30 DAS was at par with black plastic mulch (25µ) (24.61 t/ha) and treatments. The lowest tuber yield (12.87 t/ha) was recorded in unweeded control plot. Application of soil solarization with plastic mulch (25µ) fetched significantly maximum net returns (₹166933/ha) *fb* soil solarization with one hand weeding at 40 DAS (Rs. 1,39,900/ha) and stale seed bed with one hand weeding at 40 DAS (₹ 1,36,433/ha). Similarly, the highest B:C ratio of 2.44 was also recorded with application of soil solarization with plastic mulch (25µ). The minimum net returns ₹17,766/ha was recorded with weedy check treatment with poor B:C ratio of 1.16. It was due to the higher crop-weed competition during the entire crop growth period.

Sweet corn (*Kharif* 2019)

The major weed flora observed at experimental site was *Setaria glauca, Acrachne racemosa, Echinochloa crus-galli* as narrow leaved weeds and *Celosia argentea* (NLW's), *Commelina benghalensis* and *Digera arvensis* as major broad-leaved weeds. In sedges *Cyperus rotundus* was the most problematic weed in the experimental site during the year of experimentation.

At 60 DAS, the maximum weed control efficiency (89.8 and 83.9%) was recorded in soil solarization with plastic mulch *fb* soil solarization with one hand weeding (87.8 and 80.5%) and hoeing at 20 and 40 DAS (72.9 and 79.9%) during 2019 and pooled basis, respectively.

On the pooled basis the maximum plant height, number of cobs and green fodder yield was recorded in RDF + recommended dose of herbicide, number of leaves in soil solarization with plastic mulch, but maximum length and yield of cobs was recorded in intercrop (maize+greengram). However, in 2019 the maximum yield of cobs (7.50 t/ha) and green fodder (25.30 t/ha) was recorded under soil solarization with one hand weeding at 40 DAS *fb* soil solarization with plastic mulch 6.70 t/ha and 21.10 t/ha, respectively. Application of recommended dose of fertilizer + herbicide (atrazine 750g/ha PoE) fetched maximum net returns ₹ 1,97,800/ha *fb* intercrop (maize+greengram), ₹1,96,254/ha and hoeing at 20 and 40 DAS, ₹1,66,717/ha. However, the highest B:C ratio 3.46 was recorded with intercrop (maize+ greengram) *fb* application of recommended dose of fertilizer + herbicide (atrazine 750 g/ha PoE) (3.53).

WP 1.2.4 Weed management practices in okra-carrot under organic cropping system

PJTSAU, Hyderabad

An experiment was conducted with the objectives to monitor weed dynamics on crop productivity in okra and carrot due to non-chemical weed management; to monitor physical and chemical properties and to work out the economics

Treatments:

S. No.	*Kharif* (Okra)	*Rabi* (Carrot)
T_1	Live mulch with dhaincha	Mulching with rice husk 3t/ha
T_2	Stale seed bed *fb* HW at 20 & 40 DAS	Stale seed bed *fb* HW at 20 & 40DAS
T_3	Polymulch + interrow weeding at 30 DAS	Polymulch + interrow weeding at 30 DAS
T_4	Straw mulch 5t /ha*fb* intra row HW at 30 DAS	Straw mulch 5t /ha *fb* intra row HW at 30 DAS
T_5	Mechanical weeding (MW at 20 & 40 DAS *fb* HW)	Mechanical weeding (MW at 20 & 40 DAS *fb* HW)
T_6	Pendimethalin 1000g / ha *fb* HW at 30 DAS	Pendimethalin 1000g / ha *fb* HW at 30 DAS
T_7	Intercrop green leaf vegetable *fb* MW at 40DAS	Intercrop green leaf vegetable *fb* MW at 40 DAS
T_8	Unweeded control	Unweeded control

Okra (*Kharif*, 2019)

The general weed flora infesting the experimental field consisted 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 broadleaved weeds. At 60 DAS, mulching with polysheet (25 microns) + HW in the inter row at 30 DAS (21 No. /m^2) recorded lowest weed density and dry weight followed by mechanical weeding at 20 and 40 DAS (21/m^2) inturn followed by straw mulch (5 t/ha) and intra weeding at 30 DAS (25/m^2). Live mulch with dhancha (27/m^2) and SSB preparation *fb* HW at 20 & 40 (22 /m^2) were found on par with each other. Pendimethalin 1000 g/ ha *fb* HW at 30 DAS (71/m$^{2)}$ did not perform due to continuous application of the same herbicide from the beginning. Highest weed density was recorded with unweeded control (100/m^2**).**

Organic weed management practices significantly influenced fruit yield of okra. 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 (4.61 t/ha) followed by cultural practice involving mechanical weeding at 20 & 40 DAS (3.175 t/ha), straw mulch (5.0 t/ha) *fb* intra row weeding at 30 DAS (2.3 t/ha) and SSB preparation *fb* HW at 20 & 40 (2.1 t/ha). Lowest fruit yield (118 kg/ha) was recorded with unweeded control.

Carrot (*Rabi*, 2018-19)

The weed flora observed during crop growing season consisted 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.

Straw mulch or poly mulch proved effective reduced weed density. At 30 DAS, lowest weed density was recorded with straw mulch (5t/ha) (32/m^2) *fb* polymulch + inter row weeding at 30 DAS (48/m^2). Highest weed density was recorded with unweeded control (19.6 No./m^2). The same trend was followed at 60 DAS. Poly mulch + inter row weeding at 30 DAS (6.47 g/m^2) and straw mulch (5 t/ha) (16.33 g/m^2) and mulching with rice husk (25.82 g/m^2) were effective in reducing the weed dry matter. Significantly highest weed dry matter (134.72 g/m^2) was recorded with unweeded control. Highest root yield of carrot was recorded in straw mulch + intra row weeding at 30 DAS (20.3 t/ha) followed by SSB preparation (17.4 t/ha) and mechanical weeding at 20 and 40 DAS (17.14 t/ha. Pendimethalin 1000 g/ha *fb* HW at 30 DAS did not perform well due to continuous use of the same herbicide year after year. Lowest root yield of carrot were recorded in un weeded control (1.31 t/ha).

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

SKUAST, Jammu

Experiment was conducted with the objective to find out suitable organic weed management practices for basmati rice based cropping system with following treatments:

Treatments

S. No	Basmati rice	Broccoli	Green manure
1.	Stale seedbed	Paddy straw mulch (4 t/ha)	Sesbania green manure
2.	Stale seedbed +1 hand weeding at 30 DAT	Paddy straw mulch (4 t/ha) +1 hand weeding at 30 DAT	Sesbania green manure
3.	Stale seedbed *fb* 1 mechanical weeding at 30 DAT	Paddy straw mulch (6 t/ha)	Sesbania green manure
4.	Soil solarisation	Paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT	Sesbania green manure
5.	Soil solarisation *fb* 1 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

An experiemnt was conducted to find out suitable organic weed management practices for basmati rice based cropping system. In broccoli (*Rabi*, 2018-19) the major weeds viz. *Anagallis arvensis, Melilotus indica, Ranunculus arvensis, Medicago* spp., *Vicia sativa, Rumex* spp., *Phalaris minor* and *Avena* spp. were observed.

Different treatments had significant effect on weed density and weed biomass at 60 DAT. The lowest density of *Anagalis arvensis, Melilotus indica, Ranunculus arvensis, Medicago* spp., *Vicia sativa, Rumex* spp., *Phalaris minor* and *Avena* spp. were observed in paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT, whereas treatment plastic mulch was found weed free. The total weed density and weed biomass were significantly lower in treatment paddy straw mulch (6 t/ha) +1 hand weeding at 60 DAT as compared to rest of the treatments. The highest total weed density and weed biomass were recorded in treatment weedy check. The highest weed control efficiency (WCE) was recorded in weed free followed by plastic mulch treatment and T_1.

The yield attributes, yield and economics significantly influenced by different weed management treatments as compared to weedy check. The plant height, head diameter and curd yield were recorded significantly higher in treatment paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT but statistically higher than rest of the treatments except plastic mulch and weed free. The highest gross returns was recorded in treatment weed free followed by plastic mulch treatment and paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT, whereas net returns in paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT. The highest benefit cost ratio was recorded in treatments addy straw mulch (6 t/ha) +1 hand weeding at 30 DAT followed by paddy straw mulch (4 t/ha) +1 hand weeding at 30 DAT.

In *Kharif,* 2019 dominated weeds in rice were *Echinochloa* spp. amongst grassy weeds; *Alternanthera philoxeroides* and *Ammania baccifera* amongst broad-leaved weeds and *Cyperus* spp. *Caesulia axilaris* and *Commelina benghalensis* were recorded as other weeds. At 30 days after transplanting, soil solarised plots recorded significantly lowest weed density than other treatments. At 60 DAT and harvest, stale seedbed +1 hand weeding at 30 DAT recorded lowest weed density and weed biomass followed by soil solarisation *fb* 1 mechanical weeding at 30 DAT and stale seedbed *fb* 1 mechanical weeding at 30 DAT.

Among the non-chemical weed management treatments, higher growth parameters were recorded with soil solarisation *fb* one mechanical weeding at 30 DAT followed by stale seedbed + one hand weeding at 30 DAT. The highest grain and straw yields were recorded with soil solarisation *fb* one mechanical weeding at 30 DAT 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 followed by stale seedbed + one hand weeding at 30 DAT.

WP 1.2.6 Weed management in organic tea

AAU, Jorhat

The major weeds observed in the experimental plot were: Grasses: *Digitaria setigera*, *Eleusine indica, Isachne globosa*, *Sporobolus* spp.; Sedges: *Cyperus pilosus*; Broadleaved species: *Ageratum houstonianum*, *Cassia tora, Chromolaena odorata*, *Cleome rutidosperma*, *Clerodendrum colebroleianum*, *Commelina benghalensis* etc.

The bio-degradable film mulching at stages of observation resulted in the lowest density of weeds in tea although in case of observations during April and June the density of weeds in straw mulch was found to be at par with biodegradable film. With regards to the dry weight of weeds, though biodegradable film recorded the lowest value, but it was found to be statistically at par with straw mulch and cheeling twice in the month of June and in the rest of the months the treatment bio-degradable film mulching was found to be followed by straw mulch. The green leaf yield of tea was found to be influenced significantly at all the plucking stages except in case of 9th plucking. It was found to be highest in case of bio-degradable film mulching at all the stages. In the 3rd, 4th, 7th and 8th plucking stage, citronella mulching and straw mulch yielded similarly with bio-degradable film mulching. Except Guatemala leaf mulching and brush cutter, all the other treatments were found to be statistically at par with bio-degradable film mulching at 5th and 6th stages of plucking.

WP 1.2.7(i) Weed management in organic based basmati rice - wheat cropping system

PAU, Ludhiana

During *Rabi* 2018-19, durum wheat crop was infested mainly with broadleaf weeds and major weeds were *Anagallis arvensis, Coronopus didymus, Chenopodium album*, *Rumex dentatus* and *Medicago denticulata*. Other weeds present in field in small densities included *Vicia sativa and Melilotus indica*. Differential tillage types (CT, DT and ZT with or without residue), application of straw mulch, seeding density and hoeing resulted in significant effect on weed density and biomass in organically grown durum wheat at 30 and 60 DAS. Bed planting along with 25% higher plant density and one hoeing resulted in significant decrease in density and biomass of weeds at 30 and 60 DAS as compared to unweeded check. All cultural weed control treatments namely tillage, seeding density, mulching and hoeing resulted in significant more effective tillers and yield as compared to weedy check. Weed free check recorded the highest grain yield of organically grown durum wheat and it was at par to bed planted wheat sown at 25% higher plant density and one hoeing.

WP 1.2.7(ii) Weed management in organic pea-brinjal cropping system

PAU, Ludhiana

Expereiment was conducetd in collaboration with All India Network Project on Organic Farming, PAU Centre to study effect of organic sources of nutrition and weed management approaches on weed incidence and crops productivity in pea-brinjal cropping system and to develop suitable combination of crop nutrition and weed management for enhanced productivity of pea- brinjal crops raised under organic agriculture with the following treatments.

Treatments	Pea	Brinjal
Fertilization		
1.	Farmyard manure (FYM) to supply recommended N to respective crop	
2.	Vermicompost to supply recommended N to respective crop	
3.	FYM + Vermicopmpost to supply rec.N (50:50) to respective crop	
Weed management		
1	Plastic mulch	Plastic mulch
2	Intercropping with cowpea/ coriander	Intercropping with cowpea/coriander
3	Straw mulch	Straw mulch
4	Hand weeding	Hand weeding
5	Unweeded check	Unweeded check
Standard treatment: Pea -brinjal cropping system raised under conventional agriculture (For comparison only)		

In brinjal *Eleusine indica, Dactyloctenum aegyptium, Digitaria sanguinalis, Cyperus iria* and *Cyperus rotundus* were the major weeds present in the experimental field in *Kharif*, 2019. Fertlization treatments did not have any significant influence on density of different weed species at 60 and 90 DAT. Among weed control at 60 DAT, paddy straw mulch had significantly low density of *E. indica* and *D. aegyptium* than weedy check, plastic much and intercropping (cowpea) treatments at 60 and 90 DAT. Plastic mulch had the lowest density of *C. rotundus* which was at par with intercropping with cowpea at 60 DAT and with straw much at 90 DAT. In case of *C. iria*, intercropping had the lowest density at 90 DAT.

Fertilization treatments did not influence biomass of grass and sedge weeds at 60 and 90 DAT except in case of sedge biomass at 60 DAT when combined use of FYM+ plus vermicompost had significantly lower weed biomass than sole application of FYM or vermicompost . Among weed control, at 60 and 90 DAT, weedy check had significantly higher biomass accumulation of grass and sedge weeds than all weed control treatments except straw mulch in case of sedge weeds only. Straw much had significantly lower biomass of grass weeds than all weed control treatments at 60 and 90 DAT; plastic much was significantly better than intercropping in reducing biomass of grass weeds.

The brinjal crop supplied with FYM and vermicompost alone or with mixture of FYM and vermicompost gave statistically similar brinjal yield. Among weed control, hand weedings treatments gave the highest brinjal yield which was at par with plastic mulch.

WP 1.2.8 Weed management in maize-garlic organic crop production system

CSKHPKV, Palampur

Treatments:

	Kharif	*Rabi*	Remarks/ short title
	Maize (Green cob)	Garlic	
T_1	Hoeing followed by earthing up at knee high stage	Hoeing at 15 DAS & 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) 5 t/ha + HW	Mulch 5 t/ha + HW	Mulch
T_5	SSB + mulch 5 t/ha + HW	SSB + mulch 5t/ha + HW	SSB + mulch
T_6	RSSB + mulch 5t/ha + HW	RSSB + mulch 5t/ha + HW	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

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%).

During *Kharif* 2019, thirteen weed species were found associated in maize crop. *Echinochloa colona* (25%) was the most dominated weed followed by *Cyperus* sp (24%), *Commelina benghalensis* (17%), *Polygonum alatum* (12%), *Galinsoga parviflora* (10%) and *Digitaria sanguinalis* (5%).

In *Rabi*, *Phalaris minor* was the most important weed in hoeing, SSB + hoeing, RSSB + hoeing, and crop rotation and second in importance in T_4 (mulch), T_6 (RSSB + mulch, Intensive cropping and chemical check. *Vicia sativa* was the most important weed in T_5 (SSB + mulch), T_9 (intensive cropping) and chemical check. *Stellaria media* was the most important weed in T_4 (mulch) and T_6 (RSSB + mulch) and second in IVI in SSB + hoeing, SSB + mulch, intercropping and rotation. *Tulipa asiatica* was most important having highest IVI in T_7 intercropping. In a overall scenario, *Phalaris minor* was the most important weed having highest IVI, followed by *Stellaria media*, *Vicia sativa*, *Tulipa asiatica*, *Vicia hirsute*, *Avena ludoviciana*, *Poa annua* and *Anagallis arvensis*.

E. colona was the most important weed in hoeing, mulch and chemical check. It was second in importance in SSB + mulch, intercropping and rotation. *Cyperus* sp., *C. iria*, *C. esculentus* and *C. difformis* was the most important weed in SSB + hoeing, RSSB + hoeing, SSB + mulch and second important in (hoeing), RSSB + mulch and intensive cropping. *Commelina benghalensis* was having highest IVI value in intercropping and intensive cropping and second important in SSB + hoeing and chemical check. *Galinsoga parviflora* was the most important weed in intensive cropping. *Digitaria sanguinalis* was most important weed in RSSB + mulch. On the overall basis, *Echinochloa colona* was having highest IVI value followed by *Cyperus* sp., *Commelina banghalensis*, *Polygonum alatum*, *Galinsoga parviflora*, *Digitaria sanguinalis* and *Physalis minima*. *Alternanthera* was present only in intercroppping and intensive cropping, *Eleusine indica* in chemical check, *Euphorbia geniculata* in RSSB + hoeing and rotation.

Raised stale seed bed + hoeing resulted in comparable green peas yield as the chemical check. All the other treatments were below in green peas yield as

Table 1.2.8.1 Maize equivalent yield and gross returns from different crops under cultural weed management treatments during 2018-19.

	Treatment	Maize equivalent yield (t/ha)			Gross returns (000' INR/ha)				
		Rabi	*Kharif*	System's	Peas	Coriander/ buckwheat	Maize	Soybean/ sarson	Total system's
T_1	Hoeing	5.1	5.8	10.9	82.0	-	139.4	-	221.4
T_2	SSB + hoeing	12.3	5.8	18.1	188.5	-	132.4	-	320.9
T_3	RSSB + hoeing	13.5	9.2	22.8	207.8	-	196.5	-	404.3
T_4	Mulch	3.4	5.2	8.6	53.1	-	125.1	-	178.2
T_5	SSB + mulch	8.9	4.3	13.2	137.5	-	112.0	-	249.5
T_6	RSSB + mulch	12.5	6.5	19.0	194.0	-	147.7	-	341.7
T_7	Intercropping	12.8	9.3	22.1	91.9	104.2	144.0	42.0	382.1
T_8	Crop rotation	6.4	8.0	14.4	100.3	-	179.0	-	279.3
T_9	Intensive cropping	15.4	12.8	28.2	83.0	152.8	153.1	83.3	472.3
T_{10}	Chemical check	15.2	10.3	25.6	233.3	-	219.0	-	452.3
SE(m±)		1.0	0.6	1.3	13.7	-	-	-	-
LSD (P=0.05)		3.0	1.7	3.7	40.8	-	-	-	-

compared to the chemical check. Similarly, RSSB + hoeing was comparable to the chemical check for green cob yield of maize. No other treatment was as good as the chemical check probably due to low nutrition for the organic sources owing to low release from these sources.

Intensive cropping resulted in 10.4% higher maize cob equivalent yield that the chemical check. RSSB + hoeing and intercropping resulted in comparable yields as chemical check. The other treatments were below in maize equivalent yield as compared to the chemical check owing to low crop yields.

Gross returns followed the trend of maize cob equivalent yield and the highest gross returns were accrued under intensive cropping followed by the chemical check, RSSB + hoeing, intercropping and RSSB + mulch. Similar was the trend for net returns. B:C was highest for intensive cropping, intercropping, chemical check, RSSB + hoeing and RSSB + mulch.

WP 1.2.9 Weed management options in rice-wheat cropping system under organic mode of cultivation

GBPUAT, Pantnagar

Wheat (*Rabi* 2018-19)

Among different herbicidal treatments, density of all the weeds except *Coronopus didymus*, *Melilotus indica* and *Chenopodium album* was completely controlled under direct seeded rice on FIRB- stale seed bed+soybean on bed + 1 hoeing at 20 DAS + HW at 40 DAS and wheat (FIRB) two rows on bed + mentha in furrows +one HW (30 DAS). This effect was followed by treatment direct seeded rice (convt.) under sequential application of pre *fb* post emergence herbicide. In rice followed by zero till wheat with application of ready-mix post-emergence herbicide, where *Phalaris minor, Solanum nigrum, Parthenium hysterophorus* and *Chenopodium album* were completely controlled. However, under direct seeded rice +Sesbania+ MW (25 DAS) + HW (40 DAS)-wheat (CTW) + Stale bed + one HW (30 DAS), *Phalaris minor, Solanum nigrum, Parthenium hysterophorus* and *Cyperus rotundus* were completely controlled.

The density of *P. minor* was completely controlled under non chemical treatments except transplanted rice on stale bed technique *fb* one MW then HW; conventional wheat on stale bed technique *fb* one HW and direct seeded rice with soil solarization *fb* one HW; zero tillage wheat with rice residue retention *fb* one HW. The density of *Coronopus didymus* was reduced under direct seeded rice +sesbania+ MW (25 DAS) + HW (40 DAS)-Wheat (CTW) + Stale bed + one HW (30 DAS) and direct seeded rice with soil solarization *fb* one HW; zero tillage wheat with rice residue retention *fb* one HW, whereas, density of *Mellilotus indica* was completely controlled under transplanted rice on soil solarized bed +1HW; zero till wheat with rice residue retention + one HW (30 DAS).

Total density and dry matter of all grassy and non grassy weeds was recorded lowest under conventional transplanted rice with sequential application of pre *fb* post emergence herbicide conventional till wheat along with ready-mix application of post emergence herbicide followed by rice (DSR) + *Sesbania* with supplementation of MW (25 DAS) *fb* HW (40 DAS) Wheat (CTW) + stale bed along with one HW (30 DAS).

The highest grain yield (4.5 t/ha) and straw yield (6.4 t/ha) was achieved with direct seeded rice (FIRB) on stale bed technique *fb* one hoeing then one HW; wheat (FIRB) with mentha in furrows *fb* one HW, rice equivalent yield of soybean was computed and added to sole rice yield in this treatment (Fig. 1.2.9.1).

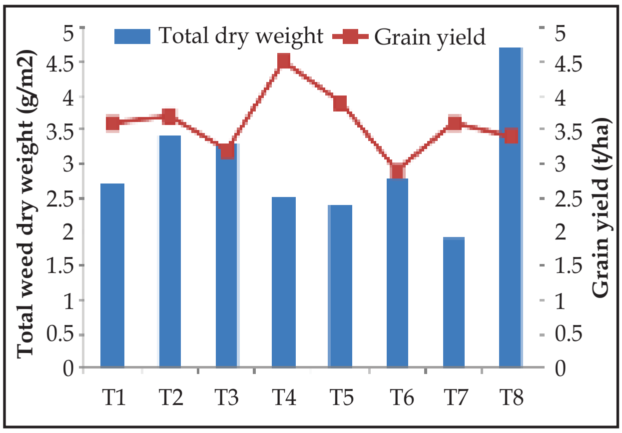


Fig 1.2.9.1 Total dry weight (g) at 60 DAS/DAT and grain yield (t/ha)

Rice (*Kharif*, 2019)

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* observed dominant which was completely controlled under direct seeded rice (DSR) with *Sesbania* incorporation *fb* one MW then one HW; wheat (CTW) on stale seed bed *fb* one HW followed by 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. Under transplanted rice control measures of rice (TRP) as well as wheat (conventional) completely controlled *Echinochloa colona, Eleusine indica, Panicum maximum, Dactyloctenium aegyptium, Mollugo stricta* and *Cyperus rotundus* being at par to rice (TPR) conventional with sequential application of pre *fb* post-emergence herbicide (control), wheat (conv.) with ready-mix post-emergence herbicide application (control). However, *Echinochloa colona*, *Eleusine indica*, *Dactyloctenium aegyptium* and *M. stricta* was also completely controlled under rice (TPR) stale bed-(10 days stagnation of water) *fb* 1HW (40 DAT), wheat (ZT) with rice residue retention along with one HW. *Eleusine indica, Dactyloctenium aegytium, Mollugo stricta* and, *C. rotundus* completely controlled under rice (TPR)- stale seed bed *fb* 1 MW (20 DAT) then supplementation of 1HW (40 DAT) wheat (conventional) stale seed bed along with 1 HW (30 DAS).

Minimum dry matter accumulation of all the recorded weed species was achieved under rice (TPR) conventional with sequential application of pre *fb* post-emergence herbicide (control) under wheat (conventional) with ready-mix application of post-emergence herbicide (control) except *Echinochloa colona*, *Ammania baccifera* and *Cyperus iria* amongst all the organic mode of control practices being at par with the rice (TPR)- summer ploughhing+ stale seed bed (10 days stagnation of water) *fb* 1MW (20 DAT) and HW(40 DAT) wheat (conventional) stale seed bed+ 1 MW (30 DAS). Under organic mode, grain and straw yield were comparable to each other but numerically highest grain and straw yield of rice (3.0 and 5.0 t/ha), respectively, achived under direct seeded rice (DSR)+ *Sesbania fb* MW and one HW; wheat (CTW)+ stale seed bed+1 HW. The lowest grain and straw yield was found with Rice (TPR) - (10 days stagnation of water) + 1 HW (40 DAT), wheat (ZT) with rice straw + one HW .

Total density and dry matter accumulation were recorded least with direct seeded rice (DSR)+ *Sesbania* and supplementation of MW (25 DAS) *fb* one HW (40 DAS), under conventional till+wheat + stale seed bed *fb* one HW and was comparable to rice (DSR) Conv.+pre-emergence *fb* post-emergence (Control) wheat (ZT) + post-emergence herbicide (Control) and (TPR)- stale seed bed +1 MW (20 DAT)+ 1 HW (40 DAT), wheat (conventional) stalebed + 1 HW (30DAS) (**Fig. 1.2.9.2**).

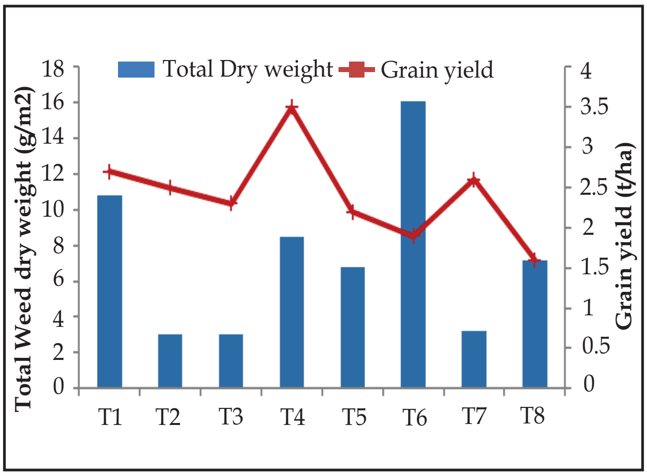


Fig 1.2.9.2 Total dry weight (g) at 60 DAS/DAT and grain yield (t/ha)

WP 1.2.10 Weed management in organic sweet corn - fennel cropping system

MPUAT, Udaipur

Effect of non-chemical methods of weed control in fennel /sweet corn and their effect on growth and yield of fennel /sweet corn was studied in collaboration with Network Project on Organic Farming with the following treatments:

S. No.	Treatment
1.	Summer ploughing + 1 hand weeding at 20 DAS
2.	Summer ploughing + straw mulch (5 t/ha) at 20 DAS+1 hand weeding at 40 DAS
3.	Summer ploughing + plastic mulch at sowing
4.	Stale seed bed preparation + 1 hand weeding at 20DAS
5.	Stale seed bed preparation + straw mulch (5 t/ha) at 20 DAS+1 hand weeding at 40 DAS
6.	Stale seed bed preparation + plastic mulch at sowing
7.	Soil solarization + 1 hand weeding
8.	Soil solarization + straw mulch (5 t/ha) at 20 DAS+1 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 + 1 HW at 40 DAS
11.	Pendimethalin 1000 ml /atrazine 500g fb straw mulching (5 t/ha) at 20 DAS
12.	Weedy check

In sweet corn (*Kharif* 2019) the major broadleaf weeds in the experimental fields were *Digera arvensis (9.12), Trianthema portulacastrum* (14.1) and *Commehina benghalensis* (16.31). The grassy weeds were *Echinochloa colona*(35.4) and *Dinebra retroflexa* (5.26). Weed density of grassy and broadleaved weeds were recorded significantly lower in either summer ploughing, stale seed bed or soil solarization in comparison to weedy check. Among these primary treatments soil solarization recorded lowest weed density and dry matter. The treatment of plastic mulch with the basic treatments of either summer ploughing, stale seed bed or soil solarization recorded significantly lower weed density (0.61, 0.57 and 0.80 /m^2) and dry matter (8.12, 6.93 and 6.18 g/m^2), respectively. While at 60 DAS, stale seed bed techniques with plastic mulch observed the lowest weed dry matter with 98.8% reduction over weedy check (71.4 g/m^2). Lowest weed density and dry matter at 30 and 60 DAS (0.27 and 1.50 g/m^2) were recorded by summer ploughing with plastic mulcing at sowing. All these treatments of plastic mulching were at par and significantly superior over soil solarization with one hand weeding either with or without straw mulch (5t/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.

Treatment of summer ploughing with plastic mulch proved most effective and recorded 99.39% reduction in total weed dry matter at 30 DAS in comparison to weedy check (44.56 g/m^2). Maximum weed control efficiency at 30 DAS (99.35%) was observed with summer ploughing with plastic mulch. Whereas at 60 DAS, maximum weed control efficiency (98.80%) observed in stale seed bed technique with plastic mulch. All the organic weed management treatments recorded significantly higher yield attributes and yield compared to weedy check. Maximum green cob weight (192.58 g) was recorded with treatment in which maize field prepared with soil solarization followed by plastic mulching, however it was found at par with other treatments of plastic mulch. Superiority of plastic mulch in organic weed management with soil solarization, stale seed bed and summer ploughing was also observed by number of cobs per plant and cob length.

Maximum values of green cob yield (8.79 t/ha) and green fodder yield (17.66 t/ha) of sweet corn were recorded with crop sown with treatment of soil solarization with plastic mulch, which was at par with plastic mulch with stale seed bed technique and summer ploughing. The highest net return (₹ 1,08,825/ha) was obtained with soil solarization *fb* plastic mulch, whereas maximum B:C ratio (2.35) was recorded with stale seed bed technique with plastic mulch.

In fennel (*Rabi* 2018-19) the major dicot weeds in the experimental fields were *Chenopodium album* (36.2%), *Chenopodium murale* (19.5%), *Fumaria parviflora* (20.6%), *Convolvulus arvensis* (2.3%), *Melilotus alba* (11.9%), *Malwa parviflora* (2.8%), *Phalaris minor* (6.46 %) was the only monocot weed at 30 DAS. Weed density of monocot and dicot weeds 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 statistically equivalent to each other 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.

Among different organic weed management treatments, maximum values of seed yield (1.48t/ha) of fennel was recorded with crop sown with treatment of stale seed bed with plastic mulch, which was at par with plastic mulch with soil solarization and stale seed bed and pre emergence application of pendimethalin 1000 g/ha with straw mulch. Application of plastic mulch with summer ploughing, stale seed bed and soil solarization recorded 226.4, 247.4 and 242.2%, increase in yield over weedy check (426 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 (₹ 94,225/ha) recorded and B:C of (2.41) was obtained with stale seed bed with one hand weeding.

WP1.2.11 Weed management in organically grown direct seeded aromatic rice- sweet corn cropping system

IGKV, Raipur

At Raipur experiments were condcuetd to find out suitable combination of organic sources for nutrient requirement and to assess the non chemical weed management practices in seeded aromatic rice- sweet corn system.

Nutrient management (Main plot)		
Treatment	***Kharif* (Rice)**	***Rabi* (Sweet corn)**
T_1	50% N (FYM) + 50% N (vermicompost) + *Azospirilium* + PSB	50% N (FYM) + 50% N (vermicompost)
T_2	50% N (FYM) + 50% N (poultry manure) + *Azospirilium* + PSB	50% N (FYM) + 50% N (poultry manure)
T_3	50% N (FYM) + 25% N (vermicompost) + 25% N (poultry manure) + *Azospirilium* + PSB	50% N (FYM) + 25% N (vermicompost) + 25% N (poultry manure)
Sub-plot *(Weed management)*		
W_1	Hand weeding twice	Black polythene mulch
W_2	Motorized weeder twice (single row type)	Paddy straw mulch (5 t/ha)
W_3	Motorized weeder twice (double row type)	Green manuring (incorporation 30 DAS)
W_4	Paddy weeder twice (manual)	Hand hoe
W_5	Green manuring(incorporation 30 DAS)	Hand weeding twice
W_6	Oxadiargyl 0.08kg /ha *fb* bispyribac-Na 0.025 kg/ha	Recommended herbicides (atrazine 1.0 kg/ha PE)
W_7	Weedy check	Weedy check

In *Kharif* and *Rabi* crops diluted cow urine + vermi wash 10% @ 500 litre/ ha was applied as foliar spray twice.

In aromatic rice (*Kharif* 2019) weed flora of the experiemental site was dominated with *Echinochloa colona* among grasses, *Cyperus iria* in sedges and *Cynotis axillaris and Alternanthera triandra* in broadleaf. Other weed flora present on the field was *Ischemum rugosum*, and *Fimbristilis miliaceae* and *Spilanthes acmella,* etc. Total weed density was lower in chemical weed control of oxadiargyl 0.08kg /ha PE *fb* bispribac-Na 0.025 kg /ha as PoE. However, among no-chemical weed management treatments, hand weeding twice and green manuring (incorporation 30 DAS) were equally effective in reducing the weed density of weeds at all the observational stages over weedy check. No significant difference in weed dry weight was recorded at all the observational stages due to various organic nutrient management sources. Weed management options showed significant variation in weed dry weight. At 40 DAS significantly lower dry weight of weeds was observed under oxadiargyl 0.08 kg /ha *fb* bispyribac Na 0.025 kg /ha, whereas at 60 DAS the lowest weed dry weight was recorded under hand weeding twice followed by herbicidal treatment. Significantly highest dry weight of weeds was recorded under weedy check over rest of the weed management options.

Significant difference in grain yield of scented rice was found under different nutrient management practices. Application of 50% N (FYM) + 50% N (poultry manure) + *Azospirilium* + PSB produced significantly higher grain yield over 50% N (FYM) + 50% N (vermicompost) + *Azospirilium* + PSB. However, in weed management practices maximum grain yield was found under application of oxadiargy l0.08 kg /ha *fb* bispyribac-Na 0.025 kg/ha which was significantly superior to rest of the treatments. In case of other than chemical method of weed management, hand weeding twice was equally effective and recorded comparable yield to that of oxadiargyl. Among mechanical WM treatments, motorized weeding twice (single and double row type) were equally effective and produced significantly higher grain yield (1.65 and 1.6 t/ha, respectively) over paddy row weeder twice and green manuring treatments. Highest net return and B:C ratio were found under 50% N (FYM) + 50% (PM) +*Azospirillum* + PSB. Whereas under weed management practices chemical weed management gave higher net return and B:C ratio, however, among other methods motorized weeder single row type twice gave maximum net return and B:C ratio.

In sweet corn (*Rabi*, 2018-19), *Medicago denticulata, Chenopodium album* and *Echinochloa colona* were the major weeds while the density of *Alternanthera triandra, Physalis minima, Cassia tora* and *Cannabis sativa* observed lesser and grouped as other weeds.

The lowest density (10.95/m^2) at 40 DAS of *Medicago denticulata* was recorded in T_2 and the highest density (12.33 /m^2) of *Medicago denticulata* was recorded in T_1. Similarly, the highest density (7.38 /m^2) of *Chenopodium album* was observed in T_1 and the lowest density (6.00 /m^2). *Echinochloa colona* was found maximum (4.90 /m^2) in T_1 and recorded minimum (3.62 /m^2) in T_2. Likewise, the density of other type of weeds was highest in (3.71 /m^2) in T1 and lowest (2.76 /m^2) in T_2.

At 60 DAS the population of *Medicago denticulata* was highest (14.52 /m^2) in T_1 and the lowest density (12.95 /m^2) of *Medicago denticulata* was recorded in T_2. Same trend was followed in the case of *Chenopodium album* and the highest density (9.29 /m^2) was observed in T_1 and the lowest density (7.81 /m^2) of *Chenopodium album* was recorded in T_2. *Echinochloa colona* was recorded highest (7.05 /m^2) in T_1 and recorded lowest (6.05 /m^2) in T_3. However, the density of other type of weeds was highest in (5.95 /m^2) in T_1 and lowest (4.76 /m^2) in T_2.

Among various weed control options, the highest density of *Medicago denticulata* was observed in W_7 (39.67 m^2) and the lowest density (0.11 /m^2) was observed in W_2. However, the lowest density (0.11/ m^2) of *Chenopodium album* was observed in W_2 and the highest density (6.44 /m^2) was observed in W_5 after weedy check (6.44 /m^2). *Echinochloa colona* was also found minimum (1.33 /m^2) in W_6 and observed maximum (5.22 /m^2) in W_5 next to weedy check. The density of other type of weeds was highest (4.78 /m^2) in W_7 and and (3.78 /m^2) in W_5 and lowest (0.11 m/m^2, 1.33 /m^2) in W_2 and W_6.

At 60 DAS the dry weight g/m^2 was maximum as the density of weeds was also maximum and the lowest dry weight of *Medicago denticulata* (0.36 g/m^2), *Chenopodium album* (1.01 g/m^2), *Echinochloa colona* (0.35 g/m^2) and other type (0.26 g/m^2) of weeds was recorded in W_2. The highest dry weight of *Medicago denticulata* (9.25 g/m^2), *Chenopodium album* (5.25 g/m^2), *Echinochloa colona* (5.75 g/m^2) and other type (3.96 g/m^2) of weeds were recorded in W_7.

Significantly the highest cob yield of sweet corn (3.40 t/ha) was obtained under 50% N (FYM) + 50% N (PM) over other organic nutrient options. 50% N (FYM) + 25% N (VM) +25% N (PM) (3.27 t/ha) was also found superior over 50% N (FYM) + 50% N (VC) where lowest cob yield was obtained (2.87 t/ha). Significantly highest yield (4.03 t/ha) was recorded under black polythene mulch which was 56.5% higher than the weedy check and from 6.5 to 32.2 % over all the other weed control options except atrazine 1.0 kg/ha (3.77 t/ha). Higher green cob yield was also recorded under atrazine 1.0 kg/ha as pre-emergence (W_6) (3.77 t/ha) over all the other weed control options (W_1, W_3, W_4, W5and W_6). Hand weeding twice at 20 and 40 DAS (3.49 t/ha) and straw mulch 5 t/ha also produced significantly higher cob yield over (W_4, W_5 and W_7). Lowest green cob yield was (1.75 t/ha) recorded under weedy check (W_7).

Organic management practices significantly affected the net return. Cost of cultivation was highest in 50% N (FYM) + 25% N (VC) + 25% N (PM) whereas, lowest in 50% N (FYM) + 50% N (PM). Cost of cultivation enhanced among different main plots is due to input cost like organic manures.

WP 1.2.12 (i) Weed management in Guava based intercrop system under organic farming

BCKV, Kalyani

Treatments having intercrop with green-gram in *Rabi* and vegetable cowpea in *Kharif* have been found to be the highest guava fruit producer (2.36 t/ha) as well as the highest guava equivalent yield (2.87 t/ha) in the system. However, highest B:C ratio of 1.93 was found in the treatment having leafy vegetable red amaranthus throughout the year. Both these treatments produced same inter crop yield of 3.39 t/ha. Regarding weed biomass production and WCE, treatment with black polythene mulch throughout the year was found to be the best treatment.

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

Rice (*Kharif* 2019)

Major weed flora observed during *Kharif* 2019 was *Echinochloa crusgalli, E. colona,* among grasses, *Cyperus iria, C. rotundus, Fimbristylis miliaceae* among sedges, *Marsilea quadrifolia, Alternanthera sessilis, Ludwigia parviflora, Ammania baccifera,* and *Commelina benghalensis* amongst broadleaved weeds. Among the weed management treatments, weedy has highest weed density and biomass followed by the treatment receiving summer deep tillage *fb* one hand weeding at 30 DAT. Application of RDF + pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT had significantly lower grassy, broad leaved, sedges, total weed density and weed biomass as compared to other weed management treatments throughout the crop growth period. Similar findings have been recorded in the second season of the crop. Treatment with closer spacing (20 X 15cm) *fb* one hand weeding at 30 DAT resulted 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.

WCE was highest of about 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 (442.67), grains/panicle (82.33) ,test wt. (20.87 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). 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.

WP 1.2.13 Weed management under turmeric - cowpea organic cropping system

KAU, Thrissur

An experiemnt was conducted to evaluate the effect of different organic mulches on weed control in turmeric based cropping system.

The experimental plot was dominated by broadleaved weeds such as *Borreria hispida*, *Alternanthera bettzickiana, Ludwigia perennis, Ageratum conyzoides*, *Cleome rutidosperma*, etc. The major sedge was found in the study area was *Cyperus iria*, while grassy weeds were very few. At 45 DAP, significant difference due to treatments was observed in the density of major weeds such as *Borreria hispida, Ludwigia perennis, Ageratum conyzoides* and *Cyperus iria*. The unmulched control along with mulching with *Eichhornia crassipes* and coconut fronds recorded the highest density of *Borreria hispida.* The lowest density of *Borreria hispida* was obtained with plastic mulch and it was followed by treatment with oxyfluorfen. Among the organic mulches, the lowest weed density of *Borreria hispida* was obtained in mulching with coir pith, followed by mulching with jack leaves and grass clippings. In case of other weeds such as *Ludwigia perennis, Ageratum conyzoides* and *Cyperus iria*, all the treatments except unmulched control were on par.

At all growth stages, the unmulched control recorded the highest weed dry matter production, followed by mulching with *Eichhornia crassipes.* The treatments with different mulching materials had varying effects on the weed control efficiency at different growth stages of turmeric. In all growth stages, mulching with polythene sheet recorded 100% weed control efficiency as the treatment was free from weeds. Mulching with polythene recorded significantly higher rhizome yield (45.97 t/ha) followed by mulching with jack leaves (34.67 t/ha) and mulching with grass clippings (33.89 t/ha), which were on par. Analysis of economics of cultivation revealed that mulching with polythene sheet recorded the highest B:C ratio of 5.00 and was followed by treatment with oxyfluorfen (4.76).

Table 1.2.13.1 Effect of treatments on weed control efficiencies at different stages

Treatments		Weed control efficiency (%)		
		45 DAP	90 DAP	135 DAP
T_1	Mulching with *Eichhornia crassipes*	23.0	22.1	21.3
T_2	Mulching with coir pith	67.4	65.3	55.0
T_3	Mulching with coconut fronds	53.5	42.2	35.3
T_4	Mulching with grass clippings	39.4	26.8	31.3
T_5	Mulching with jack leaves	51.6	53.9	45.6
T_6	Mulching with polythene sheet	100.0	100.0	100.0
T_7	Oxyfluorfen	95.0	67.9	31.5
T_8	Unmulched control	-	-	-

WP 1.2.14 Evaluation of non - chemical methods of weed management in fox tail millet – greengram cropping system.

UAS, Bengaluru

An experiemnt was conducted to evaluate the effective non- chemical methods of weed control on growth and yield of fox tail millet and greengram with the following set of treatments.

	Kharif- **Foxtail Millet**	*Rabi*- **Green gram**
T_1	*Stale seed sed technique	Stale seed bed technique
T_2	Inter cultivation twice at 25 + 1 hand weeding at 45 DAS	Inter cultivation twice at 25 + 1 hand weeding at 45 DAS
T_3	Stale seed bed technique + Intercultivation twice at 25 & 45DAS	Stale seed bed technique + Intercultivation twice at 25 & 45DAS
T_4	Straw mulching 5 t/ha at 10-15 DAS	Straw mulching 5 t/ha at 10-15 DAS
T_5	Bio-mulching (Seeds of cowpea is sown in between two rows of fox tail millet). The cover crops cowpea was mulched between rows at 30 (DAS) + 1 intercultuvation at 40 DAS	Bio-mulching (Seeds of cowpea is sown in between two rows of 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 (Seeds of Coriander is sown in between two rows of fox tail millet). The cover crops cowpea was mulched between rows at 30 (DAS) + 1 intercultuvation at 40 DAS	Bio-mulching (Seeds of Coriander is sown in between two rows of Green gram). The cover crops was mulched between rows at 30 DAS + 1 intercultivation at 40 DAS
T_8	Un weeded control	Un weeded control
T_9**	PE- pendimethalin 1.0 kg/ha + intercultivation 30 DAS	PE- pendimethalin 1.0 kg/ha + intercultivation 30 DAS

Greengram (*Rabi* 2018-19)

Major weed flora observed in the experimental field was *Cyperus rotundus* (among sedges), *Cynodon dactylon*, *Digitaria marginata, Dactyloctenium aegyptium, Echinochloa crusgalli, Echinochloa colona, Eleusine indica (*among grasses). Whereas, among broad-leaf weeds, major weeds were *Borreria hispida, Emilia sonchifolia, Euphorbia hirta, Spilanthes acmella, Lonadium supfruticesum, Ageratum conyzoides, Alternanthera sessilis, Acanthospermum hispidium, Commelina benghalensis*, *Cinebra didima*. Among the weed species, the density of grassy weeds was highest followed by broa-leaf weeds and sedges. At later stage after 60 days of crop growth *Chloris barbata* and *Bracharia ramose* weeds were noticed.

In non-chemical methods of weed control, hand weeding at 20 and 40 DAS, recorded higher weed control efficiency (85.1%) followed by inter cultivation at 25 DAS + one hand weeding at 45 DAS (81.8 %) and Stale seed bed technique + intercultivation twice at 25 and 45 DAS (78.8%). Lowest weed control efficiency was noticed in stale seed bed technique (25.4 %) and in treatment where straw mulching was imposed (19.1%) indicating, that the plots treated with only Stale seed bed technique and straw mulching were not effective in controlling weeds in green gram crop. The weed index was higher in stale seed bed technique (50.9 %) followed by straw mulching (45.2 %) owing to the fact that it produced less yield indicting the per cent yield loss varied from 50 to 55 % overhand weeding.

Highest gross return (₹ 63,000/ha) was obtained in hand weeding twice at 20 and 40 DAS followed by stale seed bed technique combined with intercultivation at 25 and 45 DAS (₹ 58,800 /ha). Highest net return was obtained in hand weeding twice at 20 and 40 DAS (₹ 38,500 /ha) followed by stale seed bed technique combined with intercultivation at 25 and 45 DAS (₹ 33,780 /ha) and one intercultivation at 25 DAS and one hand weeding at 45 DAS (₹ 33,050 /ha). The benefit: cost ratio was higher in hand weeding twice at 20 and 40 DAS (2.57), which is almost comparable with treatments T_3 - one intercultivation at 25 DAS + one hand weeding at 45 DAS (2.38) followed by treatment T_2 -Stale seed bed technique combined with intercultivation at 25 and 45 DAS (2.35), which are almost alike with twice hand weeding at 20 and 40 DAS.

Foxtail millet (*Kharif*, 2019)

Major weed species observed in experimental plots were *Cyperus rotundus* (among sedges) *Digitaria marginata, Dactyloctenium aegyptium, Eleusine indica, Setaria glauca* (among grasses). Whereas among broad leaf weeds *Borreria hispida, Spilanthes acmella, Lonadium supfruticesum, Sida acuta, Oldenlandia corymbosa, Ageratum conyzoides, Alternanthera sessilis, Acanthospermum hispidum, Commelina benghalensis*. Grasses dominated the weed flora followed by broad leaf weeds and sedges.

Under unweeded control the density of grasses (30.67 no./m^2) was highest at 60 DAS followed by broad leaf weeds (27.33 no./m^2), while it was comparatively lower in sedges (17.33 no./m^2). The same trend was followed at harvest; grasses (32 no./m^2), broad leaf weed (20.7 no./m^2) and sedges (12.0 no./m^2).

At 60 days after sowing and at harvest weed dry weight were significantly lower in hand weeding at 20 and 40 days after sowing (3.36 and 3.0 g/m^2) treatment, and was on par with stale seed bed technique + intercultivation twice at 25 & 45 days after sowing (3.86 and 3.6 g/m^2) followed by intercultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing (3.79 and 3.3 g/m^2).

Seed yield of foxtail millet was significantly higher in hand weeding at 20 and 40 DAS (1.34 t/ha) as compared to unweeded control. However, it was on par with stale seed bed technique + intercultivation twice at 25 & 45 days after sowing (1.27 t/ha) and followed by inter cultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing (1.28 t/ha). The highest yield might be due to better control of weeds at (tillering stage) which is critical stage of crop weed competition. Whereas lower seed yield (0.48 t/ha) was obtained in unweeded control.

Highest gross return (₹ 36,260 /ha) was obtained in hand weeding 20 and 40 days after sowing followed by inter cultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing (₹ 34,650 /ha); Stale seed bed technique + intercultivation twice at 25 & 45 days after sowing (₹ 34,290 /ha). While highest net return was obtained in Inter cultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing (₹ 18,775 /ha) followed by stale seed bed technique + intercultivation twice at 25 & 45 days after sowing

(₹ 18,315 /ha). Whereas, the B:C ratio was higher in inter cultivation at 25 days after sowing + 1 hand weeding at 45 days after sowing (2.18) due to lower cost of cultivation than hand weeding at 20 and 40 days after sowing (2.03). Hand weeding twice at 20 and 45 days after sowing did produce higher gross return, but net return and B:C ratio was lower because of availability of labour at crucial stage besides, the labour demands higher wages increased higher cost of cultivation thus results in lower B:C ratio.

WS 1.2.15 Evaluation of non-chemical weed management methods in fingermillet

PAJNCOA & RI, Puducherry

The dominant weed flora observed in the study area was *Echinochloa colona* (L), *Dactyloctenium aegyptium* (L.), *Eclipta prostrata* (L.), *Cleome viscosa* (L.), *Cyperus rotundus* (L.) and *Cyperus iria* (L.). Hand weeding twice significantly reduced the weed density (89 no./m^2) and resulted in higher weed control efficiency (91.4%). However, employing stale seed bed alone for weed management resulted in poor weed control efficiency (4.7%) but with the intervention of one or two mechanical weeding resulted in higher weed control efficiencies of 15.3 and 35.9%, respectively. Pre- emergence application of butachlor 1.0 kg/ha + 1 hand weeding resulted in better weed control (83%). Plants under stale seed-bed technique were shorter (80.4 cm) and produced lesser number of leaves (11.1 numbers) which resulted in yield loss of 40.2% compared to non-chemical weed management plots. Unweeded control accounted for 55.6.0% finger millet yield loss in coastal ecosystem of Karaikal, Puducherry UT.

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

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

TNAU, Coimbatore

During *Rabi* at 60 DAT 2018-19 lower total weed density and dry weight was recorded in herbicide treatments than hand weeding at 60 DAT **(Table 1.3.1.1)**. The application of bensulfuron methyl + pretilachlor *fb* hand weeding recorded lower total weed dry weight at 60 DAT and this treatment also produces higher rice grain yield (7.24 t/ha) and economic return. Significantly lower total weed density and dry weight at 60 DAT were recorded with pyrasosulfuron-ethyl (PE) *fb* hand weeding (K) and bensulfuron-methyl + pretilachlor *fb* hand weeding (R) treatment combination. And this treatment combination was also produced the maximum grain yield (8.06 t/ha) and highest economic return. The lowest grain yield was recorded with unweeded check during both the seasons. The extent of yield loss due to weeds was higher during *Kharif* season than that of *Rabi* season.

Table 1.3.1.1. Weed density, weed dry weight, grain yield and economics as influenced by long term weed management practicesl in transplanted lowland rice-rice cropping system

Treatment	Dose (g/ha)	Time of application (DAT)	*Rabi* 2018-19				*Kharif* 2019			
			Weed density (no./m^2) at 60 DAT	Weed dry weight (g/m^2)	Grain yield (t/ha)	B:C ratio	Weed density (no./m^2) at 60 DAT	Weed dry weight (g/m^2) at 60 DAT	Grain yield (t/ha)	B:C ratio
Pyrasosulfuron-ethyl (PE) *fb* hand weeding (K & R)	20	3 *fb* 30	3.02 (10.1)	1.45 (2.1)	5.58	1.61	6.15 (35.4)	2.99 (9.0)	7.71	1.62
Pyrasosulfuron-ethyl (PE) *fb* hand weeding (K); and bensulfuron methyl + pretilachlor *fb* hand weeding (R)	20 - 660	3 *fb* 30	1.37 (1.87)	1.11 (1.23)	7.24	1.99	2.91 (10.43)	1.52 (2.3)	8.06	2.10

Table continue....

Pyrasosulfuron-ethyl (PE) *fb* bispyribac sodium (PoE) (K & R)	20 *fb* 25	3 *fb* 30	4.10 (17.3)	2.13 (4.3)	6.00	1.65	5.16 (26.12)	3.59 (16.3)	7.55	1.75
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	3.37 (10.3)	2.97 (7.3)	6.85	1.77	5.95 (28.2)	3.98 (13.3)	7.12	1.74
Hand weeding twice	-	15 and 30	4.28 (17.3)	3.31 (8.9)	6.12	1.70	9.46 (90.5)	4.73 (25.3)	6.86	1.78
Unweeded check	-	-	9.68 (89.7)	5.87 (38.9)	2.15	1.11	11.79 (142.5)	6.95 (47.3)	1.69	1.33
SEm ±			0.12	0.13	0.17		0.17	0.32	0.17	
LSD (P=0.05)			0.27	0.27	0.35		0.41	0.69	0.38	

Note: **K** –*Kharif* ; **R** -*Rabi* , **DAT** : Days after transplanting; **PE**- Pre-emergence; **PoE**- Post-emergence; ***fb***- Followed by; Original figures in parentheses were subjected to square-root transformation $(\sqrt{x+0.5})$ before statistical analysis.

WP 1.3.1.2 Long-term herbicidal trial in rice-rice cropping sequence

AAU, Jorhat

Among the various nutrient and weed management practices, farmers practice (pretilachlor

Table 1.3.1.2 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				
	Weed density (no./m²) at 60 DAT	Weed dry weight (g/m²) at 60 DAT	No. of panicles /m²	Grain yield (t/ha)	Straw yield (t/ha)	Weed density (no./m²) at 60 DAT	Weed dry weight (g/m²) at 60 DAT	No. of panicles /m²	Grain yield (t/ha)	Straw yield (t/ha)
Farmers practice (pretilachlor 0.750 kg/ha as PE + NPK fertilizer)	321	48.7	119	1.65	4.25	245	36.2	184	11.7	11.7
Pyrazosulfuron 25 g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT (100% nutrient through fertilizers)	221	41.6	130	1.73	6.25	200	33.7	190	12.7	12.7
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)	300	45.2	129	1.68	5.03	215	34.6	183	13.9	13.9
Pyrazosulfuron 25 g/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)	207	41.1	142	2.08	7.25	183	31.6	241	14.2	14.2
Pyrazosulfuron 25 g/ha (PE) *fb* 2,4-D 0.5 kg/ha at 30 DAT rotated with pretilachlor (100% nutrient through fertilizers)	184	24.9	136	2.00	7.25	187	29.3	209	14.1	14.1
LSD (P=0.05)	42	6.6	10	0.11	0.60	30	NS	22	1.4	1.4

Note: **PE**-Pre-emergence; **DAT**-Days after transplanting; ***fb***- Followed by

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)**. Among other weed management treatments, pyrazosulfuron 25g/ha + 2, 4-D 0.5 kg/ha rotated with pretilachlor 0.750 kg/ha (100% nutrient through fertilizers) significantly reduced the weed density and dry biomass accumulation in autumn. Whereas, supplementation of fertilizer through organic source and application of pyrazosulfuron 25 g/ha + 2, 4-D 0.5 kg/ha rotated with pretilachlor 0.750 kg/ha enhanced the number of panicles, grain yield and straw yield of autumn rice. 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 25 g/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 1.3.1.3 Weed management and soil enrichment by concurrent growing of daincha in rice-rice-vegetable cropping system

KAU, Thrissur

The experiment could not be continued due to total loss of rice by submergence in the floods which occurred in the second week of August.

WP 1.3.2 Weed management in maize-based cropping system

WP 1.3.2.1 Efficacy of pre and post emergence herbicides in maize

MPUAT, Udaipur

The weed management 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 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 density of *E. colona* and *C. benghalensis*, however, the density of *D. retroflexa* was minimized with twice IC + HW in maize. The total lowest weed dry biomass accumulation at DAS was noticed with the application of topramezone, atrazine (25.2+500 g/ha) EPOE *fb* IC + HW at 40 DAS treatment. As a result the higher grain yield (4.57 t/ha), net return (₹ 62,648/ha) and B:C ratio (1.91) was also observed with the application of topramezone +atrazine (25.2+500g/ha) EPOE *fb* IC + HW at 40 DAS .

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

Treatments	Weed density (no./m²) at 60 DAS			Weed dry weight (g/m²) at 60 DAS	Grain yield (t/ha)	Net return (₹ /ha)	B:C Ratio
	E. colona	*D. retroflexa*	*C. benghalensis*				
Atrazine 1.0 kg/ha PE *fb* HW at 40 DAS	3.10 (9.10)	3.03 (8.67)	2.11 (3.97)	4.65 (21.1)	3.03	40,408	1.67
Atrazine + pendimethalin (0.50+0.25 kg/ha) PE	2.57 96.27)	2.61 (6.33)	1.45 (1.60)	3.95 (15.1)	2.87	33,994	1.31
Atrazine 1.0 kg/ha PE *fb* 2,4-D 1.0 kg /ha LPoE	2.82 (7.46)	2.41 (5.33)	1.83 (2.90)	4.07 (16.0)	2.84	33,772	1.32
Atrazine + pendimethalin (0.50+0.25 kg/ha) PE *fb* 2,4-D 1.0 kg /ha LPoE	2.25 (4.59) (10.3)	1.87 (3.00)	1.43 (1.56)	3.16 (9.47)	3.42	43,588	1.57

Table continue...

Topramezone 25.2 g/ha EPoE	3.29 (11.00)	2.90 (8.00)	1.42 (1.53)	4.06 (16.07)	3.32	42,355	1.58
Tembotrione 120 g /ha EPoE	3.39 (3.00)	2.85 (7.67)	1.31 (1.27)	4.07 (16.13)	3.40	44,924	1.67
Topramezone 25.2 g/ha EPoE *fb* IC +HW at 40DAS	1.86 (3.42)	1.95 (3.33)	1.29 (1.17)	2.46 (5.63)	3.91	49,769	1.56
Tembotrione 120 g /ha EPoE *fb* IC +HW at 40DAS	1.98 (2.67)	2.65 (6.67)	1.30 (1.19)	3.10 (9.16)	3.88	49,161	1.54
Topramezone + atrazine (25.2+500 g/ha) EPoE *fb* IC + HW at 40DAS	1.78 (2.00)	1.78 (2.67)	1.18 (0.91)	2.40 (5.26)	4.57	62,648	1.91
Tembotrione + atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40DAS	1.55 (5.00)	1.96 (3.33)	1.00 ((0.54)	2.41 (5.33)	4.48	60,509	1.84
IC+HW at 20 and 40DAS	2.34 (46.7)	1.77 (2.67)	1.14 (0.90)	2.82 (7.47)	4.10	50,627	1.45
Weedy check	6.86	4.49	4.01	9.09 (82.2)	2.26	24,686	1.10
SEm ±	0.13	0.13	0.10	0.13	0.18	3,695	0.13
LSD (P= 0.05)	0.39	0.38	0.29	0.39	0.53	10,836	0.38

Note: **PE:** Pre-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 1.3.2.2 Weed management with new generation herbicides in maize (sweet corn)

OUAT, Bhubaneswar

In sweet corn, at 45 DAS, the total lowest weed density and dry bio mass accumulation was recorded with IC+HW at 20 and 40 DAS, whereas, among chemical and integrated weed management approaches the minimal weed density was observed in atrazine 1.0 kg/ha PE *fb* HW at 40 DAS treated plots (**Table 1.3.2.2**). On the other hand, the minimum dry biomass of total weeds at 45 DAS was observed with EPoE application of tembotrione 100 g/ha. 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. EPoE application of tembotrione + atrazine (100+250 g/ha) recorded highest fresh kernel yield (15.8 t/ha) and cob yield (35.4 t/ha). However, the maximum green fodder yield was recorded with EPoE application of tembotrione 100 g/ha.

Table1.3.2.2 Effect of different weed management treatments on weed growth and crop yield of sweet corn

Treatments	Weed density (no./m²) at 45 DAS	Weed dry weight (No/m²) 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)	8.97	20.5	38.6
Atrazine + pendimethalin (0.50 + 0.25 kg/ha) PE	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)	10.5	24.4	40.4
Atrazine + pendimethalin (0.50 + 0.25 kg/ha) PE *fb* 2,4-D 1.0 kg/ha LPoE	5.53(30.0)	3.90(14.7)	14.3	34.5	40.7
Topramezone 25 g/ha EPoE	8.01(32.5)	1.42(1.5)	12.2	30.7	45.3

Table continue...

Tembotrione 100 g/ha EPoE	7.97(31.4)	1.26(1.33)	12.1	30.9	45.8
Topramezone 25 g/ha EPoE *fb* IC	7.48(28.7)	0.91(0.33)	13.4	32.2	47.3
Tembotrione 100 g/ha EPoE *fb* IC	7.63(31.4)	0.84(0.22)	14.4	32.2	47.9
Topramezone + atrazine (25 + 250 g/ha) EPoE *fb* IC	6.08(30.8)	1.43(1.54)	13.0	29.4	42.5
Tembotrione + atrazine (100+ 250 g/ha) EPoE *fb* IC + HW at 30 DAS	5.2(30.5)	1.97(1.84)	15.8	35.4	45.9
IC + HW at 20 and 40 DAS	2.01(3.5)	0.84(0.22)	15.1	30.8	40.8
Weedy check	82.4(102.4)	14.3(15.4)	7.4	12.1	23.4
SEm±	0.22	0.08	1.2	1.1	1.34
LSD (P=0.05)	0.53	0.19	3.3	3.6	3.12

Note: **PE:** Pre-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 1.3.2.3 Efficacy of pre and post emergence herbicides in maize

BCKV, Kalyani

Major weed flora in the experimental plots consisted of *Cynodon dactylon, Eleusine indica* (grassy weed), *Cyperus rotundus* (sedge), *Argemone mexicana, Ageratum conyzoides, Euphorbia hirta, Trianthema portulacastrum* (broad leaved weeds). It was observed that the weed density was significantly varied due to the effect of pre and post-emergence herbicides **(Table 1.3.2.3)**. At 60 DAS the lowest weed density, weed biomass and highest WCE (91.8%) in maize plots were observed with the application of topramezone+ atrazine (25.2+500 g/ha) EPoE *fb* IC + HW at 40 DAS. The next best performance was observed with the application of tembotrione +atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40 DAS and was followed by the treatment receiving IC + HW at 20 and 40 DAS. The highest grain yield and straw yield were recorded with the application of topramezone + atrazine (25.2+500 g/ha) EPoE *fb* IC + HW at 40 DAS and was followed by tembotrione + atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40 DAS and IC + HW at 20 and 40 DAS. The highest net return (₹ 66,779/ha) was realized with the application of atrazine + pendimethaline (0.50+0.25 kg/ha) PE *fb* 2,4-D 1.0 kg/ha LPoE and the highest B:C ratio (2.26) was recorded with topramezone 25.2 g/ha EPoE.

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

Treatments	Weed density (no./m^2) at 60 DAS	Weed dry weight (no./m^2) at 60 DAS	Grain yield (t/ha)	Straw yield (t/ha)	Net return (₹/ha)	B:C ratio
Atrazine 1.0 kg/ha PE *fb* HW at 40DAS	5.9(33.7)	4.8(22.1)	6.84	11.1	59,333	1.99
Atrazine + pendimethaline (0.50+0.25 kg/ha) PE	7.2(51.4)	5.8(32.7)	6.68	10.5	63,438	2.21
Atrazine 1.0 kg/ha PE *fb* 2,4-D 1.0 kg/ha LPoE	6.4(39.6)	5.2(25.7)	6.75	10.8	61,988	2.12

Table continue...

Atrazine + pendimethaline (0.50+0.25 kg/ha) PE *fb* 2, 4-D 1.0 kg/ha LPoE	5.6(30.4)	4.5(19.6)	7.05	11.5	66,779	2.19
Topramezone 25.2 g/ha EPoE	9.7(92.3)	7.8(59.9)	6.33	9.6	60,927	2.26
Tembotrione 120 g/ha EPoE	10.4(107.7)	8.6(72.8)	6.21	9.1	58,219	2.20
Topramezone 25.2 g/ha EPoE *fb* IC + HW at 40DAS	7.9(61.4)	6.6(42.6)	6.51	10.2	52,236	1.86
Tembotrione 120 g/ha EPoE *fb* IC + HW at 40DAS	8.7(74.7)	7.3(51.9)	6.43	9.9	50,526	1.83
Topramezone + atrazine (25.2+500 g/ha) EPoE *fb* IC + HW at 40DAS	3.7(13.0)	3.1(8.5)	7.22	12.5	63,133	1.99
Tembotrione + atrazine (120+500 g/ha) EPoE *fb* IC + HW at 40DAS	4.3(17.3)	4.0(14.8)	7.18	12.2	62,038	1.97
IC + HW at 20 and 40DAS	5.0(24.0)	4.3(17.5)	7.12	11.8	62,162	2.00
Weedy check	12.7(160.0)	10.2(103.2)	5.08	7.1	38,908	1.81
SEm±	0.02	0.06	0.8	0.6	-	-
LSD (P=0.05)	0.07	0.18	2.1	1.9	-	-

Note: **PE:** Pre-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 1.3.3 Weed management in other cropping system

WP 1.3.3.1 Weed management in chickpea

WP 1.3.3.1.1 Efficacy of different pre and post-emergence herbicides in chickpea (*Cicer arietinum*)

PDKV, Akola

The various weed management treatments significantly influenced the weed growth in chickpea. Among different weed management practices, hand weeding twice at 30 and 50 DAS recorded significantly lowest total weed density and dry matter accumulation at 40 DAS, and it might be due to complete removal of weed by hand weeding **(Table 1.3.3.1.1)**. Among the various post-emergence herbicides, application of imazethapyr 50 g/ha and oxyfluorfen 150 g/ha as pre-emergence performed superiorly in reducing the total weed density and dry biomass accumulation at 40 DAS in chickpea. Hand weeding twice produced significantly highest chickpea seed yield (2.07 t/ha) as compared to other treatments, and it was at par with oxyfluorfen 150 g /ha (1.96 t/ha) and imazethapyr 50 g /ha (1.88 t/ha). The highest stover yield was also recorded with two hand weeding treatments. Among different weed management practices the maximum net return was noticed with two hand weedings treatment, whereas, the highest B:C was calculated with pre-emergence application of oxyfluorfen 150 g/ha as weed management practice in chickpea.

Table 1.3.3.1.1 Effect of different pre and post-emergence herbicides on weed growth, crop yield and economics in chickpea

Treatments	Weed density (no./m²) at 40 DAS	Weed dry weight (g/m²) at 40 DAS	Seed yield (t/ha)	Stover yield t/ha)	Net return (₹/ha)	B:C ratio
Pendimetheline 1000g/ha PE	5.93(34.6)	3.84(14.4)	1.58	2.29	41,951	2.41
Oxyfluorfen 150 g/ha PE	4.75(22.2)	3.30(10.4)	1.96	2.67	58,884	3.00
Quizalofop ethyl 50 g/ ha PoE	5.44(29.1)	3.47(11.6)	1.74	2.48	49,018	2.65
Imazethapyr 50 g/ha PoE	4.50(19.8)	3.20(9.7)	1.88	2.64	55,403	2.87
Propaquizafop 25.2 g/ha PoE	5.07(25.2)	3.42(11.1)	1.84	2.63	52,888	2.74
Topramezone 33.6 g/ha PoE	4.78(22.3)	3.28(10.2)	1.51	2.21	39,355	2.35
Two hand weeding at 30 and 50 DAS	4.15(16.7)	3.00(8.5)	2.07	2.77	59,679	2.78
Weedy-check	9.35(86.9)	7.04(49.1)	1.12	1.84	23,779	1.87
SEm±	0.14	0.10	0.07	0.07	3,278	-
LSD(P=0.05)	0.41	0.30	0.22	0.21	9,672	-

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

WP 1.3.4 Herbicidal weed management in greengram

WP 1.3.4.1 Weed management in greengram and its residual carry over effect on succeeding crops

CCSHAU, Hisar

Experimental field was infested with *Trianthema portulacastrum* and *Cyperus rotundus*. Among the pre-emergence herbicide, tank mix application of pyroxasulfone + pendimethalin was most effective in reducing the density of *T. portulacastrum* **(Table 1.3.4.1)**. Whereas, among post-emergence herbicides application of imazethapyr at 70 g/ha efficiently control this weed. In case of *C. rotundus* infestation, pre-emergence application of pyroxasulfone + pendimethalin and post-emergence application of imazethapyr + pendimethalin and aciflourfen + clodinafop at higher rate was more effective. Manual removal of weeds gave lowest weed dry biomass and it was at par with pyroxasulfone 150 g/ha as pre-emergence and imazethapye + pendimethalin as post-emergence. The maximum plant dry weight (g/m²) was recorded with manual weeded plots, but the highest no. of pod/plant was observed with ready mix application of aciflourfen + clodinafop at its higher rate. The maximum seed yield of greengram was also recorded with aciflourfen + clodinafop at its higher rate.

Table 1.3.4.1 Effect of different weed management practices on weed growth and crop yield in greengram

Treatments	Dose (g/ha)	Time of application	Weed density (no./m²) at 40 DAS		Weed dry weight (g/m²) at 40 DAS	Plant dry weight (g/m²) at 40 DAS	No. of pods/ plant	Seed yield (t/ha)
			T. portulacastrum	*C. rotundus*				
Aciflourfen + clodinafop (RM)	245	3-4 leaf stage	1.82 (2.3)	2.02 (3.1)	24.6	38.7	79.9	1.20
Aciflourfen + clodinafop (RM)	305	3-4 leaf stage	1.95 (2.8)	2.14 (3.6)	19.3	38.2	75.5	1.26

Table continue...

Aciflourfen + clodinafop (RM)	370	3-4 leaf stage	2.02 (3.1)	1.70 (1.9)	13.2	39.5	82.3	1.36
Pyroxasulfone	127.5	PE	2.53 (5.4)	1.90 (2.6)	15.8	41.07	65.4	1.25
Pyroxasulfone	150	PE	2.28 (4.2)	1.90 (2.6)	10.2	43.27	53.3	1.29
Pyroxasulfone + pendimethalin (TM)	106 + 1000	PE	1.70 (1.9)	1.61 (1.6)	26.3	43.77	50.1	1.26
Quizalofop	60	3-4 leaf stage	2.74 (6.5)	2.53 (5.4)	41.5	28.27	40.6	0.75
Imazethapyr	70	3-4 leaf stage	1.82 (2.3)	2.14 (3.6)	54.3	31.6	48.9	1.07
Imazethapyr +quizalofop (TM)	70 + 60	3-4 leaf stage	2.47 (5.1)	2.21 (3.9)	65.6	30.43	46.1	1.11
Imazethapyr +imazamox (RM)	70	PE	2.19 (3.8)	2.26 (4.1)	48.7	26.8	53.9	1.14
Pendimethalin *fb* quizalofop	1000	PE	2.14 (3.6)	1.90 (2.6)	19.4	24.2	48.9	0.92
Imazethapyr + pendimethalin (TM)	1000	PoE	1.97 (2.9)	1.70 (1.9)	10.9	43.97	56.8	1.31
Two hand weeding	-	20 & 40 DAS	1.0 (0)	1.0 (0)	8.5	48.77	53.3	1.33
Weedy check	-	-	3.10 (8.6)	2.37 (4.6)	79.2	41.7	40.3	0.59
Weed free	-	-	1.0 (0)	1.0 (0)	0.0	30.47	62.0	1.34
SEm±			0.14	0.11	1.3	1.35	2.1	0.048
LSD(P=0.05)			0.41	0.31	3.8	3.90	6.2	0.141

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

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 37.5-72.8 at 30 DAS **(Table 1.3.4.2)**. 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 residual toxicity in mustard. Significantly lesser plant height, number of leaves /plant and seed yield were observed with treatments of imazethapyr alone or in combination as compared to untreated check and other herbicides. So 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 can be used safely without any toxic effect.

Table 1.3.4.2 Residual effect of different herbicides applied in greengram on growth and yield of succeeding mustard crop

Treatments	Dose (g/ha)	Time of application	Plant dry weight (g/plant) at 30 DAS	Phyto-toxicity on crop (%) at 30 DAS	Plant height (cm) at 30 DAS	No. of plants/ m row at 20 DAS	No. of leaves /plant 30 DAS	Seed yield (t/ha)
Aciflourfen + clodinafop (RM)	245	3-4 leaf stage	0.93	0	21.0	10	7.0	2.39
+ clodinafop (RM)	305	3-4 leaf stage	0.98	0	27.6	10	6.2	2.40
Aciflourfen + clodinafop (RM)	370	3-4 leaf stage	0.92	0	31.8	10.3	6.43	2.47

Table continue...

Pyroxasulfone	127.5	PE	0.80	0	34.2	9.6	5.76	2.35
Pyroxasulfone	150	PE	1.12	0	35	11	5.76	2.39
Pyroxasulfone + pendimethalin (TM)	106 + 1000	PE	1.24	0	32.9	10.1	6.86	2.31
Quizalofop	60	3-4 leaf stage	0.52	0	22	9.6	6.63	2.35
Imazethapyr	70	3-4 leaf stage	0.12	72.8	8.3	8	3.83	1.53
Imazethapyr +quizalofop(TM)	70 + 60	3-4 leaf stage	0.34	59.3	10.6	8.5	4.01	1.58
Imazethapyr +imazamox (RM)	70	PE	0.31	37.5	11.6	9.5	4.36	1.61
Pendimethalin *fb* quizalofop	1000	PE	1.10	0	18.5	10	5.76	2.19
Imazethapyr + pendimethalin (TM)	1000	PoE	0.94	0	20.6	9.3	6.53	2.48
Two hand weeding	-	20 & 40 DAS	1.21	0	26.3	10.3	6.03	2.52
Weedy check	-	-	1.23	0	29.1	10	6.21	2.43
Weed free	-	-	1.28	0	27.4	10	6.12	2.37
SEm±			0.03		0.92	0.31	0.20	0.078
LSD (P=0.05)			0.10		2.65	0.93	0.59	0.22

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

WP 1.3.5 Weed management in cotton

WP 1.3.5.1 Productivity and economics of Bt cotton under different fertigation levels and weed management practices.

PDKV, Akola

Different fertigation levels did not differed significantly the total weed density at 60 DAS of crop. Whereas, weed dry matter accumulation was influenced with the fertilizer application techniques and fertigation levels **(Table 1.3.5.1)**. The higher weed dry weight recorded with soil application of recommended dose of fertilizers compared to fertigation treatments. With the increasing rate of fertigation level, the weed dry weight was also increased significantly. The seed cotton yield, lint yield and stalk yield was also increased with the increasing rate of fertigation level and the lower values were observed with the plots receiving fertilizer through soil application. Among the different fertigation level, the maximum net return and B:C ration was found with 125% RDNK. Among the different weed management practices, farmers practice-3 hoeing 15-20 days interval after sowing *fb* 3 HW was significantly superior over all other treatments at 60 DAS and it was at par with directed spray of paraquat 0.3 kg /ha at 30 DAS *fb* 1 HW 15 days after spraying *fb* paraquat 0.6 kg/ha 60 DAS *fb* 1 HW 30 days after spraying. The farmers practice produced significantly higher seed cotton yield, lind yield and stalk yield that that of other weed management practices. Whereas, in economic point of view, the above integrated weed management practice resulted higher net monitory return and B:C ration than the farmers practice (**Table 1.3.5.2**).

Table 1.3.5.1 Effect of different fertigation levels and weed management practices on weed growth, crop yield and economics of Bt cotton

Treatments	Weed density (no./m^2) at 60 DAS	Weed dry weight at 60 DAS	Seed cotton yield (t/ha)	Lint yield (kg/ha)	Stalk yield (t/ha)	NMR (₹/ha)	B:C ratio
Fertigation level							
100% RDF in 3 split (soil application)	5.81 (37.1)	6.54 (48.2)	1.73	634	2.86	40,662	1.86

Table continue...

75% RDNK in 5 split (Fertigation)	5.37 (31.9)	5.56 (36.3)	1.95	716	3.15	42,015	1.73
100% RDNK in 5 split (Fertigation)	5.48 (33.4)	5.84 (39.0)	2.32	855	3.69	56,911	1.93
125% RDNK in 5 split (Fertigation)	5.72 (36.2)	6.11 (42.0)	2.64	974	3.94	69,774	2.09
SEm±	0.10	0.14	0.06	21	0.08	2,957	-
CD(P=0.05)	NS	0.49	0.20	73	0.30	10,232	-
Weed management practices							
Pendimethalin 1 kg /ha PE *fb* pyrithiobac sodium 0.062 kg /ha + propaquizafop 0.075 kg /ha 25-30 DAS *fb* HW at 45-50 DAS	4.75 (22.1)	5.30 (25.1)	2.42	892	3.80	64,013	2.13
Pendimethalin 1 kg /ha PE *fb* directed spray (DS) of paraquat 0.6 kg /ha at 40-50DAS.	5.18 (26.5)	5.69 (32.5)	2.27	834	3.63	60,232	2.14
DS of paraquat 0.3 kg /ha at 30 DAS *fb* HW 45 DAS *fb* paraquat 0.6 kg /ha 60 DAS (DS) *fb* 1 HW 30 Days after spraying.	4.47 (19.5)	4.65 (21.1)	2.53	930	3.99	69,189	2.22
Farmer practices – 3 hoeing 15-20 Days interval after sowing *fb* 3 HW.	4.23 (17.5)	4.30 (18.5)	2.68	988	4.16	65,214	1.95
Weedy check	9.36 (87.5)	10.39 (107.8)	0.90	330	1.47	3,055	1.07
SEm±	0.09	0.13	0.03	12	0.05	1,623	-
LSD (P=0.05)	0.26	0.38	0.09	35	0.16	4,677	-

Note: **RDF:** Recommended dose of fertilizer (120-60-60 kg/ha); **RDNK –** Recommended dose of **N & K;** Source of fertilizer – **N** and **K** through straight fertilizer i.e. urea and murate of postash (White-water soluble) through drip. Phosphorus applied in the form of single super phosphate as a basal; 5 split: 10, 20, 25, 25, 20% at basal, 20, 40, 60, 80 **DAS; PE:** Pre-emergence; **DAS:** Days after sowing; Original figures in parentheses were subjected to square-root transformation $(\sqrt{x + 0.5})$ before statistical analysis.

Table 1.3.5.2 Interaction effect of fertigation levels and weed management practices in cotton lint yield (kg/ha)

Fertigation / weed management	Pendimethalin *fb* pyrithiobac Na + propaquizafop *fb* HW	Pendimethalin *fb* paraquat (DS)	Paraquat (2 DS) *fb* HW (2)	FP-Hoeing (3) *fb* HW (3)	Weedy check
100% RDF soil application	712	674	736	782	268
75% RDNK in 5 Splits	795	724	841	892	328
100% RDNK in 5 Splits	964	902	995	1061	353
125% RDNK in 5 Splits	1095	1037	1150	1216	372
SE (m) ±			25		
LSD (P=0.05)			71		

WP 1.3.6 Weed management in sugarcane

WP 1.3.6.1 Evaluation of different herbicides in spring planted sugarcane

CCSHAU, Hisar

Cyperus rotundus was the major weed constitutes 87.6 to 93.4 % weed density at different stages of crop growth. Yield loss recorded due to weeds in weedy check plot was 55.5 % in comparison to three manual hoeings at 30, 60 and 90 DAP of crop (**Table 1.3.6.1**). All the weed control treatments significantly reduced the weed density and weed biomass accumulation compared with the weedy plot. The treatments metribuzin at 1.0 kg/ha + halosulfuron at 67.5 g/ha (TM) PoE, metribuzin PRE *fb* halosulfuron PoE, atrazine PRE *fb* halosulfuron PoE and sulfentrazone at 720 g/ha as PRE *fb* hoeing at 45 days *fb* 2,4-D ester at 1.0 kg/ha gave excellent control of complex weed flora of sugarcane during the critical crop–weed competition period. None of the applied herbicide alone, as in combination and in sequence had any phytotoxic effect on sugarcane plant crop except moderate visual phytotoxicity (scale 4) was recorded from atrazine 2.0 kg/ha PRE *fb* metsulfuron + carfentrazone 25 g/ha PoE (RM) 60 DAP at 7 and 15 days after application of metsulfuron + carfentrazone. Among all the applied treatments maximum cane yield was obtained from three hoeing treatment (92.9 t/ha) followed by metribuzin at 1.0 kg/ha + halosulfuron 67.5 g/ha (TM) PoE (91.6 t/ha) and metribuzin 1.0 kg/ha PRE *fb* halosulfuron 67.5 g/ha PoE (90.8 t/ha). Highest total cost of cultivation and gross return were obtained in three hoeing condition (₹1,74,225/ha and ₹3,25,707/ha) and highest return over variable cost and B: C ratio were recorded from metribuzin 1 kg/ha + halosulfuron 67.5 g/ha (₹ 1,49,849 /ha and 1.87) and metribuzin 1.0 kg/ha PRE *fb* halosulfuron 67.5 g/ha PoE (₹ 1,44,463/ha and 1.83).

Table 1.3.6.1 Effect of different herbicides on weed biomass, crop yield and economics of sugarcane

Treatment	Dose (g/ha)	Time of application	Weed dry weight (g/m^2) at 135 DAP				Cane yield (t/ha	B:C ratio
			Grass	Broad leaf	Sedge	Total		
Metribuzin	1000	PE	10.7 (115.6)	3.87 (14.0)	2.81 (6.9)	11.7 (136.6)	70.5	1.61
Metribuzin + halosulfuron methyl (TM)	1000+ 67.5	PE	5.41 (28.3)	3.57 (11.8)	2.68 (6.1)	6.87 (46.3)	84.9	1.77
Atrazine	2000	PE	11.2 (125.2)	4.09 (15.7)	3.43 (10.8)	12.3 (151.8)	65.5	1.47
Atrazine + halosulfuron (TM)	2000+ 67.5	PE	5.66 (31.1)	3.87 (14.0)	3.39 (1.4)	7.52 (54.9)	81.4	1.75
Metribuzin + halosulfuron (TM)	1000+ 67.5	40 DAP-PoE	2.97 (7.8)	3.75 (13.1)	2.10 (3.4)	5.04 (24.4)	91.6	1.87
Atrazine + halosulfuron (TM)	2000+ 67.5	40 DAP-PoE	3.35 (10.2)	4.70 (21.1)	3.51 (11.3)	6.61 (42.7)	81.4	1.75
Metribuzin *fb* halosulfuron	1000 & 67.5	PE *fb* 40 DAP-PoE	3.20 (9.2)	3.89 (14.1)	3.53 (11.5)	5.95 (34.8)	90.8	1.83
Atrazine *fb* halosulfuron	2000 & 67.5	PE *fb* 40 DAP-PoE	3.23 (9.5)	3.98 (14.9)	3.23 (14.6)	6.32 (39.0)	84.9	1.78
Sulfentrazone *fb* hoeing *fb*2,4-D	720 & 1000	PE *fb* 45 DAP *fb* 60 DAP-PoE	5.74 (32.0)	3.44 (10.8)	2.10 (3.4)	6.87 (46.3)	85.1	1.68
Sulfentrazone *fb* hoeing *fb* metsulfuron methyl + chlorimuron ethyl	720 & 4	PE *fb* 45 DAP *fb* 60 DAP-PoE	5.95 (34.5)	3.61 (12.1)	2.17 (3.7)	7.16 (50.3)	83.7	1.67

Table contd...

Atrazine *fb* 2,4-D	2000 & 1000	PE *fb* 60 DAP-PoE	10.8 (116.5)	4.36 (18.0)	1.75 (2.0)	11.7 (136.6)	71.8	1.65
Hoeing after first irrigation *fb* atrazine	2000	PoE to Sugarcane	10.8 (115.9)	3.33 (10.1)	1.66 (1.7)	11.3 (127.8)	75.9	1.65
Glyphosate +metribuzin + surfactant	1860 + 1000	15 DAS-EPoE	7.52 (55.6)	3.94 (14.53)	1.72 (1.9)	8.54 (72.1)	73.3	1.65
Atrazine *fb* metsulfuron + carfentrazone (RM)	2000 & 25	PE *fb* 60 DAP-PoE	10.7 (115.5)	4.36 (18.0)	1.32 (0.7)	11.6 (134.3)	66.0	1.55
Atrazine *fb* hoeing *fb* topramezone	2000 & 25	PE *fb* 45 DAP *fb* 60 DAP-PoE	10.7 (115.5)	2.66 (6.1)	1.44 (1.1)	111 (122.7)	80.3	1.64
Paraquat *fb* atrazine	800 & 2000	15 DAS-EPoE *fb* 60 DAP-PoE	10.6 (113.1)	3.50 (11.3)	1.95 (2.8)	11.32 (127.2)	66.2	1.58
Three hoeing (30, 60 and 90 DAP)	-	30, 60 and 90 DAP	7.51 (55.4)	2.93 (7.5)	2.39 (4.72)	8.29 (67.7)	92.9	1.73
Unweeded (Control)	-	-	11.1 (124.5)	4.4 (18.3)	4.07 (15.5)	12.6 (158.4)	40.7	1.24
SEm +			0.19	0.08	0.04	0.17	1.5	
LSD (P=0.05)			0.56	0.24	0.11	0.50	4.4	

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 $(\sqrt{x+1.0})$ before statistical analysis.

GBPUAT, Pantnagar

The weed density and weed dry weight of grassy, broad leaf weeds and sedges were influenced significantly at different crop growth stages. The total weed density of grassy weed was completely controlled with the application of sulfentrazone supplemented with hoeing *fb* 2,4-D (720 & 1000 g/ha) and hoeing after first irrigation followed by atrazine after second irrigation (2000 g/ha) at 75 DAP. In case of broad leaf weeds, the total weed density of broad leaf weeds was completely controlled with application of sulfentrazone *fb* hoeing *fb* 2,4-D (720 & 1000 g/ha). The total weed density of sedges was completely controlled with the tank-mix application of metribuzin at 1.0 kg/ha + halosulfuron 67.5 g/ha as post-emergence. In sugarcane, number of shoots was affected significantly at all the stages except at 45 DAP. The highest number of shoots was recorded with application of sulfentrazone supplemented with hoeing followed by metsulfuron methyl + chlorimuron-ethyl as PoE at 75 DAP. All the yield and yield attributes were influenced significantly by different herbicidal treatments and found highest over unweeded situation. Tank mix application of atrazine and halosulfuron (2000+67.5 g/ha) recorded highest average cane weight, application of sulfentrazone *fb* hoeing *fb* 2,4-D recorded highest number millable canes (184.5/ha) and the highest cane yield (118.6 t/ha) was observed with application of atrazine supplemented with hoeing followed by topramizone.

BCKV, Kalyani

The most dominating weeds found in experimental field were *Cyperus rotundus* and *C. difformis* as sedge, *Cynodon dactylon* as grass weed and *Alternanthera phyloxeroides, Physalis minima, Commelina benghalensis* and *Cucumis sativus* as broad leaved species. Among the different weed management practices, the lowest dry biomass accumulation by *C. rotundus* and *C. dactylon* at 50 and 75 DAP was observed with the treatment having atrazine 1.0 kg/ha PE *fb* hand weeding at 30 DAS **(Table 1.3.6.1)**. The biomass of *C. dactylon* at 50 and 75 DAP was also significantly diminished with the application of atrazine + pendimethalin (0.50 + 0.5 kg/ha) PE *fb* hand weeding at 30 DAS and sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS. At both the stages, biomass accumulation by all the weed species was lowest in the plots having atrazine 1.0 kg/ha as PE *fb* hand weeding at 30 DAS.

Sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS had long term effect in reducing the total weed biomass at 75 DAP. Among the various treatment combinations, the maximum cane yield was recorded with atrazine 1.0 kg/ha as PE *fb* hand weeding at 30 DAS and the second best one was sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS. Whereas, the maximum B:C ratio (2.37) was recorded with sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS in spring planted sugarcane.

Table 1.3.6.2 Effect of different weed management practices on weed density, dry weight, crop yield and economic benefits in spring planted sugarcane.

Treatment	Weed biomass (g/m²)						Cane yield (t/ha)	B:C Ratio
	50 DAP			75 DAP				
	C. rotundus	*C. dactylon*	Total	*C. rotundus*	*C. dactylon*	Total		
Atrazine 1.0 kg/ha PE	11.7 (138.4)	6.20 (38.0)	13.7 (188.9)	10.6 (113.6)	6.8 (46.8)	13.20 (173.8)	39.9	1.59
Pendimethalin 750 g/ha PE	11.0 (121.8)	6.00 (35.5)	12.9 (166.0)	8.95 (79.5)	5.45 (29.1)	11.54 (132.7)	59.5	2.17
Atrazine + pendimethalin (0.50 + 0.5 kg/ha) PE	11.2 (127.0)	5.83 (33.5)	13.0 (169.7)	9.61 (91.7)	5.25 (27.0)	11.30 (127.3)	57.4	1.97
Atrazine 1.0 kg/ha PE *fb* hand weeding at 30 DAS	7.45 (54.9)	4.06 (15.9)	8.7 (75.9)	5.60 (30.8)	4.22 (17.3)	7.32 (53.1)	81.7	2.28
Pendimethalin 750 g/ha PE*fb* hand weeding at 30 DAS	10.8 (117.4)	5.49 (29.6)	12.5 (156.0)	8.54 (72.4)	5.46 (29.4)	10.45 (108.8)	69.0	2.12
Atrazine + pendimethalin (0.50 + 0.5 kg/ha) PE *fb* hand weeding at 30 DAS	9.29 (85.8)	4.22 (17.3)	10.5 (110.0)	7.58 (56.9)	4.79 (22.4)	10.24 (104.4)	72.7	2.08
Glyphosate 1.0 kg/ha at 30 DAS (Directed application)	11.6 (136.3)	5.79 (33.1)	13.4 (179.1)	10.37 (107.1)	7.14 (50.5)	13.01 (168.9)	41.7	1.63
Sesbania co-culture *fb* 2, 4-D 1.0 kg/ha at 40 DAS	8.98 (80.1)	4.16 (16.8)	10.2 (103.9)	7.31 (52.9)	4.51 (19.8)	8.86 (78.1)	73.0	2.37
Hand weeding at 30 DAS	11.7 (137.2)	5.74 (32.4)	13.4 (180.3)	10.33 (10)6.3	6.21 (38.0)	12.48 (155.3)	39.2	1.51
Weedy check	14.7 (218.1)	8.90 (78.7)	17.8 (317.9)	16.51 (272.0)	11.7 (136.5)	21.32 (454.3)	31.5	1.27
SEm ±	0.02	0.02	0.23	0.011	0. 11	0.37	2.21	-
LSD (P=0.05)	0.05	0.06	0.54	0.032	0.32	1.04	6.30	-

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 1.3.7 Weed management in orchards

WP 1.3.7.1 Integrated weed management in established fruit (peach) orchard

Palampur

In peach orchard, the dominance of *Artemisia* was highest followed by *Trifolium repens*, *Cynodon dactylon* and *Plantago lanceolata* in March 2019. Whereas, during August 2019, the major dominating weeds were *Alternanthera philoxeroides* and *Ageratum* spp. Among the different weed management practices the lowest weed dry biomass was recorded with the plots having legume as intercrop in both the seasons. A change in weed flora in peach orchard was observed from last three years **(Table 1.3.8.1)**. During the initial survey of summer 2017, thirty-three weed species was recormed and *Cynodon dactylon* was the most dominating one. However, cultivation brought down diversity of weed from 33 species to 7 and 9 species during summer and *Kharif* 2018, respectively. In *Rabi* 2018-19 five species were observed and in *Kharif* 2019 eight species were observed during the study. Results of the study revealed that in 2019 maximum peach yield was recorded in legume intercropping followed by manual weeding which was at par with fodder intercropping and application of glyphosate. Significantly lowest peach yield was recorded in weedy check due to abundance of weeds. Whereas, maximum peach equivalent yield was recorded with turmeric intercropping. During 2018-19, highest net returns were obtained under turmeric intercropping followed by fodder intercropping, legume intercropping and sod culture. The net returns per rupee invested was highest in sod culture while lowest net return per rupee invested was in manual weeding as labour requirement was more.

Table 2.3.8.1 Effect of different treatments on weed growth, yield and economics of peach orchard

Treatment	Weed dry weight (g/m)²				Peach yield (t/ha)	Peach equivalent yield (t/ha)	Net returns (000′ Rs/ha)	Net return per rupee invested
	March, 2019		August, 2019					
	Artemisia	*Plantago lanceolata*	*A. philoxeroides*	*Ageratum*				
Legume intercropping*	0.71(0.00)	0.71(0.00)	2.63 (8.27)	2.29 (6.08)	16.0	18.9	531	2.36
Turmeric intercropping#	4.15(16.85)	3.08(9.07)	4.12 (16.4)	4.83 (22.8)	13.9	22.7	638	2.37
Fodder intercropping$	1.49(2.93)	1.51(3.04)	3.96 (15.2)	4.05 (16.2)	15.1	20.1	595	2.85
Interculture basin area + sod culture	3.25(10.1)	1.60(3.63)	4.13 (16.5)	5.45 (29.3)	14.2	17.3	518	2.95
Glyphosate (4 times)	2.19(5.39)	1.53(3.20)	3.96 (15.2)	4.74 (22.0)	14.9	14.9	427	2.54
Paraquat (4 times)	4.23(17.6)	3.76(13.7)	5.31 (27.6)	6.13 (37.1)	13.6	13.6	375	2.23
Weed mulch (Lantana/Chromolaena; 3 times in a year)	2.40(6.72)	0.71(0.00)	4.09 (16.2)	4.78 (22.4)	14.6	14.6	415	2.44
Manual weeding (3 times in a season)	1.45(2.72)	0.71(0.00)	3.65 (12.8)	4.02 (15.7)	15.4	15.4	418	2.12
Weedy check	5.85(33.8)	4.32(18.2)	5.93 (34.6)	6.25 (38.6)	12.8	12.8	352	2.22
LSD (P=0.05)	1.53	1.50	0.99	1.01	0.5	0.8		

Note: *Soybean in May-June with recommended weed control i.e quizalofop 60 g/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.

WP1.4 Station trials on weed management

WP1.4.1 Herbicide's combinations for control of complex weed flora in wheat

PDKV, Akola

The experiment on herbicides combinations for control of complex weed flora in wheat was conducted for three years during 2016-17 to 2018-19 and concluded with recommendation as follows: The post-emergence application of clodinafop-propargyl + metsulfuron-methyl 0.06 + 0.004 kg/ha or sulfosulfuron + metsulfuron-methyl 0.03 + 0.002 kg/ha at 35 DAS were the most remunerative and effective herbicides for controlling the weed flora and getting higher yield and economic returns in wheat.

WP 1.4.2 (i) Integrated weed management in summer groundnut (*Arachis hypogaea* L.)

AAU, Anand

Major weeds observed in the experimental fields were *Dactyloctenium aegyptium* (17.8%), *Eragrostis major* (14.2%), *Eleusine indica* (10.1%) and *Digitaria sanguinalis* (7.58%) among monocot weeds whereas, *Phyllanthus niruri* (31.5%), *Trianthema monogyna* (8.54%), *Digera arvensis* (3.61%) and *Amaranthus viridis* (3.25%) among dicot weeds.

Among weed management practices, IC *fb* HW at 20 and 40 DAS provided 100% control of monocot, dicot, sedges and total weeds at 30 DAS. Further, application of oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE recorded significantly lower density of monocot, dicot and total weeds (3.15, 4.19 and 5.95/m^2, respectively) as compared to rest of the treatments except oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS and oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (pre mix). Among herbicidal treatments, maximum weed control efficiency (74.8%) was achieved under oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 70 g/ha PoE (pre-mix).

Imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS recorded significantly lower dry biomass of total weeds (4.62 g/m^2) and higher weed control efficiency (95.8%). Results revealed that significantly higher pod and haulm yield of 4.46 and 6.55 t/ha, respectively was achieved under oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS as compared to other treatments. Maximum gross return (₹2,31,194/ha), net return (₹ 1,73,249/ha) and benefit cost ratio (3.60) was also achieved under same treatment.

WP 1.4.2 (i) Effect of weed management practices on weed dynamics, yield of isabgol (*Plantago ovata* Forsk) and germination of succeeding crop

MPUAT, Udaipur

An expermiment was conducted to study the bio-efficacy of different herbicides against weeds and their effect on growth and yield of isabgol. Major weed flora were *Chenopodium album (34.3%), Chenopodium murale (28.2%), Fumaria parviflora (10.3%), Convolulus arvensis (9.1%)* and *Melilotus alba (9.0%)* and *Phalaris minor (9.1 %)* at 30 DAS.

Among the various weed control treatments, two hand weeding at 25 and 45 DAS resulted in lowest density of weeds at 30 DAS as compared to other chemical weed control treatments. At 30 DAS, among the herbicidal treatments, pre-emergence application of sulfosulfuron 25 g/ha as PE recorded lowest *Chenopodium album* density which was at par with oxadiargyl at 100 g/ha PE and oxyfluorfen 75 g/ha as PE.

Among total weed dry matter, monocot weeds were lowest with pendimethalin at 750 g/ha followed by sulfosulfuron 25 g/ha as PE and oxyfluorfen 75 g/ha as PE. At 60 DAS, lowest weed dry matter of monocot weeds was observed with sulfosulfuron 25 g/ha as PoE which was found at par with post-emergence application of oxadiargyl at 100 g/ha, oxyfluorfen 75 g/ha. Maximum weed control efficiency at 30 DAS (98.8%) was observed with sulfosulfuron 25 g/ha as PE among herbicidal treatments. At 60 DAS, maximum weed control efficiency (90%) was observed with post-emergence application of oxadiargyl at 100 g/ha.

Yield attributes like number of spikelets per plant (31.99), length of spike (6.08 cm), seed yield (794 kg/ha) and straw yield (2.22 t/ha) were recorded maximum with two hand weeding at 25 and 45 DAS. However, among herbicidal treatments, oxadiargyl 100 g/ha as PE recorded maximum seed yield (666 kg/ha) and straw yield (1.90 t/ha) at par with pre-emergence application of oxyfluorfen 75 g/ha. The magnitude of seed yield increased with the pre-emergence application of oxadiargyl 100 g/ha to the tune of 73.4% over weedy check (384 kg/ha).

A perusal of visual phytotoxicity scoring revealed that at 7 DAS both levels of pendimethalin gave severe setback to isabgol crop by causing complete destruction of the crop plants under non recovery zone. Oxyfluorfen as PE, oxadiargyl PE and sulfosulfuron PE also gave setback to isabgol crop by causing injury more pronounced but not persistent injury after 21 DAS.

Sulfosulfuron 25 g/ha PoE (25 DAS)

Oxadiargyl 100 g /ha as PE

Oxyfluorfen 75 g/ha PoE (25 DAS)

Weed free (2 HW at 25 & 45 DAS)

Fig 1.4.2 (i) Effect of different treatments on weed population and crop growth of isabgol

WP 1.4.2 (ii) Management of *Malva parviflora* in wheat crop

MPUAT, Udaipur

An experiment was conducted to evaluate the bio-efficacy of different herbicides applied either alone or in combination, pre-mix and sequential application against the *Malva parviflora* and to find their effect on the growth and yield attributes of wheat crop. The experimental area was infested with *Phalaris minor (9.8%)* among the grassy weed, whereas, *Chenopodium album* (30.2%), *Chenopodium murale* (20.1%), *Malva parviflora* (26.6%), *Fumaria parviflora* (7.6 %), *Melilotus indica* (2.9%) and *Convolvulus arvensis* (2.8%) among broad leaved weeds.

Minimum number of weeds (2.53/m^2) was observed by applying carfentrazone. However, it was at par with sulfosulfuron + metsulfuron 30+2 g/ha (RM) (4.72/m^2), carfentrazone + sulfosulfuron (RM) 20+25 g/ha (4.88/m^2), pinoxaden + metsulfuron 60+4 g/ha (Tank mix) (4.83/m^2) and mesosulfurom + iodosulfuron 12+2.4 g/ha (PM) (4.30/m^2). Unlike broadleaf weeds, minimum density of grassy weeds (11.07/m^2) was exhibited by sulfosulfuron 25 g/ha. However, it was at par with carfentrazone + sulfosulfuron (RM) (3.99/m^2). Weed control through mesosulfuron + iodosulfuron with 86.6% reduction in dry matter stood first in the order of significance which affected statistically similar reduction in total weed dry matter with sulfosulfuron. Least total dry matter at harvest was observed under carfentrazone + sulfosulfuron (18.9 g/m^2) followed by pinaxaden + metsulfuron (23.2 g/m^2), mesosulfuron + iodosulfuron (23.4 g/m^2) and sulfosulfuron + metsulfuron (23.5 g/m^{-2}).

Amongst all treatments, highest yield (5.40 t/ha) was obtained by controlling weeds through mesosulfuron + iodosulfuron followed by sulfosulfuron + metsulfuron. The maximum net return (₹ 78,337/ha) was realised by applying carfentrazone + sulfosulfuron, which was 112% higher over weedy check. The economic analysis of treatments in term of B:C ratio revealed that all the weed control treatments tended to significantly surpass weedy check. Alike net returns, the highest B C ratio (2.10) was obtained by controlling the weeds through carfentrazone + sulfosulfuron. It was followed by mesosulfuron + iodosulfuron (2.07) and pinoxaden + metsulfuron (1.98).

WP 1.4.3 Weed management in jute

BCKV, Kalyani

An experiment was conducted to find out the effect of different weed management measures on weeds, yield attributes and yield of jute. The treatment consisted of pretilachlor 500 g/ha at 45-48 hours of sowing with irrigation + one hand weeding (15 DAE); nail weeder- 1st at 10 DAE and 2nd at 25 DAE + one hand weeding (within the row) at 40 DAE; jute + green gram (Pant Mung 5) (1:1 replacement series); Pretilachlor 500 g/ha at 45-48 hours of sowing with irrigation *fb* quizalofop-ethyl 60 g/ha at 25 DAE; unweeded check; and two hand weeding at 15-20 DAE and 35-40 DAE. Greengram (*var*. Pant Mung 5) intercropped with jute suppressed the weeds effectively and recorded the highest weed control efficiency but gave significantly lower jute fibre equivalent yield as compared to sole crop of jute. It has been found that from economic point of view, treatment with green gram variety TMB 37 was more promising one than variety Pant Mung 5. Finally, 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 may be a good option of weed management in jute.

WP 1.4.4 Station trials on crop-weed competition

AAU, Jorhat

An experiment was conducted to evaluate the yield performance of two highly competitive rice varieties Rangkhong and Inlongkiri for competition with weeds, and to determine the critical period of crop-weed competition of both the varieties. Major weeds in the experimental fields were *Panicum repens*, *Mimosa pudica*, *Eleusine indica, Cynodon* spp, *Ageratum* spp, *Spermacoce* spp, *Digitaria setigera*, *Panicum repens*, *Paspalum conjugatum*, *Acmella ciliate, Crassocephalum crepedioides*, *Commelina species*, *Murdannia nudiflora*, *Setaria pumila*, *Sacciolepis indica* and *Scleria terrestris*.

The data revealed that the weed dry matter was nearly 2 g/m^2 at 10 DAS and 10-12 g/m^2 at 20 DAS. The weed growth was rather active between 20 to 40 DAS, then slowed down between 40 to 50 DAS, and at 50 DAS the weed dry matter varied between 47 to 52 g/m^2 at 50 DAS. Both at 40 and 50 DAS, the weed dry matter was somewhat lesser under the variety Rangkhong comparing to variety Inlongkiri.

Crop morphology: Both the varieties were of almost similar stature and that varied from 112 to 121 cm at flowering stage. The flag leaf angle of variety Rangkhong (44.4°) was significantly higher than variety Inlongkiri. The angle of leaves and flag leaf angle were as minimum as 10.7° in the plot which was kept weed free for first 20 DAS and total weed free thereafter, and that of flag leaf 33.4° in the plot where weeding was done from 40 DAS. The maximum leaf angle and flag leaf angle was recorded when the crop was kept weed free at least up to 50 DAS.

Crop growth and critical period of crop weed competition: The crop growth pattern revealed that increase in competition has slowed down the active growth phase which may skip for 15 to 30 days resulting in rather weed growth due to reduction of crop interference in competition.

Yield and critical period of crop-weed competition: The grain yield was nearly 1 t/ha in 2017 and the varietal difference was insignificant. However in 2019, the average yield was increased up to 1.88 t/ha in the variety Rangkhong, which performed much better than variety Inlongkiri (1.82 t/ha). The difference is probably due to the use of higher amount of organic matter and continuous removal of *Panicum repens* in 2019, as compared to 2017. Treatment wise average yield was the maximum in the treatments where the weed was allowed to compete up to 20 DAS in 2017. In 2019 both the treatments where weed growth was allowed between 20 DAS and 30 DAS have yielded the highest and statistically at par grain yield. Maximum average yield was recorded in the treatment where crop was kept weed free up to 40 DAS in both the years. These results distinctly conferred that the critical period of crop weed competition for the upland direct-seeded rice variety Rangkhong and Inlongkiri.

WP 1.4.5 (i) Evaluation of pre- emergence herbicides in Kodo millet (*Paspalum scrobiculatum*)

UAS, Bengaluru

An experiment was conducted to study the bio-efficacy of pre-emergence herbicides on Kodo millet against weeds. The important grassy weed flora in kodo millet were *Echinochloa colonum, Echinochloa crusgalli, Dactyloctenium aegypticum, Elusine indica, Setaria glauca* and *Cyanodon dactylon*. The broad-leaved weeds were *Celosia argentia, Commelina benghalensis, Phyllanthus niruri, Solanum nigrum* and *Amaranthus viridis*. Significantly, higher plant height was recorded at 90 DAS and at harvest in bensulfuron-methyl pretilachlor at 0.165 kg/ha and bensulfuron-methyl + pretilachlor at 0.330 kg/ha which were on par with weed free check compared to rest others. Same treatment recorded significantly lower weed count and weed dry weight at 30, 60, 90 DAS and at harvest which was on par with weed free check.

Significantly higher grain yield (2.59 t/ha) and straw yield (4.84 t/ha) was recorded in bensulfuron methyl + pretilachlor at 0.165 kg/ha. Grain yield (8.53 g) per plant was significantly higher in bensulfuron methyl + pretilachlor at 0.165 kg/ha followed by bensulfuron-methyl + pretilachlor at 0.330 kg/ha and weed free check. Bensulfuron-methyl + pretilachlor at 0.165 kg/ha and bensulfuron-methyl + pretilachlor at 0.330 kg/ha recorded significantly higher test weight (4.16 g) which was on par with weed free check.

WP 1.4.6 Integrated weed management in turmeric

CSKHPKV, Palampur

Twelve weed control treatments were evaluated in randomized block design to study the effect of integrated weed management on the productivity of turmeric. The treatments consisted of metribuzin 0.7 kg/ha *fb* 2 handweeding, metribuzin 0.7 kg/ha *fb* straw mulch 5 t/ha *fb* 1 hand weeding, pendimethalin 1.0 kg/ha *fb* 2 hoeings, pendimethalin 0.7 kg/ha *fb* straw mulch 5 t/ha *fb* 1 hand weeding, atrazine 0.75 kg/ha *fb* 2 hand weeding, atrazine 0.75 kg/ha *fb* straw mulch 10 t/ha *fb* 1 hand weeding, pendimethalin 0.5 kg/ha + atrazine 0.375 kg/ha *fb* hand weeding twice (oxyflourfen 0.15 kg/ha *fb* HW twice in the previous year), imazethapyr 75 g/ha *fb* hand weeding twice (glyphosate *fb* HW twice in the previous year), imazethapyr 100 g/ha *fb* hand weeding twice (glyphosate *fb* HW twice in the previous year), hand weeding thrice, organic weed management (mulch twice + hand weeding) and weedy check. The yield during the second year was much higher than during the previous year and was significantly higher when the rhizomes were uprooted after the second years of crop than when uprooting was done after every cropping season. It is clearly evident that when the crop was harvested after the second crop growth cycle, it was appreciably higher than the combined of the two annual harvests. The same is the case with gross and net returns and B: C. The average annual cost of cultivation was lower under harvesting after two seasons due to reduction in the planting and harvesting cost. The percent increase in yield owing to harvesting after two years range from 58.7 to 221% under different treatments; gross returns from 63.4 to 230.7%, net returns from 138.6 to 1300%, B: C from 216 to 1874%. The corresponding decrease in cost of cultivation was 22.9 to 29.1%.

Table 1.4.6 Effect of weed control treatments on fresh rhizome yield, net returns and B:C of turmeric

Treatment	2018	2019	Net return (000' ₹/ha)	B:C
T_1 Metribuzin *fb* hand weeding twice	8.92	25.0	274	2.47
T_2 Metribuzin *fb* straw mulch *fb* hand weeding	9.02	28.4	321	2.95
T_3 Pendimethalin *fb* hand weeding twice	7.55	29.1	320	2.97
T_4 Pendimethalin *fb* straw mulch *fb* hand weeding	7.18	28.4	308	2.84
T_5 Atrazine *fb* hand weeding twice	8.69	27.7	311	2.88
T_6 Atrazine *fb* straw mulch fb hand weeding	8.62	29.7	337	3.13
T_7 Oxyfluorfen *fb* hand weeding twice	6.29	23.2	232	2.16
T_8 Glyphosate *fb* hand weeding twice	7.96	24.7	266	2.47
T_9 Glyphosate *fb* hand weeding twice	7.54	26.4	286	2.70
T_{10} Hand weeding thrice	7.78	26.8	281	2.38
T_{11} Weed control with organic practice (Mulch)	7.78	27.8	298	2.60
T_{12} Weedy check	4.26	20.4	203	2.44
Mean		T*S (2)	T*S(2)	T*S(2)
SE(m+-)	0.7	1.6	23	0.21
LSD (P=0.05)	2.1	4.5	NS	0.61

S1, harvesting after one season; **S2** harvesting after two years; **T7, T8** and **T9** were replaced with atrazine + pendimethalin *fb* **HW**, imazethapyr 75 g/ha *fb* **HW** twice and imazethapyr 100 g/ha fb **HW** twice, respectively during the second year.

WP 1.4.7 Studies on time of application of imazethapyr and its ready mix combination with imazamox (Odyssey) against weeds in blackgram

BUAT, Banda

An experiment was conducted during *Kharif*, 2019 to study the bio-efficacy of different herbicides against weeds and their effect on growth and yield of blackgram, phytotoxic effects on the blackgram, if any and to know the residual effect of herbicides applied in blackgram on succeeding mustard crop. The experimental blackgram field was infested with several grassy, broad leaved and sedge weeds. The major weed species were *Cyperus rotundus, Echinochloa colona, Elusine indica, Euphorbia hirta, Amaranthus* spp., *Digera arvensis, Solanum nigrum, Lucas aspera, Ageratum conyzoides, Physalis minima, Commelina benghalensis, Caesulia axillaris, Cynodon dactylon, etc.* Results revealed that all the herbicidal treatments significantly controlled the complex weed flora prevailing in experimental crop. Data on weed population revealed that population of sedge were in majority in comparison to broad leaved weeds and grassy weeds in the experimental field. Keeping the weeds under control applying imazethypyr + pendimethalin (RM) 1000 g/ha as pre-emergence significantly reduced the weed population. Application of imazethypyr + imazamox (RM) 80 g/ha at 3-4 leaf stage also found effective treatment for controlling all kind of weeds.

Among herbicidal treatments, application of imazethypyr + pendimethalin (RM) 1000 g/ha as pre-emergence and imazethypyr + imazamox (RM) 70 g/ha at 3-4 leaf stage significantly reduced weed dry weight and increased WCE. Maximum plant height (78.3 cm), leaves/plant (79.1) and branches was recorded in weed free plot followed by imazethypyr + pendimethalin (RM) 1000 g/ha as pre-emergence treated plot of blackgram. Maximum leaf area index recorded with application of imazethypyr 80 g/ha as pre-emergence while maximum nodulation (36.3) occurred in imazethypyr + imazamox (RM) 70 g/ha PE treated plot.

Imazethypyr + imazamox (RM) 70 g/ha at 3-4 leaf stage resulted in significantly higher number of pods/plant, seeds/pod, longer pods and bolder seeds which was at par with remaining all weed control treatments. Higher net return of ₹ 32,900 was recorded in plot treated with imazethypyr + imazamox (RM) 70 g/ha at 3-4 leaf stage followed by plot treated with imazethypyr 80 g/ha at 3-4 leaf stage and weed-free plot. Higher benefit cost ratio (BCR) of 2.0 was recorded with weed free, hand weeded (twice), imazethypyr + imazamox (RM) 70 g/ha at 3-4 leaf stage, imazethypyr + imazamox (RM) 70 g/ha as PE and imazethypyr 80 g/ha at 3-4 leaf stage Visual phytotoxic effect on crop was recorded in treatment imazethypyr +imazamox 70 g/ha and 80 g/ha at 3-4 leaf stage.

WP 1.4.8 (i) Study of weed flora and its management in lentil under temperate condition.

SKUAST, Kashmir

A field experiment was conducted during *Rabi* 2018–19 to study weed flora in lentil (*cv.* Shalimar Masoor 1) and their management through manual weeding, mechanical hoeing and herbicidal applications. The experiment was conducted in randomized block design consisting of treatments *viz.* pendimethalin (1.0 kg/ha PE), pendimethalin (1 kg/ha PE) + prometryn (0.5 kg/ha POE), pendimethalin (1 kg/ha PE) + fluazifop-p-butyl (0.1 kg/ha POE), pendimethalin (1 kg/ha PE) + quizalofop-p-ethyl (0.05 kg/ha POE), pendimethalin (1 kg/ha PE) + imazethapyr (0.04 kg/ha POE), pendimethalin (1 kg/ha PE) + two manual weeding (spring), prometryn (0.5 kg/ha PE), prometryn (0.5 kg/ha PE) + fluazifop-p-butyl (0.1 kg/ha POE), prometryn (0.5 kg/ha PE) + quizalofop-p-ethyl (0.05 kg/ha POE), prometryn (0.5 kg/ha PE) + imazethapyr (0.04 kg/ha POE), prometryn (0.5 kg/ha PE) + two manual weeding (spring), three manual weeding at 20 days interval during spring and weedy check. Annual grasses like *Lolium*, *Bromus* and *Avena* spp. and the annual BLWs like *Galium aparine*, *Anagalis arvensis*, *Fumaria parviflora*, *Rananculus arvensis*, *Capsella bursa-pastoris, Matricaria chamomila* and *Stellaria media* were the weeds found. *Lolium* sp. (grass), *Galium aparine* (BLW) and *Rananculus arvensis* (BLW) were the major species of annual weeds found. Perennial species like *Cynodon*, *Cyperus*, *Sonchus*, *Launaea, Taraxacum officinale* and *Rumex* were also emerged during grain maturity period in the weeded plots of lentil. Application of prometryn 0.5 kg/ha (PE) followed by imazethapyr 40 g/ha (POE) was found better to reduce the weed infestation (19.33/m^2; 20.03 g/m^2 weed density and weed dry weight, respectively) with maximum WCE (89%) in lentil. Significantly higher grain yield (1.43 t/ha) was also observed with this treatment.

WP 1.4.14 (ii) Performance of direct-seeded rice in temperate Kashmir as influenced by sowing dates and weed management practices.

The second year field experiment was conducted during *Kharif* 2019 to evaluate the performance of direct-seeded rice established by drum seeder as influenced by sowing dates and weed management practices in split plot design having sowing dates as main plot treatments and weed management practices as sub plot treatments. More infestation of weeds in the experimental field was occurred when sown during the first week of May. *Echinochloa crusgalli, Echinochloa colona, Cynodon dactylon, Leptochloa chinensis, Ischaemum rugosum, Cyperus difformis, Cyperus iria, Cyperus rotundus, Fimbristylis littoralis, Alisma plantago aquatica, Ammania baccifera, Marsilea quadrifolia, Monochoria vaginalis, Portulaca oleracea, Polygonum hydropiper, Potamogeton distinctus* and *Solanum nigrum* were found. Weed density was significantly reduced with the treatment of oxyfluorfen (PE 0.250 kg/ha) + HW at 40 DAS**.** Weed biomass (dry matter) having treatment of bensulfuron methyl + pretilachlor (PE, 0.5 kg/ha) + HW at 40 DAS was at par to the treatment of oxyfluorfen (PE) + HW at 40 DAS. Number of panicles per m^2 and grain yield of drum-seeded rice were recorded higher when rice was sown during the last week of May (21st SMW i.e. 21st – 27th May). These yield parameters of rice were observed significantly higher with weed free treatment and oxyfluorfen (PE) + HW at 40 DAS. However, grain yield obtained with oxyfluorfen (PE) + HW at 40 DAS (4.95 t/ha) was at par to that of of bensulfuron methyl + pretilachlor (PE) + HW at 40 DAS (4.83 t/ha). Weed control efficiency (WCE) was higher with weed free plots (100%) followed by oxyfluorfen (PE) + HW at 40 DAS (77.3%). The effective weed control with oxyfluorfen (PE) + HW at 40 DAS showed lower reduction of yields thus showing lower weed index (WI).

WP 1.4.9 Crop- weed competition studies in irrigated blackgram (*Vigna mungo* L.)

PAJNCOA & RI, Puducherry

A field experiment was conducted to study the crop-weed competition in irrigated blackgram during *Kharif*, 2019. The dominant weed flora observed in the study area were *Echinochloa colona* (L.), *Dactyloctenium aegyptium* (L.), *Trianthema portulacastrum (*L.), *Eclipta prostrata* (L.), *Cleome viscosa* (L.) and *Cyperus rotundus* (L.). Significant increase in weed density and dry weight was observed when crop - competition was prolonged from 15 DAS to the maturity of the crop. The highest weed density (524 no./m^2) and dry weight (490 g/m^2) was recorded when weeds are kept throughout crop growth. The highest yield was obtained when blackgram was sown in absence of weed competition (706.5 kg/ha) closely followed by weedy condition till 15 days after sowing (638.2 kg/ha) and the variation was non-significant. Weedy throughout crop period caused a reduction of 86.3% in grain yield. Similarly, plant growth was stunted with lesser plant height (29.8 cm) and with lesser number of leaves (12.0) in coastal ecosystem of Karaikal, Puducherry UT.

Crop-weed competition studies on irrigated blackgram concluded that highest yield was obtained when blackgram was sown in absence of weed competition (706.5 kg/ha) which was closely followed by weedy condition till 15 days after sowing (638.2 kg/ha).

Table 1.4.9 Effect of different crop- weed competition periods on weed flora, growth and yield of irrigated blackgram

Treatments	Weed density at flowering (no./m^2)	Weed dry weight at flowering (g/m^2)	Plant height (cm)	Number of leaves per plant	Grain yield (kg/ha)
Weedy till 15 DAS	10.46(99.6)	6.44(35.3)	40.9	37.8	638.2
Weedy till 30 DAS	17.14(278.0)	13.31(165.3)	36.7	34.9	429.6
Weedy till 45 DAS	19.41(361.3)	16.81(266.5)	34.6	24.4	288.7
Weedy till 60 DAS	22.06(474.6)	18.81(340.8)	30.9	15.7	170.5
Weedy throughout crop growth	22.55(524.0)	22.45(490.0)	29.8	12.0	96.8
Weed-free till 15 DAS	19.14(349.0)	16.69(263.3)	30.7	16.7	147.1
Weed-free till 30 DAS	14.82(206.0)	11.64(124.4)	32.3	25.1	329.6
Weed-free till 45 DAS	11.30(117.6)	9.78(86.8)	34.5	31.1	449.5
Weed-free till 60 DAS	9.456(81.6)	8.03(59.3)	35.1	35.9	478.8
Weed-free throughout crop growth	3.11(7.0)	2.03(2.5)	42.1	40.7	706.5
LSD (P=0.05)	5.30	2.92	6.53	8.84	110.67

*Original figures in parenthesis were subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis.

WP 1.4.10(i) Integrated weed management in horsegram

A field experiment was conducted to find out an integrated approach for weed management in horsegram during *Rabi* 2019-20. Results revealed that pendimethalin+ imazethapyr 750+50 g/ha PE *fb* hand weeding at 30 DAS (1997 kg/ha) was on par with hand weeding at 20 & 40 DAS which recorded the highest grain yield (2016 kg/ha). Pre- emergence application of pendimethalin + imazethapyr 750 + 50 g/ha *fb* hand weeding at 30 DAS and pendimethalin 750 g/ha *fb* hand weeding at 30 DAS resulted in higher weed control efficiency on par with two hand weeding. Seed yield and yield attributes were higher from these treatments. Among the post-emergence herbicides that followed pre-emergence treatment, yield recorded from fomesafen + fluazifop-butyl 111 + 111 g/ha was found to be on par with hand weeded control.

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

WP 2.1 Monitoring of appearance of new weed species

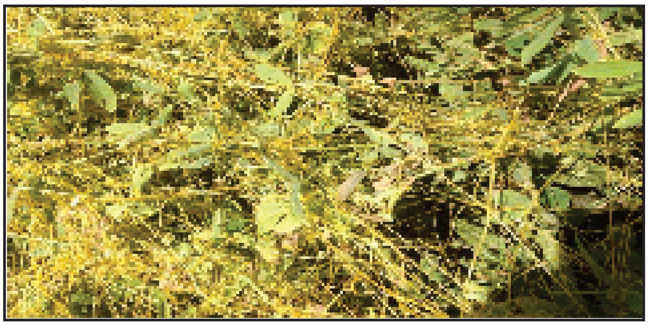
AAU, Anand

During survey at farmer's field, high weed intensity of *Argemone mexicana* infestation was observed in different parts of Gujarat. Due to thorny nature & high seed production potentiality it is spreading very fast in cultivated fields. After harvesting of *Rabi* crops the weed flourish and entering in new cultivated field as new emerging weed in Gujarat. *Fumaria parviflora* a new weed in wheat crop in north Gujarat zone was recorded during survey work.

***Argemone mexicana* infestation**

CCSHAU, Hisar

In berseem fodder, *Lepidium didymum* (Syn: *Coronopus didymus*) and *Cuscuta* sp. were emerged as major weeds causing losses in yield. Weed surveillance studies conducted in *Kharif* crops revealed broadleaf weed *Oenothera laciniata* in guava and ber orchards in sandy soils of RRS, Bawal. Pea crop in north-eastern districts of state was severely infested with grassy as well as broadleaf weeds, *viz*. *Phalaris minor*, *Poa annua*, *Polypogon monspeliensis*, *L. didymum*, *Malwa parviflora*, *Medicago polymorpha* (Syn: *Medicago denticulate*).



Berseem crop heavily infested with *Cuscuta chinensis* in Kaithal

CSKHPKV, Palampur

During survey, a new weed species *Phenax angustifolius* has been identified in soybean crop.

Phenax angustifolius

IGKV, Raipur

Hyptis suaveolens, Alternanthera triandra, *Malva pusillia* and *Celosia argentea* were reported in non-cropped areas.

MPUAT, Udaipur

During both the seasons, no new weed flora was noticed in these high risk areas.

PAU, Ludhiana

Regular survey of weeds in field areas was conducted in March 2018 and in October 2019. *Phalaris minor* in wheat and *Echinochloa crusgalli* in rice continued to be dominant weeds. *Poa annua, Polypogon monspeliensis* and *Circium arvense* in wheat; *Leptochola chinensis* and *Fimbristylis* sp. in transplanted rice; *Dactlyolctenum aegyptium*, *Leptochloa chinensis* and *Cyperus rotundus* in direct seeded rice and *Portulaca oleracea* in summer vegetables and in *Kharif* crops and *Brachiaria reptans* in sugarcane are becoming problem weeds.

PDKV, Akola

Survey was conducted during 2018-19. Heavy infestation of *Hyptis suoveolenc* (Ran Tulas) was observed along the road sides in Eastern Vidarbha. In Western and Central Vidarbha zone, *Cassia tora, Celosia argentea* and *Alteranthera trianda* were found more prominently along road side. Heavy infestation of *Cuscuta* was observed in some pocket on farmer's field in soybean and pigeonpea crop particularly in Western Vidarbha districts.

SKUAST, Jammu

During the survey no new weed species found in *Rabi* 2018-19 and *Kharif* 2019 at high risks places.

UAS, Bengaluru

A survey was conducted at Nippani and Belagavi area of Karnataka. The *Ethulia gracilis* weed was noticed in Peerawadi village (8.5 km from Nippani towards Chikkodi) at GPS location 16°24.213' N, 74°26.948' E 619 m amsl, Nippani, Belgavi district. This weed was noticed in maize and groundnut crop and fallow land in about four hectare area and also observed on road side at same location. *Ethulia gracilis* have narrow leaf without petiole and papus are absent in its seed, whereas in the case of *Vernonia,* leaf is broad and have petiole and seeds have papus. At present, this quarantined weed has been recorded from a confined area of about 4-5 hectare land. In fallow land and glyphosate can be sprayed to control it.

***Ethulia gracilis* flower**

Sever infestation of *Ethulia gracilis* weeds

Seeds of *Ethulia gracilis*(Right)

PJTSAU, Hyderabad

A survey and surveillance was conducted near public distribution systems, procurement centers, FCI godowns and other hot spots. No new weed species was found in any of these fixed spots. Following places were selected during 2018 to monitor appearance of new weed species with fixed points, GPS data and weed identified were noted.

Survey in maize field was also carried out at Kodicherla, Penjerla and Rangapuram villages and *Rottboellia cochinchinensis* (locally called as Saddha Gaddi) was found to be increased tremendously during the past three years and farmers are unable to control this weed.

Table 2.1.1. Surveillance places with GPS and weed data

S.No.	Place	GPS Reading	Weeds Identified
1	Poosala Godowns, Charlapally, Mallapur, Ranga Reddy, Hyderabad.	Alt: 521 m, Lat: 26' 53.0", Long: 078º 36'45.6"	*Euphorbia geniculata* *Parthenium hysterophorus* *Conyza canadensis* *Oldenlandia umbellata* *Amaranthus viridis*
2	Poosala Godowns,Charlapally, Mallapur, Ranga Reddy, Hyderabad.	Alt: 521 m, Lat: 26' 48.0" Long: 078º 36'52.7"	*Conyza canadensis* *Tridax procumbens* *Cyperus rotundus*
3	Malakpet (Vegetable Market), Ranga Reddy, Hyderabad.	Alt: 521 m, Lat: 22' 27.5", Long: 078º 30'15.6"	*Portulaca oleraceae* *Amaranthus viridis* *Chloris barbata*
4	Mallapur Godown, Charlapally (FCI India.)	Alt: 542 m, Lat: 17' 27'00.0", Long: 078º 35'27.7"	*Lantana camara* *Parthenium hysterophorus* *Alternanthera philoxeroides* *Euphorbia geniculata* *Tridax procumbens* *Merremia emarginata* *Euphorbia hirta* *Achyranthus aspera*
5	Gaganpahad, Dal mill(Annapurna mills), Ranga Reddy, Hyderabad.	Alt: 563 m, Lat: 17' 33.5", Long: 078º 25'16.1"	*Portulaca oleracea* *Cyperus rotundus* *Chloris barbata*
6	Rallagunda (Vegetable Waste)	Alt: 556 m, Lat: 17' 16'06.0", Long: 078º 22'34.5"	*Trianthema portulacastrum* *Cleome viscosa L.* *Amaranthus viridis* *Parthenium hysterophorus* *Paspalum conjugatum*

Table 2.1.3 Weed flora observed in maize cropped areas

Penjerla	Kodicherla	Rangapuram
Rottboellia cochinchinensis	*Rottboellia cochinchinensis*	*Parthenium hysterophorus*
Setaria viridis	*Setaria verticillata*	*Corchorus tridentata*
Commelina benghalensis	*Xanthium strumarium*	*Celosia argentia*
Cynodon dactylon	*Celosia argentia*	*Xanthium strumarium*
Merremia emarginata	*Achyranthus aspera*	*Digera arvensis*
Celosia argentia	*Commelina benghalensis*	*Cyperus rotundus*
Alternanthera philoxeroides	*Trichodesma indicum*	*Sonchus arvensis*
Parthenium hysterophorus	*Phyllanthus niruri*	*Argemone mexicana*
Corchorus olitorius	*Ageratum conyzoides*	*Commelina benghalensis*
Digera arvensis	*Parthenium hysterophorus*	*Achyranthus aspera*
Cyperus rotundus	*Cynodon* dactylon	*Sida acuta*
Trichodesma indicum		*Dactyloctenium aegyptium*
Ageratum conyzoides		*Euphorbia geniculata*
Cynotis axillaris		*Cynodon dactylon*
Phyllanthus niruri		*Euphorbia* hirta
Physalis minima		
Xanthium strumarium		
Echinochloa colonum		
Abutilon indicum		
Cassia tora		

RVSKVV, Gwalior

Surveillance was done to find out 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.

BUAT, Banda

The survey was undertaken in the fields of farmers in Banda districts during *Kharif* 2019. Total ten locations were surveyed. The major crops and cropping systems were rice -wheat, millet – chickpea, millet – mustard, rice –chickpea, pigeon pea –fallow, fallow-mustard/pulses. No new unknown weed species was observed during survey in both the districts. However, major presence of *Parthenium hysterophorus* was noticed in fallow land, near field and road side.

WP 2.2 Monitoring of weed shift due to weed management practices, changes in cropping systems and climatic parameters in prevailing ecosystems

Table 2.2.2.1 Dominant weed flora in transplanted *kharif* rice of Kokrajhar district

	RD	RF	Rdom	IVI	IVI (%)
Ludwigia hyssopifolia	0.21	5.97	3.08	9.26	3.09
Monochoria vaginalis	0.81	13.43	20.92	35.17	11.72
Marsilia quadrifolia.	3.50	14.92	5.63	24.06	8.02
Polygonum sp.	0.55	5.97	5.53	12.05	4.02
Echinochloa sp.	1.26	14.92	8.13	24.32	8.11
Isachne himalaica	1.13	4.48	1.81	7.41	2.47
Leersia hexandra	0.35	4.48	0.56	5.39	1.80
Cyperus difformis	0.79	5.97	5.07	11.83	3.94
Cyperus iria	2.08	13.43	13.36	28.87	9.62
Fimbristylis littoralis	89.32	16.42	35.90	141.64	47.21

RD= Relative density; RF= Relative frequency; R.Dom= Relative dominance; IVI- Importance value index

WP 2.2.1 Monitoring of weed shift in transplanted *Kharif* rice in Kokrajhar district

AAU, Jorhat

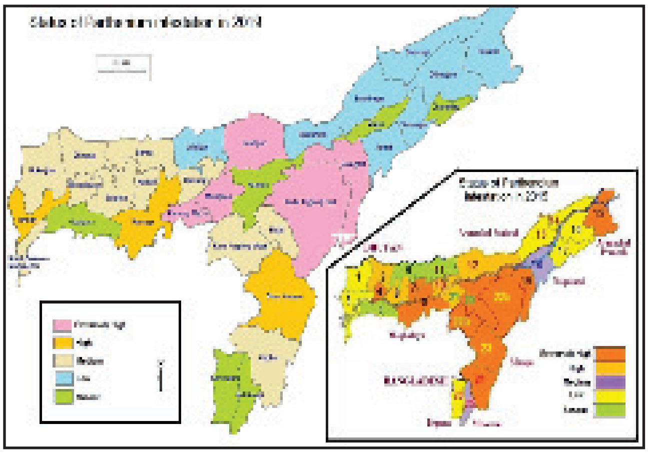
A survey was conducted in transplanted rice during *Kharif* 2019 at Kokrajhar District of Assam. It was observed under transplanted rice *Fimbristylis littoralis* (47.2% IVI) and *Monochoria Vaginalis* (11.7% IVI) were the most troublesome weeds in the district. The most common weed in the entire district was sedges represented by *Fimbristylis littoralis*, *Cyperus Iria* and *C. difformis*. The grassy weed flora was composed of *Echinochloa* spp., *Isachne himalaica* and *Leersia Hexandra*. On the other hand, the most dominant broadleaved weeds were *Ludwigia hyssopifolia*, *Monochoria vaginalis*, *Polygonus* spp., and the aquatic ferm *Marsilia quadrifolia*. Amongst all, *Fimbristylis littoralis* had 89.3% relative density, 16.4% relative frequency, and 35.9% relative dominance – all the values were the highest **(Table 2.2.1.1)**.

On comparing the data of previous survey of transplanted *Kharif* rice in around Kokrajhar and its neighbouring districts showed increase of sedge population in 2019. From a situation of *Eichhornia crassipes* dominant rice fields transforming to *Fimbristylis* dominant condition showed a distinct shift between 2015 to 2019.

WP-2.2.2 Monitoring the changes of infestation of *Parthenium* in Assam

During the survey, it was found that there is a great change in *Parthenium* distribution in Assam in last few years. The Changes occurred (Map 2.2.2) mostly due to increasing public awareness. The road divider all along Guwahati to Jorhat was infested by the weed very heavily.

In Jorhat and Sibsagar districts, seeds of *Cassia tora* and *Crotolaria striata* have been sown along the National Highway and Assam Trunk Road during 2018-19. The impact becomes very prominent in 2019; which have replaced *Parthenium* population. However, these roadside areas are now dominant by *Cassia tora, Crotolaria striata, Chromolaena odorata, Hyptis suaveolense, Colocasia esculenta, etc,* instead of *Parthenium.* Apart from this, *Parthenium* has entered the crop fields in Golaghat Karbi Anglong and Jorhat districts. During 2018-19, *Parthenium* was recorded in Ageratoli areas inside the Kaziranga National Park. This record probably the 1st record of this weed inside this National Park. Due to the increase in awareness amongst the people *Parthenium* is almost absent in Goalpara, Nogaon, Majuli and Charideu districts of Brahmaputra valley and Karimganj and Hilakandi districts of the Barak valley Agroclimatic zone. Prevalence of *Parthenium* to a great extent is still persisted in Golaghat, Karbi, Anglong Sonitpur, Marigaon and Kamrup (Metro) districts of Assam.



Map 2.2.2 Map showing the changes of severity of *Parthenium hysterophorus* infestation in Assam in 2019 comparing to 2015.

OUAT, Bhubaneswar

In *Rabi*, 2018-19 weed survey was conducted in the rainfed tracts along the state highway no.1 from Khurda to Nayagarh under East and South Eastern Coastal Plain agro-climatic zone of the state during *Rabi*, 2018-19. The covered locations were Baghamari, Pichukuli of Khurda district and Bolagarh of Nayagarh district. In this area following cropping system was adopted by the farmers since last three years-

1. Upland rice - pulse (greengram, blackgram, horsegram) in the rainfed areas (65%)
2. Rice - groundnut/vegetables in the irrigated area (25%)
3. Rice – rice in of the irrigated area (10%)

a. Location 1: Pichukoli, Bolgarh (Nayagarh district), 94 km from Bhubaneswar, GPS points: 29^{0}13'03.46"N to 88^{0}30'19.00"E, altitude: 38 m from MSL; Situation: Cropped area (greengram after rice as paira crop).

The weed survey conducted in greengram crop of Arugul area revealed that *Cynodon dactylon* was the dominant grass with IVI of 25.31 followed by *Echinochloa colona* (17.4) and *Digitaria ciliaris* (16.2). *Ageratum conyzoides* (24.0) and *Amaranthus viridis* (18) were the major BLW observed. The only sedges noticed was *Cyperous rotundus* (8.9).

The results of weed survey in non-cropped area at Arugul revealed dominance of *Cynodon dactylon* (IVI-49.5), *Digitaria ciliaris* (17.4) and *Sporobolous diander* (15.2) among grasses. Dominant broad leaf weeds were *Ageratum conyzoides* (33.1), *Amaranthus viridis* (18.5) and *Sphaeranthus indicus* (16.0). Major sedge observed *Cyperus rotundus* (12.3).

In the surveyed area *Cynodon dactylon* (IVI-25.0), *Echinochloa colona* (17.9) and *Digitaria ciliaris* (16.6) were the major grasses observed in horsegram crop at Bolagarh area (**Table 2.2.2.1**). Dominant BLW noticed were *Ageratum conyzoides* (24.0), *Amaranthus viridis* (13.6), *Acyranthus aspera* (12.8) and *Cyperus rotundus* (10.3) was the only sedges observed.

Table 2.2.2.1 Weed flora in blackgram at Gajamara, Dhenkanal sadar, Dhenkanal District (*Rabi*, 2018-19)

Sl.No.	Weed species	RD(%)	RF(%)	Rdo(%)	IVI
Grasses					
1.	*Cynodon dactylon*	13.5	11.0	0.42	**25.0**
2.	*Echinochloa colona*	10.0	7.75	0.19	17.9
3.	*Digitaria ciliaris*	8.75	7.75	0.13	16.6
4.	*Panicum repens*	9.00	6.20	0.22	15.4
5.	*Eleusine indica*	7.50	5.43	0.15	13.0
6.	*Sporobolus diander*	2.00	3.10	0.04	5.15
Broad leaved weeds					
7.	*Ageratum conyzoides*	12.5	10.8	0.65	**24.0**
8.	*Amaranthus viridis*	5.75	7.75	0.14	13.6
9.	*Achyranthus aspera*	5.50	6.98	0.29	12.7
10.	*Celosia argentea*	4.25	3.88	0.15	8.29
11.	*Spaeranthus indicus*	3.25	3.10	0.08	6.43
12.	*Euphobia hirta*	3.00	3.10	0.09	6.19
13.	*Portulaca oleracea*	1.75	3.10	0.04	4.90
14.	*Tephrosia purpurea*	2.25	2.33	0.09	4.67
15.	*Ammania bacifera*	2.25	2.33	0.01	4.59
16.	*Sida acuta*	2.00	2.33	0.09	4.42
Sedges					
17.	*Cyperus rotundus*	5.84	4.03	0.41	**10.2**

Non-cropped area of Gajamara ,Dhenkanal sadar,Dhenkanal District GPS points: $20^0$10'22.46"N to $85^0$16'34.90"E, altitude: 97m from MSL

The weed flora in the non-cropped area of Bolagarh area of Nayagarh district was dominated with grasses like *Cynodon dactylon* (IVI-56.1), *Sporobolus diander* (10.0) and *Eleusine indica* (9.5). The major broad leaved weeds observed were *Ageratum conyzoides* (36.0), *Spaeranthus indicus* (14.6) and among sedges, only *Cyperus rotundus* (8.8) was found.

Kharif, 2019

The weed survey has been conducted in the irrigated tracts along the national highway number 203 from Bhubaneswar to Puri under East and South Eastern Coastal Plain agro-climatic zone of the state during *Kharif*, 2019. The covered locations were Siula of Khurda district and Delanga of Puri district. The following cropping system was adopted by the farmers-

1. Rice - pulse (greengram, blackgram, horsegram) in the rainfed areas (45%)
2. Rice - groundnut/vegetables in the irrigated area (35%)
3. Rice – rice in of the irrigated area (20%)

a. Location 1: Kuaput, Haldia, Banki, Cuttack; Cropped area (transplanted rice); GPS points: $20^{0}09'22.41''$N to $85^{0}50'32.36''$E, altitude: 13 m from MSL

The dominant grasses in transplanted rice at Siula (Khurda district) were *Panicum repens* (IVI-13.8), *Echinochloa crusgalli* (11.5) and *Paspalum scorbiculatum* (10.2). *Ludwigia parviflora* (13.7), *Alternanthera sessilis* (10.6) and *Ammannia baccifera* were the major broad leaved weeds observed. The important sedges were *Cyperus iria* (7.7) and *Cyperus rotundus* (7.0).

Table 2.2.2.2 Weed flora in transplanted rice at Kuaput, Haldia, Banki, Cuttack (*Kharif*, 2018)

Sl. No.	Weed species	RD(%)	RF(%)	Rdo(%)	IVI
	Grasses				
1	*Panicum repens*	8.33	5.19	0.25	**13.7**
2	*Echinochloa crusgalli*	6.00	5.43	0.12	11.5
3	*Paspalum scorbiculatum*	5.50	4.65	0.09	10.2
4	*Leptochloa chinensis*	4.50	4.65	0.09	9.25
5	*Echinochloa colona*	3.50	3.10	0.06	6.67
	BLW				
6	*Ludwigia parviflora*	6.50	6.98	0.21	**13.6**
7	*Alternanthera sessilis*	5.00	5.43	0.16	10.5
8	*Ammania bacifera*	4.50	5.43	0.02	9.95
9	*Marselia quadrifolia*	3.75	4.65	0.14	8.55
10	*Alternanthera philexeroides*	3.50	3.88	0.11	7.49
11	*Eclipta alba*	3.00	3.88	0.09	6.97
12	*Monochoria vaginalis*	2.75	3.10	0.13	5.99
	Sedges				
13	*Cyperus iria*	3.00	4.65	0.07	**7.73**
14	*Cyperus rotundus*	2.25	4.65	0.05	6.96
15	*Fimbristylis milaceae*	1.75	3.10	0.04	4.89

b. Location 1: Non-cropped area of Kuaput, Haldia, Banki, Cuttack; GPS points: $20^{0}09'21.83''$N to $85^{0}50'44.45''$E, altitude: 15 m from MSL

Cynodon dactylon (IVI-29.8), *Eleusine indica* (16.7) and *Digitaria ciliaris* (15.9) were the major grasses in the non-cropped areas of Siula location. Among the broad leaf weeds, *Ageratum conyzoides* (21.9), *Achyranthus aspera* (14.3) and *Amaranthus viridis* (14.2) were dominant. *Cyperus rotundus* (11.8) was the only sedges observed.

The floristic composition in transplanted rice at Kanas area of Puri district were dominated with grasses like *Echinochloa colona* (IVI-14.4), *Panicum repens* (13.3) and *Leptochloa chinensis* (10.0). The major broad leaved weeds observed were *Ludwigia parviflora* (14.7), *Ammannia baccifera* (10.7) and *Alternanthera sessilis* (10.1). *Cyperus iria* (5.4) and *Fimbristylis miliaceae* (5.1) were the sedges observed.

The weed flora in the non-cropped area of Kanas location were dominated with grasses like *Cynodon dactylon* (IVI-27.1), *Digitaria ciliaris* (15.9), *Eleusine indica* (15.4), broad leaved weeds like *Ageratum conyzoides* (18.8), *Spaeranthus indicus* (14.4), *Amaranthus viridis* (13.4) and *Celosia argentea* (12.4). *Cyperus rotundus* 912.7) was the only sedges observed

AAU, Anand

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 MSM to manage dicot weeds. Which provide opportunities to flourish monocot weeds and that did not control by the said herbicides. Awareness campaign/training programme/OFT/FLDs conducted to manage complex weed flora in wheat by using premixed herbicides.

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* was also observed in the research farm as a result of pre-emergence application of pendimethalin.

CCSHAU, Hisar

During survey it was identified that, *Coronopus didymus* (Pithpapra), *Anagallis arvensis* (Krishanneel) and *Polypogon monspeliensis* (Loomar ghas) and *Lophochloa phleoides* (Lallu ghas) were on the rise in wheat.

Another weed survey in rice, cotton and cluster bean was conducted in second fortnight of September and first fortnight of October in 2019 in Sirsa, Fatehabad, Bhiwani and Charkhi Dadri districts of Haryana. To study weed composition of cotton and rice, Sirsa and Fatehabad districts were surveyed while for cluster bean fields were surveyed in Bhiwani and Charkha Dadri districts. Four observations on density of individual weeds were recorded per field at one spot by using quadrate of (0.5 x 0.5 m), 100 meters deep inside the fields. Pooled average values of relative weed density, relative frequency of individual weeds and IVI were thus calculated as for each crop separately.

Table 2.2.2.3 Weed flora of cotton in Sirsa and Fatehabad districts

Weeds	**RF (%)**	**RD (%)**	**IVI**
Dactyloctenium aegyptium	19.7	28.5	48.2
Digitaria sanguinalis	4.65	2.2	6.85
Echinocloa colona	6.39	6.21	12.6
Leptochloa	4.65	10.6	15.3
Cynodon	2.32	1.62	3.94
Eragrotis	12.2	22.3	34.5
Cyperus rotundus	9.88	5.04	14.9
T. portulacastrum	1.74	2	3.75
Digera arvensis	13.9	14.8	28.7
Tribulus terrestris	2.33	0.32	2.65
Mollugo	0.58	0.06	0.65
Corchorus tridens	5.23	0.71	5.94
Phyllanthus	0.58	1.29	1.87
Physalis	4.10	1.20	5.31
Cucumis callosus	1.74	0.26	2.0
Ipomea	3.49	0.71	4.2
Crotolaria	0.58	0.13	0.71
Commelina	3.50	1.4	4.9
Vernonia	0.58	0.39	0.97
Cleome	0.58	0.06	0.65

Twenty species of weeds were found to infest cotton, twenty in cluster bean (**Table 2.2.2.3** and **2.2.2.4**).

Dactyloctenium aegyptium, *Eragrostis*, *Digiteria sanguinalis* were also the dominant grassy weeds in cluster bean with IVI value of 38.2, 37.4 and 13.3%. *Mollugo spp.*, *Corchorus tridens*, *Digera arvensis and T. portulacastrum* were dominant broad-leaved weeds.

The rice fields were infested with *Echinochloa glabrescence*, *E. crusgalli*, *E. colona*, *Leptochloa chinensis*, *C. difformis*, *Scirpus tuberosus*, *Paspalum distichum*, *Ammania baccifera*, *Ipomea aquatic*, *Panicum repens*, *Lemna minor*, *Polygonum*, *Commelina benghalensis*, *Marsilea quadrifolia*, *Fimbristylis miliacea*, *Eclipta*, *Dactylectinium aegyptium* and *Chloris barbata*. *E. glabrescence*, *Leptochloa chinensis* and *E. colona* were dominant grassy weeds, *C. difformis* and *Scripus tuberosus* were dominant sedges while *Ammania* and *Lemna minor* were dominant broad leaved weeds having higher relative frequency, relative density and IVI value.

Table 2.2.2.4 Weed flora of cluster bean in Bhiwani and Charkhi Dadri districts

Weeds	RF(%)	RD(%)	IVI
Dactyloctenium aegyptium	13.2	24.9	38.2
Digitaria sanguinalis	8.43	4.89	13.3
Eleusine	2.41	1.42	3.83
Cynodon	2.41	1.54	3.95
Eragrotis	8.43	28.9	37.3
Cenchrus cilliaris	6.02	2.32	8.34
Cyperus rotundus	3.61	1.29	4.91
T. portulacastrum	3.61	3.99	7.61
Digera arvensis	6.02	2.32	8.34
Tribulus terrestris	6.02	1.29	7.31
mollugo	10.8	8.75	19.5
Mussa Dadhi	3.61	4.63	8.25
Corchorus tridens	9.64	2.06	11.7
Phyllanthus	1.20	0.13	1.33
Cucumis callosus	4.88	0.9	5.72
Ipomea	1.2	0.13	1.33
Crotolaria	2.41	2.45	4.85
Tin Patia	1.20	4.5	6.91
Amaranthus	1.20	0.26	1.46
Cathranthus pusilus	2.41	3.22	5.63

CSKHPKV, Palampur

Weed survey was conducted in rice based cropping system in Kangra District. A total of 140 randomly selected quadrats were studied to have an insight of weed flora and species composition. A total of 58 weed species (28 species in rice and turmeric during the *Kharif* seasons of 2017 and 2018; 35 species in *Rabi* 2017-18 and 2018-19), belonging to 17 families were identified. Among the 17 families, Poaceae had the highest number of species (18 species) followed by Asteraceae and Leguminosae (6 species each), Cyperaceae (5) and Brassicaceae (4 species), Polygonaceae and Amaranthaceae (3 species each), Caryophyllaceae, Plantaginaceae and Commelinaceae (2 species each), Primulaceae, Oxalidaceae, Euphorbiaceae, Ranunculaceae, Apiaceae, Pontederiaceae and Lythraceae (1 species each). The weeds, *Commelina forskalli Brassica* sp. and *Eleocharis* sp. those reported earlier were not recorded in the present survey on farmers' fields in Kangra district. *Cyperus esculentus, Eluesine indica*, *Cyperus rotundus* and *Fimbristylis miliaceum*, *Alternanthera philoxeroides* and *Amaranthus viridis, Bidens pilosa* and *Poa annua* reported by different workers were also recorded in the present survey in rice or turmeric in *Kharif* in Kangra district. The weeds *Euphorbia* sp., *Paspalum* sp., *Ageratum houstonianum, Conyza stricta*, *Pennisetum* sp., *Scirpus* sp. and *Setaria glauca* were reported in present survey only.

In *Rabi* , *Malva parviflora*, *Amaranthus* sp. and *Digitaria sanguinalis*, *Oxalis latifolia*, *Polygonum alatum* and *Lathyrus aphaca*, *Carthamus oxycantha*, *Circium arvense*, *Convolvulus arvensis*, *Agropyron repens*, *Polypogon monspeliensis*, *Plantago lanceolate* and *Chenopodium murale* those reported earlier were not recorded in the present survey on farmers' fields in Kangra district. *Coronopus didymus*, *Stellaria media*, *Avena fatua*, *Rhaphanus* sp., *Melilotus alba* and *Polypogon plevigum* those recorded in the present study were also reported earlier in *Rabi* in Kangra district. *Ageratum conyzoides*, *Euphorbia helioscopia*, *Galinsoga parviflora*, *Medicago denticulata*, *Sonchus arvensis*, *Capsella bursa-pastoris*, *Polypogon* sp., *Ranunculus arvensis*, *Rumex* sp., *Tulipa* sp. and *Trifolium repens* were reported in present survey only.

Stellaria media, *Polygonum barbatum*, *Lolium temulentum*, *Phalaris minor*, *Spergula arvensis*, *Vicia sativa*, *Polygonum alatum*, *Trifolium repens* and *Coronopus didymus* were prevalent throughout the *Rabi* season. *Bidens pilosa* has shown its occurrence at later stages of crop growth. *Rhaphanus* sp., *Daucus carota* and *Rumex* sp. had sporadic appearance in some months in some crops. *Ageratum* sp., *Artemisia* sp., *Lathyrus aphaca*, *Anagallis arvensis*, *Avena fatua* and *Poa annua* were noticed at some of the observations.

Phytosociology of weeds indicated that weed density of *Echinochloa colona* (47.8) was highest followed by *Ageratum conyzoides* (40.8), *Cyperus iria* (37.3) and *Echinochloa crusgalli* (33.5) (**Table 2.2.2.5**), however the frequency value was highest for *Echinochloa colona* (77.1) followed by *Cyperus iria* (67.1), *Commelina benghalensis* (61.4) and *Echinochloa crusgalli* (52.9).

On the farmers' fields weed flora during *Rabi* was more diverse than the *Kharif* with invasion of 35 weed species in crops like onion, garlic, potato, linseed, wheat etc during 2018-19. *Phalaris minor* was the most abundant weed followed by *Bidens pilosa* and *Avena ludoviciana*. However, *Brassica* sp. and *Euphorbia helioscopia* were least abundant. *Phalaris minor* had highest density followed by *Lolium temulentum*, *Stellaria media*, *Anagallis arvensis* and *Vicia sativa. Anagallis arvensis* was the most frequently occurring weed species followed by *Phalaris minor* and *Vicia sativa. Melilotus alba* and *Briza minor* were among the least frequently occurring weed species. *Phalaris minor* was found to be the most important weed with highest important value index (IVI). This was followed by *Lolium temulentum*, *Anagallis arvensis*, *Stellaria media*, *Vicia sativa*, *Avena fatua*, *Trifolium* sp., *Avena ludoviciana* and *Coronopus didymus*.

Table 2.2.2.5 Enumeration of abundance, frequency, density (no. /m^2) and important value index of weed species during *Kharif*

Weed species	Abundance	Density	Frequency	IVI
Echinochloa crussgalli	15.8	33.5	52.9	26.2
Echinochloa colona	15.5	47.8	77.1	34.5
Cynodon dactylon	9.2	9.5	25.7	11.1

Table continue...

Ageratum conyzoides	32.5	40.8	31.4	32.8
Ageratum haustonianum	10.2	2.9	7.1	6.5
Pennisetum sp.	7.5	2.6	8.6	5.4
Panicum dichotomiflorum	7.2	14.5	50.0	15.5
Setaria glauca	10.5	4.2	10.0	7.6
Galinsoga parviflora	3.0	0.3	2.9	1.9
Bidens pilosa L.	6.5	4.1	15.7	6.5
Conyza stricta	4.4	2.3	12.9	4.6
Ammannia baccifera L.	0.0	1.0	5.7	1.2
Euphorbia sp.	3.0	0.2	1.4	1.6
Digitaria sanguinalis	7.5	13.8	45.7	14.8
Aeschynomene indica L.	6.0	7.9	32.9	10.2
Polygonum alatum	6.8	7.0	25.7	9.2
Scirpus sp.	0.0	0.2	2.9	0.5
Paspalum sp.	5.3	5.5	25.7	8.0
Monochoria vaginalis	5.2	3.9	18.6	6.4
Amaranthus viridis L.	1.4	0.4	7.1	1.8
Cyperus iria	13.9	37.3	67.1	28.8
Cyperus difformis	10.0	1.1	2.9	5.2
Cyperus rotundus	10.3	1.8	4.3	5.8
Alternanthera sp.	9.4	12.9	34.3	13.6
Commelina benghalensis	11.7	28.9	61.4	24.1
Commelina communis	6.4	1.8	7.1	4.5
Fimbristylis sp.	3.0	2.6	21.4	5.4
Eluisine indica	6.1	4.2	17.1	6.6

Table 2.2.2.6 Enumeration of abundance, frequency, density (no. /m^2) and Important Value Index of weed species during *Rabi*

Weed species	Abundance	Density	Frequency	IVI
Polygonum sp.	3.7	2.1	14.3	4.5
Ageratum conyzoides	4.8	1.1	5.7	3.0
Avena fatua	15.7	17.9	28.6	17.2
Lolium temulentum	17.7	31.3	44.3	25.7
Vicia sativa	10.2	19.2	47.1	18.9
Spergula arvensis	8.1	9.7	30.0	11.7
Stellaria media	13.2	22.6	42.9	20.6
Phalaris minor	25.8	54.5	52.9	38.9
Avena ludoviciana	21.0	10.8	12.9	13.6
Anagallis arvensis	9.4	21.4	57.1	21.2
Veronica sp.	6.8	4.3	15.7	6.7
Brassica sp.	0.0	0.7	5.7	1.2
Trifolium repens	7.1	5.7	20.0	8.0
Poa annua	9.4	14.0	37.1	15.0
Oxalis sp.	5.4	3.1	14.3	5.5
Tulipa sp.	10.1	7.5	18.6	9.5
Euphorbia helioscopia	0.0	1.4	11.4	2.5

Table continue...

Medicago denticulatum	6.9	3.5	12.9	5.9
Capsella bursa- pastoris	4.4	1.3	7.1	3.2
Coronopus didymus	6.5	10.0	38.6	12.7
Plantago sp.	2.5	0.9	8.6	2.7
Ranunculus arvensis	11.3	4.5	10.0	7.3
Sonchus arvensis	10.3	1.8	4.3	5.0
Polygonum plebeium	10.0	0.6	1.4	3.9
Alopecurus myosuriodes	5.0	0.6	2.9	2.4
Daucus carota	15.0	3.4	5.7	7.5
Rumex sp.	3.3	1.1	8.6	3.1
Galinsoga parviflora	11.7	2.0	4.3	5.5
Bidens Pilosa	22.0	1.3	1.4	8.3
Rhaphanus sp.	1.0	0.1	1.4	0.6
Chenopodium album	3.3	1.7	12.9	4.0
Melilotus indica	4.0	0.2	1.4	1.7
Melilotus alba	3.0	0.2	1.4	1.3
Polypogon sp.	1.0	0.1	1.4	0.6
Briza minor	1.0	0.1	1.4	0.6

IGKV, Raipur

Celosia argentea was observed in organic aromatic rice experiment under AICRP on WM in place of *Alternanthera triandra*.

MPUAT, Udaipur

A survey and surveillance programme to monitor the status of weed flora in cropped and non cropped area of Chittorgarh district was undertaken for reporting period. Four tehsils i.e. Nimbahera, Kapasan, Dungla and Bari Sadri of Chittirgarh district were surveyed during 2018-19. The major crops of the surveyed tehsils was maize, soybean, groundnut, sorghum, cotton and blackgram in *Kharif* and wheat, barley and opium in irrigated areas of *Rabi*. Whereas in rainfed areas, rapeseed-mustard, chickpea, ajwain and dil were the major crops that have been taken as post rainy seson crops. Very small area was used for cultivation of medicinal crops like safed musli, ashwagandha, ajwain, isabgoal, fenugreek etc.

During *Rabi* 2018-19, in rainfed areas, rapeseed & mustard, chickpea, ajwain and dil were the major crops that have been taken as post rainy seson crops, while in irrigated areas wheat was the major cereal whereas, barley, opium poppy and fenugreek are also taken as minor crop. The foremost broad-leaved weeds observed in these crops were *Chenopodium album, Chenopodium murale, Melilotus indica, Fumaria parviflora, Malva parviflora, Anagalis arvensis, Convolulus arvensis, Sonchus asper* and *Spergulla arvensis*. Whereas *Phalaris minor* and *Avena ludoviciana* were the most important annual grassy weeds which infests *Rabi* fields. Some of rainfed areas of mustard crop were infested with *Asphodelus tenuifolius*. However, infestation of broomrapes was not observed in the surveyed areas.

In *Kharif* 2019 major weeds were *Commelina diffusa, Trianthema portulacastrum, Parthenium hysterophorus, Physalis minima, Euphorbia hirta, Celosia argentea, Euphorbia hirta* and *Corchorus olitorius* among broad-leaved weeds. While, under the category of grassy weeds, *Echinochloa colona, Eleusine indica, Dactyloctenium aegyptium, Chloris barbata, Brachiaria reptans, Rotboellia exoltata* and *Cynodon dactylon* and *Cyperus rotudus* as sedge were observed at most of the locations in the cropped fields.

PAU, Ludhiana

A long-term field experiment to study the effect of tillage and residue management practices on shifts in weed flora and productivity of rice-wheat system was started in *Kharif* 2018. In 2019, as compared to previous year 2018, there was significant shift in weed flora in rice; the density of *Echinochloa colona* increased significantly in 2019, *Cyperus iria* was recorded in 2019 (not recorded in 2018) and two broadleaf weeds (*Eclipta* *alba* and *Digera arvensis)* which were recorded in 2018 were not observed in 2019.

PDKV, Akola

Along the road side in Eastern Vidarbha region, *Parthenium* has been replaced by *Cassia tora* and *Hyptis suaveolens*. The wide spread of *Alteranthera trianda* observed on fallow lands and field. While in some areas mostly nearby cities *Ipomoea* sp. was observed on big trees and electric poles etc. In Western and Central Vidarbha zone, predominant cropping system is soybean based, where farmers are growing soybean year after year and used continuous imazethapyr to control weeds, now they are facing problem of herbicides resistance in *Commelina benghalensis* herbicides in their fields.

SKUAST, Jammu

The density of *Phalaris minor*, *Rumex* spp., *Ranunculus arvensis, Anagalis arvesnsis*, *Melilotus* spp. and other weeds were deceresed in ZTDSR/ZTDSR + residue-ZT wheat + residue treatments as compared to CT transplanted rice-CT wheat, CT transplanted rice-ZT wheat and CTDSR-CT wheat. However, density of *Medicago* spp. was increased in ZTDSR/ZTDSR + residue-ZT wheat + residue as compared to CT transplanted rice-CT wheat.

OUAT, Bhubaneswar

The weed surveillance was carried out in two major agro-climatic zones, *viz*. East and South Eastern Coastal Plain and Mid-Central Land. Some of the significant observations are as follows.

A. East and South Eastern Coastal Plain Zone

Mikania micrantha is spreading alarmingly in the interior areas of Puri, Jagatsinghpur, Kendrapara and Khurda districts. The infested areas were orchards of mango, banana, coconut and papaya, fences and road side plantations. The emergence of the weed was reported after the devastation of Super Cyclone in 28th October, 1999.

Parthenium hysterophorus is predominantly observed in the embankments of all the major canals of coastal command area such as Puri main canal, Taladanda canal, Sakshigopal main canal and Birupa canal and bunds of road side crop fields.

Eichhornia crassipes is a menace in almost all low lying waterlogged areas, ponds, canals and their sub-distributaries under coastal command area.

Alternanthera philoxerroides is observed in low land paddy areas and low lying swampy areas along the road sides of coastal districts (Jagatsinghpur, Kendrapara, Puri and Jajpur). A shift from *Alternanthera sessilis* to *Alternanthera philoxerroides* was observed in several low-lying rice areas in these regions. Sporadic incidence of *Orobanche* was observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda district along river Mahanadi.

B) Mid- Central Table Land Zone

Celosia argentea is observed to be a severe problem in *Kharif* groundnut and *Rabi* pulses in the districts of Dhenkanal and Anugul. The weed is invading mostly the upland areas nearer to the foothills with the soil types belonging to light textured red soils. The yield loss in groundnut and pulses due to *Celosia* was observed to be 35 and 40%, respectively.

Echinochloa colona and *Digitaria sanguinalis* were the major grassy weeds found in *Kharif* groundnut in this zone.

Eichhornia crassipes was confined to a particular locations like ponds, ditches etc. but now it is widely seen in the new area of low land paddy areas of coastal districts of Cuttack, Puri, Ganjam and Balasore.

Cuscuta chinenesis infestation was observed in niger crop in Semiliguda district. Heavy infestation of *Mikania* spp. in banana has been observed in all the coastal districts. *Heliotropium* spp. heavy infestation was observed in the greengram and blackgram field of coastal districts of Cuttack, Puri and Jagatsingpur.

Direct seeded rice was heavily infested with grassy weeds like *Dactyloctenium aegyptium*, *Elusine indica*, *Leptochloa chinensis*, *Panicum* spp. Whereas, *Celosia argentea* was observed to be a severe problem in upland rice and *Rabi* pulses in the districts of Keonjhar.

Chromolena infestation in road side of Sundargarh district

Mikania infestation in banana in Jagatsinghpur district

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

WP 2.3.1(i) Management of cross resistance in *P. minor* against recommended herbicides in wheat

CCSHAU, Hisar

The poor efficacy of clodinafop, sulfosulfuron and pinoxaden was observed in *Phalaris minor* since last 3-4 years at farmers field. Hence, a field experiment was conducted during *Rabi* 2018-19 to study the efficacy of different herbicides against *P. minor*. Significantly less density of *Phalaris minor* was recorded in all the treatments over the control .

The minimum density of *P. minor* (3 and 4 /m^2) at 30 DAT and 60 DAT, respectively were found with the treatment - pyroxasulfone + pendimethalin (TM) *fb* mesosulfuron + iodosulfuron (RM) when applied at the rate of 127.5+1500 *fb* 14.4 g/ha. This treatment was at par with pyroxasulfone + pendimethalin 127.5+1500 g/ha *fb* pinoxaden+ metsulfuron 64 g/ha (RM) with *P. minor* density of 3 and 5/m^2 at 30 DAT and 60 DAT respectively.

The pre-emergence application of pyroxasulfone + pendimethalin (TM) followed by post-emergence application of mesosulfuron+ iodosulfuron (RM) proved very effectively in minimizing the density of *P. minor* which showed higher WCE - 85.7% at 30 DAT and 89.4% at 60 DAT followed by pre-emergence application of pyroxasulfone + pendimethalin *fb* post-emergence application of pinoxaden + metsulfuron (RM) with WCE of 85.7 and 86.8% over control at 30 DAT and 60 DAT, respectively. There was declined in the WCE at 60 DAT with use of pre-emergence herbicide- aclonifen + diflufenican (TM) 1000+200 g/ha, which was 71.4% at 30 DAT and 68.4% at 60 DAT. The weed control efficiency also declined in some post-emergence applications. Pre-emergence application of pendimethalin 1500 g/ha followed by post-emergence application of pinoxaden+ metsulfuron (RM) 64 g/ha WCE at 30 DAT was 76.2% and WCE at 60 DAT was 63.1%. Clodinafop + metribuzin (TM) at the rate of 60+175 g/ha resulted in weed control efficiency of 52.6% at 60 DAT from 57.1% at 30 DAT.

Pre-emergence application of pyroxasulfone + pendimethalin (TM) 127.5+1500 g/ha followed by post application of mesosulfuron+ iodosulfuron (RM) and sulfosulfuron + metsulfuron (RM) showed higher yield as compared to other treatments. Pre-emergence application of pyroxasulfone + pendimethalin followed by post-emergence application of mesosulfuron + iodosulfuron gave highest number of tillers 399 per m^2 and yield 6.1 t/ha, which is highest among all the treatments. Pre-emergence application of pyroxasulfone + pendimethalin (TM) 127.5+1500 g/ha *fb* post-emergence application of clodinafop + metribuzin (TM) 60+175 g/ha gave grain yield of 5.8 t/ha with 385 tillers / m^2 (**Table 2.3.1**).

Table 2.3.1 Effect of different treatments on no. of tillers and grain yield of wheat

Treatment	Dose (g/ha)	Time (DAS)	No. of tillers / m²	Grain yield (t/ha)
Pendimethalin	1500	0	323	4.90
Aclonifen + diflufenican (TM)	1000+200	0	359	5.16
Pyroxasulfone + pendimethalin (TM)	127.5 + 1500	0	348	5.45
Pendimethalin *fb* mesosulfuron+ iodosulfuron (RM)	1500 *fb* 14.4	0/35	332	5.30
Aclonifen+diflufenican(TM)) *fb* mesosulfuron+ iodosulfuron (RM)	1000+200 *fb* 14.4	0/35	354	5.80
Pyroxasulfone + pendimethalin (TM) *fb* mesosulfuron+ iodosulfuron (RM)	127.5+1500 *fb* 14.4	0/35	399	6.17
Pendimethalin *fb* sulfosulfuron+ metsulfuron (RM)	1500 *fb* 32	0/35	353	5.01
Aclonifen+diflufenican (TM) *fb* sulfosulfuron+ metsulfuron (RM)	1000+200 *fb* 32	0/35	386	5.40
Pyroxasulfone + pendimethalin *fb* sulfosulfuron+ metsulfuron (RM)	127.5+1500 *fb* 32	0/35	391	6.04
Pendimethalin *fb* pinoxaden+ metsulfuron (RM)	1500 *fb* 64	0/35	325	5.16
Aclonifen+diflufenican(TM)) *fb* pinoxaden+ metsulfuron (RM)	1000+200 *fb* 64	0/35	314	5.09
Pyroxasulfone + pendimethalin *fb* pinoxaden+ metsulfuron (RM)	127.5+1500 *fb* 64	0/35	380	5.66
Clodinafop+metribuzin(TM)	60+175	0/35	304	5.20
Pyroxasulfone + pendimethalin (TM) *fb* clodinafop+metribuzin(TM)	127.5+1500 *fb* 60+175	0/35	385	5.82
Weedy Check	-	-	318	4.321
LSD (P=0.05)			12.0	0.15

WP 2.3.1 (ii) Inheritance of resistance against alternate herbicides in various biotypes of *Phalaris minor* from different parts of Haryana (Pot studies)

There are reports of reduced efficacy of recommended herbicides against *P. minor* in wheat at farmers' fields in Haryana. The reason might be the wrong method of application, dose or development of cross- resistance in *P. minor*. Hence, different biotypes of *P. minor* from farmers' fields were collected from different parts of Haryana and were subjected to graded doses of different herbicides under pot-culture for assessment of the herbicidal efficacy and the cross-resistance development. The experiment was undertaken during *Rabi* 2018 in screen house.

All the herbicides were applied as post-emergence on canarygrass at 2-4 leaf stage with 0.5X, X, 2X and 4X with untreated control **(Table 2.3.3)**. The pots were arranged in Completely Randomized Design. At 30 days after the herbicide application, the phyotoxicity to the canarygrass populations was recoreded with a rating scale of 0-100, where 0 stands for 0% phytotoxicity and 100 for 100 % killing of the plants. The resistance index (RI) was calculated as per Uludag *et al.* (2007) and Das (2008) for each canary grass population. The populations with a RI value of >10.0 were considered as“ highly resistant” and those of between 10.0 and 2.0 as “resistant” The rest of the populations, with a RI value of ⩽ 2.0, were designated as “susceptible”.

All the populations showed variable phytotoxicity due to doses of clodinafop. But all these populations were found resistant to clodinafop, where P_3 was slightly less resistant to clodinafop as compared to other populations. One susceptible population (check) of Hindwan, Hisar was taken to compare with these resistant populations. Expect check none of the population showed more than 80% control with the recommended dose (*i.e.* X – 60 g *a.i.* /ha). With the increase in the dose there was increase in the mortality rate. But with 4X dose of this herbicide only 3 populations showed more than 80% control (**Fig.2.3.1**). GR_{50} value of the most susceptible check population, Hindwan, Hisar, was 6.02 ± 0.78 g/ha. GR_{50} value of highly resistant populations -P_{10}, P_6, P_5 and P_1 were 1148 ± 3.06, 933.2 ± 2.97, 707 ± 2.85,251.1 ±2.40 with resistance index of 190.6, 155.0, 117.4 and 104.6, respectively. GR_{50}value of slightly resistant population (P3) was 46.7 ± 1.67 with resistance index of 7.76.

Different doses of sulfosulfuron also showed variable phytotoxicity symptoms. Some populations which were resistant to clodinafop also showed resistance against sulfosulfuron. At recommended dose of this herbicide only 4 populations (P_2, P_{12}, P_{13} and P_{14}) showed more than 80% control, whereas at 2X and 4X doses, 5 and 6 populations out of 15 populations showed more than 80% control. This showed there is a decrease in the efficacy of sulfosulfuron against these canary grass populations. This could be due to development of cross-resistance against this herbicide. GR_{50} value of the check (P_2 – Hindwan, Hisar) was 1.72 ± 0.24 g/ha whereas higher GR_{50} of P_4 was recorded with resistance index of 303.5 followed by P_{11} – 74.45, P_1 – 60.5, P_{15} – 53.9 and P_3 – 51.5. These populations were highly resistant against sulfosulfuron (**Table 2.3.2**).

Mesosulfuron + iodosulfuron (RM) showed better efficacy as compared to the clodinafop and sulfosulfuron. But poor efficacy against this herbicide is also reported in farmers' fields. Out of 15 populations only 5 populations provided more than 80% control at recommended dose of this herbicide, whereas increase in dose showed increase in the efficacy against resistant populations. At 4X dose 10 populations showed more than 80% control (**Fig.2.3.1**). GR_{50} value of the most susceptible check population, Hindwan, Hisar, was 1.02 ± 0.01 g/ha. 3 populations (P_{10}, P_{11} and P_{15}) showed highly resistant against this ready mix with resistant index of 13.21, 18.25 and 15.17, respectively. P_5 and P_{14} are susceptible with this ready mix with resistant index < 2, whereas P6 showed resistance with resistance index of 7.43 and rest populations was slight resistant (**Table 2.3.3**).

Very poor control of P_{10} was observed at recommended dose (50 g/ ha) of pinoxaden with only 15% mortality but with the increase in dose upto 4X, there was control of 62.5%. Except check, only one population found susceptible to pinoxaden, whereas P_3, P_9, P_{11}, and P_{15} were resistant and rest populations were highly resistant against pinoxaden.

Table 2.3.2 Efficacy (% control) of herbicides in pot-studies against biotypes *P.minor* obtained from farmers' fields in Haryana (*Rabi* 2018-19)

Treatments	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Untreated check	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clodinafop 30 g/ha	21.2	100	30	20	0	2.5	10	0	20	0	0	0	0	0	0
Clodinafop 60 g/ha	20	100	70	20	0	0	20	0	30	0	10	2.5	16.2	10	0
Clodinafop 120 g/ha	20	100	71.2	10	20	5.25	30	20	50	0	10	15	28.7	20	5
Clodinafop 240 g/ha	50	100	100	60	10	30	40	40	95	10	40	40	50	30	10
Sulfosulfuron 12.5 g/ha	0	100	0	5	70	35	40	25	25	5	5	85	75	75	0
Sulfosulfuron 25 g/ha	0	100	5	5	77.5	50	47.5	50	37.5	30	20	90	85	85	2.5
Sulfosulfuron 50 g/ha	33.7	100	35	20	80	50	65	50	60	60	20	90	90	90	32.5
Sulfosulfuron 100 g/ha	42.5	100	48.7	20	90	63.7	62.5	65	86.2	57.5	46.2	95	90	90	50
Mesosulfuron + iodosulfuron RM (7.2 g/ha)	62.5	87.5	60	60	72.5	50	50	60	65	30	15	81.2	70	75	40
Mesosulfuron + iodosulfuron RM (14.4g/ha)	81.2	86.2	70	65	90	60	80	60	72.5	60	15	85	75	75	45
Mesosulfuron + iodosulfuron RM (28.8 g/ha)	90	98.5	62.5	65	93.5	80	80	73.75	86.25	70	18.75	85	88	85	60
Mesosulfuron + iodosulfuron RM (57.6 g/ha)	95	95	80	65	88.75	77.5	87.5	80	90	75	20	87.5	90	90	75
Pinoxaden 25 g/ha	40	100	100	50	40	40	20	75	70	0	045	35	20	50	45
Pinoxaden 50 g/ha	70	100	100	52.5	55	70	60	81.2	92.5	15	85	75	65	75	80
Pinoxaden 100 g/ha	96.5	100	100	70	75	80	65	80.2	91.2	25	92.5	75	77.5	80	90
Pinoxaden 200 g/ha	100	100	97.5	90	90	87.5	81.2	92.5	100	62.5	100	87.5	75	100	95

Populations: P_1- Kachhwa (Karnal), P_2- Hindwan (Hisar), P_3 - KhijrabadRaiyawala (Yamuna nagar), P_4- KhairiRaiwali (Kaithal), P_5 - Ramba (Karnal), P_6 - 78 IB, Farm H.A.U (Hisar), P_7 - Rasidan (Jind), P_8–Teek (Kaithal), P_9- Laloda (Fatehabad), P_{10}- Kalwan (Jind), P_{11}- Sitamai (Karnal), P_{12}- Danoda (Jind), P_{13}- Uchana (Karnal), P_{14}- Ujahana (Jind), P_{15}- Chanarathal (Kurukshetra)

(Figure 4.3.1 Efficacy of different herbicides against *Phalaris minor* biotypes in pot studies

Table 2.3.4 GR_{50} value and resistance index of the canary grass populations against mesosulfuron + iodosulfuron (RM)

Resistant canary grass populations	GR_{50} value (g/ha)	Regression equation	Resistance index
P_1	4.07 ± 0.61	Y = 1.45 x + 4.11	3.99
P_3	3.98 ± 0.6	Y = 0.65 x + 4.61	3.90
P_4	2.08 ± 0.32	Y = 0.46 x + 4.85	2.03
P_5	1.58 ± 0.20	Y = 1.12 x + 4.77	1.54
P_6	7.58 ± 0.88	Y = 1.23 x + 3.91	7.43
P_7	5.01 ± 0.69	Y = 1.12 x + 4.42	4.91
P_8	4.26 ± 0.63	Y = 0.71 x + 4.5	4.17
P_9	3.16 ± 0.50	Y = 1.04 x + 4.47	3.09
P_{10}	13.4 ± 1.13	Y = 1.27 x + 3.56	13.2
P_{11}	18.6 ± 1.27	Y = 1.10 x + 3.59	18.2
P_{12}	3.98 ± 0.61	Y = 1.59 x + 4.02	3.90
P_{13}	2.08 ± 0.32	Y = 0.92 x + 4.69	2.03
P_{14}	1.16 ± 0.06	Y = 0.73 x + 4.95	1.13
P_{15}	15.4 ± 1.19	Y = 1.04 x + 3.76	15.1

WP 2.3.2(i) Monitoring and management of herbicide resistance to different herbicides in *P. minor* biotypes from farmers' fields (Pot-culture)

PAU, Ludhiana

Different biotypes of *P. minor* collected from farmers' fields during *Rabi* 2017-18. These biotypes were tested for different herbicides, *viz*. sulfosulfuron 25 g/ha, clodinafop 60 g/ha, pinoxaden 50 g/ha, mesosulfuron + iodosulfuron (RM) 14.4 g/ha and metribuzin+clodinafop (RM) 270 g/ha at 2-4 leaf stage with 0.5X, X, 2X and 4X doses during *Rabi* 2018-19. Per cent control of *P. minor* was noted at 15 days after spray.

PAU population of *P. minor* showed cross resistance to sulfosulfuron and clodinafop at double the recommended dose, parital resistance to pinoxaden and mesosulfruon + iodosulfruon at recommended dose, and no resistance to pre-mix of clodinafop + metribuzin. The population from farmers' field was found to have high level of resistance against all these herbicides except clodinafop + metribuzin at recommended doses.

GR_{50} values for PAU population were more than two times the recommended dose in case of sulfosulfuron, more than 4 times in case of clodinafop and fairly high for mesosulfuron + iodosulfuron, however, the values were lower than recommended dose for pinoxaden and pre-mix of clodinafop + metribuzin. In case of farmer field population, it was highly resistant to sulfosulfuron and clodianfop with resitance index >30), moderately resistant to pinoxaden and fair resistance to clodianfop plus metribuzin with resistance index 1.4) (**Table 2.3.5 to 2.3.7**).

Table 2.3.5 Percent mortality of *P. minor* populations as influenced by sulfosulfuron

Populations	Mortality (%)					
	Sulfosulfuron (g/ha)					
	0	12.5	25	50	100	Mean
Sensitive	0.0 (0)	39.2 (40)	79.5 (95)	81.4 (97)	90.0 (100)	58.0 (66)
PAU	0.0 (0)	25.3 (18)	26.4 (20)	35.2 (33)	61.1 (77)	29.6 (30)
Resistant	0.0 (0)	14.8 (7)	21.3 (13)	24.0 (17)	27.7 (22)	17.6 (12)
Mean	0.0 (0)	26.4 (22)	42.4 (43)	46.9 (49)	59.6 (66)	
			LSD (P=0.05)			
Sulfosulfuron				3.55		
Populations				2.75		
Sulfosulfuron x Populations				6.14		

Original figures in parenthesis were subjected to arcsine transformation.

Table 2.3.7 Percent mortality of *P. minor* populations as influenced by mesosulfuron+iodosulfuron (RM)

Populations	Mortality (%)					
	Mesosulfuron+Iodosulfuron (g/ha)					
	0	7.2	14.4	28.8	57.6	Mean
Sensitive	0.0 (0)	43.1 (47)	50.8 (60)	60.1 (75)	90.0 (100)	48.8 (56)
PAU	0.0 (0)	22.6 (15)	32.1 (28)	45.9 (52)	71.9 (90)	34.5 (37)
Resistant	0.0 (0)	12.9 (5)	21.3 (13)	37.2 (37)	45.0 (50)	23.3 (21)
Mean	0.0 (0)	26.2 (22)	34.7 (34)	47.7 (54)	69.0 (80)	
			LSD (P=0.05)			
Herbicide					2.32	
Populations					1.80	
Herbicide x Populations					4.01	

Original figures in parenthesis were subjected to arcsine transformation.

Table 2.3.7 GR_{50} (g/ha) and resistance index values of *P. minor* populations for different herbicides

Herbicides	GR 50 (g/ha)			Resistance Index	
	Populations			Populations	
	Sensitive	PAU	Resistant	PAU	Resistant
Sulfosulfuron	13.2	56.6	775.4	4.3	58.7
Clodinafop	29.2	215.6	987.9	7.4	33.8
Pinoxaden	28.3	33.7	84.9	1.2	3.0
Mesosulfuron + iodosulfuron	9.4	22.8	50.3	2.4	5.4
Clodinafop + metribuzin	135.4	154.0	192.3	1.1	1.4

WP 2.3.2 (ii) Management of cross resistance in *Phalaris minor* against recommended herbicides in wheat through use of pre - and post-emergence herbicides.

Phalaris minor, Rumex dentatus, Anagallis arvensis, medicago denticulate, Coronopus didymus were major weeds in the experimental area. Aclonifen + diflufenican as pre-emergence alone or in sequence with mesosulfuron + iodosulfuron/ sulfosulfuron + metsulfuron as post-emergence and sequential application of pendimethalin/ pyroxasulfone as pre-emergence and sulfosulfuron + metsulfuron/ mesosulfuron + iodsulfuron were found to be effective to control broad-spectrum weeds (**Table 2.3.8 and 2.3.9**). Sequential application of aclonifen + diflufenican as pre-and sulfosulfuron + metsulfuron as post-emergence gave the highest wheat grain yield (4.82 t/ha), which was at par to weed free check, application of aclonifen + diflufenical alone or in sequence with mesosulfuron + iodosulfuron/ sulfosulfuron + metsulfuron as post-emergence and sequencial application of pendimethalin/ pyroxasulfone as pre- and sulfosulfuron + metsulfuron/ mesosulfuron + iodosulfuron as post-mergence.

Table 2.3.8 Effect of different weed control treatments on density of weeds at 60 DAS (*Rabi* 2018-19)

Treatments	Weed density (no./m²)			
	Phalaris minor	*Anagallis arvensis*	*Medicago denticulata*	*Coronopus didymus*
Pendimethalin PRE 1500 g/ha	3.32 (10)	1.97 (3)	1.00 (0)	1.82 (3)
Aclonifen + diflufenican (TM) PRE 1000+200 g/ha	3.69 (13)	1.49 (1)	1.49 (1)	1.41 (1)
Pyroxasulfone PRE 127.5	2.07 (3)	2.73 (7)	1.00 (0)	1.91 (3)
Pendimethalin *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 1500/14.4 g/ha	3.08 (9)	1.67 (2)	1.24 (1)	1.82 (3)
Aclonifen + diflufenican (TM) *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 1000 + 200/14.4 g/ha	2.08 (3)	1.00 (0)	1.00 (0)	1.24 (1)
Pyroxasulfone *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 127.5/14.4 g/ha	2.37 (5)	1.00 (0)	1.00 (0)	1.00 (0)
Pendimethalin *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 1500/40 g/ha	3.28 (10)	1.00 (0)	1.00 (0)	1.24 (1)
Aclonifen + diflufenican (TM) *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 1000 + 200/40 g/ha	2.51 (7)	1.24 (1)	1.00 (0)	1.00 (0)

Table continue...

Pyroxasulfone *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 127.5/40 g/ha	2.37 (5)	1.90 (3)	1.00 (0)	2.08 (3)
Pendimethalin *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 1500/64 g/ha	3.59 (12)	1.00 (0)	1.00 (0)	1.00 (0)
Aclonifen + diflufenican (TM) *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 1000 + 200/64 g/ha	2.88 (7)	1.00 (0)	1.00 (0)	1.49 (1)
Pyroxasulfone *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 127.5/64 g/ha	2.75 (7)	2.08 (3)	1.00 (0)	1.67 (3)
Farmers' practice (clodinafop + metribuzin (TM) PRE *fb* POST 60 + 175 g/ha)	4.75 (22)	1.00 (0)	1.00 (0)	1.55 (2)
Weedy check	6.24 (38)	3.60 (12)	1.73 (2)	3.55 (12)
Weed free	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
LSD (P=0.05)	0.84	0.61	0.25	0.91

Data was subjected to square root transformation. Values within parenthesis are means of original values

Table 2.3.9 Wheat growth at 60 DAS, yield attributes at harvest and yields under different weed control treatments in *Rabi* 2018-19.

Treatments	Tiller density (no./m)^2	Crop biomass (g/m^2)	Plant height (cm)		Ear height (cm)	Grain yield (t/ha)	Biological yield (t/ha)
	60DAS		60DAS	At harvest	At harvest		
Pendimethalin PRE 1500 g/ha	437	161.5	41.3	91.0	10.1	4.06	9.93
Aclonifen + diflufenican (TM) PRE 1000+200 g/ha	442	163.4	40.1	93.9	10.1	4.54	10.4
Pyroxasulfone PRE 127.5	422	149.8	40.7	92.4	10.2	4.17	9.61
Pendimethalin *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 1500/14.4 g/ha	497	183.7	40.4	93.7	10.1	4.51	10.4
Aclonifen + diflufenican (TM) *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 1000 + 200/14.4 g/ha	508	188.0	42.9	92.0	10.1	4.06	9.82
Pyroxasulfone *fb* mesosulfuron + iodosulfuron (RM) PRE *fb* POST 127.5/14.4 g/ha	470	173.9	41.4	91.7	10.3	3.74	9.31
Pendimethalin *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 1500/40 g/ha	473	175.1	40.2	92.2	9.9	4.76	11.4
Aclonifen + diflufenican (TM) *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 1000 + 200/40 g/ha	507	199.8	40.5	92.7	9.8	4.82	11.8
Pyroxasulfone *fb* sulfosulfuron + metsulfuron (RM) PRE *fb* POST 127.5/40 g/ha	440	162.8	39.5	92.3	10.6	4.34	10.1
Pendimethalin *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 1500/64 g/ha	482	185.6	40.6	91.8	10.5	4.37	10.2
Aclonifen + diflufenican (TM) *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 1000 + 200/64 g/ha	447	165.2	40.8	93.7	10.3	4.15	9.60
Pyroxasulfone *fb* pinoxadin + metsulfuron (RM) PRE *fb* POST 127.5/64 g/ha	427	157.8	41.5	93.2	10.3	4.30	10.3
Farmers' practice (clodinafop + metribuzin (TM) PRE *fb* POST 60 + 175 g/ha)	503	191.1	40.9	92.7	10.3	4.44	11.0
Weedy check	423	154.4	42.3	93.0	9.9	3.91	9.82
Weed free	497	170.3	41.8	92.2	9.9	4.80	11.5
LSD (p=0.05)	NS	18.5	NS	NS	NS	0.53	0.93

WP 2.4 Biology of important weeds

IGKV, Raipur

Echinochloa colona, *Alternanthera triandra*, *Ischaemum rogusum* and *Cyperus iria* are the important and serious weeds found in the rice fields. Hence, the weed biology of the aforesaid weeds were carried out during *Kharif* 2019. Five plants were selected for each species from rice fields. Following character were studied for above mentioned four weeds:

Table 2.4.2 Biology of important weeds studied during *Kharif* 2019

Traits	Name of weed			
	Echinochloa colona	*Ischaemum rugosum*	*Alternanthera triandra*	*Cyperus iria*
Plant height (cm)	65.3	120.7	120	75.4
Tillers/branch (per plant)	5.67	6.33	8.66	3.67
Weed biomass (g/plant)	3.56	5.25	19.5	1.93
Days to flower (Numbers)	30-35	85-90	45-55	48-52
Days to maturity (Days)	60-65	120-125	100 -110	95-105
Seeds (numbers/plant)	3006	1632	5628	1545
100 seed weight (g)	0.078	0.45	0.026	0.30

E. colona produced average plant height of 65.30 cm with 5.67 tillers/plant. This weed produced 3.56 g/plant of dry biomass and took 60-65 days to maturity and produced 3006 seeds/ plant. *I. rugosum* recorded average height of 120.7 cm and 6.33 tillers/plant and biomass of 5.25 g/plant and took 120-125 days to maturity and produced 1632 seeds/ plant and 100 - seed weight of 0.45 g (with husk). Similary, *A. triandra* acheived the plant with spreading habit of 120 cm long with 8.66 branches /plant and biomass of 19.5 g/ plant and took 100-110 days for maturity and produced 5628 seeds per plant with 100 seed weight of 0.026 g. While, *C. iria* produced average height of 75.4 cm with 3.67 tillers/ plant and biomass of 1.93 g/ plant and took 95-105 days to maturity and produced 1545 seeds per plant with 100 seed weight of 0.30 g (**Table 2.4.2**).

PJTSAU, Hyderabad

Biology of *Trianthema portulacastrum*

Trianthema portulacastrum seeds were reniform, dull black in colour. The seeds were sown at three depths (2.5, 5 and 7.5 cm) replicated thrice. The seed sown at 2.5 cm emerged on 5th day after sowing and the seed sown at 5 cm depth emerged 7th to 10 days after sowing, but the seeds sown at 7 cm depth did not germinate. The leaves were fleshy with dilated and membranous petiole. It showed rapid and vigorous growth putting forth 4 to 7 branches, with each branch growing up to 27 to 37 cm in length prostrately. Peak growth was noticed at 40 to 45 days after emergence. Flowering started at 25 days after emergence with axillary budding. Flowers were pinkish white in colour. The plants matured and dried at 85 to 90 days after emergence.

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

WP 3.1 Management of problematic weeds

WP 3.1.1 (a) *Cuscuta* management in onion

An experiment was conducted at Anand and Raipur to study the effect of different herbicides on the emergence of *Cuscuta* and their phytotoxicity on onion crop. Experiment conducted at Anand indicated that number and length of *Cuscuta* twins recorded at 30 days after transplanting (DATP) was higher under weedy check and imazethapyr 75 g/ha as post-emergences, PoE (20 DATP). At 45 DATP, number and length of *Cuscuta* was recorded higher under weedy check while imazethapyr 75 g/ha as PoE at 20 DATP, stale seedbed *fb* pendimethalin 0.750 kg/ha PE, oxadiargyl 90 g/ha PE and oxyfluorfen 0.120 kg/ha PE showed effective control of *Cscuta* at 45 DATP (**Table 3.1.1**). Significantly higher onion bulb yield was achieved under application of PE oxyfluorfen 0.120 kg/ha but it was at par with stale seedbed *fb* pendimethalin 0.750 kg/ha as PE. Further, it was observed that imazethapyr 75 g/ha as PoE at 20 DATP recorded significantly the lowest onion bulb yield (7.0 t/ha) due to its phytotoxic effect, which was 87.4% less then pre-emergence application of oxyfluorfen 0.120 kg/ha. Application of oxyfluorfen 0.120 kg/ha PE recorded maximum gross return, net return and benefit cost ratio which was closely followed by stale seedbed *fb* pendimethalin 0.750 kg/ha PE **(Table 3.1.2**).

Table 3.1.1 Number and length of *Cuscuta* twines at 30, 45 and 60 DATP (9.0 x 4.0 m) and phytotoxicity effect of herbicides

Treatment	30 DATP		45 DATP		60 DATP		Pt. (%)	Remark
	No.	L.(cm)	No.	L. (cm)	No.	L. (cm)		
Oxyfluorfen 0.120 kg/ha PE	0	0	0	0	1	0.75	0	-
Oxadiargyl 90 g/ha PE	0	0	0	0	1	0.78	0	-
Stale seedbed *fb* pendimethalin 0.750 kg/ha PE	0	0	0	0	1	1.2	0	-
Imazethapyr 75 g/ha as PoE at 20 DATP	1	0.25	0	0	0	0	65	Stunted growth
Weedy check	3	0.75	5	2.5	5	7.5		

No.- Number ; **L. –** Length (cm); **Pt.-** Phytotoxicity % on crop

Table 3.1.2 Onion bulb yield and economics as influenced by different treatments

Treatment	Yield (t/ha)	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	B:C ratio
Oxyfluorfen 0.120 kg/ha PE	55.4	6,64,800	1,01,679	5,63,121	6.54
Oxadiargyl 90 g/ha PE	50.1	6,01,200	1,02,202	4,98,998	5.88
Stale seedbed *fb* pendimethalin 0.750 kg/ha PE	52.9	6,34,800	1,05,305	5,29,495	6.03
Imazethapyr 75 g/ha as PoE at 20 DAS	7.00	84,000	1,01,377	-17,377	0.83
Untreated check	4.80	57,600	99,602	-42,002	0.58
S. Em. ±	1.15	-	-	-	-
LSD (P=0.05)	3.61	-	-	-	-

WP 3.1.1 (b) Management of *Cuscuta* in barseem

Berseem (*Trifolium alexandrinum*) is a fast-growing *Rabi* legume feed to the milch animals as a green fodder by the dairy farmers. Apart from common *Rabi* weeds, berseem is generally affected due to *Cuscuta campestris* infestation, which is an annual obligate stem parasite. The most common source of its invasion is through contamination with berseem seeds. In view of above, an experiment was done at Raipur, Gwalior and Jammu.

At Raipur, first appearance of *Cuscuta* in the experimental field was observed after 30 DAS of berseem where the herbicide applied only after 1st cut.

At the time of just before first cut of berseem, highest length (67.3 cm) of *Cuscuta* with highest average number of threads (2.33/m^2) were measured under the treatment where imazethapyr 0.04 kg/ha was to be applied only after last cut. While, there was no infestation of *Cuscuta* found under the treatments having pre-emergence application of herbicides *viz.* pendimethalin 1.0 kg/ha as PE, pendimethalin 1.0 kg/ha at 10 DAS as early post-emergence (EPoE) and oxyfluorfen 0.25 kg/ha as PE. The other dominated weed species in the experimental field were *Medicago denticulata, Chenopodium album* and *Cichorium intybus*. Other broad-leaf weeds were *Rumax dentatus*, *Alternanthera triandra*, *Melilotus alba* and *M. indica* and *Parthenium hysteroforus* while, *Cynadon dactylon* and *Echinochloa colona* were the other grassy weeds found in the field.

Application of oxyfluorfen 0.25 kg/ha (PE) reduced the density of *Medicago denticulata, Chenopodium album* and *Cichorium intybus.* Other weeds and total weed density veried at 30, 60 DAS and at harvest. Using imazethapyr either at 0.04 kg/ha after first cut or at last cut and even imazethapyr at 0.04 kg/ha after 1st cutting *fb* imazethapyr at 0.04 kg/ha after last cut had least effect on controlling weed density of *Medicago denticulata, Chenopodium album* and *Cichorium intybus*. Whereas, pendimethalin 1.0 kg/ha as PE or at 10 DAS as EPoE performed better than imazethapyr. However, imazethapyr at 0.04 kg/ha after 1st cutting *fb* imazethapyr at 0.04 kg/ha after last cut found better to control other weeds population as compared to pendimethalin 1.0 kg/ha as PE or at 10 DAS as EPoE.

Maximum plant height of berseem plant measured before 1st, 2nd and 3rd cut in the treatment where oxyfluorfen 0.25 kg/ha (PE) was applied. Imazethapyr at 0.04 kg/ha after last cut got the shortest plant among all the treatments just before the 3rd cut whereas at the same time, rest of the treatments were at par with each other. Significantly highest total green fodder yield (65.0 t/ha) and seed yield (0.21 t/ha) was registered with the application of oxyfluorfen 0.25 kg/ha (PE) over rest of the treatments Pre-emergence application of oxyfluorfen 0.25 kg/ha recorded maximum net return and B:C ratio as compared to rest of the treatments (**Table 3.1.3**).

Table 3.1.3 Green forage yield of berseem after 1st, 2nd and 3rd cutting total green forage yield, seed yield and economics of berseem as influenced by weed management practices for problem weeds *Cuscuta* in berseem in *Rabi* 2018-2019.

Treatment	Green forage yield, (t/ha)			Total green forage yield (t/ha)	Seed yield (t/ha)	Net income (₹/ha)	B:C Ratio
	After 1st cut	After 2nd cut	After 3rd cut				
Pendimethalin 1.0 kg/ha (PE)	16.1	21.5	22.5	60.17	0.18	56,870	2.87
Pendimethalin 1.0 kg/ha (EPoE) at (10 DAS)	16.6	21.0	22.6	60.34	0.19	58,290	2.92
Oxyfluorfen 0.25 kg/ha (PE)	18.4	22.6	23.9	65.07	0.21	66,070	3.18
Imazethapyr at 0.04 kg/ha after 1st cut ting	11.8	19.5	21.1	52.50	0.16	46,700	2.56
Imazethapyr at 0.04 kg/ha after last cut	12.8	11.0	11.8	35.77	0.15	28,470	1.95
Imazethapyr at 0.04 kg/ha after 1st cutting *fb* Imazethapyr at 0.04 kg/ha after last cut	12.0	20.1	22.3	54.58	0.17	48,530	2.54
SEm±	1.34	0.98	0.89	1.24	0.003	-	-
LSD (P= 0.05)	4.30	3.15	2.85	3.96	0.01	-	-

At SKUAST, Jammu, herbicidal treatments had significant effect on weed density, weed biomass and green fodder yield of berseem. At first cut, the lowest total weed density was recorded in oxyfluorfen 250 g/ha as pre-emergence and at last cut, the lowest total weed density was observed in imazethapyr at 40 g/ha after 1st cutting *fb* imazethapyr at 40 g/ha after last cut in February. The highest green fodder was recorded in imazethapyr at 40 g/ha after 1st cutting *fb* imazethapyr at 40 g/ha after last cut in February, which was at par with imazethapyr at 40 g/ha after 1st cutting. The pendimethalin 1.0 kg/ha (PE), oxyfluorfen 250 g/ha (PE) and pendimethalin 1.0 kg/ha (EPOE) at 10 days after sowing caused reduction in plant population of berseem over weedy check. It was found that imazethapyr at 40 g/ha after 1st cutting reduced the *Cuscuta* biomass over weedy check and also increased green fodder yield of berseem over weedy check (**Table 3.1.4**).

Table 3.1.4 Effect of different herbicides on weeds and green fodder yield of berseem (*Rabi*-2018-19)

Treatment	Reduction of berseem over weedy check (%)	At first cut		At last cut		Green fodder yield (t/ha)
		Total weed density (No./M^2)	Total weed biomass (g/m^2)	Total weed density (No./M^2)	Total weed biomass (g/m^2)	
Pendimethalin 1.0 kg/ha (PE)	65	3.00 (8.00)	1.94 (2.78)	3.42 (10.67)	1.88 (2.52)	9.38
Pendimethalin 1.0 kg/ha (EPOE) at 10 Days after sowing	26	4.51 (19.3)	2.30 (4.27)	3.27 (9.67)	1.79 (2.20)	17.1
Oxyfluorfen 250 g/ha (PE)	87	2.52 (5.3)	1.47 (1.15)	3.00 (8.00)	2.27 (4.17)	3.80
Imazethapyr at 40 g/ha after 1st cutting	-	6.51 (41.3)	3.13 (8.80)	3.79 (13.3)	2.59 (5.72)	35.3
Imazethapyr at 40 g/ha after last cut in February	-	6.35 (39.3)	3.09 (8.56)	3.37 (10.3)	2.26 (4.11)	23.3
Imazethapyr at 40 g/ha after 1st cutting *fb* Imazethapyr at 40 g/ha after last cut in February	-	6.53 (41.6)	3.01 (8.06)	2.94 (7.67)	2.12 (3.48)	35.9
Weedy check	-	6.38 (39.6)	3.10 (8.62)	5.57 (30.0)	3.81 (13.5)	20.6
SEm ±		0.22	0.09	0.15	0.13	1.04
LSD (P=0.05)		0.66	0.29	0.45	0.41	3.20

At RVSKVV, Gwalior, the major weed flora was comprised by *Cuscuta reflexa, Cyperus rotundus, Phalaris minor, Chenopodium album* and *Spergula arvensis.* All the herbicides significantly controlled the weed population over weedy check. Among pre-emergence herbicides, the application of pendimethalin 1.0 kg/ha effectively controlled the population of target weed *Cuscutta reflexa fb* oxyfluorfen 250 g/ha at 20 DAS which was at par with pendimethalin 1.0 kg/ha applied at 10 DAS (EPoE) (**Table 3.1.5**).

The pendimethalin effectively controlled the weed *Cuscutta reflexa* at 20 DAS. The WCE of pendimethalin was 61% where it was applied as pre-emergence and 55% was recorded where it was applied as early post-emergence (after 10 DOS). Although, the maximum weed control efficiency (69%) was recorded where imazethapyr 40 g/ha was sprayed after 1st cut of berseem and again it was applied after last cut of berseem *fb* the application of oxyfluorfen 250 g/ha (64%) as PE. It was concluded that early post-emergence application of pendimethalin 1.0 kg/ha (after 10 DAS) produced higher fodder yield (682 kg/ha) and seed yield (273 kg/ha) and application of imazethapyr 40 g/ha after 1st cut + again application of herbicide after last cut were also found effective to control the *Cuscutta reflexa* and other weeds and getting higher yield (**Table 3.1.6**).

Table 3.1.5 Population of *Cuscutta reflexa*, other weeds and total weeds as influenced by different weed control treatments in berseem

Treatment	*Cuscutta reflexa*						Total weed					
	Weed density (no./m²)		Weed dry weight (g/m2)		WCE (%)		Weed density (no./m²)		Weed dry weight (g/m2)		WCE (%)	
	45 DAS	110 DAS	45 DAS	110 DAS	45 DAS	110 DAS	45 DAS	110 DAS	45 DAS	110 DAS	45 DAS	60 DAS
Pendimethalin 1.0 kg/ha (PE)	10.9	12.6	1.42	2.43	49.4	39.8	36.9	42.1	6.12	8.10	8.07	6.00
Pendimethalin 1.0 kg/ha (EPOE) at 10 DAS	9.63	11.0	1.62	2.13	42.4	47.3	25.6	31.3	4.36	6.03	34.4	30.0
Oxyfluorfen 250 g/ha (PE)	7.07	8.75	1.00	1.68	64.3	58.4	21.7	27.8	3.53	5.35	46.8	37.9
Imazethapyr 40 g/ha after 1st cut	8.59	4.30	1.02	0.83	63.7	79.5	34.8	11.5	3.39	2.21	49.0	74.3
Imazethapyr 40 g/ha after last cut	17.4	5.20	1.66	1.00	40.7	75.3	39.4	8.71	5.55	1.67	16.6	80.5
Imazethapyr 40 g/ha after 1st cut *fb* imazethapyr 40 g/ha after last cut	8.06	3.73	0.87	0.72	69.0	82.2	35.0	6.53	1.89	1.26	71.5	85.4
Weedy check	18.6	21.0	2.81	4.05	49.4	39.8	41.1	44.8	6.65	8.62	8.07	6.00
SEm (±)	1.10	0.91	0.21	0.17			1.69	1.02	0.32	0.19		
CD (5%)	3.24	2.68	0.61	0.51			3.86	2.99	0.95	0.57		

Table 3.1.6 Green fodder and seed yield and economics of berseem as influenced by different weed control treatments

Treatment	Fodder yield (t/ha) after different cuts				Seed yield (kg/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹ /ha)	Net returns (₹/ha)	B:C ratio
	45 DAS	70 DAS	90 DAS	Total					
Pendimethalin 1.0 kg/ha (PE)	21.8	28.7	23.1	73.7	226	45,350	1,04,613	59,263	2.31
Pendimethalin 1.0 kg/ha (EPOE) at 10 DAS	26.1	32.4	27.5	86.1	273	45,350	1,22,817	77,467	2.71
Oxyfluorfen 250 g/ha (PE)	21.4	28.6	22.9	72.9	217	45,650	1,03,085	57,435	2.26
Imazethapyr 40 g/ha after 1st cut	21.7	27.2	23.7	72.6	233	45,750	1,03,685	57,935	2.27
Imazethapyr 40 g/ha after last cut	22.3	24.6	22.5	69.5	212	45,750	98,568	52,818	2.15
Imazethapyr 40 g/ha after 1st cut *fb* imazethapyr 40 g/ha after last cut	22.9	27.0	24.3	74.3	248	47,350	1,06,610	59,260	2.25
Weedy check	19.5	21.2	19.4	60.1	180	44,150	85,011	40,861	1.93
SEm (±)	0.84	0.95	0.89	1.74	12.6	-	-	-	-
LSD (P=0.05)	2.47	2.78	2.60	5.10	36.9	-	-	-	-

WP 3.1.1 (c) Management of problem weeds *Leptochloa chinensis* and *Alternanthera* spp. in rice

At Raipur, *Leptochloa chinensis* is a serious weed of rice in water logged and moist conditions however, it was almost absent in the experimental field, which was well drained direct-seeded rice. *Alternanthera* spp. particularly *A. triandra* made its serious presence in the field throughout the season. Although, weed free treatment produced the highest grain yield, and highest weed control index; penoxsulam + cyhalofop 0.135 kg/ha PoE produced significantly higher grain yield over rest of the treatments except bispyribac-sodium 0.025 kg/ha PoE, penoxsulam + cyhalofop 0.135 kg/ha PoE and penoxsulam 0.022 kg/ha PoE among the weed management practices. Similarly, highest net return accompanied by maximum B: C ratio generated under the penoxsulam + cyhalofop 0.135 kg/ha PoE (**Table 3.1.7**).

Table 3.1.7 Test weight, seed yield and economics of rice as influenced by weed management practices in direct - seeded rice, *Kharif* 2019.

Treatment	Test weight (g)	Grain Yield (t/ha)	Net income (₹/ha)	B:CRatio	WCI (%)
Pretilachlor 0.750 kg/ha PE	27.0	383	67,815	4.09	43.7
Bispyribac sodium 0.025 kg/ha PoE	27.1	4.63	66,583	4.82	59.1
Fenoxaprop-p-ethyl 0.056 kg/ha PoE	26.9	3.74	51,042	4.03	40.5
Cyhalofop butyl 0.080 kg/ha PoE	26.8	3.64	49,134	3.90	29.1
Penoxsulam + cyhalofop 0.135 kg/ha PoE	29.3	5.04	72,726	4.89	69.0
Penoxsulam 0.022 kg/ha PoE	29.2	4.65	66,048	4.60	63.0
Metsulfuron-methyl 0.004 kg/ha PoE	27.7	3.96	54,874	4.23	47.7
2,4-D ethyl ester 0.750 kg/ha PoE	27.8	4.04	56,226	4.28	54.8
Weed free	29.2	5.08	62,702	3.13	97.3
Weed check	26.5	1.78	16,307	2.02	0.0
SEm±	1.14	0.16	-	-	-
LSD (P= 0.05)	3.40	0.47	-	-	-

Price of rice in Chhattisgarh: ₹ 18,150/ per tonne

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

The trial was conducted in farmers' field in Chithali in Palakkad district in Kerala. Dry sowing was done on 01-06-2019 and the crop was harvested on 10-10-2019. The major weeds in the experimental area were *Sacciolepis interrupta*, *Cyanotis axillaris, Fimbristylis miliacea, Echinochloa crus-galli, Cyperus* spp. and *Ludwigia perennis.* Effect of pretilachlor + bensulfuron-methyl followed by cyhalofop-butyl + penoxsulam followed by hand weeding was significant on *S. interrupta,* with lowest values for density recorded. The next best treatment for controlling *S. interrupta* was pretilachlor+ bensulfuron-methyl followed by hand weeding. All the other treatments were at par and superior to unweeded control. Weed densities of *Cyanotis axillaris* and *Fimbristylis miliacea* were lowest in all herbicidal treatments except cyhalofop-butyl + penoxsulam followed by hand weeding. The density of *Echinochloa crus-galli* was not significantly different between treatments at this stage (**Table 3.1.8**).

Table 3.1.8 Effect of integrated weed management treatments on weed density (number/m^2) at 30 DAS

Treatment	*Sacciolepis interrupta*						Rice yield (t/ha)
	Weed density (no./) m^2		Dry weight (g/m^2)		WCE (%)		
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	
Pyrazosulfuron ethyl *fb* hand weeding	25.1* (634.6)	9.13 (84.0)	233.3	552.9	21.8	47.5	2.46
Cyhalofop-butyl + penoxsulam *fb* hand weeding	24.3 (592.0)	8.53 (74.6)	182.6	508.0	31.1	72.0	2.44
Pyrazosulfuron-ethyl *fb* cyhalofop butyl + penoxsulam fb hand weeding	26.3 (692.0)	9.66 (94.6)	197.3	564.0	28.0	68.9	2.82
Pretilachlor + bensulfuron-methyl *fb* hand weeding	13.9 (194.6)	12.3 (153.3)	76.0	340.0	55.5	48.2	2.24
Pretilachlor + bensulfuron-methyl *fb* cyhalofop butyl + penoxsulam *fb* hand weeding	10.9 (121.3)	5.71 (34.6)	49.3	348.0	64.1	80.8	3.11
Hand weeding	23.8 (573.3)	9.39 (92.0)	228.0	588.0	23.0	67.6	2.94
Unweeded control	33.7 (1141.3)	28.7 (837.3)	381.3	1816.0	-	-	1.58
LSD (P=0.05)	2.85	2.17	59.4	161.5			0.23
SEm	0.92	0.64	157.1	427.3			0.07

*$\sqrt{x+1}$ transformed data; **Original values are given in parentheses.

High infestation of *S. interrupta* had adverse effect on the rice yield and returns. Highest returns was obtained with pretilachlor + bensulfuron-methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding, which was the only treatment which had a B: C ratio of more than 1.17. Though hand weeding had resulted in comparable returns of ₹,1,05,694/ha, the B: C ratio was only 0.88 due to high labour cost involved. All the other treatment gave B: C ratio of less than 1 and hence were uneconomic (**Table 3.1.9**).

Table 3.1.9 Effect of treatments on economics of cultivation

Treatment	Cost of cultivation (₹ / ha)	Cost of weed control (₹ /ha)	Total cost (₹/ ha)	Returns (₹ /ha)		Total returns (₹ /ha)	B:C ratio
				Grain	Straw		
Pyrazosulfuron-ethyl *fb* hand weeding	72,000	27,215	99,215	57,802	37,044	94,846	0.95
Cyhalofop-butyl + penoxsulam *fb* hand weeding	72,000	27,250	99,250	57,394	36,278	93,672	0.94
Pyrazosulfuron-ethyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	72,000	30,375	1,02,375	66,223	34,305	1,00,528	0.98
Pretilachlor + bensulfuron-methyl *fb* hand weeding	72,000	27,825	99,825	52,647	36,912	89,560	0.90
Pretilachlor + bensulfuron-methyl *fb* cyhalofop-butyl + penoxsulam *fb* hand weeding	72,000	31,075	1,03,075	73,045	47,487	1,20,532	1.17
Hand weeding	72,000	48,000	1,20,000	68,972	36,721	1,05,694	0.88
Unweeded control	72,000	0	72,000	37051	28,270	65,321	0.91

WP 3.1.2 (a) *Orobanche*

WP3.1.2 (a) *Orobanche* management in tomato

Experiments for management of Egyptian broomrape (*Orobanche aegyptiaca* Pers.) were done at Bhubaneswar, Hisar, Udaipur, Hyderabad and Anand centers.

In Haryana, survey revealed severe infestation of *Orobanche aegyptiaca* in Nuh, Ferozepur Jhirka, Nagina; Taoru areas of Mewat, Charkhi Dadri of district Bhiwani regions. Farmers reported 40-7% loss in fruit yield due to its infestation in tomato crop depending on intensity of infestation. Excellent control of broomrape was obtained with PoE treatments of sulfosulfuron and ethoxysulfuron when compared with untreated control (weedy check) at 120 DAP and at harvest. At both the stages, significant reduction in the number of spikes of broom rape per m^2 was obtained with the ethoxysulfuron 20 g/ha PPI *fb* ethoxysulfuron 25 g/ha at 30 DAS *fb* sulfosulfuron 50 g/ha at 60 DAS and sulfosulfuron 25 g/ha PPI *fb* sulfosulfuron 25 g/ha at 30 DAS *fb* sulfosulfuron 50 g/ha at 60 DAS with very few number of spike, whereas, in weedy check it was 64.5 spikes per m^2 at harvesting stge. There was no toxicity of the ethoxysulfuron on the crop and a little toxicity of sulfosulfuron during the initial stage was found (10 DAP) but it was mitigated after 20 DAP and did not translate in to any yield reduction.

At Udaipur**,** eight demonstrations on *Orobanchae* weed management in tomato through herbicide were conducted at Shayampura and Maudi village Tehsil-Sarada. Irrespective of the dose, timings and number of sprays, significant reduction in *Orobanche* weed infestation and subsequent improvement in fruit yield was noticed with sulfosulfuron and ethoxysulfosulfuron application in tomato. Single application of ethoxysulfuron herbicide 20 g/ha at 45 DAT though provided effective weed control up to 70-75 DAS, but the late emergence of new shoots in the later half of crop growth ultimately caused reduction in fruit yield due to increased weed seed bank in the soil. Supplementation of second spray of ethoxysulfuron 15 g/ha at 90 DAT not only prolonged the effective period of weed control, but also increased 10.5% tomato fruit yield in comparison to farmers practice (**Table 3.1.9**).

Table 3.1.9 Performance of herbicides in terms of *Orobanche* control and yield of tomato in comparison to farmer's practice

Treatment	*Orobanche* control (%)	Grain yield (t/ha)	% increase in yield over FP
Sulfosulfuron 20 g/ha at 45 DAT *fb* 15 g/ha at 90 DAT	49 (37-58)	33.7	2.37
Ethoxysulfosulfuron 20 g/ha at 45 DAT *fb* 15 g/ha at 90 DAT	57 (45-65)	34.5	10.5
Farmer practice	-	31.2	-

*Sale price (₹/kg): Tomato- 10/kg

At Anand, application of glyphosate 25 g/ha at 25 DATP *fb* 50 g/ha at 60 DATP showed 38% phytotoxicity on tomato crop with yellowing of tips and stunted growth and necrosis of tomato leaves which was closely followed by sulfosulfuron 50 g/ha at 60 DATP *fb* 50 g/ha at 90 DATP. In general, all the applied herbicides found phytotoxic on tomato except which sulfosulfuron 25 g/ha at 45 DAT *fb* 50 g/ha at 90 DATP which comparative less phytotoxic effect on tomato as compared to their higher dose applied at 60 DATP. Significantly higher tomato fruit yield was recorded under sulfosulfuron 25 g/ha at 45 DATP *fb* 50 g/ha at 90 DATP as compared to sulfosulfuron 50 g/ha at 60 DATP *fb* 50 g/ha at 90 DATP and rest of the treatments.

However, due to phytotoxic effect of glyphosate 25 g/ha at 25 DATP *fb* 50 g/ha at 60 DATP on tomato resulted in the lowest production of tomato fruit yield, which was 49.5 % less, than untreated check. Maximum gross return, net return and benefit cost ratio was observed under sulfosulfuron 25 g/ha at 45 DATP *fb* 50 g/ha at 90 DATP, which was closely followed by ethoxysulfuron 25 and 50 g/ha at 60 and 90 DATP (**Table 3.1.10)**. Residue analysis of the tomato fruit of 4th picking (115 DATP) revealed no residues in tomato fruit (BDL)**.**

Table 3.1.10 Tomato fruit yield and economics as influenced by different treatments

Treatment	Yield (t/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
Ethoxysulfuron 25 and 50 g/ha at 45 and 90 DATP	77.0	1,71,054	3,85,000	2,13,946	2.25
Ethoxysulfuron 25 and 50 g/ha at 60 and 90 DATP	77.5	1,71,054	3,87,500	2,16,446	2.27
Sulfosulfuron 25 g/ha at 45 DATP *fb* 50 g/ha at 90 DATP	77.7	1,69,960	3,88,500	2,18,540	2.29
Sulfosulfuron 50 g/ha at 60 DATP *fb* 50 g/ha at 90 DATP	60.6	1,70,762	3,03,000	1,32,238	1.77
Glyphosate 25 g/ha at 25 DATP *fb* 25 g/ha at 60 DATP	48.2	1,67,604	2,41,000	73,396	1.44
Glyphosate 25 g/ha at 25 DATP *fb* 50 g/ha at 60 DATP	37.9	1,67,629	1,89,500	21,871	1.13
Untreated check	75.0	1,65,954	3,75,000	2,09,046	2.26
SEm. ±	2.43	-	-	-	-
LSD (P=0.05)	7.36	-	-	-	-
Selling price of tomato fruit = ₹ 5/kg					

WP. 3.2.1(b) Management of *Orobanche* in brinjal

At Bhubaneswar, a field trial as OFT on management of *Orobanche* in brinjal crop was initiated in vegetable tract of Cuttack district (Talabasta village) during September, 2018 in farmers field. Application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT recoded the highest *Orobanche* control efficiency (67.1%) while practice of two hand weeding was observed to be the best (64.3%) at harvest. Among weed management practices, hand weeding twice recoded the highest yield (34.7 t/ha) which was at par with the yield from the plots applied with 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 done at Hisar on brinjal revealed lowest (1.0/m^2) number of total broom rape spike per unit area in the treatments of ethoxysulfuron 15 g/ha (Pre-) and at 45 DAT, ethoxysulfuron 20 g/ha (Pre-) and at 45 DAT and sulfosulfuron 25 g/ha at sowing and 45 DAT, whereas in weedy check, it was 29.0 per unit area. Significantly higher visual control (90.3%) was obtained with the application of sulfosulfuron at the rate of 25 g/ha at sowing and 45 DAT over other treatments but visual control of ethoxysulfuron at both the application rate was at par with each other. Maximum herbicide efficiency index (2.11) was obtained with ethoxysulfuron 15 g/ha (PRE) and at 45 DAT. Maximum fruit yield (19.7 t/ha) was recorded with sulfosulfuron 25 g/ha at 25 and 45 DAT which was

(33.1%) higher over the untreated check and significantly at par with all other chemical treatment.

AT Udaipur, eight demonstrations on *Orobanchae* weed management in brinjal were conducted. Application of ethoxysulfuron twice; 20 g/ha at 45 DAT *fb* by 15 g/ha at 90 DAT was found helpful in reducing the *Orobanche* infestation and increasing brinjal yield by 11.1 % over farmers practice (**Table 3.1.11**).

Table 3.1.11 Performance of herbicides in terms of *orobanche* control and yield of brinjal in comparison to farmer's practice

Treatment	*Orobanche* control (%)	Grain yield (t/ha)	% increase in yield over FP
Sulfosulfuron 20 g/ha at 45 DAT *fb* 15 g/ha at 90 DAT	52 (40-64)	36.30	7.39
Ethoxysulfosulfuron 20 g/ha at 45 DAT *fb* 15 g/ha at 90 DAT	58 (47-69)	37.55	11.1
Farmer practice	-	33.80	-

Sale price (₹/kg): Tomato- 12/kg

At Hyderabad, results of on farm experiment conducted during *Rabi* 2018-19 at Chenvelly village of Telangana state revealed that application of neem cake 200 kg/ha followed by glyphosate 20 g/ ha at 25 and 55 days after transplanting was effective to certain extent in controlling *Orobanche* 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. Application of neem cake 200 kg/ha at sowing followed by 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 **(Table 3.1.12)**

Table 3.1.12 Effect of different treatments for *Orobanche* control in brinjal

Treatment	Plant height (cm)	Prim branches (no.)	Plant spread (cm)	Fruit wt. (g)	Fruits /plant (no.)	Fruit yield (t/ha)
Neem cake 200 kg/ha at basal *fb* pendimethalin 1.0 kg/ha as PE, 3 DAP *fb* metalaxyl MZ 0.2 % (soil drench) at 20 DAP	62.4	5.4	0.20	33.9	19.3	20.4
Neem cake 200 kg/ha at basal *fb* alachlor 0.5 kg/ha PE, 3 DAP *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAT	64.4	5.4	0.22	34.2	20.7	19.2
Neem cake 200 kg/ha at sowing *fb* glyphosate at 30 and 30 g/ha at 25-30 DAP and 55 DAP (recommended practice)	71.2	6.1	0.31	43.4	25.1	27.3
Neem cake 200 kg/ha at sowing *fb* glyphosate at 430 and 40 g/ha at 25-30 DAP and 55 DAT (recommended practice)	67.1	5.8	0.27	40.5	21.3	24.2
Neem cake 200 kg/ha at sowing *fb* glyphosate at 50 and 50 g/ha at 25-30 DAP & 55 DAP (Recommended practice)	53.8	4.4	0.19	24.7	18.5	7.2
Application of UV resistant polythene mulch of 25 mm thickness before planting	74.7	6.4	0.36	45.6	27.4	34.2
Control	52.0	4.4	0.19	27.3	15.6	9.8
LSD (P=0.05)	3.1	0.2	0.02	9.1	1.3	3.3
CV%	2.7	2.5	6.60	3.4	3.5	9.2

At Anand, among all the applied herbicides, glyphosate 25 g/ha at 25 DATP *fb* 25 g/ha at 60 DATP showed less phytotoxicity (10%) as compared to glyphosate 25 g/ha at 25 DATP *fb* 50 g/ha at 60 DATP (27%) and ethoxysulfuron 15 g/ha at 90 DATP (22%). In general, all the applied herbicides found somewhat phytotoxic on growth of the brinjal crop. In general, *Orobanche* shoots emergence status was observed at 90 DATP and maximum values was noticed at 120 DATP then after *Orobanche* shoots emergence was reduced drastically at 150. Significantly, highest brinjal fruit yield of 33.2 t/ha was achieved under glyphosate 25 g/ha at 25 DATP *fb* 25 g/ha at 60 DATP. Further, it was observed that sulfosulfuron 15 g/ha at 45 and 90 DATP, untreated check and ethoxysulfuron 15 g/ha at 90 DATP recorded brinjal fruit yield of 22.3, 21.8 and 21.6 t/ha, respectively and remained at par with each other, but found significantly superior over glyphosate 25 g/ha at 25 DATP *fb* 50 g/ha at 60 DATP; sulfosulfuron 20 g/ha at 45 and 90 DATP and ethoxysulfuron 20 g/ha at 45 and 90 DATP. Among all the herbicidal treatments, ethoxysulfuron 20 g/ha at 45 and 90 DATP recorded significantly the lowest brinjal fruit yield of 8.7 t/ha which was 60% less then untreated check due to highly phytotoxic effect on crop. With respect to economics of different treatments, overall maximum fruit yield of brinjal (33.2 t/ha), gross return (₹ 2,49,000/ha), net return (₹ 1,43,889/ha) and benefit cost ratio of 2.37 was achieved under application of glyphosate 25 g/ha at 25 DATP *fb* 25 g/ha at 60.

WP 3.3 Management of *Parthenium hysterophorus*

In view of the seriousness and magnitude of the threat posed by this weed, all the centers of AICRP-WM observed country-wide "*Parthenium* Awareness Week (PAW)" from 16-22 August, 2019 by involving KVKs, SAUs, State Agricultural Departments, NGOs, municipalities, railway departments, schools and colleges, *etc.* During this week, activities like lectures, photo exhibitions, farmers' meetings, students' rallies, uprooting of *Parthenium*, releasing and distribution of *Parthenium* eating beetle, demonstrations on management *etc.* were done by different institutions in different districts and villages covering almost all the states of India.


'ಮೂಲದಲ್ಲಿಯೇ ಪಾರ್ಥೇನಿಯಂ ನಿಯಂತ್ರಿಸಿ' 'ಸರ್ಕಾರಿ ಶಾಲೆ

Activities done during Parthenium Awarness Week (2019) by different centers

WP 3.4.1 Biological control of water hyacinth by *Neochetina* spp.

Water hyacinth has emerged as one of the most problematic weeds in aquatic situation in India. Releases of bioagent *Neochetina* sp. have been made by different centers for its biological control.

At Anand, experiment was conducted by selecting new pond infested with water hyacinth at village Sadanapur, Taluka Anand. The adult weevils were released on 05-12-2019. At Udaipur, weevils were released in the heavily infested area of Sukhanaka near Bhoiyon ki Pancholi1, Udaipur. There were not significant build up in the population of the weevil on water hyacinth but only scars were developed on 10-25% portion of the leaf sheath.

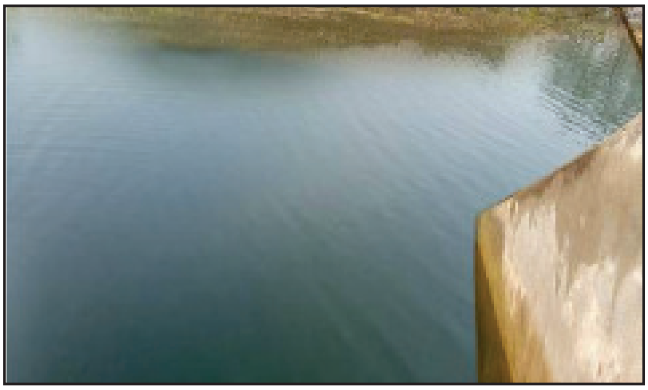
At Ludhiana, weevils were released in pond of village Boparai Kalan in district Ludhiana. The feeding scars on leave were found increased progressively form 1 Nov. (20.2 rear/leaf) till 15 December (35 rear /leaf). The insect population was good on water hyacinth plants in the pond and did fair damage of leaf tissues even though the growth rate of water hyacinth plant was very high. At Jammu centre, *Neochetina* beetles were released on 07.09.2016 in perennial pond at Tanda village. After three year of release of beetles on an average, 20 feeding scars/leaf were observed in water hyacinth infested pond and only 8-12% (1 scale) die back symptoms were observed. The clear water appearance was not observed even after three years and after one year, again beetles were release in same infested pond at Tanda village. At Coimbatore, *Neochetina* beetles were released on 10.09.2015 at Krishnampathy tank near wetland farm of TNAU. The symptoms on water hyacinth plants were moderate (rating - 3) and feeding is was average.

At Bengaluru centre, antagonistic interactions between *Eichhornia crassipes* and *Alternanthera philoxeroides* was studied. The experiment was imposed successively at two different seasons 2018-19 and 2019-20 with slight modification in the treatment. It was observed that growing of *Alternenthera philoxeroides* along with *Eichhornia* or application of *Alternenthera* leachates of 20 and 40 days old had significant effect over *Eichhornia* growth. There was reduction in plant height (cm) number of leaves, number of branches and fresh weight (g/plant). It was opined from the might have study that *Alternenthera philoxeroides* (alligator weed) would seem to leached out an inhibitory chemical, which resulted in turning roots to black, unhealthy look and chlorosis of leaf, which suggested the possibility of its effect on growth of *Eichhornia.*

At Kalyani, trial on biological control of water hyacinth was conducted in a farmers' pond at the Village-Panchkahania, GP-Fatehpur, Block-Haringhata, District - Nadia. However, the pond became fully dry during the summer months of 2019. At Bhubaneswar, weevils have been released in two perennial ponds situated *i.e.* one near to the airport of

Bhubaneswar and other at the central farm, OUAT in October 2019. The observations will be taken up at next season after its population build up.

At Gwalior, two ponds (3-4 acre size) were selected and weevils were released for biological control of water hyacinth in district Morena. First time, about 1000 weevils of *Neochetina* spp. were released on 6th September, 2016 and again about 1000 weevils were augmented in the pond on 14th September, 2017. The water hyacinth density of the selected ponds where weevil released was 15 /m^2. The effect of weevils was first seen in January, 2018 after about 17 months. By the end of June 2018, 50 % of the water hyacinth becomes dry corresponding to the increase of weevil population. Weevils were collected from the pond to multiply in earthen pots filled up with water and water hyacinth for further release in other ponds. By December 2018, about 75 % water become visible and water hyacinth remained in 25 u/m area only. Complete control of water hyacinth was observed by the month of April 2019.



WP4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment

WP4.1 Study herbicide residues in the long-term conservation agriculture experiment

At PAU, Ludhiana, metribuzin and clodinafop-propargyl from soil/wheat grain samples were extracted by MSPD and the residues were quantified using HPLC with LOD and LOQ 0.02 and 0.05 µg/g, respectively. Initial residues of metribuzin in soil ranged from 0.101 to 0.191 µg/g in different treatments (Table 4.1) and found below the detectable limit (<0.01 µg/g) in soil and grain at the harvest of crop. The clodinafop-propargyl residues in the soil and wheat grain at harvest under recommended herbicide and IWM treatments were below detectable limit (<0.05 µg/g). Initial residues of penoxsulam in the soil ranged from 0.107 to 0.228 µg/g in different treatments (**Table 4.1.1**). Penoxsulam and cyhalofop-butyl residues were below the detectable limit (<0.01 µg/g) in soil and rice grain at the harvest of crop.

Table 4.1.1 Residues (µg/g) of metribuzin in different treatments

Treatments	Recommended herbicide treatment			Integrated weed management treatment		
	0 DAT	Soil harvest	Wheat harvest	0 DAT	Soil harvest	Wheat harvest
CT-PTR-CT	0.149	<0.01	<0.01	0.101	<0.01	<0.01
PTR-CT MB	0.170	<0.01	<0.01	0.156	<0.01	<0.01
PTR-ZT HS	0.186	<0.01	<0.01	0.173	<0.01	<0.01
ZT MTR-ZT HS	0.191	<0.01	<0.01	0.189	<0.01	<0.01

At CSKHPKV, Palampur residue studies on isoproturon in wheat (*Rabi* 2018-19); and atrazine in maize and pendimethalin in soybean (*Kharif* 2019) under different tillage and residue management techniques were undertaken (**Table 4.1.2**). Soil samples (0-15 cm) were collected immediately after herbicide application and at crop harvest for residue analysis. Initial residues of isoproturon (35 DAS) applied at 1.25 and 1.0 kg/ha in the treatments CT-CT, CT-ZT, ZT-ZT, ZT- ZT + R and ZT+ R -ZT+ R were found to be 0.460, 0.483, 0.558, 0.527 and 0.532 µg/g; and 0.447, 0.468, 0.486, 0.454 and 0.448 µg/g, respectively. In the soil and wheat grain under different tillage and residue management techniques, isoproturon residues were below detectable limits at the time of harvest.

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

Treatment		Residues (µg/g)			
		W_1 (Isoproturon 1.25 kg/ha)		W_2 (Isoproturon 1.0 kg/ha)	
Maize	Wheat	Initial oil	Harvest oil	Initial oil	Harvest oil
CT	CT	0.460	<0.05	0.447	<0.05
CT	ZT	0.483	<0.05	0.468	<0.05
ZT	ZT	0.558	<0.05	0.486	<0.05
ZT	ZT+R	0.527	<0.05	0.454	<0.05
ZT+R	ZT+R	0.532	<0.05	0.448	<0.05

The initial deposits of atrazine in soil immediately after application of atrazine in case of atrazine applied plots were found to be 0.625, 0.635, 0.597, 0.553 and 0.528 µg/g under conventional tillage practice and zero tillage practice**.** The residue in the soil and maize grain under different tillage with residue management techniques were found below the detectable limits (0.005 ppm) at the time of harvest. Pendimethalin residues in the soil and soybean under different tillage and residue management techniques were below detectable limits at the time of harvest**.**

At PJTSAU, Hyderabad pendimethalin, pretilachlor and bispyribac-sodium and atrazine were studied in conservation agriculture in rice (*Kharif, 2019*) – maize (*Rabi 2018*) – green manure (summer) cropping system. Along with the herbicide persistence, impact of different methods of rice establishment/ tillage and weed management was studied. Determination of pretilachlor, pendimethalin, atrazine residues was done by GLC and bispyribac sodium by HPLC. 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. There were no significant changes in pH 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. Initial residues of pretilachlor were 0.269 and 0.282 mg/kg in T_1W_1 and T_2W_1 treatments, respectively. In the soils of transplanted rice initial detected amount (IDA) of bispyribac sodium varied from 0.021 to 0.026 mg/kg. In aerobic rice soils, the IDA varied from 0.018 to 0.021 mg/kg. Pendimethalin in aerobic rice soils varied from 0.399, 0.206 and 0.177 mg/kg on 0 DAA in T_3, T_4 and T_5, respectively. Presence of the green manure residues and weed biomass might have resulted in lower initial concentration of pendimethalin in the soil. In all the treatments residues of pendimethalin, bispyribac-sodium and pretilachlor were below detection limit of 0.05 and 0.010 mg/kg in rice grain, plant and soil at the time of harvest. Initial concentration of atrazine in the soil applied to maize as pre-emergence herbicide varied from 0.365 to 0.488 mg/kg. 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.

Different methods of establishment of rice (transplanted and DSR) and residue retention had shown significant influence on the urease and dehydrogenase enzyme activity (DHA) of the soil. However, the weed management treatments impact on urease and DHA was not-significant. Highest urease activity of 44.99 µg NH_4^+/g/day was recorded in DSR-residue retention (*Kharif* and *Rabi*) treatment which was on par with DSR (*Kharif* residue retention) treatment. In case of *Rabi* maize, the zero tillage maize treatments showed higher urease activity compared to the conventional tillage treatments. In general, higher urease and dehydrogenase enzyme activities were noticed at the time of flowering compared to harvest time urease activity. Highest urease activity (29.7µg NH_4^+/ g/ day) was recorded in T_5 main treatment (ZT +R - ZT+R – ZT) which was significant superior over conventional tillage treatments

At Coimbatore, residues of pendimethalin during *Rabi* 2018-19 (sunflower) and atrazine during *Kharif* 2019 (maize) were analyzed at different periods viz., 0, 15, 30, 45, 60, 75 DAHA for atrazine and up to 45 days for pendimethalin and at harvest**.** LOD of pendimethalin and atrazine were found to be 0.01 mg/kg. The dissipation of both the molecules was found to follow first order reaction kinetics (R^2>0.94) irrespective of tillage practices under both the weed control methods with the half life of 9.69 - 12.4 days and 13.7 – 16.2 days for pendimethalin and atrazine, respectively. 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 (**Table 4.1.3**).

Table 4.1.3 Influence of conservation tillage and weed management practices on pendimethalin (mg/kg) residues in soil sunflower (*Rabi* 18-19) in maize –sunflower system

Treatments	W_1 (Pendimethalin 1.0 kg/ha)					W_1 (Atrazine 0.5 kg/ha)						
	Days					Days						
	0	15	30	45	Harvest	0	15	30	45	60	75	Harvest
CT-CT	0.561	0.152	0.098	0.024	BDL	0.280	0.156	0.09	0.022	0.018	0.010	BDL
CT-ZT	0.516	0.192	0.106	0.033	BDL	0.294	0.163	0.095	0.024	0.020	0.014	BDL
ZT+R-ZT	0.521	0.215	0.093	0.021	BDL	0.245	0.134	0.072	0.022	0.017	0.012	BDL
ZT-ZT+R	0.533	0.219	0.12	0.035	BDL	0.259	0.112	0.061	0.019	0.014	0.012	BDL
ZT+R-ZT+R	0.512	0.231	0.123	0.039	BDL	0.266	0.108	0.053	0.020	0.012	0.011	BDL

At Jorhat, pretilachlor and residue ranged 0.388–0.396 mg/Kg on the day of application and observed up to the range of 0.004–0.006 mg/Kg on the 30th day of application of pretilachlor in case of conventional tillage with transplanted rice. Pretilachlor residues were BDL from 60th of application in minimum tillage with direct seeded rice. However, lower level of pretilachlor residues were resulted from the combination treatments of minimum tillage with direct seeding rice and residue incorporation. Pendimethalin residues in the soil samples ranged 0.932 – 0.990 mg/Kg on the day of application of pendimethalin and observed up to the ranged 0.006 – 0.076 mg/Kg on the 30th day of application of pendimethalin. Pendimethalin residues were found BDL in case of minimum tillage from 45th day of application of pendimethalin and in case of conventional tillage at harvest. However, lower pendimethalin residues were resulted from the combination treatments of minimum tillage with residue incorporation.

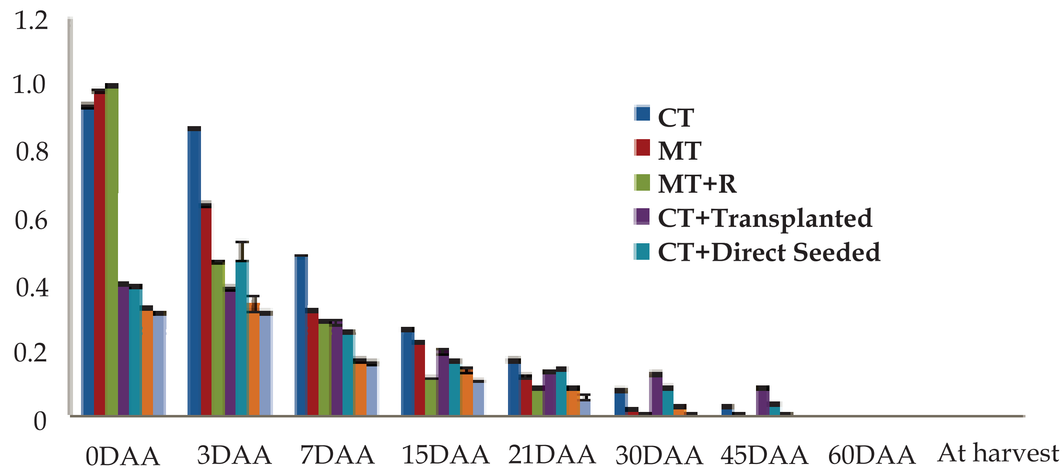


Figure 4.1.1 Persistence of pendimethalin in the (soil) in mustard crop in rice – mustard sequence

At Bhubaneswar, effect of herbicide on soil properties were evaluated. Initially the carbon content of the soil was low but continuous application of crop residue gradually increases the organic carbon content of the treated plots. The soil belongs to order *Alfisols.* 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 and higher phosphate activities with herbicide application in rice strongly support this result. 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 degrades in to the soil itself within one or one and half month which justified the role of organic amendments in stabilizing soil properties.

WP 4.2 Herbicide residues in high-value crops

At Ludhiana metsulfuron-methyl at harvest were found below detectable limit (<0.01µg/g). At Palampur, herbicide residues were evaluated in soil and crop in fruit-based system influenced by integrated weed management. Initial pendimethalin residues in soil were 0.58 µg/g. Atrazine and pendimethalin residues in the soil and crop produce were below detectable levels (>0.01 µg/g) at harvest. At Hyderabad, an experiment was conducted to assess the impact of organic weed management practices on soil properties and herbicide residues in okra (okra) and carrot cropping system in Alfisols of Southern Telangana Zone of Telangana state. No significant effect of organic weed management practices was noticed on any of the soil physico-chemical and fertility properties of the soils at the time of harvest of the first crop (okra). Residues of pendimethalin in okra fruit samples collected from pendimethalin sprayed plots were below the detection limit of 0.05 mg/kg. In carrot and okra crop fields at flowering stage and at harvest, highest urease, phosphatase and dehydrogenase activities (UA) were recorded in straw mulch treatment which was significantly superior over all other treatments followed by the intercropping with green-leafy vegetable treatment. Lowest urease activity at flowering was recorded in hand weeding treatment. No adverse effect of pendimethalin was detected on urease and phosphatase activities at both flowering and harvest stages. At Coimbatore, field experiment was conducted at Sennanur village to estimate the harvest time residues of oxyfluorfen in/on onion and soil. After the application of oxyfluorfen, the residues of 0.093 and 0.187 mg/kg were found with the applied concentration of 200 and 400 g/ha application, respectively. At harvest the residues of oxyfluorfen were not detected in soil as well as in onion plant top whereas in the onion bulb the residue of 0.019 mg/ kg was found, however, it was below the MRL (0.05 mg/kg) which was fixed by FSSAI -2018.

WP 4.3 Degradation and mitigation of selected persisting herbicides

At Ludhiana the dissipation behavior of imazethapyr was evaluated in loamy sand, sandy loam, loam and loam soil under laboratory conditions. The loamy sand soil was also amended with FYM at 0.5 and 1% level. Commercially available formulation of imazethapyr was applied at 300 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, 90 days after treatment (DAT). The initial residues of imazethapyr varied from 0.751, 0.784, 0.796, 0.705 µg/g and 1.488, 1.574, 1.598, 1.420 µg/g in studied soils at 300 and 600 ml/acre, respectively. The residues of imazethypar in soils decreased with time and 0.032 to 0.071, 0.041 to 0.092, 0.05 to 0.111 and 0.049 to 0.108 µg/g residues of imazethypar were detected in loamy sand, sandy loam, loam and loam soil, respectively. In FYM amended LS1 and LS 2 soils the initial residues of imazethapyr ranged from 0.635 to 0.649 µg/g and the residues decreased successively with time. In soils amended with 0.5 and 1.0% of FYM comparatively faster dissipation was observed and half-life of imazethapyr ranged from 6.36 to 5.74 days in initial phase and 88.3 to 80.4 days in final phase in both the treatments. The dissipation of imazethapyr in the soil followed a biphasic first order kinetics. The half-life of imazethapyr for the first phase was faster and found to be 6.57 to 7.65 and 6.68 to 7.79 days, respectively (**Table 4.3.1)** and it was relatively slower in second phase in the range of 93.7 to 128.5 and 108.6 to152.8 days in studied soils at 300 and 600 ml/acre, respectively. In LS1 and LS2 soil, half life ranged from 6.36 to 5.74 days for the initial phase and 88.3 to 80.4 days for the final phase comparable faster dissipation of imazethapyr in FYM amended soils.

The effect of temperature on degradation of imazethapyr was studied at 35 and 45°C in loamy sand, sandy loam and loam soils. Irrespective of temperature, dissipation followed biphasic first order kinetics (BFOK). Half life of imazethapyr in the studied soils varied non-significantly from 6.25 to 7.40 days in initial fast phase whereas it varied significantly from 87.2 to134.4 days in final slower phase at 35 and 45°C. Dissipation of imazethapyr was positively correlated with soil pH and temperature and negatively correlated with soil organic matter. Initially at 15 DAT, the bacterial count declined significantly at both application rates in comparison to control and after 15 DAT, bacterial count increased. This effect was more pronounced at higher application rate of imazethapyr. Additionally, the microbial count was highest in loam soil followed by sandy loam and loamy sand soils, respectively. Furthermore, temperature had a great influence on microbial population. With rise in incubation temperature from 25 to 35°C and 35 to 45°C microbial population increased by 2-5 folds due to comparatively faster dissipation of imazethapyr at 35 and 45°C.

At Palampur, degradation of tembotrione consisting of three treatments 60, 120, and 240 g/ha was evaluated during *Kharif* 2019. In all three treatments, more than 50% of applied herbicide in soil dissipated within 7 days after herbicide application. At 30 days after herbicide application, percent dissipation of tembotrione was maximum in tembotrione 60 g/ha (89.9%) followed by tembotrione 240 g/ha (81.9%) and least in tembotrione 120 g/ha (80.2%). Tembotrione in soil persisted up to day 30 at 60 g/ha and up to 45 days at 120 and 240 g/ha.

Table 4.3.1 Kinetic parameters for dissipation of imazethapyr in studied soils

Temperature (°C)	Soils	Application rate (mL/acre)	SFOK			BFOK					
						Initial fast phase			Final slow phase		
			K	R^2	DT^a_{50}	K	R^2	DT^a_{50}	K	R^2	DT^a_{50}
25	Loamy sand	300	0.033	0.72	20.5	0.105	0.97	6.57	0.007	0.96	93.7
		600	0.032	0.70	21.4	0.103	0.92	6.68	0.006	0.88	108.6
	Sandy loam	300	0.031	0.70	22.0	0.105	0.96	6.59	0.006	0.98	102.2
		600	0.031	0.69	23.0	0.103	0.96	6.72	0.005	0.96	118.6
	Loam	300	0.030	0.70	23.3	0.095	0.97	7.29	0.006	0.93	116.2
		600	0.028	0.70	24.2	0.093	0.96	7.47	0.005	0.97	138.6
	Loam1	300	0.028	0.71	24.2	0.090	0.93	7.65	0.005	0.88	128.4
		600	0.027	0.07	25.5	0.089	0.94	7.79	0.005	0.96	152.8
	LS 1	300	0.031	0.69	22.0	0.109	0.91	6.36	0.008	0.95	88.3
	LS 2	300	0.031	0.65	22.0	0.121	0.92	5.74	0.009	0.98	80.4
35	Loamy sand	300	0.035	0.73	19.6	0.108	0.96	6.40	0.008	0.98	90.6
		600	0.033	0.71	20.8	0.105	0.92	6.62	0.007	0.88	104.2
	Sandy loam	300	0.033	0.71	21.1	0.108	0.96	6.44	0.007	0.90	98.4
		600	0.031	0.69	22.6	0.104	0.96	6.67	0.006	0.90	114.8
	Loam	300	0.031	0.72	22.5	0.097	0.97	7.14	0.006	0.98	113.0
		600	0.029	0.70	23.8	0.094	0.968	7.40	0.005	0.93	134.4
45	Loamy sand	300	0.037	0.73	18.8	0.111	0.97	6.25	0.008	0.97	87.2
		600	0.034	0.71	20.2	0.106	0.92	6.54	0.007	0.83	100.2
	Sandy loam	300	0.034	0.71	20.3	0.110	0.97	6.30	0.007	0.85	96.9
		600	0.03	0.70	22.1	0.105	0.92	6.60	0.006	0.95	110.9
	Loam	300	0.032	0.72	21.71	0.099	0.97	6.99	0.006	0.91	109.4
		600	0.030	0.71	23.41	0.095	0.96	7.31	0.005	0.99	129.3

$^aDT_{50}$ represents half-life of herbicide (days)

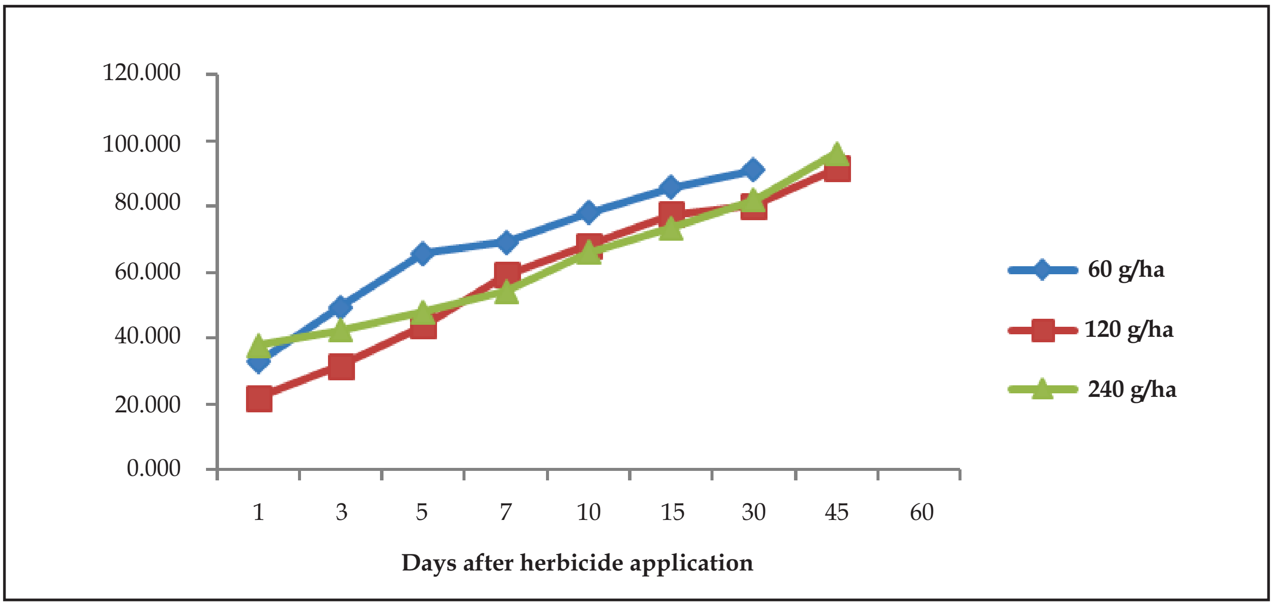


Fig 4.3.1 Percent dissipation of tembotrione applied at 60, 120 and 240g/ha

At Hyderabad, sorption/desorption of topramezone in the red and black soils was conducted. The extent of adsorption of topramezone on the soil samples at initial concentration of 5.0 µg/mL was 3.20 to 2.44 µg/g in red and black soils, respectively. While at highest concentration (50.0 µg/mL), the adsorbed topramezone was 29.5 to 25.4 µg/g in red and black soils, respectively. Topramezone adsorption was higher in red soil with lower pH and higher organic matter content compared to the black soil which had alkaline reaction and lower organic carbon. The adsorption was slower at the lower initial concentrations (<15 µg/mL) and increased rapidly at the intermediate concentrations and tended to slow down at higher concentrations of >40 µg/mL.

Table: 4.3.2 Adsorption of topramezone in the red and black soil samples (2 mm seived)

Red soil					Black soil				
Initial conc. (µg/mL)	Ce Eq. conc (µg/mL)	x/m Amount adsorbed (µg/g)	Log Ce	log x/m	Initial conc.	Ce Eq. conc (µg/mL)	x/m Amount adsorbed (µg/g)	Log Ce	log x/m
5	4.20	3.20	0.62	0.50	5	4.39	2.44	0.64	0.38
10	8.61	5.55	0.93	0.74	10	8.86	4.56	0.94	0.65
15	13.0	7.98	1.11	0.90	15	13.2	7.03	1.12	0.84
20	17.0	11.9	1.23	1.07	20	17.4	10.0	1.24	1.00
25	20.7	17.1	1.31	1.23	25	21.4	14.2	1.33	1.15
30	24.5	21.8	1.39	1.34	30	25.4	18.0	1.40	1.25
35	28.5	25.8	1.45	1.41	35	29.7	21.1	1.47	1.32
40	33.1	27.4	1.52	1.43	40	34.2	22.9	1.53	1.36
45	37.7	29.1	1.57	1.46	45	38.8	24.5	1.59	1.39
50	42.6	29.5	1.63	1.47	50	43.6	25.4	1.64	1.40

The adsorption isotherms were mainly parabolic in nature with 'S' shaped character in both soil samples. The adsorption data fitted well with Freundlich equation. Isotherms for the soils samples are presented in the below figures.

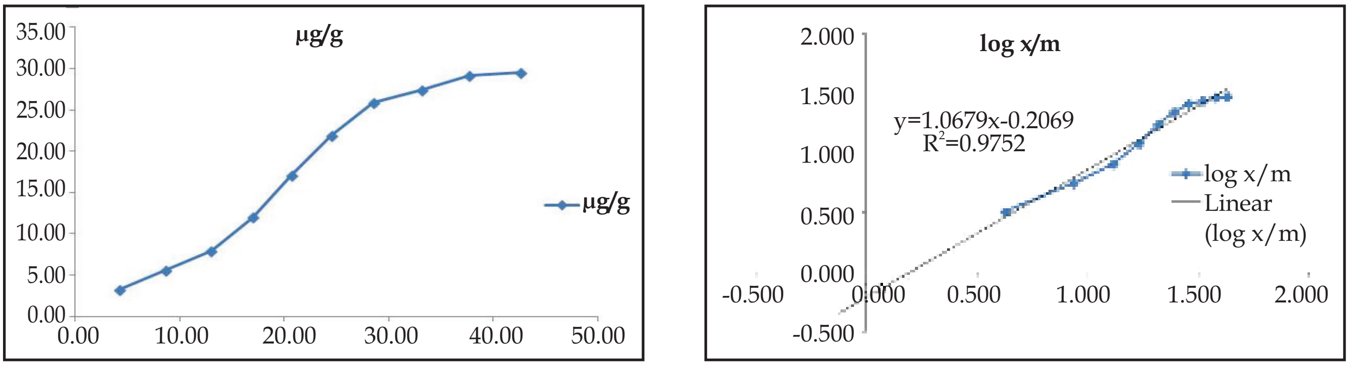


Figure 4.3.2 Adsorption isotherms in red soils

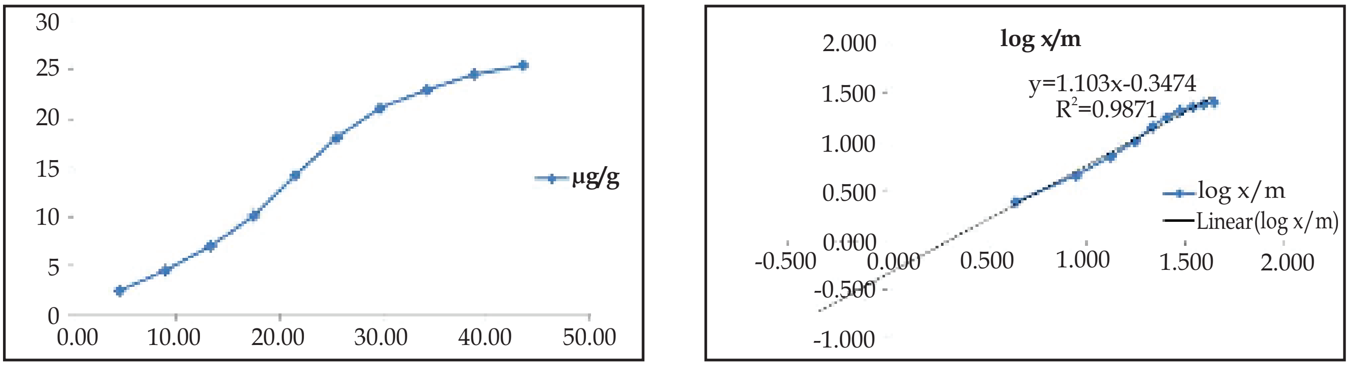


Figure 4.3.2 Adsorption isotherms in black soils

Table 4.3.3 44 K_d and K_{doc}, Freundlich constants ($K_{f, and}$ $K_{foc)}$ values for adsorption of topramezone

Adsorption parameter	Red soil	Black soil
Slope	1.06	1.10
Intercept	-0.20	-0.34
OC (%)	0.53	0.45
1/n	0.93	0.90
K_f	0.62	0.44
K_{foc}	117.17	99.77
K_d	0.77	0.63
K_{doc}	146.79	140.88

Adsorption was not linear (1/n <1) and the shape of the isotherms showed that adsorption decreased at higher concentrations which could be explained by a decrease in affinity of adsorption sites or competition with water molecules for the same adsorption sites (**Table 4.3.3**). The lower adsorption of topramezone in alkaline soil indicates the dissociation of topramezone at higher pH in the soil. Topramezone is a weak acid herbicide (pKa=4.06, 1:1 ratio of anionic form to in dissociated acid). Thus, in the environmentally ideal pH range of 6.5 to 7.5 topramezone is not likely to predominate as undissocated species. On the basis of the value of pKa alone topramezone is expected to have lower sorption and higher mobility in soils with alkaline range of soil reaction.

Table 4.3.4 Amount of topramezone at different day intervals, moisture levels µg /20 g soil in red soil sample

	Dose	
Days	33.6 g/ha	67.2 g/ha
0	0.321	0.667
15	0.246	0.582
30	0.174	0.456
45	0.131	0.332
60	0.111	0.261
90	0.082	0.174
120	0.049	0.102
135	0.031	0.065

Initial detected amount (IDA) of topramezone extractable from soil sample at 2 hours after application of the herbicide was 0.321 µg /20 g and 0.667 µg /10 g at X and 2x dose, respectively in the red soil. Dissipation of herbicide in the soil was estimated upto 135 days after incubation. At 135 days after incubation the detected amount topramezone residues in soil varied from 0.031 µg/20 g and 0.061 µg/10 g at X and 2X doses respectively. Topramezone dissipation followed a first-order decay process and dissipation trends of the topramezone at different doses of application was following.

Dissipation at X dosey = 0.3015 $e^{-0.016x}$ R^2 = 0.984 -------------------(3)

Dissipation at 2X dose y = 0.7258 $e^{-0.017x}$ R^2 = 0.991 ----------------(4)

DT_{50} calculated for the red soil at field capacity was found 43.31 days at X dose and 40.76 days at 2X rate of application. Prolonged half-life of topramezone in experimental conditions revealed the herbicides carryover capacity and probability for damage to crop grown in rotational sequence.

At Coimbatore, degradation of oxyfluorfen under X (200 g / ha) and 2X (400 g / ha) doses in sandy loam soils (pH of 8.01, EC of 0.46 dS/m and OC of 0.37%) was determined. After the application of oxyfluorfen, residues were from found to be 0.013 to 0.308 mg/kg and 0.028 to 0.525 mg/kg in the soil for 200 and 400 g/ha application, respectively. Oxyfluorfen in the soil declined sharply and persisted up to 45 days after application. Oxyfluorfen dissipated according to the first order degradation with the R^2 values of >0.93 at both the doses of 200 and 400 g /ha. Increase in the concentration of application increased the half life of oxyfluorfen with DT_{50} values of 9.5 and 10.6 days, respectively at 200 and 400 g/ha applied treatments.

Table 4.3.5 Persistence, half- lives and statistical parameters for oxyfluorfen dissipation in the soil

Dose	Days after oxyfluorfen application (mg/kg)							k	R^2	DT_{50} (days)
	0	3	7	10	15	30	45			
200 g/ha	0.308	0.265	0.178	0.080	0.047	0.022	0.013	0.081	0.91	9.5
400 g/ha	0.525	0.410	0.314	0.248	0.124	0.065	0.028	0.064	0.97	10.6

At Jorhat, degradation studies of quizalofop - ethyl 50 g/ha was done in pot in sandy loam and silty loam soils. The experiment was conducted in two sets viz. with and without vermicompost. Soil samples were collected started from on the day of herbicide application (within 4 hours of herbicide application) and periodically up to 90 days after application. The residue was found up to 60th DAA (0.018 mg/Kg) in sandy loam soil with vermicompost 2 t/ha and up to 90th DAA (0.014/Kg) w in silt loam with vermicompost 2 t/ha.

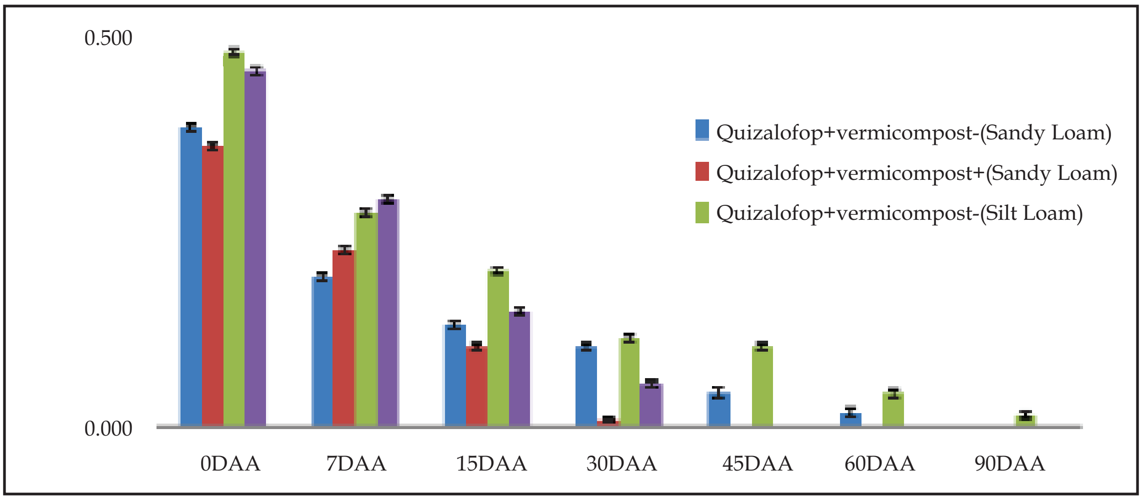


Fig. 4.3.4 Degradation pattern of quizalofop–ethyl in the soil in laboratory

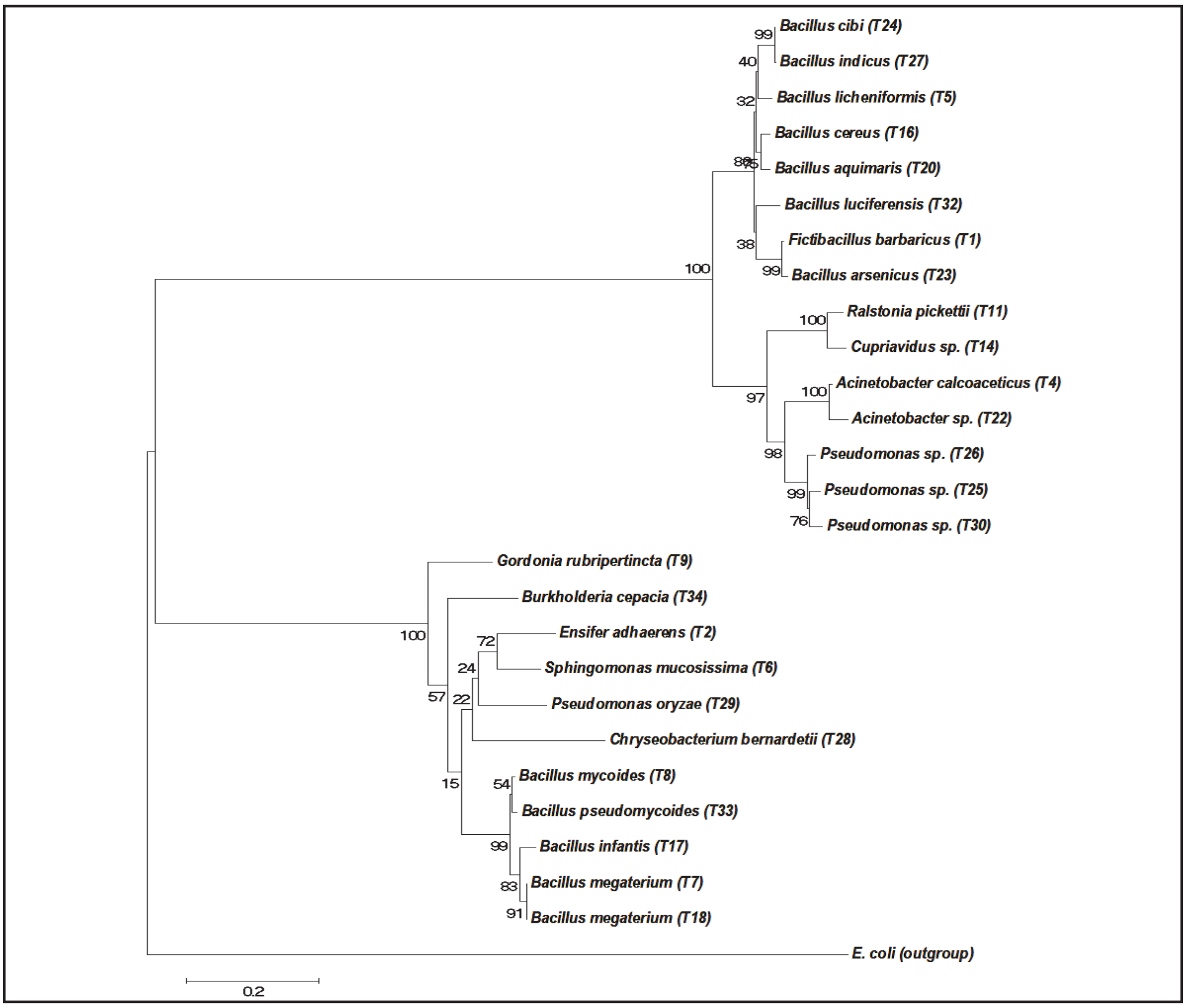
The degradation pattern of quizalofop-ethyl and metribuzin either single or in combination with or without inoculation of bacterial consortia with respect to the time of application were conducted to determine mitigation potential bacterial consortium in polluted soil, water and the environment. Random soil samples (6 nos.) were collected from each polluted site by using rectangular soil sampler up to a constant depth of 10 cm (from surface). The microbes were isolated using specific specified media from the polluted sites. The isolated microbes were selected for molecular characterization using 16sRNA sequencing. 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 (**Table 4.3.6**). 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). Bacterial isolates were identified by sequencing of 16SrRNA and phylogenetic tree for all the 26 bacterial isolates were prepared.

Table 4.3.6 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

Table continue...

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



Quizalofop – ethyl and metribuzine were applied at 50 and 500 g/ha, respectively in single and in combination and bacterial consortia were inoculated at 10 ml per 6 kg soil with the range of dilution of CFU (52.32 – 782.4)x10^6 CFU/g. Soil samples were collected periodically from the day of application of herbicide till 90^{th} day of application. Degradation of quizalofop-ethyl followed a first order equation. Degradation of quizalofop – ethyl and metribuzin was significantly faster with inoculation of bacterial consortia over the without inoculation Degaradation of metribuzin was found faster than quizalofop - ethyl. Irrespective of the treatments and residues of the applied herbicides were detected beyond 60 DAA.

WP 4.4 Mitigation of herbicides residues

At Ludhiana, the removal of imazethapyr and imazamox from artificially contaminated soils was evaluated using β-cyclodextrin-chitosan biocomposites (LCD, MCD and HCD) through adsorption-desorption and pot trials. It was found that the amount of imazethapyr and imazamox adsorbed on the studied soils increased with increase in initial concentration and the isotherms of imazethapyr and imazamox were C-shape. K_F of imazethapyr and imazamox ranged from 0.85 to 16.55 and 0.63 to 10.56 $\mu g^{1-n} g^{-1} ml^{n}$, respectively in studied soils indicating strong influence of soil properties on adsorption of imazethapyr and imazamox. In addition, greater amount of imazethapyr was adsorbed on studied soils as compared to imazamox. Desorption experiments were carried out employing distilled water (DW). In all the studied soils, imazethapyr and imazamox was not desorbed at low concentrations (0.01 and 0.1 µg/ml) indicating herbicide molecules were more strongly adsorbed at low surface coverage. At high concentrations (1.0 and 10 µg/ml), only 1.23 to 5.48 and 3.1 to 8.6 % of adsorbed imazethapyr and imazamox, respectively could be desorbed. To enhance the removal efficiency of various extracting agents such as β-CD, chitosan (LMW, MMW and HMW) and biocomposites (LCD, MCD and HCD) were analysed. The efficiency of chitosan, β-CD and biocomposites to remove imazethapyr and imazamox from studied soils ranged from 2.4 to 34.2, 18.5 to 40.9 and 9.2 to 57.9%, respectively. These results indicated greater efficiency of chitosan, β-CD and biocomposites to remove imazethapyr and imazamox from each soil as compared to distilled water which could remove only 1.2 to 8.6 % of the adsorbed herbicides.

Dissipation studies in soils amended with biocomposite

Considering the highest removal efficiency of LCD as compared to MCD and HCD in removal experiments, it was employed in dissipation study and the effect of various experimental parameters such as selection of extractant, concentration of LCD, liquid to soil ratio, amount of soil on dissipation of imazethapyr and imazamox in inceptisol 3 was assessed and optimized for efficient dissipation of imazethypar and imazethypar and imazamox. The residues of imazethapyr and imazethapyr+imazamox were below the detection limit within 10 to 45 days in alfisol and vertisol, 7 to 30 days in inceptisol 1, 7 to 21 days in aridisol and inceptisol 2 and 5 to 15 days in entisol and inceptisol 3 at studied application rates. The highest dissipation of imazethapyr and imazethapyr + imazamox was observed in inceptisol 3 followed by entisol, inceptisol 2, aridisol, inceptisol 1, vertisol and alfisol. The experimental results also revealed that imazethapyr in premix formulation (imazethapyr + imazamox; 35+35WP) dissipated slowly as compared to imazethapyr when applied alone (10 SL) and the residues of imazethapyr in studied soils were below the detectable limit within 10 to 45 and 5 to 30 days, respectively. It was also inferred that in premix formulation, imazamox dissipated faster as compared to imazethapyr and the residues were below the detectable limit within 7 to 30 and 10 to 45 days, respectively.

Chitosan-bentonitebiocomposites

Synthesis of chitosan-bentonite biocomposites is given in **Table 4.4.1**. The synthesized composites were characterized using spectral techniques such as Fourier transform-infrared (FT-IR), X-ray diffraction (XRD), thermogravimetric analysis (TGA), scanning electron microscopy (SEM) and Brunauer Emmett-Teller (BET) surface area and pore size analyzer. The adsorption capacity of bentonite and biocomposites enhanced with increasing initial concentrations of herbicide. The adsorption data fitted well to the Freundlichas well as Langmuir model. Among the biocomposites, the highest adsorption capacity was observed for LMWCB biocomposite which was about 7.92-8.25 fold higher than bentonite. K_F values for adsorption of imazethapyr and imazamox on adsorbents ranged from 14.1 to 112.3 and 3.8 to 31.9 $\mu g^{1-n} g^{-1} ml^{n}$, respectively suggesting greater adsorption of imazethapyr as compared to imazamox (**Table 4.4.2**).

Table 4.4.1 Optimized experimental parameters for synthesis of chitosan-bentonitebiocomposites

Factors	Experimental conditions	Optimized conditions
Chitosan:bentonite molar ratio	1:10, 1:5, 1:2, 1:1, 2:1, 5:1 and 10:1	1:1
Ultrasonication temperature (^{0} C)	20, 30, 40, 50 and 60	60
Ultrasonication time (min)	15, 30, 45, 60, 90 and 120	30

Table 4.4.2 Freundlich and Langmuir parameters for adsorption of imazethapyr and imazamox onbentonite and biocomposites

Adsorbent	Herbicide	Freundlich			Langmuir			
		K_F	n	R^2	q_m x 10^3	K_L x 10^{-3}	R^2	R_L
Bentonite	Imazethapyr	14.1	0.79	0.97	1.13	8.43	0.98	0.91
	Imazamox	3.87	0.65	0.99	0.12	14.60	0.99	0.87
LMWCB	Imazethapyr	112.3	0.80	0.99	5.96	13.80	0.99	0.87
	Imazamox	31.9	0.85	0.99	3.96	5.99	0.99	0.93
MMWCB	Imazethapyr	48.2	0.82	0.99	4.36	7.88	0.99	0.91
	Imazamox	11.2	0.87	0.99	2.39	3.40	0.99	0.95
HMWCB	Imazethapyr	45.2	0.92	0.99	3.93	3.90	0.99	0.94
	Imazamox	6.72	0.86	0.99	1.69	2.76	0.99	0.96

Desorption efficiency of adsorbents for initial imazethapyr and imazamox concentration of 1.0 µg/ml was evaluated using distilled water adjusted to pH 1, 3, 5, 7 and 9. Only 16.8 to 52.3% and 21.2 to 63.1 % of the adsorbed imazethapyr and imazamox, respectively was desorbed from adsorbents at acidic pH. The percent desorption of imazethapyr and imazamox from adsorbents increased with increasing pH and 69.8 to 85.0% and 90.1 to 96.2 % of imazethapyr and imazamox, respectively was successively desorbed at pH 7 and 9. The maximum desorption of imazethapyr and imazamox from adsorbents was found at pH 9.—Desorption of imazethapyr and imazamox from studied adsorbents varied from 91.5 to 96.2% and 92.3 to 97.0 %.

Table 4.4.3 Pendimethalin dissipation equation, correlation coefficient and half lives in the soil

Treatments	Regression equation	R^2	Half life (days)
FYM 10 t/ha	y = -0.0833x + 0.853	0.95	8.32
Vermicompost 5 t/ha	y = -0.0741x + 0.739	0.92	9.35
Biochar 5 t /ha	y = -0.0608x + 0.962	0.92	9.90
Phosphobacteria 10 kg/ha	y = -0.0696x + 0.969	0.93	9.96
Trichoderma 10 kg /ha	y = -0.0678x + 0.897	0.89	10.2
VAM 10 kg /ha	y = -0.0649x + 0.654	0.97	10.6
Pseudomonas 10 kg/ha	y = -0.0712x + 0.921	0.98	10.6
Urea 100 kg/ha	y = -0.0736x + 0.818	0.93	9.42
Crop residue (maize straw) incorporation 5 t/ha	y = -0.0648x + 0.763	0.94	10.7
Control (no manure/bioagents)	y = -0.0618x + 0.751	0.88	11.2

At Coimbatore, mitigation of pendimethalin 1.0 kg/ha in the of greengram were conducted in the pot study. On 3rd day after greengram sowing, the pendimethalin was applied to each pot. Soil samples were collected from a depth of 0-15 cm on 0, 1, 3, 5, 10, 15, 30 and 45 DAA for pendimethalin residues. The soil was sandy loam having pH 7.81, EC 1.52 dS/m, OC 0.36 %, available N, P, K of 167.2, 19.5 and 542 kg/ha. Pendimethalin residue at initial deposition on day zero ranged from to 0.589 - 0.741 mg /1 kg across different treatments sources consisting of cultural and microbes application to enhance the degradation of atrazine from the soil. Irrespective of the treatments the pendimethalin residues persisted up to 45 DAS. Dissipation was faster under FYM, VAM and biochar applied treatments and the slowest degradation was noticed in control (**Table 4.4.3).** Irrespective of mitigation measures followed, the atrazine persisted up to 45 DAS.

It was found that the FYM 10 t/ha or vermicompost 5/ha or biochar 5 t/ha was efficient in reducing the residual concentration of pendimethalin in greengram grown soil. The application of FYM degraded the pendimethalin.

WP 4.5 Testing of persistence of herbicides in the farmers' field (Soil, water and crop produce)

At Ludhiana, soil, water and crop samples were collected at harvest from farmers' fields from Ludhiana, Moga, Kapurthala, Fazilka and Sangrur districts of Punjab in rice-wheat cropping system. The residues of pretilachlor, butachlor, anilophos, penoxsulam, clodinafop-propargyl, sulfosulfuron, metsulfuron-methyl, pinoxaden, pendimethalin and metribuzin in soil, water and crop produce were found to be below the detectable limit (<0.01 µg/g). The residue of these herbicides in the soil and wheat crop was also collected from farmer fields (Dholan) where metribuzin was applied at higher application rate. The residues of metribuzin in the soil and grain samples were below detectable limit (<0.05 µg/g). The seeds of cucumber were also seeded in these soils. No germination was observed in the samples treated with higher concentrations (300-330 g/acre) of metribuzin while phytotoxicity was observed in rest of the samples. At Palampur, eight samples of Kangra district at the harvest of the crop and were analyzed for clodinafop-propagryl and metsulfuron-methyl residues in soil wheat and rice. The clodinafop and metsulfuron-methyl residues in the soil and grain samples were below detectable levels. Atrazine (BDL >0.01 µg/g) residues in the soil and maize grains were below detectable levels of treated field of five farmers of Kangra district. The residues of bispyribac - sodium were not detected in rice grain and soil.

At Hyderabad, four fodder maize samples were collected from different farmers at the time of harvest in fodder growing areas. In all the soil and fodder maize samples, atrazine residues were below the detection limit of 0.05 mg/kg. At 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, quizalofop-ethyl and oxyfluorfen. 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 Jorhat, soil (0-15 cm), grain and straw samples were collected after harvest of winter rice and mustard in Rabi from farmers' field growing with pretilachlor and pendimethalin application, respectively and analyzed for the residues by GC. The pretilachlor residues at 0.75 kg/ha in the soil, grain and straw after harvest of winter rice were found below the detectable limit. The pendimethalin (1.5 kg/ha) residues in the soil, seed and straw after harvest of mustard was found below detectable limit.

WP 5 On-farm research and demonstration of weed management technologies, their adoption and impact assessment

WP 5.1 On-farm research

At Anand, OFR trial was conducted in two farmers' fields in greengram during summer, 2019. IC *fb* HW at 20 and 40 DAS (Farmers practice) was compared with imazethapyr *fb* IC + HW at 30 DAS and imazamox + imazethapyr *fb* IC + HW at 30 DAS. Results revealed that application of imazethapyr 75 g/ha *fb* IC + HW at

30 DAS recorded lowest weed density and dry weight at 50 DAS and at harvest as compared to others. Although, it recorded lower yield as compared to farmers practice but in terms of net return and B C ratio, it performed well. Results of OFR trials conducted in soybean during 2019 revealed that IC *fb* HW at 20 and 40 DAS (Farmers practice) was more effective in controlling weed dry weight at 50 DAS and weed density at harvest as compared to herbicidal treatments (Quizalofop 50 g/ha *fb* HW at 30 DAS and imazethapyr 100 g/ha *fb* IC + HW at 30 DAS). It also gave highest grain yield (2.42 t/ha) than others. However, imazethapyr 100 g/ha *fb* IC + HW at 30 DAS performed well as far as B:C ratio is concerned.

At Hisar, pre-emergence use of pyroxasulfone at 127.5 g/ha demonstrated at 5 sites in rice – wheat growing areas of Haryana provided 84 % 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 5.53 t/ha which was 9.32% higher than earlier recommended herbicide pendimethalin 1.5 kg/ha. Pyroxasulfone even at 255 g/ha (2X) did not cause any toxicity to wheat crop. Pendimethalin at 1.5 kg/ha (PRE) followed by post-emergence herbicide at 35 DAS provided only 65.6% control of *P. minor*.

At Palampur, four OFR trials on rice, four on maize, five on wheat, three on peas and four in grasslands were undertaken during 2018-19. In case of rice, pyrazosulfuron 25 g/ha, bispyribac 20 g/ha and butachlor 1.5 kg/ha were compared with hand weeding (farmers practice). Results revealed that application of bispyribac 20 g/ha provided higher grain yield of rice but was on par with pyrazosulfuron 25 g/ha as compared to farmers practice. In case of maize, tembotrione 120 g/ha and atrazine 1.5 kg/ha were compared with hand weeding 20 & 45 DAS as farmers practice. Among these, tembotrione 120 g/ha provided higher grain yield of maize (2.5-5.2 t/ha) as compared to others two. Results of OFR on wheat revealed that clodinafop 60 g/ha + metsulfuron-methyl 4 g/ha provided better weed control as well as higher grain yield as compared to clodinafop 60 g/ha *fb* 2,4-D 0.5 kg/ha and isoproturon 1.25 kg/ha. In OFR trials conducted in pea, application of imazethapyr 100 g/ha + HW provided better weed control and higher yield on par with pendimethalin 1.50 kg/ha + HW as compared to hand weeding thrice (farmers practice). Results of OFTs on the control of obnoxious weeds in grasslands revealed that metsulfuron-methyl 0.5 g/ha and 2,4-D 0.75 kg/ha were effective in controlling obnoxious weeds in grasslands as compared to farmers practice (cutting and uprooting bushes once in a season in summer).

At Pantnagar, OFR trials on wheat crop were conducted at two farmer's field in Tarai region of U.S. Nagar district and Bhabar area of Nainital district each during *Rabi* 2018-19. Treatments were comprised of tank-mix combination of clodinafop-propargyl + metsulfuron-methyl 60 + 4 g/ha, sulfosulfuron + metsulfuron methyl 30 + 2 g/ha applied at 30-35 DAS were taken as improved practice, whereas, sulfosulfuron 25 g/ha or sulfosulfuron + MSM (tank mix) 25+4g/ha was taken as farmers practices. In Tarai region, the reduction in grain yield due to uncontrolled weeds in weedy plots was 27.5%. On an average an increase in grain yield due to adoption of improved practice was 27.5% higher than farmers' practice. Among the weed management treatments, highest weed control efficiency was recorded with improved practice (83.0 and 79.54%) over farmer's practice (66.17%). Application of clodinafop-propargyl + MSM (tank mix) 60+4 g/ha recorded highest grain yield 5.2 t/ha, net return (₹ 54,715/ha) and B:C ratio (2.33) followed by sulfosulfuron + MSM which produced grain yield 5.15 t/ha, net return (₹ 53,989/ha) and B:C ratio (2.32), which were higher than farmer's practice (grain yield (5 t/ha); net return (₹ 51,317/ha) and B:C ratio (2.26). In Bhabar area, the loss in grain yield due to weeds in weedy check plot was 28.9% in comparison to improved practice, whereas an increase in grain yield due to adoption of improved practice viz. clodinafop-propargyl + MSM 60+4 g/ha (tank mix) was 42.2%, Sulfosulfuron + MSM at 30+2 g/ha 39.9% as compared to weedy check. On an average, increase in grain yield in improved practice was 2.3% higher than farmers' practice. Among weed management treatments, highest weed control efficiency was recorded with improved practice (81.3 and 74.4%) followed by farmers' practice (73.7%). Clodinafop-propargyl + MSM 60 + 4g/ha recorded the higher grain yield (4.55 t/ha), net return (₹ 42,755/ha) and B:C ratio (2.0) followed by sulfosulfuron + MSM 30+2 g/ha which was closely followed by farmer's practice.

Two on-farm research trials on transplanted rice were conducted at different locations of farmers' field Tarai area in Dist. U.S. Nagar, Uttarakhand during *Kharif* season of 2019. The treatments were consisted of bispyribac- sodium 20 g/ha and pretilachlor 750 g/ha under improved practice, whereas pretilachlor 750 g/ha was taken as farmers' practice and weedy check as control. An increase in grain yield with bispyribac-sodium 20 g/ha was found as 37.5%, with pretilachlor 33.3% and in farmers' practice 31.2% over weedy check. Among different weed management treatments, highest grain yield (6.6 t/ha), net return (₹ 70,538/ha) and B: C ratio (2.52) were achieved with bispyribac-Na at 20 g/ha which was closely followed by pretilachlor 750 g/ha grain yield (6.4 t/ha), net return (₹ 67,566/ha) and B: C (2.47) followed by farmers' practice which recorded (6.3 t/ha) grain yield, ₹ 66,456/ha net return and 2.47 of B:C. In Bhabar area of Dist. Nainital, two sets of OFR on transplanted rice were conducted at farmers' field during *Kharif* 2019. The treatments were comprised of bispyribac-sodium 20 g/ha and pretilachlor 750 g/ha under recommended practice, whereas butachlor 1500 g/ha was taken as the farmer's practice and weedy check. An increase in grain yield with bispyribac-sodium 20 g/ha was found higher by 37.5% followed by pretilachlor 750 g/ha and farmers' practice (butachlor 1500g/ha) 21.9% over weedy check. The highest grain yield (4.4 t/ha), net return (₹ 31,598/ha) and B:C ratio (1.68) was recorded with bispyribac-sodium 20 g/ha followed by pretilachlor 750 g/ha (grain yield 4.3 t/ha), net return (₹ 30,396/ha) and B:C ratio (1.66).

At Raipur, OFR trials in 08 farmers fields were conducted on weed management in direct seeded rice with treatment application of pre-emergence pyrazosulfuron 20 g/ha at 0-7 DAS *fb* bispyibac- Na 20 g/ha at 20 DAS, pre- emergence application of oxadiargyl 80 g/ha *fb* bispyribac-Na 20 g/ha at 20 DAS and one hand weeding (25-35 DAS) as farmers' practice. The average yield of farmers' practice and recommended practice was 3.65 and 4.24 t/ha, respectively. However, percent increase under recommended practice over farmers practice was 16%. The average benefit cost ratio was calculated to be 2.88 and 3.90 under farmers' practice and recommended practice, respectively.

At Ludhiana, OFR trials on control of *Phalaris minor* in wheat with pre-emergent herbicide pyroxasulfone in 4 Farmers' fields were conducted during *Rabi* 2018-19. In nearby areas, *Phalaris minor* has developed cross resistance to recommended herbicides like clodinafop, fenoxaprop and pinoxaden. In such fields, pendimethalin has been recommended for the control of *P. minor* in wheat. In these OFR trials, pre-emergence herbicide pyroxasulfone was tested against pendimethalin at farmers' field. Pyroxasulfone recorded effective control of *P. minor* in wheat and increased wheat grain yield as compared to unsprayed control and was at par with pendimethalin. The herbicide may provide relief to farmers facing multiple resistance problems and reduce early crop-weed competition. During *Kharif*, 2019, 4 OFR trials were conducted for weed control in cotton with ready-mix of pyrithiobac-sodium and quizalofop-p-ethyl. New post-emergence herbicide, pre-mix of pyrithiobac-sodium and quizalofop-p-ethyl 1.25 l/ha recorded effective control of grasses, and broadleaf weeds and was more effective than already recommended post - directed herbicide paraquat in controlling weeds and provided higher seed cotton yield (18.8 q/ha) as compared to paraquat 1.25 l/ha (15.5 q/ha).

At Akola, OFR trials were conducted in 10 farmers' fields in soybean during *Kharif* 2019. Pre-emergence herbicide diclosulam 22 g/ha *fb* post-emergence use of imazethapyr + imazamox 100 g/ha at 20-25 DAS was compared with farmers practice (2 hoeing) in soybean. Application of pre- and post-emergence herbicides provided better weed control in soybean along with its higher grain yield (2.44 t/ha) as compared to farmers practice (1.96 t/ha).

At Jammu, on-farm research trial was conducted on weed management in maize at 2 farmers' fields of Nagrota and Kot Balwal block each under rainfed conditions in collaboration with KVK, Jammu during *Kharif* 2019. Atrazine 1000 g/ha at 0-3 DAS, tembotrione 100 g/ha + atrazine 500 g/ha at 15-20 DAS and atrazine 1000 g/ha *fb* tembotrione 100 g/ha were compared at farmers' fields. 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 at all the locations. The highest grain yield (2.38 t/ha), straw yield (5.43 t/ha) and B: C ratio (2.46) 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 all the locations.

At Coimbatore, OFT was conducted to demonstrate the integrated weed management in aggerigatum onion at five farmers' fields of Sennanur and Kalampalayam villages of Thondamuthur block during *Kharif* 2019. PE oxyflourfen 200 g/ha + hand weeding on 25-30 DAP and PE pendimethalin 1000 g/ha + hand weeding on 25-30 DAP were compared with farmers practice (hand weeding twice). 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. This treatment also recorded higher bulb yield (13.8 to 14.7 t/ ha) and net return (₹ 1.90 – 2.10 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 DAP.

At Kalyani, OFR trials were conducted in 5 farmers' fields of Matiagacha village of North 24 Parganas district in transplanted rice during *Kharif* 2019. Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT and pretilachlor 750 g/ha *fb* hand weeding at 20 DAT were compared with two hand weeding each at 20 and 50 DAT as farmers practice. Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT recorded lowest weed density (54.2, 153.3 no./m^2) and dry biomass (63.5, 168.5 g/m^2) at 30 DAT and at harvest. It also recorded highest grain yield (5.36 t/ha) and B C ratio (1.37) as compared to other treatments. During *Kharif* 2019, pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 25 DAT recorded lowest weed density (18.7, 65.4 no./m^2) and dry biomass (26.34 and 61.5 g/m^2) at 30 DAT and at harvest. It also performed well in terms of grain yield (5.19 t/ha) and B:C ratio (1.32) as compared to other treatments.

At Gwalior, OFR trials were conducted in four farmers' fields under OFR programme during *Rabi* 2018-19 in wheat crop. Combinations of post-emergence herbicides viz. sulfosulfuron + metsulfuron (30+2) g/ha, and clodinafop+ metsulfuron (60+4) g/ha were tested for chemical weed control and compared with farmers' practices at three locations of Gwalior district. It was observed that both the combinations of weed management practices gave lower weed population and higher seed yield over farmer's practices. The maximum yield of 4.34 t/ha was obtained with the application of sulfosulfuron + metsulfuron (30+2) g/ha PoE followed by clodinafop + metsulfuron (60+4) g/ha PoE (4.25 t/ha) which was 30 and 27% higher over farmer's practice (3.34 t/ha). The B: C ratio was found as 2.55 and 2.50 in these weed management practices, respectively, as compared to 2.38 in farmers' field. Total 4 OFRs were conducted in pearlmillet and 4 OFRs were conducted in blackgram crops at farmers' fields in three villages of Gwalior district. Atrazine 0.5 kg/ha + 2, 4-D at 0.5 kg/ha and pendimethalin 1.0 kg/ha (PE) were tested on pearlmillet and compared with farmers practice. It was observed that all the chemical weed management practices gave higher grain yield over farmers practice. The maximum yield of pearlmillet 2.06 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 32.0% and 29.0% higher than farmers practices, respectively. The B: C ratio (2.85) was also recorded higher with the application of atrazine 0.5 kg/ha + 2 ,4-D 0.5 kg/ha (PoE). Similarly, imazethapyr + imazamox (RM) 80 g/ha PoE and pendimethalin + imazethapyr (RM) 750 g/ha PE were tested on blackgram crop and compared with farmers practice. The maximum yield (809 kg/ha) was recorded with the application of imazethapyr + imazamox (RM) 80 g/ha PoE *fb* pendimethalin + imazethapyr (RM) 750 g/ha PE, which was 41.0%, and 37.0% higher than farmers practice. The B:C ratio was also recorded highest (3.01) in imazethapyr + imazamox (RM) 80 g/ha PoE.

WP 5.2 Front Line Demonstration (FLD)

At Anand, four FLDs were conducted in maize during *Kharif* 2019. In the demonstrations, atrazine *fb* topramezone 336 g/l 25.2 g/ha were tested against IC *fb* HW at 20 and 40 DAS as farmers practice.

At Hisar, during *Kharif* 2019, 11 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, pretilachlor + pyrazosulfuron had an edge over pretilachlor as it provided more than 92.9% control of complex weed flora as against 82% by use of pretilachlor with yield increase of 592 kg/ha (7.71 % increase over FP by the use of pretilachlor). Pretilachlor + pyrazosulfuron showed excellent efficacy against broad-leaf weeds and sedges such as *Scirpus tuberosus* and *Cyperus rotundus* not being controlled by pretilachlor alone. B:C in case of pretilachlor + pyrazosulfuron was 3.02 against 2.88 with pretilachlor. Similarly, 199 demonstrations in Bhiwani, Hisar and Mahendergarh districts were 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 79.5% control of *Orobanche* in mustard with yield gain of 33.6% over untreated control.

At Palampur, 26 front line demonstrations were conducted during 2018-19 in rice (8), maize (4), wheat (12) and peas (2). In rice, bispyribac-Na 20 g/ha was considered as improved practice v/s butachlor 1.5 kg/ha as farmers practice; in maize, tembotrione 120 g/ha as technological intervention v/s hoeing 20 DAS v/s earthing up 45 DAS as farmers practice; in wheat clodinafop-propargyl 60 g/ha + metsulfuron-methyl as improved practice v/s farmers' practice and in peas, imazethapyr as technological intervention v/s pendimethalin as farmers practice. Average yield of 3.46, 4.52, 4.01 and 6.5 t/ha of grain yield was obtained with improved practice in rice, maize, wheat and peas, respectively, as compared to farmers practice (2.38, 3.64, 3.12 and 4.5, respectively).

At Pantnagar, the efficacy of selected herbicides at farmers' field were demonstrated through three sets of front line demonstrations conducted in various villages of Tarai area of Dist. U.S. Nagar, Uttarakhand during *Rabi*, 2018-19 in wheat. The treatments were comprised of clodinafop-propargyl + metsulfuron-methyl (tank mix) 60+4 g/ha at 30-35 DAS as improved practice, whereas metsulfuron-methyl 4 g/ha at 25-30 DAS as farmers' practice. An increase of 3.8% was recorded in grain yield with improved practice over farmers' practice. The higher grain yield (5.4 t/ha), net return (₹ 58,395/ha), B: C ratio (2.42) and weed control efficiency of 54.3% were recorded with improved practices. In Bhabar area of Dist - Nainital, three sets of front line demonstrations were conducted at farmers' field on wheat crop during *Rabi* 2018-19 to compare the performance of improved vis-a-vis farmers' practice. The demonstration consisted of clodinafop-propargyl + MSM (tank mix) 60+4 g/ha at 30 - 35 DAS as improved practice and sulfosulfuron 75% WG + MSM 20% WP (tank mix) 25+4 g/ha as farmers' practice. An increase in grain yield (2.1%) was recorded with improved practice as compared to farmers' practice.

Three sets of front line demonstrations were conducted at farmers' field in Tarai area of dist. U.S. Nagar, Uttarakhand to compare the performance of improved vis-a-vis farmers' practice in transplanted rice. The trials comprised of bispyribac-sodium 20 g/ha applied at 20 DAT under improved practice, whereas butachlor 1500 g/ha was taken under farmers' practice. An increase of 4.8% in grain yield was recorded in improved practice as compared to farmers' practice. The highest grain yield (6.5 t/ha), net return (₹ 68,768/ha), B:C ratio (2.48) and weed control efficiency of 91% was observed in improved practice which was higher than farmers' practice. Two sets of front line demonstrations on transplanted rice were conducted at different locations of farmers, field during *Kharif*, 2019 in Bhabar area of Dist - Nainital, Uttarakhand. The treatments were comprised of bispyribac-sodium(EPOE) as improved practice and butachlor was taken as farmers' practice. Application of bispyribac-sodium taken as improved practice increased grain yield by 28.2% over farmers' practice with net return as ₹ 23,976/ha and B:C ratio 1.91 with 70% weed control efficiency.

At Raipur, five FLDs in village Mauhbhata (Bemetra) were laid down on direct-seeded rice cultivar

CG Devbhog with application of oxadiargyl 80 g/ha PE and bispyribac- Na 25 g/ha at 20 DAS. There was 15.4% increase in grain yield due to recommended practice over farmers practice. Higher B:C ratio (3.81) was also observed in demonstrated technology as compared to farmers practice (2.88).

At Udaipur, nine FLDs on broad spectrum weed control in wheat with premix application of sulfosulfuron + metsulfuron (30 + 2 g/ha) at 35 DAS were conducted at Maudi village Tehsil- Sarada during *Rabi* 2018-19. The farmers' field was infested with *Phalaris minor* among the monocots *Chenopodium album, Chenopodium murale, Convolvulus arvensis, Fumaria parviflora, Spergula arvensis* and *Melilotus indica* were observed among dicots. The farmers were highly impressed with the weed control performance of herbicide. Application of ready mix herbicide at 35 DAS was recorded minimum weed density and weed dry matter as compared to farmers practice with increased wheat grain yield by 11.9% over farmers' practice wheat yield (3.99 t/ha). During *Kharif* 2019, seven demonstrations on weed management in maize through post - emergence herbicide tembotrione was conducted at village Kanthoda and Bootwas, Tehsil- Sarada. The data revealed that the minimum weed density and weed biomass was recorded with the application of atrazine *fb* tembotrione 500 g/ha as PE + 120 g/ha at 3-4 leaf stage (15 DAS) in maize. It also showed mild phyto-toxicity symptoms on crop but crop recovered after some days. Maximum value of grain and straw yield was also obtained with the same herbicide by increasing 10.5 % grain yield over farmers practice. Twelve demonstrations on weed management in soybean through herbicide imazethapyar + propaquizafop 75+75 g/ha PoE at 21 DAS (Tank mix) were conducted at village Kanthoda and Bootwas, Tehsil- Sarada. Minimum density and dry matter of total weeds were recorded with the treated plot. Maximum seed yield (780 kg/ha), haulm yield (1060 kg/ha) of soybean and net returns (₹ 15,724/ha) was observed with tank mix application of imazethapyar + propaquizafop 75+75 g/ha at 21 DAS than farmers practice.

At Ludhiana, 8 demonstrations on control of *Phalaris minor* in wheat with pre-mix combination of clodinafop 12% + metribuzin 42 % (post-emergence herbicide) were conducted in Ludhiana district during *Rabi* 2018-19. Farmers were provided with new herbicide free of cost. New herbicide recorded effective control of *P. minor* in wheat. Around 40-53% increase in weed control and 5-19% increase in grain yield was observed with this new herbicide. Six demonstrations on weed control with post-emergence herbicides (tembotrione 110 g/ha) in maize were conducted during *Kharif* 2019 in Jalandhar, Kapurthala and Hoshiarpur districts. Farmers were provided with herbicide free of cost. The effective weed control was observed with this herbicide and farmers were happy to get new post-emergence window for the weed control in maize. Approximately 40.6% increase in yield was obtained in the plots treated with this herbicide as compared to farmers' practice.

At Akola, 10 FLDs on weed management in cotton through pre-emergence application of pendimethalin 1.00 kg/ha followed by directed spray (by using protective shield) of non-selective herbicide paraquat 24 SL 0.60 kg/ha at 45 DAS after sowing was demonstrated and compared with farmers practice (3-4 hoeing + 2-3 weeding). Farmers were fully satisfied with the benefits obtained with the demonstrated technology in monetary returns. Therefore, due to high labour charges for weeding in cotton and their unavailability at the right time, it is recommended to use pre - and post-emergence herbicides in cotton for control of weeds and to get higher monetary returns.

At Jammu, 2 front line demonstrations were conducted in *Rabi* 2018-19 at 8 farmers' fields of different blocks of Jammu region under irrigated conditions with collaboration of KVK, Jammu. In first FLD, clodinafop-propargyl + metsulfuron (60+4 g/ha) at 30-35 DAS was taken as test treatment and compared with farmer's practice (metribuzin 200 g/ha at 30-35 DAS). In second FLD, sulfosulfuron + carfentrazone (25+20 g/ha) at 30-35 DAS was taken as test treatment and compared with farmer's practice (metribuzin 200 g/ha at 30-35 DAS). In both the demonstrations, the lower weed density, higher grain yield and higher B: C ratio were recorded with test treatments (clodinafop-propargyl + metsulfuron 60 + 4 g/ha and sulfosulfuron + carfentrazone (25+20 g/ha at 30-35 DAS) as compared to farmers' practice (metribuzin 200 g/ha at 30-35 DAS) at all the locations. The new herbicidal interventions i.e. clodinafop-propargyl + metsulfuron 60+4 g/ha at 30-35 DAS and sulfosulfuron + carfentrazone 25 + 20 g/ha at 30-35 DAS recorded 10.3 and 6.0% higher mean yield as compared to farmers' practice (metribuzin 200 g/ha at 30-35 DAS).

At Coimbatore, front line demonstrations were conducted in tomato (*var* PKM 2) at five farmers' field of Devarayapuram village, Thondamuthur block of Coimbatore District. Pendimethalin 1000 g/ha + hand weeding on 30-35 DAT was compared with farmers' practice (hand weeding twice at 25 and 50 DAT). Due to application of PE pendimethalin 1000 g/ha, on an average, tomato yield increases ranging from 21.3 to 38.9% over farmers' practice. 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 2 locations of Vellanikkara Panchayat. Almost 87-92% control of weedy rice through Wiper was observed in the farmers' fields.

At Bhubaneswar, 10 front line demonstrations were conducted in rice during *Kharif* 2019. Commercial application of bispyribac-Na 200 ml/ha was demonstrated against farmers practice in these demonstrations. Farmers were satisfied with the performance of the herbicide in controlling weeds and in increasing grain yield (32%) over farmers practice.

At Hyderabad, five FLDs were conducted in rice during *Kharif* 2019 to popularize the integrated weed management technology at Galijally village, Dhoma Mandal in Vikarabad district, respectively. The results from FLDs on rice during *Kharif* 2019 showed that IWM involving post-emergence application of penoxulam 25g/ha w/w + cyhalofop–butyl 125g/ha w/w OD *fb* hand weeding resulted in efficient weed control and increase in yield ranged from 8.1 to 13.3%. 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 in place of manual weeding. Five FLDs were conducted in maize during *Kharif* 2019 to popularize the integrated weed management technology at Kummera village, Chevella Mandal in Ranga reddy district. The results showed that IWM involving post-emergence application of tembotrione 120 g/ha + atrazine 500g/ha *fb* hand weeding resulted in broad spectrum weed control and increase in yield ranged from 7.4 to 11.8%. Mean reduction of 15-20% was observed in the cost of cultivation of improved practice over the farmers' practice due to onetime use of herbicide in place of manual weeding. Five FLDs were conducted at Kothur village, Midjil Mandal in Mahaboobnagar district for demonstrating integrated weed management technology in groundnut during *Rabi* 2018-19. IWM involving post-emergence application of imazethapyr + propaquizafop 2000 ml/ha *fb* hand weeding resulted in broad-spectrum weed control and increase in yield ranged from 8.1 -13.3%. Mean reduction of 18-22% was observed in cost of cultivation of improved practice over the farmers practice due to usage of herbicide for one time by avoiding manual weeding.

At Gwalior, during *Kharif* 2019, two FLDs were conducted on pearlmillet and blackgram each at farmers' fields of villages of Gwalior district. Herbicide atrazine 500 g/ha + 2, 4-D 500 g/ha and atrazine 500 g/ha alone were tested on pearlmillet and compared it with farmers' practice. During the entire period of *Kharif* 2019, heavy rainfall was received and thus huge loss occurred in yield of pearlmillet and blackgram. In pearlmillet, it was observed that both the chemical weed management practices gave higher grain yield over farmers practice. Maximum yield of 2.01 t/ha was obtained with the application of atrazine 500 g/ha PE + 2, 4-D 500 g/ha (PoE) *fb* atrazine 500 g/ha alone, which was 42 and 40% higher than farmers practice, respectively. Similarly, higher B: C ratio of 1.45 was recorded in atrazine 500 g/ha PE + 2, 4-D 500 g/ha (PoE). In blackgram, it was observed that maximum yield of 775 kg/ha was obtained with the application of imazethapyr + imazamox (RM) 80 g/ha PoE followed by quizalofop-p-ethyl 75 g/ha PoE, which was 42% and 35% higher than farmers practice. The highest B : C ratio of 2.54 was also recorded in imazethapyr + imazamox (RM) 80 g/ha PoE.

Table 5.1 Extension activities undertaken by coordinating centres

Sl. No.	Centre name	Training imparted	Radio talks	TV progra-mmes	Kishan melas/ Kisan Day	Handouts/ folders/ pamphlets	Bulletins /booklet	Training partici-pated	On - farms trials	Frontline demons-trations	Parth-enium awar-eness
1	PAU, Ludhiana	8	0	2	0	1	6	6	0	14	√
2	UAS, Bengaluru	2	3	2	0	0	0	4	50	0	√
3	RVSKVV, Gwalior	0	0	0	1	7	1	1	12	8	√
4	GBPUAT, Pantnagar	2	0	0	2	0	0	0	10	12	√
5	CSKHPKV, Palampur	0	2	0	0	1	3	0	0	0	√
6	AAU, Jorhat	0	0	0	0	0	2	3	7	0	√
7	AAU, Anand	7	1	5	1	0	0	3	4	14	√
8	TNAU, Coimbatore	0	2	3	0	0	2	12	5	5	√
9	KAU, Thrissur	0	0	0	0	0	0	1	3	2	√
10	OUAT, Bhubaneshwar	2	0	0	0	0	0	0	8	2	√
11	PJTSAU, Hyderabad	0	0	7	0	0	1	16	2	15	√
12	CCSHAU, Hisar	3	0	0	5	0	0	0	5	210	√
13	IGKV, Raipur	0	3	0	0	0	0	1	8	5	√
14	PDKV, Akola	0	0	0	0	4	0	20	10	10	√
15	BCKV, Kalyani	0	0	1	0	0	0	7	5	0	√
16	MPUAT, Udaipur	7	1	0	0	10	0	7	0	28	√
17	SKUAST, Jammu	0	0	0	0	0	4	0	4	16	√
	Total	**31**	**12**	**20**	**9**	**23**	**19**	**81**	**133**	**341**	

4. RECOMMENDATIONS FOR PACKAGE OF PRACTICES

AAU, Anand

- Application of sulfosulfuron 25 g/ha at 45 DATP *fb* 50 g/ha at 90 DATP in tomato found less phytotoxic (14%) with higher control of *Orobanche* (84%), higher tomato fruit yield (77.7 t/ha) and B:C ratio (2.25) followed by ethoxysulfuron 25 and 50 g/ha at 45 and 90 DATP and ethoxysulfuron 25 and 50 g/ha at 60 and 90 DATP, wheareas glyphosate was found more phytotoxic on tomato crop.
- Application of oxyfluorfen 0.120 kg/ha PE found effective for *Cuscuta* control without any phytotoxicity on onion crop with higher onion bulb yield (55.4 /ha) and benefit cost ratio (6.54).

CCSHAU, Hisar

- For effective weed management spray penoxsulam + cyhalofop 6%OD 900 ml/acre at 15-20 days after transplanting 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.
- For effective fweed management spray penoxsulam 2.5%OD 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.

CSKHPKV, Palampur

- For higher productivity of maize-wheat system, zero tillage with 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 + hoeing; intercropping and intensive cropping may be an effective mean of suppressing weeds and increasing garlic bulb equivalent yield.
- In peach, intercropping of turmeric, legumes or fodders are the effective alternatives to increase the income and effective land use.
- 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.

GBPAUT, Pantnagar

- Apply pendimethalin 1.0 kg/ha *fb* metsulfuron-methyl 4 g/ha and one hand weeding if needed is recommended for dry direct seeded rice.
- Application of halosulfuron-methyl at 67.5 g/ha and atrazine at 2000 g/ha is recommended for higher yield of sugarcane crop.
- For higher turmeric yield and B:C ratio application of pendimethalin 1.0 kg/ha (PE) *fb* straw mulch 10 t/ha along with one hand weeding at 75 DAP is recommended .

IGKV, Raipur

- Oxadiargyl 80 g /ha *fb* post-emergence bispyribac-Na 25 g/ha in direct-seeded rice is recommended for weed management.
- Oxadiargyl 80 g /ha *fb* post-emergence penoxsulam 22.5 g/ha is recommended in direct-seeded rice for weed management.

PAU, Ludhiana

- Pre-emergence application of pyroxasulfone at 127.5 g /ha is recommended for effective control of herbicide resistant *Phalaris minor* in wheat.
- Pre-emergence application of ready-mix formulation of pendimethalin plus metribuzin at 962.5 g/ha is recommended for control of *Phalaris minor* and annual weeds in wheat.
- Uniform spreading of paddy straw mulch 6 t/ha, immediately after sowing of soybean followed by one hand weeding after six week provided effective control of weeds in organic soybean.

PDKV, Akola

- Post-emergence application of imazethapyr +

imazamox 0.070 kg/ha PoE 15 DAS was found the most remunerative and effective herbicide for controlling weed flora and getting higher yield and economic returns in soybean.

- In cotton, pre-emergence application of pendimethalin 1.00 kg/ha followed by directed spray (by using protective shield) of paraquat 0.60 kg/ha at 45 days after sowing is recommended for controlling weeds with higher yield and monetary returns.
- In maize pre-emergence application of atrazine 0.50 kg/ha followed by post-emergence application of tembotrione 0.120 kg/ha at 20 DAS were the most remunerative and effective herbicides for controlling the weed flora and getting higher yield and economic returns.
- In turmeric pre-emergence application of pendimethalin 1.0 kg/ha or metribuzin 0.7 kg /ha or atrazine 0.75 kg/ha (0-5 DAP) *fb* straw mulch 10 t/ha (10 DAP) *fb* one HW (75 DAP) is recommended for controlling weeds with higher yield and monetary returns.

TNAU, Coimbatore

- Application of PE pyrazosulfuron-ethyl 150 g/ha on 3 DAT + hand weeding (HW) on 45 DAT in transplanted rice-rice cropping system is recommended.
- In line sown crop, application of PE atrazine 0.25 kg/ha on 3-5 DAS followed by Twin Wheel hoe weeder weeding on 30-35 DAS in maize 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 in maize-sunflower cropping system is recommended.
- Pre-emergence application of pendimethalin 0.75 kg on 3 DAS followed by early post-emergence application of imazethapyr 60 g/ha on 15 DAE of weeds (2 - 3 leaves stage of weeds) and quizalofop ethyl 50 g/ha on 20 DAE of weeds (2 - 3 leaves of weeds) are recommended for controlling broad leaved and grassy weeds, respectively in blackgram and greengram.
- 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* and with no regeneration even after 60 days after herbicide application.
- Post-emergence tank mix directed application of glyphosate 10 ml/ha + 2, 4-D sodium salt 5 g/lit is recommended for control of *Portulaca quadrifida* in cropped fields.

PJTSAU, Hyderabad

- Application of penoxsulam + cyhalofop–p-butyl at 150g (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.
- Diuron at 1.0 kg /ha as PE followed by pyrithiobac-sodium at 62.5 g /ha + quizalofop-p-ethyl (2-4 leaf stage of weeds) and diuron at 0.75 kg/ha as PE followed by pyrithiobac- sodium at 62.5 g/ha + quizalofop-p-ethyl at 50 g/ha (2-4 leaf stage of weeds) respectively in red and black soils can be recommended for cotton.
- Halosulfuron -methyl 67.5 g/ha + atrazine 500 g/ha as early post-emergence can be recommended for broad spectrum weed control especially *Cyperus rotundus* in maize.

5. SCHEDULED CAST SUB-PLAN (SCSP) PROGRAMME

RVSKVV, Gwalior

Scheduled Cast Sub-Plan (SCSP) Programme is in operation from 2019-20. Seeds of wheat and chickpea Urea, SSP, herbicide and Rhizobium culture for chickpea crop were purchased and distributed among 51 Scheduled cast farmers of different villages.

CSKHPKV, Palampur

Four trainings programmes were conducted in different villages, Tamber-Dhad, Kangra; Jhickly Bhate, Baiznath; Bandla, Palampur; Khanog, Nagrota Bagwan of the SCSP population of district Kangra where 203 farmers were made aware of the losses being caused by the weeds in commercial crops , field crops and as well as in grasslands/pastures. Training were provided in Scope and importance of weed control; technique of weed management; weed management in *Rabi* & *Kharif* crops; management of obnoxious weeds; safe use of herbicides. Farmers-scientists interactions were organized.

TNAU, Coimbatore

Basic weed management technologies for agricultural and horticultural crops, inputs like herbicides and crop nutrient mixtures and technological knowhow by leaflets and pamphlets were provided to the farmers. Three training programmes on “Integrated Weed Management” were conducted at different ecological zone of Tamil Nadu and the details are as follows:

S. No	Date of Training	Place	District	Agro ecological zone of Tamil Nadu	Number of farmers
1.	01.2.2020	Periyakumarapalayam, Karamadai	Coimbatore	North Eastern zone	46
2.	15.2.2020	Thindalanoor	Dharmapuri	North Western Zone	25
3.	04.3.2020	Thandrampattu	Thiruvannamalai	Western Zone	40

OUAT, Bubaneswar

Distribution of farm implements mostly related to weed management (sprayer, sickle, spade, protective gadgets, tarpaulin sheets, etc. and conducted awareness training programmes in Ali pingala, Nimapra, Puri, Hatasahi, Brahmana Beruni and Khorda areas. In two villages 30 farm family were benefited.

PJTSAU, Hyderabad

Under SCSP programme herbicides and sprayers were distributed to the 24 numbers of scheduled caste farmers selected with the help of KVK, Kampasagar, Nalgonda district and KVK, Palem, Nagarkurnool district and DAATT centre, Rangareddy district. Training program on “Integrated weed management in different crops and cropping systems” and "Precautions to be taken while selecting and using the herbicides", were organised Distributed knapsack sprayers and herbicides like imazethapyr, propaquizafop for groundnut, blackgram and greengram; tembotrione and atrazine for maize and premix herbicide bensulfuron methyl + pretilachlor for rice. FLDs are being organized in rice, maize, groundnut, blackgram and greengram.

PDKV, Akola

Need based application of INM, IWM and IPM is incorporated under SC/SP program. The farmers are also advocated to use these technologies in the field as a ICM component. All these efforts are directed to minimize the cost of cultivation to increase the margin of profit. Demonstrations were given to 10 farmers each of soybean and Cotton in *Kharif* at Redma and Varkhed

Village Tq. Barshitakli Dist Akola. The *Rabi* demonstrations on wheat was given to 40 farmers in which 20 at Salpi village Tq & Dist. Akola & 20 at Redva village Tq Barshitakli, Dist Akola.

Trainings on improved production technologies for increasing productivity of major *Kharif* and *Rabi* crops with special emphasis on integrated weed management, 'Calibration of sprayer, preparation of herbicide solution and Time & method of herbicide spray' and seed production technologies for major *Kharif* & *Rabi* crops, were given.

IGKV, Raipur

During *Kharif*, 2019, 35 front line demonstrations on weed management in direct seeded rice by chemical weed control in an area of 35 acres were conducted in schedule caste dominated villages of Pendri, Gondhi and Dorenga district Bhatapara. Out of 40 FLDs, 30 demonstrations were conducted in wheat variety 'Ratan' on weed management with PoE of metsulfuron 4g/ha over farmers practice i.e. one HW at 30-40 DAS as per his convenience. The average yield increase in technology given was 39.53% over farmer's practice. Whereas, demonstrations on chickpea variety 'JG 14' in 10 acres area on weed management by chemical weed control i.e. PE of pendimethalin 1000 g/ha was conducted under rainfed condition. The average yield increase attributed in chickpea was 36.5% over farmers practice i.e. one HW at 30-40 DAS as per his convenience. All the demonstrations were conducted with the help of KVK, Bhatapara.

An awareness programme on use of pre and post-emergence herbicides in rice, wheat and chickpea before conduction of FLD programme was organized. Distribution of herbicides and certified seed of crops. Demonstration of weed management technologies developed in Raipur centre in rice and chickpea/ wheat crops were given.

MPUAT, Uaipur

Scheduled Caste Sub Plan (SCSP) activities were initiated since *Kharif*, 2019 at selected locations and demonstrations, trainings and human resources development activities were undertaken. demonstrations on different crops were conducted for the SCSP beneficiaries with improved and high yielding varieties of maize, soybean, blackgram, wheat, chickpea, and summer greengram on the farmers field and their performances were compared with the available local varieties. During the *Kharif* & *Rabi* seasons, five trainings on improved crop production technologies were conducted on capacity building and skill improvemnt of the SCSP farmers in the selected villages. One-day training programmes on "Increasing productivity of *Rabi* crops through integrated weed management", Calibration of sprayer, preparation of herbicide solution and method of herbicide spray; and' Improved production technologies for summer moong cultivation' were conducted for approximetly 134 SC farmers were conducted.

During the *Kharif, Rabi* & summer season of 2019-20, 213 demonstrations were conducted with support of inputs like improved variety seed, herbicides and knapsack sprayers, sprayer nozzles, measuring cylinder, *etc*. in selected villages, Meghwal basti, Visma, Sayra, Udaipur, Bansi wada, Birothi, Judli, Rohimal, Dabla of Tehsil Jhadol Falasiya, Udaipur and Daroli, Teh.-Bhindar of this community.

SKUAST, Jammu

The village New Plot Salehar of Bishnah Block of Jammu was selected during 2019-20 for SCSP programme. During survey work, it is felt that the many farmers don't sow wheat crop due to untimely rains for longer period. Therefore, cultivation of summer blackgram in fallow fields is found suitable option to compensate loss of *Rabi*. For cultivation of summer blackgram, a training programme was organized awareness among Scheduled Caste farmers for production practices with especially reference to weed management in summer blackgram. During the event, Scientists-Farmers interaction was conducted to aware them about improved agri-technologies including weed management to enhance farm income while working on resource optimization at farm level. Besides this, high quality seed of pulse crop like urd bean (mash) along with other production inputs like fertilizer (DAP) were also distributed among the scheduled caste farmers. During the programme more than 200 farmers have been benefited.

BCKV, Kalyani

Work has been undertaken during 2019-20 starting from the jute crop season initially in two villages under Ranaghat-II Block in the District Nadia, West Bengal. Fifteen farmers covering 2 ha of jute area in each of the two villages were benefited under the demonstration. RDF based application of chemical fertilizers was followed. Intercultural operations viz nail weeding and thinning were done timely. Plant protection measures were taken against semilooper, and bihar hairy caterpiller with the use of Ustad (Cypermethrin 10% EC) as and when required. Performance was recorded separately. Crop demonstration centres have been conducted as follows.

Name of village	Name of crop	No. of beneficiary farmers	Total area covered (ha)	Interventions
Village – I Sridharpur	*Kharif* rice	19	2.5	Seed replacement+ RDF based fertilizer application+ weed management versus farmer's practice
Village – II Gopinagar	*Kharif* rice	22	3.2	-do-

Implements namely seed drill (4), and Knapsack sprayer (8) were distributed among the beneficiaries on cooperative basis.






Distribution of inputs and awarneness program under SC-SC Subplan

6. LINKAGES AND COLLABORATION

AAU, Anand

For transfer of technology, Director of Research, Director of Extension Education, AAU, Anand and KVKs for organized training programme on weed management. Collaboration was made for scientific work, AINP on Pesticide Residue, Department of Agriculture Chemistry & Soil Science and Department of Agriculture Microbiology helped in analysis. Management of unwanted vegetation/weeds on road side of runway and surrounding to control bird hit issues at ahemdabad, Surat, Rajkot and Vadodara airports is under progress between airport authority of India and AICRP-Weed Management, AAU, Anand.

CSKHPKV, Palampur

Cropping system's influence on weeds floristic diversity

The present study aimed at having an appraisal of weeds floristic diversity in rice based cropping systems.

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.

Ageratum conyzoides (28%) was the most dominant weed in *Kharif*. *Commelina benghalensis* (19%) and *Cynodon dactylon* (17%) were next in dominance. *Scirpus* sp. was other important weed contributing 7% to total weed flora.

In *Rabi*, *Phalaris minor* was the most dominating weed contributing 56% to total weed flora. *Coronopus didymus* (9%), *Stellaria media* (6%), *Spergula arvensis* (4%), *Vicia sativa* (4%), *Ageratum houstonianum* (4%), *Trifolium repens* (3%) and *Polygonum alatum* (3%) were the next important weeds. Other weeds constituted 12% of the total weed population. *Paspalum scrobiculatum* and *Chromolaena adenophorum* were the common weeds of bunds/terrace risers (**Table 6.1**).

Table 6.1 Effect of cropping systems and weed control methods on weed count (no. /m^2) during *Kharif* and *Rabi*

	Treatment	*Cynodon dactylon*	*Trifolium repens*	*Ageratum conyzoides*	*Polygonum alatum*	*Cyperus* sp.	*Bidens pilosa*	*Scirpus* sp.	*Phalaris minor*	*Stellaria media*	*Spergula arvensis*	*Polygonum alatum*	*Trifolium repens*	*Coronopus didymus*	*Vicia sativa*
	Cropping system														
C_1	Rice – wheat	3.9	0.8	2.7	1.5	3.6	2.5	4.2	21.2	4.8	5.7	3.8	3.1	2.2	4.2
		(16)	(0)	(10)	(3)	(13)	(7)	(18)	(454)	(25)	(35)	(16)	(10)	(9)	(17)
C_2	Rice – pea – summer squash	4.4	1.7	2.8	2.4	2.7	1.5	2.5	15.3	4.4	2.8	3.3	3.5	7.7	5.2
		(20)	(3)	(8)	(6)	(9)	(3)	(20)	(235)	(20)	(10)	(12)	(13)	(53)	(31)
C_3	Okra – radish - onion	5.7	4.2	10.8	3.1	3.2	4.4	0.8	15.7	5.5	4.9	3.9	2.3	7.7	5.2
		(33)	(19)	(119)	(10)	(11)	(20)	(0)	(249)	(31)	(28)	(16)	(8)	(69)	(30)
C_4	Turmeric – pea – summer squash	6.6	4.0	9.7	2.0	4.1	2.7	1.4	20.2	4.2	4.3	3.0	4.4	5.6	3.3

Table contd...

C_5	Rice – lettuce – potato + coriander	(43) 5.7	(17) 0.7	(95) 3.3	(5) 1.4	(18) 1.5	(9) 1.6	(2) 2.6	(418) 13.8	(20) 7.2	(25) 3.0	(13) 3.6	(21) 4.4	(32) 5.5	(11) 3.9
C_6	Rice – palak – cucumber	(33) 4.6	(0) 1.9	(13) 4.2	(2) 1.5	(3) 3.1	(3) 3.2	(22) 4.3	(191) 13.4	(55) 1.4	(10) 2.1	(14) 2.2	(21) 3.6	(33) 5.0	(17) 1.7
C_7	Rice – broccoli – radish	(22) 5.3	(5) 1.1	(19) 3.2	(3) 2.2	(11) 1.5	(10) 3.6	(19) 4.1	(179) 12.4	(2) 1.2	(6) 4.1	(9) 1.9	(15) 2.1	(28) 4.1	(3) 1.9
C_8	Colocasia – pea + coriander	(29) 6.7	(1) 2.1	(13) 10.1	(7) 1.9	(3) 2.9	(15) 3.6	(18) 1.3	(160) 14.5	(2) 7.0	(18) 4.3	(5) 4.0	(5) 3.7	(18) 8.5	(4) 4.8
	SEm± LSD (P=0.05)	(45) 0.40 1.1	(5) 0.4 1.2	(105) 0.6 1.8	(5) 0.5 NS	(9) 0.4 1.3	(15) 0.6 1.7	(2) 0.3 1.0	(210) 0.8 2.4	(52) 0.4 1.1	(23) 0.8 NS	(17) 0.5 NS	(15) 0.3 1.0	(73) 0.7 2.1	(23) 0.4 1.2
	Tillage														
W1	Weed control	4.8 (24)	1.9 (5)	5.3 (40)	1.8 (4)	2.7 (9)	2.6 (9)	2.9 (11)	14.9 (232)	3.4 (15)	4.1 (20)	3.1 (12)	3.6 (15)	5.8 (42)	3.5 (15)
W2	No weed control	5.9 (36)	2.2 (7)	6.4 (56)	2.2 (6)	3.1 (11)	3.1 (12)	3.4 (15)	16.7 (293)	5.5 (37)	3.8 (18)	3.5 (14)	3.2 (12)	5.8 (39)	4.1 (19)
	SEm± LSD (P=0.05)	0.1 0.4	0.2 NS	0.2 0.6	0.2 NS	0.1 NS	0.2 NS	0.2 0.4	0.2 0.6	0.2 0.5	0.3 NS	0.2 NS	0.3 NS	0.3 NS	0.2 NS

* Figures in the parentheses are the means of original values. Data transformed to square root transformation ($\sqrt{x+0.5}$)

Cropping systems brought about significant variation in its count but weed control methods could not. *Scirpus* sp. was absent in 'okra-radish-onion' and had lowest populations in 'turmeric-pea-summer squash' and 'colocasia-pea+coriander' followed by 'rice-wheat' and 'rice-broccoli-radish', 'rice-palak-cucumber', 'rice-pea-summer squash' and 'rice-lettuce-potato+coriander'. However, the count was highest in rice based cropping systems *viz.* 'rice-lettuce-potato+coriander', 'rice-pea-summer squash', 'rice-palak-cucumber', 'rice-broccoli-radish' and 'rice-wheat'. The variation in its population due to weed control methods was also significant and diverse weed control practices significantly brought down its count over no weed control.The population of *Commelina benghalensis* was lowest in 'okra-radish-onion' which was statistically at par with 'colocasia-pea + coriander' and 'turmeric-pea-summer squash'. 'rice-wheat', 'rice-broccoli-radish', 'rice-lettuce-potato+coriander', 'rice-pea- summer squash' and 'rice-palak-cucumber' were next in order. Population of *Commelina benghalensis* was relatively higher in rice based cropping systems i.e. 'rice-palak-cucumber' followed by 'rice-pea-summer squash', 'rice-lettuce-potato+coriander', 'rice-broccoli-radish' and 'rice-wheat' than other upland cropping systems (turmeric-pea-summer squash, colocasia-pea+coriander and okra-radish-onion). Cropping systems significantly affected its population but the count of weed control and weedy check didn't differ significantly. Cropping systems also brought about significant variation in the count of *Monochoria vaginalis*. The population was lowest in 'okra-radish-onion' being at par with colocasia-pea + coriander, rice-pea-summer squash, turmeric-pea-summer squash, rice-palak-cucumber and 'rice-lettuce-potato+coriander'. It was found mainly in rice based cropping systems *viz*. 'rice-broccoli-radish', 'rice-wheat', 'rice-lettuce-potato+coriander', 'rice-palak-cucumber' and 'rice-pea-summer squash'. It was also found in other upland based cropping systems *viz.* 'turmeric-pea-summer squash', 'colocasia-pea + coriander' and 'okra-radish-onion' during the rainy months but with either limited in number or growth. The count in weedy check was higher than weed control.

Galinsoga parviflora, Phyllanthus ninuri and *Conyza stricta* had sporadic appearance and were not significantly affected due to treatments.

Polygonum barbatum, *Cynodon dactylon* and *Lathyrus* sp. was uniformly distributed in all cropping systems. The variation in their population due to weed control methods was not significant.

Influence of long-term application of fertilizers on weed floristic diversity in in wheat (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 and gave significant variation in the count of weeds. In wheat (2017-18), *Polygonum plebium* was most dominant weed constituting 47% of the total weed flora followed by *Anagallis arvensis* (18%), *Phalaris minor* (16%), *Poaannua* (5%), *Plantago lanceolate* (4%), *Gnaphalium luteoalbum* (3%), *Vicia sp.* (2%), *Coronopus didymus* (2%), *Avena fatua* (2%) and *Artemisia vulgaris (1%).*

During 2017-18, 0 to 3 weed species were found different from 'control' in different fertility treatments whereas, in *Rabi* 2018-19, none of the species were different in treatments from 'control'. (**Table 6.2)** clearly indicated that with changes in fertility, variation in infestation of weed flora occurred. With the controlling/eradicating/limiting one species, another species find its way indicating that weed control would be a continuous effort.

Table 6.2 Effect offertility treatments on diversity indices of weeds in wheat

Treatment	No. of weed species common as Control		No. of weed species present in new system but absent in Control		Shannon Weiner index		Similarity index	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
50% NPK	7	11	2	0	1.60	2.16	0.87	0.95
100% NPK	7	11	3	0	0.73	1.43	0.82	0.91
150% NPK	7	12	0	0	1.13	1.06	1.00	0.96
100% NPK + HW	5	9	2	0	0.74	1.63	0.71	0.81
100% NPK + Zn	6	11	1	0	1.08	1.54	0.70	0.92
100% NP	7	13	3	0	0.97	1.40	0.82	1.00
100% N	5	9	3	0	0.96	1.51	0.66	0.81
100% NPK + FYM	7	12	2	0	1.43	2.02	0.87	0.96
100% NPK(-S)	7	13	2	0	1.27	1.39	0.87	1.00
100% NPK + LIME	7	13	1	0	1.64	2.11	0.93	1.00
Control	7	13	-	-	1.11	1.02	-	

Shannon Weiner index was highest under 100% NPK + lime or 50% NPK followed by 100% NPK + FYM. Lowest values of this index were under 100% NPK 100% NPK + HW during 2017-18 and 150% NPK during 2018-19. Similarity index determined using Soverson's coefficient (SC) showing weed communities under most of the fertility treatments varied considerably in composition and structure than the control treatment. However, 150% NPK in 2017-18 and 100% NP , 100% NPK (-S) and 100% NPK + lime during 2018-19 had weed communities much similar to the control. Simpson's index of diversity and Simpson's reciprocal index also indicated highest weed diversity under 100% NPK + lime followed by 50% NPK during both the years (**Table 6.3**).

Table 6.3 Effect of fertility treatments on other weed indices in wheat

Treatment	Simpson's index		Simpson's index of diversity		Simpson's reciprocal index		Species richness		Evenness/Shannon equitability (EH)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
50% NPK	0.23	0.13	0.77	0.87	4.3	7.7	0.51	0.78	0.72	0.90
100% NPK	0.67	0.41	0.33	0.59	1.5	2.4	0.67	0.78	0.31	0.59
150% NPK	0.45	0.49	0.55	0.51	2.2	2.0	0.54	0.64	0.58	0.42
100% NPK + HW	0.53	0.13	0.47	0.87	1.9	7.7	0.53	0.61	0.38	0.74
100% NPK + Zn	0.51	0.35	0.49	0.65	2.0	2.9	0.56	0.88	0.55	0.64
100% NP	0.52	0.32	0.48	0.68	1.9	3.1	0.76	0.86	0.42	0.54
100% N	0.50	0.34	0.50	0.66	2.0	2.9	0.51	1.14	0.46	0.68
100% NPK + FYM	0.33	0.15	0.67	0.85	3.0	6.7	0.80	0.77	0.65	0.81
100% NPK (-S)	0.38	0.17	0.62	0.83	2.6	5.9	0.78	0.84	0.57	0.54
100% NPK + lime	0.21	0.12	0.79	0.88	4.8	8.3	0.62	0.75	0.78	0.82
Control	0.41	0.52	0.59	0.48	2.4	1.9	0.51	0.76	0.57	0.39

The lower diversity as per these indices was under 100% NPK during 2017-18 and 150% NPK during 2018-19. Species richness was highest under 100% NPK + FYM during 2017-18 and 100% N during 2018-19. The lowest was under 50% NPK, 100% N and control during 2017-18 and 100% NPK + HW during 2018-19. The evenness index also showed wide variation in weed community structure under different fertility treatments. It varied from 0.31 to 0.78 during 2017-18 and 0.39 to 0.90 under different fertility treatments during 2018-19 (value equal to one means complete evenness).

TNAU, Coimbatore

AICRP centre has linkage with Airport Authority of India to give advise about airside vegetation management to mitigate birds activities at airport area. The airport area is clean and there was no much vegetation due to drought and the soils were evacuated and placed in the outside Airport area. Some airport land area was infested predominantly with grassy weeds and to some extent with broad leaved weeds. The following weeds were infested predominantly in the airport area.

S.No.	Common Name	Scientific Name	Group
1.	Black spear grass	*Andropogon contortus*	Grass
2.	Bermuda grass	*Cynodon dactylon*	Grass
3.	Spear grass	*Heteropogon contortus*	Grass
4.	Nut sedge	*Cyperus sp.*	Sedge
5.	long-leaved wattle and golden wattle	*Acacia longifolia*	Broad leaved weed
6.	Devil's back bone	*Cissus quadrangularis*	Broad leaved weed/Creepers
7.	Indian heliotrope	*Heliotropium indicum*	Broad leaved weed

Report on airside vegetation management at Trichy International Airport

The vast area of land was infested predominantly with broad leaved weeds and to some extent grassy weeds and shrubs. The following weeds were infesting predominant.

S.No.	Common Name	Scientific Name	Group
1.	Black spear grass	*Andropogon contortus*	Grass
2.	Bermuda grass	*Cynodon dactylon*	Grass
3.	Purple chloris	*Chloris barbata*	Grass
4.	Indian mulberry	*Morinda tinctoria*	Shrub
5.	Kapok bush	*Aerva to mentosa*	Broad leaved weed
6.	Indian Mallow	*Abutilon indicum*	Broad leaved weed
7.	Gigantic swallow wort	*Calotropis gigantean*	Broad leaved weed
8.	Milk weed	*Euphorbia geneculata*	Broad leaved weed
9.	Dwarf copper leaf	*Alternanthera sessillis*	Broad leaved weed
10.	Coat buttons	*Tridax procumbens*	Broad leaved weed
11.	Field bindweed	*Convolvulus arvensis*	Broad leaved weed
12.	Madras leaf -flower	*Phyllanthus madraspatensis*	Broad leaved weed
13.	Stonebreaker	*Phyllanthus niruri*	Broad leaved weed
14.	Asthma herb	*Euphorbia hirta*	Broad leaved weed

Periodical removal of weed plants from the air force area through manual or mechanical means was suggested. If necessary, post emergence herbicides may be used.

PJTSAU, Hyderabad

Linkages with Department of Agriculture, Government of Telangana

Scientists are participating for a period of 15 days which is mandatory in Telangana state. Weed management practices were explained to farmers and brochures in local language in Rythu Chaitanya Yatras (Pre-*Kharif* Campaign) and Rythu Sadassu (*Kisangoshthies*) every year are also distributed. AICRP Centre also have effective linkages with Horticultural University, CRIDA, Krishi Vigyan Kendras and other deparments of the PJTSAU, Hyderabad

CCSHAU, Hisar

AICRP-WM, CCS HAU Hisar has established linkages with National and International institutes such as IRRI, CIMMYT, Rice-Wheat Consortium, CSISA, Australian Council of Agricultural Research and many multinational companies. It has very strong linkage with State Department of Agriculture, Haryana. All the recommendations in pipe line are tested at farmers' fields by extension officers of KVK's and Department of Agriculture, Haryana before their inclusion in package of practices. Problems faced by extension officers in implementation of weed control technology are discussed during monthly T&V meetings and ZREAC workshop held twice in a year.

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Table 7.1 Different publications by the coordinating centres during 2019-20.

Sl. No.	Centre Name	Research Paper	Popular articles	Paper presented/ seminars/ symposia/ conferences	Books	Book Chapter	Lecture delivered during training	Student guided	
								M.Sc.	Ph.D.
1	PAU, Ludhiana	5	0	8	0	0	15	3	1
2	UAS, Bengaluru	2	0	6	0	0	0	6	0
3	RVSKVV, Gwalior	4	7	0	0	0	0	3	1
4	GBPUAT, Pantnagar	3	3	0	0	0	15	6	2
5	CSKHPKV, Palampur	12	0	1	1	1	159	5	1
6	AAU, Jorhat	4	2	4	0	1	2	1	1
7	AAU, Anand	7	1	1	0	2	9	3	0
8	TNAU, Coimbatore	6	2	3	2	3	8	2	0
9	KAU, Thrissur	3	0	2	0	0	0	1	1
10	OUAT, Bhubaneshwar	3	0	0	0	0	0	3	0
11	PJTSAU, Hyderabad	4	2	1	0	4	0	2	0
12	CCSHAU, Hisar	16	5	11	0	4	3	2	1
13	IGKV, Raipur	6	1	0	0	0	2	10	2
14	PDKV, Akola	3	6	5	0	0	0	2	0
15	BCKV, Kalyani	1	0	1	0	0	0	2	0
16	MPUAT, Udaipur	8	4	1	1	2	22	4	3
17	SKUAST, Jammu	4	0	4	0	0	5	4	0
	Total	91	33	48	4	17	240	59	13

8. AWARDS AND RECOGNITIONS

CSKHPKV, Palampur

- Dr Atul Kumar, Dr Neelam Sharma, Dr A.K. Panda received 2nd Best presentation award for oral presentation in 9th IMSACON and International Symposium 2019.

AAU, Jorhat

- Dr IC Barua received Appreciation award during Annual Review Meeting of AICRP centre at AAU, Johrat on 15-16 October, 2019.

AAU, Anand

- Dr. B. D. Patel awarded with life time achievment award (Weed Science) in recognition of his meritorious contributions to weed science by National Symposium on Sustainable Management of Posts and Diseases in Augmonting Food and Nutritional Seccurity, Navsari Agricultureal University, Navsari, Gujarat.
- Dr. B. D. Patel awarded "Best Scientist Award" by EET CRS Research Wing.

KAU, Thrissur

- Best Team Research Award – 2018 by Kerala Agricultural University was given to Dr. Meera V. Menon in recognition of the outstanding research contributions.

CCSHAU, Hisar

- AICRP-WM Hisar centre was adjudged best AICRP centre during workshop at AAU, Johrat on 15-16 October ,2019.

PDKV, Akola

- The AICRP-Weed Management stall received the "Second Prize" for displaying the exhibit's in a good manner on the stall in a mega agriculture exhibition held at Dr.Panjabrao Deshmukh Krishi Vidyapeeth held during 27-31st December, 2019.

MPUAT, Udaipur

- Appreciation award to Dr. Roshan Choudhary by the Vice-Chancellor, MPUAT, Udaipur during Republic day, 2019 for outstanding work.

9. RECOMMENDATIONS OF XXVI ANNUAL REVIEW MEETING

Recommendations of XXVI Annual Review Meeting of All India Coordinated Research Project On Weed Management held at Assam Agricultural University, Jorhat (Assam) during 15-16 October, 2019 are given below:

- During spraying of herbicide safety precautions, used correct nozzles and right method of application should be followed.
- While presenting the data, unit should be given as per guidelines.
- The B: C ratio should be mentioned in the table.
- Data under collaborative experimental with other institutions/AICRPs should also be given in the annual report and presented during ARM reflecting the collaborations made with other research institutes
- Mention chemical name of the herbicide instead of trade name during presentation.
- Preparation of the annual report should be strictly based on the guidelines provided.
- Always take photographs with date and time so that it can give the idea of weather condition of that time.
- New weed species or weed infestation must be reported with proper GPS location along with good photograph.
- Executive summary in Hindi language should be included in the annual report by all the centre.
- While presenting the data original as well as transformed data should be included.
- Weed data transformation (X+0.5) or (X+1.0) should be adopted uniformly by all the centres.
- Whenever, weed-free treatment is maintained in any experiment, details of the activities adopted should be described.
- Each experiment raw data should be submitted through online data management system from *Rabi* 2019-20 onwards.
- Submit AUC in the prescribed format only.

10. 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.
- 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 proposed.
- 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' was 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 shared with the scientists of AICRP-Weed Management during the Annual Review Meeting.
- 'Parthenium-free campus' was under taken with great enthusiasm with the involvement of students and other staff of the University.
- New Volunteer centre BUAT, Banda and ANGRAU, Guntur were opened.

11. STATUS OF EXPERIMENTS

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

Table Contd...

10.	OUAT, Bhubanesh war	WP 1.1.1.1, WP1.2.2(i), WP1.2.2(ii) WP1.3.2.1	WP2.1, WP2.2	WP3.1.1(a) WP3.1.1(e), WP3.4.1	-	WP5.1, WP5.2
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 WP1.3.7	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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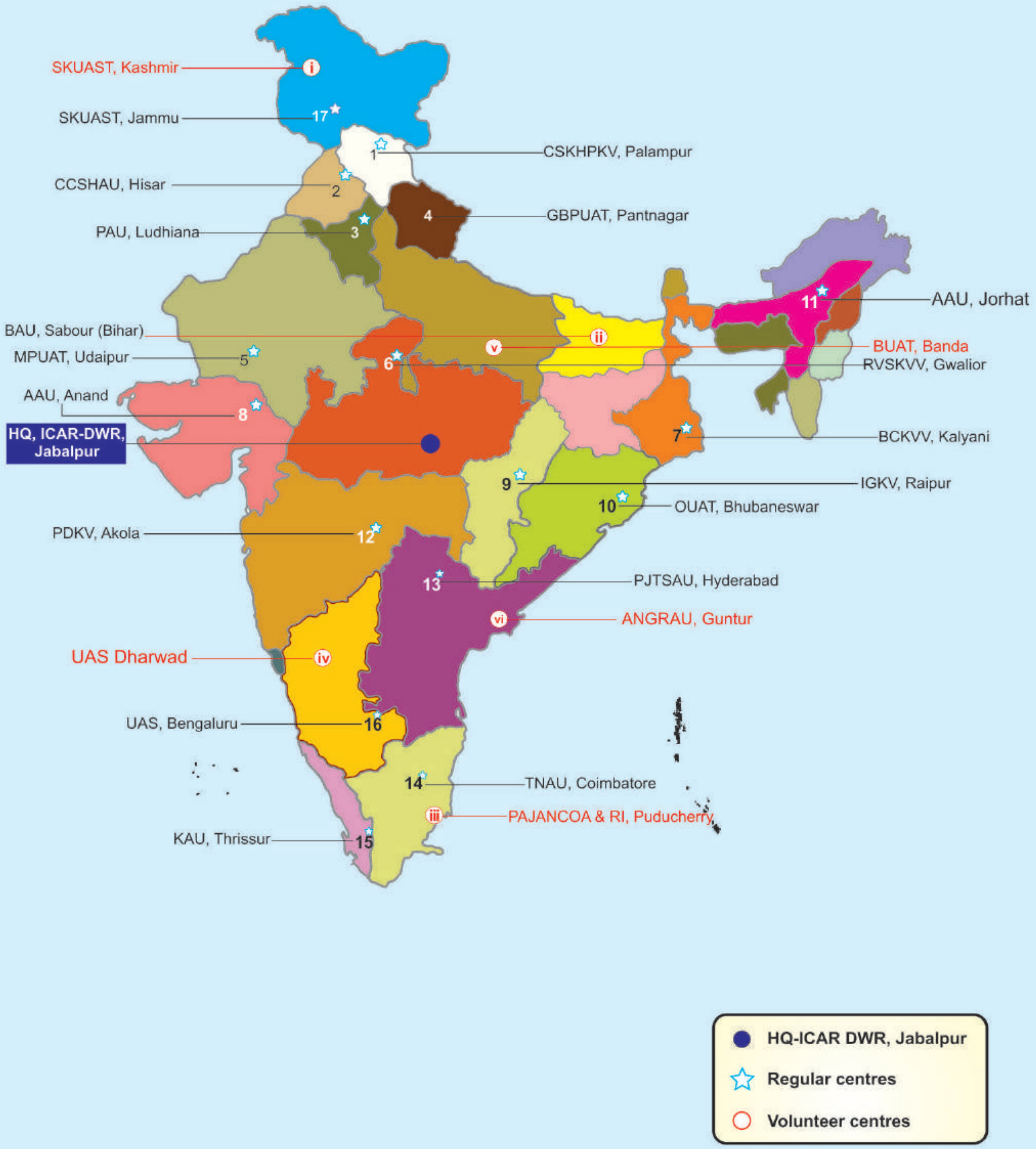
13. STATUS OF SUBMISSION OF ANNUAL REPORT 2019-20

Sl No.	Centre's name	Received	
		Before due date (10.01.2020)	After due date
Regular centres			
1.	PAU, Ludhiana	-	13.01.2020
2.	UAS, Bengaluru	06.01.2020	-
3.	RVS KVV, Gwalior	09.01.2020	-
4.	GBPUAT, Pantnagar	-	31.01.2020
5.	CSKHPKVV, Palampur	08.01.2020	-
6.	AAU, Jorhat	-	11.01.2020
7.	AAU, Anand	02.01.2020	-
8.	TNAU, Coimbatore	07.01.2020	-
9.	KAU, Thrissur	-	14.01.2020
10.	OUAT, Bhubaneswar	10.01.2020	-
11.	PJTSAU, Hyderabad	-	03.02.2020
12.	CCSHAU, Hisar	08.01.2020	-
13.	IGKVV, Raipur	10.01.2020	-
14.	SKUAST-Jammu	-	02.02.2020
15.	PDKV, Akola	10.01.2020	-
16.	MPUAT, Udaipur	-	10.02.2020
17.	BCKV, Kalyani	-	14.01.2020
Volunteer centres			
1.	SKUAST-Kashmir	-	30.01.2020
2.	PJNCA&RI, Karaikal	-	18.01.2020
3.	BAU, Sabour	-	16.07.2020
4.	UAS, Dharwad	-	-
5.	BUAT, Banda	-	15.01.2020
6.	ANGRAU, Guntur	10.01.2020	

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

Activities



SKUAST, Kashmir
i
SKUAST, Jammu
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CSKHPKV, Palampur
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CCSHAU, Hisar
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GBPUAT, Pantnagar
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PAU, Ludhiana
3
AAU, Jorhat
11
BAU, Sabour (Bihar)
ii
v
BUAT, Banda
MPUAT, Udaipur
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6
RVSKVV, Gwalior
AAU, Anand
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HQ, ICAR-DWR, Jabalpur
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BCKVV, Kalyani
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IGKV, Raipur
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OUAT, Bhubaneswar
PDKV, Akola
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PJTSAU, Hyderabad
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ANGRAU, Guntur
UAS Dharwad
iv
UAS, Bengaluru
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TNAU, Coimbatore
iii
PAJANCOA & RI, Puducherry
KAU, Thrissur
15
HQ-ICAR DWR, Jabalpur
Regular centres
Volunteer centres