अखिल भारतीय समन्वित खरपतवार प्रबंधन अनुसंधान परियोजना

All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन

ANNUAL REPORT

2020

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

ICAR - Directorate of Weed Research, Jabalpur

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AICRP-WM in the NEWS

दिव्य हिमाचल

11/16

घोरपीठ में गाजर घास पर जागरूक किए किसान

पालमपुर। रोटरी इंटरनेशनल के नए प्रकल्प 'पर्यावरण संरक्षण' के अंतर्गत पार्थेनियम कांग्रेस घास, गजर घास जागरूकता शिविर का कृषि विश्वविद्यालय और रोटरी क्लब पालमपुर द्वारा संयुक्त रूप से गांव घोरपीठ में आयोजन किया गया। कृषि से जुड़ी महिलाओं और किसानों को पार्थेनियम घास और रोटरी क्लब पालमपुर की गतिविधियों के बारे में जानकारी दी गई। रोटरियन डा. एसएस राणा, प्रिंसीपल साइंटिस्ट (एग्रोनॉमी) ने बताया इस पार्थेनियम (गाजर घास) का खरपतवार अविश्वसनीय रूप से विनाशकारी है। यह अन्य पौधों की प्रजातियों को खत्म कर देता है और फसलों के पूरे खेतों को मिटा सकता है। इस घास की तीव्र विकास दर और बीज उत्पादन के कारण खेतों व चारगाहों से इसे सफलतापूर्वक नियंत्रित करना मुश्किल हो

अमर उजाला

सीधी बुआई विधि से धान उत्पादन में बढ़त

जागरूकता सप्ताह का आयोजन

'తగిన మోతాదులో కలుపు మందులను వాడాలి'

ಕೃಷಿ

ईने दी सिंधी बिजाणी बारे पी. ए. यू. वलों ढेसबुॅक ते आन-लाइन 200 किसानां नाल विचार चरचा

दिनु मराठी विश्व

रब्बी पिकातील तण व्यवस्थापन, काळाची आवश्यकता

നെൽക്കൃഷിയിൽ കളശല്യം രൂക്ഷം; പരിഹാരവുമായി കാർഷിക സർവകലാശാല

കേരള കാർഷിക സർവകലാശാല വികസിപ്പിച്ച കെ.എ.യു. വീഡ് വൈപ്പർ എന്ന ഉപകരണം ഉപയോഗിച്ചുള്ള കളനാശികരണം

തൃശ്ശൂർ ▸ ലോക്ഡൗൺ പ്രതിസന്ധി കാരണം പണിക്കാരെ കിട്ടാനില്ലാത്തതിനാൽ നെൽപ്പാടങ്ങളിൽ വരിനെല്ല് (കള) പിടിമുറുക്കുന്നു. കോവിഡ് കാലത്ത് അതിഥിതൊഴിലാളികളും അവരുടെ നാട്ടിലേക്ക് മടങ്ങിയതോടെ ഞാറുനടാൻ ആളില്ലാത്തതാണ് പ്രതിസന്ധിയുണ്ടാക്കിയത്. പണിക്കാരി കുമ്മെന്നാണ് പാനങ്ങാം സൂചിപ്പിക്കുന്നത്.

കള പറിക്കാനുള്ള തൊഴിലാളികളെ കിട്ടാനില്ലാതായതോടെ കളനാശിനി പ്രയോഗം വ്യാപകമാകുന്നുണ്ട്. കളയും നിലവുമനുസരിച്ച് കളനാശിനി പ്രയോഗിച്ചില്ലെങ്കിൽ വിളയും നഷ്ടത്തിലേക്ക് കൂപ്പുകുത്തും.

കതിരിട്ട വരിനെല്ലിനെ നിയ

ആവളപാണ്ടിയിലെ പൂക്കാഴ്ച

പായൽ നിക്കണമെന്ന് കാർഷികവിദഗ്ധർ

फसल के साथ किसानों को बीमार करती है गाजरघा

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 122, PR 127 and, second fortnight of June is optimum for basmati rice varieties, like Pusa Basmati 1121, Pusa Basmati 1509 and Pusa Basmati 1718

SEED AND SEED TREATMENT

Use 8kg seed (maximum 10 kg) per acre. Use of more seed will result in mo dense plant populati which will restrict the flow leading to greater cidence of diseases li sheath blight and high percent of empty grai Before sowing, soak seed 10 litres of water fo hours (maxim 12 hours), in sha and tr with f gicide

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 o 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 (9872811350) and Jasvir Singh Gill (7986188110) of the PAU agronomy department

AICRP Weed Management SKUAST Jammu organises Parthenium awareness campaign

TT CORRESPONDENT

JAMMU, AUG 17: In the light of growing menace of Parthenium- Gajarghass, a nationwide campaign on the management of Parthenium is organised every year from 16-22 August, 2020 under the technical backstopping of the Directorate of Weed Research, Jabalpur (M.P.). AICRP-Weed Management, Division of Agronomy, SKUAST-Jammu initiated Week long Parthenium awareness campaign on 16th of August. On 2th day (17th August, 2020) of Parthenium Awareness Week, AICRP-Weed Management, SKUAST-Jammu organized the awareness campaign in collaboration with Advanced Centre for Rainfed Agriculture (ACRA) at Rakh Dhiansar Jammu. Dr. A. P. Singh, Incharge ACRA, SKUAST Jammu was Chief Guest on this occasion. Dr. Singh highlighted that Parthenium popularly known as Gajarghass is considered to be one of the most obnoxious weeds of the world, it has now spread throughout the length and breadth of the country including all the districts of Jammu region and described history of Parthenium spread in India. Dr. B. R. Bazaya, Senior Scientist, In-charge AICRP Weed Management appraised that the Parthenium infestation is serious issue in rainfed areas of Jammu region and highlighted its harmful effects on crops along with the associated health hazards in humans and animal health and suggested remedial measures like chemical and physical control of Parthenium. He also suggested that the Parthenium plants should be uprooted before flowering in rainy season. Dr. Permendra Singh, Dr. A.P.Rai, Dr. Jai Kumar, Dr.Brinder Singh, Dr.A. C. Jha, Dr.Vikas Gupta and non-teaching staff of ACRA Dhainsaralong with farmers of the nearby area among those who participated in this campaign.

The programme ended with vote of thanks by Miss. SupneetKour, AICRP Weed Management, SKUAST Jammu.

Photo by Surinder

गेंदा से रोक सकते हैं रोग लाने वाले गाजर घास का फैलाव

चोरया (नईदुनिया प्रतिनिधि)। गेंदा का फूल न केवल हमारे घर-आंगन और खेतों को खूबसूरत रंगत से नवाजते हैं, बल्कि सेहत और खेतों को नुकसान पहुंचाने वाले गाजर घास के फैलाव को रोकने में भी मददगार साबित हो सकते हैं। हर वृष्टि से मनुष्य और पशुओं के लिए रोग व उनमें नुकसान का कारण बनने वाले गाजर घास से मुक्ति पाने अक्टूबर-नवंबर में किसान अपने खेतों के आसपास के क्षेत्रों में गेंदे के पौधे लगाकर इस खरपतवार को फैलने से रोक सकते हैं।

कृषि विज्ञान केंद्र कटघोरा के तत्वाधान में पोंड़ी-उपरोड़ा विकासखंड के ग्राम भांवर, सोनपुरी व लखनपुर में गाजर घास उन्मूलन सप्ताह मनाया गया। 16 से 22 अगस्त के बीच आयोजित कार्यक्रम में कृषि विज्ञान केंद्र के वैज्ञानिकों ने गांव के कृषकों को गाजर घास के नुकसान व उससे मुक्ति के उपाय की जानकारी प्रदान की। केंद्र के कृषि वैज्ञानिक डॉ. एसके उपाध्याय ने बताया कि गाजर घास यह एक प्रकार का खरपतवार है, जो वर्ष भर उगता, फलता व फूलता रहता है।

इसका फूल सफेद व पत्तियां गाजर के समान होती हैं, इसलिए इसे गाजर घास कहा जाता है। प्रतिवर्ष ग्रामीण कृषकों को इस खरपतवार से नियंत्रण के लिए आवश्यक सुझाव प्रदान किए गए। उन्हें बताया गया कि घर-बाड़ी के आसपास इनकी पौधावस्था दिखाई देने पर तत्काल गाजर घास को उखाड़कर जला देना चाहिए। ऐसा न हो पाया तो फूल आने के पहले ही पौधों को उखाड़कर कंपोस्ट पिट में डालकर खाद बना लेना चाहिए।

कोरया। गाजरघास का नुकसान बताते कृषि विज्ञान केंद्र कटघोरा के वैज्ञानिक। • पड़ुनिया

डॉ. महोबिया ने बताई रासायनिक विधि

कृषि विज्ञान केंद्र प्रमुख एवं वरिष्ठ वैज्ञानिक डॉ. आरके महोबिया ने गाजर घास को नष्ट करने और इसके फैलाव को नियंत्रित करने की रासायनिक विधियों की जानकारी प्रदान की। डॉ. महोबिया ने बताया कि गाजर घास में फूल आने के पहले ग्लाएफोसेट 1.0-1.5 किग्रा या मेट्रीब्यूजिन 0.3-0.5 पीसदयोल का छिड़काव करने पर इससे निजात पाकर उससे होने वाली हानि से बचा जा सकताहै। इसके अलावा इस खरपतवार के नियंत्रण के लिए अक्टूबर-नवंबर में खेत के आसपास के क्षेत्रों में गेंदे के पौधे लगाकर फैलाव और वृद्धि को रोका जा सकताहै। इस तरह गेंदा लगाकर गाजर घास को रोकने के साथ-साथ अपने खेतों के आसपास खूबसूरती बिखेर सकते हैं।

चर्म, एविजया, एलर्जी दमा की बीमारी

केंद्र के कृषि वैज्ञानिक डॉ. उपाध्याय ने बताया कि गाजर घास क्याहै और उससे मनुष्य, पशु और पर्यावरण को किस तरह से हानि को रही। उन्होंने इस संबंध में किसानों से वर्ष कर विस्तार से मार्गदर्शन प्रदान किया। डॉ. उपाध्याय ने बताया कि गाजर घास से मनुष्यों में त्वचा संबंधी रोग, एविजया, एलर्जी, दमा जैसी बीमारियां उत्पन्न होती हैं। इन बीमारियों में खासकर दमा के रोगियों के लिए गाजर घास के फूलों से निकलने वाले परागकण काफी नुकसान पहुंचाते हैं। इस तरह के रोगों के बचने के लिए गाजर घास को अपने आसपास पनपने से रोकने का प्रयास जरूरी है। इसी तरह कुक्कुट पशुओं के खाए जाने पर गाजर घास के असर से उनके बचाव का कदम उठाना है।

अखिल भारतीय समन्वित खरपतवार प्रबंधन अनुसंधान परियोजना
All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन
Annual Report
2020

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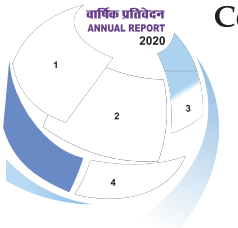


Cover page photographs

1. *Orobanche* infestation
2. Striga sp. infestation
3. Uprooting of *Parthenium hysterophorius*;
4. XXVII Annual Review Meeting of AICRP-WM

Preface

Weeds are one of the major constraints in agricultural production systems. The systematic research on weed management in different agro-ecosystems in India was initiated by the Indian Council of Agricultural Research (ICAR) in 1978 with the launch of All India Coordinated Research Project on Weed Management (AICRP-WM). At present, the AICRP-WM is operating with 17 regular and 7 voluntary centres located in different State Agricultural Universities of the country, with basic mandate to develop and disseminate location-specific weed management technologies in diverse crops and cropping systems, non-cropped areas and aquatic environments. The AICRP-WM centres have been conducting research in the thematic areas of sustainable weed management in diversified cropping systems, conservation agriculture, organic weed management, weed dynamics and management under changing climate, herbicide resistance management, biology and management of problem weeds, monitoring, degradation and mitigation of herbicide residues in the environment, on-farm research and demonstration of improved weed management technologies, and impact assessment.

The research progress and technical programme at the centers were thoroughly reviewed during the XXVIII Annual Review Meeting in a virtual mode due to COVID-19 pandemic. In this Annual Report 2020 of AICRP-WM, the salient achievements of network experiments, on-farm research and demonstrations, activities under SCSP programme, recommendations included in the State package of practices, and other activities are briefly presented. It is hoped that the information in this report is useful to the researchers, students and other stakeholders engaged in weed management research and development.

My sincere thanks to Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR, Dr. S.K. Chaudhari, DDG (NRM) and Dr. S. Bhaskar, ADG (A, AF & CC) for their kind support and guidance in executing the mandate of the project. I also thank the scientists and officials from NRM Division, ICAR for their constant support.

The contributions and cooperation of the scientists from different AICRP-WM centres are highly appreciated. I wish to complement Dr. Shobha Sondhia, Incharge, AICRP-WM for coordination and monitoring of the project activities, and implementation of the technical programme. The support and cooperation received from Dr. P.K. Singh, Pr. Scientist, Dr. Sushilkuamr, Pr. Scientist, Dr. R.P. Dubey, Pr. Scientist, Dr. P.K. Mukharjee, Pr. Scientist, Dr. V.K. Choudhary, Sr Scientist, Dr. D. Sreekanth, Scientist, Mr. Pankaj Shukla and Mr. O.N. Tiwari in compilation of data and bringing out the report in present form is duly acknowledged.

(J.S. Mishra)
Director
ICAR-DWR, Jabalpur

Contents

विशिष्ट सारांश

यह निदेशालय, अखिल भारतीय समन्वित खरपवार प्रबंघन परियोजना के 17 नियमित और 7 स्वैच्छिक केन्द्र, जो कि देश के विभिन्न राज्यों के स्थित कृषि विश्वविद्यालयों में स्थित है, के माध्यम से विभिन्न फसलों, फसल प्रणाली और गैर फसलीय क्षेत्रों में खरपतवार प्रबंधन हेतु अनुसंधान कार्य कर रहा है। वर्ष 2020 के दौरान किये गये मुख्य अनुसंधानीय उपलब्धियॉ निम्नानुसार है :

डब्लू पी 1: खरपतवार प्रबंधन की स्थान विशिष्ट पद्धतियों का विकास

- आनंद (गुजरात) में सूखी सीधी बुवाई धान में खरपतवार प्रबंधन के लिए (पूर्व मिश्रित) ट्रायफामोन + इथाक्सी सल्फयूरान (44.0+22.5 ग्रा/हे) अंकुरण पश्चात् तदोपरांत 30 दिन पश्चात् यांत्रिकी निंदाई के अनुप्रयोग से उच्चतर खरपतवार नियंत्रण दक्षता (91.0%) पायी गयी। सभी उपचारों में प्रेटिलाक्लोर + पाइरोजोसल्फयूरान–इथाईल (600+15 ग्रा हे) का प्रयोग अंकुरण पूर्व (पूर्व मिश्रित) करने पर अंकुरण के 30 दिन पश्चात् पौधे का शुष्क भार (5.41 ग्रा/पौधा), उपज शुद्ध मिश्रित एवं अनुपात सार्थक रूप से उच्चतर दर्ज की गई । शुद्ध लाभ ₹ 34,226/हे एवं लागत अनुपात (1.83) पाया गया।
- कोयम्बटूर में, रोपित धान–धान की फसल प्रणाली पर दीर्घकालिक परीक्षण में, अंकुरण के पूर्व पाइरोजोसल्फयूरान –इथाईल (20 ग्रा/हे) एवं पेनाक्सुलम+साइहैलेफाप व्यूटाइल (135 ग्रा/हे.) (पूर्व मिश्रित) के प्रयोग से उपज में सार्थक रूप से वृद्धि दर्ज की गई एवं मृदा एवं धान के दानों में शाकनाशी अवशेष आपेक्षित स्तर पहचान सीमा (0.01 मिग्रा/किग्रा) से कम पाये गये।
- रायपुर में, रोपित धान – चना फसल पद्धति में अंकुरण के पूर्व प्रेटिलाक्लोर+ बेनसल्फयूरान 660 ग्रा/हे रोपण के 10–12 दिन पश्चात् तदोपरांत पेनाक्सुलम+सायहेलोफाप 135 ग्रा/हे रोपण के 25–30 दिन पश्चात, के प्रयोग से दानों की अधिकतम उपज (6.28 ट/हे) एवं शुद्ध लाभ (₹ 81,767/हे) एवं लाभ लागत अनुपात (3.30) पाया गया ।
- कोयम्बटूर में, कपास – बेबीकार्न आधारित संरक्षित खेती के अंतर्गत परंपरागत जुताई – शून्य जुताई – शून्य जुताई पद्धति में उच्चतर खरपतवार नियंत्रण दक्षता (79.9%) दर्ज की गई। खरपतवार प्रबंधन पद्धतियों में अंकुरण पूर्व पेंडीमेथालिन (680 ग्रा/हे) तदोपरांत पेराक्वाट (0.6 कि ग्रा/हे) का नियंत्रित छिड़काव करने पर उच्चतर खरपतवार नियंत्रण दक्षता (80.7%) दर्ज की गई ।
- बैंगलुरू में, मक्का में संरक्षित खेती पद्धति के अंतर्गत एकीकृत खरपतवार प्रबंधन पद्धतियों की बिना उपचार की तुलना में निम्नतम खरपतवार घनत्व (7.57 नं./मी.^{2}) और शुष्क भार (2.50 ग्रा/मी^{2}) बुवाई के 60 दिन पश्चात् दर्ज किया गया। खरपतवार

This Directorate coordinates its network programme, through its 17 regular centres at SAUs and 7 voluntary centres under All India Coordinated Research Project on Weed Management (AICRP-WM) all over the country in different agro-climatic zones. The salient achievements during 2020 are as follows:

WP 1 Development of location specific sustainable weed management practices

- At Anand, application of triafamone + ethoxysulfuron (44.0+22.5 g/ha) EPoE (PM) *fb* mechanical weeding at 30 DAS recorded higher weed control efficiency (91.0%) in dry direct seeded rice. Application of pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (pre-mix) *fb* HW at 30 DAS resulted in significantly higher plant dry biomass (5.41 g/plant), yield, net realization (₹ 34,226/ha) and benefit cost ratio (1.83).
- At Coimbatore in a long-term herbicide trial in transplanted lowland rice-rice cropping system, significantly higher grain yield and income was obtained with PE pyrasosulfuron-ethyl (20 g/ha) *fb* penoxsulam+ cyhalofop butyl (135 g/ha) ready mix (RM). Residues of herbicides in the soil and rice grain at harvest were found below the detection limit of 0.01 mg/kg.
- In transplanted rice-chickpea cropping system at Raipur; the lowest weed dry weight (18.7 g/m^2) was registered under EPoE of pretilachlor + bensulfuron 660 g/ha 10-12 DAT *fb* penoxsulam + cyhalofop 135 g/ha PoE as ready-mix at 25-30 DAS and achieved maximum grain yield (6.28 t/ha), highest net returns (₹ 81,767/ha) and higher B:C (3.30).
- At Coimbatore, higher weed control efficiency of 79.5% was recorded in CT+ZT+ZT system in cotton-baby corn based cropping system under conservation agriculture. Among weed management practices, PE pendimethalin (CS) 680 g/ha followed by directed spray of paraquat 0.6 kg/ha recorded higher weed control efficiency (80.7%) in cotton.
- In conservation agriculture systems, integrated weed management practices i.e. pendimethalin 750 g/ha followed by hand weeding at 30 DAS recorded highest seed yield (3.51 t/ha) compared to use of only

प्रंबधन पद्धतियों में एकीकृत खरपतवार प्रबंधन जैसे पेंडीमेथालिन 750 ग्रा/हे तदोपरांत 30 दिन पश्चात हाथ द्वारा निंदाई करने से उच्चतम उपज 3.51 ट./हे प्राप्त की गई, जबकि अनुसंशित शाकनाशी पेंडीमेथालिन 750 ग्रा/हे तदोपरांत टेम्बोट्रायन 120 ग्रा/हे + एट्राजिन 500 ग्रा/हे में 3. 18 ट./हे पायी गयी ।

- भुवनेश्वर में, रोपित धान – बिना जुताई – बिना जुताई की पद्धति से रबी (5.3 टन/हे.) एवं खरीफ (4.47 टन/हे.) में अधिक उपज दर्ज की गई। दोनो ही मौसम में परंपरागत जुताई की तुलना में बिना जुताई सीधी बुवाई की धान फसल अवशेष सहित बिना जुताई सीधी बुवाई की उपज में 25% की कमी पायी गई।
- अकोला की कछारी भूमि में सोयाबीन – गेंहू–मूंग फसल चक्र में संरक्षित खेती के अंतर्गत दो बार हैरोइंग एक बार टाईन हैरो और एक बार ब्लेड हैरो (पारंपरिक जुताई) के बदले में रोटोटिल (न्यूनतम जुताई) और शून्य जुताई के साथ शाकनाशी के प्रयोग के साथ एकीकृत खरपतवार प्रबंधन द्वारा मृदा के भौतिक गुण सुधरने के फलस्वरूप फसल उत्पादकता में बढ़ोत्तरी के साथ आर्थिक सुरक्षा पायी गई ।
- त्रिशूर में, विभिन्न प्रकार के कार्बनिक मल्चों द्वारा जलकुंभी घास की कतरनों और कटहल की पत्तियों द्वारा मल्च के रूप में प्रयोग करने से अदरक के कंदो की उच्चतर उपज दर्ज की गयी।
- त्रिशूर में, कसावा के जैविक उत्पादन में अंतःफसल दलहन/मूंग/चने की दाल तदोपरांत रोपण के 60 दिन पश्चात् एक बार मिट्टी चढ़ाने पर खरपतवार प्रबंधन तकनीक से उपज में 29: की बढ़ोत्तरी दर्ज की गई।
- जम्मू में धान की जैविक खेती में, ढैंचा हरी खाद तदोपरान्त रोपड़ के 30 दिन पश्चात एक बार हाथ द्वारा निंदाई तदोपरान्त ढ़ैंचा हरीखाद तदोपरान्त गेहूँ का कटा हुआ भूसा (5 टन/हे.) रोपड़ के समय प्रयोग करने पर उच्चतम दानो की उपज और लाभ लागत अनुपात दर्ज किया गया।
- हैदराबाद में, बेबी कार्न में स्टेल सीड बेड तकनीक अथवा पुआल की मल्चिंग (5 टन/हे.) का प्रयोग बेबी कार्न–गोभी–फसल–प्रणाली में अरासयनिक खरपतवार नियंत्रण विधियों में अधिक प्रभावशाली पाया गया।
- उदयपुर में, सौंफ में, बुवाई के समय प्लास्टिक मल्च के साथ ग्रीष्मकालीन जुताई, स्टेल सीड बेड और मृदा सूर्यीकरण से अधिक उपज दर्ज की गई। जैविक खरपतवार प्रबंधन पद्धतियों में स्टेल सीड बेड तैयारी+बुवाई के समय प्लास्टिक मल्च के प्रयोग से उच्चतम शुद्ध लाभ (₹ 83,619/हे.) और लाभ : लागत अनुपात (2.16) पाया गया।

recommended herbicide pendimethalin 750 g/ha *fb* tembotrione 120 g/ha + atrazine 500 g/ha (3.18 t/ha) at Bengaluru. This also resulted in lowest weed density (7.57 No./m^2) and dry weight (2.50 g/m^2) of weeds at 60 DAS in maize.

- At Bhubaneswar, the practice of CT (transplanting)-ZT-ZT system of tillage recorded significantly higher grain yield in both *Rabi* (5.3 t/ha) and *Kharif* (4.47 t/ha). Practice of ZT (DSR)-ZT+R-ZT system resulted in 25% yield reduction as compared to CT-CT in both the seasons.
- At Akola, in soybean-wheat-greengram cropping system, 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 not only improved the physical properties of soil, but provided added productivity and economic security in vertisols under conservation agriculture.
- Among the various organic mulches *Eichhornia*, grass clippings and jack leaves resulted in higher yield in ginger at Thrissur.
- In organic production of cassava, intercropping of a legume - cowpea/green gram/horse gram *fb* one earthing up at 60 DAP was found effective weed management technique and resulted in 29% increase yield at Thrissur.
- In organic farming of rice, the highest grain yield and B:C of transplanted rice was recorded with *Sesbania* green manure *fb* 1 hand weeding at 30 DAT followed by *Sesbania* green manure *fb* chopped wheat straw mulch (5 t/ha) at transplanting at Jammu.
- At Hyderabad, stale seedbed technique or straw mulching 5 t/ha were effective non-chemical weed control methods and resulted in higher yield of baby corn in baby corn-cabbage cropping system.
- At Udaipur, in fennel, application of plastic mulch with summer ploughing, stale seed bed and soil solarization increased yield over weedy check (420 kg/ha). Among organic weed management practices, the highest net returns (₹ 83,619/ha) and BC ratio (2.16) was obtained with stale seed bed preparation + plastic mulch at sowing.

- कल्याणी में, गन्ने में अंकुरण पूर्व एट्राजिन 2000 ग्रा./हे. तदोपरान्त मेटसल्फ्यूरॉन+कारफेन्ट्राजोन (रेडीमिक्स) 25 ग्रा./हे. तदोपरान्त बुवाई के 60 दिन पश्चात् पुनः उपयोग करने पर 81.6 ट./हे. गन्ने की उपज के साथ–साथ 2.21 लाभ : लागत अनुपात दर्ज किया गया।
- आनंद में पेंडीमेथालिन 680 ग्रा/हे अंकुरण पूर्व पेंडीमेथालिन + इमेजाथापायर (640–800 ग्रा/हे) अंकुरण के प्रयोग से लूसर्न की फसल में पादप विषाक्ता पायी गयी। फ्लुआजीफाप–ब्यूटाईल + फोमेसाफेन 250 ग्रा/हे अंकुरण पूर्व प्रयोग से लूसर्न में कम अंकुरण पाया गया और लूसर्न के पत्तों में जलने के लक्षण पाये गये ।
- हिसार में, *फैलरिस माइनर* में क्लोडिनाफाप–प्रोपारजिल, सल्फोसल्यूरॉन और पिनाक्सॉडेन के प्रति क्रास प्रतिरोधी क्षमता दर्ज की गई। अंकुरण के पूर्व पायरोजासल्यूरान+पेन्डीमीथेलिन (टेन्क मिक्स) 127.5+1500 ग्रा./हे. तदोपरान्त अंकुरण पश्चात् शाकनाशी के प्रयोग से *फैलारिस माइनर* का 98% नियंत्रण के साथ 5.49 ट./हे. दानो की उपज दर्ज की गई जो कि पूर्व में अनुशंसित किये गये शाकनाशी पेन्डीमीथेलिन 1500 ग्रा./हे. से 10.7% ज्यादा पाया गया।

डब्लू पी 2: गैर फसलीय एवं जलीय क्षेत्रों में खरपतवार प्रबंधन

- हिमाचल प्रदेश के किन्नौर जिले में एक नई खरपतवार *इरीजेरोन कैनडेनसिस* पायी गई। यह भविष्य में जैव विविधता के लिए एक प्रबल खतरा हो सकती है।
- त्रिशूर में पोयेसी फेमिली की एक नई खरपतवार *रोटबोलिया कोचिन चाइनेंसिस* को पहचाना गया जो एफसीआई गोदामों, वेयर हाउस, सार्वजनिक वितरण की दुकानों और फर्नीचरों की दुकानों में पायी गयी।
- जोरहट में, गहरे पानी वाले धान में दो नये खरपतवार *बूटोमोप्सिस लेटीफोलिया* और पोलीगोनम बारबेटम वर्ष 2020 के दौरान दर्ज किये गये।
- तेलंगाना में, नागार्जुन सागर परियोजना की बाँई नहर के धान उपजाने वाले क्षेत्रों में सीधी बुवाई वाले धान में *लेप्टोक्लोआ चाइनेंसिस* नामक नया खरपतवार आर्थिक महत्व के रूप में उभर रहा है।
- कोयम्बटूर में, घासकुल का खरपतवार *इकाईनोक्लोवा क्रसगाली* का *लेप्टोक्लोआ चेनिसिस* द्वारा विस्थापन नौवें धान चक्र में धान – धान फसल प्रणाली में पाया गया ।
- त्रिशूर में गैर फसली क्षेत्रों में 2,4–डी, 1.25 किग्रा/हे + ग्लायफोसेट 2 किग्रा/हे के प्रयोग से 10 दिनों में *स्फाजेनतिकोला ट्राइलोबाटा* का 100% नियंत्रण पाया गया ।

- At Kalyani, application of atrazine 2000 g/ha *fb* metsulfuron+carfentrazone (RM) 25 g/ha PE *fb* PoE-60 DAP recorded 81.6 t/ha sugarcane yield and 2.21 BC ratio.
- At Anand, application of pendimethalin 680 g/ha PE, pendimethalin + imazethapyr (pre-mix) 640 g/ha and 800 g/ha PE were found phytotoxic to lucerne crop and poor germination was observed in treated plots as compared to untreated check. Further, fluazifop-p-butyl + fomesafen 250 g/ha PoE was also found phytotoxic to lucerne crop and showed burning effect on leaves of lucerne.
- At Hisar, *P. minor* has developed cross resistance against clodinafop-propargyl, sulfosulfuron and pinoxaden and use of pre-emergence use of pyroxasulfone + pendimethalin (TM) 127.5 + 1500 g/ha followed by POE herbicides provided 98% control of *P. minor* with grain yield of 5.49 t/ha which was 10.7% higher than earlier recommended herbicide pendimethalin at 1500 g/ha.

WP 2 Management of weeds in non-cropped and aquatic areas

- *Erigeron canedensis* had made its entry in district Kinnaur of Himachal Pradesh. It may be a potential future threat for biodiversity and habitat loss in the valley.
- At Thrissur, a new weed of family Poaceae was identified as *Rottboellia cochinchinensis* and found to be distributed near FCI godowns, warehouses, public distribution shops and furniture shops.
- Two new weeds, viz., *Butomopsis latifolia* (D.Don) Kunth and *Polygonum barbatum* (Linn.) have been recorded during 2020 in deep water paddy situation at Jorhat.
- *Leptochola chinensis* is emerging as a new weed of economic importance in rice fields especially in DSR fields in rice-growing areas of Nagarjuna Sagar Project Left Canal.
- Shift in grassy w eed from dominant *Echinocloa crus-galli* to *Leptochloa chinensis* was found after 9th rice in the rice - rice cropping system at Coimbatore.
- For non-cropped areas, a combination spray of 2,4-D (1.25 kg/ha) + glyphosate (2 kg/ha) gave 100% control of *Sphagnetticola trilobata* within 10 days of spraying at Thrissur.

- त्रिशूर में जलमग्न जलीय खरपतवार इंडियन स्टार वार्ट (*हाइड्रिला वर्टीसिलाटा*) का पानी में अम्लीय पी.एच. बनाए रखने और चूना का उपयोग या तो त्वरित चूना या हाइड्रेटेड चूने के रूप में करने से 4 दिनों के भीतर 90% से अधिक नियंत्रण पाया गया।

डब्लू पी 3: विभिन्न कृषि परिस्थितिकीय तंत्र में शाकनाशी की स्थिरता

- कोयम्बटूर में सभी जुताई विधियों में पेंडीमेथालिन के मृदा, अनाज एवं पुआल में अवशेष 0.01 मिग्रा प्रति किग्रा से कम पाये गये । खरपतवार नियंत्रण में जुताई प्रबंधन पद्धति में फसल अवशेष के साथ बिना जुताई की विधि एवं मृदा एंजाइमों जैसे फासफेट, डिहाईड्रीजेनेज एवं उच्च माइक्रोबियल बायोमास नाइट्रोजन एवं माइक्रोबियल बायोमास कार्बन में उल्लेखनीय रूप से वृद्धि एवं अंकुरण के पूर्व पेंडीमेथालिन 1.0 किग्रा/हे + बुवाई के 45 दिनों बाद हाथ द्वारा निंदाई में पायी गई।
- लुधियाना में, पाइरोक्जासल्फोन की हाफ लाईफ (डीटी$_{50}$) की रेंज 28.07 से 42.11 दिनो तक 76.5, 102, 127.5, 204 और 255 ग्रा./हे. के प्रयोग की दर में थी। पाइरोक्जासल्फोन का प्रभाव डीहाइड्रोजिनेस क्रियाविधि एवं मृदा माइक्रोबियल बायोमास पर अल्पकालिक पाया गया।
- हैदराबाद में, धान उपजाने वाले क्षेत्रो से जल निकास नाली, सतह एवं भूजल से एकत्र किये गये जल के नमूनों में प्रेटिलाक्लोर के अवशेष 0.052 और 0.081 कि.गा./ली. पाये गये।
- पालमपुर में, विभिन्न जुताई एवं अवशेष प्रबंधन तकनीकों में मृदा एवं अनाज के नमूनों में ब्यूटाक्लोर एवं आइसोप्रोटूरान के अवशेष कटाई के समय अपेक्षित स्तर (0.05 मिग्रा/ग्रा) से कम पाये गये ।
- कोयम्बटूर में कटाई के समय आक्सीफलोरफेन के अवशेष प्याज के पौधे एवं मृदा में नहीं पाये गये जबकि प्याज के कंद में अवशेष 0.036 मिग्रा/ग्रा दर्ज किया गया जो कि एमआरएल 0.05 मिग्रा/ग्रा से कम था ।

डब्लू पी 4: खरपतवार प्रबंधन तकनीको का प्रथम पंक्ति प्रदर्शन द्वारा प्रसार

- कोयम्बटूर में मूंगफली में खेत परीक्षण पर एकीकृत खरपतवार प्रबंधन इमेजोथापायर + क्वाजालाफोप (50+50 ग्रा/हे) तदोपरांत बुवाई के 30–35 दिन पश्चात् हाथ से निंदाई करने पर विस्तृत खरपतवार नियंत्रण एवं अधिक बीज उपज तथा आर्थिक लाभ पाया गया।

- More than 90% submerged aquatic weed Indian star wort (*Hydrilla vertcillata*) was controlled by maintaining acidic pH and lime application either as quick lime or hydrated lime within 4 days of liming.

WP 3 Fate of herbicide in different agro ecosystem

- The residues of pendimethalin in soil, grain and straw were found to be below 0.01 mg/kg irrespective of the tillage management practices followed for weed control. Among the tillage methods, soil enzymes viz., alkaline phosphatase, dehydrogenase and urease and microbial biomass carbon were significantly higher in ZT+R system and PE pendimethalin at 1.0 kg/ha + HW on 45 DAS.
- At Ludhiana, the half- lives (DT_{50}) of pyroxasulfone ranged from 28.07 to 42.11 days at application rates of 76.5, 102, 127.5, 204 and 255 g/ha. Pyroxasulfone had a transitory effect on dehydrogenase activity and soil microbial biomass.
- At Hyderabad, pretilachlor residues were detected (0.052 and 0.081 mg/l) in two water samples collected from drain channels, (out of a total of 10 samples) in surface and groundwater in rice cultivated areas.
- At Palampur, under different tillage and residue management techniques, residues of butachlor and isoproturon in soil and grains samples were found to be below detectable limits (<0.05 µg/g) at the time of harvest.
- At harvest oxyfluorfen residues were not detected in soil as well as in onion plant top whereas in onion bulb the residue of 0.036 mg/ kg was recorded. However, it was below the MRL of 0.05 mg/kg at Coimbatore.

WP 4 Dissemination of weed management technologies through FLDs and capacity building

- On farm trial on integrated weed management in groundnut with EPOE imazethapyr + quizalafob-ethyl (50+50 g/ha) *fb* hand weeding 30 - 35 DAP provided broad spectrum weed control and higher seed yield and economic returns in groundnut at Coimbatore.

- आनंद में, सोयाबीन में किसानों की पद्धति (इमेजोथापायर+ इमेजाफाक्स पूर्व मिश्रित 70 ग्रा/हे) की तुलना में प्रोपाक्विजाफोप + इमेजेथापायर (पूर्व मिश्रित) 125 ग्रा/हे से 9.09% अधिक उपज एवं लाभ–लागत अनुपात (1.63) प्राप्त हुआ एवं गेहूं में पूर्व मिश्रित शाकनाशी क्लोडिनाफोप + मेटससल्फयूरान–मिथाइल (60 ग्रा/हे) का अंकुरण के पश्चात प्रयोग करने से किसानों की पद्धति (मेटसलफयूरान 4 ग्रा/हे) की तुलना में प्रभावकारी खरपतवार नियंत्रण एवं 9.19% अधिक उपज, शुद्ध लाभ एवं लाभ–लागत अनुपात (2.39) प्राप्त हुआ ।
- लुधियाना में, पाइरोक्जासल्फोन 127.5 ग्रा./हे. का प्रयोग सभी स्थानो पर प्रतिरोधक *फैलारिस माइनर* के प्रति प्रभावी पाया गया एवं कृषक इस नये शाकनाशी के उपयोग से संतुष्ट पाये गये।
- उदयपुर में, बैगन में *औरोबेंकी* के प्रबंधन पर पांच प्रदर्शन शारदा तहसील के कन्टोड़ा गांव में किये गये। इथाक्सीसल्फ्यूरान 20 ग्रा./हे. का दो बार प्रयोग रोपड के 45 दिन पश्चात् करने पर औरोबेंकी के प्रकोप को कम करने पर बहुत ही मददगार पाया गया एवं कृषक पद्धति से बैगन की उपज में 11.86% की तुलना में अधिक उपज दर्ज की गयी।
- भुवनेश्वर में, रबी 2019–20 में सिंहबरहामपोर, देलंगा, पुरी जिले में मूंग और मूंगफली में दो कृषक प्रक्षेत्रो में पेन्डीमीथेलिन 750 ग्रा./हे. के उपयोग से मूंग में अधिकतम उपज 1.0 टन/हे. और मूंगफली में 1.6 टन/हे.पायी गयी। मूंग में शुद्ध आय ₹ 6,500/हे. और मूंगफली में ₹ 10,000/हे. प्राप्त हुई।
- कोयम्बटूर में विकसित खरपतवार प्रबंधन की पद्धति (अंकुरण से पूर्व आक्सीफलोरफेन 0.25 किग्रा/हे तदोपरांत 30–35 दिनों पश्चात् हाथ से निंदाई में किसानों की हाथ द्वारा निंदाई पद्धति की अपेक्षा हल्दी की उपज में 22 से 25.9% अधिक उपज प्राप्त हुई।
- कर्नाटक के एक जिले में अनुसूचित जाति के कार्यक्रम क्रियान्वयन के अंतर्गत् खरीफ 2020 में खरपतवार प्रबंधन के उपकरण जैसे साइकिल बीडर, कुदाल, बरवारी, हसिया आदि 68 किसानों को वितरित किये गये ।

- At Anand, application of propaquizafop + imazethapyr (premix) 125 g/ha gave 9.09% higher yield, net returns and B:C (1.63) as compared to farmers practice [(imazethapyr + imazamox (premix) 70 g/ha)] in soybean. In wheat, application of pre mixed herbicides clodinafop + metsulfuron-methyl 64.0 g/ha PoE gave effective control of complex weed flora and 9.19% higher yield, net profit and B:C (2.39) as compared to farmers practice (metsulfuron 4 g/ha PoE).
- At Ludhiana, pyroxasulfone at 127.5 g/ha found to be effective against resistant *Phalaris minor* at all locations and farmers were satisfied with the performance of new herbicide.
- At Udaipur, five demonstrations on management of *Orobanchae* in brinjal was conducted at Kantoda village of tehsil- Sarada. Application of ethoxysulfuron twice; 20 g/ha at 45 DAT followed by 15 g/ha at 90 DAT was found very helpful in reducing the *Orobanche* infestation and increasing brinjal yield by 11.8% over farmer's practice.
- At Bhubaneswar, two OFR were conducted on greengram and groundnut during *Rabi* 2019-20 at Singhberhampore, Delanga, Puri districts which resulted in maximum yield of 1.0 t/ha in greengram and 1.6 t/ha in groundnut in the plot applied with pendimethalin 750 g/ha. A net saving of ₹ 6,500/ha in greengram and ₹ 10,000/ha in groundnut were obtained in the plots treated with herbicides.
- On adoption of improved weed management technology (PE oxyfluorfen 0.25 kg/ha *fb* hand weeding at 30-35 DAP) turmeric yields increased from 22.2 to 25.9% higher over farmers' practice (two hand weeding). Higher income was also obtained by improved practice over farmers practice at Coimbatore.
- Under implemented Scheduled Caste Sub Plan Programme during *Kharif* 2020, sixty eight (65+3) new weed management equipments/ tools (Cycle weeder, Varvari, Spade, Sickles and Rakes) were distributed to 68 farmers.

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, Bengaluru (Karnataka); Indian Institute of Technology, Kharagpur (West Bengal); Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.); Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (U.P.); and Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur (H.P.). The project came into operation in April, 1978 with the financial outlay of ₹ 42.97 lakhs for five years. The tenure of the project was, however, extended for one more year till March, 1984. 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, Bengaluru (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 ₹ 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 ₹ 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), XII plan (2012-17) and 3 year plan 2017-20, the total expenditure incurred under AICRP-WM was ₹ 823.79, 1696.57, 3548.78 and 4007.26 lakhs and 2883.33 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 Sciences, Raichur; Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola; Bidhan Chandra Krishi Viswavidyalaya, Kalyani; Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Central Agricultural University, Pasighat by redeployment of existing manpower were opened. As per the approval of SFC (2017-20), other six coordinating centres (NDUAT, Faizabad; CAU, Pasighat; RAU, Pusa; BAU, Ranchi; DBSKKV, Dapoli and UAS, Raichur) were closed w.e.f. 1.4.2018.

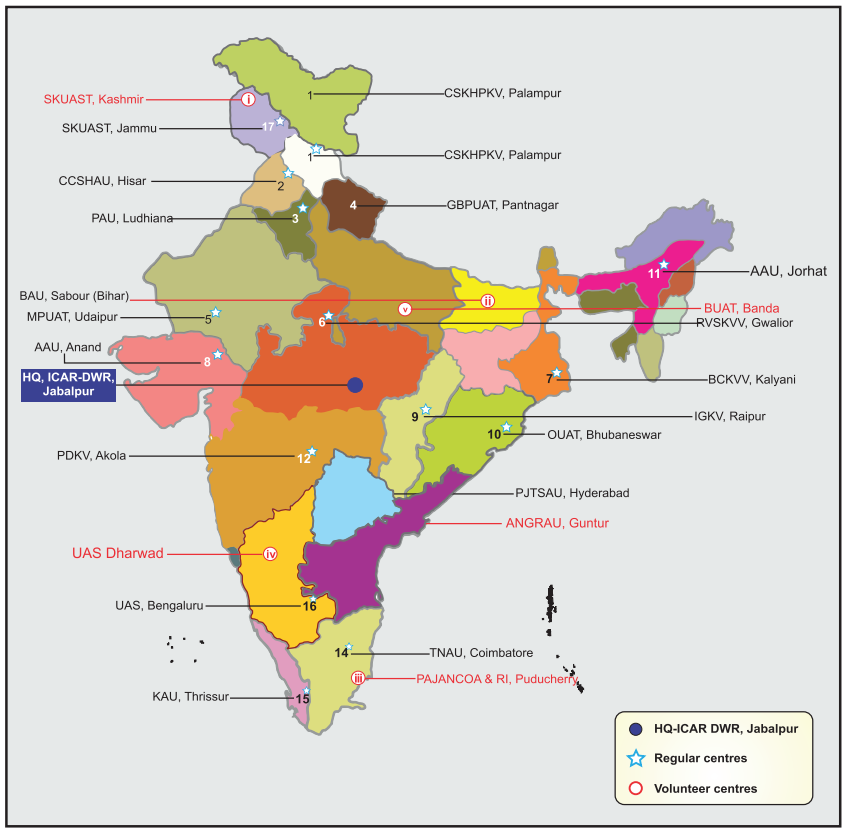
The coordinating unit of the project was located initially at Central Rice Research Institute, Cuttack, and shifted to ICAR- Directorate of Weed Research, Jabalpur and earlier known as "AICRP on Weed Control" which was renamed as "AICRP on Weed Management" during XII Plan.

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
iii PAJNCOA & RI Puducherry
iv UAS, Dharwad
v BUAT, Banda
vi ANGRAU, Guntur
vii SK NAU, Jobner

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 Agronomy, Residue Chemistry and Taxonomy are working in inter-disciplinary mode. Besides 17 main centres, 7 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2020-21 are given below:

Staff position at different coordinating centres during 2020-21

S.No.	Centre	Scientific		Technical		Driver	
		Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled
1.	PAU, Ludhiana	2	2	1	1	-	-
2.	UAS, Bengaluru	2	2	1	1	1	1
3.	RVSKVV, Gwalior	2	2	1	1	-	-
4.	GBPUAT, Pantnagar	2	2	1	1	-	-
5.	CSKHPKV, Palampur	2	2	1	1	1	1
6.	AAU, Jorhat	2	2	1	1	1	1
7.	AAU, Anand	2	2	1	1	1	1
8.	TNAU, Coimbatore	2	2	1	1	1	1
9.	KAU, Thrissur	2	2	1	1	1	1
10.	OUAT, Bhubaneshwar	2	2	1	1	1	1
11.	PJTSAU, Hyderabad	2	2	1	-	1	-
12.	CCSHAU, Hisar	2	2	1	-	-	-
13.	IGKVV, Raipur	2	2	1	1	-	-
14.	PDKV, Akola	2	2	1	1	-	-
15.	MPUAT, Udaipur	2	2	1	-	-	-
16.	SKUAST, Jammu	2	2	1	1	-	-
17.	BCKV, Kalyani	2	2	1	1	-	-
	Total	**34**	**34**	**17**	**14**	**08**	**07**

Funds released to different coordinating centres during the financial year 2020-21

(₹ in lakh)

S.N.	Centre name	Grant in aid Capital		Grant in aid Salary		Grant in aid General					
		Other than NEH and TSP	SCSP	Salary	TA	Research expenses	Operational expenses	SCSP (General)	Other Adminis-trative expenses	Total	Total ICAR share
1	PAU, Ludhiana	1.00	0.00	39.00	0.60	4.78	2.84	1.90	0.50	10.62	50.62
2	UAS, Bengaluru	0.00	0.00	39.00	0.60	4.62	1.78	1.81	0.00	8.81	47.81
3	RVSKVV, Gwalior	0.00	0.28	24.02	0.60	4.79	3.14	1.97	0.00	10.50	34.80
4	GBPUAT, Pantnagar	1.00	0.00	34.36	0.60	4.43	2.27	1.80	0.00	9.10	44.46
5	CSKHPKV, Palampur	0.00	0.00	41.46	0.60	4.63	3.10	1.77	0.00	10.10	51.56
6	AAU, Jorhat	0.00	0.00	54.79	0.60	4.40	3.15	0.00	0.00	8.15	62.94
7	AAU, Anand	1.35	0.00	45.22	0.60	5.32	2.66	0.00	0.00	8.58	55.15
8	TNAU, Coimbatore	0.00	0.00	35.65	0.60	5.18	2.69	1.89	0.60	10.96	46.61
9	KAU, Thrissur	0.00	0.00	31.52	0.60	5.25	1.16	1.89	0.00	8.90	40.42
10	OUAT, Bhubaneshwar	0.80	0.00	50.31	0.60	4.79	3.58	1.88	0.00	10.85	61.96
11	PJTSAU, Hyderabad	1.00	0.00	48.01	0.60	4.74	3.32	0.00	0.40	9.06	58.07
12	CCSHAU, Hisar	1.32	0.00	27.31	0.60	4.39	1.78	1.96	0.00	8.73	37.36
13	IGKV, Raipur	0.00	0.00	33.27	0.60	4.65	2.56	0.00	0.00	7.81	41.08
14	PDKV, Akola	0.00	0.00	31.65	0.60	4.93	3.19	0.00	0.00	8.72	40.37
15	BCKV, Kalyani	0.50	0.28	26.86	0.60	4.81	1.78	1.92	0.00	9.11	36.75
16	MPUAT, Udaipur	0.00	0.30	40.97	0.60	4.67	2.28	1.95	0.00	9.50	50.77
17	SKUAST, Jammu	0.00	0.28	28.26	0.60	5.02	3.13	1.87	0.00	10.62	39.16
18	V. B., Sriniketan	0.00	0.00	6.30	0.00	0.00	0.00	0.00	0.00	0.00	6.30
	PC, Unit, Jabalpur	0.84	0.00	0.00	0.00	0.40	0.28	0.00	0.00	0.68	1.52
	Total	**7.81**	**1.14**	**637.96**	**10.20**	**81.80**	**44.69**	**22.61**	**1.50**	**160.80**	**807.71**

3. RESEARCH ACHIEVEMENTS

WP1 Development of location specific sustainable weed management practices

WP1.1 Weed management in major crops and cropping systems of the state

WP1.1.1 Weed management in rice, and rice-based cropping systems TNAU, Coimbatore

WP1.1.1.1 Long term herbicide trial in transplanted lowland rice-rice cropping system (Old)

During Rabi the relative density of grasses was more in pre-emergence treatment (PE) of bensulfuron methyl + pretilachlor *fb* hand weeding (HW) at 30 DAT and T_3. Among the grasses, *Echinochloa crusgalli* and *Leptochloa chinensis* were the dominant weeds and *Ludwigia parviflora* was the dominant weed among the broadleaf weeds. Higher weed control efficiency (82.5% and 75.7% at 45 and 60 DAT, respectively) and lower total weed dry weight were recorded with T_3. Among the treatments, significantly higher grain yield of 7.45 kg/ha, net returns of ₹ 56506/ha and benefit cost ratio of 2.05 were recorded with PE T_3 *fb* HW at 30 DAT followed by T_3. Significantly lower grain yield was recorded with unweeded control treatment. The total energy requirement of various treatments was varied from 20864 MJ/ha to 96611 MJ/ha. The higher energy use efficiency was recorded with the treatment PE bensulfuron methyl + pretilachlor *fb* HW and T_4 treatments (**Table 1.1.1.1**).

During Kharif, the relative density of grasses was more with the treatment PE pyrazosulfuron ethyl *fb* HW at 30 DAT and PE pyrazosulfuron ethyl *fb* PoE bispyribac sodium. Among the grasses, *Echinochloa crusgalli* and *Leptochloa chinensis* whereas, among the broadleaf weeds, *Ludwigia parviflora* were the dominant weed flora in the experimental plots. The lower value of total weed dry weight was recorded with T_4 at 60 DAT, which was comparable with PE pyrasosulfuron ethyl *fb* HW. Higher weed control efficiency (90.5% and 85.0% at 45 and 60 DAT, respectively) was recorded with T_4. Significantly higher grain yield, higher net returns and benefit cost ratio was recorded with T_3 followed by PE pyrasosulfuron ethyl *fb* PoE bispyribac sodium (10% EC). The total energy requirement of various treatments ranged from 21922 MJ/ha to 100908 MJ/ha (**Table 1.1.1.1**).

Among the different herbicides combination, significantly higher grain yield and income were obtained with the treatment T_3 PE bensulfuron methyl + pretilachlor *fb* hand weeding during *Rabi* and in T_4 during *Kharif* in transplanted lowland rice-rice cropping system. Residues of all the studied herbicides in soil and rice grain at harvest from both *Rabi* and *Kharif* seasons were found below the detection limit of 0.01 mg/kg. Higher microbial biomass carbon and microbial biomass nitrogen were observed with bensulfuron-methyl + pretilachor (6%),bispyribac sodium and with pyrasosulfuron ethyl *fb* bispyribac sodium during *Rabi* and *Kharif*, respectively. Microbial biomass carbon and microbial biomass nitrogen were significantly affected by the combined application of herbicides than its single application.

WP1.1.1.2 Long-term herbicidal trial in rice-rice cropping sequence

AAU, Jorhat

In Summer/Autumn (*Ahu*) rice, initial weed flora was composed of grasses like *Echinochloa crusgali*, *Hymanachne acutigluma*, *Isachne himalaica*, *Leersia hexandra*, *Oryza rufipogon*, *Paspalum conanjugatum*; sedges like *Cyperus iria*, *Eleocharis acutangula, Eleocharia dulcis* and *Scirpus maritimus,* and weeds other than grasses and sedges were *Alternanthera philoxeroides*, *Ceratophyllum utricularia*, *Hydrolea zeylanica*, *Marsilia minuta*, *Monochoria vaginalis.*

Weed density was significantly influenced by

Table 1.1.1.1. Effect of treatments on weed control efficiency, number of effective tillers, yield, net returns and energy use efficiency in transplanted lowland rice-rice cropping system.

Treatments	Weed control efficiency (%) DAT				Effective tillers (No./m²)		Grain yield (t/ha)		Net returns (₹/ha)		B:C		Net energy (MJ/ha)		Energy use efficiency	
	Rabi		*Kharif*													
	45	60	30	60	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*
T_1	63.6	59.8	63.6	59.8	509	524	5.74	5.91	28,582	29,439	1.66	1.71	72473	75076	7.06	7.31
T_2	82.5	75.7	62.5	75.7	545	544	7.45	6.36	56,506	38,481	2.05	1.75	96611	81632	8.45	7.87
T_3	66.5	59.7	90.5	85.0	528	561	6.17	7.68	37,360	58,201	1.70	2.11	78973	100908	7.68	9.44
T_4	51.2	55.2	60.5	65.5	537	553	7.06	7.27	47,970	49,409	1.82	1.87	90954	95144	8.09	9.09
T_5	46.0	53.2	55.0	56.2	515	530	6.30	6.49	40,100	41,303	1.75	1.80	80536	83389	7.65	7.93
T_6	-	-	-	-	98	101	2.21	2.28	4,032	4,153	1.14	1.17	20864	21922	2.78	2.88
SEm ±	-		-		12	12	0.017	0.017	-	-	-	-	3550	3665	0.34	0.36
LSD (P=0.05)	-		-		28	29	0.036	0.037	-	-	-	-	NS	NS	NS	NS

T_1 PE pyrasosulfuron ethyl *fb* hand weeding (*Kharif* & *Rabi*) 20 3 *fb* 30; T_2 PE pyrasosulfuron ethyl *fb* hand weeding (*Kharif*) + PE bensulfuron methyl + pretilachlor *fb* hand weeding (*Rabi*) 20 +6603 *fb* 30; T_3:PE pyrasosulfuron ethyl (10% WP) *fb* PoE bispyribac sodium (*Kharif* & *Rabi*) 20 *fb* 253 *fb* 30 T_4: PE pyrasosulfuron ethyl *fb* PoE bispyribac sodium (*Kharif*) + PE bensulfuron methyl + pretilachlor *fb* PoE bispyribac sodium (*Rabi*) 20 *fb* 25 + 660 *fb* 25 3 *fb* 30 ; T_5 Hand weeding twice 15 and 30; T_6 Unweeded control

the different weed management treatments at 15 DAT only whereas, the dry weight of weeds were found to be statistically significant at all the stages except 30 DAT. Among the weed management treatments, application of pyrazosulfuron 25g/ha + 2, 4-D 0.50 kg/ha rotated with pretilachlor (100% nutrient through fertilizers) i. e. T_5 registered highest weed density and dry weight in most of the growth stages. Application of pyrazosulfuron 25g/ha + 2,4-D 0.50 kg/ha rotated with pretilachlor 0.75 kg/ha in combination with 75% nutrient through fertilizers + 25% nutrient through organic source (T_4) significantly reduced both the density and dry weight of weeds in autumn rice. In case of growth, yield attributes and grain yield the T_4 registered the highest values of all the parameters except number of grains/panicle and recorded comparatively higher value among the rest of the treatments. However, there was no statistical difference among the treatments (**Table 1.1.1.2**).

In *Kharif*/ winter rice, the boradleaf weed flora were *Alternanthera sessilis*, *Cuphea balsamona*, *Hydrolea zeylanica* and *Monochoria vaginalis*; *Ceratophyllum utricularia; Sagittaria guayanensis* and *Marsilia minuta.* All the narrowleaf weeds were anchored emerged species with amphibious in nature, which included sedges like *Scirpus maritimus* and *Eleocharis dulcis,* and grasses like *Leersia hexandra*, *Sacciolepis interrupta*, *Oryza rufipogon* and *Paspalum disticum.*

Among the weed management practices, farmers' practice (pretilachlor 0.75 kg/ha + 75% nutrient through fertilizers + 25% nutrient through organic source) provided better weed control in winter rice. In case of yield attributes and grain yield, significantly highest number of grains per panicle (260.6) was recorded in T_6. However, the higher values of grain yield were observed in T_4 and T_5 (**Table 1.1.1.3**).

Some very distinct changes were observed in weed dynamics in autumn rice. Treatments (T_2& T_3) that received pyrazosulfuron 25g/ha *fb* 2,4-D 0.50 kg/ha (Bispyribac-sodium since 2019) have successfully controlled *Ludwigia linifolia* and *Cuphea balsamina* among the broadleaf weeds and their appearance was

not observed after 2018. Out of the narrowleaf weeds, pyrazosulfuron 25g/ha *fb* 2,4-D 0.50 kg/ha (Bispyribac-sodium since 2019) has eliminated *Eleocharis acutangula* and *E. dulcis* in 2018, and *Echinochloa crusgalli* in 2019 from the field. In 2020, none of these weeds appeared neither in autumn, nor in winter rice. However, the disappearance of *Echinochloa crusgalli* from the autumn rice field has happened in 2018 in the treatments where 100% nutrients were applied through chemical fertilizers and that was in 2019, where 25% nutrients were applied through organic sources.

Table 1.1.1.2 Effect of treatments on weed population, weed dry weight, yield attributes and grain yield of summer/autumn(*Ahu*) rice under rice-rice cropping sequence.

No.	Treatment	Weed population (No./m²)*			Dry weight of weeds (g/m²)*			No. of panicles/m²	Panicle length (cm)	No. of grains/ panicle	Grain yield (q/ha)
		30 DAT	60 DAT	Harvest	30 DAT	60 DAT	Harvest				
T_1	Farmers practice (pretilachlor 0.75 kg/ha + NPK fertilizer)	7.12	7.27	6.70	3.34	3.38	3.73	203.3	21.2	51.4	29.3
T_2	Pyrazosulfuron 25g/ha + 2,4-D 0.50 kg/ha (100% nutrient through fertilizers)	7.84	7.71	8.37	3.61	3.64	3.81	209.0	21.1	58.6	31.6
T_3	Pyrazosulfuron 25g/ha + 2,4-D 0.50 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source)	7.64	7.60	10.14	3.03	3.59	3.52	213.6	22.5	52.9	33.0
T_4	Pyrazosulfuron 25g/ha + 2,4-D 0.50 kg/ha rotated with pretilachlor 0.75 kg/ha (75% nutrient throughfertilizers + 25% nutrient through organic source)	7.52	6.93	9.10	3.18	3.25	3.08	210.0	21.8	54.3	30.0
T_5	Pyrazosulfuron 25g/ha + 2,4-D 0.50kg/ha rotated with pretilachlor 0.75 kg/ha (100% nutrient through fertilizers)	8.41	7.38	7.96	3.49	4.29	4.67	191.6	21.7	50.7	30.8
	SEm±	0.40	0.24	0.46	0.11	0.10	0.12	11.26	0.30	1.48	1.57
	LSD (P= 0.05)	NS	NS	NS	NS	0.32	0.36	NS	NS	NS	NS

* Squareroot ($\sqrt{(x + 0.5)}$ transformed value

WP 1.1.1.3 Weed management in rice-pea-rice cropping sequence

AAU Jorhat

The weed density was significantly affected by crop establishment methods at 30 days after sowing (DAS), 45 DAS and at 120 DAS. Weed density was found higher under direct seeding plots as compared to transplanted method of establishment. Conventional transplanting method of rice establishment recorded lowest weed dry matter accumulation as compared to direct seeding with drum seeder and direct seeding with reduced tillage. However statistical differences were observed at 30 and 45 DAS only. Among the weed management practices, the lowest weed drymatter was recorded in pretilachlor 0.75 kg/ha as pre-emergence (PE) + working with grubber/Paddy weeder at 30DAS/DAP at all the dates except 120 DAS and remained at par with pretilachlor 0.75 kg/ha at 60 DAS.

Table 1.1.1.3 Effect of treatments on weed population, weed dry weight, yield attributes and grain yield of *Kharif* rice under rice-rice cropping sequence.

Treatment	Weed population (No./m²)*			Dry weight of weeds (g/m²)*			No. of panicles/m²	Panicle length (cm)	No. of grains/ panicle	Grain yield (q/ha)
	30 DAT	45 DAT	Harvest	30 DAT	45 DAT	Harvest				
T_1 Farmers practice (pretilachlor 0.75 kg/ha + NPK fertilizer)	11.4	11.3	6.19	7.47	5.50	4.54	186.0	24.7	195.1	50.0
T_2 Farmers practice (pretilachlor 0.75 kg/ha + 75% nutrient through fertilizers + 25% nutrient through organic source)	12.8	12.2	4.22	5.32	5.63	6.45	195.6	25.3	188.8	52.5
T_3 Pyrazosulfuron 25 g/ha *fb* bispyribac-sodium 25 g/ha (100% nutrient through fertilizers)	12.3	12.5	9.01	5.03	6.13	3.53	203.6	25.6	214.8	53.0
T_4 Pyra zosulfuron 25 g/ha *fb* bispyribac-sodium 25 g/ha (75% nutrient through fertilizers + 25% nutrient through organic source)	11.2	14.4	8.00	7.17	6.42	3.16	199.3	25.5	219.4	59.1
T_5 Pyrazosulfuron 25 g/ha rotated with pretilachlor 0.75 kg/ha *fb* bispyribac-sodium 25 g/ha (100% nutrient through fertilizers)	11.1	13.7	8.63	7.50	6.78	4.24	199.6	24.6	193.4	59.1
T_6 Pyrazosulfuron 25 g/ha rotated with pretilachlor 0.75 kg/ha *fb* bispyribac-sodium 25 g/ha (75% nutrient through fertilizers + 25% nutrient through organic source)	13.7	15.2	7.78	7.82	6.11	7.16	202.6	26.1	260.6	53.3
SEm±	0.37	0.38	0.40	0.37	0.23	0.22	6.39	0.34	6.24	1.37
LSD (P= 0.05)	NS	1.21	1.26	NS	NS	0.68	NS	NS	19.66	NS

* Squareroot ($\sqrt{(x + 0.5)}$ transformed value

WP1.1.1.4 Weed management in dry seeded rice (DSR)

AAU, Anand

In general, dominancy of dicot weed (66.5 %) was observed in the experimental field and the major weeds recorded in the experimental field were *Dactyloctenium aegyptium* (8.87 %), *Digitaria sanguinalis* (8.87 %), *Echinochloa colona* (3.60 %), *Echinochloa crus-galli* (3.32%) as monocot weeds whereas, *Trianthema monogyna* (54.3%), *Digera arvensis* (5.54%) and *Amaranthus spinosus* (4.53%) as dicot weed and *Cyperus rotundus*as sedge. Among all the weed management practices, mechanical weeding at 20 and 40 days after sowing (DAS) recorded maximum weed control efficiency (94.5%) which was followed by pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) ready mix/pre mix (PM) as pre-emergence (PE) *fb* hand weeding (HW) at 30 DAS (87.1%), pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (PM) (85.3%) and bentazone 480 g/l SL 960 g/ha + bispyribac-sodium 25 g/ha tank mix (TM) as early post-emergence(EPoE) (82.2%) at 30 DAS whereas at 60 DAS application of triafamone + ethoxysulfuron (44.0+22.5 g/ha) EPoE (PM) *fb* mechanical weeding at 30 DAS recorded maximum weed control efficiency (91.0%), which was closely followed by application of pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (PM) *fb* HW at 30 DAS (88.1%) and mechanical weeding at 20 and 40 DAS (87.2%). Weed control efficiency at harvest was recorded higher (89.6%) under mechanical weeding at 20 and 40 DAS, which was closely followed by application of penoxsulam + cyhalofop-butyl 120 g/ha EPoE (PM) *fb* HW at 30 DAS and triafamone + ethoxysulfuron (44.0+22.5 g/ha) EPoE (PM) *fb* mechanical weeding at 30 DAS.

Among all the treatment, mechanical weeding at 20 and 40 DAS registered significantly higher (3.66 t/ha and 5.30 t/ha) grain and straw yields, respectively as compared to rest of the treatment except application of pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (PM) *fb* HW at 30 DAS, penoxsulam + cyhalofop-butyl 120 g/ha EPoE (PM) *fb* HW at 30 DAS, triafamone + ethoxysulfuron (44.0+22.5 g/ha) EPoE (PM) *fb* mechanical weeding at 30 DAS and bispyribac-sodium 25 g/ha EPoE *fb* HW at 30 DAS. Yield reduction due to presence of weed was recorded maximum under weedy check (77.9%) which was closely followed by metsulfuron-methyl + chlorimuron-ethyl 4 g/ha EPoE (PM), triafamone + ethoxysulfuron 1 (44.0+22.5 g/ha) PoE (PM) and penoxsulam + cyhalofop-butyl 120 g/ha EPoE (PM).

Maximum net returns of ₹ 34,226/ha with benefit cost ratio of 1.83 was achieved under application of pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (PM) *fb* HW at 30. Application of pretilachlor + pyrazosulfuron-ethyl (600+15 g/ha) PE (PM) and pretilachlor 600 g/ha PE was found to become slightly phytotoxic on germinating seedlings of rice with the appearance of yellowing symptom on newly emerged leaves at the initial stages of crop growth, however, crop was recovered within 20 days after herbicide application.

WP1.1.1.7 (i) Effect of green manures and herbicides on weed dynamics and yield of transplanted rice-wheat cropping system

SKUAST, Jammu

Transplanted rice

The dominantweed flora recorded in the experimental field was *Echinochloa* spp., *Alternanthera philoxeroides, Caesulia axillaris, Cyperus* spp., *Ammannia baccifera, Eclipta alba, Ludwigia parviflora*, *Commelina benghalensis*. Different green manuring crops showed non-significant effect on weed density and weed biomass at 30, 60 days after transplanting (DAT) and at harvest. The lowest weed density as well as weed biomass of grasses, broadleaf weeds and sedges were observed in dhaincha as green manuring crop followed by green manuring of cluster bean. Among the herbicidal treatments, lowest weed density and biomass were recorded with triafamone + ethoxysulfuron 66.5 g/ha applied at 25 DAT and it was significantly superior to bispyribac-sodium 25 g/ha applied at 25 DAT and pretilachlor+pyrazosulfuron-ethyl 615 g/ha as PE. It is significantly higher weed

Table 1.1.1.4 Effect of in-situ green manuring and herbicides on weed biomass, tiller number, yields, net returns, benefit cost ratio in transplanted and direct seeded rice.

Treatment		Weed biomass at 60 DAT/DAS (g/m²)		Tillers/m² at harvest		Grain yield (t/ha)		Straw yield (t/ha)		Net returns (₹/ha)		B:C	
Transplanted rice (TR)	**Direct seeded rice (DSR)**	**TR**	**DSR**	**TR**	**DSR**	**TR**	**DSR**	**TR**	**DSR**	**TR**	**DSR**	**TR**	**DSR**
In-situ green manuring	*In-situ green manuring*												
Cowpea	Cowpea	4.72 (21.2)	6.50 (41.1)	240	268	2.72	2.51	4.77	4.31	64,902	63,812	1.64	1.95
Dhaincha	*Dhaincha*	4.48 (19.0)	6.32 (38.9)	246	275	2.78	2.58	4.83	4.50	66,656	65,968	1.67	1.99
Cluster bean	Stale seedbed	4.69 (20.9)	6.62 (42.7)	240	258	2.73	2.12	4.78	3.71	65,590	52,450	1.67	1.78
SEm ±		0.09	0.06	6	2	0.06	0.05	0.09	0.07				
LSD (P=0.05)		NS	NS	NS	10	NS	0.18	NS	0.27				
Herbicides	*Herbicides*												
Pretilachlor+pyrazosulfuron-ethyl 600+15 g/ha as PE	Pendimethalin 1.0 kg/ha as PE	6.39 (39.87)	10.02 (99.4)	233	207	2.61	1.86	4.65	3.59	61,918	41,118	1.60	1.32
Bispyribac-sodium 25 g/ha at 25 DAT	Bispyribac-sodium 25 g/ha at 25 DAS	4.40 (18.37)	6.41 (40.0)	241	275	2.72	2.41	4.78	4.10	65,967	60,965	1.71	1.92
Triafamone + ethoxysulfuron 66.5 g/ha at 25 DAT	Triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS	4.16 (16.3)	5.80 (32.6)	245	279	2.75	2.42	4.79	4.17	68,726	62,972	1.85	2.08
Mechanical weeding at 20 & 40 DAT	Pendimethalin 1 kg/ha as PE *fb* bispyribac-sodium 25 g/ha at 25 DAS	2.85 (7.12)	4.27 (17.2)	248	287	2.88	2.66	4.95	4.50	66,252	68,514	1.49	2.04
-	Pendimethalin 1 kg/ha as PE *fb* triafamone + ethoxysulfuron 66.5 g/ha at 25 DAS	-	4.06 (15.4)	-	288	-	2.67	-	4.52	-	70,147	-	2.18
SEm ±		0.08	0.11	4	4	0.06	0.05	0.07	0.06	-	-	-	-
LSD (P=0.05)		0.24	0.31	11	11	0.19	0.15	0.21	0.18	-	-	-	-
Interaction		NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-

Note: Data were subjected to square root transformation √ X+1. Figures in parentheses are means of original values. DAT-Days after transplanting. DAS-Days after sowing

density and biomass values than two mechanical weeding at 20 and 40 DAT.

Different treatments of green manuring crop showed non-significant effect on growth, yield attributes and yields of transplanted rice. However, highest plant height, tillers/m^2, yield attributes and yields of rice were observed with the treatment of green manuring of dhaincha followed by green manuring of cluster bean. Among the herbicidal treatments, higher growth parameters, yield attributes and yields of rice were recorded with the treatment of triafamone + ethoxysulfuron 66.5 g/ha and it was statistically at par with bispyribac-sodium 25 g/ha and two mechanical weeding at 20 and 40 DAT. Highest benefit cost ratio was recorded with the treatment of green manuring of either dhaincha or cluster bean with the application of triafamone + ethoxysulfuron 66.5 g/ha applied at 25 DAT.

Direct seeded rice

The dominant weed flora in the experimental field was *Echinochloa* spp., *Digera arvensis, Physalis minima, Caesulia axillaris, Cyperus* spp. whereas, *like Digitaria sanguinalis, Dactyloctenium aegyptiu, Cyanodon dactylon*, *Cucumis* spp., *Eclipta alba, Solanum nigrum* and *Phyllanthus niruri* in the experimental plots. Different treatments of green manuring crops and stale seedbed technique showed non-significant effect on total weed density and weed biomass at 60 days after sowing (DAS) and at harvest. At 30 DAS, incorporation of dhaincha or cowpea as green manuring crop recorded significantly lower *Echinochloa* spp. density, dry biomass of *Echinochloa* spp. and dry biomass of total weeds than stale seedbed treatment. The lowest weed density as well as weed biomass of grasses, broadleaf weeds and sedges were observed with the treatment of green manuring of dhaincha or cowpea than stale seedbed technique at 30, 60 DAS and at harvest.

Different treatments of green manure crops and stale seedbed technique registered significant effect on yield attributes like total number of tillers/m^2, , effective tillers/m^2 and yields of direct seeded rice. The highest number of tillers/m^2, effective tillers/m^2 and yields of direct seeded rice were recorded with the treatment of green manuring of dhaincha, which was statistically at par with the treatment of green manuring of cowpea and significantly higher than stale seedbed technique.The highest number of tillers/m^2, effective tillers/m^2 and yields of direct seeded rice were recorded in pendimethalin 1 kg/ha PE*fb* triafamone + ethoxysulfuron 66.5 g/ha PoE, which was statistically at par with pendimethalin 1 kg/ha PE *fb* bispyribac-sodium 25 g/ha PoE. Among all the green manuring and herbicidal treatment combinations, the highest benefit cost ratio was obtained with the treatment of green manuring of cowpea in combination of triafamone + ethoxysulfuron 66.5 g/ha applied at 25 DAS **(Table 1.1.1.4)**.

Yield attributes like number of tillers/m^2, panicle length, number of grains/panicle, grain and straw yields were not significantly influenced by crop establishment methods. However, comparatively higher values of all the parameters were recorded under conventional method of transplanting (M_1). Among the weed management practices pretilachlor 0.75 kg/ha PE + working with grubber/Paddy weeder at 30DAS/DAP resulted significantly higher grain yield of *Kharif* rice and was closely followed by pretilachlor 0.75 kg/ha. Pretilachlor 0.75 kg/ha (M_1) also remained at par with pyrazosulfuron-ethyl 25g/ha PE + bispyribac-sodium 25 g/ha at 30 DAS/DAP **(Table 1.1.1.7).**

WP 1.1.1.10 Weed management in transplanted rice-chickpea cropping system

Raipur

Major weed flora observed in the experimental field of transplanted rice during rainy seasons were *Echinochloa colona, Ischeamum rugosum, Alternanthera triandra, Cyanotis axillaris, Cyperus iria, Commelina benghalensis, Croton bonplandianus, Spilanthus acmella* and *Ludwigia parviflora.* Significantly the lowest weed dry weight (2.57 g/m^2) was recorded under two hand weeding (20 & 40 DAT) among all the chemical and mechanical weed management treatments at 30 DAT and at 60 DAT. While, at harvest, the effect of hand weeding was not sustained and the lowest weed dry

Table 1.1.1.7 Effect of crop establishment methods and weed management practices on plant height and yield attributing characters of *Kharif* rice under rice – pea- rice cropping sequence

Treatment	Weed population (No./m²)*			Dry weight of weeds(g/m²)*			No. of tillers/ m²	Panicle length (cm)	No. of grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)
	DAS			DAS							
	30	60	120	30	60	120					
Crop establishment methods											
Conventional transplanting	0.71	4.50	3.77	0.71	2.44	2.38	319.6	27.8	208.3	4.56	5.88
Direct seeding by drum seeder	5.45	4.78	5.02	4.32	2.54	2.24	319.2	27.2	199.1	4.27	5.73
Reduced tillage up to 50% with direct-seeding	6.23	5.27	4.46	5.08	3.12	2.32	310.6	26.6	198.4	4.25	5.97
SEm ±	0.20	0.28	0.12	0.09	0.07	0.08	16.6	0.55	8.77	0.098	0.13
LSD (P=0.05)	0.78	NS	0.47	0.35	0.26	NS	NS	NS	NS	NS	NS
Weed management practices											
Pretilachlor 0.75 kg/ha PE	3.27	4.68	4.43	3.66	2.30	2.26	316.8	27.1	197.8	4.45	5.86
Pretilachlor 0.75 kg/ha PE + working with grubber/Paddy weeder at 30DAS/DAP	4.20	4.55	4.24	2.62	2.22	2.54	315.1	27.0	208.1	4.60	6.14
Pyrazosulfuron-ethyl 25g/ha PE + bispyribac-sodium 25 g/ha at 30 DAS/DAP	4.37	5.43	4.19	3.81	2.94	1.99	317.2	27.5	202.4	4.26	5.89
Working with grubber/paddy weeder at 20 and 40 DAS/DAP	4.68	4.76	4.81	3.39	3.35	2.46	316.8	27.1	199.4	4.13	5.55
SEm ±	0.16	0.25	0.12	0.15	0.08	0.11	10.3	0.35	9.43	0.084	0.14
LSD (P=0.05)	0.49	NS	NS	0.45	0.24	0.31	NS	NS	NS	0.25	NS
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Squareroot ($\sqrt{(x + 0.5)}$ transformed value. PE: Pre-emergence; DAS: Days after sowing; DAP: Days after planting

weight (18.7 g/m^2) was registered under the treatment of EPoE of pretilachlor + bensulfuron 660 g/ha 10-12 DAT *fb* penoxsulam + cyhalofop 135 g/ha PoE as ready-mix at 25-30 DAT closely followed by EPoE pretilachlor+bensulfuron 660 g/ha 10-12 DAT *fb* triafamone + ethoxysulfuron 66.5 g/ha as ready-mix at 25-30.

Among weed managements options significantly higher number of effective tillers (338/m^2) was recorded under EPoE of pretilachlor+bensulfuron 660 g/ha 10-12 DAT *fb* penoxsulam + cyhalofop 135 g/ha PoE as ready-mix at 25-30 DAT. Significant difference in grain yield of rice was found under different weed management practices. Maximum grain yield (6.28 t/ha) was achieved under application of EPoE of pretilachlor+bensulfuron 660 g/ha 10-12 DAT *fb* penoxsulam + cyhalofop 135 g/ha PoE as ready-mix at 25-30 DAS (T_6) which was significantly superior to rest of the treatments except EPoE pretilachlor + bensulfuron 660 g/ha 10-12 DAT *fb* triafamone + ethoxysulfuron 66.5 g/ha as ready-mix at 25-30 DAT (T_7), oxadiargyl 80g/ha PE *fb* PoE penoxsulam + cyhalofop butyl 135 g/ha PoE as ready-mix at 20-25 DAT (T_2) and two hand weeding at 20 & 40 DAT.

Highest net return (₹ 81,767/ha) was recorded under EPoE of pretilachlor + bensulfuron 660 g/ha 10-12 DAT *fb* penoxsulam + cyhalofop 135 g/ha PoE as ready-mix at 25-30 DAS (T_6) with higher B:C (3.30) among different weed management practices. Although, the oxadiargyl 80g/ha PE *fb* PoE penoxsulam + cyhalofop butyl 135 g/ha PoE as ready-mix at 20-25 DAT generated lesser net return to that of T_6 but registered maximum B:C of 3.31 because of lesser cost of cultivation.

WP 1.1.2 Weed management in maize and maize-based cropping system

WP 1.1.2.4 Integrated weed management in maize

Ludhiana

Kharif maize crop was infested mainly with grasses, sedges and broadleaf weeds. The weed flora were comprised by *Digitaria sanguinalis, Dactyloctenium aegyptium, Acrachner acemosa, Commelina benghalensis,*

Table 1.1.2.4 Effect of different weed management treatments on weed dry matter and yields of *Kharif* maize

Treatment	Weed dry matter (g/m²) at 30 DAS			Weed dry matter (g/m²) at 45 DAS			Weed dry matter (g/m²) at harvest			Maize cob yield (t/ha)	Maize grain yield (t/ha)	Maize stover yield (t/ha)
	Grass	Sedge	Broadleaf	Grass	Sedge	Broadleaf	Grass	Sedge	Broadleaf			
Pyroxasulfone 76.5 g/ha	2.80 (7)	2.45 (5)	2.19 (4)	2.70 (6)	3.60 (12)	3.25 (10)	4.30 (18)	11.39 (129)	2.67 (6)	11.55	7.264	15.71
Pyroxasulfone 102 g g/ha	1.00 (0)	2.33 (5)	1.98 (3)	1.00 (0)	3.40 (11)	3.77 (13)	4.63 (20)	10.31 (105)	2.86 (7)	12.61	7.333	19.33
Pyroxasulfone 127.5 g/ha	2.52 (5)	2.08 (3)	1.87 (3)	1.00 (0)	2.99 (8)	1.00 (0)	1.00 (0)	8.10 (65)	1.00 (0)	13.13	7.708	20.81
Pyroxasulfone 102 g/ha *fb* paddy straw mulch (6.25t/ha)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	7.19 (51)	1.00 (0)	12.60	7.480	18.56
Pyroxasulfone 102 g/ha *fb* intercultural operationat 20-25 DAS	1.00 (0)	1.24 (0.6)	1.94 (3)	2.56 (6)	1.52 (1)	3.68 (13)	4.04 (15)	8.05 (64)	2.81 (7)	12.66	7.957	21.02
Black plastic mulch (25um)	1.00 (0)	3.20 (9)	2.56 (6)	3.69 (13)	4.79 (22)	5.13 (25)	4.68 (21)	9.19 (83)	5.87 (33)	11.57	6.357	20.44
Paddy straw mulch (6.25t/ha)	1.00 (0)	3.01 (8)	2.12 (4)	1.00 (0)	4.50 (19)	5.20 (26)	1.00 (0)	8.20 (66)	4.84 (22)	12.95	7.427	19.55
Tembotrione 120 g/ha/ha	1.00 (0)	2.78 (7)	1.83 (2)	1.00 (0)	4.12 (16)	1.00 (0)	1.00 (0)	7.98 (63)	1.00 (0)	14.33	7.570	21.46
Tembotrione 40 g/ha (band spray) *fb* intercultural operation in inter-row spaces	3.26 (10)	3.20 (9)	2.44 (5)	1.00 (0)	4.79 (22)	3.78 (13)	3.02 (8)	8.26 (67)	2.75 (7)	13.37	7.463	19.72
Atrazine 625 g/ha	3.44 (11)	3.20 (9)	2.48 (5)	6.34 (39)	4.79 (22)	4.12 (16)	8.42 (70)	12.93 (166)	2.38 (5)	12.63	7.372	19.87
Weedy check	4.31 (18)	3.33 (10)	2.65 (6)	11.36 (128)	5.00 (24)	6.97 (48)	8.72 (75)	12.66 (160)	4.46 (19)	11.05	6.156	15.72
LSD (P=0.05)	0.21	0.29	0.19	0.33	0.47	0.59	0.25	0.59	0.20	0.76	0.256	2.70

Note: Data subjected to (X+1) transformation. Figures in parentheses are means of original values.

Cyperus compressus and *Trianthema portulacastrum*. Pyroxasulfone at 127.5 g/ha, pyroxasulfone at 102.5 g/ha *fb* intercultural operation, tembotrione at 120g/ha and tembotrione at 40g/ha (band spray) *fb* intercultural operation in inter-row spaces and paddy straw mulch (PSM) at the rate of 6.25 t/ha were found effective in reducing the weed density of grasses and broadleaf weeds, however, recorded higher values of weed density and weed biomass of sedge as compared to weedy check treatment.

All the weed control treatments resulted in significantly higher maize grain yield as compared to weedy check (**Table 1.1.2.4**). Pyroxasulfone at 102.5 g/ha *fb* intercultural operation recorded the highest grain yield and it was at par with the treatment pyroxasulfone at 127.5 g/ha.

WP 1.1.2.2 Effect of herbicides on weed dynamics and yield of maize-chick pea cropping system (Collaboration with Advanced Centre for Rainfed Agriculture (ACRA), SKUAST-J)

The maize experimental field was dominated by *Digitaria sangunalis, Echinochloa colona, Cynodon dactylon, Acrachera cemosa, Eragrostis tenella, Eleusine* spp. *Amaranthus viridis, Solanum nigrum, Commelina benghalensis, Cyperus* spp. and *Physalis minima* weeds. Among the different weed management practices, the lowest weed density was recorded with the treatment mechanical weeding at 20 and 40 days after sowing (DAS). Among the herbicidal treatment topramezone + atrazine 25.2 + 500 g/ha as post-emergence (PoE) recorded lowest values of weed density at 60 DAS and at harvest stage. The lowest weed biomass value was recorded with the treatment mechanical weeding at 20 & 40 DAS followed by topramezone + atrazine 25.2 + 500 g/ha PoE.

Different weed management treatments showed a significant influence on growth, yield attributes, yields and economics as compared to weedy check. The treatment mechanical weeding at 20 and 40 DAS recorded significantly higher plant height, dry matter, number of grains/cob, 1000 grain weight, grain yield and straw yield as compared to weedy check. Among the herbicidal treatment topramezone + atrazine 25.2 + 500 g/ha PoE recorded highest grain and straw yields. The highest values of net returns and benefit cost ratio were recorded with the treatment mechanical weeding at 20 & 40 DAS and it was followed by topramezone + atrazine 25.2 + 500 g/ha PoE **(Table 1.1.2.2)**.

WP 1.1.2.3 Weed management with new generation herbicides in maize (sweet corn) in maize –black gram cropping system.

Bhubaneswar

Among the all the weed management treatments, topramezone25 g/ha applied as early post-emergence (EPoE) at 20 DAS, tembotrione 115 g/ha EPoE and two hand weeding (HW) at 20 and 40 days after sowing (DAS) recorded best result in minimising total weed dry weight at 30 DAS. At 45 DAS, pendimethalin 1 kg/ha applied as pre-emergence (PE) *fb* tembotrione 115 g/ha PoE at 40 DAS, pendimethalin (1kg/ha) *fb* topramezone 25 g/ha PoE at 40 DAS registered minimum weed dry weight. Both the treatments are significantly superior over the remaining treatments.

Pre-emergence application of (T_8) pendimethalin (1kg/ha) *fb* tembotrione (115 g/ha) or topramezone (25 g/ha) at 40 DAS recorded higher fresh kernel yield (17.84 t/ha) and (17.43 t/ha) over rest of the treatments. However, pre-emergence application of pendimethalin (1kg/ha) *fb* tembotrione (115 g/ha) at 40 DAS (17.43 t/ha), pre-emergence application of pendimethalin (1kg/ha) *fb* 1 HW at 40 DAS (16.82 t/ha), pre-emergence application of atrazine (1kg/ha) *fb* 1 HW at 40 DAS (16.27 t/ha) recorded higher yield which were at par T_8.The highest B:C of the treatments of 3.93 and 3.87 were observed with the application of pendimethalin (1kg/ha) *fb* tembotrione (115 g/ha) and topramezone (25 g/ha) at 40 DAS, respectively.

Table 1.1.2.2 Effect of different weed management treatments on weed density, weed biomass, yields, net returns and benefit cost ratio of *Kharif* maize.

Treatment	Total weed population (No. /m²)		Total weed biomass (g/m²)		Grain yield (t/ha)	Stover yield (t/ha)	Net returns (₹/ha)	B:C
	60 DAS	At harvest	60 DAS	At harvest				
Atrazine 1000 g/ha as PE	5.03 (24.3)	5.17 (26.0)	10.47 (108.3)	13.72 (187.7)	2.89	5.76	34,487	1.13
Pyroxasulfone 127.5 g/ha as PE	4.81 (22.3)	4.90 (23.0)	10.19 (102.8)	14.09 (199.3)	2.93	5.81	29,831	0.83
Tembotrione 120 g/ha as PoE	4.30 (17.8)	4.28 (17.5)	9.61 (91.5)	12.83 (163.7)	2.97	5.90	31,057	0.87
Topramezone 25.2 g/ha PoE	4.10 (16.0)	3.96 (14.8)	9.56 (90.3)	12.62 (158.5)	3.03	6.04	33,671	0.98
Tembotrione + atrazine 120 + 500 g/ha as PoE	2.54 (5.50)	2.72 (6.50)	8.22 (66.8)	11.40 (129.7)	3.33	6.66	38,721	1.07
Topramezone + atrazine 25.2 + 500 g/ha PoE	2.43 (5.00)	2.24(4.17)	7.87 (61.0)	10.95 (119.0)	3.39	6.78	41,452	1.19
Mesotrione + atrazine 87.5 +875 g/ha as PoE	2.99 (8.00)	3.03 (8.33)	8.37 (69.1)	11.96 (143.5)	3.22	6.45	37,637	1.08
Tembotrione + 2, 4-DEE 120 + 500 g/ha as PoE	3.73 (13.0)	3.87 (14.00)	8.98 (79.87)	12.03 (144.1)	3.04	6.07	32,205	0.89
Topramezone + 2, 4-DEE 25.2 + 500 g/ha PoE	3.42 (11.0)	3.50 (11.3)	8.78 (76.50)	11.92 (143.8)	3.13	6.24	35,598	1.02
Two mechanical weeding at 20 and 40 DAS	2.08 (3.67)	2.06 (3.33)	7.08 (49.33)	9.75 (94.3)	3.55	7.05	43,979	1.23
Weedy check	6.05 (35.7)	6.24 (38.0)	11.68 (135.7)	15.85 (250.5)	2.52	4.97	27,250	0.93
SEm ±	0.29	0.25	0.29	0.58	0.12	0.24	-	-
LSD (P=0.05)	0.85	0.74	0.85	1.71	0.37	0.72	-	-

Note: Data subjected to (X+1) transformation. Figures in parentheses are means of original values. PE: Pre-emergence; PoE: Post-emergence; DAS: Days after sowing

WP1.1.3 Weed management in black gram/green gram/chickpea/ pigeonpea crops and cropping systems

WP1.1.3.1 Evaluation of pre and post-emergence herbicides against complex weed flora in blackgram (*Vignamungo* (L.) Hepper) during *Kharif* season

Udaipur

The experimental plots were infested with grassy, broadleaf weeds and sedges. The dominant weed flora were *Echinochloa colona*(39.5%), *Dinebra retroflexa* (16.6%), *Digera arvensis* (7.0%), *Commelina benghalensis* (13.2%), *Trianthema portulacastrum* (5.5%), *Amaranthus viridis* (9.2%) and *Setaria viridi* (9.0%). At 60 days after sowing (DAS), the lowest weed dry matter of monocots was recorded with imazethapyr 60 g/ha + propaquizafop 75 g/ha (Tank mix) applied at 15- 20 days after sowing (DAS), whereas, application of imazethapyr + imazamox 60 g/ha at 15- 20 DAS resulted in significantly minimum dry matter of dicot weeds. The lowest value of total weed dry matter was recorded with imazethapyr 60 g/ha + propaquizafop 75 g/ha (Tank mix) at 15- 20 DAS. Maximum value of weed control efficiency at 60 DAS of total weed flora (89.59%) was recorded with imazethapyr 60 g/ha + propaquizafop 75 g/ha (Tank mix) at 15- 20 DAS followed by imazethapyr 60 g/ha +quizalofop-ethyl 60 g/ha (Tank mix) at 15- 20 DAS.

The maximum seed yield of blackgram was recorded with intercultural operation *fb* hand weeding at 20 and 40 DAS compared to other treatments. Among herbicidal treatments significantly highest seed yield (749.8 kg/ha) and haulm yield (1.199 t/ha) were recorded with the treatment imazethapyr + quizalofop-ethyl 60 /ha (Tank mix). The magnitude of increase by these treatments was to the tune of 109.6 and 103.7 % over weedy check treatment. Imazethapyr + imazamox

showed mild necrotic and wilting symptoms at initial stages of blackgram, however, the crop recovered with the progress of growing period. The highest net returns and benefit cost ratio were realized with the treatment imazethapyar + imazamox 60 g/ha PoE applied at 15-20 DAS (**Table 1.1.3.1).**

Table 1.1.3.1 Effect of weed management treatments on weed dry matter at 60 DAS, weed control efficiency at 60 DAS, yield attributes, seed yield, net returns and benefit cost ratio of blackgram.

Treatment	Dose (g/ha)	Time of application	Weed dry matter (g/m^2)*			Weed control efficiency (%)			No. of branches/ plant	Seeds/ pod	Pods/ plant	Seed yield (kg/ha)	Net returns (₹/ha)	B:C
			Monocot	Dicot	Total	Monocot	Dicot	Total						
Pendimethalin	750	PE DAS	11.8	8.20	20.0	76.0	53.0	70.0	4.58	4.18	30.9	572.0	25,115	1.42
Pendimethalin *fb* IC and HW at 40 DAS	750	PE	9.55	8.94	18.4	80.7	49.0	72.5	5.05	4.53	31.6	585.8	22,655	1.07
Imazethapyr + pendimethalin (RM)	750	PE	13.1	10.2	23.3	73.4	41.5	65.1	4.42	4.58	32.6	603.9	27,511	1.56
Imazethapyr + pendimethalin (RM) *fb* mechanical weeding at 40 DAS	750	PE	12.2	8.65	20.8	75.4	50.5	68.9	4.55	5.07	32.0	591.9	22,926	1.07
Imazethapyr	60	PoE	8.65	3.37	12.0	82.5	80.7	82.1	5.20	4.31	36.8	682.0	33,830	1.97
Imazethapyr + imazamox	60	PoE	6.29	2.46	8.75	87.3	85.9	86.9	5.10	4.66	38.0	704.2	35,092	2.00
Acifluorfen + clodinofoppropargyl (RM)	245	PoE	7.07	7.05	14.1	85.7	59.6	78.9	5.07	4.78	30.6	567.3	25,057	1.44
Imazethapyr + quizalofop-ethyl (TM)	60 +	PoE	3.25	4.70	7.95	93.4	73.1	88.1	5.58	4.58	40.5	749.8	37,420	2.00
Imazethapyr + propaquizafop (TM)	60 +	PoE	1.97	5.04	7.01	96.0	71.1	89.5	5.68	5.51	35.9	664.7	30,990	1.65
Oxyfluorfen + imazethapyr	150+	PE	6.85	6.43	13.2	86.2	63.0	80.1	4.42	4.36	30.2	559.3	22,861	1.20
Pendimethalin + imazethapyr	750	PE	10.5	3.10	13.6	78.7	82.3	79.6	5.42	4.16	35.1	649.3	25,808	1.13
IC *fb* hand weeding at 20 and 40 DAS			5.19	8.72	13.9	89.5	50.1	79.3	6.53	5.73	40.6	755.6	32,569	1.36
Weedy check			49.6	17.4	67.1	0.00	0.00	0.00	1.45	2.17	19.3	357.6	10,848	0.68
SEm ±			0.48	0.49	0.66	-	-	-	0.07	0.20	2.53	24.2	1,778	0.09
LSD (P = 0.05)			1.41	1.42	1.93	-	-	-	0.19	0.60	7.38	70.7	5,189	0.28

* Squareroot ($\sqrt{}$ (x + 0.5) transformed value. PE: Pre-emergence; PoE: Post-emergence; RM: Ready mix; TM: Tank mix; IC: Intercultural operation; DAS: Days after sowing

WP1.1.3.3 Development of sustainable weed management strategies in diversified cropping systems of Krishna zone under ID conditions.

Guntur (Volunteer centre)

Greengram, as sole crop and as intercrop in redgram during Kharif was sown on 15.6.2020. The crop growth was luxuriant during vegetative stage, profuse flowering but due to continuous rains flower drop occurred, poor pod setting and rains at harvest damaged the matured pods leading to complete loss of yield. Rabi crop maize harvested and summer crop (fodder jowar) to be sown.

WP1.1.3.4 Studies on herbicidal effect of imazethapyr and its ready-mix with imazamox and pendimethalin against weeds in blackgram and their residual effect on succeeding mustard crop.

BUAT, Banda (Volunteer centre)

The experimental field of blackgram was infested with several grasses, sedges and broadleaf weeds. The major weeds species were *Cyperus rotundus, Eclipta alba, Tridax procumbance, Phyllanthus niruri, Digera arvensis, Lucas aspera, Cyanotis axillaris, Commelina benghalensis*, *Caesulia axillaris*, *Cynodon dactylon*, etc. Application of imazethapyr + pendimethalin ready mix (RM) 1000 g/ha as pre-emergence (PE) and imazethapyr + imazamox (RM) 60 g/ha applied at 3-4 leaf stage significantly reduced weed dry weight and increased weed control efficiency. Highest values of yield attributes were recorded with weed-free treatment, which were closely followed by the treatment imazethapyr + pendimethalin (RM). Similarly highest seed yield (5.11 q/ha), biological yield (14.9 q/ha) and harvest index (34.3%) were recorded from weed-free plot closely followed by the treatment imazethapyr + pendimethalin (RM) (Seed yield 4.79 q/ha, biological yield 14.2 q/ha and harvest index 33.8%). Higher net returns of ₹ 13,000/ha and benefit cost ratio of 1.7 were recorded with the treatment imazethapyr + pendimethalin (RM) 1000 g/ha PE. Visual phytotoxic effect on black gram was recorded in treatment imazethapyr + imazamox 50 g/ha and 60 g/ha at 3-4 leaf stage.

WP1.1.3.5 Weed dynamics and productivity of chickpea (*Cicerarietinum*) under pre and post-emergence application of herbicides.

BUAT, Banda (Volunteer centre)

The experimental field of chickpea was infested with *Cyperus rotundus, Digera arvensis, Chenopodium album, Chenopodium murale, Anagallis arvensis, Euphorbia dracunculoides, Asphodelus tenuifolius, Eclipta alba, Vicia sativa,* etc. Pendimethalin 1000 g/ha as pre-emergence (PE) coupled with 1 hand weeding at 30 days after sowing (DAS) and oxyfluorfen 100 g/ha PE followed by 1 hand weeding significantly reduced the weed population and dry weight. Among the weed control treatments, application of pendimethalin 1000g/ha PE coupled with 1 hand weeding at 30 DAS and pendimethalin 1000 g/ha PE *fb* imazethapyr 40g/ha as post-emergence (PoE) recorded higher weed control efficiency of 77.7% and 76.4%, respectively. Lower weed index value (5.5%) was recorded with the treatment pendimethalin 1000g/ha PE *fb* quizalofop-ethyl 50g/ha PoE.

Highest values of seed yield (23.1 q/ha), straw yield (24.3 q/ha) and harvest index (48.2 %) were recorded in weed-free treatment, which were closely followed by pendimethalin 1000g/ha *fb* quizalofop-ethyl 50g/ha (Seed yield 21.8 q/ha,straw yield 26.0 q/ha and harvest index 45.9%) and pendimethalin 1000g/ha coupled with 1 hand weeding (Seed yield 21.7 q/ha, straw yield 25.1 q/ha and harvest index 46.6%). Higher benefit cost ratio of 4.3 was recorded with pendimethalin 1000 g/ha coupled with one hand weeding and pendimethalin 1000g/ha PE *fb* quizalofop-ethyl 50g/ha PoE with the net returns of ₹ 89,200/ha and 88500/ha, respectively.

WP1.1.3.6 Weed management in sesame under chickpea–sesame cropping sequence.

BUAT, Banda (Volunteer centre)

The experimental field of sesame was infested with several grasses, broadleaf weeds and sedges. The major weeds species were *Cyperus rotundus, Eclipta alba, Tridax procumbance, Phyllanthus niruri, Digeraa rvensis, Leucas aspera, Cyanotis axillaris, Commelina benghalensis*,

Chromolina odorata, Cynodon dactylon, Parthenium hysterophorus etc.

Population of grassy weeds was very low in experimental field. Application of imazethapyr 40 g/ha as pre-emergence (PE) coupled with one hand weeding at 30 days after sowing (DAS) significantly reduced the weed population. Herbicides applied in sesame caused injury to the plants to a certain extent. Imazethapyr 40 g/ha applied PE caused severe injury (46.7%) while post-emergence (PoE) application of imazethapyr 40 g/ha caused 23.3% injury to plants. Post-emergence application of imazethapyr 40 g/ha led to reduce the height of the crop plants.

Highest seed yields (3.18 q/ha) and harvest index (22.8%) were obtained from the plots treated with pendimethalin 1 kg/ha coupled with one hand weeding, which were closely followed by the treatment with hand weeding twice. Highest benefit cost ratio of 1.54 and net returns of ₹ 7500/ha were recorded with the treatment imazethapyr 40 g/ha PoE, which were closely followed by the treatment pendimethalin 1kg/ha PE (benefit cost ratio of 1.49 and net returns of ₹ 6800/ha).

WP 1.1.3.8 Evaluation of herbicides against complex weed flora in pigeonpea (TP 2020-22)

Hisar

The experimental field was infested with *Digera arvensis, Echinochloa colona* and *Cyperus rotundus*. Pyroxasulfone 127.5 g/ha *fb* imazethapyr 100 g/ha as post- emergence (PoE) and pendimethalin + imazethapyr as ready mix (RM) (1000 g/ha) or tank mix (1000+75 g/ha) provided good control of *Digera arvensis* while pendimethalin alone could not control *Digera arvensis* effectively. All the pre-emergence herbicides shown the effectiveness against another dominant weed *Echinochloa colona*. Post-emergence application of propaquizafop + imazethapyr (50 +75 g/ha, RM) and imazethapyr 100 g/ha also showed good control of *Digera arvensis* and *Echinochloa colona*. Weed dry matter accumulation by weeds at 30 days after sowing (DAS) was significantly higher under weedy check treatment as compared to the treatments with the application of pre-emergence herbicides and hand weeding at 20 and 45 DAS. At 60 DAS, two hand weeding at 20 and 45 DAS resulted in lower weed dry matter accumulation followed by pendimethalin + imazethapyr (RM) 1000 g/ha as pre-emergence (PE) *fb* manual weeding at 45 DAS, which was significantly lower than pendimethalin 1500 g/ha (PE) and pendimethalin 1500 g/ha (PE) *fb* imazethapyr + imazamox (70 g/ha, RM), however, at par with other herbicidal treatments.

Maintaining the weed free situation throughout the growing season resulted in more plant height (290.5 cm), higher number of pods/plant (254.8) and seed yield (1.86 t/ha) and these values were statistically at par with two hand weeding at 20 and 45 DAS, pendimethalin + imazethapyr (RM) 1000 g/ha *fb* hand weeding at 45 DAS, pendimethalin + imazethapyr (TM) (1000 +75 g/ha). Pendimethalin 1500 g/ha resulted in lower seed yield as compared to other herbicidal treatments. Application of pendimethalin + imazethapyr (RM) 1000 g/ha PE *fb* hand weeding at 45 DAS resulted in 57% higher seed yield as compared to weedy check (**Table1.1.3.8**).

WP 1.1.4 Weed management in groundnut based system

WP 1.1.4.1 Weed management and fertility levels on growth, yield and soil health in groundnut–okra cropping system

Bhubaneswar

The dominant weed flora of the experimental site were *Cynodon dactylon*, *Digitaria sanguinalis*, *Elusine indica*, *Dactyloctenium aegyptium* among grasses, whereas *Cyeprus rotundus* among the sedge and *Celosia argentea*, *Ludwigia parviflora*, *Heliotropium indicum* among the broadleaf weeds.Among the treatments of different fertilizer levels, application of 50 % recommended dose of fertilizers (RDF) along with 50 % N through FYM significantly reduced the weed population and dry matter accumulation in comparison to other treatments. Addition of nutrients through chemical fertilizers encouraged weed infestation significantly. Application of 50 % RDF along with 50 % N through FYM significantly increased the pod yield and economic return in comparison to other treatments. Among the different weed control treatments application of pendimethalin as pre-emergence 0.75 kg/ha significantly reduced the weed

population and dry matter accumulation in comparison to other treatments and also significantly increased the pod yield and economic return of groundnut cultivation (**Table 1.1.4.1)**.

WP1.1.4.2 Integrated weed management in groundnut-wheat cropping system

Udaipur

The experimental area was infested with *Echinochloa colona* (46.4%), *Dinebra retroflexa* (12.1%), *Commelina benghalensis* (8.4%) and *Dactyloctenium aegyptium* (8.7%) among the monocot weeds, whereas, *Digera arvensis* (8.8%), *Amaranthus viridis* (6.6%) and *Physalis minima* (9.1%) were the dicot weeds. In case of dicot weeds, the minimum weed density was recorded with the treatment oxyfluorfen 180 g/ha as pre-emergence (PE) *fb* imazethapyr 100g/ha as post-emergence(PoE) applied at 25 DAS and it was found at par with oxyfluorfen PE *fb* imazethapyr + imazamox as PoE and imazethapyr *fb* intercultural operation (IC) + hand weeding (HW) at 40 days after sowing (DAS). Whereas, in case of monocot weeds, the same treatment showed lowest weed density and this treatment was statistically at par with imazethapyr *fb* IC + HW at 40 DAS. Weed control through oxyflrofen PE +

Table 1.1.3.8 Effect of different herbicide treatments ontotal weed dry matter, weed control efficiency, plant height, no. of pods/plant and seed yield of pigeonpea.

Treatment	Total weed dry weight (g/m²)		Weed control efficiency (%)		Plant height (cm)	Pods/ plant	Seed yield (t/ha)
	30 DAS	60 DAS	30 DAS	60 DAS			
Pyroxasulfone at 127.5 (PRE) *fb* imazethapyr 100 g/ha (PoE),	2.9 (7.6)	9.5 (90.0)	73.4	82.3	261.8	212.3	1.43
Pendimethalin 1500 g/ha (PE)	4.1 (17.6)	16.0 (254.1))	37.0	49.5	248.0	163.2	1.18
Pendimethalin 1500 g/ha (PE) *fb* imazethapyr 100 g/ha (PoE)	4.4 (18.4)	10.0 (99.0)	33.7	80.4	262.3	190.0	1.36
Pendimethalin 1500 g/ha (PE) *fb* hand weeding at 45 DAS	4.8 (21.9)	9.2 (84.5)	22.3	82.2	275.8	215.4	1.54
Pendimethalin 1500 g/ha (PE) *fb* imazethapyr + imazamox (RM) 70 g/ha (PoE)	4.6 (20.3)	11.9 (141.2)	28.2	72.9	254.7	185.1	121
Pendimethalin+ imazethapyr (RM) 1000 g/ha (PE) *fb* hand weeding at 45 DAS	2.4 (5.0)	8.1 (65.2)	82.2	87.5	279.1	230.1	1.62
Pendimethalin + imazethapyr (TM) 1000 +75 g/ha (PE)	2.5 (5.3)	8.9 (78.9)	80.7	84.1	263.1	213.3	1.493
propaquizafop + imazethapyr (TM) 50 +75 g/ha (PoE)	5.2 (25.7)	9.2 (83.6)	-	83.4	257.7	189.3	1.36
Two hand weeding at 20 and 45 DAS	2.4 (4.7)	8.1 (67.9)	83.6	85.2	289.9	230.7	1.67
Weedy check	5.4 (28.3)	23.1 (544.0)	-	-	223.8	150.0	1.06
Weed free	1.0 (0.0)	1.0 (0.0)	-	-	290.5	254.8	1.86
Imazethapyr 100 g/ha (PoE)	5.4 (28.5)	9.3 (85.6)	-	83.5	265.1	186.3	1.31
SEm ±	0.2	0.8			9.0	10.6	0.09
LSD (P=0.05)	0.7	2.4			26.7	31.4	0.28

Note: Data was subjected to (X+1) transformation. Figures in parentheses are means of original values. PE: Pre-emergence; PoE: Post-emergence; RM: Ready mix; TM: Tank mix; DAS: Days after sowing

Table 1.1.4.1 Effect of treatments on weed density, weed dry weight, pod yield, gross returns, net returns and benefit cost ratio of groundnut.

Treatments	Weed density (no/m²)		Weed dry weight (g/m²)		Pod yield (kg/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
	40 DAS	At harvest	40 DAS	At harvest				
Fertility								
100 % Recommended dose of fertilizer	7.0(48.7)	6.2(38.0)	275.5	80.3	948	89,348	20,211	1.62
75% Recommended dose of fertilizer + 25% N through FYM	5.6(30.7)	5.7(31.3)	268.9	51.8	1082	72,179	25,776	1.80
50% Recommended dose of fertilizer + 50% N through FYM	4.2(16.3)	3.7(12.7)	30.7	47.7	1322	91,275	28,548	1.97
Without fertilizer + Without FYM	13.9(14.0)	9.6(12.0)	59.7	72.9	847	60,815	16,211	1.22
SEm±	1.3	2.4	9.8	8.4	13			
LSD (P=0.05)	4.1	7.3	28.4	24.3	41	-	-	-
Weed management practices								
Pre-emergence application of pendimethalin 0.75 kg/ha (2 DAS)	6.7(43.3)	6.1(36.0)	224.9	458.2	912	69,573	27,629	1.81
Pre-emergence application of pretilachlor 0.50 kg/ha (2 DAS)	7.5(56.0)	6.7(43.3)	262.7	505.9	770	79,262	23,175	1.62
Manual weeding (20 & 40 DAS)	4.3(17.3)	4.0(15.3)	18.5	263.3	1454	84,411	18,734	1.60
Twin wheel hoe *fb* HW at 40 DAS	4.0(15.3)	3.9(14.0)	17.2	235.7	1550	82,813	19,495	1.52
SEm±	0.5	0.7	4.6	7.4	24			
LSD (P=0.05)	1.7	2.9	14.6	29.7	78	-	-	-
Interaction (Fertility × Weed management)								
SEm±								
LSD (P=0.05)	NS	NS	NS	NS	NS			

Note: Data were subjected to square root transformation √ X+1. Figures in parentheses are means of original values.DAS: Days after sowing

imazethyper PoE, imazethyper + HW at 40 DAS and imazethyper + imazamox as PoE with HW at 40 DAS were at par and brought about significant reduction in weed dry matter, respectively. At 30 DAS, the highest weed control efficiency in controlling monocot (96.4%) was recorded with the treatment imazethapyr *fb* IC + HW at 40 DAS followed by oxyfluorfen *fb* imazethapyr (95.9%), oxyfluorfen *fb* imazethapyr + imazamox (95.2%). In case of controlling dicot weeds, highest weed control efficiency was recorded with the treatment oxyfluorfen *fb* imazethapyr (98.32%) and it was followed by imazethapyr *fb* IC + HW (96.3%), oxyfluorfen *fb* imazethapyr + imazamox (94.0%). The highest total weed control efficiency was registered by oxyfluorfen *fb* imazethapyr (98.3%). At 60 DAS, highest weed control efficiency of controlling monocot, dicot and total weeds were recorded with the treatment oxyfluorfen *fb* imazethapyr (97.3%), imazethyper + HW at 40 DAS (93.4%) and imazethapyr *fb* IC + HW at 40 DAS (96.50%), respectively.

In case of yield attributes, maximum number of seeds per pod (2.94) were recorded with the treatment IC *fb* HW at 20 and 40 DAS, however, it was at par with imazethapyr + propaquizafop (RM)+HW at 40DAS and oxyfluorfen *fb* imazethapyr + imazamox (RM). Maximum shelling % (74.6) and highest pod yield (2.07

t/ha)was recorded with the treatment IC *fb* hand weeding at 20 and 40 DAS. The pod yield was statistically at par with fluazifop-p-bultyl + fomesafen (RM) + HW at 40 DAS. The maximum net returns of ₹ 91,350/ha was fetched by the treatment IC *fb* HW at 20 and 40 DAS. Highest value of benefit cost ratio (2.71) was recorded with the treatment oxyfluorfen *fb* imazethapyr + imazamox (RM). It was followed by the treatments imazethapyr + propaquizafop (RM) (2.70) and imazethapyr + propaquizafop (RM) with HW at 40 DAS (2.66) (**Table 1.1.4.2**).

WP 1.1.5 Weed management in cotton based inter cropping system

WP 1.1.5.1 Integrated weed management in cotton based inter cropping system

Hyderabad

Due to heavy rains received during September and October 2020, intercrops and main crop were totally damaged and the experiments could not be considered

Table 1.1.4.2 Effect of treatments on weed control efficiency, yield attributes, shelling per cent, yields, net returns and benefit cost ratio of groundnut

Treatments	Dose (g/ha)	Time of application	Weed control efficiency (%)		No. of pods/ plant	No. of seeds /pod	Shelling per cent	Pod yield (t/ha)	Haulm yield (t/ha)	Net returns (₹/ha)	B:C
			30 DAS	60 DAS							
Pendimethalin + imazethapyr (RM)	750	PE	80.1	76.6	14.7	2.40	72.4	1.48	3.59	63,106	2.27
Oxyfluorfen *fb* imazethapyr	180 *fb* 100	PE *fb* PoE	98.3	96.3	15.8	2.43	71.1	1.49	3.47	61,271	2.07
Oxyfluorfen *fb* imazethapyr + imazamox (RM)	180 *fb* 70	PE *fb* PoE	94.0	95.5	16.8	2.69	72.6	1.82	4.24	80,800	2.71
Imazethapyr *fb* IC + HW at 40 DAS	100	PoE	96.3	96.5	15.6	2.18	71.5	1.68	4.00	71,318	2.29
Imazethapyr + propaquizafop (RM)	125	PoE	85.6	84.2	15.6	2.42	71.8	1.72	4.10	76,678	2.70
Imazethapyr + propaquizafop (RM) *fb* IC + HW at 40 DAS	125	PoE	69.0	65.6	16.4	2.87	73.0	1.72	4.34	76,737	2.66
Imazethapyr + imazamox (RM)	70	PoE	80.6	83.3	14.6	2.10	71.2	1..64	3.87	72,251	2.60
Imazethapyr + imazamox (Pre-mix) *fb* HW at 40 DAS	70	PoE	86.1	87.2	15.2	2.40	70.8	1.83	4.28	80,330	2.59
Fluazifop-p-butyl + fomesafen (Pre-mix)	250	PoE	60.8	58.2	15.8	2.45	71.8	1.50	3.63	63,814	2.30
Fluazifop-p-butyl + fomesafen (Pre-mix) *fb* IC + HW at 40 DAS	250	PoE	56.2	54.9	16.2	2.55	73.5	1.68	3.94	74,410	2.63
IC *fb* HW at 20 and 40 DAS	-	-	100.0	98.0	18.1	2.94	74.6	2.07	4.90	91,350	2.60
Weedy Check	-	-	0.00	0.00	10.40	1.80	70.2	0.87	2.03	27,839	1.10
SEm ±			-	-	0.44	0.13	0.92	0.05	0.15	-	-
LSD (P = 0.05)			-	-	1.29	0.37	2.71	0.17	0.45	-	-

Note: PE:Pre-emergence; PoE: Post-emergence; IC: Intercultural operation; HW: Hand weeding; DAS: Days after sowing; RM: Ready mix

for valid results. The experiment will be conducted during next year.

WP 1.1.6 Weed management in millets

WP 1.1.6.1 Bio-efficacy and phytotoxicity of herbicides and herbicide mixtures for weed control in finger millet.

Hyderabad

The crop was damaged due to heavy rains in *Kharif* experiment 2020, however it was again laid out during *Rabi*. The treatments were imposed as per the technical program of the work and the remaining package of practices was followed as per the recommendations of PJTSAU. Experiment and data collection is under progress.

WP 1.1.9 Management and *in situ* utilization of weeds in different cropping systems

Pantnagar

Experiment was conducted for management and utilization of the weeds *in situ* condition under the cropping system of black gram-maize and sugarcane-maize during *Kharif* 2020. In blackgram, application of imazethapyr 100 g/ha as post-emergence (PoE) completely controlled the grass *Echinochloa colona* and the broadleaf weeds *Celosia argentia*, *Celome viscosa* and *Phyllathus niruri*. Similarly, the lowest density of *Cyperus rotundus* was also recorded with imazethapyr 100 g/ha, which was also effective to record lowest total weed density and weed dry weight among all the treatments at 40 days after sowing (DAS). The highest weed control efficiency (78.2%) and seed yield (1225 kg/ha) were also registered with this treatment.

In maize, among the broadleaf weeds, *Celome viscosa*, *Eclipta alba* and *Phyllanthus niruri* were completely controlled with the application of topramezone 33.6 g/ha PoE *fb* one hand weeding (HW), which was also recorded lowest weed density of *Cyperus rotundus* at 40 DAS. Similarly, lowest values of total weed density, total weed dry weight and highest weed control efficiency (84.6%) and grain yield (5.5 t/ha) were also recorded with topramezone 33.6 g/ha PoE *fb* one HW.

WP 1.1.12 Evaluation of different herbicides in spring planted sugarcane

Pantnagar

The experimental plots were comprised by several weeds. The most dominating weeds found in two consecutive years were *Cyperus rotundus* and *C. differmis* as sedge, *Cynodon dactylon* as grassy weed and *Alternanthera phyloxeroides, Physalis minima, Commelina benghalensis* and *Cucumis sativus* as broadleaf weed.

Minimum weed biomass accumulation at 45 days after planting (DAP) in sugarcane was recorded with the sequential application of metribuzin 1000g/ha as pre-emergence (PE) *fb* halosulfuron methyl 67.5g/ha applied at 40 DAP as post-emergence (PoE), whereas observations recorded at 75 DAP indicated that sequential application of atrazine 2000g/ha PE *fb* metsulfuron+carfentrazone ready-mix (RM) 25g/ha PoE applied at 60 DAP recorded minimum weed biomass among the eighteen weed control treatments. Similar observations were also recorded at 110 DAP of sugarcane. Maximum number of millable canes (11.3 canes/m^2) was produced with the treatment atrazine 2000g/ha PE *fb* metsulfuron+ carfentrazone (RM) 25g/ha PoE. Highest cane yield of 81.6 t/ha was also recorded in this treatment and this was might be due to better weed control during the crop growth as evidenced by minimum production of weed biomass. Sequential application of atrazine 2000g/ha PE *fb* metsulfuron + carfentrazone (RM) 25 g/ha PoE applied at 60 DAP registered maximum benefit cost ration of 2.21 (**Table 1.1.12**).

Pantnagar centre

The experimental field was mainly infested with *Eleusine indica*, *Digiteria sanguinalis*, *Bracharia* spp., *Datyloctenium aegyptium, Alternanthera sessilis*, *Trienthemam onogyna*, *Ipomea* spp., *Spergulla avensis*, *Spilanthes calva*, *Coronopus didymus,* and *Cyperus rotundus*, which were accounted 2.24, 2.24, 5.24, 2.6, 10.8, 1.5, 1.12, 1.9, 2.1, 1.12 and 69.2% relative weed density, respectively at 45 days after planting (DAP).

The total weed density of grassy weeds was completely controlled with the application of sulfentrazone supplemented with hoeing *fb* 2,4-D (720 &

Table 1.1.12.1 Effect of different weed control treatments on weed biomass production, production of millable cane, cane yield and benefit cost ratio of spring planted sugarcane

Treatment	Total weed biomass production(g/m²)			No. of cane/ m²	Cane yield (t/ha)	B:C
	45 DAP	75 DAP	110 DAP			
Metribuzin 1000g/ha-PE	10.9(118.3)	12.7(160.8)	15.6(242.9)	7.5	57.4	1.30
Metribuzin 1000g/ha + halosulfuron methyl (TM) 67.5g/ha -PE	6.7(44.39)	13.1(171.1)	16.4(268.5)	7.6	58.5	1.33
Atrazine 2000g/ha-PE	11.6(134.1)	13.0(168.5)	16.8(281.7)	7.8	58.8	1.32
Atrazine 2000g/ha + halosulfuron methyl (TM) 67.5g/ha – PE	7.5(55.7)	12.4(153.3)	15.0(224.5)	7.7	58.2	1.33
Metribuzin 1000g/ha + halosulfuron methyl (TM) 67.5g/ha - PoE 40 DAP	4.2(17.1)	11.8(138.7)	14.7(215.6)	7.8	58.7	1.31
Atrazine 2000g/ha + halosulfuron methyl (TM) 67.5g/ha - P_0E 40 DAP	4.4(18.9)	11.2(124.9)	14.5(209.7)	8.1	60.2	1.39
Metribuzin 1000g/ha *fb* halosulfuron methyl 67.5g/ha – PE *fb* 40 DAP-PoE	3.2(9.7)	10.8(116.1)	13.9(192.8)	8.6	63.6	1.44
Atrazine 2000g/ha *fb* halosulfuron methyl 67.5g/ha – PE *fb* 40 DAP-PoE	3.6(12.5)	9.7(93.6)	12.6(158.3)	9.5	70.5	1.60
Sulfentrazone 720g/ha *fb* hoeing *fb* 2,4-D 1000g/ha-PE *fb* 45 DAP *fb* 60 DAP-PoE	7.2(51.3)	4.4(18.9)	7.8(60.3)	10.1	71.1	1.69
Sulfentrazone 720g/ha *fb* hoeing *fb* almix 4g/ha-PE *fb* 45 DAP *fb* 60 DAP-PoE	7.1(49.9)	4.9(23.5)	8.4(70.1)	10.2	72.9	1.74
Atrazine 2000g/ha *fb* 2,4-D 1000g/ha PE *fb* 60 DAP-PoE	12.4(153.3)	7.6(57.3)	10.9(118.3)	9.6	70.5	1.64
Hoeing after first irrigation *fb* atrazine 2000g/ha- PoE to Sugarcane	12.5(155.7)	9.8(95.5)	12.7(160.8)	9.4	68.9	1.59
Glyphosate (41% SL) 1860g/ha + Metribuzin 1000g/ha + surfactant - 15 DAP early PoE	8.6(73.5)	9.3(86.0)	12.4(153.3)	9.4	68.7	1.57
Atrazine 2000g/ha *fb* metsulfuron+carfentrazone (RM) 25g/ha PE *fb* PoE-60 DAP	12.1(145.9)	3.8(13.9)	6.9(47.1)	11.3	81.6	2.21
Atrazine 2000g/ha *fb* hoeing *fb* topramezone 25g/ha PE *fb* 45 DAP *fb* 60 DAP-PoE	11.8(139.7)	4.1(16.3)	7.3(52.8)	10.5	75.4	1.87
Paraquat 800g/ha *fb* Atrazine 2000g/ha 15 DAP early PoE*fb* 60 DAP-PoE	12.9(165.9)	10.5(109.7)	13.7(187.2)	9.0	65.3	1.51

Note: Data were subjected to (X+1) transformation. Figures in parentheses are means of original values. PE: Pre-emergence; PoE: Post-emergence; RM: Ready-mix; TM: Tank-mix; DAP: Days after planting

Table 1.1.12.2 Effect of different weed control treatments on weed biomass production, production of millable cane, cane yield and economics in spring planted sugarcane.

Treatment	Dose (g/ha)	Time of application	Total weed biomass production(g/m²)									Millable Cane (000/ha)	Cane yield (t/ha)	Net returns (₹/ha)	B:C
			45 DAP			75 DAP			105 DAP						
			Grass	Sedge	Broadleaf	Grass	Sedge	Broadleaf	Grass	Sedge	Broadleaf				
Metribuzin	1000	PE	1.4 (0.9)	6.7 (46.3)	3.8 (13.7)	2.3 (4.2)	7.5 (55.9)	10.8 (115.5)	4.5 (19.3)	3.5 (11.2)	9.7 (92.3)	92.4	63.4	60,672	1.46
Metribuzin + haosufuron methyl (TM)	1000+ 67.5	PE	1.3 (0.7)	6.3 (39.3)	3.9 (14.6)	2.4 (4.7)	5.4 (28.4)	13.5 (182.1)	3.7 (12.9)	1.0 (0.0)	11.4 (130.7)	96.3	72.6	84,522	1.63
Atrazine	2000	PE	1.5 (1.2)	6.8 (45.3)	3.5 (11.5)	5.0 (24.7)	7.1 (50.4)	12.5 (154.5)	1.0 (0.0)	3.2 (9.5)	9.9 (98.1)	96.7	65.6	69,000	1.53
Atrazine + halosulfuron (TM)	2000+ 67.5	PE	2.1 (3.4)	6.1 (36.1)	3.7 (12.7)	6.3 (39.1)	2.5 (5.1)	13.3 (176.3)	5.8 (32.5)	1.0 (0.0)	10.9 (118.7)	99.1	72.8	86,850	1.66
Metribuzin +halosulfuron (TM)	1000+ 67.5	PoE 40 DAP	1.8 (2.4)	6.3 (38.9)	4.0 (15.0)	7.1 (49.7)	1.6 (1.6)	10.9 (117.7)	8.7 (75.1)	1.1 (0.3)	8.7 (75.7)	94.0	61.5	51,222	1.38
Atrazine + halosulfuron (TM)	2000+ 67.5	PoE 40 DAP	2.4 (4.9)	6.0 (34.7)	4.3 (17.3)	7.7 (57.9)	1.4 (0.9)	11.9 (141.9)	8.4 (70.8)	1.0 (0.0)	9.3 (86.3)	90.2	65.2	64,050	1.49
Metribuzin *fb* hal osulfuron	1000 & 67.5	PE *fb* 40 DAP-PoE	1.0 (0.0)	5.0 (24.2)	3.6 (11.9)	4.5 (19.5)	1.8 (2.1)	7.7 (59.2)	1.0 (0.0)	1.1 (0.3)	8.8 (76.3)	102.9	70.8	78,422	1.58
Atrazine *fb* halosulfuron	2000 & 67.5	PE *fb* 40 DAP-PoE	1.8 (2.4)	6.4 (39.6)	4.3 (17.8)	6.7 (43.9)	1.0 (0.0)	11.5 (131.8)	9.3 (85.0)	1.0 (0.0)	10.3 (106.1)	98.4	75.7	94,850	1.71
Sulfentrazone *fb* hoeing *fb* 2,4-D	720 & 1000	PE *fb* 45 DAP *fb* 60 DAP-PoE	1.0 (0.0)	2.1 (3.6)	1.8 (2.2)	1.0 (0.0)	1.8 (2.3)	2.5 (4.7)	3.0 (7.7)	2.6 (6.0)	5.6 (31.1)	121.5	84.6	1,16,379	1.85
Sulfentrazone *fb* hoeing *fb* CME+MSM 20WP	720 & 4	PE *fb* 45 DAP *fb* 60 DAP-PoE	1.0 (0.0)	2.6 (5.6)	2.4 (4.8)	4.3 (17.7)	3.5 (11.1)	3.2 (9.2)	3.9 (14.4)	3.2 (9.0)	4.7 (21.5)	105.6	87.7	1,26,075	1.92
Atrazine *fb* 2,4-D	2000 & 1000	PE *fb* 60 DAP-PoE	2.6 (5.9)	7.2 (50.7)	4.0 (14.7)	8.9 (78.0)	2.0 (3.2)	4.6 (19.9)	9.0 (80.6)	1.8 (2.1)	4.6 (20.3)	98.5	69.3	78,479	1.60
Hoeing after first irrigation *fb* atrazine after second irrigation	2000	PoE to Sugarcane but PRE to weeds	1.2 (0.5)	1.7 (1.9)	1.0 (0.0)	2.5 (5.3)	3.9 (14.1)	6.9 (47.1)	8.4 (69.2)	2.9 (7.5)	7.7 (58.3)	126.1	87.8	1,31,100	1.99
Glyphosate + metribuzin + surfactant (1%) - (TM)	1860 + 1000	15 DAS-EPoE	1.2 (0.5)	5.7 (31.6)	1.5 (1.5)	2.5 (5.5)	6.1 (36.8)	6.8 (46.0)	1.0 (0.0)	3.3 (10.1)	8.3 (67.7)	125.5	79.5	1,07,473	1.82
Atrazine *fb* metsulfuron + carfentrazone (RM)	2000 & 25	PE *fb* PoE-60 DAP	1.6 (1.5)	6.9 (47.3)	3.7(13.0)	8.7 (74.1)	5.3 (26.7)	1.0 (0.0)	8.9 (77.8)	3.2 (9.1)	1.0 (0.0)	96.1	67.1	71,788	1.55
Atrazine *fb* hoeing *fb* topramizone	2000 & 25	PE *fb* 45 DAP *fb* 60 DAP-PoE	1.4 (1.1)	1.9 (2.7)	3.9 (14.5)	2.4 (4.6)	2.5 (5.2)	3.9 (14.0)	3.4 (10.7)	3.4 (10.5)	5.1 (25.4)	96.1	96.0	1,50,800	2.10
paraquat *fb* atrazine	800 & 2000	15 DAS-E PoE *fb* 60 DAP-PoE	1.7 (1.9)	6.4 (39.6)	4.5 (19.3)	6.0 (35.6)	6.4 (39.7)	7.2 (51.1)	3.5 (11.3)	2.5 (5.2)	8.6 (73.1)	91.0	74.3	92,534	1.71
Three hoeing (30, 60 and 90 DAP)			1.4 (0.9)	4.0 (15.3)	1.6 (1.9)	5.3 (26.9)	4.5 (19.3)	4.2 (16.4)	5.6 (30.9)	2.8 (6.7)	3.3 (10.1)	117.5	95.2	1,47,100	2.06
Unweeded control			4.1 (15.7)	7.1 (49.5)	5.8 (32.8)	10.2 (102.3)	7.5 (55.9)	16.4 (269.7)	14.0 (194.1)	7.0 (48.7)	15.5 (239.7)	62.6	52.6	32,800	1.26
SEm ±			0.07	0.2	0.2	0.2	0.2	0.4	0.3	0.1	0.3	3.7	1.9	-	-
LSD (P= 0.05)			0.21	0.6	0.5	0.6	0.5	1.2	0.9	0.3	1.0	10.6	5.4	-	-

1000 g/ha) at 45 and 75 DAP and also with metribuzin *fb* halosulfuron (1000 & 67.5 g/ha) and sulfentrazone *fb* hoeing *fb* CME+MSM (720 & 4 g/ha) only in case of 45 DAP. At 105 DAP, application of atrazine (2000 g/ha), metribuzin *fb* halosulfuron (1000 & 67.5 g/ha) and tank mix of glyphosate (41% SL) + metribuzin+ surfactant (1%) (1860+1000 g/ha) were found significantly most effective to achieve complete control on grassy weeds among the treatments. In case of sedges, the lowest total weed density was recorded with the treatment hoeing after first irrigation *fb* atrazine after second irrigation (2000 g/ha) at 45 DAP. However, tank mix of atrazine + halosulfuron (2000 & 67.5 g/ha) at 75 DAP and tank mix of metribuzin + halosulfuron (1000 & 67.5 g/ha), atrazine + halosulfuron (2000 & 67.5 g/ha) as pre-emergence (PE), atrazine + halosulfuron (2000 & 67.5 g/ha) as post-emergence (PoE) applied at 40 DAP and atrazine 2000 g/ha PE *fb* halosulfuron 67.5 g/ha PoE applied at 40DAP completely controlled the density of sedge at 105 DAP among all the treatments. In case of broadleaf weeds, the total weed density was completely controlled with hoeing after first irrigation *fb* atrazine after second irrigation (2000 g/ha) applied at 45 DAP. While, sequential application of atrazine 2000 g/ha PE *fb* metsulfuron + carfentrazone RM25 g/ha PoE completely controlled broadleaf weeds at 75 and 105 DAP.

The highest cane length (433 cm) was observed with tank mix of glyphosate + metribuzin + surfactant (1%) (1860+1000 g/ha). However, application of tank mix atrazine + halosulfuron (2000 & 67.5 g/ha) recorded highest average cane weight (1.066 kg), hoeing after first irrigation *fb* atrazine after second irrigation (2000 g/ha) recorded highest number millable canes (₹ 12,600/ha). Highest cane yield (96.0 t/ha), net returns (₹ 1,50,800/ha) and benefit cost ratio (2.10) were recorded with the treatment atrazine supplemented with hoeing followed by topramizone (2000 & 25 g/ha).

WP 1.1.14 Evaluation of herbicides against weed complex of Frenchbean (*Kharif*) - Field bean (*Rabi*) cropping system

Bengaluru

The experiment was initiated during *Kharif* 2020. During the crop season heavy rains coupled with herbicide toxicity, crop failed.

The experiment was initiated during *Rabi* 2020. Observation on phytotoxicty and the treatment imposition has been made as per the protocol. Crop was at vegetative stage.

WP 1.2 Weed management under resource conservation technique

WP 1.2.1 Weed management in different cropping systems under conservation agriculture systems

WP 1.2.1.1 Weed management in rice-based cropping systems

Cooperating centres:

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

Treatment details:

Treatments	*Kharif*	*Rabi*	Summer
Tillage & 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	(RH)	
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

OUAT, Bhubaneswar

WP1.2.1.1.1 Weed management in rice- maize-cowpea under conservation agriculture system

In *Kharif* rice 2020, *E. crus-galli, E. colona, P. scorbiculatum, L. parviflora* among BLWs, *C. difformis, C.iria, C. rotundus* and *F. miliacea* among sedges were the major weeds. At 60 DAP, CT plots had considerably lower weeds over CT (DSR). The average weed density and dry biomass of weeds were lowest with CT (transplanting)-CT system (79.4/m^2 and 32.5 g/m^2, respectively) followed by CT (transplanting)-ZT-ZT system. The rest of the treatments had significantly higher weed density and dry biomass; however, weed values were lowest in CT (transplanting)-CT system. The highest grain yield (3.30 t/ha) was recorded with CT (Transplanting)-CT system followed by CT (transplanting)-ZT-ZT system (3.23 t/ha) with the highest gross returns. The net return was recorded the highest with ZT(DSR)+R-ZTR-ZT system over the other tillage and residue management. Among weed management practices, application of pretilachlor 0.75 kg/ha *fb* hand weeding (IWM) recorded fewer weeds and lesser weed dry biomass *fb* pretilachlor 0.75 kg/ha over one hand weeding (113.4/m^2 and 38.5 g/m^2, respectively). Lower weed density and dry biomass under IWM resulted in higher grain yield (3.70 t/ha) *fb* pretilachlor 0.75 kg/ha (3.57 t/ha) and proved better than weedy check. However, pretilachlor 0.75 kg/ha obtained the highest B:C ratio (2.95) over one hand weeding (2.80 t/ha). These helped in obtaining higher gross and net return over others.

In *Rabi* maize, the experimental field was comprised of 60% grassy weeds [*Panicum repens* (25%), *Echinochloa crus-galli* (18%), *Echinochloa colona* (11%)], followed by *Marselia quadrifolia* (10%), *Alternanthera sessilis* (7%), and sedges with *Cyperus difformis* (9%) and *Cyperus iria* (3%). At 60 DAS, the lowest weed density was recorded in CT (transplanting)-ZT-ZT (33.5/m^2). Inclusion of CT in the tillage methods reduced the weed densities to 21.1, 19.6 and 28.1%, respectively, and weed dry biomass by 16.2, 17.5 and 21.2%, respectively over ZT-ZT. Application of pendimethalin 1.0 kg/ha *fb* one manual weeding recorded the lowest weed density (23.4/m^2) at 25 DAP as compared to sole recommended herbicide application pendimethalin 1.0 kg/ha (66.2/m^2) and weedy check (66.5/m^2). The practice of IWM however reduced the weed density by 44.1% and 50.1% at later stages of crop growth (60 DAP and at harvest). However, the grain yield was higher with CT(transplanting)-ZT-ZT system (4.52 t/ha) whereas, ZT(DSR)-ZT+R-ZT system resulted in the lowest grain yield and the yield reduction was to the tune of 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 seasons. Among various tillage systems, CT (trans)-ZT-ZT method recorded the highest B:C of 3.5 in the entire rice-maize-cowpea system *fb* CT (DSR)-CT-ZT method (2.8). 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. The establishment method CT to rice and ZT+R in maize and ZT in cowpea produced the highest REY of 13.4 t/ha. But the application of pretilachlor + hand weeding (IWM) to rice and pendimethalin to the maize of ZT+R with one hand weeding and ZT with cowpea recorded the highest B:C of 3.5.

SKUAST, Jammu

WP1.2.1.1.2 Weed management in rice-wheat-greengram cropping system under conservation agriculture

During *Rabi* 2019-20, in wheat field, *Phalaris minor, Rumex* spp., *Anagalis arvesnsis*, *Medicago* spp., *Ranunculus arvensis, Melilotus* spp. were the major weeds. Among the tillage and residue management treatments, significantly lower grassy weed, BLWs, total weed density and weed biomass were recorded in ZTDSR/ZTDSR+R-ZTwheat+R plots as compared to CT-wheat and ZT-wheat. The density of *Phalaris minor, Rumex* spp., *Ranunculus arvensis, Anagalis arvensis, Melilotus* spp. and other weeds were significantly lower in ZTDSR/ZTDSR + R-ZT wheat+R plots as compared

to CT transplanted rice-CT wheat, CT transplanted rice-ZT wheat and CTDSR-CT wheat. However, the significantly lower density of *Medicago* spp. was observed in CT transplanted rice-CT wheat as compared to ZTDSR/ZTDSR+R-ZT wheat+R and CT transplanted rice-ZT wheat and it was statistically at par with CTDSR-CT wheat. Among the weed management treatments, sulfosulfuron + metsulfuron 30+2 g/ha at 30 DAS *fb* HW at 45 DAS (IWM) 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). 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 1.2.1**).

The highest grain and straw yield and B: C ratio were recorded in ZTDSR+residue-ZTwheat+residue which were significantly higher than CT transplanted rice-ZT wheat without residue. Among the weed management treatments, the IWM recorded significantly higher panicles/m^2, grains/panicle, test weight, grain and straw yields and B:C ratio of wheat as compared to weedy check and sulfosulfuron + metsulfuron (30+2 g/ha) at 30 DAS.

During *Kharif* 2020 in rice, *Echinochloa* spp., *Cynodon dactylon*, *Digitaria sanguinalis*, *Alternanthera philoxeroides, Physalis minima* and *Cyperus* spp. were the major weeds. Among the tillage and residue management treatments significantly lower grassy, broad-leaved, sedges, total weed density, and weed biomass were recorded in transplanted rice as compared to ZT-DSR+residue, ZT-DSR and CT-DSR. 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* was significantly higher in DSR under ZT and CT as compared to transplanted rice. A significantly higher number of panicles, grain and straw yields were recorded in

Table 1.2.1 Effect of tillage and weed management practices on weed biomass in wheat (*Rabi*-2019-20)

Treatments	Weed biomass (g/m^2) at 60 DAS				Weed biomass (g/m^2) at harvest				Grain yield (t/ha)
	Grassy	BLWs	Total	WCE	Grassy	BLWs	Total	WCE	
Tillage and residue management									
TRM 1	4.79 (21.9)	6.19(37.2)	7.76 (59.2)	58.9	7.57 (56.2)	8.31 (68.0)	10.78 (115.1)	60.3	3.91
TRM 2	4.04 (15.3)	7.03 (48.3)	8.04 (63.7)	58.9	6.84 (45.8)	9.37 (86.7)	10.9 (119.8)	60.2	3.74
TRM 3	4.42 (18.5)	6.01 (35.0)	7.39 (53.5)	58.6	7.19 (50.7)	7.85 (60.6)	10.4 (107.6)	60.2	4.09
TRM 4	2.98 (7.89)	4.73 (21.4)	5.51 (29.3)	62.1	4.96 (23.6)	6.90 (46.6)	8.17 (65.7)	61.8	4.28
TRM 5	2.91 (7.46)	4.64 (20.5)	5.39 (28.0)	61.9	4.78 (21.8)	6.66 (43.2)	7.89 (61.3)	61.8	4.35
SEm ±	0.07	0.11	0.10		0.09	0.15	0.09		0.12
LSD (P=0.05)	0.23	0.37	0.32		0.29	0.49	0.30		0.38
Weed management									
Herbicide	2.76 (6.61)	3.91 (14.3)	4.68 (20.9)	82.9	4.78 (21.8)	4.67 (20.8)	6.27 (38.3)	84.3	4.36
IWM	1.49 (1.23)	1.77 (2.12)	2.09 (3.35)	97.4	2.00 (2.98)	2.02 (3.1)	2.33 (4.43)	98.4	4.71
Weedy	5.99 (34.8)	9.07 (81.2)	10.8 (116.0)	0.0	9.75 (94.1)	12.6 (159.3)	15.5 (239.1)	0.0	3.16
SEm ±	0.06	0.06	0.06		0.07	0.07	0.08		0.07
LSD (P=0.05)	0.17	0.18	0.19		0.21	0.22	0.25		0.22
Interaction	S	S	S		S	S	S		NS

Data were subjected to square root transformation √ X+1. Original values are in parenthesis

transplanted rice as compared to ZT-DSR+R, ZT-DSR, and CT-DSR (**Table 1.2.2**).

The pendimethalin 1.0 kg/ha *fb* bispyribac-sodium 25 g/ha *fb* 1 hand weeding in DSR (IWM) and bispyribac-sodium 25 g/ha *fb* 1 hand weeding in transplanted rice (IWM) recorded significantly lowest density and biomass of weeds as compared to weedy check and herbicidal treatment (Pendimethalin 1 kg/ha *fb* bispyribac-sodium 25 g/ha in DSR and bispyribac-sodium 25 g/ha in transplanted rice). A significant interaction was found between tillage and weed management treatments with respect to weed density and weed biomass. Amongst all the tillage and residue and weed management combinations, the highest net returns and B:C was recorded in ZT-DSR+R and IWM treatment combination.

AAU, Jorhat

WP 1.2.1.1.3 Weed management in rice-mustard-green manure cropping system under conservation agriculture

In rice, among the different combinations of tillage CT(S)-CT(TR)-CT(IM) and MT(S)-CT(TR)-MT(IM) significantly reduced the density and dry biomass of weeds at 60 DAT of winter rice as compared to MT(S)-CT(DSR)-CT(IM), MT(S)-MT(DSR)-MT+R(IM) and MT(S)-MT(DSR)-MT(IM). The panicles and grain yield of rice increased under MT(S)-CT(TR)-MT(IM) followed by CT (TR) as compared to CT (DSR) and other tillage treatments. Among the weed management treatments, the lowest weed density and dry biomass at 60 DAS were observed in pretilachlor 0.75 kg/ha + HW at 30. The highest grain yield was found in IWM followed by pretilachlor 0.75 kg/ha as well as weedy check (**Table 1.2.3)**.

The treatment MT(S)-CT(TR)-MT(IM) recorded the highest plant height and biomass of *Sesbania* in case of tillage practices and pendimethalin 0.75 kg/ha (PE) + HW at 30 DAS recorded the highest among all other treatments. In *Rabi* 2019-20, CT in rice and mustard significantly reduced weed population and dry biomass in mustard at 50 DAS as compared to MT treatments. The plant height and yield attributes like the number of siliqua/plant and seed yield were significantly

Table 1.2.2 Effect of tillage and weed management practices on weed biomass in rice (*Kharif* 2020)

Treatment	Weed biomass (g/m²) at 60 DAS/DAT				WCE	Grain yield (t/ha)	Straw yield (t/ha)	B:C
	Grassy	BLWs	Sedges	Total				
Tillage & residue management								
TRM 1	3.85 (13.8)	2.91 (7.5)	2.92 (7.5)	5.46 (28.8)	54.9	4.05	5.24	1.64
TRM 2	3.95 (14.6)	2.95 (7.7)	2.97 (7.8)	5.58 (30.1)	53.8	3.98	5.09	1.59
TRM 3	6.50 (41.3)	3.90 (14.2)	4.28 (17.3)	8.59 (72.8)	57.5	3.02	4.19	1.12
TRM 4	6.94 (47.2)	3.82 (13.6)	4.85 (22.5)	9.18 (83.3)	57.2	2.96	3.58	1.21
TRM 5	5.78 (32.4)	3.25 (9.6)	4.11 (15.9)	7.68 (57.9)	59.1	3.24	4.38	1.46
SEm ±	0.09	0.05	0.05	0.07		0.14	0.21	
LSD (P=0.05)	0.28	0.15	0.17	0.23		0.45	0.68	
Weed management								
Herbicide	4.58 (19.9)	2.58 (5.7)	2.64 (6.0)	5.71 (31.6)	73.7	3.90	5.04	1.74
IWM	1.84 (2.4)	1.00 (0.0)	1.85 (2.4)	2.41 (4.8)	95.8	4.47	5.78	1.97
Weedy	8.26 (67.3)	5.18 (25.9)	5.94 (34.3)	11.3 (127.4)	0	1.98	2.67	0.51
SEm ±	0.07	0.05	0.05	0.07		0.09	0.11	
LSD (P=0.05)	0.22	0.16	0.15	0.21		0.26	0.32	
Interaction	S	S	S	S		S	S	

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

increased under CT(S)-CT(TR)-CT(IM) over rest of the treatments.

There was no significant impact of weed management practices except dry biomass of weeds at 50 DAS when one HW/hoeing and IWM (pretilachlor 0.75 kg/ha (PE) in rice + one mechanical weeding, pendimethalin 0.75 kg/ha (PE) in rapeseed + one mechanical weeding) resulted in significantly lower weed dry biomass than weedy check and recommended herbicides (pretilachlor 0.75 kg/ha (PE) in rice, pendimethalin 0.75 kg/ha (PE) in rapeseed) alone. Among weed management practices, IWM increases seed yield (693.9 kg/ha) significantly over the rest of the weed management treatment followed by one HW/hoeing and recommended herbicide (pretilachlor 0.75 kg/ha (PE) in rice, pendimethalin 0.75 kg/ha (PE).

IGKV, Raipur

WP1.2.1.1.4 Weed management in rice-wheat-cowpea fodder cropping system under conservation agriculture systems

In wheat 2019-20, 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 a lower number. The *Medicago denticulata* was the most serious weed. At 60 DAS, weed density and dry biomass were recorded lowest ZT (DSR) +R-ZT+R followed by ZT+R as compared to CT-

Table 1.2.3 Effect of tillage practices and weed management on yield of Sali rice and Indian mustard

Treatment	Sali rice			Indian mustard		
	Weed dry biomass (g/m^2)	Panicles/m^2	Grain yield (t/ha)	Weed dry biomass (g/m^2)	Siliqua/plant	Seed yield (kg/ha)
Tillage practices						
CT(S)-CT(TR)-CT(IM)	2.98	145.8	2.89	3.93	42.9	741.8
MT(S)_CT(TR)_MT(IM)	2.99	148.5	2.90	3.57	40.7	692.2
MT(S)-CT(DSR)-CT(IM)	6.81	108.5	2.70	3.74	36.7	562.3
MT(S)-MT(DSR)-MT+R(IM)	7.50	101.7	1.80	3.61	36.4	528.7
MT(S)-MT(DSR)-MT(IM)	8.59	106.2	1.51	4.05	34.8	505.0
SEm±	0.38	6.44	0.13	0.15	0.95	10.2
CD (P=0.05)	1.50	25.2	0.51	NS	3.75	40.3
Weed management						
W_1: Recommended herbicides (Pretilachlor 0.750 kg/ha pre-em in rice, pendimethalin 0.75 kg/ha pre-em in rapeseed)	5.72	118.4	2.30	4.08	39.0	578.9
W_2:IWM (Pretilachlor 0.750 kg/ha pre-em in rice + one mechanical weeding, pendimethalin 0.75 kg/ha pre-em in rapeseed + one mechanical weeding)	5.52	126.3	2.60	3.66	39.4	693.9
W_3: One hand weeding/hoeing	5.75	130.3	2.30	3.43	38.5	606.1
W_4: Weedy check	6.10	113.6	2.20	3.95	36.5	545.1
SEm±	0.18	7.28	0.09	0.12	1.57	16.1
LSD (P=0.05)	NS	NS	0.26	0.35	NS	46.5

CT and CT-ZT. The higher grain yield (3.34 t/ha) was obtained under ZT (DSR)+R-ZT+R compared to ZT(DSR)-ZT without residue tillage (3.23 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 high under ZT+R.

Among weed management practices, weed density and dry biomass were recorded lowest under IWM (clodinofop 60 g/ha + metsulfuron 4 g/ha PoE *fb* HW 40 DAS) over recommended herbicide (clodinofop 60 g/ha + metsulfuron 4 g/ha) and control. The higher grain yield was recorded under IWM followed by recommended practice and both were significantly superior over control. The IWM found more profitable in terms of net returns as well as B: C over recommended herbicide practice (**Table 1.2.4**).

In cowpea 2020, the experimental field was dominated by *Echinochloa colona* and *Cynodon dactylon* among grasses and *Alternanthera triandra* was major BLW. *Cyperus iria* and *Brachiaria ramose,* were the other weeds present in small numbers. 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+R than CT/ZT without residue. Highest net return and B:C obtained under ZT (DSR) +R-ZT +R-ZT+R followed by ZT (DSR)-ZT+R-ZT. It was found that ZT+R had 14.8% higher resource use efficiency over CT, ZT with no residue had shown 3.9% higher efficiency over CT. Application of pendimethalin 1.0 kg/ha *fb* HW at 20 DAS kept the weed density and dry biomass considerably lower than other weed management practices. This leads to a higher fodder yield recorded under the recommended practice of application of pendimethalin 1.0 kg/ha *fb* HW at 20 DAS than rest. Similarly, net returns and benefit cost ratio were highest under the IWM. The IWM recorded resource use efficiency by 226.1% followed by recommended herbicide 176.6% over un-weeded.

In rice in 2020, weed flora of the experimental field consisted of *Echinochloa colona* among grasses,

Table 1.2.4 Weed dry biomass, grain yield and economics as influenced by weed management practices in conservation agriculture in wheat in *Rabi* 2019-20

Treatments	Weed dry biomass (g/m²)	Grain yield (t/ ha)	Net returns (₹/ha)	B:C
Tillage & residue management				
CT (Transplanted) -CT-CT	5.47 (29.4)	3.01	27,988	1.94
CT (Transplanted) -ZT-ZT	4.90 (23.5)	3.09	32,792	2.23
CT (Direct seeded)-CT-ZT	5.34 (28.0)	3.06	29,079	1.97
ZT (Direct seeded)-ZT+R-ZT	4.38 (18.7)	3.23	35,530	2.33
ZT (Direct seeded)+R - ZT+R-ZT+R	4.30 (18.0)	3.34	37,583	2.41
SEm±	0.23	0.06	-	-
LSD (P= 0.05)	0.76	0.20	-	-
Weed management				
Clodinofop 60 g/ha + metsulfuron 4 g/ha	4.42 (19.0)	3.80	44,237	2.53
Integrated (clodinofop 60 g/ha + metsulfuron 4 g/ha *fb* HW 40 DAS)	3.97 (15.3)	4.00	47,097	2.58
Weedy check	6.24 (38.4)	1.64	3,761	1.14
SEm±	0.13	0.06	-	-
LSD (P= 0.05)	0.39	0.19	-	-

Cyperus iria among sedges and *Alternanthera triandra* among BLWs. Broadleaved and sedges were dominated over grasses. Other weeds like *Brachiaria ramosa*, *Sporobolus diander*, *Cynotis axillaris, Commelina benghalensis, Ludwigia parviflora, etc.* were found in less number. *Cyanotis axillaris* and *Sporobolus diander* being late *Kharif* weeds dominated the weed flora during the maturity of crop.

The lowest weed density and weed dry biomass was 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 were lower in ZT (DSR) +R as compared to ZT alone, this might be due to retaining crop residues between rows. Lower weed parameters lead 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 (3.14) 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 were less under IWM (oxadiargyl 80 g/ha *fb* HW at 25 DAT/S) followed by recommended herbicide (pyrazosulfuron 20 g/ha *fb* penoxsulam 22.5 g/ha) over control. Although, significant variation in seed yield was obtained and significantly higher seed yield was recorded under IWM practices followed by pyrazosulfuron 20 g/ha *fb* penoxsulam 22.5 g/ha. Both the weed management practices were significantly superior over untreated control. Lower weed parameters and higher yield resulted in higher net returns and B:C in IWM followed by pyrazosulfuron 20 g/ha *fb* penoxsulam 22.5 g/ha (**Table 1.2.5**).

CCSHAU, Hisar

WP 1.2.1.1.5 Weed management in conservation agriculture systems in rice-wheat cropping system

Under different tillage and residue management scenarios [with and without weste decomposer (WD)], the population density and dry biomass of *P. minor* was lower in case of ZT wheat with or without residue compared to CT, while, it was reverse in the case of BLWs (*Rumex dentatus*). In ZT wheat with

Table 1.2.5 Weed dry biomass, seed yield and economics of rice as influenced by weed management practices in conservation agriculture during *Kharif* 2020.

Treatment	Weed dry biomass (g/m²)	Grain yield (t/ha)	Net income (₹/ha)	B:C
Tillage & residue management				
CT (Transplanted)-CT-CT	4.79 (22.7)	5.44	58,268	2.34
CT (Transplanted)-ZT-ZT	5.17(26.2)	5.27	55,113	2.27
CT (Direct Seeded)-CT-ZT	6.27 (38.9)	4.19	44,162	2.30
ZT (Direct Seeded)-ZT+R-ZT	5.70 (32.0)	5.11	64,686	3.10
ZT(Direct Seeded)+ R-ZT+R-ZT+R	5.65 (31.4)	5.18	65,946	3.14
SEm±	0.19	0.16	-	-
LSD (P= 0.05)	0.62	0.51	-	-
Weed management				
Recommended (pyrazosulfuron 20 g/ha *fb* penoxsulam 22.5 g/ha PoE	4.34 (18.4)	5.63	60,734	2.37
Integrated weed management (oxadiargyl 80 g *fb* HW at 25 DAT/S	3.00 (8.5)	6.19	75,192	2.86
Unweeded	9.21 (84.3)	3.30	23,058	1.60
SEm±	0.19	0.19	-	-
LSD (P= 0.05)	0.57	0.55	-	-

partial residue load (unchopped) resulted in significantly higher grain yield (5.57 t/ha) (**Table 1.2.6**) being at par with anchored stubble as compared to other scenarios [full residue retention (chopped) with and without waste decomposer, and conventional sown wheat]. Application of herbicides (mesosulfuron + iodosulfuron, 14.4 g/ha) along with one hand weeding comprises as IWM resulted in more grain yield as compared to alone application of the same herbicide. Crop received concurrence rains during the early stage of the crops resulting in filling of open slits with silt thus recorded poor emergence. Higher dehydrogenase activity (µgTPF/g soil/24 Hrs) was recorded under zero-till wheat (ZTW) + Full residue + WD from soil after wheat harvest. *Kharif* 2020 was the third season of the rice and in all the plots, it was transplanted under conventional puddled conditions (CT-PTR). The grain yields of rice were similar amongst all the treatments (5.77-6.13 t/ha) mainly due to a similar planting method of rice establishment.

PJTSAU, Hyderabad

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

In *Rabi* maize during 2019-20, the major weed flora was consisted of *Cyperus rotundus, Parthenium hysterophorus, Alternanthera sessilis, Melilotus alba, Trianthema portulacastrum, Eclipta alba*, and *Aeschynomene* spp at 30 DAS. However, in addition to these weeds, *Amaranthus viridis, Amaranthus polygamus, Acalypha indica* and *Physalis minima* at 60 DAS were recorded.

Among tillage practices at 60 DAS, significantly the lowest weed density and dry biomass (6.2/m^2 and 4.28 g/m^2, respectively) were recorded with CT (TPR) - CT (maize) followed by CT (TPR) - ZT (maize). CT (TPR) - CT (maize) recorded higher grain and stover yield and on par with CT (TPR) - ZT (maize) while it was lowest under CT (DSR)- CT (maize). Maize in ZT or CT after CT (TPR) and CT (DSR), respectively had the benefit cost ratio of 2.58 followed by CT (TPR)-CT (maize). Higher grain yield (5.21 and 5.17 kg/ha), gross returns (₹ 1,02,175/ha and ₹ 1,00,176/ha) and B:C (2.58 and 2.52) could be obtained in *Rabi* maize raised conventionally and zero tillage in sequence to transplanted rice during *Kharif*, respectively. With respect to weed management practices, significantly lowest weed density and dry biomass were recorded in PE application of atrazine 1000 g/ha + paraquat 600g/ha (PE) *fb* HW at 40 DAS (IWM). Unweeded control recorded the highest weed density and dry matter. Either 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 (5.64 and 5.16 t/ha), gross returns (₹ 1,09,565 and 99,545/ha) and net returns

Table 1.2.6 Effect of tillage and residue management treatments on yield and yield attributes of wheat

Treatments	Effective (tillers/ mrl)	Plant height (cm)	Wheat grain yield (t/ha)	Dehydrogenase activity (µgTPF/g soil/24 Hrs)	Rice grain yield (t/ha)
Tillage & residue management					
ZTW + Full residue (Happy seeder) + WD	60	91	4.82	32.2	6.13
ZTW + Full residue (Happy seeder)	60	93	5.00	38.0	5.77
ZTW + Partial residue (Happy seeder)	77	96	5.57	48.5	5.89
ZTW + Anchored stubbles (Happy seeder)	76	95	5.46	49.5	5.79
CTW (Drill sown)	72	96	5.25	61.7	5.79
LSD (P=0.05)	3.4	1.8	0.24	32.2	NS
Weed management					
Recommended herbicides	73	92	5.81		
IWM	71	93	5.71		
Weedy check	62	97	4.14		
LSD (P=0.05)	5.2	1.8	0.10		

(₹ 64,885 and 57,765/ha) and BC ratio (2.45 and 2.38) respectively.

In rice-maize system, more system productivity, gross returns, net returns and B:C obtained under CT *Kharif* rice followed by maize under CT (10.62 t/ha, ₹ 1,92,845, ₹ 1,15,098 and 2.48) and ZT practices, respectively (10.42 t/ha, ₹ 1,89,214 ₹ 1,11,467 and 2.43), 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 were obtained with IWM (9514 kg/ha, ₹ 1,72,679, ₹ 96,192 and 2.26) for both *Kharif* rice and *Rabi* maize in sequence due to the realization of higher yields.

GBPUAT, Pantnagar

WP1.2.1.1.6 Weed management in rice-wheat-sesbania cropping system under conservation agriculture

In wheat (2019-20), experimental plot comprised of *Phalaris minor* (27.6%), *Melilotus indica* (25.1%), *Coronopus didymus* (21.8%), *Medicago denticulata* (10.2%) and *Rumex acetosella* (6.4%) at 60 DAS, alongwith these other weeds like *Chenopodium album, Solanum nigrum, Fumaria parviflora, Polygonum plebejum,* and *Mollugo* spp. also recorded at this stage but less in density.

CT (TPR) along with residue incorporation and ZT+R and *Sesbania* incorporation recorded minimum density of weeds amongst all the treatments. Rice TPR with the incorporation of residue and ZT wheat + R and *Sesbania* incorporation attained the lowest total weed density and total weed dry biomass of grassy as well as BLWs. The highest plant height (98.5 cm), number of spikes was achieved with rice DSR *fb* CT wheat without residue and *Sesbania* incorporation but higher grain yield (4.14 t/ha) and straw yield (6.54 t/ha) with TPR along with residue incorporation and ZT wheat + R and *Sesbania* incorporation at par with CT (DSR) along with residue incorporation and ZT wheat + R and *Sesbania* incorporation. The highest net returns and B:C of ₹ 70,148 and 1.72 was recorded in the plots, where, wheat was sown in the rice (DSR) followed by CT wheat without incorporation of residue and *Sesbenia* .

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* HW 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 the lowest total weed density and weed dry biomass of all grassy and BLWs leads to obtained the highest grain yield (4.54 t/ha) and was found significantly superior to the rest of the practices. Clodinafop propargyl + MSM 60+4 g/ha recorded the highest net return (₹ 54,431) and highest B:C (1.43) which was remarkably higher than the weedy check.

In rice during *Kharif* 2020, *Echinochloa colona*, *Echinochloa crus-galli, Leptochloa chinensis, Ischaemum rugosum, Panicum maximum*, *Ammania baccifera, Alternanthera sessilis, Cyperus rotundus*, *Cyperus iria* and *Cyperus difformis* were the major weed species. 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 + R 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 (DSR)-wheat (CTW) followed by rice (DSR)-wheat (CTW). The highest grains per panicle, grain yield (5.8 t/ha) and straw yield (12.0 t/ha) of rice were achieved under rice (TPR) incorporated with residue and *Sesbania* followed by ZT wheat +R and *Sesbania* the highest net returns and B:C and followed by ZTW+R (**Table 1.2.7**).

IWM (Recommended herbicide *fb* HW at 45 DAS/DAT) achieved the lowest total weed density and total weed dry biomass of all grassy and non-grassy weeds over the unweeded situation. Similarly, IWM was 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 returns (₹ 52,035) and highest B:C (1.06).

Table 1.2.7 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 & residue management								
Rice (TPR)-Wheat (CTW)	2.4 (5.8)	3.4 (16.8)	3.9 (15.6)	2.0 (3.3)	2.5 (6.7)	2.4 (6.2)	5.1	8.6
Rice (TPR) + RC- Wheat (CTW)+R-*Sesbenia* (INC)	2.4 (7.6)	3.9 (26.8)	3.8 (15.1)	2.4 (4.9)	2.6 (10.7)	2.5 (9.8)	5.8	12.0
Rice (TPR) + RC- Wheat (ZTW)+RR-*Sesbenia* (INC)	1.8 (3.6)	2.4 (8.4)	5.1 (29.3)	2.2 (4.0)	2.8 (13.8)	2.4 (8.6)	5.3	10.7
Rice (DSR) -Wheat (CTW)	2.4 (6.7)	3.9 (23.8)	2.3 (4.9)	1.9 (3.0)	2.0 (4.9)	2.5 (9.9)	4.0	8.3
Rice (DSR) + R-Wheat (CTW)+R-*Sesbenia* (INC)	5.3 (34.7)	7.6 (69.4)	2.9 (8.0)	1.9 (3.0)	2.9 (12.2)	3.2 (15.1)	3.4	6.9
Rice (DSR) + R- Wheat (ZTW)+RR-*Sesbenia* (INC)	2.2 (5.3)	4.6 (30.7)	3.5 (11.6)	2.9 (7.8)	4.6 (22.2)	3.7 (18.8)	3.6	7.5
SEm±	0.06	0.2	0.1	0.08	0.06	0.07	0.2	0.4
LSD (P=0.05)	0.2	0.5	0.3	0.2	0.2	0.2	0.7	1.3
Weed management								
Rec.herb. (Penoxsulam + cyhalofop –butyl 135 g/ha (15-20 DAS/DAT)	3.6 (4.5)	3.3 (15.0)	3.6 (13.1)	1.9 (2.9)	1.9 (3.8)	1.6 (2.0)	4.8	9.5
IWM (Rec. herbicide *fb* one HW at 45 DAS/DAT)	2.4 (1.3)	1.5 (1.8)	2.4 (4.9)	1.7 (1.9)	1.3 (1.3)	1.1 (0.4)	5.4	10.5
Un-weeded	4.8 (26.0)	8.2 (70.6)	4.8 (24.2)	3.0 (8.5)	5.5 (30.1)	5.6 (31.8)	3.4	7.0
SEm±	0.06	0.2	0.08	0.04	0.05	0.06	0.1	0.2
LSD (P=0.05)	0.2	0.4	0.2	0.1	0.1	0.2	0.2	0.5

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

PAU, Ludhiana

WP1.2.1.1.7 Weed management in rice-wheat cropping system under conservation agriculture

During *Rabi* 2019-20 in wheat, major weeds were *Phalaris minor, Rumex dentatus, Coronopus didymus, Anagallis arvensis* and *Medicago denticulata*. As compared to the previous year 2018-19, a shift in weed flora was recorded in ZT-ZT (HS) where *Avena fatua* population was recorded at 60 days after sowing (DAS) which was significantly higher than all other tillage and residue management treatments; *A. fatua* was also recorded under PTR-CT (MB plough). Among tillage and residue management at 60 DAS, PTR-ZT had the lowest biomass of grass and broadleaf weeds (BLWs) which were similar to PTR-CT (MB plough/rotavator) (**Table 1.2.8**). The PTR-CT (rotavator) treatment gave the highest wheat grain yield which was at par with PTR-ZT and PTR-CT (MB plough), however, yield attributes like panicle density, ear height, net returns and B:C were at par among all tillages and residue management treatments.

At harvest, residues of metribuzin and clodinafop-propargy, under RH and IWM treatments, were below the detectable limit (<0.05 µg/g) in soil and wheat grain. Post-emergence application of ready-mix of metribuzin (214 g/ha) + clodinafop (61 g/ha) significantly decreased dehydrogenase activity at 7

Table 1.2.8 Effect of tillage, crop residue and weed management on growth, yield and yield attributes of wheat and economics of different treatments (*Rabi* 2019-20).

Treatment	Weed biomass (g/m²)		Crop biomass (g/m²)	Grain yield (t/ha)	Biological yield (t/ha)	Net returns (₹/ha)	B:C
Tillage & residue management							
PTR-CT	2.66(9.6)	2.97(13.3)	492.8	6.46	17.2	89,092	3.53
PTR- CT (MB)	2.12(6.9)	2.15(5.8)	500.8	6.75	17.7	91,674	3.40
PTR- ZT (HS)	1.82(3.7)	1.82(3.4)	520.0	6.92	18.0	1,00,658	4.08
ZT - ZT (HS)	3.34(15.1)	3.27(17.0)	479.0	6.05	16.6	83,815	3.56
PTR- CT (Rotavator)	1.63(2.5)	2.33(8.0)	534.5	7.11	18.7	1,03,662	4.12
SEm±	0.41	0.22	12.6	0.27	0.6		
LSD (P=0.05)	0.94	0.51	29.1	0.62	NS		
Weed management practices							
Weedy check	4.35(20.5)	5.14(27.5)	436.1	5.58	15.7	76,367	3.45
RH	1.54(2.0)	1.21(0.5)	522.4	7.05	18.1	1,02,599	4.10
IWM	1.06(0.1)	1.17 (0.4)	557.8	7.35	19.1	1,02,374	3.62
SEm±	0.29	0.07	13.9	0.23	1.1		
LSD (P=0.05)	0.61	0.16	22.4	0.49	1.9		
Interaction LSD (P=0.05)	NS	NS	NS	NS	NS		

days after treatment (DAT) as compared to unsprayed control, under all tillage and residue management treatments ($p<0.05$). DHA activity increased significantly from 31 DAT till crop harvest (145 days).

In rice during *Kharif* 2020, *Echinochloa colona, Echinochloa crus-galli* and *Cyperus iria* were major weeds in the experimental field. As compared to the previous year there was no shift in weed flora in 2020. Yield attributes like plant height, panicle density and panicle length did not vary statistically among tillage and residue management treatments. PTR-ZT (HS) gave the highest rice grain yield, however, the grain yield was at par among all tillage and residue management treatments. The PTR-ZT (HS) treatments gave the highest net returns while the highest B:C under CT DSR- ZT (HS). Among weed control, IWM and RH had similar density and biomass but significantly lower than the weedy check. CT-DSR had significantly higher biomass of grassy weeds and all PTR treatments and had the lowest sedge biomass. The RH and IWM had similar and significantly higher panicle density than the weedy check resulted in higher grain yield with IWM and RH (**Table 1.2.9**). RH gave the highest net returns and B:C.

Harvest time residues of pendimethalin, bisparybac-sodium, penoxsulam and cyhalofop-butyl in soil and rice grains were below the detectable limit. Conservation agriculture practices had higher soil enzymatic activities and microbial population than conventional agriculture practices.

BCKV, Kalyani

WP 1.2.1.1.8 Weed management in rice- rapeseed-greengram cropping system under conservation agriculture

In rapseed during 2019-20 at 60 DAS, field was comprised with grasses like *Cynodon dactylon, Digitaria sanguinalis, Trianthema portulacastrum, Amaranthus viridis, Phyllanthus niruri* and *C. rotundus* was the only sedge. CTTP-MT recorded the lowest weed density and weed biomass with higher WCE (53.7%) and highest with MT-MT-MT. CTTP-MT recorded with better growth and yield attributes resulted in higher seed and straw yield, net returns and B:C whereas the lowest yield was recorded with MT-MT-MT. Among weed management practices, at 60 DAS, pendimethalin 1.0 kg/ha PRE + mechanical weeding at 30 DAS (IWM)

Table 1.2.9 Effect of tillage, residue and weed management on growth, yield and yield attributes of wheat and economics of different treatments (*Rabi* 2019-20).

Treatment	Weed biomass (g/m²)		Crop biomass (g/m²)	Grain yield (t/ha)	Biological yield (t/ha)	Net returns (₹/ha)	B:C
Tillage & residue management							
PTR-CT	7.01(64)	4.94(29)	545.0	7.22	11.3	83,095	2.56
PTR- CT (MB)	8.24(80)	4.99(35)	536.6	6.69	10.8	72,975	2.37
PTR- ZT (HS)	6.02(43)	5.55(37)	595.2	7.35	11.5	85,417	2.60
ZT - ZT (HS)	10.8(150)	8.43(80)	523.6	6.65	10.3	83,520	2.99
PTR- CT (Rotavator)	8.40(91)	5.77(47)	562.4	6.74	10.91	73881	2.38
SEm±	0.71	0.60	35.5	0.34	0.44		
LSD (P=0.05)	1.65	1.37	NS	NS	NS		
Weed management							
Weedy check	13.4(190)	9.60(96)	498.4	5.83	10.0	64076	2.39
RH	6.16(43)	4.62(26)	566.1	7.40	11.1	89120	2.76
IWM	4.78(24)	3.60(14)	593.2	7.56	11.7	86141	2.52
SEm±	0.78	0.53	19.6	0.15	0.31		
LSD (P=0.05)	1.62	1.11	40.8	0.32	0.65		
Interaction LSD (P=0.05)	2.61	NS	NS	NS	NS		

recorded the least weed density and weed biomass and resulted in the highest WCE (72.7%) followed by pendimethalin 1.0 kg/ha (36.3%) over control. The IWM recorded better growth and yield attributes resulted in higher seed and straw yield. However higher net returns and B:C was recorded in pendimethalin 1.0 kg/ha. The lowest yield and return were recorded with one hand weeding at 30 DAS (**Table 1.2.10**).

In greengram 2020, field comprised with *Cynodon dactylon, Digitaria sanguinalis* and *Dactyloctenium aegyptium* as major grassy weed, *Cyperus rotundus* as sedge, *Phylanthus niruri* and *Physalis minima* as BLWs. CTTP-MT-MT recorded the lowest weed density and weed biomass (25.6 no./m^2 and 12.81 g/m^2, respectively) with higher WCE (42.9%), highest density and dry biomass with MT-MT-MT (44.6 no./m^2 and 22.4 g/m^2, respectively) at 60 DAS. CTTP-MT-MT recorded with better growth and more yield attributes and resulted in higher seed and stover yield (0.92 and 2.66 t/ha, respectively), whereas the lowest yield was recorded with MT-MT-MT treatment (0.76 and 2.42 t/ha, respectively). Similarly, the economic parameters *viz.*, net returns and B: C were found highest with CTTP-MT-MT (₹ 31,578/ha and 1.82, respectively).

Among weed management practices, at 60 DAS, quizalofop-ethyl 50 g/ha at 20 DAS + mechanical weeding at 30 DAS (IWM) recorded least weed density and weed biomass (25.0 no./m^2 and 14.09 g/m^2, respectively), and resulted in the highest WCE (41.42%) followed by quizalofop-ethyl 50 g/ha at 20 DAS (40.4%) over un-weeded control. The IWM recorded better growth and yield attributes resulted in higher seed and stover yield (0.92 and 2.65 t/ha, respectively). However, quizalofop-ethyl 50g/ha at 20 DAS recorded with higher net returns and B:C (29,064 ₹/ha and 1.75, respectively). The lowest yield and return were

Table 1.2.10 Effect of tillage, residue and weed management practices on weeds, yield attributes, yield and economics of rapseed during *Rabi* 2019-20

Treatments	Weed dry biomass (g/m²)	WCE (%)	Seeds/ siliqua	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Tillage &residue management										
CTTP-CT	4.20 (17.2)	47.6	20.6	2.66	1.15	3.71	20,195	57,128	36,933	2.90
CTTP-MT	3.96 (15.2)	53.7	21.9	2.70	1.21	3.73	19,595	59,969	40,374	3.13
CTDSR-CT	5.39 (28.5)	13.1	18.6	2.67	1.11	3.62	20,195	55,187	34,992	2.80
MT-MT	5.77 (32.8)	0.00	17.7	2.34	0.96	3.55	19,595	48,198	28,603	2.51
MT+R-MT+R	4.87 (23.2)	29.1	19.2	2.69	1.08	3.57	20,095	53,569	33,474	2.73
SEm±	0.052	-	0.51	0.01	0.005	0.01	-	-	-	-
LSD (P=0.05)	0.161	-	1.68	0.03	0.017	0.04	-	-	-	-
Weed management										
Pendimethalin 1.0 kg/ha PRE	4.89 (23.4)	36.33	19.7	2.68	1.15	3.75	16,168	57,083	40,915	3.53
Pendimethalin 1.0 kg/ha PRE + mechanical weeding at 30 DAS	3.25 (10.0)	72.68	20.9	2.71	1.17	3.79	22,168	57,865	35,697	2.61
One hand weeding at 30 DAS	6.10 (36.7)	0.00	18.1	2.43	0.99	3.36	21,468	49,482	28,014	2.31
SEm±	0.02	-	0.19	0.005	0.003	0.01	-	-	-	-
LSD (P=0.05)	0.06	-	0.57	0.015	0.008	0.03	-	-	-	-

recorded with one hand weeding at 30 DAS (**Table 1.2.11**).

In *Kharif* 2020, major weeds were *Echinochloa crus-galli, E. colona, Cyperus iria, C. difformis, C. rotundus, Fimbristylis miliaceae*, *Eclipta alba* etc. At 60 DAS, MT-DSR + R observed with lower weed density (58.0 no./m²) and biomass (13.6 g/m²) than MT-DSR (79.6 no./m² and 17.60 g/m², respectively). Reduction in density and dry biomass of weeds leads to maximum grain (2.46 t/ha) and straw yield (5.33 t/ha) with CT-TR followed by CT-DSR (2.41 and 5.33 t/ha, respectively) over MT-DSR (2.32 and 5.02 t/ha, respectively).

Among weed management practices, pretilachlor 0.75 kg/ha *fb* bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT showed the least weed density (32.7/m²) and weed dry biomass (9.8 g/m²) as compared to other treatments. This resulted in higher yield attributes, grain and straw yield (2.52 and 5.47 t/ha, respectively). However, higher net returns (₹ 1,35,346/ha) and B:C (2.12) were recorded under pretilachlor 0.75 kg/ha *fb* bispyribac-Na 25 g/ha at 25 DAT.

WP1.2.2 Weed management in maize-based cropping systems

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

TNAU, Coimbatore

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

The experimental field consisted of thirteen species of BLWs, six species of grasses and a sedge weed such as *Amaranthus viridis, Cleome viscose*, *Parthenium hysterophorus*, *Cynodon dactylon, Setaria verticiliata;* and

Table 1.2.11 Effect of tillage, residue and weed management practices on weeds, yield attributes, yield and economics of rice during *Kharif*, 2020

Treatments	Weed dry biomass (g/m²)	WCE (%)	Grains/ panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Tillage & residue management										
CT-TR	3.51 (11.8)	32.9	24.8	16.5	2.42	5.35	1,26,931	2,48,839	1,21,908	1.96
CT-TR	3.36 (10.8)	38.7	25.0	16.5	2.46	5.33	1,29,589	2,52,275	1,22,686	1.95
CT-DSR	3.72 (13.4)	24.1	23.9	16.4	2.41	5.33	1,29,986	2,47,685	1,17,699	1.91
MT-DSR	4.26 (17.6)	0.0	22.4	16.5	2.32	5.02	1,20,952	2,37,967	1,17,015	1.97
MT-DSR + R	3.76 (13.6)	22.7	23.0	16.6	2.37	5.28	1,23,240	2,43,932	1,20,691	1.98
SEm±	0.03	-	0.08	0.05	0.02	0.02	-	-	-	-
LSD (P=0.05)	0.12	-	0.26	0.16	0.06	0.05	-	-	-	-
Weed management										
Pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT	3.38 (10.9)	44.1	23.9	16.5	2.49	5.42	1,20,566	2,55,912	1,35,346	2.12
Pretilachlor 0.75 kg/ha PRE *fb* bispyribac-Na 25 g/ha at 25 DAT + mechanical weeding at 50 DAT	3.21 (9.8)	49.9	24.6	16.5	2.52	5.47	1,29,511	2,58,225	1,28,714	2.00
One hand weeding at 30 DAS	4.48 (19.6)	0.00	23.0	16.5	2.18	4.89	1,28,342	2,24,281	95,939	1.75
SEm±	0.03	-	0.06	0.04	0.01	0.01	-	-	-	-
LSD (P=0.05)	0.12	-	0.19	0.14	0.04	0.04	-	-	-	-

Chloris barbata, and *Cyperus rotundus* was the only sedge weed present. In sunflower, at 45 DAS, among tillage methods, significantly ($p<0.05$) lower total weed density and dry biomass (65.3/m^2 and 16.7 g/m^2, respectively) were recorded in ZT+R-ZT+R system resulted in higher WCE of 82.4%. Suppression in weeds considerably helped the plant to attain higher plant height (175.1 cm), dry matter production (7.13 t/ha), seed yield (1.69 t/ha), net return (₹ 9,189/ha) and B: C ratio (1.41). Among weed management practices, IWM pendimethalin at 1.0 kg/ha *fb* HW at 45 DAS recorded lower weed density and dry biomass (54.2/m^2 and 20.2 g/m^2), respectively with the highest WCE (78.7%) it was followed by pendimethalin at 1.0 kg/ha (PE). The highest weed values were recorded with unweeded check. Better weed suppression helped the plant to recorded significantly higher plant height (170.5 cm), dry matter production (7008 kg/ha), higher seed yield (2.03 t/ha), higher net return (₹ 14,793/ha) and B: C of 1.52 (**Table 1.2.12**).

CSKHPKV, Palampur

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

In wheat 2019-20, the lowest density of *Lolium temulentum* was recorded under ZT-ZT, *Avena* sp. and *Phalaris minor* under CT-ZT, *Vicia sativa* under CT-CT,

Table 1.2.12. Effect of conservation tillage and weed management practices on weed density, weed dry biomass and WCE of sunflower

Treatment	Sunflower (*Rabi* 2019-20)		
	Total weed density (no./m²)	Total weed dry biomass (g/m²)	WCE (%)
Tillage and residue management			
T1(CT-CT)	15.7 (189.0)	8.53 (71.3)	49.5
T2(CT-ZT)	15.4 (202.3)	8.58 (71.6)	40.1
T3(ZT+R-ZT)	11.8 (125.0)	7.21 (48.2)	50.3
T4(ZT-ZT+R)	8.32 (70.0)	7.21 (42.7)	78.2
T5(ZT+R-ZT+R)	8.39 (65.3)	4.22 (16.7)	82.4
SEd	0.90	0.04	-
LSD (P=0.05)	0.22	0.07	-
Weed management			
Recommended herbicides	8.21 (77.0)	5.21 (28.1)	61.2
Integrated Weed Management	7.24 (54.2)	4.21 (20.2)	78.7
Unweeded control	18.9 (251.0)	12.8 (101.9)	-
SEd	0.09	0.08	-
LSD (P=0.05)	0.19	0.16	-

C*ornopous* sp. with ZT-ZTR although were at par to other tillage. The CT-CT had the lowest density of *Dacus carota* and *Poa annua* during 90 DAS on wheat crop. CT-ZT had recorded the highest grain yield which was statistically at par with those under ZTR-ZTR and CT-CT. On contrarily, 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. mustard grown in replacement series in integrated weed management treatment.

In maize, tillage treatments resulted in significant variation in the population of *Cyprus* sp., *Commelina benghalensis, Digitaria* sp., *Ageratum* sp., *Echinochloa* sp. and *Polygonum alatum* at 60 DAS. *Panicum* sp. was at par to all the tillage, *Cyperus* sp. was lower with ZTR-ZTR but was at par with ZT–ZT and ZT-ZTR over other treatments. In case of *Commelina benghalensis,* ZT-ZT remained at par with CT-ZT. CT-ZT had a lower population of *Digitaria* sp. as compared to other tillage treatments which remained statistically similar with CT-CT, ZT-ZT and ZTR-ZTR. The density of *Ageratum* sp. and *Echinochloa* sp. was significantly lower under ZTR-ZTR. ZT-ZTR had the lowest population of *Polygonum alatum* at 60 DAS followed by ZT-ZT and ZTR-ZTR. The green cob and stover yield of maize, and grain and straw yield of intercrop was influenced by the intensity of tillage. The yield levels realized were satisfactory but below the potential yield levels. There was a non-significant variation in seed and straw of intercrop planted in additive series in maize due to tillage. Among tillage treatments, CT-ZT behaving statistically alike with ZTR-ZTR had significantly higher green cob yield as compared to other tillage practices, whereas ZTR-ZTR remained at par with CT-ZT resulted in a significantly higher stover yield of maize. Weed control treatments brought about significant variation in the cob yield of maize whereas the stover yield of maize remained non-significant. IWM-IWM behaving statistically similar with H-H resulted in a higher cob yield of maize over HW-HW. The wheat equivalent yield and economics of maize-wheat cropping system are presented in **Table 1.2.13**.

Table 1.2.13 Effect of weed control treatments on wheat grain equivalent yield, gross returns, cost of cultivation, net returns and B: C in the wheat-maize cropping system

Treatment (Maize–wheat)	Wheat grain equivalent yield (t/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C
Tillage & residue management					
CT-CT	14.7	4,40,796	1,14,615	3,26,181	3.97
CT-ZT	15.0	4,50,026	1,07,487	3,42,540	4.37
ZT-ZT	12.3	3,65,754	1,00,224	2,65,530	3.84
ZT-ZTR	14.6	4,22,322	1,08,662	3,13,660	4.02
ZTR-ZTR	15.4	4,46,622	1,15,434	3,31,188	3.99
SEm±	0.49	-	-	-	-
LSD (P=0.05)	1.61	-	-	-	-
Weed management					
H-H	15.8	4,69,705	86,847	3,82,858	5.42
IWM-IWM	13.3	3,97,366	1,13,293	2,84,073	3.51
HW-HW	14.1	4,08,241	1,27,714	2,80,527	3.19
SEm±	0.47	-	-	-	-
LSD (P=0.05)	1.84	-	-	-	-

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

MPUAT, Udaipur

WP 1.2.2.2.2 Weed management in maize-wheat cropping system under conservation agriculture systems

In wheat (2019-20), the major monocot weeds observed in the experimental fields were *Avena ludoviciana* (5.9%) and *Phalaris minor* (6.3%) whereas 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-leaved weeds were dominant (88.3%), where *Chenopodium album* and *Chenopodium murale* consisted of 60% and monocot weeds were only 11.7%. The Dry biomass of monocots and dicot weeds were recorded maximum in maize (CT)-wheat (ZT)-greengram (ZT). Minimum total weed dry biomass observed under maize (ZT+R)-wheat (ZT+R)-greengram (ZT+R) establishment method. Grain, stover yield and harvest index of wheat were comparable with tillage and residue management practices. The maximum net return (₹ 57,044/ha) was recorded in (CT-CT) but maize (ZT)-wheat (ZT)- greengram (ZT) recorded maximum B:C (2.20) (**Table 1.2.14**).

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, gains/spike, 1000 seed weight, highest grain yield (4.59 t/ha) and stover yield (5.98 t/ha). The maximum net return (₹ 61,915/ha) was recorded with recommended herbicides but the maximum B:C (2.24) was recorded in IWM plots.

In maize during *Kharif* 2020, dominant weed species in the experimental field were *Echinochloa colona* (31.9%), *Dinebra retroflexa* (16.4%), *Commelina benghalensis* (15.3%), *Digera arvensis* (14.3%), *Trianthema partulacastrum* (15.0%) and *Corchorus olitorious* (7.1%). Among tillage and residue management treatments,

Table 1.2.14 Effect of tillage, residue and weed management on yield and economics of maize and wheat

Treatment	Maize				Wheat			
	Grain yield (t/ha)	Stover yield (t/ha)	Net returns (₹/ha)	B:C	Grain yield (t/ha)	Stover yield (t/ha)	Net returns (₹/ha)	B:C
Tillage &residue management								
CT-CT	3.23	4.13	42,197	1.65	4.18	5.67	58,390	2.14
CT-ZT-ZT	3.50	4.37	47,454	1.86	3.96	5.54	55,470	2.13
ZT-ZT-ZT	3.34	4.12	45,660	1.91	4.03	5.74	57,044	2.20
ZT-ZTR-ZT	3.32	4.12	45,275	1.89	4.25	5.54	55,838	1.81
ZTR-ZTR-ZTR	3.25	4.14	42,042	1.62	4.14	5.70	54,128	1.73
S.Em.±	0.08	0.10		NS	0.10	0.08		
LSD (P=0.05)	NS	NS			NS	0.24		
Weed management								
IWM	3.86	4.78	54,427	2.17	4.23	5.75	59,926	2.24
Recommended herbicide	3.82	4.75	53,494	2.03	4.59	5.98	61,915	1.94
Weedy check	2.28	2.99	25,655	1.16	3.50	5.18	46,680	1.82
S.Em.±	0.05	0.06			0.09	0.08		
LSD (P=0.05)	0.15	0.16			0.25	0.23		

dry matter accumulation of BLWs was recorded maximum in maize (CT)-wheat (ZT)- greengram (ZT), while the weed dry biomass of monocot weeds were almost the same with different establishment methods. Minimum weed dry biomass 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 were recorded significantly higher under (ZT)-wheat (ZTR)-greengram (ZT). But, grain and stover yield failed to record significant response with different tillage and residue management practices. The maximum net return (₹ 47,454 /ha) was recorded with maize (ZT)-wheat (ZT)- greengram (ZT) plot but B:C (1.91) was recorded maximum under (ZT)-wheat (ZTR)-greengram (ZT).

Among weed management practices, both weed control treatments resulted in a significant decrease in density and dry biomass of monocot and dicot weeds over weedy check. Application of atrazine 500 g/ha PE followed by hand weeding at 30-35 DAS recorded minimum density and dry biomass of weeds at 60 DAS and at harvest. This has a significant effect on yield attributes, except yields of maize. IWM and atrazine 500 g/ha (PE) *fb* tembotrione 125 g/ha (PoE) recorded longer, wider and heavier cobs with higher test weight over weedy check. 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 the application of atrazine 500 g/ha *fb* temotrione 125 g/ha but was comparable with IWM. However, it has considerably better over weedy check. The maximum net return (₹ 54,427/ha) and B:C (2.17) was realized by IWM followed by the application of atrazine 500 g/ha *fb* tembotrione 125 g/ha.

UAS, Bengaluru

WP1.2.2.1 Weed management in maize-based cropping system in conservation agriculture

Greengram during *Rabi* 2019-20, major weed flora observed in the experimental plots was *Cyperus rotundus* (only sedge), *Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium,* (among grasses), *Euphorbia hirita, Commelina benghalensis*, *Boreria hispida,*

Alternanthera sessilis, Ageratum conyzoides, Spilanthes acmella were major broad-leaved weeds.

Total weed density did not differ significantly between tillage treatments. However, under permanent bed tillage system, the overall density of sedges, grasses and broadleaf weeds was lower than other tillage. Among tillage practices, adopting permanent bed tillage practices recorded significantly higher yields (0.90 t/ha) followed by CT (0.83 t/ha). The yield difference was due to differences in weed emergence being low under a permanent bed.

At 60 DAS, unweeded plots recorded with higher dry biomass of sedges followed by grasses and then BLWs with total density of 81.5/m^2. Application of pendimethalin 750 g/ha *fb* HW at 30 DAS recorded fewer density (52.3 no./m^2) than that of herbicide alone (57.6 no./m^2). These led to achieve higher seed yield (1.07 t/ha) and B: C (3.43) with pendimethalin 750 g/ha *fb* HW 30 DAS as compared to unweeded control. Unweeded control lowered yield (0.51 t/ha) as a result of severe weed competition of weeds particularly sedges at early stages, grasses and BLWs at a later stage of crop growth.

In summer maize 2019, major weed flora observed in the experimental plots were *Cyperus rotundus* (from initial stage- among sedges), *Cynodon dactylon, Digitaria marginata; Bracharia repens Dactyloctenium aegyptium* (among grasses), *Commelina benghalensis, Alternanthera sessilis, Euphorbia geniculata* and *E. hirita* (major broad-leaved). Among the weed species, the density of weed flora under different tillage practices, the permanent bed had lower weed density over other tillage treatments.

At 60 DAS, IWM (pendimethalin 750 g/ha *fb* HW at 30 DAS) recorded significantly lower weed density and weed dry biomass. Un-weeded control recorded the highest weed density and dry biomass. IWM recorded a significantly higher yield (3.80 t/ha) compared to un-weeded control (2.33 t/ha) and use of only recommended herbicide (pendimethalin 750g/ha *fb* tembotrione 120g/ha + atrazine 500g/ha) recorded with grain yield of 3.50 t/ha. The higher B:C (1.81) was noticed in permanent bed tillage + IWM.

Kharif maize 2020 major weed flora observed in the experimental plots were *Cyperus rotundus* (from initial stage-among sedges), *Cynodon dactylon, Digitaria marginata; Bracharia repens* (among grasses), whereas *Borreria hispida*, *Commelina benghalensis, Alternanthera sessilis, Spillanthus acmella, Echinochloa colona, Ageratum conyzoides, Euphorbia geniculata, etc.* (BLWs) throughout the crop growth period. Among these *Cyperus rotundus* (sedge) and *Cynodon dactylon* (grass species) were dominant throughout the crop growth period. The tillage and weed management practices differed significantly at 30 and 60 DAS, the interaction effect between tillage and weed management practices was not significant. Among tillage, permanent beds at all stages had slightly lower weeds density and dry biomass of weeds over other tillage practices. The plots imposed with permanent bed numerically recorded significantly the highest seed yield (3.52 t/ha) and higher B:C (1.44).

Weed management practices significantly influenced the weed density and weed dry biomass at 30, 60 and 90 DAS. IWM recorded significantly lower weed density and dry biomass of sedges, grasses and BLWs compared to recommended herbicide treatments. Under un-weeded control at 30, 60 and 90 DAS recorded the highest weed density and dry biomass. Among the weed management practices, the plots treated with IWM recorded the highest seed yield (3.51 t/ha) than that of pendimethalin 750 g/ha *fb* tembotrione 120 g/ha + atrazine 500 g/ha (3.18 t/ha). Un-weeded control recorded the lowest seed yield (2.44 t/ha) due to less effective control of weeds throughout crop growth period.

WP 1.2.2.3 Weed management in pearlmillet based cropping system

RVSKVV, Gwalior

WP 1.2.2.3.1 Weed management in pearlmillet–mustard–cowpea cropping system under conservation agriculture (year of commencement: *Kharif* 2019)

In mustard, the main weeds observed at the experimental site were *Phalaris minor, Spergula arvensis*,

and *Cynodon dactylon* as grasses and *Chenopodium album, Anagallis arvensis, Convolvulus arvensis* and *Medicago hispida* as major BLWs. *Cyperus rotundus* was the most dominating sedges among all the weeds. The IWM (oxyfluorfen 0.23 kg/ha as PE *fb* one HW) gave maximum seed yield (2.16 t/ha) as well as reduced the weed density and dry biomass of weeds *fb* oxyfluorfen 0.23 kg/ha as PE (1.95 t/ha). Although the maximum net returns (₹ 66,680/ha) and B:C (4.10) were obtained in ZT+R–ZT+R–ZT+R *fb* CT-CT was maximum with the application of oxyfluorfen 0.23 kg/ha as PE (**Table 1.2.15**). In case of tillage practices, the ZT+R gave maximum seed yield (2.03 t/ha) and it was at par with CT-CT-F with seed yield of 1.98 t/ha and ZT in *Kharif* and summer without residue and with crop residue in *Rabi* only, as compared to other tillage practices. However, the maximum B:C (4.10) was recorded in ZT+R *fb* CT practice (3.97) without crop residue. Therefore, conservation agriculture, especially ZT+R practices during entire the year *fb* the application of CT practices without crop residue during *Kharif* and *Rabi* both and fallow in summer, can contribute to decrease the narrow and BLWs and give higher productivity and profitability of mustard in pearlmillet-mustard-cowpea cropping system. Application of preceding crop residues with ZT, prevents the germination, growth and development of weeds in the initial and subsequent stages of weed growth. Similarly, application of plant residues can be more environmental friendly.

Table 1.2.15 Effect of different weed management and conservation tillage practices on yield and economics in mustard under pearlmillet based cropping system (2019-20).

S.N.	Treatment	Weed density (no./m²)	Weed biomass (g/m²)	Seed yield (t/ha)	Stover yield (t/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Tillage & residue management									
T_1	CT	16.99 (370.2)	336.5	2.03	7.18	21,148	84,654	63,506	3.97
T_2	ZT	19.5 (505.4)	478.5	1.72	5.87	20,100	71,537	51,437	3.51
T_3	ZT	21.6 (602.9)	548.0	1.53	5.85	20,100	64,146	44,046	3.18
T_4	ZT + R	17.4 (399.1)	378.8	1.88	6.62	21,411	78,448	57,036	3.66
T_5	ZT + R	13.4 (220.7)	186.8	2.10	7.98	21,422	88,102	66,680	4.10
	SEm (±)	0.36	16.83	0.08	0.23	112	3,365	3,417	0.17
	LSD (P=0.05)	1.18	54.89	0.27	0.75	367	10,976	11,145	0.55
Weed management									
W_1	Oxyflourfen 0.23 kg/ha as PE	14.4 (213.2)	203.0	1.95	6.87	20,540	81,484	60,944	3.97
W_2	Oxyflourfen 0.23 kg/ha as PE *fb* 1 HW at 35 – 40 DAS (IWM)	8.1 (68.10)	65.4	2.16	7.48	22,989	90,097	67,109	3.91
W_3	Weedy check	30.8 (977.7)	888.8	1.44	5.74	18,980	60,550	41,570	3.17
	SEm (±)	0.15	4.15	0.04	0.06	108	1592	1562	0.08
	LSD (P=0.05)	0.476	13.5	0.13	0.22	354	5194	5095	0.28

In pearlmillet, during the experimentation (2020) the weeds observed in the experimental site were *Echinochloa crus-galli, Celosia argentia, Acrachne racemosa, Cynodon dactylon, Phyllanthus niruri, Brachiaria reptans* and *Eragrostis* spp. as narrow-leaved weeds, *Digera arvensis,* and *Commelina benghalensis* as BLWs and *Cyperus rotundus* as sedges. In 2019 the *Cynodon dactylon* was not seen in the experimental trial up to 30 DAS but in 2020 it was observed with the germination of the crop. Similarly, the *Brachiaria reptance* was not germinated up to 30 DAS in the experimental trial executed in 2020 but after 30 DAS it has emerged in different treatments. Whereas, the *Acrachne racemosa* was not seen at 60 DAS during both years. Based on two years of experimentation (2019 and 2020). It was concluded that the population of narrow and BLWs continues to be less under ZT+R which was applied during entire the year. The IWM (atrazine 500g/ha PE with one HW at 30-35 DAS) resulted in the maximum control of grassy weeds and provided the maximum grain and stover yield, gross and net returns under ZT+R during entire the year. Therefore, among different tillage practices, the ZT+R can contribute to decrease narrow and BLWs and higher productivity and profitability of pearlmillet in pearlmillet-mustard-cowpea cropping system. Based on analysis, the maximum net returns (₹ 42,154/ha) and B:C (2.98) were obtained in the treatment where ZT+R was applied during entire the year *fb* CT without residue in *Kharif* and ZT in *Rabi* and summer both (**Table 1.2.16)**. However, the lowest production and profitability was recorded where ZT without crop residue was applied during entire the year.

Table 1.2.16 Effect of different weed management & conservation tillage practices on yield and economics in pearlmillet under pearlmillet based cropping system (2019-20).

S.N.	Treatment	Weed density (no./m²)	Weed biomass (g/m²)	Seed yield (t/ha)	Stover yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Tillage & residue management								
T_1	CT	15.1 (233.6)	32.1	2.76	5.52	57,931	36,450	2.70
T_2	CT	15.0 (231.0)	32.8	2.49	5.12	52,332	31,676	2.53
T_3	ZT	18.4 (346.0)	51.4	2.15	4.49	45,273	26,651	2.41
T_4	ZT	13.5 (188.2)	27.3	2.64	4.99	55,300	33,944	2.59
T_5	ZT + R	11.8 (143.0)	19.9	3.03	5.75	63,465	42,154	2.98
	SEm (±)	0.43	1.52	0.07	0.18	1,412	1,387	0.06
	LSD (P=0.05)	1.422	4.98	0.23	0.61	4,605	4,523	0.22
Weed management								
W_1	Atrazine 0.5 kg/ha PE *fb* 2,4-D 0.5 kg/ha (EPoE) at 15-20 DAS	14.5 (228.2)	29.2	2.80	6.22	59,037	38,117	2.81
W_2	Atrazine 0.5 kg/ha PE *fb* HW at 35-40 DAS (IWM)	12.9 (179.6)	22.3	2.84	5.25	59,405	37,090	2.68
W_3	Weedy check	17.0 (339.4)	46.6	2.21	4.05	46,139	27,319	2.44
	SEm (±)	0.46	1.78	0.06	0.15	1,369	1,398	0.06
	LSD (P=0.05)	1.51	5.81	0.22	0.51	4,464	4,562	0.22

WP1.2.2.4. Weed management in soybean-based cropping systems

PDKV, Akola

WP1.2.2.4.1 Weed management in soybean-greengram cropping system under conservation agriculture

The major weed flora during *Kharif* and *Rabi* in soybean–chickpea crop 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*, *etc.* both broad and narrow-leaved weeds were observed.

In soybean, CT plots recorded the lowest weed density and weed dry biomass (48.7 no./m^2 and 37.3 g/m^2, respectively) at 60 DAS and highest with ZT (59.0 no./m^2 and 58.9 g/m^2, respectively). A similar trend was recorded in another stage of the crop, this resulted in the highest WCE in CT (57.2%) followed by reduced tillage (RT, 32.4%). The yield attributes were better with CT followed by RT, resulted in the higher grain and straw yield in CT (2.37 and 2.79 t/ha, respectively), whereas, the lowest yield was recorded with ZT (1.52 and 1.86 t/ha, respectively) (**Table 1.2.17**). Among weed management practices, at 60 DAS, weed free recorded the lowest weed density and dry biomass (8.5 no./m^2 and 4.49 g/m^2, respectively), whereas the higher weed values were recorded in unweeded check (88.0 no./m^2 and 77.7 g/m^2, respectively). The highest WCE in weed-free (92.5%) over unweeded checks. The yield attributes were better with weed-free, resulting in the higher grain and straw yield in weed free (2.61 and 3.03 t/ha, respectively), whereas, the lowest yield was recorded with control (1.25 and 1.59 t/ha, respectively).

Table 1.2.17 Total weed parameters (at 60 DAS) and grain and straw yield as influenced by weed control treatments in soybean

Treatment	Weed density (no./m^2)	Weed dry biomass (g/m^2)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage & residue management					
T1 : Conventional tillage (1 Plo +2 Hr by tc +1Hr by Blade harrow)	6.51 (48.7)	6.15 (37.3)	57.1	2.37	2.79
T2 : Reduced tillage (1Hr by tc +1 Rototill)	6.88 (52.2)	6.75 (45.1)	48.3	2.11	2.54
T3 : Minimum tillage (1 Rototill)	7.16 (55.6)	7.15 (50.6)	42.0	1.94	2.41
T4 : Zero tillage (No tillage) +R	7.40 (59.0)	7.71 (58.9)	32.4	1.52	1.86
SE(m) ±	0.15	0.11		0.05	0.06
LSD (P=0.05)	0.54	0.37		0.16	0.19
Weed management					
W1: Diclosulam 0.030 kg/ha PE	8.69 (75.0)	8.07 (64.6)	11.4	1.77	2.12
W2 : Propaquizafop + imazethapyr 0.125 kg /ha POE at 20 DAS	7.45 (55.0)	7.19 (51.2)	30.2	2.05	2.42
W3: Diclosulam 0.030 kg/ha PE *fb* propaquizafop + imazethapyr 0.125 kg /ha POE at 20 DAS	6.59 (43.0)	6.46 (41.2)	47.5	2.36	2.77
W4 : Weed free (2H at 15 & 30 DAS + 1HW at 20 DAS)	3.00 (8.5)	2.23 (4.49)	92.4	2.61	3.03
W5 : Weedy check	9.40 (88.0)	8.85 (77.7)	0.00	1.25	1.59
SE (m) ±	0.14	0.03		0.05	0.04
LSD (P= 0.05)	0.46	0.11		0.17	0.13

Plo, Plowing; Hr, homowing

In greengram, CT-MT-MT recorded the lowest weed density and dry biomass (28.4 no./m^2 and 33.4 g/m^2, respectively) resulted in the highest weed control efficiency (86.0%). The lower values of weeds led to synthesizing more yield attributes resulted in the highest seed (0.71 t/ha) and haulm yield (1.34 t/ha). The highest weed parameters and lowest yield were recorded with ZTR-ZTR-ZTR. Among weed management practices, weed free i.e. two hand weeding recorded the lowest weed density and dry biomass followed by sequential application of herbicides i.e. pendimethalin 1.0 kg/ha *fb* imazethapyr+imazamox 0.07 kg/ha. This resulted in a higher WCE over a weedy check. Weed-free recorded the highest seed (0.78 t/ha and haulm yield (1.54 t/ha) followed by sequential application of herbicides, whereas the lowest yield was recorded under weedy check (**Table 1.2.18**).

Table 1.2.18 Total weed parameters (at 60 DAS) and yield attributes as influenced by weed control treatments in greengram

Treatment	Weed density (no./m^2)	Weed dry biomass (g/m^2)	WCE (%)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage & residue management					
T_1 : MT 1 Rototill	5.38 (28.4)	5.83 (33.48)	86.0	0.71	1.34
T_2 : MT 1 Rototill	5.93 (34.7)	6.73 (44.8)	54.6	0.68	1.26
T_3 : MT 1 Rototill	6.94 (47.7)	7.21 (51.5)	47.8	0.64	1.18
T_4 : Zero tillage + R	7.47 (55.4)	7.96 (62.9)	36.2	0.61	1.16
SE (m) ±	0.11	0.14	-	0.01	0.03
LSD (P= 0.05)	0.32	0.37	-	0.05	0.12
Weed management practices					
Pendimethalin 1 kg/ha as PE	5.27 (27.3)	5.49 (29.7)	69.9	0.49	0.92
Imazethapyr + imazamox 0.07 Kg/ha PoE at 20 DAS	4.34 (18.3)	4.13 (16.9)	83.2	0.67	1.31
Pendimethalin 1 kg/ha as PE *fb* imazethapyr + imazamox 0.07 kg/ha PoE at 20 DAS	4.19 (17.0)	4.01 (15.6)	84.2	0.73	1.44
Weed free (2 HW at 20, 40 DAS)	2.86 (7.5)	3.39 (11.0)	88.8	0.78	1.54
Weedy check (unweeded)	9.05 (81.5)	9.95 (98.6)	-	0.34	0.70
SE (m) ±	0.12	0.15	-	0.00	0.03
LSD (P=0.05)	0.36	0.45	-	0.02	0.11

WP 1.2.2.5 Weed management in cotton-based cropping systems

Cooperating centres:

TNAU, Coimbatore; PJTSAU, Hyderabad, AAU, Anand;

TNAU, Coimbatore

WP 1.2.2.5.1 Weed management in cotton – baby corn based cropping system under conservation agriculture

The predominant weeds were *Amaranthus viridis, Cleome viscoso, Trianthema Portulacastrum* and *Parthenium hysterophorus, Cynodon dactylon, Setaria verticiliata* and *Cyperus rotundus*. The relative density of grasses, sedge and BLWs did not varied distinctly with different tillage methods in cotton crop under CA. Whereas, in respect of weed management methods, pre-emergence application of pendimethalin 680 g /ha followed by a directed spray of paraquat 0.6 kg/ha resulted in lower percentage of grasses and BLWs. At 60 DAS, among tillage methods, significantly lower total weed density and dry biomass were recorded in CT-ZT-ZT system with 80.7% WCE. Among weed management

practices, pendimethalin 680 g/ha followed by a directed spray of paraquat 0.6 kg/ha recorded lower weed density and dry biomass with 80.3% WCE and it was followed by PE pendimethalin at 680 g/ha + brush cutter weeder weeding on 60 DAS.

Hyderabad

WP1.2.2.5.2 Weed management in cotton – maize – green manure conservation agriculture systems

Among the weed management plots, at 60 DAS higher weed density was recorded with IWM compared to control as mechanical weeding could not be done due to the very slushy status of soil. Weed dry biomass followed a similar trend of weed density. Significantly higher cotton yield was obtained in chemical weed control compared to IWM and one HW at 50 DAS. However, the yield levels were very low due to damage by heavy rains and water-logging conditions prevailed continuously for more than a month (**Table1.2.19**).

AAU, Anand

WP1.2.2.5.3 Weed management in cotton-green gram cropping system under conservation agriculture

In cotton, at 60 DAS, the significantly lower density of monocot and total weed (6.2 and 8.6/m^2, respectively) was recorded under ZT+R followed by ZT but it was at par with CT. Whereas, the density of dicot weed (5.0/m^2) was recorded significantly lower under CT followed by ZT but it was at par with CT-CT and CT-ZT. CT-CT recorded significantly the lowest dry biomass of dicot weeds (2.35 g/m^2). The ZT-ZT+R and ZT+R-ZT+R system recorded considerably higher seed cotton yield (1.79 t/ha) followed by CT-CT system (1.75 t/ha).

Among the weed management practices, the density of monocot weed (5.0/m^2) was recorded significantly the lowest 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 it was at par with HW at 20, 40 and 60 DAS. Dry biomass of monocot, dicot and total weed (3.58, 1.88 and 3.93 g/m^2, respectively) was recorded significantly the lowest under HW at 20, 40 and 60 DAS except for dry biomass of monocot weed it was at par with an application of quizalofop ethyl 50 g/ha PoE+ pyrithiobac sodium 62.5 g/ha PoE (tank mix) *fb* HW at 40 and 60 DAS. The seed cotton yield was comparable with all weed management practices and ranged from 1.58-1.88 t/ha and higher value 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.

In greengram, at 30 DAS, dry biomass of monocot was lowest (21.9 g/m^2) with ZT+R-ZT+R, however dicot and total biomass was recorded with CT-CT (14.4 and 43.1 g/m^2, respectively). Significantly the highest seed and haulm yield (612 and 820 kg/ha, respectively) was achieved under ZTR-ZTR, while, significantly lower seed yield was recorded under ZT-ZT system (498 and 671 kg/ha, respectively). Among weed management practices, significantly the lowest density (24.0, 12.3 and 36.3/m^2) and dry biomass (14.2, 12.1 and 26.2 g/m^2) of monocot, dicot and total weed, respectively was observed under HW at 20 and 40 DAS. The imposition of twice hand weeding recorded the highest seed and haulm yield (592 and 794 g/ha, respectively) followed by under imazethapyr 75 g/ha PoE *fb* HW at 30 DAS. However, both the herbicidal treatment was found to be at par with each other with respect to seed yield.

In cotton-greengram cropping system, the highest seed cotton equivalent yield, gross returns, net returns, and B:C were recorded with ZT+R-ZT+R (2.60 t/ha, ₹ 1,44,300 and ₹ 44,951/ha, and 1.45, respectively) and the lowest under ZT-ZT system. Among weed management practices, the higher seed cotton equivalent yield (2.58 t/ha), gross returns (₹ 1,43,190/ha), net returns (₹ 48,475/ha) and benefit-cost ratio (1.51) obtained 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 followed by thrice hand weeding in the system.

Table 1.2.19 Effect of tillage and weed management practices in cotton-based cropping system at Coimbatore and Hyderabad centres

Treatment	Coimbatore Centre				Hyderabad centre		
	Total weed density (no./m²)	Total weed dry biomass (g/m²)	WCE (%)		Total weed density (no./m²)	Total weed dry biomass (g/m²)	Cotton yield (kg/ha)
Tillage							
T_1 (CT-CT-ZT)	4.64 (21.4)	2.92 (9.5)	61.7	T_1 (CT-CT)	7.86 (63.3)	8.97 (96.8)	64.4
T_2 (CT-ZT-ZT)	3.57 (12.6)	2.47 (6.2)	80.7	T_2 (CT-ZT-ZT)	7.46 (57.0)	8.84 (92.2)	78.5
T_2 (ZT+(R)-ZT+(R)-ZT+(R))	4.13 (17.2)	2.71 (7.3)	67.5	T_3 (ZT+R-ZT+R- ZT+R)	7.91 (64.3)	8.45 (81.5)	80.2
SEd	0.03	0.04	-		0.38	0.48	17.1
LSD (P=0.05)	0.10	0.08	-		NS	NS	NS
Weed management							
W_1 - Recommended herbicides	3.81 (14.5)	2.12 (5.0)	80.3	W_1 Chemical weed control	7.47 (56.6)	7.42 (55.2)	106.0
W_2 - Herbicide + BC	4.57 (21.1)	2.67 (7.4)	74.2	W_2 Chemical weed control Herbicide Rotation	7.73 (60.3)	6.66 (45.4)	90.1
W_3 - Herbicide rotation	4.78 (23.7)	3.51 (12.4)	70.9	W_3 IWM	9.31 (87.0)	14.89 (223.1)	53.5
W_4 - (UWC)	9.53 (92.8)	4.81 (23.5)	-	W_4 Control	6.47 (42.2)	6.05 (37.1)	47.9
SEd	0.08	0.04	-		0.60	0.73	11.6
LSD (P=0.05)	0.17	0.09	-		1.26	1.54	24.6

W_1: Diuron PE 0.75 kg/ha *fb* tank mix application of pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha as PoE (2-3 weed leaf stage) *fb* directed spray (inter-row) of paraquat 0.5 kg/ha at 50-55 DAS; W_2: Rotation of herbicides in alternate year Diuron PE 0.75 kg/ha *fb* tank mix application of pyrithiobac sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha as PoE (2-3 weed leaf stage) *fb* directed spray (inter-row) of paraquat 0.5 kg/ha at 50-55 DAS; Pendimethalin 1.0 kg/ha *fb* tank mix application of pyrithiobac- sodium 62.5 g/ha + quizalofop ethyl 50 g/ha as PoE (2-3 weed leaf stage) *fb* directed spray (inter-row) of paraquat SL 0.5 kg/ha at 50-55 DAS; W_3: Diuron PE 0.75 kg/ha *fb* mechanical brush cutter twice at 25 and 60 DAS; W_2: One hand weeding will be done after the critical period of crop-weed competition i.e., between 45- 50 days after sowing)

WP 1.3 Weed management in organic agriculture

AAU, Anand

WP 1.3.1 Weed management in turmeric under organic cropping system and its residual effect on succeeding summer greengram

Major weeds observed in the experimental field were *Eleusine indica* (23.9%), *Dactyloctenium aegyptium* (22.6 %), *Digitaria sanguinalis* (9.87%) in monocot weeds category whereas, *Oldenlandia umbellate* (7.02%), *Digera arvensis* (6.58%), *Phyllanthus niruri* (548%), *Trianthema monogyna* (5.26%) in dicot weed category. At 60 DAP, IC *fb* HW at 20, 40, 60 and 80 DAP recorded significantly lower dry biomass of monocot weed (4.49 g/m^2) as compared to weedy check, IC *fb* HW at 30 DAP + WSM 5 t/ha (0-3 DAP) *fb* HW at 60 and 90 DAP and plastic mulch (0-3 DAP) *fb* HW at 30 and 60 DAP. However, IC *fb* HW at 30 DAP + WSM 5 t/ha (0-3 DAP) *fb* HW at 60 and 90 DAP recorded significantly lower dry biomass of dicot weed (4.14 g/m^2) but it was at par with IC *fb* HW at 30 DAP + PSM 5 t/ha (0-3 DAP) *fb* HW at 60 and 90 DAP, plastic mulch (0-3 DAP) *fb* HW at 20, 40 and 60 DAP and IC *fb* HW at 20, 40, 60 and 80 DAP. Maximum weed control efficiency was recorded under IC *fb* HW at 20, 40, 60 and 80 DAP (63.8%) which was closely followed by plastic mulch (0-3 DAP) *fb* HW at 20, 40 and 60 DAP (61.8%) and IC *fb* HW at 30 DAP + PSM 5 t/ha (0-3 DAP) *fb* HW at 60 and 90 DAP (61.6%).

Table 1.3.1 Effect of weed management practice on weed control, yield and yield attributes of turmeric

S. No.	Treatment	Total weed dry biomass (g/m²)			WCE (%)	Rhizome yield (pooled) (t/ha)	Net returns (₹/ha)	B:C
		2018-19	2019-20	Pooled				
T_1	Paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP	7.70^{c} (58.8)	8.35^{bc} (69.2)	8.02^{bc} (64.0)	55.9	23.2^{a}	1,53,420	1.79
T_2	Wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP	7.38^{cd} (54.1)	8.00^{bc} (63.6)	7.69^{bc} (58.9)	57.7	22.9^{a}	1,48,920	1.77
T_3	IC + HW at 30 DAP + PSM 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP	6.37^{cd} (39.9)	7.62^{bc} (58.2)	6.99^{c} (49.1)	61.6	18.6^{b}	79,260	1.40
T_4	IC + HW at 30 DAP + WSM 5 t/ha (30 DAP) *fb* HW at 60 and 90 DAP	6.29^{d} (38.7)	9.25^{b} (84.6)	7.77^{bc} (61.7)	57.3	19.2^{b}	88,260	1.44
T_5	Plastic mulch (0-3 DAP) *fb* HW at 20, 40 and 60 DAP	6.39^{cd} (40.3)	7.51^{bc} (57.1)	6.95^{c} (48.7)	61.8	12.9^{cd}	-22,007	0.90
T_6	Plastic mulch (0-3 DAP) *fb* HW at 30 and 60 DAP	9.23^{b} (84.7)	9.23^{b} (85.0)	9.23^{b} (84.9)	49.3	12.1^{de}	-32,227	0.85
T_7	Turmeric + sunnhemp intercropping *fb* HW at 30 DAP *fb* HW + mulch of sunnhemp at 60 DAP *fb* HW at 90 DAP	9.16^{b} (83.1)	8.97^{b} (79.5)	9.06^{b} (81.3)	50.2	10.6^{e}	-27,770	0.85
T_8	IC *fb* HW at 20, 40, 60 and 80 DAP	6.37^{cd} (39.8)	6.79^{c} (45.3)	6.58^{c} (42.6)	63.8	14.9^{d}	25,400	1.13
T_9	Weedy check	18.3^{a} (333)	18.2^{a} (329)	18.2^{a} (331)	-	2.31^{f}	-1,39,250	0.20
	S. Em. ±	0.41	0.52	0.33	-	-	-	-
	LSD (P=0.05)	Sig.	Sig.	Sig.	-	-	-	-
	CV%	8.4	9.6	9.1	-	-	-	-

Note: Data subjected to (X+1) transformation. Figures in parentheses are means of original values. Treatment means with the letter in common are not significant by Duncan's New multiple range test at 5% level of significant.

Rhizome yield was significantly altered due to different weed management practices during individual years as well as in pooled analysis. Paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP and wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP remained at par with each other but recorded significantly the highest rhizome yield (23.2 and 22.9 t/ha, respectively). The maximum gross return (₹ 3,48,000/ha), net return (₹ 1,53,420/ha) and benefit:cost ratio of 1.79 was achieved under paddy straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP. which was closely *fb* wheat straw mulch 5 t/ha (0-3 DAP) *fb* HW at 30, 60 and 90 DAP **(Table 1.3.1)**.

Gwalior

WP 1.3.9 Non-chemical weed management under maize-potato-greengram (*as green manuring*) cropping system

Treatments:

	Maize	Potato
T_1	Black plastic mulch (25µ)	Black plastic mulch (25µ)
T_2	Soil solarization *fb* Plastic mulch (25µ)	Soil solarization *fb* Plastic mulch (25µ)
T_3	Soil solarization *fb* one HW at 40 DAS	Soil solarization *fb* one HW at 40 DAS
T_4	Intercrop (maize+greengram)	Straw mulching of the previous crop at 5 DAP
T_5	Stale seed bed *fb* one HW at 40 DAS	Stale seed bed *fb* one HW
T_6	Hoeing at 20 & 40 DAS	Earthing up at 20 & 40 DAS
T_7	Weedy check	Weedy check
T_8	One hand weeding at 20 DAS *fb* Straw mulch (5 t/ha) at 25 DAS	One hand weeding at 20 DAS *fb* straw mulch (5 t/ha) at 25 DAS

Potato (*Rabi* 2019-20)

The major weed flora of experimental site during *Rabi* 2019-20 were comprised by *Cyperus*

rotundus, Phalaris minor, Spergula arvensis, and *Polypogon monspeliensis* as grasses and *Chenopodium album, Medicago hispida, Anagallis arvensis* and *Convolvulus arvensis* as major broad-leaved weeds (BLW's). The sedges *Cyperus rotundus* was most dominating among all the weeds in potato field.

Among different weed management practices the weeds were effectively controlled by soil solarization with plastic mulch and it was followed by soil solarization with one hand weeding at 40 DAP and stale seed bed with one hand weeding at 40 DAP. The maximum weed population was recorded in weedy check *fb* RDF+ recommended herbicide (metribuzine 500 g/ha). At 60 DAP, the minimum dry weight of narrow leaved weeds was found under soil solarization with plastic mulch which was at par with soil solarization with one hand weeding at 40 DAP *fb* stale seed bed with one hand weeding at 40 DAP. The maximum weed control efficiency (90%) was also recorded where soil solarization was done with plastic mulch *fb* soil solarization with one hand weeding at 40 DAP (85%) and stale seed bed with one hand weeding at 40 DAP (75%).

The tuber yield of potato was recorded maximum (28.4 t/ha) in soil solarization with plastic mulch which was at par with soil solarization with one hand weeding at 40 DAP (25.8 t/ha). The lowest tuber yield (13.9 t/ha) was recorded in unweeded control plot. Application of soil solarization with plastic mulch recorded the maximum net returns (₹ 2,46,642/ha) and B:C of 3.30 *fb* soil solarization with one hand weeding and stale seed bed with one hand weeding.

Sweet corn (*Kharif 2020)*

The major weed flora during *Kharif* 2020 was *Setaria glauca, Echinochloa crus-galli, Cynodon dactylon, Commelina benghalensis, Digera arvensis* and *Cyperus rotundus*. At 60 DAS the significantly lowest population and dry matter was recorded where soil solarization with one hand weeding was done and it was at par with the treatments one hand weeding at 20 DAS *fb* straw mulch at 25 DAS, soil solarization with plastic mulch and application of black plastic mulch. However the population of broad leaved weeds was not observed in the same treatments except the plot where black plastic mulch was used. The maximum weed control efficiency (63.56%) was recorded where soil solarization with one hand weeding at 40 DAS was done and it was *fb* one hand weeding at 20 DAS *fb* straw mulching at 25 DAS (62.29%).

The highest yield of cobs (7.0 t/ha) was recorded with the treatment where soil solarization *fb* one hand weeding at 40 DAS was done and it was at par with the treatment soil solarization with plastic mulch *fb* one hand weeding at 20 DAS. One hand weeding at 20 DAS *fb* straw muich at 25 DAS fetched significantly maximum BC ratio (2.93) with net returns ₹ 1,44,767/ha and it was at par with the treatments intercrop (maize+greengram) and soil solarization with one hand weeding at 40 DAS.

CSKHPKV, Palampur

WP 1.3.7 Weed management in organic crop production system (maize-garlic/peas)

Treatments

	Maize (Green cob), *Kharif*	Garden pea, *Rabi*
T_1	One hoeing followed by earthing up at knee high stage	Hoeing (twice) at 30 DAS & 60 DAS
T_2	Stale seed bed + hoeing + earthing up	Stale seed bed + hoeing + HW
T_3	Raised stale seed bed + hoeing + earthing up	Raised stale seed bed + hoeing + HW
T_4	Mulch (*Lantana*) 5 t/ha + HW	Mulch (*Lantana*) 5 t/ha + HW
T_5	Stale seed bed + mulch 5 t/ha + HW	Stale seed bed + mulch 5 t/ha + HW
T_6	Raised stale seed bed + mulch 5t/ha + HW	Raised stale seed bed + mulch 5 t/ha + HW
T_7	Intercropping (soybean) + hoeing	Intercropping (fenugreek) + hoeing
T_8	*Maize/soybean + hoeing+ hand weeding	*Pea / mustard + hoeing+ earthing up
T_9	Mulch + manual weeding *fb* autumn crop of mustard (green)	Mulch + manual weeding *fb* summer crop of buckwheat
T_{10}	Chemical check	Chemical check

Common organic practices [seed/seedling treatment with beejamrit, 120 kg/ha N equivalent dose in *Kharif* and 50 kg/ha in *Rabi* from sources like FYM/Vermicompost/other organic manures followed by three sprays of jeevamrit/panchgavya/ amritpani/ vermiwash at the vegetative stage of the crop] was followed for raising of crops along with imposed treatments including the herbicide check.

Weed flora shift

During *Rabi* 2019-20, twenty-two weed species were found invading the peas crop. *Stellaria media* was the most dominant weed species constituting 23% of the total weed flora. *Poa annua* (13%), *Tulipa* (12%), *Daucus carrota* 96%), *Vicia sativa* (6%), *Anagallis arvensis* (5%), *Euphorbia helioscopia* (5%), *Alopecurus* (4%), *Medicago* (4%) and *Phalaris minor* (4%) were the other major weeds. During *Kharif* 2020, nine weed species viz. *Brachiaira, Commelina, Cyperus, Digitaria* and *Echinochloa* amongst monocots and *Aeschynomene*, *Ageratum*, *Alternanathera* and *Polygonum alatum* amonst dicots invaded the experimental maize. The *Alternanthera* was present at 30 and 60 DAS. *Cyperus* sp (25%) had the highest density followed by *Ageratum* (21%), *Echinochloa* (20%), *Polygonum alatum* (15%), *Commelina* (11%), *Brachiaria* (4%) and *Digitaria* (3%).

Cultural weed management treatments in organically raised peas resulted in significant variation in grass and broad-leaved weed count. Chemical check resulted in significantly lower grass and broad-leaved weed count. RSSB+mulch, mulch and intensive cropping treatment resulted in comparable grass weed control as the chemical check. Total weed count during *Rabi* 2019-20 was lowest in checmial check. Intercropping and crop rotation being at par with intensive cropping, RSSB+ hoeing, mulch had significantly lower total weed count during 2019-20. Cultural weed management treatments also resulted in significant variation in the monocot and dicot weed count during *Kharif* 2020. SSB + mulch, intensive cropping and intercropping resulted in significantly lower count of monocots over the chemical check and other treatments. Except crop rotation, SSB + hoeing and hoeing treatments, all the other treatments were statistically similar to checmial check in influeincing the count of monocots. Mulch, SSB + mulch, RSSB + mulch and intercropping were the other superior treatments in influencing the broad-leaf weed count. SSB/RSSB + mulch, mulch, intercropping and chemical check being at par resulted in significantly lower total weed count.

Raised stale seed bed + mulch resulted in significantly higher green peas yield as compared to chemical check. All the other treatments were at par in green peas yield with the chemical check. Similarly, all the treatments exept mulch, hoeing and intercropping were comparable to the chemical check for green cob yield of maize.

Intensive cropping resulted in more than double maize cob equivalent yield than the chemical check. RSSB + hoeing and intercropping also resulted in higher equivalent yield as chemical check. The other treatments were comparable in maize equivalent yield as the chemical check. Gross returns followed the trend of maize cob equivalent yield and the highest gross returns were accrued under intensive cropping followed by the intercropping, RSSB + mulch, RSSB + hoeing and chemical check. Similar was the trend for net returns. Intensive cropping because of more crops gave higher net returns followed by intercropping, RSSB+ mulch and RSSB + hoeing. B:C was highest for intensive cropping, intercropping, chemical check, RSSB + hoeing and RSSB + mulch.

Ludhiana

WP 1.3.10 Weed management in organically grown pea-brinjal cropping system
Collaboration: All India Network Project on Organic Farming (AINPOF), PAU Centre

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)	

Pea

Poa annua, Coronopus didymus, Anagallis arvensis, Rumex dentatus, Medicago denticulata and *Cyperus* were major weeds in the experimental field in pea field. Fertlization treatments did not have any significant influence on density of different weed species at 30 and 60 DAS. Among weed control, hand weeding and plastic mulch had significnalt lower weeds density than aother weed control treamtnets. At 60 DAS, PSM had significantly lower density of *C.*

rotundus and higher density of *P. annua, R. dentatus* and *A. arvensis* than weedy check. Intercropping of coriander treamtnets had simalr density of grass and broadleaf weeds than weedy check. Broad leaf weeds contributed more than 95% to total weed biomass. At 60 DAS, vermicompost alone had significnalty lower broadleaf weed biomass than FYM alone or combination of FYM + vermicompost. Hand weeding and plastic mulch treatments had the lowest weed biomass. PSM had significantly lower broad leaf weeds than weedy check while coriander intercropping had similar weed biomass to weedy check.

Pea crop supplied with vermicompost alone gave the highest pod yield which was at par to FYM alone; sole FYM gave significantly higher pea yield than mixture of vermicompost + FYM. Among weed control, hand-weeding gave the highest pea yield which was at par with paddy straw mulch and plastic mulch. 2nd picking of pea pod could not be harvested due to Covid-19 lockout.

Brinjal

Echinochloa colona, Dactyloctenum aegyptium, Digitaria sanguinalis, Cyperus compressus and *Cyperus rotundus* were the major weeds. At 30 and 60 DAT, fertlization treatments did not have any significant influence on density of different weed species. Among weed control, hand weeding and plastic mulch had significnalty low weeds density than rest othe treatments. PSM had significantly low density of all weeds except *Digitaria sanguinalis* than weedy check. Simialr trend was recorded for grass and sedge weed biomass.

Brinjal crop supplied with mixture of FYM+ vermicompost gave significantly higher brinjal yield than vermicompost alone, however, it was at par with FYM applied alone; FYM and vermicompost applied alone had similar brinjal yield. Among weed control, plastic mulch treatment gave the highest brinjal yield which was at par with hand weeding. Paddy straw mulch gave similar yield to hand weedings. Interaction effect of fertilization and weed control treatments was significant where combination of FYM and hand weedings gave the highest brinjal yield which was similar to the combination of FYM alone and plastic mulch and, FYM+vermicompost mixture and plastic mulch/PSM/HW.

Hyderabad

WP 1.2.8 Non-chemical weed management practices in okra-carrot organic cropping system (*Rabi 2019-20*)

Treatments

	Kharif (Okra)	*Rabi* (Carrot)
T_1	Live mulch with dhaincha	Mulching with rice husk 3 t/ha
T_2	Stale seed bed *fb* HW at 20 & 40 DAS	Stale seed bed *fb* HW at 20 & 40 DAS
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 40 DAS	Intercrop green leaf vegetable *fb* MW at 40 DAS
T_8	Unweeded control	Unweeded control

The weed flora consisted of *Cyperus rotundus, Parthenium hysterophorus, Alternanthera paranychioides, Melilotus alba, Digera arvens, Blumea* sp, *Sonchus* sp. at 30 DAS. However in addition to these weeds, *Amaranthus viridis, Amaranthus polygamus, Aacalypha indica* at 60 DAS, *Dactyloctenium aegyptium, Portulacaa oleracea* at 90 DAS, *Euphorbia geniculata* and *Cyanotis axillaris* at harvest were recorded.

Different organic weed management practices influenced the weed density significantly at different stages. At 30 DAS, lowest weed density was recorded with straw mulch (5 t/ha) (26/m^2) *fb* polymulch + inter row weeding at 30 DAS (42/m^2). Highest weed density was recorded with unweeded control (378 No./m^2). The same trend was followed at 60 DAS. Different organic weed management practices significantly exerted influence on weed dry matter at different stages of crop growth. Poly mulch + inter row weeding at 30 DAS (3.47 g/m^2) and straw mulch (5 t/ha) (13.33 g/m^2) were effective in reducing the weed dry matter at 30 DAS. But at 60 DAS, all the treatments were at par except the intercrop. Significantly higher weed dry matter (131.7 and 298.6 g/m^2, respectively) was recorded with unweeded control. The highest weed control efficiency

was recorded with poly mulch at 30 and 90 DAS (97.4 and 76.5%, respectively) which was followed by straw mulch (89.9 and 75.4%, respectively). Among all weed management treatments, lowest weed control efficiency was recorded with intercropping with green leafy vegetable.

Organic weed management practices significantly influenced root yield of carrot. Highest root yield was recorded in straw mulch + intra row weeding at 30 DAS (19.0 t/ha) which was significantly higher than all the other treatments. It was followed by stale seedbed preparation (16.2 t/ha) which was at par with mechanical weeding at 20 and 40 DAS (15.9 t/ha), poly mulch (15.8 t/ha) and rice husk (15.3 t/ha). Lowest root yield of carrot was recorded in unweeded control (825 kg/ha).

WP 1.3.12 Non-chemical weed management practices in Baby corn – cabbage organic cropping system

Treatments

	Kharif (Baby corn)	*Rabi* (Cabbage)
T_1	Live mulch with *Dhiancha* at 30 day	Groundnut shell mulch 2 t/ha
T_2	Stale seed bed *fb* HW at 20 & 40 DAS	Rice husk mulch 3 t/ha
T_3	Polymulch + intra row manual weeding at 30 DAS	Polymulch + intra row manual weeding at 30 DAS
T_4	Rice straw mulch 5 t/ha *fb* intra row HW at 30 DAS	Rice straw mulch 5 t/ha *fb* intra row HW at 30 DAS
T_5	Cultural practice (MW at 20 & 40 DAS *fb* HW)	Hoeing/(twice) at 15 DAS & 30 DAS
T_6	Intercrop green leaf vegetable *fb* HW at 40 DAS	Intercrop green leaf vegetable *fb* HW at 40 DAS
T_7	Unweeded control	Unweeded control

Baby corn (*Kharif* 2020)

The weed flora consisted of *Cyperus rotundus, Parthenium hysterophorus, Alternanthera 1paranychioides, Digera arvens, Amaranthus viridis, Amaranthus polygamus, Aacalypha indica, etc* at various stages of observation.

In the baby corn grown under non-chemical farming, poly mulch along with intra-row manual weeding at 30 DAS could lower weed density significantly compared to weedy check and other weed management practices at 25 DAS. The next best treatment was stale seedbed *fb* HW at 20 and 40 DAS but was on par with rice straw mulch 5 t/ha *fb* intra row hand weeding at 30 DAS and cultural practice i.e., MW at 20 and 40 DAS *fb* HW. Due to heavy rains, the green leaf vegetable's intercrop failed to emerge in the treatment where it was included for the weed suppression. By 50 DAS, the weed density in poly mulch, stale seed bed and rice straw mulch was statistically comparable and significantly reduced over other treatments.

The weed dry weight (WDW) exhibited a different trend. At 25 DAS, the WDW in poly mulch was the lowest but comparable with stale seedbed, straw mulch and cultural practice. Whereas at 50 DAS, the weed dry weight was significantly reduced in all the treatments and comparable except in weedy check. Significantly taller plants with higher number of leaves were observed in poly mulch + intra row manual weeding over all the other treatments. Similar trend was observed with respect to dry matter production at 30 and 60 DAS. Baby corn yield obtained in poly mulch was significantly superior to all the other mulches and weed management practices except stale seedbed and rice straw mulch. Similarly, the green stalk yield in poly mulch was the highest and superior to the rest of the. The green leaf vegetable intercrop treatment could not be established and recorded no yield due to heavy rains.

1.3.12 (i) Weed management in organically grown ginger

Thrissur

Treatments:

1. Mulching with *Eichhornia crassipes*, 15 t/ha (fresh weight) after planting *fb* weeding, earthing up and mulching again at 50 DAP
2. Mulching with banana leaves, 15 t/ha (fresh weight) after planting *fb* weeding, earthing up and mulching again at 50 DAP
3. Mulching with coconut fronds, 20 t/ha (fresh weight) after planting *fb* weeding, earthing up and mulching again at 50 DAP
4. Mulching with grass clippings, 15 t/ha (fresh weight) after planting *fb* weeding, earthing up and mulching again at 50 DAP
5. Mulching with jack leaves, 15 t/ha (fresh weight) after planting *fb* weeding, earthing up and mulching again at 50 DAP
6. Weeding and earthing up at 50 DAP
7. Two hand weedings at 45 DAP and 90 DAP
8. Mechanical weeding

a) Soil weed seed bank assessment

The data on weed seed bank studies showed there was no difference in seed load between surface and subsurface layer. This is probably due to weed seed incorporation to deeper soil layer due to tillage operations done regularly at the farm. This indicate the ability of weed seeds to remain dormant in deeper soil layers. More number of seeds germinated by 30th day and then a decline in number was noticed in the case of both soil layers (**Table 1.3.2**).

Table 1.3.2 Weed count of surface and subsurface soil layers

Type of weed	Soil from surface (0-10 cm layer)				Sub surface soil (10-20 cm layer)				(0-20 cm layer)
	Number of weed seedlings emerged at different days after first irrigation								
	0-15th day	16-30th day	31-45th day	Total count	0-15th day	16-30th day	31-45th day	Total count	(0-20cm)-Total count
BLWs	20	25	11	56	19	31	7	57	113
Grasses	5	7	2	14	7	4	1	12	26
Sedges	0	5	0	5	0	7	1	8	13
Total	**25**	**37**	**13**	**75**	**26**	**42**	**9**	**77**	**152**

Weed flora constituted mainly of broad-leaved weeds, followed by grasses. Of the total weed seedlings emerged, 75% was BLWs, 19% was grasses and only 6% was sedges in the case of surface layer. In the subsurface soil the corresponding figures were 74%, 16% and 10%, respectively. The broad-leaved weeds present were *Alternanthera bettzickiana*, *Borreria hispida*, *Cleome* spp., *Euphorbia geniculata*, *Mitracarpus verticillatus*, *Ludwigia parviflora*, *etc.*

At 25 DAP effect of mulching was clear and mulched fields registered lower values ranging from 9.33 to 18.1 g/m^2 and were on par. The treatments which did not receive mulching registered higher and statistically comparable weed dry matter production. As earthing up was done in all treatments at 50 DAP there was a drastic decrease in weed growth by 75 DAP. However, mulching significantly influenced weed competition and all treatments where mulching was done registered lower values. The highest weed dry matter production was in mechanical weeding (177.6 g/m^2) due to the practical difficulty in carrying out mechanical weeding operation in inter spaces of ginger.

By 120 DAP, mulched fields showed weed growth and values were higher and comparable in various mulches (168.6 to 215.3 g/m^2). Mechanically weeded plots continued to register higher values of weed dry matter (133 g/m^2). However, in non-mulched treatments, weed growth was more as indicated by higher weed dry matter and these three treatments were statistically on par.

Among broad-leaved weeds, Ludwigia was the major one and the population varied widely from 28.6 to 148.0 nos./m^2. Mulching with eichhornia resulted in higher population of weeds. At 75 DAP also broad-leaved weeds were dominant and sedges were not present. Treatments without mulching registered higher weed population. Among the various organic mulches Eichhornia, grass clippings and jack leaves registered higher as well as statistically comparable yield (29.8, 28.0 and 27.8 t/ha). The next best treatment was coconut leaf mulching with a yield of 25.3 t/ha which in turn was comparable to mulching with grass clipping and mulching with jack leaves. Mulching using banana leaf was inferior with yield of 20.2 t/ha mainly due to poor plant stand which resulted from severe infestation of stem borer. This was comparable with hand weeding and earthing up where the yield was low due to more weed growth as evident from data on weed dry matter production at different stages of crop growth. Net returns as well as B:C were the highest for *Eichhornia* mulching (B:C, 4.05). This was followed by mulching with jack leaves or with grass clippings. The lowest B:C ratio of 1.94 was for hand weeding.

WP 1.3.13 (ii) Legume intercropping for weed management in organically grown cassava

Treatments:

1. Cassava intercropped with fodder cowpea; fodder cowpea incorporated and earthing up done at 60 DAP
2. Cassava intercropped with fodder cowpea; fodder cowpea incorporated and earthing up done at 60 DAP, followed by shallow digging and earthing up at 90 DAP
3. Cassava intercropped with green gram; green gram incorporated and earthing up done at 60 DAP
4. Cassava intercropped with green gram; green gram incorporated and earthing up done at 60 DAP, followed by shallow digging and earthing up at 90 DAP
5. Cassava intercropped with horse gram; horse gram incorporated and earthing up done at 60 DAP
6. Cassava intercropped with horse gram; horse gram incorporated and earthing up done at 60 DAP, followed by shallow digging and earthing up at 90 DAP
7. Cassava with shallow digging and earthing up at 30, 60 and 90 DAP
8. Mechanical weeding at 30, 60 and 90 DAP and earthing up

Of the total weed seedlings emerged, 76% was BLWs, 20% was grasses and only 4% was sedges in the case of surface layer. In the subsurface soil the corresponding figures were 65, 23 and 12%, respectively. The broad-leaved weeds present were *Alternanthera bettzickiana*, *Borreria hispida*, *Cleome* spp., *Euphorbia geniculata*, *Mitracarpus verticillatus*, *Ludwigia parviflora*, *Catharanthus pusillus* and *Pepperomia* sp. Grasses included *Pennisetum pedicellatum, Eleusine indica, Digitaria ciliaris* and *Panicum maximum. Cyperus rotundus* was the only sedge present.

Weed density was very low at 90 DAP as all treatments received earthing up at 60 DAP. However, legume intercropped plots registered lower (6 nos./m^2) values compared to others. The other two treatments *i.e.*, earthing up and mechanical weeding followed by earthing up had slightly higher comparable weed count of 7.77 and 8.32 nos./m^2. By 120 DAP, weed population did not increase due to earthing up done at 60 and 90 DAP in many treatments. It was seen that plots which received earthing up at 60 as well as 90 DAP, had comparable weed population. This may be due to the fact that, as the cassava crop had good canopy, by this stage further weed growth was low. Mechanically weeded plots registered statistically higher weed population, followed by horse gram intercropped plots. Reduction in weed population was observed at harvest stage of the crop, as there was good canopy coverage of the field by good growth of cassava. The trend was same as in other stages of observation and intercropped fields continued to register lower weed population.

At 30 DAP and 90 DAP, very low weed dry matter production was observed in legume intercropped fields and many treatments had statistically comparable values ranging from 4 g/m^2 to 10 g/m^2. In treatments without legume intercrops, availability of space and sunlight due to slow growth of cassava resulted in more weed population and dry matter production.

Legume intercropped treatments had comparable tuber yield ranging from 27.3 to 30.2 t/ha. There was no additional advantages due to a second earthing up at 90 DAP. Hence, intercropping of a legume - cowpea/green gram/horse gram, followed by one earthing up at 60 DAP is sufficient and there is less weed competition in the initial growth phase due to smothering effect of legumes. There is yield advantage due to green manure application which is also evident as the yields in the earthing up alone and mechanical weeding was lower. The increase in yield due to green manure intercropping was 29 % on an average. The green biomass addition due to legume intercropping was 4t/ha in the case of cowpea, 3.2 t/ha in green gram and 3 t/ha in horse gram. So nutrient addition and better soil conditions also might have contributed to better tuber yield.

Field after earthing up

Horse gram as intercrop in cassava

Tuber yield in different treatments

WP 1.3.14 (iii) Weed management in organically grown chilli

Treatments

1.	Stale seed bed (SSB) for 14 days followed by transplanting of chilli, followed by two hand weeding at 30 DAT (days after transplanting) and 60 DAT
2.	Stale seed bed for 14 days followed by transplanting of chilli, followed by one hand weeding at 45 DAT
3.	Black polythene mulch (30 µ thickness)
4.	Rice straw mulch at 7.5 t/ha applied at transplanting and 7.5 t/ha one month after transplanting
5.	Rice straw mulch at 7.5 t/ha applied at transplanting and 7.5 t/ha one month after trans planting followed by hand weeding at 60 DAT
6.	Mechanical weeding at 30 and 60 DAT
7.	Unweeded control (UWC)

Weed density was recorded at 30, 60 and 90 DAT. In the experimental plot, population of broad-leaved weeds was more and sedges were the least. The weed spectrum in unweeded plot at 30 DAT showed 82% BLWs, 7% sedges as well as 11% grasses. A reduction in weed density compared to unweeded plots was observed in stale seed bed. However straw mulching registered still lower population of weeds. The trend was almost same at 60 DAT also. Polythene mulching continued to register lower weed population at all stages of observation, with population as low as 2 nos/m^2 at 90 DAT. The next best treatments were straw mulching as well as straw mulching followed by hand weeding at 60 DAT.

Polythene mulching resulted in more than 90% WCE at all stages . At 30 DAT, SSB technique resulted in about 50% WCE, whereas straw mulching could achieve about 80% weed control. At 60 DAT, all treatments except polythene mulch registered WCE in the range of 75-87%. By 90 DAT, the trend was same with average WCE of 85%.The highest yield of 23.0 t/ha was recorded in polythene mulched plots which was statistically superior to all others. The next best treatment was (18.8 t/ha) straw mulching followed by hand weeding at 60 DAT which differed statistically from straw mulching alone (17.0 t/ha). Stale seed bed *fb* two hand weeding and mechanical weeding twice registered comparable fruit yield of 13.36 and 12.40 t/ha, respectively. Stale seed bed *fb* one hand weeding was inferior to the above treatments with yield of 9.52 t/ha.

Stale seed bed along with two hand weedings at 30 and 60 DAT realized higher yield compared to mechanical weeding at 30 and 60 DAT. This was due to the fact that the soil had good weed seed bank and with stale seed bed technique depletion of weed seed could be achieved to some extent. Stale seed bed technique followed by one hand weeding at 45 DAT was inferior to stale seed bed followed by two hand weedings due to more weed competition as evident from the data on weed drymatter production.

The highest net returns and B:C was in polythene mulch. Mechanical weeding was more profitable than stale seed bed + hand weeding.

Rice (*Kharif* 2020)

The experimental field was dominated by *Echinochloa* spp. amongst grassy weeds; *Alternanthera philoxeroides* and *Ammannia baccifera* amongst broad-leaved weeds and *Cyperus* spp. The other weeds were *Caesulia axilaris* and *Commelina benghalensis.*

The different weed management treatments had significant effect on weed density and weed biomass at 30 and 60 days after transplanting and at harvest. At 60 DAT and harvest, Sesbania green manure *fb*1 hand weeding at 30 DAT recorded lowest weed density and weed biomass.

Weed management treatment had a significant influence on number of tillers/m^2, plant dry matter (g/m^2), number of panicles/m^2, grain yield and straw yield. However, the test weight of rice grain was not influenced significantly due to different weed management treatments. The highest grain and straw yields were recorded with Sesbania green manure *fb* 1 hand weeding at 30 DAT which was significantly higher than *Sesbania* green manure *fb* rice hull mulch (2 t/ha) at transplanting and Azolla (1 t/ha) incorporation before transplanting. Highest B:C was recorded in *Sesbania* green manure *fb* 1 hand weeding at 30 DAT followed by *Sesbania* green manure *fb* chopped wheat straw mulch (5 t/ha) at transplanting (**Table 1.3.3**).

WP1.3.3 Weed management in basmati rice-broccoli-sesbania (green manure) cropping system under organic farming (Technical programme 2018-20)

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	Oxyflourfen 200 g/ha before transplanting	Sesbania green manure

Broccoli (*Rabi*-2019-20)

The major weeds flora *Medicago* spp., *Melilotus indica, Ranuculus arvensis, Anagalis arvensis, Vicia sativa, Rumax* spp., *Phalaris minor* and *Avena* spp were observed in broccoli field.

All the treatments brought significantly effect on weed density and weed biomass at 60 DAT and at harvest. Plastic mulch treatment was found than other treatments, however lowest density of *Anagalis arvensis, Melilotus indica, Ranuculus arvensis, Medicago spp., Vicia sativa, Rumax spp., Phalaris minor* and *Avena spp* were observed in treatment paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT. 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 and paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT.

The plant height, head diameter, curd yield and benefit cost ratio were recorded higher in treatment weed free and plastic mulch, however paddy straw mulch (6 t/ha) +1 hand weeding at 30 DAT statistically higher over weedy check.

Bhubaneswar

WP.1.3.5 Weed management in organically grown rice-tomato-okra system

Treatments

	Kharif (Rice)	*Rabi* (Tomato)	Summer (Okra)
T_1	50% RDF+ 50 % as FYM (8 t/ha) + 2HW (Hand weeding)	50% RDF+ 50 % as FYM (8 t/ha)+ 2HW	50% RDF+ 50 % as FYM (8 t/ha)+ 2HW
T_2	Different organic sources 1/3 rd of N as FYM+ 1/3 rd as Dhaincha + 1/3 rd as NEO (non edible oil cake)+2HW	1/3 rd of N as FYM + 1/3 rd as vermicompost + 1/3 rd as NEO+2HW	1/3 rd of N as FYM+ 1/3 rd as vermicompost + 1/3 rd as NEO) + 2HW
T_3	T2+*Azospirillum*+ PSB	T2+*Azotobacter*+PSB	T2+*Azotobacter*+PSB
T_4	T3 – 1 HW+ 1 MW	T3 – 1 HW+ 1 MW	T3 – 1 HW+ 1 MW
T_5	T2+residue recycling	T2+residue recycling	T2+residue recycling

The weed flora observed in rice crop were *Echinochloa crusgalli, E.colona, Panicum repens, Paspalum scorbiculatum, Cyperus difformis, C. rotundus, Fimbristylis miliaceae, Marsilia quadrifolia, Alternanthera sessilis, Luduwigia parviflora* and *Monocharia vaginalis.*

Both the weed population (no/m^2) and dry weight (g/m^2) were found to be the minimum in organic agriculture where all standard agriculture were practiced (T_4) with one mechanical and one manual weeding is being 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 (T_3) in rice resulted in reduction in weed population and dry weight and its found to be at par with other chemical weed control practices.

The weeds present in the tomato crop were *Digitaria sanguinalis, Eleusine indica, Eichnochloa colona, Panicum repens, Cynodon dactylon* among grasses, *Cyperus iria, C. rotundus, Chenopodium album, Amaranthus viridi, Eclipta alba, Trianthema portulacastrum, Oldenlandia corymbosa, Euphorbia hirta* and *Heliotropium indicum.*

At 50 DAT the treatment where two manual weddings were carried out in all other organic practices like T_2 & T_3 were found to be the best treatment w.r.t controlling the weed population and weed dry weight and it's well comparable to T_4.

The weeds present in the okra crop were *Eleusine indica, Eichnochloa colona, Sorghum halepense, Brachiaria ramose, Cynodon dactylon, Cyperus diformis & C. rotundus* among sedges and *Digera arvense, Portulaca oleracea* and *Euphorbia hirta*. The organic treatments with manual weeding and manual + mechanical weeding were found to be best treatment w.r.t controlling weed population and dry weight in T_2, T_3 & T_4.

Treatment (T_4) was well comparable to other organic treatments and T_4 resulted in the maximum grain yield of rice (4.5 t/ha), fruit yield of tomato (17.7 t/ha) and lady's finger (7.2 t/ha) with REY of 23.6 t/ha/yr followed by T_1 and T_5 with REY of 21.50 and 21.45 t/ha/yr respectively. But the same treatment (T_4) with the highest gross returns of ₹ 2, 89,217/ha/yr fetched NMR of only ₹ 1,24,340/ha/yr with BCR of 0.75 as compared to corresponding values of ₹ 2,56,301/ha/yr and 0.77 in organic treatment (T_1). Uptake of nutrients by rice (77.82 kg N, 23.78 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_1 at the end of the cropping cycle.

Akola

WP1.3.16 Weed management practices in organically grown cotton-chickpea crop sequence (Year of commence-ment *kharif* 2020).

Results not reported

Udaipur

WP1.3.8 Weed management in organically grown baby corn - fennel cropping system (This trial was taken in collaboration with Network Project on Organic Farming-NPOF)

Fennel

Treatments

S.No.	Fennel
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

The major dicot weeds in the experimental fields were *Chenopodium album* (36.3%), *Chenopodium murale* (10.7%), *Fumaria parviflora* (25.3%), *Convolulus arvensis* (2.9%), *Melilotus alba (*11.2%) and *Malwa parviflora (*6.3%) and *Phalaris minor* (6.9%) was the only monocot weed at 30 DAS.

Weed density of monocot and dicot weeds at 60 DAS were recorded significantly lower in plastic mulch either with summer ploughing (6.52 and 6.72 m^2), sowing after stale seed bed preparation (6.48 and 6.76/ m^2) or soil solarization (7.78 and 8.2/m^2). 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 (11.8 and 12.4/m^2) or without straw mulch (5t/ha) (16.8 and 18.0/m^2), *Sesbania* as smothering crop with hand weeding (13.71/m^2) or pre-emergence application of herbicide with straw mulch (5 t/ha)(12.1 and 12.94 and 14.7/m^2), summer ploughing and stale seed bed with one hand weeding at 20 DAS (16.53, 16.53 and 16.44, 17.64/m^2 respectively).

The broad leaf weeds contributed about 90 % of total dry matter at both the stages. All the three treatments of plastic mulch either with soil solarization (7.80 and 7.91, respectively), summer ploughing (2.79 and 5.54 respectively) and stale seed bed techniques (2.64 and 4.78, respectively) proved equally effective in reduction of weed dry matter. Plastic mulch in different combinations proved most effective and recorded 95-100 % per cent reduction in total weed dry matter at 60 DAS and at harvest, in comparison to weedy check which was 73.50 and 119.23 g/m^2. Lowest weed dry matter (2.64 and 4.78 g/m^2) at 60 DAS and at harvest was recorded with stale seed bed with plastic mulching.

Among different organic weed management treatments, maximum values of seed yield (1.44 t/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 (1.23 t/ha) and summer ploughing (1.13 t/ha) and pre emergence application of pendimethalin 1000 g/ha with straw mulch (1.11 t/ha). Application of plastic mulch with summer ploughing, stale seed bed and soil solarization recorded 169.0, 242.8 and 192.8% respectively, increase in yield over weedy check (420 kg/ha).

Among organic weed management practices, highest net returns (₹ 83,619/ha) recorded and B: C of (2.16) was obtained with stale seed bed preparation + plastic mulch at sowing.

Field view of experiment

Soil solarization + straw mulch at sowing

Weedy check

Stale seed bed + plastic mulch at sowing

Effect of different treatments on weed density & growth of fennel

Baby corn

Treatments

S.No.	Baby corn
1.	Stale seedbed preparation *fb* Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
2.	Stale seedbed preparation *fb* straw mulch (5 t/ha) at 20 DAS *fb* Inter culture at 20 DAS *fb* hand weeding at 40 DAS
3.	Stale seedbed preparation *fb* plastic mulch at sowing
4.	Soil solarization *fb* Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
5.	Soil solarization *fb* straw mulch (5 t/ha) at 20 DAS *fb* Inter culture at 20 DAS *fb* hand weeding at 40 DAS
6.	Soil solarization + plastic mulch at sowing
7.	Stale seedbed preparation *fb* Sesbania as smothering crop in between rows and used same as mulch after 30 days and 1 HW at 40 DAS
8.	Soil solarization *fb* Sesbania as smothering crop in between rows and used same as mulch after 30 days *fb* 1 HW at 40 DAS
9.	IC at 20 DAS *fb* straw mulch (5 t/ha)
10.	Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
11.	Straw mulch (5 t/ha) at 20 DAS+HW 20 days
12.	Weedy check

*Straw of previous crop is to be used in next crop

The major broadleaf weeds in the experimental field were *Digera arvensis* (9.89%), *Amaranthus viridis* (10.71%) and *Commelina benghalensis* (4.03%). The grassy weeds were *Echinochloa colona* (17.30%) and *Dinebra retroflexa* (5.26%), *Cynodon dactlyon* (28.57%) and *Cyperus rotundus* (19.17%)

Weed density recorded at 30 DAS and 45 DAS was significantly lower in both stale seed bed and soil solarization in comparison to weedy check. The treatment of plastic mulch with the basic treatments of stale seed bed or soil solarization recorded significantly lower weed density 0.08 and 0.05 /m^2, respectively. All these treatments of plastic mulching were at par and significantly superior over other treatments like staleseed bed *fb* interculture at 20 DAS *fb* mechanical weeding at 40 DAS and soil solarization *fb* Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS.

Treatment with plastic mulch proved most effective and recorded nil population of weeds with zero dry matter at 30 DAS and 45 DAS (98.8%) in comparison to weedy check (89.6 g/m^2). Maximum weed control efficiency at 30 DAS (100%) was observed with stale seedbed and solarization with plastic mulch.

Maximum values of green cob yield (2.67 t/ha) and green fodder yield (29.06 t/ha) of babycorn were recorded with crop sown with treatment of seed bed technique with plastic mulch, which was at par with plastic mulch with soil solarization (2.18 t/ha and 27.5 t/ha, respectively).

The highest net returns (₹ 74,097 /ha) was obtained with IC at 20 DAS *fb* straw mulch (5 t/ha) whereas maximum B:C (2.86) was recorded with Soil solarization *fb* sesbania as smothering crop in between rows and used same as mulch after 30 days *fb* 1 HW at 40 DAS.

S.No.	Baby corn
1.	Stale seedbed preparation *fb* Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
2.	Stale seedbed preparation *fb* straw mulch (5 t/ha) at 20 DAS *fb* Inter culture at 20 DAS *fb* hand weeding at 40 DAS
3.	Stale seedbed preparation *fb* plastic mulch at sowing
4.	Soil solarization *fb* Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
5.	Soil solarization *fb* straw mulch (5 t/ha) at 20 DAS *fb* inter culture at 20 DAS *fb* hand weeding at 40 DAS
6.	Soil solarization + plastic mulch at sowing
7.	Stale seedbed preparation *fb* Sesbania as smothering crop in between rows and used same as mulch after 30 days and 1 HW at 40 DAS
8.	Soil solarization *fb* Sesbania as smothering crop in between rows and used same as mulch after 30 days *fb* 1 HW at 40 DAS
9.	IC at 20 DAS *fb* straw mulch (5 t/ha)
10.	Inter culture at 20 DAS *fb* mechanical weeding at 40 DAS
11.	Straw mulch (5 t/ha) at 20 DAS+HW 20 days
12.	Weedy check

Kalyani

WP 1.3.6(i) Weed management in rice-capsicum system under organic cropping

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

Rice

Major weeds observed during *Kharif* 2020 were *Echinochloa crusgalli, E. colona, Chloris barbata* among grasses, *Cyperus iria, C. rotundus, Fimbristylis miliacea* among sedges, *Marsilea quadrifolia, Monochoria vaginalis, Alternanthera sessilis, Ludwigia parviflora, Ammannia baccifera* and *Commelina benghalensis*.

At 30 DAS, significantly low total weed (21.7/m^2) and dry weed biomass (9.49 g/m^2) were noticed as compared to 60 DAS (44 g/m^2 and 28.4 g/m^2, respectively) and at harvest (72.3 g/m^2 and 33.3 g/m^2, respectively) with the treatment receiving RDF + Pretilachlor 750 g/ha *fb* bispyribac Na 25 g/ha at 25 DAT. The second best results as panicle/m^2 (431.67), grains/panicle (79.3), test wt. (20.6g), grain (4.90 t/ha), straw yield (6.33 t/ha) and net returns (₹ 20,785 /ha) were recorded.

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 (442.6), grains/panicle (82.3), test wt. (20.8 g) and yield *viz.*, grain (5.12 t/ha), straw yield (6.41 t/ha) reducing in the experiment with rice, total weed density, total weed biomass production, density as well as biomass production by sedge, grasses and broad leaved weeds.

Capsicum

Treatment having sesbania intercrop 25 kg/ha up to 30 DAS *fb* mechanical incorporation *fb* one hand weeding at 45 DAT achieved maximum weed control efficiency value (83.87%) followed by the treatment with two hand weedings at 20 & 40 DAT. Better weed control efficiency, yield attributes, yield of capsicum crop and better benefit-cost ratio values were recorded in the treatment having full RDF + pendimethalin 1.0 kg/ha PE in capsicum. Yield of vegetable capsicum was found to increase by 23.62 % over the treatment in which the crop was grown without any weed control measure. More profit is possible if greenhouse structure is installed as permanent one for capsicum crop in the rice-capsicum field.

Treatments having closer spacing (60X30cm) *fb* one hand weeding at 30 DAT and black polythene mulch did not differ significantly from economic point of view and the treatment with paddy straw mulch 7.5 t/ha *fb* one hand weeding at 30 DAT was proved to be the poor performer among all the treatments regarding benefit-cost ratio as well as weed pressure on the crop. Highest capsicum yield of 28.6 t/ha was recorded in the treatment having Sesbania intercrop 25 kg/ha up to 30 DAS *fb* mechanical incorporation *fb* one hand weeding at 45 DAT followed by 27.9 t/ha at two hand weeding at 20 & 40 DAT. Though statistically differed significantly from each other, the other treatments failed to prove to be the better ones.

WP 1.3.6 (ii) Weed management in Guava based intercrop system under organic farming

Though maximum weed control efficiency value of 96.6 % was obtained in the treatment black polythene mulch throughout the year during the initial year of experimentation, havened in 2020 disclosed different thing. Growing of various short duration crops in between the rows of guava plants in the orchard provided better weed management and higher

weed control efficiency throughout the year and this was reflected in yield of guava, final guava equivalent yield and ultimately the benefit-cost ratio of the experiment.

Growing red amaranthus throughout the year in between the guava rows provided maximum economic return and highest benefit-cost ratio of 2.64 followed by the treatment having growing green gram in *Rabi* and cowpea in summer in between the rows of guava plants (**Table 1.3.4**).

Table 1.3.4 Effect of different treatments on weed biomass, yield and economics in guava during 2020

Treatment	Weed biomass production (g/m)			WCE (%)	Yield (t/ ha)	Inter crop yield (t/ha)	Guava equivalent yield (t/ha)	B:C
	BLW	Sedge	Grass					
T_1-Black polythene mulch throughout the year	2.57 (5.8)	2.37 (5.12)	3.29 (10.31)	76.2	2.09	--	2.09	1.73
T_2- Straw mulch	3.21 (9.8)	3.55 (12.1)	3.41 (11.12)	63.1	2.56	--	2.56	1.91
T_3- Leafy vegetables throughout the year	2.73 (6.94)	3.22 (9.9)	3.23 (9.96)	70.0	2.39	2.80	3.11	2.17
T_4- Intercrop with greengram in *Rabi* and cowpea in summer	2.96 (8.26)	3.31 (10.5)	3.17 (9.58)	68.3	2.92	3.58	3.50	2.25
T_5-Hand weeding as per requirement	2.91 (3.99)	2.95 (4.19)	2.82 (3.47)	86.9	2.81	--	2.81	1.80
T_6- Weedy	4.28 (17.8)	5.85 (33.8)	6.20 (37.96)	0.00	1.49	--	1.49	1.53
T_7- Glyphosate 1.0 kg/ha as directed spray in between rows required	2.85 (7.6)	2.97 (8.3)	2.50 (5.77)	75.7	2.28	--	2.28	1.92
T_8-Red amaranthus throughout the year	2.51 (5.83)	2.79 (7.27)	2.48 (5.68)	79.0	2.97	3.72	4.01	2.64
SEm ±	0.95	0.78	0.49	--	0.19	--	--	--
LSD (P=0.05)	2.86	2.21	1.32	--	0.43	--	--	--

WP 1.3.11 Weed management in organically grown aromatic rice in transplanted rice-sweet corn cropping system

Raipur

Aromatic rice (*Kharif* 2020)

Weed flora of the experimental site was dominated with *Echinochloa colona*, *Cyperus iria, Alternanthera triandra, Spilanthes acmella* and *Sporobolus diander*. *Spilanthes acmella* was found during later or maturity stage of the crop in the field. At 30 DAT, effective control of *Echinochloa colona* (0.67/m^2) was observed in the treatment where mechanical weeding was done through either motorized weeder twice (single row type) + one intra row HW or using Ambika paddy weeder at 20 DAT as compared to the other treatments. Lowest number of *Cyperus iria* was counted in the mechanical weeding through Ambika paddy weeder at 20 DAT. Ambika paddy weeder did not control the *Alternanthera triandra*. During later stages, at 60 DAT and at harvest, green leaf manuring (incorporation at puddling) + one HW at 20 DAT controlled *Alternanthera triandra* effectively and recorded lowest number (6.0 and 8.0/m^2) as compared to the others. Highest weed control efficiency (73.9%) was recorded under hand weeding (HW) twice at 20 and 40 DAT closely followed by motorized weeder twice (single row type) + one intra row HW (73.4%) and Ambika paddy weeder at 20 DAT+ one intra row HW (71.9%) at 60 DAT (**Table 1.3.5**).

Table 1.3.5 Weed dry matter at 30, 60 DAT and at harvest as influenced by weed management practices in organically grown aromatic rice in transplanted rice-sweet corn cropping system

Treatments	Weed dry weight (g/m^2)			WCE (%)	
	30 DAT	60 DAT	At harvest	60 DAT	at harvest
Hand weeding (HW) twice at 20 and 40 DAT	2.07 (3.7)	3.80 (13.9)	5.91 (34.4)	73.9	57.2
Motorized weeder twice (single row type)	2.46 (5.5)	4.26 (17.6)	6.66 (43.8)	67.0	45.5
Motorized weeder twice (single row type) + one intra row HW	2.14 (4.0)	3.84 (14.2)	6.35 (39.7)	73.4	50.5
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	2.37 (5.1)	4.40 (18.8)	6.83 (46.1)	64.8	42.6
Mechanical weeding through Ambika paddy weeder at 20 DAT + one intra row HW	2.32 (4.8)	3.95 (15.0)	6.40 (40.4)	71.9	49.7
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	2.11 (3.9)	4.86 (23.1)	7.38 (53.9)	56.8	32.9
10 days delayed planting with incorporation of emerged weeds	4.32 (18.1)	6.64 (43.6)	8.19 (66.6)	18.7	17.2
Dense planting (closer spacing of 15x10 cm)	4.37 (18.5)	7.36 (53.6)	9.00 (80.4)	-	-
SEm±	0.16	0.22	0.31	-	-
LSD (P= 0.05)	0.50	0.62	0.95	-	-

Maximum grain yield (2.65 t/ha) was achieved under application of hand weeding (HW) twice at 20 and 40 DAT which was significantly superior to rest of the treatments except motorized weeder twice (single row type) + one intra row HW (2.53 t/ha).

Highest net returns (₹ 32,286/ha) was recorded under hand weeding (HW) twice at 20 and 40 DAT Whereas, highest B:C (1.92) under weed management practice Motorized weeder twice (single row type) + one intra row HW.

Sweet corn (*Rabi* 2019-20)

Treatments

***Rabi* (Sweet corn)**

Main plot

50% N (FYM) + 50% N (vermicompost)

50% N (FYM) + 50% N (poultry manure)

50% N (FYM) + 25% N (vermicompost) + 25% N (poultry manure)

Sub plot

1. Black polythene mulch
2. Paddy straw mulch (5 t/ha)
3. Green manuring (incorporation 30 DAS)
4. Hand hoe
5. Hand weeding twice
6. Recommended herbicides (atrazine 1.0 kg/haPE)
7. Weedy check

The major weeds were *Medicago denticulata*, *Chenopodium album* and *Echinochloa colona* while the density of *Alternanthera triandra, Physalis minima, Cassia tora* and *Cannabis sativa was* observed less in numbers and grouped as other weeds.

The lowest weed density and dry weed was found under under 50% N (FYM) + 50% N (PM) followed by 50% N (FYM) + 25% N (VC) + 25% N (PM). Almost similar trend in weed density was observed at all the observational stages. As regards to weed management practices, density of weeds was found to be significantly lowest under black polythene mulch over rest treatments at all observational stages.

Significantly the highest cob yield of sweet corn (4.76 t/ha) was obtained under 50% N (FYM) + 50% N (PM) over other organic nutrient options. 50% N (FYM) + 25% N (VC) +25% N (PM) (4.33 t/ha) was also found

superior over 50% N (FYM) + 50% N (VC) where lowest cob yield was obtained (3.87 t/ha). Black polythene (25µ) mulch (5.62 t/ha) had significant effect on increased green cob yield of sweet corn over rest treatments and was at par with hand weeding twice and atrazin 1 kg/ha PE.

Net returns and BC ratio was highest in 50% N (FYM) + 50% N (PM) and atrazin 1.0 kg/ha PE under nutrient and weed management practices, respectively.

WP 1.3.15 Weed Management in organically grown *Kharif*- Kodo millet (*Paspalum scrobiculatum*)- *Rabi*- Black gram (*Vigna mungo*)

Bengaluru

Experiment 1 Weed Management in organically grown *Kharif*- Kodo millet (*Paspalum scrobiculatum*)

Treatments

	Kharif (Kodo Millet)	*Rabi* (*Blackgram*)
T_1	Intercultivation at 25 DAS + 1 Hand weeding at 45 DAS	Intercultivation at 25 DAS + 1 Hand weeding at 45 DAS
T_2	Stale seed bed technique + Intercultivation at 25 DAS & 45 DAS	Stale seed bed technique + Intercultivation at 25 DAS & 45 DAS
T_3	Hand weeding at 20 & 40 DAS	Hand weeding at 20 & 40 DAS
T_4	Straw Mulching 5t/ha at 10-15 DAS	Straw Mulching 5t/ha at 10-15 DAS
T_5	Kodo millet + fodder cowpea as intercrop + 1 Intercultivation at 20 DAS	Black gram+fodder cowpea as intercrop (multicut) + 1 Intercultivation at 40 DAS
T_6	Kodo millet + fodder cowpea as smothering crop in between rows of Kodomillet + 1 Intercultivation at 40 DAS	Black gram + fodder cowpea as smothering crop in between rows of Black gram + 1 Intercultivation at 40 DAS
T_7	Kodo millet + fodder cowpea as intercrop with in-situ incorporation on 35 DAS + 1 Intercultivation at 40 DAS	Black gram + fodder cowpea as intercrop with in-situ incorporation on 35 DAS + 1 Intercultivation at 40 DAS
T_8	Mechanical (Cycle weeder) weeding at 35 DAS	Mechanical (Cycle weeder) weeding at 35 DAS
T_9	Two mechanical (Cycle weeder) weeding at 20 and 40 DAS	Two mechanical (Cycle weeder) weeding at 20 and 40 DAS
T_{10}	Unweeded check	Unweeded check
T_{11}	-	Cucumber leaf extract 100ml/ltr at 2-4 leaf stage
T_{12}	-	Ageratum conyzoides leaf extract 100ml/ltr at 2-4 leaf stage

Major weed flora observed in the experimental plots was *Cyperus rotundus*, *Cynodon dactylon, Brachiaria ramose*, *Digitaria marginata, Echinochloa colona, Dactyloctenium aegyptium, Eleusine indica, Borreria hispida, Commelina benghalensis, Phyllanthus niruri, Alternanthera sessilis, Spilanthus acmella; Oldenlandia corymbosa* and *Portulaca oleracea;* Among the weed species, the density of sedge weeds was highest followed by grasses and broad leaf weeds.

Among non-chemical method of weed control treatments, T_2, T_9, T_7 reduced the weed density and weed dry weight significantly over other treatments, which was comparable to hand weeding at 20 and 40 DAS. Straw mulching 5t/ha at 10-15 DAS, Kodo millet + Fodder cowpea as intercrop + 1 intercultivation at 20 DAS and mechanical (Cycle weeder) weeding at 35 DAS recorded higher weed density at later stages of crop growth compared to other weed control treatments, which was on par with control.

Two hand weeding (20 & 40 DAS) recorded significantly higher seed yield (2.04 t/ha) which was on par with T_2 (1.71 t/ha), T_1 (1.67t/ha), T_7 (1.72 t/ha) and T_9 (1.71 t/ha). Unweeded control resulted in the lowest grain yield (0.93 t/ha) owing to severe weed competition.

Highest net returns was obtained in T_3 (₹ 25,410/ha) followed by T_2 (₹ 22,074/ha), T_8 (₹ 21,193/ha) and T_1 (₹ 20,763/ha).

The benefit cost ratio was higher in T_2 (2.3), which is almost comparable with treatments T_9, T_2 and T_1.

T_9 - Two Mechanical (Cycle weeder) weeding at 20 and 40 DAS

T_1 - Intercultivation at 25 DAS + 1 Hand weeding at 45 DAS

Organically grown *Kharif*- Kodo millet

WP 1.3.17 Non-chemical methods to control weeds in radish

Treatments

T_1	Radish as a sole crop with the spacing of 30 cm × 10 cm -Hand Weeding 25 DAS
T_2	Vegetable amaranthus as a sole crop
T_3	Vegetable Methi as a sole crop
T_4	20/50 cm paired row planting of radish with three rows of vegetable amaranthus in between paired rows of radish
T_5	20/50 cm paired row planting of radish with four rows of vegetab le amaranthus in between paired rows of radish
T_6	25/50 cm paired row planting of radish with two rows of vegetable amaranthus in between paired rows of radish
T_7	25/50 cm paired row planting of radish with three rows of vegetable amaranthus in between paired rows of radish
T_8	20/50 cm paired row planting of radish with three rows of vegetable methi in between paired rows of radish
T_9	20/50 cm paired row planting of radish with four rows of vegetable methi in between paired rows of radish
T_{10}	25/50 cm paired row planting of radish with two rows of vegetable methi in between paired rows of radish
T_{11}	25/50 cm paired row planting of radish with three rows of vegetable methi in between paired rows of radish
T_{12}	Weedy check

Major weed species observed in the experiment plots were *Cyperus rotundus*, *Brachiaria reptans*, *Chloris barbata*, *Dactyloctenium aegyptium*, *Digitaria marginata*, *Echinochloa crusgalli*, *Echinochloa colona*, *Eleusine indica*, *Ageratum conyzoides*, *Borreria hispida*, *Commelina benghalensis*, *Ionidium suffruticosum* and *Mimosa pudica*.

Weed dry weight (g/m^2) was highest in unweeded control in grasses (1.32 g/m^2) and broad leaf weeds (1.86 g/m^2) and total weeds (2.17 g/m^2), which was on par with pure crop of radish (1.30, 1.80 and 2.10 g/m^2 of grasses, broad leaf weeds and total dry weight of weeds respectively). The weeds dry weight in all other treatments, where intercrop was followed recorded lower weed dry weight in grasses (0.83 to 1.06 g/m^2) broad leaf weeds (1.22 to 1.59 g/m^2) and total dry weight (1.45 to 1.76 g/m^2) which was significantly lower than unweeded and pure radish crop.

Weed control efficiency was higher in all the intercrop treated plots compared to pure crop of radish. Weed control efficiency ranged from 50.7 to 61.7 % over other treatment where pure radish crop (6.19%) was adopted.

There was no significant effect on radish yield by planting patterns. Average yield ranged from 16.0 to 16.5 t/ha which was comparable to monocropped radish (16.5 t/ha) under which on par as compared that of intercropping.

In case of vegetable amaranthus and methi there was significant difference among treatments and the average ranged from 12.0 to 14.0 t/ha in intercropping. Among the two vegetable greens, amaranthus yield 12.6 to 16.0 t/ha was high compared to methi vegetable which ranged (12.0 to 13.1 t/ha). In the present study, paired row planting of radish intercropped with vegetable amaranthus or methi in between paired rows of radish would be the most suitable planting system to control weeds through non-chemical method of weed management.

WP 1.3.4 Weed management in organically grown rice based cropping system (Rice -vegetable pea – sweet corn) (*Kharif* 2020)

Pantnagar

Main-plot	
M_1	Stale seed bed-direct seeded rice + *Sesbania*
M_2	Direct seeded rice (Without Stale seed bed)
M_3	*Sesbania* (GM)-Transplanted rice
M_4	Transplanted rice
Sub-plot	
S_1	Mechanical weeding (Two pass of cono weeder) (25 & 45 DAS/DAT)
S_2	Mechanical weeding (one pass of cono weeder*) fb* one hand weeding (25 & 45 DAS/DAT)
S_3	Mechanical weeding (by hoe) *fb* one hand weeding (25 & 45 DAS/DAT)

Total weed density and dry matter accumulation of all the weeds were significantly influenced by different treatments at 40 and 60 DAS/DAT, except grass weed dry weight at 40 DAS/DAT. At 40 DAS/DAT, under different establishment system, Sesbania (GM) *fb* transplanted rice recorded significantly lowest weed density of all the types of weed, which was at par with (M_4) transplanted rice with respect to total weed density of grass weeds and sedges and with stale seed bed-direct seeded rice + *Sesbania* with respect to BLWs. Among weed management practices, significantly lowest total weed density and dry matter accumulation of grass weeds and BLWs were recorded under mechanical weeding (one pass of conoweeder *fb* one HW) and under mechanical weeding (Two pass of conoweeder) in case of sedges.

At 60 DAS/DAT, grassy weeds were significantly controlled under *Sesbania* (GM) *fb* transplanted rice and transplanted rice, whereas, significantly lowest total weed density and dry matter accumulation of BLWs was recorded under *Sesbania* (GM) *fb* transplanted rice followed by stale seed bed-direct seeded rice + *Sesbania,* whereas, sedges was found significantly lowest in density under Sesbania (GM) *fb* transplanted rice and in dry weight under stale seed bed-Direct seeded rice + *Sesbania.* Among weed management practices, significantly lowest total weed density and dry matter accumulation of grass weeds and BLWs were recorded under (S_3) which was at par with (S_2) *fb* one HW, which recorded the lowest weed density and dry matter accumulation of sedges at 60 DAS/DAT.

Under organic mode, grain and straw yield were comparable to each other but numerically highest grain and straw yield of rice (3.1 and 5.8t/ha), respectively, was achieved under stale seed bed-direct seeded rice + *Sesbania*, which was at par with *Sesbania* (GM) *fb* transplanted rice. Under non- chemical weed management practices, highest grain and straw yield (2.9 and 5.5t/ha) was recorded under S_3. The lowest grain and straw yield was found with S_1.

Among different establishment methods, the highest net returns and benefit: cost ratio of ₹ 36,390 and 1.8 was recorded under stale seed bed-direct seeded rice + *Sesbania* followed by *Sesbania* (GM) *fb* transplanted rice. Within non- chemical weed management practices, Mechanical weeding (one pass of conoweeder *fb* one HW) practice recorded the highest net returns (₹ 30,043) and highest benefit cost ratio (1.6).

WP 1.4 Management of herbicide resistance weeds

Hisar

WP 1.4.1 (i) Management of cross resistance in *Phalaris minor* against recommended herbicides in wheat

To study the efficacy of different herbicides against *P. minor* with poor control by clodinafop,

sulfosulfuron and pinoxaden since last 3-4 years, a field experiment was conducted during *Rabi* 2019-20 using different herbicides including weedy chak and weed free. Pre-emergence herbicides were applied just after sowing and post-emergence herbicides were applied at 35 DAS.

Highest weed control efficiency among the treated plots was observed with the application of pyroxasulfone + pendimethalin (TM) 127.5+1500 g/ha *fb* pinoxaden + metsulfuron (RM) 54 g/ha. Total weed control efficiency was higher with the application of pyroxasulfone + pendimethalin 127.5+1500 g/ha *fb* pinoxaden+ metsulfuron (RM) 54 g/ha and there was no phyto-toxicity on the crop with the application of this mixture, more number of effective tillers were also obtained from these plots.

There was no significant effect of different weed control treatments on the test weight of the crop. Test weight of the crop lies between 39.6-47.7 g. But, there was significant effective of different weed control treatments on the numbers of grains per spike. Highest number of grains per spike were attained from the fields under weed free situation and it was statistically at par with the application of pyroxasulfone + pendimethalin 127.5+1500 g/ha *fb* pinoxaden + metsulfuron (RM) 54 g/ha, aclonifen + diflufenican (RM) *fb* mesosulfuron + iodosulfuron (RM) 14.4 g/ha. Weeds growing throughout the crop-growing season significantly reduced the grain yield of wheat to the extent of 43-45%. All the herbicide treatments produced significantly higher grain yield as compared to weedy treatment. The sequential application of pyroxasulfone + pendimethalin 127.5+1500 g/ha *fb* pinoxaden + metsulfuron (RM) 54 g/ ha recorded significant increase in grain yield over weedy treatment and produced grain yield (5.6 t/ha) comparable to weed free (5928 kg/ha) recorded significant increase in grain yield over weedy treatment (3.22 t/ha).

Hisar (Old experiment)

WP1.4.1 (ii) Inheritance of resistance against alternate herbicides in various biotypes of *Phalaris minor* from different parts of Haryana (Pot studies)

The seeds of 15 canarygrass populations (14 populations with poor control and one population *i.e.* susceptible to compare the results) were collected from wheat fields of farmers on the basis of problem reported by the farmers. Of these 15 populations; 4 were from Karnal (Kachhwa, Ramba, Sitamai, Uchana), 4 from Jind (Rasidan, Kalwan, Danoda, Ujahana), 2 from Kaithal (Kheri Raiwali and Teek), 2 from Hisar (Hindwan and H.A.U Farm), 1 from each Yamunanagar, Fatehabad and Kurukshetra districts of Haryana, Hindwan and Hisar were taken as susceptible population to check the level of resistance against the herbicides.

The soil for the pot experiment was taken from CCSHAU research farms where there was no application of herbicide form last 2 years. Soil: Vermicompost – 4:1 mixture was used to fill the pots. Then, 1020 pots were filled with this soil and *Phalaris minor* seeds were sown. After germination, *P. minor* populations were thinned out and 20 plants per pot were maintained. Pots were watered regularly as per the requirement.

All the herbicides were applied as post-emergence on *P. minor*. At 30 days after the herbicide application, the phyotoxicity to the canary grass populations was recorded with a rating scale of 0-100, where 0 stands for 0% phytotoxicity and 100 for 100 % killing of the plants.

All the populations showed variable phytotoxicity with graded doses of clodinafop. Expect the susceptible (check) none of the population showed $\geqslant$80% control with the recommended dose (60 g/ha) of clodinafop. With 4x dose of this herbicide, only 3 populations showed more than 80 % control. Only three populations out of the 15 popultations under the testing showed $\geqslant$ 80% control to the recommended dose of sulfosulfuron (25 g/ha), mesosulfuron + iodosulfuron (RM) (14.4 g/ha) and pinoxaden (50 g/ha). It showed the development of resistance to the *P. minor* populations against these tested herbicides. Herbicides were applied at 1/2X, X, 2X, 4X doses (where X is the recommended dose). Out of total 15 populations under testing only 1,3,11,11 populations showed $\geqslant$ 80% control with the 2X dose of clodinafop, sulfosulfuron,

mesosulfuron + iodosulfuron (RM) and pinoxaden respectively. Even at 4x of clodinafop and sulfosulfuron only 2 and 5 populations showed more than 80 % control. This showed that the higher level of resistance has developed against these herbicides and it was also confirmed with the computation of the GR_{50} and Resistance Index (**Table 1.4.2 and 1.4.3**).

Table 1.4.1 Weed control efficiency, dry weight yield and yield attributes of wheat as influenced by different herbicide treatments at harvest

Treatments	Dose (g/ha)	Grains/ spike	*P. minor* density (no./m²)	*P. minor* weight (g/m²)	*P. minor* WCE (%)	Total weeds dry weight (g/m²)	Effective tillers/m²	Test weight (g)	Grain yield (kg/ha)
PMN	1500	40	4.8 (22)	5.2 (26.0)	61.3	7.5 (54.9)	306	47.7	3,775
ACN + DFN	1000+200	42	5.4 (28)	5.8 (32.1)	52.1	7.2 (51.1)	317	43.1	4,035
PXN +PMN	127.5+1500	47	3.8 (13)	4.1 (15.9)	76.3	6.1 (35.6)	328	47.5	4,128
PMN *fb* MSN + ISN	1500 *fb*14.4	52	3.7 (13)	4.2 (16.3)	75.7	5.7 (31.6)	375	43.8	4,830
ACN + DFN *fb* MSN + ISN	1000+200 *fb* 14.4	53	4.1 (16)	4.5 (19.5)	70.9	5.4 (28.2)	359	45.2	4,663
PXN +PMN *fb* MSN + ISN	127.5+1500 *fb* 14.4	52	3.4 (11)	3.6 (11.7)	82.5	5.1 (25.4)	434	44.0	5,369
PMN *fb* SSN + MSM	1500 *fb* 32	44	3.9 (14)	4.3 (17.2)	74.3	6.1 (35.8)	335	44.0	4,317
ACN + DFN *fb* SSN + MSM	1000+200 *fb* 32	50	4.3 (17)	4.7 (21.1)	68.4	5.7 (32.0)	386	43.2	4,925
PXN +PMN *fb* SSN + MSM	127.5+1500 *fb* 32	50	3.2 (9)	3.5 (11.0)	83.6	5.2 (26.0)	421	44.5	5,183
PMN *fb* PDN + MSM	1500 *fb* 54	49	3.5 (11)	3.8 (13.6)	79.6	6.4 (40.1)	348	42.1	4,346
ACN + DFN *fb* PDN + MSM	1000+200 *fb* 54	52	3.0 (8)	3.3 (9.8)	85.4	5.4 (28.2)	400	45.0	5,091
PXN +PMN *fb* PDN + MSM	127.5+1500 *fb* 54	53	1.6 (2)	1.8 (2.1)	96.8	5.1 (25.3)	451	45.1	5,605
CDF + MTZ	60+175	43	4.3 (17)	4.8 (22.5)	66.4	8.0 (63.2)	330	44.7	4,254
PXN +PMN *fb* CDF + MTZ	127.5+1500 *fb* 60+175	46	3.9 (14)	4.2 (16.4)	75.6	7.5 (55.3)	324	44.5	4,054
Weedy check	-	34	7.1 (50)	8.2 (67.0)	0.0	12.9 (164.3)	296	39.6	3,221
Weed free	-	54	1.0 (0)	1.0 (0.0)	100.0	1.0 (0.0)	463	45.2	5,928
SE(m) ±		1.2	0.12	0.1		0.14	7	2.4	101
LSD (P=0.05)		3.5	0.35	0.4		0.4	19	NS	295

PMN = Pendimethelin, ACN = Aclonifen, DFN = Diflufenican, PDN = Pinoxaden, MSN = Metsulfuron, CDF = Clodinafop, MTZ = Metribuzin, SSN = Sulfosulfuron, PXN = Pyroxasulfone, MSN = Mesosulfuron, ISN = iodosulfuron.

Table 1.4.2 Efficacy (% control) of herbicides in pot-studies against biotypes *Phalaris minor* obtained from farmers' fields in Haryana (*rabi* 2019-20)

Populations: P_1 - Kachhwa (Karnal), P_2 - Hindwan (Hisar), P_3 – Khijrabad Raiyawala (Yamuna nagar), P_4 - Kheri Raiwali (Kaithal), P_5 - Ramba

Treatments	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}
Untreated check	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clodinafop 30g/ha	0	65	0	0	0	0	0	0	15	0	0	0	40	0	5
Clodinafop 60g/ha	20	90	40	25	20	10	5	0	30	0	10	10	40	10	10
Clodinafop 120g/ha	25	100	45	35	20	20	25	10	55	5	20	25	41.2	15	20
Clodinafop 240g/ha	45	100	50	45	35	30	47.5	57.5	85	12.5	25	45	55	30	50
Sulfosulfuron 12.5 g/ha	5	78	15	10	45	26.2	33.7	20	22.5	0	10	45	30	45	10
Sulfosulfuron 25 g/ha	27.5	90	20	20	60	37.5	33.7	20	30	26.2	13.7	65	80	83.7	12.5
Sulfosulfuron 50 g/ha	37.5	100	26.2	26.2	72.5	40	40	45	65	27.5	50	77.5	81.2	85	26.2
Sulfosulfuron 100 g/ha	40	100	50	27.5	78.7	57.5	73.7	66.2	90	50	65	85	82.5	91.2	35
Mesosulfuron + iodosulfuron (RM) (7.2 g/ha)	40	60	42.5	20	42.5	50	50	55	50	10	10	40	62.5	68.7	33.7
Mesosulfuron + iodosulfuron (RM) (14.4 g/ha)	70	100	57.5	50	95	70	75	70	90	60	30	75	77.5	75	50
Mesosulfuron + iodosulfuron (RM) (28.8 g/ha)	98	100	60	62.5	97.2	80	92.5	90	92.5	81.2	50	92.5	83.7	85	67.5
Mesosulfuron + iodosulfuron (RM) (57.6 g/ha)	100	100	61.2	70	100	96.2	100	95	96.2	97.5	60	95	92.5	90	78.7
Pinoxaden 25 g/ha	40	75	70	5	10	10	35	40	50	5	20	10	15	41.2	36.2
Pinoxaden 50 g/ha	87.5	96	79	60	60	15	50	47.5	96.2	20	60	55	50	68.7	70
Pinoxaden 100 g/ha	90	100	90	90	95	82.5	78	88.7	100	45	90	78	73.7	80	90
Pinoxaden 200 g/ha	100	100	96.25	93.75	100	96	86	100	100	70	100	90	82.5	95	96.2

(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)

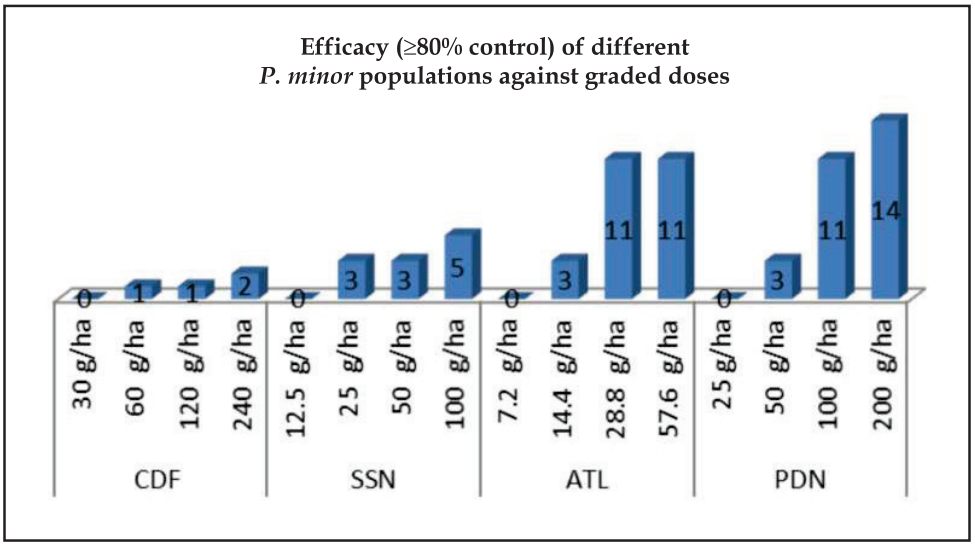


Fig 6. Efficacy (≥ 80 % control) of different *P. minor* populations against graded doses

Table 1.4.3 Resistance index of different *Phalaris minor* populations against clodinafop, sulfosulfuron, mesosulfuron + iodosulfuron (RM) and pinoxaden

Populations	Resistance index against herbicide			
	Clodinafop	Sulfosulfuron	Mesosulfuron+iodosulfuron (RM)	Pinoxaden
Kachhwa (Karnal)	10.96	15.86	3.02	2.13
Hindwan (Hisar)	1	1	1	1
Khijarabad Raiyawala (Yamunanagar)	7.58	19.5	3.89	0.93
Kheri Raiwali (Kaithal)	9.55	72.5	6.91	2.18
Ramba (Karnal)	14.46	2.29	2.23	3.55
H.A.U Farm (Hisar)	16.98	10.2	2.63	5.62
Rasidan (Jind)	11.22	6.61	2.81	3.39
Teek (Kaithal)	12.30	8.71	2.13	3.02
Laloda (Fatehabad)	4.46	4.68	1.65	1.51
Kalwan (Jind)	75.8	12.3	5.01	9.33
Sitamai (Karnal)	14.4	8.92	11.48	3.39
Danoda (Jind)	11.2	2.04	2.69	4.46
Uchana (Karnal)	10.7	2.18	1.28	4.90
Ujahana (Jind)	18.6	1.48	0.77	2.57
Chanarathal (Kurukshetra)	13.4	33.92	4.89	2.57

Plate 1. Response of Kachhwa (karnal) against graded doses of sulfosulfuron

Plate 2. Response of Hindwan (Hisar) against graded doses of sulfosulfuron

Plate 3. Response of K. Raiwali (Kaithal) against graded doses of sulfosulfuron

Plate 4. Response of Laloda (Fatehabad) against graded doses of clodinafop-propargyl

WP 1.4. Management of herbicide resistance weeds

Ludhiana

WP 1.4.2(ii) Management of multiple herbicide resistant population of *P. minor* in wheat

WP 1.4.2 (2.3.2) Management of cross resistance in *P. minor* against recommended herbicides in wheat through use of pre and post emergence herbicides

Objectives:

- To study bio-efficacy of combination of herbicides against cross resistant *P. minor*
- To study the phytotoxic effects on the crop, if any

Phalaris minor, Rumex dentatus, Anagallis arvensis, Medicago denticulata, 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 suflosulfuron + metsulfuron/ mesosulfuron + iodsulfuron were found to be effective against broad spectrum of weeds (**Table 1.4.4 to 1.4.6**). Sequential application of aclonifen + diflufenican as pre-emergence gave the highest wheat grain yield which was at par to weed free check and all the other pre-

emergence and pre-*fb* post-emergence application combinations except farmers' practice - clodinofop + metribuzin (TM) (**Table 1.4.12**). Wheat yield attributes like panicle density, crop biomass followed the same trend as was recorded for grain yled. Pre-emergecne application of ready mix of aclonifen + diflufneican at 1000+200 g/ha recorded the highest net returns and B:C.

Table 1.4.4 Effect of weed control treatments on weed density at 60 DAS during 2019-20.

Treatments	Dose g/ha	Weed density (no./m²)				
		Phalaris minor	*Anagallis arvensis*	*Rumex dentatus*	*Medicago denticulata*	*Coronopus didymus*
Pendimethalin	1500	2.66 (6)	1.38 (1)	1(0)	1.38 (1)	1.61 (2)
Aclonifen+diflufenican ™	1000+200	1.33 (1)	1.14 (1)	1(0)	1.14 (1)	1.00 (0)
Pyroxasulfone	127.5	1.72 (3)	1.58 (2)	1.33 (1)	1.58 (2)	1.33 (1)
Pendimethalin *fb* mesosulfuron+ iodosulfuron (RM)	1500/14.4	3.54 (12)	1.91 (3)	1.00 (0)	1.91 (3)	1.24 (1)
Aclonifen+diflufenican ™ *fb* mesosulfuron+ iodosulfuron (RM)	1000+200/ 14.4	1.24 (1)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* mesosulfuron+ iodosulfuron (RM)	127.5/14.4	1.27 (1)	1.80 (2)	1.00 (0)	1.80 (2)	1.14 (1)
Pendimethalin *fb* sulfosulfuron+ metsulfuron (RM)	1500/40	2.82 (7)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Aclonifen+diflufenican ™ *fb* sulfosulfuron+metsulfuron (RM)	1000+200/ 40	1.24 (1)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* sulfosulfuron+ metsulfuron (RM)	127.5/40	1.00 (0)	1.24 (1)	1.00 (0)	1.24 (1)	1.00 (0)
Pendimethalin *fb* pinoxaden+ metsulfuron (RM)	1500/64	3.51 (12)	1.41 (1)	1.00 (0)	1.41 (1)	1.00 (0)
Aclonifen+diflufenican ™ *fb* pinoxaden+metsulfuron (RM)	1000+200/ 64	1.38 (1)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* pinoxaden+ metsulfuron (RM)	127.5/64	1.79 (3)	1.52 (1)	1.00 (0)	1.52 (1)	1.00 (0)
Farmers' practice – clodinofop+ metribuzin ™	60+175	5.51 (31)	1.67 (2)	1.14 (1)	1.67 (2)	3.56 (12)
Weedy check		8.34 (69)	3.90 (14)	2.15 (4)	3.90 (14)	5.16 (27)
Weed free		1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
SEm±	-	0.57	0.26	0.14	0.26	0.32
LSD (P=0.05)		1.16	0.53	0.30	0.53	0.66

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

Table 1.4.5 Effect of weed control treatments on weed dry biomass in wheat (2019-20)

Treatments	Dose g/ha	Weed biomass (g/m²)			
		60 DAS		At harvest	
		Grass	Broad leaf	Grass	Broad leaf
Pendimethalin	1500	2.37 (5)	1.00 (0)	4.48 (20)	1.40 (1)
Aclonifen+diflufenican (TM)	1000+200	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone	127.5	1.22 (1)	1.46 (1)	1.30 (1)	1.00 (0)
Pendimethalin *fb* mesosulfuron+iodosulfuron (RM)	1500/14.4	2.35 (5)	1.15 (0)	3.93 (15)	1.00 (0)
Aclonifen+diflufenican (TM) *fb* mesosulfuron+iodosulfuron (RM)	1000+200/14.4	1.14 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* mesosulfuron+iodosulfuron (RM)	127.5/14.4	1.10 (0)	1.06 (0)	1.25 (1)	1.00 (0)
Pendimethalin *fb* sulfosulfuron+metsulfuron (RM)	1500/40	2.12 (4)	1.00 (0)	3.66 (12)	1.24 (1)
Aclonifen+diflufenican (TM) *fb* sulfosulfuron+metsulfuron (RM)	1000+200/40	1.29 (1)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* sulfosulfuron+metsulfuron (RM)	127.5/40	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pendimethalin *fb* pinoxaden+metsulfuron (RM)	1500/64	2.26 (4)	1.00 (0)	3.38 (10)	1.00 (0)
Aclonifen+diflufenican (TM) *fb* pinoxaden+metsulfuron (RM)	1000+200/64	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Pyroxasulfone *fb* pinoxaden+metsulfuron (RM)	127.5/64	1.10 (0)	1.00 (0)	1.00 (0)	1.00 (0)
Farmers' practice - clodinofop+metribuzin (TM)	60+175	3.49 (11)	1.69 (2)	4.69 (21)	1.25 (1)
Weedy check		5.89 (34)	4.48 (20)	7.16 (50)	2.72 (6)
Weed free		1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
SEm±	-	0.33	0.20	0.33	0.13
LSD (P=0.05)		0.67	0.40	0.69	0.27

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

Table 1.4.6 Wheat growth, yield attributes and grain yield and economics of different weed control treatments (2019-20).

Treatments	Dose g/ha	Crop biomass (g/m^2)	Spikes ($No./m^2$)	Plant height (cm)		Grain yield (t/ha)	Biological yield (t/ha)	Variable cost (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
		60 DAS	At harvest	60 DAS	At harvest						
Pendimethalin	1500	396.6	385	47.3	93.2	5.58	16.0	32,998	10,747	74,475	3.26
Aclonifen+diflufenican (TM)	1000+200	413.1	411	47.5	94.6	5.88	16.2	33,623	11,336	79,740	3.37
Pyroxasulfone	127.5	414.4	413	45.5	94.0	5.80	16.3	36,123	11,177	75,643	3.09
Pendimethalin *fb* mesosulfuron+iodosulfuron (RM)	1500/14.4	373.7	376	47.7	92.5	5.19	15.0	34,123	9,998	65,862	2.93
Aclonifen+diflufenican (TM) *fb* mesosulfuron+iodosulfuron (RM)	1000+200/14.4	388.5	413	46.3	93.4	5.250	15.3	34,48	10,106	66,315	2.91
Pyroxasulfone *fb* mesosulfuron+iodosulfuron (RM)	127.5/14.4	408.8	424	44.5	92.6	5.72	16.0	37,248	11,015	72,901	2.96
Pendimethalin *fb* sulfosulfuron+metsulfuron (RM)	1500/40	406.1	412	46.1	92.5	5.53	15.8	34,123	10,651	72,387	3.12
Aclonifen+diflufenican (TM) *fb* sulfosulfuron+metsulfuron (RM)	1000+200/40	409.4	422	43.6	95.1	5.67	15.6	34,748	10,909	74,342	3.14
Pyroxasulfone *fb* sulfosulfuron+metsulfuron (RM)	127.5/40	415.8	420	44.8	93.8	5.78	15.5	37,248	11,123	73,979	2.99
Pendimethalin *fb* pinoxaden+metsulfuron (RM)	1500/64	383.5	388	47.5	92.6	5.41	14.7	35,036	10,428	69,241	2.98
Aclonifen+diflufenican (TM) *fb* pinoxaden+metsulfuron (RM)	1000+200/64	412.0	413	46.4	92.8	5.61	15.4	35,661	10,801	72,351	3.03
Pyroxasulfone *fb* pinoxaden+metsulfuron (RM)	127.5/64	411.4	414	46.6	92.8	5.61	15.8	38,161	10,801	69,851	2.83
Farmers' practice-clodinofop+metribuzin (TM)	60+175	363.5	393	47.7	92.5	4.61	13.6	33,623	8,876	55,139	2.64
Weedy check	-	358.1	349	49.3	94.6	3.22	11.4	31,123	6,202	30,901	1.99
Weed free	-	434.8	426	47.1	93.9	6.22	16.3	33,598	11,977	86,176	3.56
SEm±	-	44.2	12	1.33	2.18	0.45	0.78	-	-	-	-
LSD (P=0.05)	-	NS	24	2.7	NS	0.419	1.09	-	-	-	-

WP 1.5 Management of parasitic weeds

WP 1.5.1 Management of *Cuscuta* in Lucerne AAU, Anand

Objectives:

1. To study the effect of different herbicides on the emergence of *Cuscuta*
2. To study the visual phytotoxicity on lucerne crop, if any

Year of commencement: *Rabi* 2020-21

Treatments:

Treatment	Dose (g/ha)	Application time
Pendimethalin	680	PE
Pendimethalin	680	10 DAS
Pendimethalin+ imazethapyr (PM)	640	PE
Pendimethalin+ imazethapyr (PM)	800	PE
Imazethapyr	50	PoE
Imazethapyr + imazamox (PM)	70	PE
Fluazifop-p-butyl+ fomesafen (PM)	250	PoE
Propaquizafop+ imazethapyr ME (PM)	125	PoE
Weedy check	-	-
PE = 0-3 DAS and PoE = 20-25 DAS		

Application of pendimethalin 680 g/ha PE, pendimethalin + imazethapyr 640 g/ha PE, pendimethalin 30% + imazethapyr 800 g/ha PE were found phytotoxic to lucerne crop and poor germination was observed in treated plot compared to untreated check. Further, fluazifop-p-butyl + fomesafen 250 g/ha PoE was also found phytotoxic to lucerne crop and burning effect on leaves of lucerne was observed.

Gwalior

WP 1.5.2 (ii) Management of problematic weed (*Cuscuta campestris*) in berseem (*Trifolium alexandrinum* L.) fodder crop

Field experiment was conducted at the research farm of RVSKVV, Gwalior during *Rabi* 2018-19 and 2019-20 in a sandy clay loam in texture with organic carbon 0.3% having pH 7.8, low in available nitrogen (237 kg/ha), medium in available phosphorus (19.7 kg/ha) and potash (277.1 kg/ha) to investigate the interference of *C. campestris* densities and the efficacy of herbicides for its control in berseem. Eight treatments consisting of pre- emergence application of pendimethalin 1000g/ha, early post-emergence pendimethalin 1000g/ha at 10 DAS, pre emergence application of oxyfluorfen 250 g/ha, imazethapyr 40g/ha after first cutting of berseem, imazethapyr 40 g/ha after last cutting of berseem, imazethapyr 40 g/ha after first cutting *fb* 40 g/ha after last cutting, *Cuscuta* free with hand weeding and control plot (no herbicide application) were laid out in the randomized block design with three replications.

The *Cuscuta* infested berseem seeds were sown in rows 20 cm apart in first week of November with a seed rate of 25 kg/ha. Before sowing it was soaked for half an hour and treated with *Rhizobium melilotii* culture which helps in nitrogen fixation after the establishment of the seedlings. Basal dose of N:P:K 20:80:20 kg/ha through urea, single super phosphate and murate of potash was applied in the field respectively. Number of *Cuscuta campestris* emerged /m^2 was recorded at at 30, 60 90 and at 120 DAS whereas the clover emerged/m^2 were recorded at 30 DAS only. The first cutting of fodder was done at 60 DAS and subsequent 2 cuttings were done at 30 days intervals when the crop attained the height of around 45 cm from the ground. The cuttings were done at about 5-7 cm height for better quick growth. The total fodder yield also included the weight of *Cuscuta* vines as it was very difficult to remove it from the host plants. The crop was left for seed production after the 3rd cut and given light irrigations until flowering and seed setting. It was harvested in the last week of May.

Effect on *Cuscuta*

Among pre-emergence herbicides the higher dose of pendimethalin 1000 g/ha and oxyfluorfen 250 g/h though significantly reduced the *Cuscuta* emergence but also caused phytotoxicity to berseem crop and reduced its population significantly. The post-

emergence application of imazethapyr 40 g/ha after 1st cut of berseem effectively controlled *Cuscuta campestris* and produced the maximum green fodder and seed yields and it was *fb* the post-emergence application of imazethapyr 40 g/ha after 1st cut *fb* same dose at last cut. The maximum *Cuscuta* density was recorded in weedy check. **(Table 1.5.1.1)**.

Effect on crop:

The lowest green fodder yield (9.41 t/ha) and seed yield (94 kg/ha) was obtained where oxyflorfen 250 g/ha was applied which was followed by pre-emergence herbicide pendimethalin 1.0 kg/ha. The higher dose of both the herbicides caused phytotoxicity to berseem crop and reduced its population significantly. Among the application of herbicides the maximum fodder yield (65.8 t/ha) and seed yield (357 kg/ha) was recorded where imazethapyr 40g/ha was applied after first cut of berseem and it proved significantly superior over rest of the treatments and it was *fb* imazethapyr 40 g/ha sprayed after 1st cut of berseem and again applied after last cut of berseem. The highest fodder yield 72 t/ha, seed yield 376 kg/ha with net monitory returns (₹ 1,26,161/ha) and B:C 3.81 was recorded in *Cuscuta* free treatment. However, among herbicide application the maximum monetary returns (₹ 1,18,154/ha) with B:C 3.99 was recorded with the application of imazethapyr 40g/ha after 1st cut which is best in terms of profitability.

It is concluded that among herbicides application, the imazethapyr 40g/ha after 1st cut provided the maximum fodder yield and seed yield with BC ratio *fb* imazethapyr 40 g/ha after 1st cut + imazethapyre 40g/ha after last cut and fodder and seed yield respectively. It was also observed that the higher dose of pendimethalin 1000g/ha and oxyflourfen 250 g/ha though significantly reduced the *Cuscuta* emergence but also caused phytotoxicity to berseem crop and reduced the yield significantly **(Table 1.5.1.2 and 1.5.1.3)**.

Hisar

WP 1.5.6.1 *Orobanche* management in tomato

Objectives

- To study the bio-efficacy of combination of herbicides against *Orobanche* and their effect on growth and yield of tomato
- To study the phytotoxic effects on the crop, if any

Year of start : 2019-20

Treatments:

1. Sulfosulfuron 25 g/ha as PRE
2. Ethoxysulfuron 50 g/ha as 60 and 90 DAT
3. Ethoxysulfuron 50 g/ha as 45 and 90 DAT
4. Sulfosulfuron 25 g/ha at 60 DAT *fb* 50 g/ha at 90 DAT
5. Sulfosulfuron 50 g/ha at 60 DAT and 90 DAT
6. Untreated check

Tomato hybrid 2853 was planted for on November 19, 2019 in *Orobanche* sick plots. Post emergence herbicides were applied at various stages as per treatment using 375 litres of water/ha. Observations on number of broom rape spikes/m^2 and broom rape visual control (0-100 scale) by different treatments was recorded at 60, 90, 120 DAP and at harvest. Data on plant height, were recorded at 120 DAP. Number of fruits/plant was recorded from five tagged plants at 90, 120 DAT and harvest which were averaged to compute values /plant. Tomato fruits picked in four flushes were weighed and thus total yield/plot was computed. Crop phyto-toxicity due to different treatments was assessed at 10, 30 DAT and harvest on a scale of 0-100, where 0 means no injury and 100 = complete mortality of tomato plant. Foliar necrosis, yellowing, stunting, necrosis and wilting were the main symptoms considered while making visual estimate of visual injury on tomato plants.

Orobanche panicles did not appear in any of the treatment even up to 60 DAS except ethoxysulfuron treatments and number of panicles emerged above ground were few even at 90 DAS. Excellent control of *Orobanche* was obtained with PoE treatments of sulfosulfuron and ethoxysulfuron when compared with non-treated controls. At harvest, *Orobanche* stalks to the tune of 1.3-3.5 panicles/m^2 appeared in various

Table 1.5.1.1 Effect of different weed management practices on density of *Cuscuta* emerged/m^2 in berseem during 2018-19 and 2019-20 (pooled)

Treatment	Density of *Cuscuta* emerged/m^2											
	30 DAS			*60 DAS*			*90 DAS*			120 DAS		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Pendimethalin 1000g/ha (PE)	1.02 (0.54)	1.17 (0.86)	1.09 (0.70)	1.66 (2.27)	1.76 (2.67)	1.71 (2.47)	1.70 (2.38)	1.22 (0.99)	1.46 (1.69)	1.71 (2.43)	1.23 (1.02)	1.47 (1.73)
Pendimethalin 1000g/ha (EPOE) at 10 DAS	1.05 (0.61)	1.07 (0.64)	1.06 (0.63)	1.56 (1.94)	3.65 (12.83)	2.61 (7.39)	1.61 (2.09)	1.16 (0.85)	1.39 (1.47)	1.59 (2.10)	1.21 (0.95)	1.40 (1.53)
Oxyfluorfen 250g/ha (PE)	1.26 (1.09)	1.31 (1.23)	1.29 (1.16)	1.43 (1.53)	1.41 (1.50)	1.42 (1.52)	1.48 (1.69)	1.24 (1.04)	1.36 (1.37)	1.47 (1.65)	1.29 (1.17)	1.38 (1.41)
Imazethapyr 40g/ha after 1^{st} cut	1.32 (1.23)	2.53 (5.97)	1.92 (3.60)	1.14 (0.81)	4.49 (19.67)	2.82 (10.24)	1.15 (0.81)	1.23 (1.01)	1.19 (0.91)	1.17 (0.88)	1.23 (1.01)	1.20 (0.94)
Imazethapyr 40g/ha after last cut	1.33 (1.27)	2.49 (5.70)	1.91 (3.48)	2.02 (3.60)	4.50 (19.83)	3.26 (11.72)	2.03 (3.63)	1.58 (2.00)	1.80 (2.82)	1.22 (1.00)	1.59 (2.04)	1.41 (1.52)
Imazethapyr 40g/ha after 1^{st} cut *fb* imæzethapyr 40g/ha after last cut	1.35 (1.32)	2.48 (5.70)	1.91 (3.51)	1.26 (1.08)	4.88 (23.33)	3.07 (12.21)	1.25 (1.06)	1.18 (0.90)	1.22 (0.98)	1.11 (0.73)	1.20 (0.95)	1.15 (0.84)
Cuscuta free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	5.17 (26.33)	2.94 (13.17)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	1.35 (1.32)	2.81 (7.40)	2.08 (4.36)	2.10 (3.93)	5.04 (25.00)	3.57 (14.47)	2.02 (3.58)	1.59 (2.03)	1.80 (2.81)	2.13 (4.03)	1.65 (2.23)	1.89 (3.13)
SEm (±)	0.021	0.098	0.071	0.054	0.150	0.113	0.025	0.051	0.040	0.069	0.025	0.052
LSD (P=0.05)	0.062	0.287	0.205	0.158	0.438	0.325	0.072	0.149	0.115	0.203	0.075	0.150
Transfomation	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$	$\sqrt{x+0.}$

Table 1.5.1.2 Effect of different weed management practices on fodder yield (kg/plot) in berseem during 2018-19 and 2019-20 (pooled)

Treatment	Fodder yield (kg/plot)											
	First cut at 60 DAS			Second cut at 90 DAS			Third cut at 120 DAS			Total fodder yield in three cuts (kg/plot)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Pendimethalin 1000g/ha (PE)	4.00	2.67	3.33	5.60	3.83	4.72	7.83	7.17	7.50	17.4	13.6	15.5
Pendimethalin 1000g/ha (EPOE) at 10 DAS	22.8	12.8	17.8	22.8	22.0	22.4	18.0	32.0	25.4	64.6	66.8	65.7
Oxyfluorfen 250g/ha (PE)	2.33	1.50	1.92	5.33	2.83	4.08	6.50	4.17	5.33	14.1	8.50	11.3
Imazethapyr 40g/ha after 1^{st} cut	21.1	19.6	20.3	26.0	25.5	25.7	25.0	41.3	33.1	72.1	86.5	79.3
Imazethapyr 40g/ha after last cut	22.3	19.8	21.0	23.5	22.3	22.9	25.0	41.0	33.2	71.3	83.1	77.2
Imazethapyr 40g/ha after 1^{st} cut *fb* imazethapyr 40g/ha after last cut	22.6	23.3	23.0	26.0	16.1	21.0	24.3	41.6	33.2	73.5	81.1	77.3
Cuscuta free	24.8	26.3	25.6	27.1	24.3	25.7	26.3	44.6	35.5	78.3	95.3	86.8
Weedy check	15.6	17.3	16.5	16.6	18.0	17.3	18.0	25.0	21.7	50.8	60.3	55.5
SEm (±)	1.13	1.07	1.10	0.84	1.29	1.09	0.91	1.94	1.52	1.94	2.91	2.47
LSD (P=0.05)	3.32	3.14	3.18	2.48	3.78	3.15	2.66	5.70	4.38	5.70	8.52	7.15

Table 1.5.1.3 Effect of different weed management practices on economics of Berseem during 2018-19 and 2019-20 (pooled)

Treatments	Total cost of cultivation			Gross returns			Net returns			B:C		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Pendimethalin 1000g/ha (PE)	45,350	37,450	41,400	30,868	30,676	30,772	-14,483	-6774	-10,628	0.68	0.82	0.75
Pendimethalin 1000g/ha (EPOE) at 10 DAS	45,350	37,383	41,367	1,21,402	1,50,014	1,35,708	76,052	1,12,631	94,341	2.68	4.02	3.35
Oxyfluorfen 250g/ha (PE)	45,650	37,650	41,650	27,217	19,079	23,148	-18,433	-18,571	-18,502	0.60	0.51	0.55
Imazethapyr 40g/ha after 1st cut	45,517	37,083	41,300	1,24,751	1,94,158	1,59,454	79,234	1,57,075	1,18,154	2.74	5.23	3.99
Imazethapyr 40g/ha after last cut	47,350	39,350	43,350	1,20,556	1,86,676	1,53,616	73,206	1,47,326	1,10,266	2.55	4.75	3.65
Imazethapyr 40g/ha after 1st cut *fb* imazethapyr 40g/ha after last cut	45,750	37,750	41,750	1,28,693	1,82,187	1,55,440	82,943	1,44,437	1,13,690	2.81	4.83	3.82
Cuscuta free	49,117	43,017	46,067	1,32,969	2,11,486	1,72,228	83,852	1,68,470	1,26,161	2.71	4.92	3.81
Weedy check	44,150	36,150	40,150	85,362	1,59,415	1,22,388	41,212	1,23,265	82,238	1.93	4.41	3.17
SEm (±)	211.6	640.4	476.9	2622.3	6279.1	4811.6	2587.5	6268.4	4795.2	0.056	0.175	0.130
LSD(P=0.05)	619.5	1874.7	1375.8	7676.5	18381.5	13881.4	7574.6	18350.3	13834.1	0.164	0.513	0.375

Table 1.5.6.1 Effect of different weed control measures on *broom rape (Orobanche)* population, visual control, plant height, crop toxicity and fruit yield of tomato during 2019-20

Treatment	Number of broom rape spikes/m^2	Visual phytotoxicity (%) on crop	Visual broom rape control (%)	Fruit yield (t/ha)
	Harvest	10 DAT	Harvest	
Sulfosulfuron 25 g/ha as PRE	2.1 (3.5)	0 (0)	53.7 (65.0)	12.5
Ethoxysulfuron 50 g/ha as 60 and 90 DAT	2.0 (3.2)	0(0)	60.0 (75.0)	16.4
Ethoxysulfuron 50 g/ha as 45 and 90 DAT	1.8 (2.3)	15.3 (7)	63.4 (80.0)	15.2
Sulfosulfuron 25 g/ha at 60 DAT *fb* 50 g/ha at 90DAT	1.5 (1.3)	11.5 (4.0)	66.7 (84.7)	17.7
Sulfosulfuron 50 g/ha at 60 and 90DAT	1.8 (2.3)	16.4 (8.0)	68.4 (86.7)	14.0
Untreated check	3.9 (14.0)	0(0)	0.0 (0.0)	6.0
SEm±	0.22	0.7	1.8	0.4
LSD (P=0.05)	0.74	2.2	5.5	1.5

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

herbicide treatments which was significantly less than 13.67/m^2 in untreated control. Toxicity to tomato crop due to post emergence use of ethoxysulfuron and sulfosulfuron 50 g/ha at 60 and 90 DAT varied from 4-8% at 10 DAT with reduction in plant height. Plant height and number of fruits per plant varied significantly due to various herbicide treatments. Maximum fruit yield (17.7 t/ha) was recorded from use of sulfosulfuron 25 g/ha at 60 DAT *fb* 50 g/ha at 90 DAT, which was at par with ethoxysulfuron 50 g/ha as 45 and 90 DAT and significantly higher than weedy check with 66.0 % increase over untreated check (**Table 1.5.6.1**).

WP. 1.5.6.2. (a). Management of Orobanche in Brinjal

Bhubaneswar

A field trial as OFT on management of *Orobanche* in brinjal crop was initiated in *Orobanche* infested vegetable tract of Cuttack disrict (Talabasta village) during September, 2019 in farmers field. The objective of the study is to find out the effective management practices for *Orobanche* in brinjal.

Treatments

T_1-Sulfosulfuron 50 g/ha at 60 DAT

T_2- Sulfosulfuron 25 g/ha at 60 DAT *fb* 25 g/ha at 90 DAT

T_3- Sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT

T_4-Weedy check

The emergence of the shoot takes around 49 days and there were on an average 5.2 shoots per a single brinjal plant. The shoot of *Orobanche* goes up to a height of 14.3 cm. And the shoot dries in 38 days. The parasite produces around 4500 seeds / floret and there were 40.0 florets per shoot (**Table 1.5.6.2**).

Table 1.5.6.2 Biology of *Orobanche* in brijal

Parameters		Range	Mean
Days to emergence of shoot above ground (from date of planting)		43-56	49
No of shoots of parasite / plant		3-7.4	5.2
Shoot height(cm)		11.3–17.0	14.3
Days to flowering (from the date of planting)		50-60	55
Days to drying of shoot (from the date of emergence)		35-41	38
Dry weight / plant	Stem	1.1–4.5	3.0
	Florets	0.5-2.0	1.4
	Seeds	0.30-1.36	0.76
	Total	1.90–7.86	5.16
No. of florets / shoot		26–95	40.0
No. of seeds / floret		3500–5700	4500
No. of seeds / inflorescence		96400-550200	280000

Application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT recorded significantly the lowest number of *Orobanche*/plant (9.2) at 30 DAP and the lowest weed density of 5.2 and 10.6 g/plant at 30 DAP and at harvest, respectively. However, the practice of two hand weedings at 35 and 55 DAP recorded significantly the lowest density (10.2) at harvest and the reduction in density was in the tune of 25% over application of sulfosulfuron 50 g/ha at 60 DAT.

Application of sulfosulfuron 25 g/ha at 30 DAT *fb* 25 g/ha at 60 DAT recoded the highest *Orobanche* control efficiency (67.1%) at 30 DAP and 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)

Udaipur

WP 1.5.6.3 Management of problematic weed *Orobanche*

OFR was conducted in solanaceous vegetables in the village Kantoda of Sarada tehsil.

Crop: Tomato

Five demonstrations on management of *Orobanchae* in tomato through herbicide were conducted at Kantoda village of 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 both the chemicals i.e. sulfosulfuron and ethoxysulfosulfuron. Single application of ethoxysulfuron 20 g/ha at 45 DAT though provided effective weed control upto 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 10.01% tomato fruit yield in comparison to farmers practice (**Table 1.5.6.3**).

Table 1.5.6.3 Performance of herbicides in terms of *orobanche* control and yield of tomato in comparison to farmer's practice

Treatments	*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	45 (36-50)	30.10	5.79
Ethoxysulfosulfuron20 g/ha at 45 DAT *fb* 15 g/ha at 90 DAT	53 (40-60)	31.30	10.01
Farmer practice	-	28.45	-

Sale price (₹/kg): Tomato- 10/kg

Crop : Brinjal

Five demonstrations on management of *Orobanchae* in brinjal through herbicide were conducted at Kantoda village of tehsil- Sarada. The data observed that application of ethoxysulfuron twice; 20 g/ha at 45 DAT followed by 15 g/ha at 90 DATwould be very helpful in reducing the *Orobanche* infestation and increasing brinjal yield by 11.86 % over farmers practice.

Table 1.5.6.4 Performance of herbicides in terms of *orobanche* control and yield of brinjal in comparison to farmer's practice

Treatments	*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	45 (34-60)	33.70	7.15
Ethoxy sulfuron20 g/ha at 45 DAT fb 15 g/ha at 90 DAT	52 (40-58)	35.18	11.86
Farmer practice	-	31.45	-

Sale price (₹/kg): Brinjal- 12/kg

Raipur

WP1.5.6.4 Management of problematic weeds *Cuscuta in* berseem (*Trifolium alexadrinum L.*) fodder crop.

Treatments

1. Pendimethalin 0.1 kg/ha (PE)
2. Pendimethalin 0.1 kg/ha (EPoE) at 10 Days after sowing
3. Oxyfluorfen 0.25 kg/ha (PE)
4. Imazethapyr at 0.04 kg/ha after 1st cutting
5. Imazethapyr at 0.04 kg/ha after last cut
6. Imazethapyr at 0.04 kg/ha after 1st cutting *fb* Imazethapyr at 0.04 kg/ha after last cut

Treatments : Six **Variety :** Muskawi

The first appearance of cuscuta in the experimental field was observed after 30 DAS of berseem under the treatment herbicide applied only after 1st cut. At the time of just before first cut of berseem, highest length (46.32 cm) of cuscuta with highest average number of threads (4.00/m^2) was 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 kg/ha as PE, pendimethalin 1 kg/ha at 10 DAS as EPoE and oxyfluorfen 0.25 kg/ha as PE. The dominated weed species observed in the experimental field were *Medicago denticulata, Chenopodium album* and *Cichorium intybus*. Other broad leaf weeds were *Rumax dentatus*, *Alternanthera triandra*, *Melilotus alba* & *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 very effectively 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 kg/ha as PE or at 10 DAS as EPoE have performed better to that of 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 kg/ha as PE or at 10 DAS as EPoE (**Table 1.5.6.5 and 1.5.6.6**). Treatment of oxyfluorfen 0.25 kg/ha (PE) registered lowest total weed dry weight at 30, 60 DAS and at harvest (102.67 g/m^2). Pendimethalin 1 kg/ha at 10 DAS as EPoE did also well and reduced the weed dry weight as compared to imazethapyr at 0.04 kg/ha after last cutat all the stages .

The treatment of oxyfluorfen 0.25kg/ha (PE) recorded the significantly highest green fodder than rest of the treatments at 1st, 2nd and 3rd cut. Imazethapyr at 0.04 kg/ha after last cut produced least fodder after 2nd (11.16 t/ha) and 3rd cut (16.00 t/ha) whereas, imazethapyr at 0.04 kg/ha after 1st cutting *fb* imazethapyr at 0.04 kg/ha after last cut attained the comparable fodder yield (21.59 t/ha after 3rd cut) to that of oxyfluorfen 0.25 kg/ha (PE). Significantly highest total green fodder yield (60.12 t/ha) and seed yield (0.35 t/ha) was registered with the application of oxyfluorfen 0.25 kg/ha (PE) over rest of the treatments. The selective action of oxyfluorfen and effective early post emergence control of weeds by pendimethalin 1 kg/ha at 10 DAS as EPoE might have better control of grassy as well as broadleaves weeds resulted in poor crop-weed competition during critical crop growth period for moisture, nutrients and light which cause better growth of crop.

Pre emergence application of oxyfluorfen 0.25kg/ha recorded maximum net return (₹ 92,610/ha) and B:C (3.84) as compared to rest of the treatments. It was followed by pendimethalin 1 kg/ha PE for net returns (₹ 76,085/ha) and B:C (3.38). Imazethapyr at 0.04 kg/ha after last cut generated lowest net returns of ₹ 48,105/ha with an ordinary B:C of 2.54 .

WP 1.5.6.5 Total count, no/m^2, Length and dry weight of cuscuta as influenced by weed management practices for problem weeds cuscuta in berseem during *Rabi* 2019-20

Treatment	Cuscuta			
	No./m^2	Length, (cm)	Dry weight, (g)	Observation period
Pendimethalin 1 kg/ha (PE)	--	--	--	--
Pendimethalin 1 kg/ha (EPoE) at (10 DAS)	--	--	--	--
Oxyfluorfen 0.25 kg/ha (PE)	--	--	--	--
Imazethapyr at 0.04 kg/ha after 1st cutting	2.67	40 .32	0.44	up to first cut
Imazethapyr at 0.04 kg/ha after last cut	4.00	46.32	0.74	up to last cut
Imazethapyr at 0.04 kg/ha after 1st cutting *fb* Imazethapyr at 0.04 kg/ha after last cut	2.00	9.20	0.34	up to first cut

WP 1.5.6.6 Weed dry weight at 30, 60 DAP and harvest as influenced by weed management practices for problem weeds cuscuta in berseem during *Rabi* 2019-20

Treatments	Weed dry weight (g/m^2)			Total green forage yield (t/ha)	Seed yield (t/ha)	Net income (₹/ha)	B:C
	30 DAP	60 DAP	At harvest				
Pendimethalin 1 kg/ha (PE)	2.25 (4.57)	4.63 (20.9)	10.75 (115.16)	56.73	0.23	76,085	3.38
Pendimethalin 1 kg/ha (EPoE) at (10 DAS)	2.49 (5.68)	4.92 (23.6)	11.30 (127.21)	54.41	0.25	74,605	3.33
Oxyfluorfen 0.25 kg/ha (PE)	1.89 (3.09)	4.25 (17.5)	10.16 (102.67)	60.12	0.35	92,610	3.84
Imazethapyr at 0.04 kg/ha after 1st cutting	3.21 (9.81)	6.23 (38.3)	12.51 (156.00)	44.25	0.18	54,485	2.74
Imazethapyr at 0.04 kg/ha after last cut	3.27 (10.14)	6.31 (39.3)	12.73 (161.48)	45.17	0.13	48,105	2.54
Imazethapyr at 0.04 kg/ha after 1st cutting *fb* Imazethapyr at 0.04 kg/ha after last cut	3.22 (9.86)	6.26 (38.6)	10.27 (104.89)	51.59	0.21	66,055	3.04
SEm ±	0.16	0.21	0.24	2.24	0.01	-	-
LSD (P= 0.05)	0.53	0.63	0.95	7.19	0.05	-	-

WP 2 Management of weeds in non-cropped and aquatic areas

WP 2.1 Surveillance and management of new/ invasive/ quarantine weed

Objective

- To monitor the appearance of new weed species in particular region

Coimbator: Survey was carried out in five villages the year (2020) at Coimbatore, Tirupur and Erode districts covering the potential weed threat areas. *Parthenium hysteroporus* was the predominant broad leaved weed and was followed by *Trianthema portulacastrum* and *Euphorbia geniculata*. Among the grasses, *Dactyloctenium aegyptium* and *Cynodon dactylon* showed their existence. The *Cyperus rotundus* was dominant sedge weed in the surveyed areas. There was no new weed species noticed in all the three districts of study areas.

Anand: *Rumex dentatis* a new weed in wheat crop in Tarapur village of Anand district was observed during survey work.

Gwalior: Surveillance was done to find out the appearance of any new /invasive/ quarantine weeds in nearby area of public distribution systems, procurement centres, FCI godowns, garbage areas. During the visit no new weeds were found in these areas.

Palampur: Erigeron canedensis in Batseri village of Kinnaur district is suspected to be the potential threat in the future especially in the non-cropped land first and equally under apple orchards.

Erigeron infestation at Palampur

Hisar: Weed surveillance studies conducted in *Kharif* crops revealed that new broadleaf weed *Oenothera laciniata* was found to infest few fields in sandy soils of south Haryana.

Hyderabad: Public distribution systems, procurement centers, FCI godowns, garbage area or any other hot spot. Weed survey was again conducted in the places selected during 2018 to monitor appearance of new weed species with fixed points and GPS data. No new weed species was found in any of these fixed spots. A survey was conducted in Halia, Ibrahim palle, Mukundapuram, Tummadam, Adavi Devulapalli, Kukkadam, Tripuraram, Babusai pet villages in NSP left canal command area during *Kharif* 2020. Following weed species were identified as predominant weed species in farmer's rice fields. *Leptochola chinensis* is a new emerging weed of economic importance in rice fields especially in DSR fields.

Jammu: There were no any new weed species found in *Rabi* 2019-20 at high risks places (i.e. nearby area of public distribution system, procurement centres. FCI, godowns, garbage area and other spots) as compared to bench mark survey of *Rabi* 2015-16. At farmer's field R. S. Pura block the *P. minor* was not controlled by application of sulfosulfuron and seeds of *P. minor* were collected from those field of further study.

Bhubaneswar: The weed survey has been conducted in the irrigated tracts along with the national highway no.203 from Bhubaneswar to Puri under East and South Eastern Coastal Plain agro-climatic zone of the state during *Kharif*, 2020. The covered locations were Siula of Khurda district and Kanas of Puri district.

Crop rotation for the last three years of the region

i. Rice- pulse (greengram, blackgram, horsegram) in the rainfed areas (45%)

ii. Rice- groundnut/vegetables in the irrigated area (35%)

iii. Rice – rice in of the irrigated area (20%)

Weed control methods followed in last three years: The farmers of this region are following mostly the manual methods of weed control (60%). However, the use of herbicides for weed control is gaining momentum and around 40% of the farmers are practicing chemical method of weed control (butachlor 1.0kg/ha, pretilachlor 0.5 kg/ha) in rice. Farmers using herbicides are satisfied with the technologies.

a. Location 1: Kuaput, Haldia, Banki, Cuttack

Situation: Cropped area (transplanted rice)

GPS points: $20^0$09'22.41"N to $85^0$50'32.36"E, **altitude:** 13 m from MSL

Findings: The dominant grasses in transplanted rice (Table 7) at Siula (Khurda district) were *Panicum repens* (IVI-13.8), *Echinochloa crus-galli* (11.5) and *Paspalum scorbiculatum* (10.2). *Ludwigia parviflora* (13.7), *Alternanthera sessilis* (10.6) and *Ammania bacifera* were the major BLW observed. The important sedges were *Cyperus iria* (7.7) and *Cyperus rotundus* (7.0).

Table 2.1 Weed flora in transplanted rice at Kuaput, Haldia, Banki, Cuttack during *Kharif* 2020

Weed species	RD (%)	RF (%)	Rdo (%)	IVI
Grasses				
Panicum repens	8.33	5.19	0.250	**13.7**
Echinochloa crus-galli	6.00	5.43	0.121	11.5
Paspalum scorbiculatum	5.50	4.65	0.096	10.2
Leptochloa chinensis	4.50	4.65	0.094	9.25
Echinochloa colona	3.50	3.10	0.069	6.67
BLW				
Ludwigia parviflora	6.50	6.98	0.215	**13.6**
Alternanthera sessilis	5.00	5.43	0.161	10.5
Ammania bacifera	4.50	5.43	0.025	9.95
Marselia quadrifolia	3.75	4.65	0.149	8.55
Alternanthera philexeroides	3.50	3.88	0.111	7.49
Eclipta alba	3.00	3.88	0.095	6.97
Monochoria vaginalis	2.75	3.10	0.138	5.99
Sedges				
Cyperus iria	3.00	4.65	0.079	**7.73**
Cyperus rotundus	2.25	4.65	0.057	6.96
Fimbristylis milaceae	1.75	3.10	0.044	4.89

Situation: 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 (Table 8). 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.

b. Location 2: Patanpur, sujanpur, Delanga (Puri district**),** 21 km from Bhubaneswar

Situation: Cropped area (transplanted rice)

GPS points: $20^0$07'04.18N to $85^0$50'48.48"E, **altitude:** 11 m from MSL

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 BLW observed were *Ludwigia parviflora* (14.7), *Ammania bacifera* (10.7) and *Alternanthera sessilis* (10.1), *Cyperus iria* (5.4) and *Fimbristylis miliaceae* (5.1) were the sedges observed.

Situation: Non-cropped area of Delanga, Puri

GPS points: $20^0$07'06.11"N to $85^0$50'00.55"E, **altitude:** 13 m from MSL

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), BLWs like *Ageratum conyzoides* (18.8), *Spaeranthus indicus* (14.4), *Amaranthus viridis* (13.4), *Celosia argentea* (12.4) and *Cyperus rotundus* 912.7) were the only sedges observed.

Table 2.2 Weed flora in non-cropped area at Kuaput, Haldia, Banki, Cuttack location during *Kharif* 2020)

Weed species	RD (%)	RF (%)	Rdo (%)	IVI
Grasses				
Cynodon dactylon	16.2	12.9	0.505	**29.7**
Eleusine indica	8.75	7.75	0.188	16.6
Digitaria ciliaris	8.00	7.75	0.129	15.8
Sporobolus diander	7.50	6.98	0.188	14.6
Panicum repens	4.00	5.43	0.102	9.53
Eragrostis minor	3.00	3.88	0.059	6.93
Dactyloctenium aegyptium	2.75	3.10	0.065	5.92
BLW				
Ageratum conyzoides	10.5	10.8	0.563	**21.9**
Amaranthus viridis	5.50	8.53	0.142	14.1
Spaeranthus indicus	5.25	7.75	0.130	13.1
Achyranthus aspera	5.50	8.53	0.289	14.3
Celosia argentea	5.00	6.98	0.190	12.1
Gnaphalium indicum	4.00	5.43	0.093	9.52
Euphobia hirta	3.00	4.65	0.094	7.75
Portulaca oleracea	2.50	3.88	0.067	6.44
Tephrosia purpurea	2.25	3.88	0.088	6.21
Sida acuta	2.00	3.10	0.094	5.19
Cleome viscosa	1.12	1.68	0.086	2.89
Tridax procumbens	1.24	1.01	0.094	2.34
Trianthema portulacastrum	0.90	1.01	0.150	2.06
Sedges				
Cyperus rotundus	4.72	6.71	0.340	**11.7**

Akola

During 2019-20 survey work, heavy infestation of *Hyptis suoveolens* (*Ran Tulas*) was observed along the road sides in Eastern Vidarbha. In Western and Central Vidarbha zone weed species viz; *Cassia tora, Celosia argentea* and *Alteranthera trianda* were found more prominently along road side. 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.

Common name: *Dodder , Cuscuta sp.*

Local name: *Amarvel*

Parasitic weed heavy infestation in some pocket of Western and Central Vidarbha zone (Akola, Buldana Amravati Dist, Yeotmal & Wardha Dist).

Host Preference: Pulse crop Viz: Soybean, Pigeonpea, Greengram, etc. and some weeds also.

Cause: Monocropping

Management: Crop rotation

Udaipur: Weed surveillance and monitoring of appearance of new weed species were conducted periodically during *Rabi* 2019-20 and *Kharif* 2020. During both the seasons, no new weed flora was noticed in these high-risk areas.

Banda: The survey was undertaken in the fields of farmers in Banda districts during *Rabi* 2019-20 and *Kharif* 2020. Total ten locations were surveyed. The major crops and cropping systems were rice -wheat, Fallow- wheat, Millet–chickpea, Millet–mustard, rice–chickpea, sesame-chickpea, Pigeon pea–fallow, fallow-mustard/pulses.

On the basis of IVI values and relative weed density, dominant weeds in wheat crop were *Chenopodium album, Chenopodium murale, Convolvulus arvensis, Anagallis arvensis, Sonchus oleraceus, Avena fatua, Phalaris minor* and *Cyperus rotundus*. Floristic composition of broad leaved weeds, grassy weeds and sedge weeds were 56.8, 23.4 and 18.8 %, respectively. On the basis of IVI values and relative density, dominant weeds in transplanted rice were *Echinochloa colona, Cyperus rotundus, Caesulia axillaris. Fimbristylis miliaceae, Alternanthera sessilis* and *Echinochloa crusgalli*. Floristic composition of grasses, sedges and BLW were 36.7, 41.8 and 21.5%, respectively.

In pigeon pea, among grassy weeds, *Echinochloa colona, Dactyloctenium aegtyptium, Eleusine indica* and *Panicum repens* were dominant weeds. Among broad leaved weeds, *Digera arvansis, Amaranthus viridis, Physallis minima, Trianthema portulacastrum* and *Phyllanthus niruri* were dominant weeds. *Cyperus rotandus* was dominant sedges weed in pigeonpea.

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, play ground and road side.

WP 2.1.1 Biology and management of important weeds

Palampur centre conducted biology of *Syndrella nodiflora* and *Persicaria hydropiper*. Following observations were made.

1. *Syndrilla nodiflora*

Morphological character	Growth parameters
Plant height	12cm
Number of branches	10
Number of leaves	70
Leaf length	1-2 cm
Leaf width	0.5-1.0 cm
Leaf arrangement	Opposite
Leaf shape	Ovate
Fresh plant weight	3.5 g
Dry plant weight	0.75 g
Root depth in soil	4 cm
Number of flowers	16
Family	Asteraceae (sunflower family)
Oder	Asterales
Common name	Node weed, pig grass

Inflorescence: Consist of terminal or axillary cluster of flower head with yellow floret subtended by leafy bracts (lateral or terminal inflorescence).

Flower: Axillary flower head, ray floret 3-5 yellow disc floret 8-9 corolla tubular 4 lobed yellow.

Stem: Erect and sometimes prostate woody at the base.

2. *Ranunculus acris*

Morphological character

Plant height	21cm
Number of branches/plants	5
Number of leaves/plants	7
Leaf length	3.5-4.5
Leaf width	3-3.5
Leaf arrangement	Alternate type
Leaf shape	lanceolate
Fresh plant weight	12.3g
Dry plant weight	2.5g
Root depth in soil	15cm
Flowering time	May to july
Flower shape	5 sepals,5petel
Common name	Meadow buttercup, tall buttercup, snowy buttercup
Family	Ranunculaceae
Subfamily	Ranunculoidaea

All Ranunculus (buttercup) are poisonous when eaten fresh. Symptom of poisonous includes bloody diarrhea. The species is herphordite. It can grow in semi shade or no shade. It prefers moist and wet soil. Buttercup contain poison. Stem leaves are generally smaller than the basal leaves.

Flower: Yellow shining flower, flower has regular 5 petals.

WP 2.1.1.1 Management of *Sphagneticola trilobata* in non-cropped areas

Thrissur

For conducting the experiment, farmers' field heavily infested with *Sphagneticola trilobata* was selected to develop an herbicide management strategy for the invasive weeds and divided into plots of 5mX4m size and the herbicides were sprayed. Vegetative and reproductive characteristics of *Sphagneticola trilobatais* given in **Table 2.3**. Metsulfuron-methyl, 7.5 g/ha and 10g/ha, were also included as treatments as there are reports that this herbicide is also effective against this weed (**Table 2.4**).

Table 2.3 Vegetative and reproductive characteristics of *Sphagneticola trilobata*

Plant part	Description
Plant height	*Sphagneticola trilobata* is a spreading, mat forming perennial herb, average height is 30 cm
Leaf characteristics	Leaves are fleshy 6.5 cm length and 6 cm wide, simple obovate, irregular, toothed or serrate with a pair of lateral lobes. The leaf arrangement is opposite or sub opposite
Shoot characteristics	Spreading, mat forming perennial herb. Has rounded stems of average 35 cm length, rooting at nodes, with the flowering stems ascending.
Root characteristics	Adventitious roots, originate from stem cuttings
Inflorescence	Bisexual flowers, yellow/golden coloured. Inflorescence is head/capitulum type
Flowering period	Flowering period is throughout the year
Fruit and seeds	Fruits are inconspicuous. Simple and indehiscent dry fruit seedsand seeds are non-viable
Propagation	Vegetative with stem cuttings forming new plants where they touch the ground. Stem fragments readily form roots and spread out fast
Growth pattern	Though perennial, the growth of the weed is found dependent upon the availability of water. Therefore, the growth of the weeds during the dry season is less and vigorous growth is observed during monsoon season

Table 2.4 Phytotoxicity rating after 10 days of application of herbicides

Treatment details	Phytotoxic symptom on plants after 10 days (Rating on 0 to 5 scale)	Extent of Control (%)
2,4-D, 1.25 kg/ha	2	60
Glyphosate, 2 kg/ha	4	90
Glyphosate, 2.25 kg/ha	4	90
2,4-D, 1.25 kg/ha + glyphosate 2 kg/ha	5	100
Metsulfuron-methyl+ chlorimuron-ethyl, 4 .0 g/ha	3	70
Metsulfuron-methyl+ chlorimuron-ethyl 6.0 g/ha	3	70
Metsulfuron-methyl+ chlorimuron-ethyl, 10.0 g/ha	4	90
Metsulfuron-methyl+ chlorimuron-ethyl, 12.5 g/ha	4	90
Metsulfuron-methyl, 7.5 g/ha	3	70
Metsulfuron-methyl, 10 g/ha	4	90
Control	-	-

*On scale from 0 to 5 (0-none, 1-slight, 2- moderate, 3- good control, 4- very good control, 5- complete control)

A combination spray of 2,4-D, 1.25 kg/ha + glyphosate 2 kg/ha resulted in 100% control of *Sphagneticola trilobata.* Spraying glyphosate at 2 or 2.5 kg/ha, combination product of metsulfuron-methyl and chlorimuron-ethyl at 10.0 or 12.5 g/ha and metsulfuron- methyl, 10 g/ha resulted in 90 – 95 % control of the weed. 2,4-D alone at 1.25 kg/ha was not very effective and resulted in only 60 % control. metsulfuron-methyl + chlorimuron-ethyl at 4.0 and 6.0 g/ha and metsulfuron-methyl at 7.5 g/ha resulted in only 70% control. Therefore, combination spray of 2,4-D, 1.25 kg/ha + glyphosate 2 kg/ha, glyphosate at 2 or 2.5 kg/ha, combination product of metsulfuron-methyl

and chlorimuron-ethyl at 10.0 or 12.5 g/ha and metsulfuron-methyl, 10 g/ha can be recommended for effective control of *Sphagneticola trilobata.*

WP 2.1.1.3 Biology and management of problem weeds *Alternanthera triandra* and *Leptochloa chinensis* in rice

Raipur

As the *Leptochloa chinensis* is a serious weed of rice in water logged and moist conditions, it was almost absent in the experimental field which was well drained direct seeded rice. However, *Alternanthera* spp particularly *A. triandra* made its serious presence in the field throughout the season. Weed flora of the experimental field consisted of *Echinochloa colona*, *Brachiaria ramosa* and *Sporobolus diander* among grasses, *Cyperus iria* among sedges and *Alternanthera triandra* among the broad leaf weeds. *Echinochloa colona* and *Alternanthera triandra* dominated the weed flora at early vegetative growth stage. While, *Brachiaria ramosa* and *Sporobolus diander* were present during later stage of the crop. Other weeds like *Ischeamum rugosum, Cynotis axillaris, etc.* were also found in irregular and less number.

Application of metsulfuron-methyl 0.004 kg/ha PoE and 2,4-D Ethyl Ester 0.750 kg/ha PoE reduced the density of targeted weed *Alternanthera triandra* appreciably as compared to other herbicidal treatments at 30, 60 DAS and at harvest (**Table 2.6** and **2.7**). Among the other dominant weed species, the population of *Echinochloa colona* was controlled by application of various weed management treatments at 30 and 60 DAS specially under fenoxaprop-p-ethyl 0.056 kg/ha PoE and cyhalofop butyl 0.080 kg/ha PoE. Whereas penoxsulam alone or mix with cyhalofop also reduced the *Cyperus iria* at 30 and 60 DAS. At harvest, *Brachiaria ramosa* and *Sporobolus diander* which generally emerged during late *Kharif* season. Bispyribac sodium 0.025 kg/ha PoE, fenoxaprop-p-ethyl 0.056 kg/ha PoE and cyhalofop-butyl 0.080 kg/ha applied as post emergence has found effective against *Brachiaria ramose* and *Sporobolus diander* reduced the population considerably. While, penoxsulam alone or mix with cyhalofop PoE controlled the overall weeds as compared to rest of the treatments.

All the weed management practices have significant effect on the dry weight and total weed dry weight of *Alternanthera triandra*. Penoxsulam alone or mix with cyhalofop PoE significantly reduced the weed dry weight of *Alternanthera triandra* over weedy check, cyhalofop butyl 0.080 kg/ha PoE, fenoxaprop-p-ethyl 0.056 kg/ha PoE and pretilachlor 0.750 kg/ha PoE at 30 and 60 DAS. Penoxsulam alone or mix with cyhalofop PoE maintained its effect on weed dry weight up to at harvest and registered the significantly lowest value than the rest of the treatments except weed free treatment. Lowest dry weight of *Alternanthera triandra* (6.40 g/m^2) and total weed dry weight (12.39 g/m^2) was recorded under weed free treatment (**Table 2.5**).

Table 2.5 Weed dry matter of *Alternanthera triandra* at 30, 60 DAS and at harvest as influenced by weed management practices in direct seeded rice during *Kharif* 2020

Treatments	Weed dry weight, g/m^2		
	30 DAS	60 DAS	At harvest
Pretilachlor 0.750 kg/ha PE	3.77 (13.6)	6.30 (39.2)	7.74 (59.4)
Bispyribac sodium 0.025 kg/ha PoE	4.19 (17.0)	5.17 (26.1)	7.02 (48.7)
Fenoxaprop-p-ethyl 0.056 kg/ha PoE	4.97 (24.2)	7.00 (48.5)	9.36 (87.0)
Cyhalofop butyl 0.080 kg/ha PoE	4.31 (18.0)	7.04 (49.01)	8.97 (80.0)
Penoxsulam + cyhalofop 0.135 kg/ha PoE	1.84 (2.88)	3.80 (13.9)	5.46 (29.3)
Penoxsulam 0.022 kg/ha PoE	1.80 (2.75)	3.92 (14.8)	5.54 (30.1)
Metsulfuron methyl 0.004 kg/ha PoE	2.02 (3.60)	2.26 (4.60)	5.07 (25.2)
2,4-D ethyl ester 0.750 kg/ha PoE	1.79 (2.72)	2.47 (5.58)	4.69 (21.4)
Weed free	1.44 (1.56)	1.60 (2.05)	2.56 (6.07)
Weedy check	5.12 (25.7)	7.13 (50.3)	9.96 (98.6)
SEm±	0.17	0.21	0.26
LSD (P= 0.05)	0.50	0.62	0.79

Although, weed free treatment produced the highest grain yield (4.98 t/ha) and highest weed control efficiency penoxsulam + cyhalofop 0.135 kg/ha PoE (4.63 t/ha) produced significantly higher grain yield over rest of the weed management practices. Similarly, highest net return (₹ 65,563/ha) accompanied by maximum B:C (4.15) generated under the penoxsulam + cyhalofop 0.135 kg/ha PoE followed by bispyribac- sodium 0.025 kg/ha PoE (4.01) **(Table 2.6**).

Table 2.6 Test weight, seed yield and economics of rice as influenced by weed management practices in direct seeded rice during *Kharif* 2020

Treatments	Test weight (g)	Tillers/ m row length		Grain yield (t/ha)	Net income ₹/ha	B:C	WCE (%)
		30 DAS	60 DAS				
Pretilachlor 0.750 kg/ha PE	26.3	46.3	57.7	2.94	35,219	2.79	49.4
Bispyribac sodium 0.025 kg/ha PoE	26.7	49.8	60.6	4.25	59,527	4.01	62.9
Fenoxaprop-p-ethyl 0.056 kg/ha PoE	26.0	45.3	55.4	2.29	23,014	2.17	46.6
Cyhalofop butyl 0.080 kg/ha PoE	25.7	45.3	53.7	2.04	18,344	1.93	36.5
Penoxsulam + cyhalofop 0.135 kg/ha PoE	27.3	55.3	64.2	4.63	65,563	4.15	71.8
Penoxsulam 0.022 kg/ha PoE	27.0	53.5	61.0	4.14	56,972	3.81	66.9
Metsulfuron methyl 0.004 kg/ha PoE	26.3	46.6	58.5	3.56	47,500	3.50	52.9
2,4-D ethyl ester 0.750 kg/ha PoE	26.6	49.0	59.3	4.00	55,470	3.88	59.5
Weed free	27.0	56.1	65.0	4.98	64,764	3.62	97.4
Weed check	25.3	36.5	45.7	0.94	-703	-0.96	-
SEm±	0.80	1.08	1.38	0.10	-	-	-
LSD (P= 0.05)	NS	3.22	4.11	0.31	-	-	-

Price of rice in Chhattisgarh: ₹ 18,680/ per ton

WP 2.1.2 Integrated management of problematic weed *Parthenium hysterophorus* in University campus to achieve status of *Parthenium* free campus

In view of the seriousness and magnitude of the threat posed by Parthenium weed, all the 17 AICRP-Weed Management centers organized different activities during 15th *Parthenium* Awareness Week (PAW)" from 16-22 August, 20120 on appeal of ICAR-Directorate of Weed Research, Jabalpur**.** All the scientists of AICRP-WM centers also attended training programme 'On mass multiplication of bioagent *Zygogramma bicolorata* for biological control of Parthenium' organized ICAR-DWR, Jabalpur

In North-Eastern region of the country, programmes were organized by Assam Agricultural University, Jorhat; Bidhan Chandra Krishi Vishwavidhyalya, Mohanpur; Orissa University of Agricultural and Technology, Bhubaneswar in collaboration with KVKs, schools and colleges in the respective region. In Northern region of the country, universities like SKUAST, Jammu; GBPUAT, Pantnagar; CSKHPKV, Palampur; CCSHAU, Haryana; and PAU, Ludhiana organized various awareness programmes in collaboration with Krishi Vigyan Kendras, colleges and schools**.** In central India, IGKVV, Raipur and RVSKVV, Gwalior observed the Parthenium awareness week in collaboration with schools and colleges and KVks. In Southern India, also participated and organized various programs on parthenium management all the AICRP-WM centers like PJTSAU, Hyderabad, Telangana,; TNAU, Coimbatore; KAU, Kerala; and UAS, Bengaluru. From the western part of India, awareness programmes were organized by AICRP-WM centres located at AAU, Anand; MPUAT, Udaipur and Dr.PDKV, Akola.

All the AICRP-WM centers organized activities like online lectures, webinars, photo exhibitions, farmers' meetings, students' rallies, uprooting of Parthenium, releasing and distribution of Parthenium eating beetle, demonstrations on management, *etc.* Such awareness activities attracted print and electronic media and news were published and telecasted on different news channels. Awareness was also made using social media platforms like Youtube, facebook, WhatsApp, etc.

WP2.1.3 Mass rearing and distribution of *Zygogramma bicolorata* at selected AICRP-WM centres for distribution to stakeholders.

Only AICRP-WM of Bhubaneswar and Raipur centers started the mass rearing of Mexican beetle *Zygogramma bicolorata***.**

Note: Other centers, like Gwalior, Hyderabad, Akola, Udaipur were allotted the work but not done this work.

WP 2.2 Weed flora shift under changing climatic scenario

Coimbatore

Monitoring the weed flora was done in the ongoing permanent herbicide trial with rice- rice cropping system. *Echinocloa crusgalli* and *Leptochloa chinensis* were the dominant species in grasses, *Ludwigia parviflora* was the dominant in broad leaved weeds, where as *Cyperus iria* and *Cyperus nudans* under sedges present in the field in both *Rabi* and *Kharif* 2019 of 9th crop in the long term herbicidal trial rice - rice system. Hence, it is concluded that after 9th rice in the rice – rice cropping system, there was a shift in grassy weed from dominant *Echinocloa crusgalli* to *Leptochloa chinensis.*

AAU, Anand

During survey work and farmers field visit, high weed intensity of *Argemone mexicana* infestation was observed in different parts of Gujarat. Due to thorny nature and high seed production potentiality, spreading very fast in cultivated fields. *Argemone mexicana* flourished after harvesting of *Rabi* crops and entering in new cultivated field as new emerging weed in Gujarat. In many areas of different districts of Gujarat weed flora shifted towards monocot weeds in wheat fields due to continuous use of 2, 4-D or metsulfuron-methyl to manage dicot weeds, which provide opportunities to flourish monocot weeds and that did not control by the recommended herbicides. Awareness campaign/training programme/ OFT/FLDs conducted to manage complex weed flora in wheat by using premixed herbicide.

Escape incidence of monocot weed *Commelina benghalensis* after application of pendimethalin 750-1000 g/ha in cotton, greengram, soybean 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 750-1000 g/ha in cotton, greengram and soybean crops.

Gwalior

In the long term field experiment on "Weed management in pearl millet-mustard-cowpea cropping system under conservation agriculture" which was started during *Kharif* 2018 with 5 different tillage practices and 3 weed management practices. In Pearl millet the *Cynodon dactylon* was not seen in 2019 in the experimental trial up to 30 DAS but in 2020 it was observed from the initiation of the crop. Similarly the *Brachiaria reptance* was not germinated up to 30 DAS in the experimental trial executed in 2020 but after 30 DAS it was emerged in different treatments. Whereas, the *Acrachne racemosa* was not seen at 60 DAS during both the years, in the experimental trial. In Mustard *Cyperus rotundus* was most dominating sedges among all weeds.

Palampur

Weed shift study undertaken in district Kinnaur of Himachal Pradesh is based on the earlier survey undertaken in 2008 and the current survey of 2020. The detailed description will be reported later on. The brief summary is given in **Table 2.7.**

Table 2.7 Weed shift in Kinnaur district

Weed species	2020			2008
	Sangla valley	**Leo Farm**	**Lari**	**Kinnaur**
Achyranthus aspera	-	-	-	Yes
Alternenthera sp	-	-	-	Yes
Amaranthus deflexus	Yes	Yes	-	-
Amaranthus viridis	Yes	Yes	-	Yes
Artemisia compestris	-	Yes	Yes	Yes
Bidens Pilosa	-	-	-	Yes
Bromus sp	Yes	-	-	-
Canabis sativa	Yes	-	-	-
Capsella bursa-pastoris	Yes	-	-	Yes
Cenchrus setacus	-	Yes	Yes	-
Chenopodium album	Yes	Yes	Yes	Yes
Commelina benghalensis				Yes
Convolvulus arvensis	-	Yes	Yes	Yes
Conyza denticulata				Yes
Conyza stricta/Erigeron bonarensis	Yes		-	-
Croton californicus	-	Yes	-	-
Cyperus sp (C. iria)				Yes
Dactylis glomerata	-	Yes	-	-
Darlingtonia californica (Cobra lily)	Yes	-	-	-
Daucus carota				Yes
Digitaria sanguinalis	Yes	Yes	-	Yes
Echinochloa colona	-	Yes	-	Yes
Ephedera distichum	-	Yes	Yes	-
Equisetum arvense	Yes	-	-	Yes
Eragrostis pectinacea	-	Yes	-	-
Erigeron canedensis	Yes	-	-	-
Fagopyram sp.				Yes
Fragaria virginiana				Yes
Gallinsoga parviflora	Yes	Yes	-	Yes
Geranium carolianum	Yes	-	-	-
Lepidium bonarensis	Yes	-	-	-
Malva neglecta				Yes
Malva rotundifolia	Yes	Yes	Yes	-
Malva verticillata	Yes	Yes	Yes	-
Medicaga denticulate				Yes
Medicago minima	Yes	-	-	-
Medicago sativa (Yellow and purple flowers)	-	Yes	Yes	-
Oxalis corniculata	-	Yes	-	Yes
Panicum dichotomiflorum				Yes
Penesetum typhoides	-	-	Yes	-
Poa annua	Yes	-	-	Yes
Polygonum alatum	Yes	-	-	Yes
Polygonum arenastrum	Yes	-	-	-
Polygonum plebizium				Yes
Polygonum polystachium	Yes	-	-	-
Rumex obtusifolius	Yes	-	Yes	Yes
Rumex sp.				Yes
Setaria glauca				Yes
Setaria viridis	-	Yes	Yes	-
Sonchus asper	-	Yes	-	-
Stellaria media				Yes
Tagetus minuta	-	Yes	-	-
Trifolium sp.	Yes			Yes
Tulipa	-	-	Yes	-
Vicia sativa				Yes
White clover	Yes	-	-	-
Wild onion	Yes	-	-	-

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 2020, shift in weed flora was recorded in ZT-ZT (HS) treatment in wheat in which *Avena fatua* population was recorded which was significantly higher than all other tillage and residue management treatments; *A. fatua* was also recorded in PTR-CT (MB plough). In case of rice, no weed flora shift was recorded in 2020 (**Table 2.8**).

Table 2.8 Weed flora shift in wheat under different tillage and residue management practices

Weed species	
2018-19	**2019-20**
Phalaris minor	*Phalaris minor*
Rumex dentatus	*Rumex dentatus*
Anagallis arvensis	*Anagallis arvensis*
Coronopus didymus	*Coronopus didymus*
Medicago denticulate	*Medicago denticulata*
-	*Avena fatua*

Hisar

Broadleaf weed *Mazus pusilus* infestation is increasing under heavy residue load in zero till rice residue scenario under conservation agriculture in rice-wheat cropping system. *Coronopus didymus* (Pithpapra), *Anagallis arvensis* (Krishanneel) and *Polypogon monspeliensis* (Loomarghas) and *Lophochloa phleoides* (Lallughas) were found to be on the rise in wheat. Direct seeded rice was heavily infested with grassy weeds like *Dactyloctenium aegyptium, Elusine indica, Panicum* spp., *Eragrostis tenella* and *Leptochloa chinensis* responsible for heavy yield reductions at farmers' fields. Infestation of *Cannabis sativa* was increasing in wheat and sugarcane fields near village Phirni.

P. minor has developed cross-resistance against clodinafop-propargyl, sulfosulfuron and pinoxaden not only in north-eastern but also south-western and central districts of state. To control resistance problem against these herbicides at farmers fields, use of tank mixtures of pendimethalin + metribuzin (2000+120 g/ha) *fb* sequential use of mesosulfuron + iodosulfuron (RM) 14.4 g/ha, sulfosulfuron + metsulfuron (RM) at 40 g/ha and pinoxaden at 70 g/ha did not provide satisfactory control (less than 50%) of *P. minor*.

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

Wild rice (*Oryza rufipogon*) was not observed in any of the rice growing districts. In Sirsa, Fatehabad and Hisar areas of Haryana. *Ipomoea* spp. (Bael) was infesting cotton, groundnut and cluster bean crops and the infestation is increasing every year causing economic losses to the growers. None of recommended herbicide was effective against this weed. Brinjal crop was severely infested with parasitic weed *Orobanche ramose* in Nuh, Punahana, Meoli areas of Mewat. Mustard crop was severely infested with parasitic weed *Orobanche* in Bhiwani, Jhjjjar, Hisar, Fatehabad, Sirsa areas.

New broad leaf weed *Carthamus pusilus* in sand dunal areas of Bhiwani

SKUAST, Jammu: The density of *Medicago spp.* was increased in *ZTDSR/ZTDSR+residue*-ZT wheat+ residue as compared to CT transplanted rice-CT wheat.

Bhubaneswar

The weed surveillance exercise was carried out in two major agro-climatic zones viz - East and South Eastern Coastal Plain and Mid-Central Table Land during 2019. Some of the significant observations are as follows.

A) East and South Eastern Coastal Plain Zone

1. ***Mikania micrantha*:** The weed is spreading alarmingly in the interior areas of Puri, Jagatsinghpur, Kendrapara and Khurda districts. The infested areas are orchards of mango, banana, coconut and papaya, fences, road side plantations. The emergence of the weed was reported after the devastation of Super Cyclone in 28th October, 1999.
2. ***Parthenium hysterophorus*:** This dreaded weed 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.
3. ***Eichhornia crassipes*:** This exotic weed is a menace in almost all low lying waterlogged areas, ponds, canals and their sub-distributaries under coastal command area.
4. ***Alternanthera philoxerroides*:** Commonly known as alligator weed, it 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 recorded in several low-lying rice areas in these regions.
5. ***Orobanche aegyptica*:** Sporadic incidence of *Orobanche* was observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda district along river Mahanadi

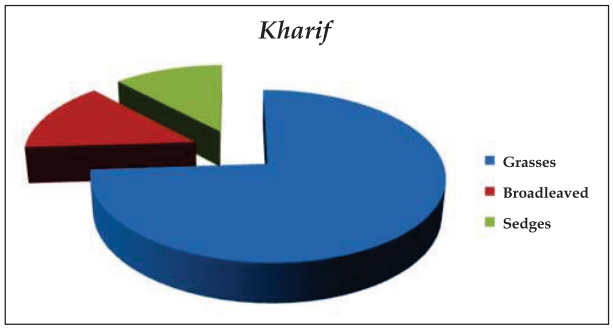
B) Mid- Central Table Land Zone

1. ***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 pluses due to *Celosia* was observed to be in the tune of 35% and 40%, respectively
2. ***Echinochloa colona* and *Digitaria sanguinals*** are the major grassy weeds found in *Kharif* ground nut in this zone.

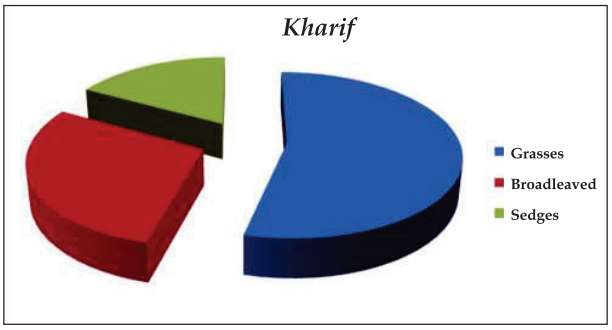
Weed shift and appearance of new weeds are being occurred in the long term experiments conducted in the farm in rice-groundnut cropping system. These shifts and appearance of new weeds are due to the management practices and climatic parameters prevailing in these areas.

Weed shifts occur when weed management practices do not control an entire weed community or population. The management practice could be herbicide use or any other practice such as tillage, manure application, or harvest schedule that brings about a change in weed species composition.

- Direct seeded rice was heavily infested with grassy weeds like *Dactyloctenium aegyptium. Elusine indica, Leptochloa chinensis, Panicum spp.* in the farmers field.
- ***Celosia argentea*** is observed to be a severe problem in upland rice and *Rabi* pulses in the districts of Keonjhar. 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 rice and pulses due to *Celosia* was observed to be 40% and 35%, respectively.
- ***Eichhornia crassipes*:** Earler it 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, Balasore.
- ***Alternanthera philoxerroides*:** Commonly known as alligator weed, it is observed in low land paddy areas and low lying swampy areas along the road sides of coastal districts (Jagatsinghpur, Kendrapara, Puri, Khurda and Jaipur). A shift from *Alternanthera sessilis* to *Alternanthera philoxerroides* was recorded in several low-lying rice areas in these regions.
- ***Orobanche aegyptica*:** Sporadic incidence of *Orobanche* was observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda district along river Mahanadi.
- Infestation of C*uscuta* chinenesis a parasitic weed was observed in niger crop of Semiliguda district.
- Heavy infestation of *Heliotropium* spp. was observed in the green gram and black gram field of coastal districts of Cuttack, Puri, Jagatsingpur.
- Heavy infestation of *Mikania* spp. in banana has been observed in all the coastal districts.



Initial status 2013



CT-ZT –ZT System at 2019

Akola

During the year 2019-20 along the road side *Parthenium* is replaced by *Cassia tora* and *Hyptis suoveolens* in Eastern Vidarbha region. The wide spread appearance of *Alteranthera trianda* was observed on fallow lands and field bunds in Eastern Vidarbha region. 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 farmers growing soybean year after year and used continuous imazethapyr to control weeds, now they are facing problem of resistance of weed viz., *Commelina benghalensis* to herbicides in their fields. AICRP-WM, Akola suggested for crop rotation.

Parthenium replaced by *Cassia tora* in Western and Central Vidarbha region

Alteranthera trianda (Reshimkata) wide spread in non-crop area and on farmer's field. After rainy season fast spread on grazing land, which create problem to grazing animals.

Parthenium and *Cassia tora* replaced *Hyptis suoveolens* (Ran Tulas) wide spread along the road side in Eastern Vidarbha

Heavy infestation of *Ipomoea sp.* in Western Vidarbha.

Udaipur

A survey and surveillance programme to study the GPS data base status of weed flora from cropped and non-cropped area of Chittorgarh district was undertaken in three tehsils i.e. Bhadesar, Gangrar and Begun tehsil of Chitorgarh district during 2020. The major crops of the surveyed tehsils are wheat, barley, chickpea, opium, mustard, ashwagandha, dil, isabgoaland fenugreek in *Rabi* and maize, soybean, groundnut, sorghum, cotton, ajwain and blackgram in *Kharif* season.

During *Rabi*, major broadleaf weeds in the field were *Chenopodium album, Chenopodium murale, Melilotus indica, Fumaria parviflora, Malva parviflora, Asphodelus tenuifolious, Convolulus arvensis, Sonchus asper* and *Spergulla arvensis* and *Phalaris minor. Malwa parviflora* was the new emerging weed that quickly spreading in *Rabi* crops particularly wheat and not being controlled by commonly used herbicides like ready mix combination of Total and Vestaor Sandesh. In berseem, *Coronopus didymus* was also found problematic and not being controlled by pendimethalin.

During *Kharif*, *Commelina diffusa, Trianthema portulacastrum, Parthenium hysterophorus, Physalis minima, Euphorbia hirta, Celosia argentia, Corchorus olitorius, Echinochloa colona, Eleusine indica, Dactyloctenium aegyptium, Chloris barbata, Rotboellia exoltata, Cynodon dactylon,* and *Cyperus rotundas* were observed in the cropped and non- cropped area. It has been observed that *Commelina diffusais* was not being controlled by imazethapyr and RM Odyssey.

Bench mark survey

Bench Mark Survey of three tehsils of Chittorgarh was conducted during *Kharif* and *Rabi* 2019-20. This survey was carried out to find out the existing weed flora of the region and weed technologies adopted by the farmers. For this survey nine villages of three tehsils Bhadesar, Gangrar and Begun of the Chittorgarh district were selected (**Table 2.9**).

WP 2.3 Management of aquatic weeds

WP 2.3.1 Biological control of water hyacinth by *Neochetina* spp.

At Coimbatore, after release of bioagent *Neochtina* spp. the weed was removed by Municipality Corporation employing JCB, but soon water hyacinth regenerated and occupied the pond in Krishnampathy tank. New feeding symptoms were observed on the weed indicating its population buildup on the weed. At AAU, Anand, bioagent were released on 05/12/2019 in one of the new ponds at village Sadanagar of Anand District. Samples taken at quarterly interval showed no feeding scars and back-die symptoms.

After successful control of water hyacinth by the bioagent *Neochetina* spp. in Pilua dam of Morena district in Madhya Pradesh by the Gwalior center, a new perennial pond infested with water hyacinth was selected in village Hanumangarh of Gwalior district. Weevils 500 in numbers were collected from the Pilua dam and released in September 2019. The average adult population and feeding scars were recorded 3.2 and 7.2 per plant, respectively. Mild die-back symptoms were also observed.

At Ludhiana, weevils were released on water hyacinth in village Boparai Kalan in district Ludhiana in 2020, but so far no population buildup has been observed. At SKUAST, Jammu, *Neochetina* beetles first time released on 07.09.2016 in perennial pond at Tanda village. Again *Neochetina* spp. weevils were released in same pond but only average 15-20 feeding scars/leaf were observed in water hyacinth. Infested pond and only few die back symptoms were observed. At Bhubaneswar, biological control attempts were made by releasing 200 weevils in one of the ponds at village Delang of Puri district in 2019. Only little defoliation of weed was observed. At Raipur, weevils were released at Kachna village. The grubs and adults were found on the weed indicating its establishment at the site.

Table 2.9 Benchmark survey of weed with GPS value

Village	Tehsil	GPS value			Major crops	Major weed flora		WM practices followed by farmers
		Latitude	Longitude	Altitude		Broad leave	Grassy	
Amarpura	Bhadesar	24°52′ 48.00′′	74°37′.48.00′′	421m	Maize, Jowar, Wheat, Oat, Ajwain, Gram and Mustard	*Commolina bengalensis, Dinebraretroflexa, Chronolena odorata, Chenopodium album, C. murale & Covolvulous arvensis *Rotboelliaexoltata* (maize & sorghum)	*Elusine indica, Dactylocteni um aegyptium & Phalaris minor*	One HW & atrazine in maize, 2, 4-D in wheat
Antri	Bhadesar	24°52′ 48.00′′	74°48′.94.00′′	418m	Maize, urd, moong, Wheat, barley & Mustard	*Digera arvensis,Commolina bengalensis, & Chinopodium Murale*	*Echinochloa colona, Setariagaluca, Dactyloctenium aegyptium & Chloris barbata, Chorchorus aestunas*	HW & earthing up in maize at 40 DAS
Tejpura	Bhadesar	24°44′ 03.9′′	74°33′.18.9′	418m	Maize, groundn ut, Wheat & gram cotton	*Commolina bengalensis &Digeraarvensi, Chemopodium album, Melilotus alba & Chorchorus tricularis*	*Echinochloa colona Dactyloctenium aegyptium & Phyllanthus niruri , Rotboellia exoltata*	HW in maize & 2, 4–D in wheat crop kulpa in maize & cotton
Bhadesar	Bhadesar	24°68′ 17′09′′	74°50′.96.28′′	430m	Maize, sorghum, urd& Wheat, gram & Ajwain	*Commolina bengalensis,Chronole na odorata Euphorbia hirta, Chenopodium mural , & Melilotus indica*	*Echinochloa colona,Cynod on dactylon & Dinebra retroflexa, Elusine indica, Phyllanthus niruri*	HW & Imazethapyr in urd, 2, 4-D in wheat
Ekling-pura	Gangrar	24°44′ 03.9′′	74°33′.18.9′	412m	Maize, Cotton & Wheat	*Euphorbia hirta, Chenopodium album, Covolvulous arvensis & Chenopodium murale*	*Dinebra retroflexa Echinochloa colona &*	HW & kulpa in maize & cotton 2, 4-D in cotton
Jaisingh-pura	Gangrar	25°06′ 17.78′′	74°62′.52.13′	416m	Maize, urd, wheat and gram	*Commolina bengalensis,Trianthe ma portulacstrum, Digera arvensis,& Chinopodium. album*	*Echinochloa colona, Dactyloctenium aegyptium& Chloris barbata, Chorchorus aestunas, Phalaris minor*	2, 4-D in wheat and HW
Mansingh ji Khera	Gangrar	25°43′ 03.09′′	74°41′.30.09′	412m	Wheat, maize, mustard, groundnut and gram	*Commolina bengalensis, Dinebraretroflexa, Chenopodium album, C. murale*	*Dactyloctenium aegyptium& Phalaris minor, Cynodon dactylon*	HW, Earthing up in maize and groundnut
Daulat-pura	Begun	29°71′ 0.85′′	73°88′.7.65′	413m	Maize, moong, soybean, wheat and gram	*Digera arvensis, Commolina bengalensis, Trianthima portulacstrum Melilotus indica*	*Cynodondact ylon, Cyperus rotundus, Fumaria parviflora*	HW and one hoeing and 2,4-D, in wheat
Fatah-pura	Begun	25°44′ 03.19′′	74°33′.18.19′	388m	Maize, sorghum, ajwain, urd, wheat and mustard	*Chenopodium album, Digera arvensis, Phalaris minor*	*Echinochloac olona, Cynodondactylon, Cyperus rotundus*	HW and 2, 4-D in wheat

WP 2.4 Utilization of weeds

WP 2.4.1 Utilization of weeds for decomposting by using microorganism

(Collaboration with Agril. Microbiology department)

AAU, Anand initiated one experiment for utilization of weeds namely *Digera arvenis, Parthenium hysteronphorus. Trianthema monogyna* and *Amaranthus sinosus* to make compost by using different microbial consortium. The weeds were put in the pit. Experiment is undergoing.

WP 3 Fate of herbicide residues in different agro-ecosystems

WP 3.1 Assessment of herbicide residues in long term experiments and farmers field

TNAU, Coimbatore

During *Rabi* 2019-20 sunflower was grown as test crop which received pendimethalin as pre emergence herbicide to control weeds. Soil and crop produce samples were collected from the herbicides applied and hand weeding plots on 0, 15, 30, 45, 60, 75 and at harvest stage to find out the persistence and residue in soil as influenced by the tillage practices. Pendimethalin residues were analyzed by HPLC. LOD and LOQ for both the molecules were found to be 0.01 and 0.05 mg/kg in all matrices. The dissipation of pendimethalin was found to follow first order reaction kinetics ($R^2 > 0.90$) irrespective of tillage practices under both the weed control methods with the half life of 12.0-16.7 days for pendimethalin. Irrespective of tillage practices and weed management methods, >80 % of both the herbicides dissipated from the soil at 60 DAHA **(Table 3.1 and 3.2).** Residues of pendimethalin in soil, maize grain and straw were found to be below 0.01 mg/kg irrespective of the tillage management practices followed for weed control.

Table 3.1 Influence of conservation tillage and weed management practices on pendimethalin residue in soil with sunflower in maize –sunflower system during *Rabi* 2019-20

Treatments	W_1 (Pendimethalin 1.0 kg/ha)						
	Residues (mg/kg)						
	0 day	15 day	30 day	45 day	60 day	75 day	90 day
(CT-CT)	0.463	0.381	0.265	0.181	0.085	0.010	BDL
(CT-ZT)	0.429	0.372	0.279	0.173	0.079	0.009	BDL
(ZT+R - ZT)	0.418	0.390	0.280	0.190	0.080	0.010	BDL
(ZT – ZT+R)	0.474	0.402	0.287	0.202	0.087	0.015	BDL
(ZT+R – ZT+R)	0.486	0.395	0.298	0.211	0.010	0.019	BDL

Table 3.2 Influence of conservation tillage and weed management practices on pendimethalin residue in soil with sunflower in maize –sunflower system in *Rabi* 2019-20

Treatments	W_2 (Pendimethalin 1.0 kg/ha) + HW on 45 DAS)						
	Residues (mg/kg)						
	0 day	15 day	30 day	45 day	60 day	75 day	90 day
(CT-CT)	0.442	0.331	0.257	0.132	0.047	0.018	BDL
(CT-ZT)	0.478	0.367	0.262	0.147	0.052	0.020	BDL
(ZT+R - ZT)	0.478	0.378	0.267	0.158	0.057	0.015	BDL
(ZT– ZT+R)	0.464	0.386	0.287	0.176	0.069	0.019	BDL
(ZT+R-ZT+R)	0.471	0.398	0.290	0.178	0.073	0.025	BDL

The post harvest soil samples were collected for the available nutrients (N, P and K), organic carbon pH and EC content. There was no significant difference in the soil pH and EC. In case of organic carbon content it was significantly influenced by the zero tillage with residue addition, however, the method of weed management did not influence the OC content. Soil available, P and K were not significantly differed due to tillage method and residue addition except available N and at the same time soil available P was higher in pendimethalin applied plots than unweeded control.

Microbial population

Soil samples were analyzed at initial stage and at 7, 15, 30 DAS and harvest from sunflower crop for enumeration of microorganisms viz., total bacteria, fungi and actinomycetes. Among the tillage method, zero tillage in ZT+R system recorded maximum number of total bacteria, fungi and actinomycetes at 30 DAS. Among the weed management practices, PE pendimethalin at 1.0 kg/ha + HW on 45 DAS recorded maximum number of microbial population. The enzymes activities such as alkaline phosphatase,

Table 3.3 Effect of tillage methods and herbicides on soil enzyme activities in maize - sunflower cropping system (*Rabi* 2019-20)

Treatments	Alkaline phosphatase µg p-nitrophenol/g soil/hr		Dehydrogenase µg TPF/ g soil /24 hr		Urease µg NH_3 released/g soil/ hr		Microbial biomass carbon (mg/kg)	Microbial biomass nitrogen (mg/kg)
	30 days	Harvest	30 days	Harvest	30 days	Harvest		
T_1 (CT-CT)	199.2	159.3	49.6	31.3	19.6	12.8	224.6	21.0
T_2 (CT-ZT)	201.6	165.8	53.2	32.8	22.6	14.3	250.4	26.7
T_3 (ZT+R - ZT)	195.4	175.2	63.7	36.4	35.7	18.6	296.2	31.5
T_4 (ZT – ZT+R)	204.3	186.3	59.3	40.3	35.0	19.2	301.4	30.2
T_5 (ZT+R – ZT+R)	225.1	196.5	68.1	43.1	39.2	16.8	324.6	36.4
SEd	9.8	8.1	2.3	1.6	2.1	0.8	12.9	1.5
LSD (P=0.05)	21.4	17.8	4.9	3.5	4.6	1.8	28.4	3.2
W_1 (PE Pendimethalin 1.0 kg /ha)	208.9	180.6	60.5	38.2	32.6	15.6	312.5	32.4
W_2 (PE Pendimethalin 1.0 kg /ha + HW on 45 DAS)	210.5	175.3	56.8	37.2	30.6	12.3	307.2	30.2
W_3 (UWC)	195.3	163.5	43.5	30.2	20.8	11.0	230.4	22.5
SEd	9.0	7.2	1.7	1.4	1.8	0.7	11.8	1.3
LSD (P=0.05)	19.6	15.8	3.7	3.1	3.8	1.6	25.7	2.9

dehydrogenase and urease were assessed at 30 DAS and at harvest. Among the tillage methods soil enzymes viz., alkaline phosphatase, dehydrogenase and urease were significantly higher in zero tillage in ZT+R system and in PE pendimethalin at 1.0 kg/ha + HW on 45 DAS. The activity was maximum at 30 DAS and got reduced at the time of harvest. Higher microbial biomass carbon and microbial biomass nitrogen were recorded with zero tillage in ZT+R system.

At Coimbatore, in *Kharif* 2020, soil enzyme activities were evaluated after application of herbicide in cotton under WP 1.2.1.5.1. weed management in cotton – baby corn based cropping system under conservation agriculture.

At Palampur, a long term field experiment is being conducted since 2013 in maize and wheat crops during *Rabi* and *Kharif,* respectively under 'Weed management in conservation agriculture system in maize–wheat is cropping system'. From this experiment soil and grain samples were collected immediately after herbicide application and at harvest during *Rabi* (2019-20) to study the buildup of isoproturon and 2,4-D residues in the soil and in wheat grain under different tillage and residue management techniques. Initial residues (immediately after spray) of isoproturon (35 DAS) applied at 1.25 kg/ha in W_1 and 1.0 kg/ha in W_2 treatments CT-CT, CT-ZT, ZT-ZT, ZT-ZT + R and ZT+ R -ZT+ R were found to be in range of 0.524 to 0.578 µg/g and 0.494 to 0.484 µg/g, respectively. However, initial residues (immediately after spray) of 2,4-D applied at 0.75 kg/ha in W_1 treatments (CT-CT, CT-ZT, ZT-ZT, ZT- ZT + R and ZT+ R-ZT+R) were in the range of 0.20 to 0.29 µg/g, respectively. The residues of 2,4-D in soil and grain samples collected at harvest were below detectable level. In the soil and wheat grain under different tillage and residue management techniques, isoproturon and 2,4-D residues were found to be below the detectable limits at the time of harvest (**Table 3.4**).

Table 3.4 Residues of isoproturon in the soil under different planting pattern

Treatment	Residues(µg/g) in soil					
	W_1 (Isoproturon 1.25 kg/ha)		**W_2 (Isoproturon 1.0 kg/ha)**		**W1(2,4-D 0.75 Kg/ha)**	
Wheat	Immediately after spray	Harvest soil	Immediately after spray	Harvest soil	Immediately after Spray	Harvest soil
CT	0. 560	<0.05	0. 494	<0.05	0.26	<0.01
ZT	0.543	<0.05	0.486	<0.05	0.29	<0.01
ZT	0.578	<0.05	0.486	<0.05	0.26	<0.01
ZT+R	0.524	<0.05	0.474	<0.05	0.24	<0.01
ZT+R	0.536	<0.05	0.484	<0.05	0.20	<0.01

The residues of butachlor and bispyribac-sodium under different tillage and residue management techniques in rice crop was studied in the soil (0-15 cm) at 2hr after spray and at harvest and rice grain samples at harvest in a field experiment entitled, **WP 1.2.1.1** Aerobic rice-based cropping systems which was initiated in *Kharif* 2020 at Palampur.

Residues of butachlor in soil samples collected at 2.0 hours after application of the herbicide was in range of 0.490 - 0.528 µg/g. The quantity of residue present in the soil and rice grain under different tillage and residue management techniques were below detectable limits at the time of harvest**.** The deposits of butachlor in soil after application of butachlor was 0.490 to 0.628 µg/g and in case of bispyribac-sodium applied plots residues were found to be 0.340, 0.329, 0.324, 0.310 and 0.320 µg/g under conventional tillage practice and zero tillage practice**.** Bispyribac-sodium residues in both soil and rice grain under different tillage and residue management techniques were below detectable limits (0.001 ppm) at the time of harvest (**Table 3.5**)**.**

Table 3.5 Residues of butachlor in the soil of rice crop under different planting pattern

Treatment	Residues (µg/g)			
	W_1 Bispyribac-sodium (25 g/ha)		W_1 (Butachlor 1.00 kg/ha)	
	Immediately after spray	Harvest soil	Immediately after spray	Harvest soil
CT	0.310	<0.05	0.490	<0.05
CT	0.369	<0.05	0.496	<0.05
ZT	0.364	<0.05	0.528	<0.05
ZT	0.270	<0.05	0.507	<0.05
ZT+R	0.282	<0.05	0.520	<0.05

At Ludhiana, metribuzin and clodinafop-propargyl from soil/wheat grain samples were extracted by MSPD and quantified using HPLC. Initial residues of metribuzin in soil ranged from 0.022 to 0.133 µg/g in different treatments and the residues were below the detectable limit (<0.02 µg/g) in the soil and rice grains at the harvest of crop. The residues of clodinafop-propargyl in soil and wheat grain at harvest under recommended herbicide and IWM treatments were below detectable limit (<0.05 µg/g) **(Table 3.6)**.

Table 3.6 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
PTR-CT	0.133	<0.01	<0.01	0.129	<0.01	<0.01
PTR-CT (MB)	0.110	<0.01	<0.01	0.108	<0.01	<0.01
PTR-ZT (HS)	0.092	<0.01	<0.01	0.048	<0.01	<0.01
ZT-ZT (HS)	0.075	<0.01	<0.01	0.022	<0.01	<0.01
PTR-CT (Rotavator)	0.109	<0.01	<0.01	0.102	<0.01	<0.01

In the rice crop, initial residues of pendimethalin and bisparybac-sodium in soil ranged from 0.025 to 0.078 µg/g and 0.032 to 0.086 µg/g in CT-DSR-HS treatment, respectively and the residues were below the detectable limit (<0.01 µg/g) in the soil and rice grain at the harvest of crop. Initial residues of penoxsulam and cyhalofop-butyl in the soil ranged from 0.050 to 0.161 µg/g in different treatments (**Table 3.7**) and the residues were below the detectable limit (<0.01 µg/g) in the soil and rice grain at the harvest of crop.

Table 3.7 Residues of penoxsulam in different treatments

Treatments	Residues (µg/g)					
	Recommended herbicide treatment (W2)			Integrated weed management treatment (W3)		
	0 DAT	Soil harvest	Rice harvest	0 DAT	Soil harvest	Rice harvest
PTR-CT	0.161	<0.01	<0.01	0.141	<0.01	<0.01
PTR-CT(MB)	0.130	<0.01	<0.01	0.115	<0.01	<0.01
PTR-ZT(HS)	0.105	<0.01	<0.01	0.094	<0.01	<0.01
PTR-CT(Rotavator)	0.120	<0.01	<0.01	0.109	<0.01	<0.01

At Hyderabad, field experiment and lab studies were conducted to assess pretilachlor, pendimethalin and bispyribac-sodium residues in the post-harvest soil, rice grain/ straw during *Kharif* and atrazine in maize grain and soils in *Rabi* and to study the influence of tillage and weed management options on different soil properties under conservation agriculture in rice (*Kharif* 2019)-maize (*Rabi* 2019-20) – green manure (Summer) cropping system under WP 1.1.1. After harvest of rice crop, soil samples were collected from different treatments for analysis of soil physico-chemical properties and nutrient status analysis. For residue analysis from maize crop, soil samples were collected from each plot at 4 hours after herbicide application and harvest. The experimental soil was very dark greyish brown. Bulk density and particle density of the soil were 1.38 and 2.59 Mg/m^3 respectively. Soils were moderately alkaline in reaction, non-saline with a CEC of 23.12 c.mol (p^+)/ kg. The organic carbon content of the soil was medium. Soil of the experiment site was low in available nitrogen, high in available phosphorus and medium in available potassium.

The initial concentration of atrazine in the soil applied to maize as preemergence herbicide varied from 0.372 to 0.482 mg/kg. A higher concentration of atrazine was recorded in CT-CT and CT(DSR)-CT and lowest concentration was recorded in ZT+R-ZT+R. 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

The LOD and LOQ reported for diuron was found to be 0.0163 µg/g and 0.05 µg/g, respectively. Initial residues of diuron at 4 hours after herbicide application varied from 0.306 to 0.312 µg/g in the soil samples. At the time of harvest, the diuron residues were below the detection limit of 0.05 µg/g in all the soil samples. No significant changes in soil physico-chemical properties were recorded as impacted by different tillage and weed management options after harvest of the cotton crop. The interaction was also non-significant.

Influence of CA treatments on soil properties after harvest of *Rabi* maize 2019-20

Tillage and weed management practices did not significantly influence soil pH and EC. The pH of soil was slightly alkaline and higher under CT-ZT. IWM showed higher pH under weed management practices. EC was higher under CT-CT and ZT-ZT recorded the lowest EC. Chemical weed management treatments showed higher EC and lower soil conductivity under unweeded control. Tillage significantly influenced organic carbon however, it was non-significant under weed management practices. ZT+R-ZT+R recorded higher organic carbon and lowest under CT(DSR)-CT and on par with CT-CT. Unweeded control recorded higher soil organic carbon and IWM recorded the lowest organic carbon. Tillage practices did not significantly influenced the available P and K status of the soil. However available N was significantly influenced by tillage. Weed management practices did not significantly influence available soil N, P, K. Soil NPK were higher under ZT with or without residues and among weed management practices, unweeded control recorded higher available soil N-P-K and lowest nutrient status was observed under IWM **(Table 3.8).**

Soil enzyme activity

Soil enzymatic activities (soil dehydrogenase, soil acid and alkaline phosphatase, soil urease and soil catalase activitites) increased up to the flowering stage and significant reduction in activity was found at harvest stage of the crop. Tillage showed a significant effect on DHA at all the crop stages, whereas effect of weed management practices was non-significant at flowering and harvest stage. Dehydrogenase activity was higher under CT treatments (transplanted rice) and lowest DHA under CT (DSR)-CT. Tillage practices significantly affected urease activitity (UA) at all sampling stages of crop and weed management practices. Urease activitity was significantly higher under ZT treatments with or without residues and the lowest was recorded under CT (DSR)-CT. Among weed management practices, unweeded control recorded

Table 3.8 Soil properties after the harvest of maize crop (*Rabi* 2019-20)

Treatments		pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Main plots							
T_1	CT (Transplanted)	8.11	0.60	0.54	198.5	35.4	224.1
T_2	CT (Transplanted)	8.21	0.58	0.57	202.1	36.5	220.1
T_3	CT (Direct seeded)	8.14	0.59	0.61	200.5	37.2	226.5
T_4	ZT (Direct seeded) + R	8.07	0.58	0.63	214.4	35.2	218.6
T_5	ZT(Direct seeded) + R	8.18	0.56	0.64	218.5	38.1	216.4
LSD (P=0.05)		NS	NS	0.07	15.6	NS	NS
Sub Plots							
W_1	Chemical	8.12	0.62	0.60	210.5	37.4	225.1
W_2	IWM	8.21	0.58	0.56	201.2	35.4	218.5
W_3	Unweeded	8.09	0.56	0.64	208.6	36.7	219.9
LSD (P=0.05)		NS	NS	NS	NS	NS	NS

higher urease, phosphatase activity and soil catalase activitites followed by IWM and lowest under chemical weed management practices. Soil alkaline phosphatase was higher compared to soil acid phosphatase because of the alkaline pH of soil. Phosphatase activity was higher under ZT with or without residues and lowest phosphatase activity was observed under CT (DSR)-CT. ZT with or without residues showed higher CA at all sampling stages and among CT treatments, CT-ZT recorded the highest CA and lowest under CT(DSR)-CT.

Soil microbial population

Soil microbes (bacteria, fungi, actinomycetes, PSB and free-living nitrogen-fixing organisms (*Azospirillum* and *Azotobacter*)) increased up to the flowering stage and decreased at harvest stage of the crop. The bacterial and fungal population was significantly higher under ZT treatments compared to CT treatments. ZT+R-ZT+R recorded higher bacterial population followed by ZT-ZT. Among CT treatments, CT(DSR)-CT recorded higher bacterial and fungal population followed by CT-ZT and CT-CT. IWM on par with unweeded control recorded higher bacterial population among weed management practices followed by IWM and chemical weed management practices. CT-CT recorded higher actinomycetes population followed by CT-ZT, ZT+R-ZT+R and ZT-ZT. Lowest actinomycetes population was observed under CT (DSR)-CT. Among weed management practices, unweeded control recorded higher actinomycetes population followed by IWM and chemical weed management. PSB population was significantly higher under CT treatments compared to ZT treatments. CT- CT and CT-ZT reported higher PSB population followed by ZT with or without residues and lowest PSB population was observed CT (DSR)-CT.

Azospirillum growth was higher under CT-ZT and was on par with CT-CT followed by ZT with or without residues. In CT(DSR)-CT microbial population was significantly lower among all the treatments. Among the weed management practices, unweeded control recorded higher *Azospirillum* population followed by IWM and lowest under chemical weed management practices. ZT+R-ZT+R recorded higher *Azotobacter* population followed by ZT-ZT. Among CT treatments, CT(DSR)-CT recorded higher *Azotobacter* population followed by CT-ZT and least under CT-CT. Unweeded control reported higher fungal and *Azotobiacter* population followed by IWM and chemical weed management practice.

Soil Quality Index (SQI)

The input data required for the SQI analysis was arranged in CSV format and principal component analysis was done for the input data. Eigen value, Eigen vector, PCA cord and PCA contribution were generated from the data. Eigen values greater than one were

selected and arranged in a new table. Weight score was calculated from the eigen values and variable selection from PCA coordinated table were performed. Scoring was performed from the initial input based on 3 properties:

1. Less is better
2. More is better
3. Optimum is better

Finally, soil quality was calculated using the updated weight and scoring output as below:

S.No.	Indicators	Scoring curve	S.No.	Indicators	Scoring curve
1.	BD	Less is better	16	Available Zn	Optimumis better
2.	MWD	More is better	17	TOC	More is better
3.	K_{Sat}	optimum is better	18	Total N	More is better
4.	SPR	Less is better	19	DHA	More is better
5.	pH	Optimum is better	20	UA	More is better
6.	EC	Optimum is better	21	AlPA	More is better
7.	CEC	More is better	22	AcPA	More is better
8.	Org. C	More is better	23	CA	More is better
9.	Available N	More is better	24	Bacteria	More is better
10.	Available P	More is better	25	Fungi	More is better
11.	Available K	More is better	26	Actinomycetes	More is better
12.	Available Fe	Optimum is better	27	PSB	More is better
13.	Available Cu	Optimum is better	28	*Azospirillum*	More is better
14.	Available Mn	Optimum is better	29	*Azotobacter*	More is better

Table 3.9 Effect of tillage on soil organic carbon fractions in conservation agriculture

Treatments	Soil organic carbon fractions management practices on soil organic carbon									
	C_{VL}		C_{L}		C_{LL}		C_{NL}		TOC	
Tillage practices										
T_1 (CT-CT)	1.91		1.21		1.61		3.37		8.10	
T_2 (CT-ZT)	2.42		1.28		1.87		3.49		9.06	
T_3 (CT(DSR)-CT)	1.58		1.11		1.82		3.20		7.71	
T_4 (ZT-ZT)	2.65		1.42		1.81		3.83		9.71	
T_5 (ZT+R-ZT+R)	2.81		1.59		1.87		3.92		10.1	
LSD (P =0.05)	0.150		0.093		0.011		0.092		0.48	
SE(m)±	0.023		0.028		0.003		0.028		0.14	
Weed management practices										
W_1	2.05		1.32		1.85		3.80		9.02	
W_2	2.40		1.24		1.53		3.27		8.44	
W_3	2.36		1.36		2.01		3.85		9.58	
CD(P=0.05)	0.023		0.012		NS		NS		0.020	
SE(m)±	0.008		0.004		0.003		0.291		0.007	
Interaction	W	T	W	T	W	T	W	T	W	T
LSD (P=0.05)	0.057	0.155	0.029	0.096	NS	NS	NS	NS	NS	NS
SE(m)±	0.078	0.047	0.049	0.029	0.031	0.052	0.048	0.532	0.253	0.159

Tillage practices significantly influenced soil organic carbon fractions (C_{VL}, C_L, C_{LL} and C_{NL}) and TOC. C_{VL}, C_L and TOC showed significant influence by weed management practices and C_{LL} and C_{NL} were non significant. Soil organic carbon fractions and TOC were significantly higher under ZT+R-ZT+R followed by ZT-ZT. Among CT treatments, CT-ZT reported higher soil organic carbon fractions(C_{VL}, C_L, C_{LL} and C_{NL}) and TOC followed by CT-CT and lowest under CT(DSR)-CT. C_{VL} was higher under IWM followed by unweeded control and lowest under chemical weed management among weed management practices. C_L, C_{LL}, C_{NL} and TOC were higher under unweeded control followed by IWM and chemical weed management practices.

Table 3.10 Effect of tillage and weed management on soil quality index

Treatments	SQI	Treatments	SQI
T_1W_1	36.7	T_3W_3	49.1
T_1W_2	35.6	T_4W_1	57.8
T_1W_3	37.2	T_4W_2	55.4
T_2W_1	40.7	T_4W_3	52.2
T_2W_2	43.6	T_5W_1	55.2
T_2W_3	44.7	T_5W_2	57.8
T_3W_1	42.7	T_5W_3	60.0
T_3W_2	45.6		

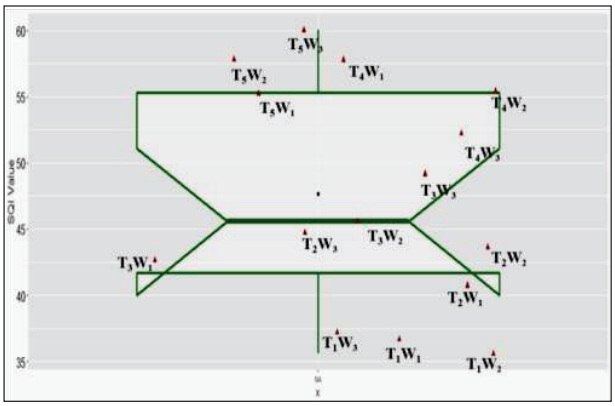


Figure 3.2 Box plot graph of SQI

Soil quality index was significantly higher in ZT treatments compared to CT treatments. ZT(DSR)-ZT+R with crop residues under unweeded control recorded highest SQI (60.0) among all the treatments followed by ZT(DSR)-ZT+R - IWM (57.8). Among the CT treatments, CT (DSR)-CT (49.1) unweeded control recorded higher SQI value followed by CT(DSR)-CT under IWM(45.6). The least SQI value was observed in CT-CT under IWM (35.6) followed by CT-CT chemical (36.7) among all treatments. As evidenced from crop dry matter and grain yield data, even though ZT treatments recorded higher SQI, the net productivity of these was low compared to the CT treatments. CT treatments registered lower SQI but the crop productivity was higher, which explains higher productivity but poor soil health. IWM under CT-ZT, recorded moderated SQI (43.60) i.e., conventionally tilled rice followed by zero tillage maize with IWM practices can maintain the soil health and gives good productivity to the farmer. Hence, following sustainable agriculture and IWM helps to improve soil health and optimum productivity can be obtained by the farmer.

At Hyderabad, soil and plant sample were collected from a field experiment on conservation agriculture in cotton (*Kharif* 2020) – maize (*Rabi* 2020-21) – *Sesbania* green manure (summer) cropping system to study the influence of herbicides on soil properties and also to assess the carryover of the herbicide residues. Diuron PE 0.75 kg/ha, pyrithiobac-sodium 62.5 g/ha, quizalofop-p-ethyl 50 g/ha were applied to the cotton crop. Impact of herbicides on soil enzyme activity and the microbial population was assessed after herbicide application, flowering stage and harvest of the crop. Along with the herbicide persistence, impact of tillage and weed management practices on soils properties was also initiated.

Soil dehydrogenase activity (DHA) was assessed at 5, 15 days after preemergence herbicide application, on the day of PoE herbicide application, 30 days after preemergence herbicide application, flowering and harvest stages of the crop. The DHA increased gradually from sowing up to the crop's flowering stage, which later on decreased at harvest of the crop. Tillage treatments did not significantly

Table 3.11 Soil dehydrogenase activity (µg TPF released/g/24hr) as influenced by tillage and weed control measures

Treatments	5 days after PE	15 days after PE	On the day of PoE	30 days after PE	Flowering	Harvest
Tillage practices						
T_1 : (CT-CT)	5.08	8.88	9.63	9.50	13.6	5.69
T_2 : (CT-ZT-ZT)	5.37	9.40	10.1	10.0	14.4	6.01
T_3 : (ZT+R- ZT+R-ZT+R)	5.02	8.77	9.51	9.39	13.4	5.62
SE(m)±	0.32	0.35	0.42	0.40	0.56	0.23
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management practices						
W_1 : Chemical weed control	4.25	7.56	8.21	8.86	10.5	6.56
W_2: Chemical weed control	5.21	8.21	8.56	8.25	10.4	5.21
Herbicide Rotation						
W_3 : IWM	4.65	8.05	9.12	10.2	12.1	5.87
W_4 : Control	6.52	12.2	13.2	11.2	15.2	5.45
LSD (P=0.05)	4.25	7.56	8.21	8.86	12.5	6.56
SE(m)±	1.21	1.15	2.31	2.67	NS	NS
Interaction	W T	W T	W T	W T	W T	W T
LSD (P=0.05)	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS

W: W at the same level of T; **T**: T at the same level of W

influence DHA and UA at any growth stage of the crop. At 5 and 15 DAA (PE) the DHA decreased significantly in all the treatments where diuron was applied as a preemergence herbicide. The negative effect of postemergence herbicide was evident from the significantly lower DHA in chemical weed management treatments which were significantly lower than the IWM and control treatments. At the crop's flowering stage, the soil DHA was statistically on par in all the treatments (**Table 3.11 and 3.12**).

Table 3.12 Soil urease activity (µg NH_4^+-N/g/2hr) as influenced by tillage and weed control measures

Treatments	5 days after PE	15 days after PE	On the day of PoE	30 days after PE	Flowering	Harvest
Tillage practices						
T_1 :(CT-CT)	11.4	32.9	44.4	48.7	51.0	16.6
T_2 :(CT-ZT-ZT)	12.0	34.8	47.0	51.6	53.9	17.5
T_3 :(ZT+R- ZT+R-ZT+R)	11.2	32.5	43.9	48.1	50.3	16.4
SE(m)±	**0.88**	**2.21**	**2.15**	**1.85**	**3.41**	**1.77**
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management practices						
W_1 : Chemical weed control	9.7	31.6	42	47.8	49.2	18.1
W_2: Chemical weed control Herbicide Rotation	10.2	29.8	41.8	48.6	53.5	16.5
W_3 : IWM	9.9	30.8	46.6	50.2	54.2	17.4
W_4 : Control	16.5	41.6	50.1	51.5	50.2	15.4
SE(m)±	0.89	2.12	2.85	3.23	4.12	1.56
C.D (P=0.05)	2.54	6.08	8.15	NS	NS	NS
Interaction	W T	W T	W T	W T	W T	W T
LSD (P=0.05)	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS

W: W at the same level of T; **T**: T at the same level of W

Acid and alkaline phosphate activities of the soil were assessed at 5, 15 DAS, on the day of PoE herbicide application, 30 days after preemergence herbicide application, flowering and harvest stages of the crop. Impact of tillage was non-significant on activities of both enzymes at all the stages of sampling. Impact of diuron on phosphatase activities was evident in the early stages after application. Impact of herbicide on alkaline phosphatase activity was visible only upto 15 days after application. Whereas in the case of acid phosphatase the impact was apparent up to 21 days after preemergence application. Activities both phosphatase enzymes increased from sowing until the crop's flowering stage, which later decreased, and very low activity was noticed at the crop's harvest stage.

Soil microbial populations

Soil microbial counts in the soil were estimated at 5, 30 and 60 DAS in the cotton crop. Total bacteria, fungi and actinomycetes populations were not significantly influenced by the tillage treatments at any of the sampling stages. However, the impact of weed management options was evident. At 5 DAS highest bacterial, fungal and actinomycetes colonies were observed in unweeded control treatment compared to other treatments wherein diuron was applied as a preemergence herbicide. AT 30 DAS, the lowest bacterial and actinomycetes population were recorded in chemical weed management treatment which was significantly lower than IWM and unweeded control. In case of fungi, the number of colonies recorded at 30 DAS was on a par in all the treatments. Impact of herbicides was not witnessed at flowering stages in any of the group of organisms studied.

The long term experiment on weed management in conservation agriculture system was initiated in *Kharif* at Bhubaneswar to monitor the weed dynamics, crop productivity, herbicide residues, changes in physico-chemical and biological properties of soil health. Initially the carbon content of the soil was low but continuous application of crop residue increases gradually the organic carbon content of the concerned treatment 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 activity and higher phosphate activity 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 justifies the role of organic amendments in stabilizing soil properties

Application of herbicides to rice significantly reduced some of the microbial attributes like fungal and bacterial population by 6.0 - 9.0 % and 7.0 - 9.0 %, respectively. Addition of crop residue enhanced the bacterial and fungal population by 9.0 % and 8.0 %, respectively. In general, an increasing trend in microbial population and enzyme activities was observed since the initial year of study (2013-14). Addition of organic matter (crop residue) could not significantly influence the BD, pH, OC, and nutrients like available N, available K and available S. However, the available nutrients status of the soils showed an increasing trend over the years in treatments with organic matter, which justifies the role of organic amendments in stabilizing soil properties.

Use of herbicides in conjunction with crop residue improved soil fertility through better microbial activity. Addition of crop residues increases the organic carbon content on the soil which helps in increase in microbial activity.

WP 3.2 Assessment of herbicide residues in high value crops

At Coimbatore, field experiment was conducted in farmers field to estimate the harvest time residues of oxyfluorfen in/on onion and soil. A single pre emergence application of oxyfluorfen was done at different doses (T_1 - 200 g/ha, T_2 - 400 g/ha and T_3 – unweeded control). After the application of oxyfluorfen, 0.101 and 0.189 mg/kg residues were found with the applied concentration of 200 and 400 g/ha of oxyfluorfen, respectively. At harvest the residues of oxyfluorfen were not detected in soil as well as onion plant top whereas in onion bulb the residue of 0.036 mg/ kg was recorded, however, it was below the MRL of 0.05 mg/kg (**Table 3.13**).

Table 3.13 Residue of oxyfluorfen in soil at 0 DAA and plant at harvest

Treatment (g/ha)	Residues (mg/kg)			
	Soil on 0th day	Onion plant top at harvest	Onion bulb at harvest	Field soil at harvest
T_1 – 200	0.101	<0.01	<0.01	<0.01
T_2 – 400	0.189	<0.01	0.036	<0.01

At Palampur experiment was conducted to estimate herbicide residues in the soil and crop in fruit-based system influenced by integrated weed management. Soil samples were collected immediately after spray from imposed treatment pendimethalin 1.5 kg/ha in turmeric intercropping from the experiment entitled "Integrated weed management in established peach orchard" for residue analysis. Initial pendimethalin residues in soil immediately after spray were found to be 0.48 µg/g. Pendimethalin residues in both soil and turmeric were below detectable limits at the time of harvest. In second experiment, herbicide samples were collected from the harvest of pea and maize crop in *Rabi* 2019-20 and *Kharif* 2020, respectively for determination of pendimethalin (1.5 kg/ha) and atrazine (1.5 kg/ha) residues. The residues of pendimethalin and atrazine in post-harvest soil and crop produce were below the detection levels (>0.01 µg/g). In Experiment 3, soil samples were collected from experiment on potato for metribuzin residue analysis applied at 500 g/ha along. The initial deposits of metribuzin in soil immediately after application of metribuzin were found to be 0.328 µg/g and in post-harvest soil and crop produce residues of metribuzin were below detectable levels.

At Hyderabad, atrazine (applied 1000g/ha as preemergence spray 24 hours after sowing using a spray volume of 500 liters/ha) residues in the soil, stover and grain of sweet corn crop were determined. After two hours of application, 0.452 atrazine residues in the surface soil were detected. No detectable residues (0.05 µg/g) of atrazine were detected in the samples of baby corn and stover collected from the field experiment at harvest.

WP 3.3 Assessment of herbicide residues in farmers field

At Coimbatore, sandy loam and sandy clay loam soils and plant samples were collected at the time of harvest from the maize, tomato, bhendi and pulses grown fields of different farmers from Devarayapuram, thondamuthur village of Coimbatore district which received atrazine and oxyfluorfen. None of the applied herbicides were detected in the different plant matrices and soil (**Table 3.14**).

On farm trial have been conducted in 5 locations with groundnut consisting of 4 treatments. Soil and plant samples were taken at the time of harvest and analyzed for the residues. Oxyflourfen and atarzine residues were found below the detectable level in soil and plant parts in all the locations.

At Palampur soil and grain samples from farmers' fields of Jawali area of Kangra were collected at harvest from different 20 locations for determination of clodinafop, metsulfuron-methyl during *Rabi* 2019-20 and 2,4-D and bispyribac sodium, butachlor, pyrazosulfuron ethyl and pretilachlor during *Kharif* 2020. Herbicide residues were analyzed by HPLC-DAD for their residue content in collected soil and plant produce except 2,4-D (spectrophotometric method). No residues of clodinafop, metsulfuron-methyl and 2,4-D were found below the detection limit in wheat grain and soil. Similarly, the residues of bispyribac-sodium, butachlor, pyrazosulfuron-ethyl and pretilachlor were not detected in the rice grains and soil.

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 for determination of pretilachlor, butachlor, anilophos, penoxulam, clodinafop-propargyl, sulfosulfuron, metsulfuron-methyl, pinoxaden, pendimethalin and metribuzin residue**.** Residue of these herbicides in soil, water and crop produce were below the detectable limit (<0.01 µg/g). Soil and crop produce samples were collected at harvest from OFR and FLD trials sprayed with pyroxasulfone and cladinofop+metribuzin in

Table 3.14 Herbicides residue in soil and crop produce from farmers' field

Name of the farmer	Crop	Herbicide & dose	LOD & LOQ (mg/kg)	Soil at harvest	Plant parts at harvest
Mr. Nanju kutti Vadakku Thottam Devarayapuram	Onion	Oxyfluorfen 200 g/ha	0.01 & 0.05	BDL	BDL
Mr. M. Shanmugam Naddukattu thottam	Maize	Atrazine 0.5 kg/ha	0.001 &0.01	BDL	BDL
Rangamuthusamy Dhandapani Thottam Devarayapuram, North	Maize	Atrazine 0.5 kg/ha	0.001 &0.01	BDL	BDL
Mr. Ranjith Thoppu thottam Itchikuli road Devarayapuram	Tomato	Oxyfluorfen 200 g/ha	0.01 & 0.05	BDL	BDL
Mr. P. K. Selvakumar S/o. Kandhasamy gounder Nallurvayal thottam	Onion	Oxyfluorfen 200 g/ha	0.01 & 0.05	BDL	BDL

Table 3.15 Sampling details for determination of residues location details

S. No	Name of the Farmer	Location	GPS location	Herbicide application details
1.	Veeranna S/o Mallaah	Kesaram village, Chevellamandal, Vikarabad district	17°18'44.2" 78°09'39.2"	Oxyfluorfen 100 ml/acre (58.8 g/ha) as PoE at 20 DAP
2.	Krsihnareddy S/o Ram Reddy	Kesaram village, Chevellamandal, Vikarabad district	17°18'33.3" 78°09'40.8"	Oxyfluorfen 100ml/acre (58.8 g/ha) as PoE at 20 DAP
3.	Krishna S/o Komuraiah	Appareddypalli villagevillage, Moinabad mandal	17°16'05.8" 78°05'54.8"	Oxyfluorfen 150 ml/acre (88.2 g/ha) as PoE at 20 DAP
4.	Mallesh S/o Venkanna	AppareddyPalli village Moinabad mandal	17°19'32.1" 78° 10'22.4"	Oxyfluorfen 150ml/acre (88.2 g/ha) as PoE at 20 DAP

wheat. The residue of these herbicides in soil, water and crop produce were below the detectable limit (<0.01 µg/g).

At Hyderabad four soil/onion bulbs were collected from different farmers for determination of oxyfluorfen residues in soil and onion bulbs in samples drawn from farmers' fields.

Soil samples were collected from the farmers' fields at onion bulb stage of the crop. Among the soil samples collected from the farmers' fields, two samples collected showed residues of oxyfluorfen (0.045 and 0.051 mg/kg) and in other two soil samples oxyfluorfen were found to be below the detection limit of 0.025 mg/kg. Oxyfluorfen residues in onion bulb samples collected from the farmers fields were found below the detection in limits in all the four samples (0.025 mg/kg). From tomato growing regions of Ranga Reddy district, fruit (4 samples) and soil samples (4 samples) were collected during *Rabi*. Residues of metribuzin in the soil and tomato samples were below detection limit (0.05 mg/kg) in all four samples.

WP 3.4 Degradation of herbicide in plants, soil and aquatic bodies

At Coimbatore, soil, plant produce and water samples were collected at 0, 7, 15, 30, 45, 60 days after herbicide application from the rice growing farmers' fields at Nallurvayal and Saadivayal to determine herbicides degradation and residues. None of the applied herbicides were detected in soil up to 30 DAHA. In water sample residue detected only up to 7 DAHA in 2 locations. Whereas in 3rd location, residues were detected upto 3DAHA (**Table 3.16).**

Table 3.16 Butachlor (1.0 kg/ha) persistence in rice soil from farmers' field

Farmer Name and Location	Butachlor residue (mg/kg)					
	0 DAHA	7 DAHA	15 DAHA	30 DAHA	45 DAHA	60 DAHA
Mr. S.R. Palanisamy SRP Thottam Nallur vayal	0.472	0.244	0.183	0.022	BDL	BDL
Mr. A, Sivasamy S/o/ Ayyagounder Nallur vayal	0.505	0.292	0.204	0.030	BDL	BDL
Mr. Anand Nallur vayal Saadivayal	0.450	0.219	0.175	0.026	BDL	BDL

Table 3.17 Butachlor residues in water from farmer's field

Farmer Name and Location	Source	TIme of sampling			
		3 DAHA	7 DAHA	15 DAHA	30 DAHA
Mr. S. R. Palanisamy	Field water	0.189	0.018	BDL	BDL
SRP Thottam	Bore well	BDL	BDL	BDL	BDL
Nallur vayal					
Mr. A. Sivasamy	Field water	0.106	0.020	BDL	BDL
S/o/ Ayyagounder	Bore well	BDL	BDL	BDL	BDL
Nallur vayal					
Mr. Anand	Field water	0.112	BDL	BDL	BDL
Nallur vayal	Bore well	BDL	BDL	BDL	BDL
Saadivayal					

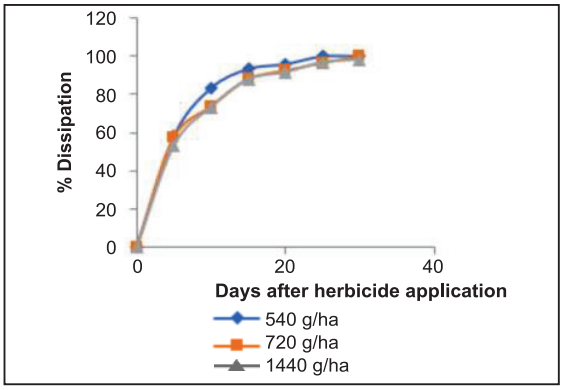
At Palampur a field experiment was conducted at Kangra during *Kharif* 2020 consisting of four treatments viz. ethalfluralin 540, 720 and 1440 g/ha for weed control in determine dissipation of ethalfluralin in soil. Samples of soil (0-15 cm) at five days interval were collected replication wise from three imposed treatments of ethalfluralin along with control.

Initial residues of ethalfluralin in soil immediately after application of herbicide applied at 540, 720 and 1440 g/ha were found to be 0.514, 0.778 and 1.655 µg/g which after 10 days degrdaded to 0.086, 0.204 and 0.443 µg/g, respectively. The corresponding remaining residues of applied ethalfluralin were 83.2, 73.7 and 73.2%, respectively. At 30 days after herbicide spray, residues were below the detectable limit at lower doses i.e. ethalfluralin 540 and 720 g/ha whereas, at higher dose i.e. 1440 g/ha residues were found to be 0.034 µg/g. This indicated that ethalfluralin at higher dose persisted in the soil for longer periods than at lower doses **(Table 3.18)**. Dissipation of ethalfluralin at all application rates viz. 540, 720 and1440 g/ha followed first order kinetics decay. The correlation coefficient (r^2) for all the three applied doses of ethalfluralin 540, 720 and 1440 g/ha were 0.961, 0.992 and 0.994, respectively.

At Ludhiana residues of pyroxasulfone applied at different application rate to maize under field conditions were determined at various time intervals. The LOD and LOQ of pyroxasulfone were 0.02 and 0.05 µg/g, respectively. The initial residues of pyroxasulfone at 0 day (3 hours after herbicide application) ranged from 0.032 µg/g at 76.5 g/ha whereas at higher application rates the residues varied from 0.05, 0.061, 0.101 and 0.124 µg/g at 102, 127.5, 204 and 255 g/ha application rates. The residues of pyroxasulfone decreased significantly over time and were found to be 0.018 and 0.022 µg/g at 90 DAA **(Figure 3.3)**. The degradation of pyroxasulfone was found according to first order kinetics with correlation coefficient > 0.99 and half- lives (**Table 3.19**).

Table 3.18 Percent dissipation of ethalfluralin inn the soil at different doses

Days after herbicide application	Dissipation (%)		
	Rates of ethalfluralin (g/ha)		
	540	720	1440
0	0	0	0
5	57.9	57.4	52.9
10	83.2	73.7	73.2
15	93.3	88.1	87.6
20	95.9	92.6	91.3
25	100	96.6	96.5
30	100	100	97.9



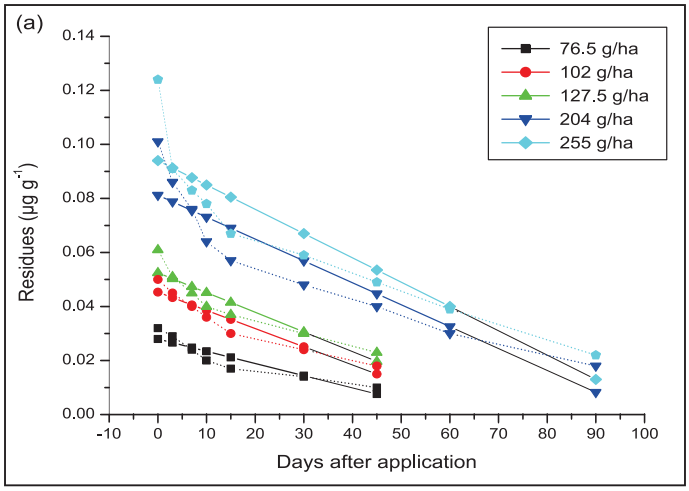


Figure 3.2 Predicted verses observed residues for pyroxasulfone in different treatments

Table 3.19 Statistical parameters for dissipation of pyroxasulfone in different treatments

Application rate *(g/ha)	R^2	k	DT_{50}*
76.5	0.96	0.024	28.07
102	0.94	0.022	31.37
127.5	0.92	0.019	35.29
204	0.93	0.017	39.36
255	0.97	0.016	42.11

DT_{50}* varied significantly ($p < 0.05$) with application rate and soil type

Carryover effect of pyroxasulfone applied to maize crop was studied on succeeding crops (potato, peas, mustard, spanich, mentha, methi and toria) under field conditions. Plant count, root length, shoots length and biomass was recorded 30 days after sowing. Pyroxasulfone showed significant reduction in plant count, root length, shoot length, fresh and dry biomass of all succeeding crops, except plant count of potato, compared to weedy check with every increase in dose of pyroxasulfone from 76.5 to 255 g/ha and at highest dose, presence of higher amounts of residue of pyroxasulfone in soil affected emergence and growth of succeeding crops (**Table 3.20**).

Table 3.20 Effect of pyroxasulfone on plant count of succeeding crops

Treatments	Plant count/ m²						
	Potato	Pea	Cabbage	Spinach	Metha	Methi	Toria
Weedy check	3.5	3.0	6.5	23.0	25.0	105.5	29.0
Pyroxasulfone 127.5 g/ha	3.5	2.8	6.3	20.0	24.7	102.8	27.0
Pyroxasulfone 204 g/ha	3.5	2.5	5.0	18.2	23.0	101.7	21.0
Pyroxasulfone 255 g/ha	3.5	2.3	1.5	13.0	9.1	79.5	11.5
LSD (P=0.05)	NS	0.47	0.62	0.69	0.49	0.41	0.35

The bacteria, fungi and actinomycetes populations increased continuously with time in control soils. After the application of herbicide at initial days, an inhibition was observed in microbial counts from 0 to 30 DAT at application rates of 76.5, 102.0 and 127.5 g/ha and from 0 to 60 DAT at application rates of 204.0 and 255 g/ ha (**Table 3.8**) due to the toxic effect of herbicide on soil microorganisms. After initial inhibition, microbial counts increased significantly ($p < 0.05$) with increase in incubation days because the toxic effect of herbicide declined with time due to degradation of herbicide in soil.

Table 3.21 Effect of pyroxasulfone on soil microflora in maize during *Kharif* 2020

Application rate* g/ha	Bacteria*10³(cfu/g)					Actinomycetes*10³(cfu/g) Days after treatment[a]					Fungi*10³(cfu/g)				
	0	30	60	90	Harvest	0	30	60	90	120	0	30	60	90	Harvest
Control	119.9	127.2	133.6	136.7	140.7	80.8	84.5	88.9	91.2	94.0	54.1	56.2	59.2	62.7	65.2
76.5	119.2	84.6	90.89	101.1	139.6	80.1	62.1	86.1	89.2	92.0	53.8	48.3	55.7	58.1	64.1
102.0	11867	80.8	86.2	95.2	138.8	79.7	78.7	80.2	84.2	88.6	53.2	44.1	47.4	51.2	65.9
127.5	118.3	77.4	82.3	90.0	138.2	79.0	70.7	74.8	78.5	80.00	52.6	40.3	44.3	48.1	65.3
204.0	117.3	71.6	66.2	74.2	137.6	78.4	65.7	63.1	67.5	74.3	52.1	35.8	30.3	38.2	64.6
255	116.9	67.5	62.5	70.5	136.0	77.6	60.0	57.2	61.2	69.7	51.5	29.4	25.1	31.2	65.9

*Statistically significant at 5% level of significance

At Hyderabd, water samples were collected from the aquatic bodies under Nagarjuna Sagar Project Left canal command area in Nalgonda district surrounded by rice-growing areas to study the persistence and contamination of the aquatic bodies by rice herbicides (pertilachlor and bispyribac sodium). Samples were collected two times i.e. at the time of transplanting (01-09-2020) and at 20-25 DAT (20-09-2020). Pretilachlor residues (above the detection of 0.05 mg/l) were detected in two samples (sample no 2 and 8). In both the water samples collected from drain channels, pretilachlor residues were detected (0.052 and 0.081 mg/L). pH and EC of the water samples did not change significantly compared with the first sampling (**Table 3.22)**.

Table 3.22 Analytical details of water samples collected at first sampling (02-09-2020)

Water sample	Location	GPS	pH	EC	Pretilachlor residue (mg/L)
Canal water	Krishna river Project	N: 17º-19'-2″ E:78º-24'-59.2″	7.88	0.459	BDL
Drain water	Lingampally village	N:16º-45'-4.4" E: 79º-14'-59.1″	7.58	0.342	0.052
Drain water	Namudupalem village	N:16º-46'-15.2″ E: 79º-15'-24.5″	7.50	0.401	BDL
Hand pump	Ibrahimpet village	N:16º-47'-58″ E: 79º-19'-39.9″	8.10	0.751	BDL
Drain water	Ibrahimpet village	N:16º-47'-56.9″ E: 79º-19'-54.0″	7.50	0.928	BDL
Tank water	Tummadam village	N:16º-50'-0.18″ E: 79º-26'-37.5″	7.84	0.580	BDL
Bore well	Venkannagudem village	N:16º-49'-52.0″ E: 79º-24'-14.4″	7.48	0.602	BDL
Drain water	Kukkadam village	N:16º-56'-19.0″ E: 79º-28'-57.8″	8.18	0.589	0.081
Tank water	Miryalaguda	N:16º-52'-59.8″ E: 79º-34'-22.1″	8.15	0.646	BDL
Tank water	Nalgonda	N:17º-52'-34.1″ E: 79º-18'-30.6″	7.75	0.619	BDL

WP 4 Demonstration and impact assessment of weed management technologies

WP 4.1 Assessment of weed management technologies through on farm research

At Coimbatore, OFT was conducted to demonstrate the integrated weed management in groundnut at Nallur, Pollachi South Block, Coimbatore and Chinnapudur, Kangayam Block, Tiruppur districts during *Kharif* 2020. The major weeds present in aggerigatum onion fields were *Acanthospermum hispidum, Boerhaavia hispida, Amaranthus viridis, Digeria arvensis, Cyperus rotundus* and *Panicum repens, etc.* Total weed density and weed dry weight were considerably lower with application of EPOE imazethapyr + quizalafob-ethyl (50+50 g/ha) *fb* hand weeding 30 - 35 DAP in all five locations next to POE propazuizfop + imazethapyr 125 g/ha and PE oxyfluorfen 0.20 kg/ha *fb* hand weeding 30-35 DAP. It was higher in farmers practice (PE Pendimethalin 1 kg/ha *fb* hand weeding 30-35 DAP). Two hand weeding reduced the emergence of new weeds and regrowth of present weed seeds which ultimately resulted in higher weed density and weed dry weight in farmers practice. EPOE imazethapyr + quizalafob-ethyl (50+50 g/ha) *fb* hand weeding 30 - 35 DAP recorded seed yield (1430 to 1870 kg/ ha). Net returns were higher in the same treatment (₹ 0.60 –1.03 lakh /ha). Effective control of early and late emerged weeds was the reason for higher yield of seed and economic returns in the above treatment. EPOE imazethapyr + quizalafob-ethyl (50+50 g/ha) *fb* hand weeding 30 - 35 DAP for broad spectrum weed control and higher seed yield and economic returns in groundnut **(Table 4.1 to 4.3).**

Table 4.1 Effect of treatments on yield and economics in onion

	L_1				L_2				L_3				L_4			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Yield t/ha	1.64	1.87	1.76	1.58	1.57	1.80	1.70	1.49	1.52	1.84	1.62	1.43	1.60	1.74	1.56	1.47
GR (₹ lakh/ha)	1.56	1.76	1.66	1.49	1.48	1.70	1.60	1.41	1.44	1.75	1.53	1.35	1.52	1.65	1.47	1.39
NR (₹ lakh/ha)	0.80	1.03	0.91	0.74	0.75	0.97	0.85	0.66	0.69	1.00	0.77	0.60	0.77	0.90	0.71	0.64
Income over FP ₹/ha	5,765	28,593	16,794	-	7,494	30,323	18,523	-	8,647	40,699	17,370	-	12,682	26,864	7,570	-
% yield increase over FP	3.79	18.35	11.39	-	5.4	20.8	14.1	-	5.9	28.7	9.95	-	8.8	18.4	6.2	-

L-Location, T-Treatment, FP-Farmer practice, GR-Gross return, NR - Net return

At Ludhiana, four OFTs on weed management in wheat were conducted with pre-emergence herbicide, pyroxasulfone. Pyroxasulfone at 127.5 g/ha found to be effective against resistant *Phalaris minor* at all locations and farmers were satisfied with the performance of this herbicide. *Phalaris minor* has developed cross resistance to recommended herbicides like clodinafop, fenoxaprop and pinoxaden in wheat fields. In such fields, pendimethalin has been recommended for control of *P. minor*. Pyroxasulfone recorded effective control of *P. minor* and increased wheat grain yield than unsprayed control and was at par with pendimethalin 1125 g/ha. Four OFTs on weed control in maize were conducted during *Kharif* 2020 with tembotrione as post-emergence herbicide and, its band spray followed by (*fb*) inter-culture in inter-rows. The band application followed by inter-culture provided effective control of weeds. Tembotrione blanket at 120 g/ha and its band spray at 40 g/ha plus interculture in inter rows recorded effective control of grasses and broadleaf weeds.

At Hisar, pre-emergence use of pyroxasulfone at 127.5 g/ha demonstrated at seven sites in rice –wheat growing areas of Haryana provided 87% 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 98% with grain yield of 5.49 t/ha which was 10.7% higher than earlier recommended herbicide pendimethalin at 1.5 kg/ha *fb* POE herbicides. None of herbicide caused any toxicity to wheat crop. Pendimethalin at 1500 g/ha (PRE) followed by post emergence herbicide at 35 DAS provided only 68 % control of *P. minor*. Five on farm trials were conducted on use of herbicides in green gram. Application of pendimethalin + imazethapyr (RM) 1000 g/ha (PRE) provided 83.4% control of *Trianthema, Digera* and *Echinochloa, Dactyloctenium* with seed yield of 797 kg/ha which was 14% higher than pre-emergence application of pendimethalin 1000 g/ha alone (698 kg/ha). Post-emergence application of Iris (aclonifen + clodinafop) gave only 68% control of weeds with 8% phytotoxicity to crop caused yield penalty with seed yield of 684 kg/ha which was 16% less than pendimethalin + imazethapyr (RM) 1000 g/ha (PRE).

At Thrissur, on-farm research on early post emergence weed control was conducted at five locations, two in *Kole* lands and two in other wetland fields. The weed spectrum of the field consisted of *Echinochloa crusgulli, Sacciolepis interrupta*, *Fimbristylis miliaceae*, *Cyperus difformis* and *Ludwigia parviflora*. *Ludwigia*. Ready mix herbicide combination of cyhalofop-butyl + penoxsulam was not very effective against *Ludwigia*. However all graminaceous weeds as well as sedges were effectively controlled. Bispyribac followed by fenoxaprop spray resulted in effective weed control and was the best treatment. Bispyribac alone application could not control *Sacciolepis* effectively. The increase in yield over farmers practice in bispyribac- sodium *fb* fenoxaprop-p-ethyl application was 15%.

At Jammu, on farm research experiment was conducted at 2 farmers' field at village Chorlli and Arnia of Jammu region in *Kharif* 2020. The highest grain yield and B:C were recorded in pendimethalin 1000g/ha (PE) *fb* bispyribac-sodium 25 g/ha+ ethoxysulfuron- ethyl 18 g/ha as post-emergence at both the locations.

At Bhubneswar, four numbers of OFTs on transplanted rice were conducted during *Rabi* 2019-20 at Rout pada, Begunia, Khurda districts. The major weed flora were *Echinochloa crusgalli, Panicum repens, Ludwigia parviflora, Cyperus iria, Cyperous rotundus* and *Splenochlea zeyalanica.* Maximum yield of 3.65 t/ha was recorded in the plot applied with pretilachlor 0.75 kg/ha followed by oxadiargyl 75 g/ha (3.47 t/ha). A net saving of ₹ 2450 - 2550/ ha was obtained in the plots treated with herbicides.

Four OFTs on rice were conducted in Bhubasuni Patna, Baghamari, Khurda area during *Kharif* 2020. The major weed flora was ansisted of *Echinochloa colona, Eclipta alba, Celosia argentea, Cynodon dactylon* and *Cyperous rotundus.* Highest yield was obtained in the plots applied bispyribac- Na (20 g/ha) (4.5 t/ha) followed by penoxsulam (23.5 g/ha) (4.3 t/ha). The saving in weeding cost over farmers practice was in the tune of ₹ 2600 to ₹ 2950 / ha.

At Raipur, 08 demonstrations were conducted on weed management in direct seeded rice (rice cultivar "Rajeshwari") with treatment application of pre emergence pyrazosulfuron 20 g/ha at 0-7 DAS *fb* bispyibac- Na 20 g/ha at 20 DAS and other treatment application of pre emergence oxadiargyl 80g/ha *fb* bispyribac-Na 20 g/ha at 20 DAS was laid down. The average yield of farmers practice and recommended practice was found to be 4.5 and 5.4 t/ha, respectively. However, percent increase under recommended practice over farmers practice was 11.9%. The average benefit cost ratio was calculated to be 3.00 and 4.0 under farmers practice and recommended practice, respectively.

At Gwalior, the study was carried out during *Rabi* 2019-20 for wheat crop. Four on-farm trials were conducted at farmers' fields under OFR programme. In wheat crop, the combinations of post emergence

herbicides 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. The dominant weeds on farmers' fields were consisted of *Cyperus rotundus, Anagallis arvensis, Phalaris minor, Convolvulus arvensis, Chenopodium album* and *Spergula arvensis,* etc. Both the combinations of weed management practices gave lower weed population and higher seed yield over farmers' practices. The maximum yield of 4.31 t/ha was obtained with the application of sulfosulfuron + metsulfuron (30+2) g/ha PoE *fb* clodinafop + metsulfuron (60+4) g/ha PoE (4.21 t/ha) which was 30.55 and 27.60% higher over farmers' practice (3.34 t/ha). Application of sulfosulfuron + metsulfuron (30+2) g/ha PoE gave maximum yield (4.31 t/ha) *fb* clodinafop + metsulfuron (60+4) g/ha PoE (4.21 t/ha) in the farmers field, which was 30.5% and 27.6% higher over farmers' practice (no herbicide applied), respectively.

The B:C was found 2.52 and 2.47 in these weed management practices as compared to 2.33 in farmers' field respectively. Two OFRs were conducted on pearlmillet at farmers' fields in two villages of Gwalior district. Atrazine 0.5 kg/ha *fb* 2, 4-D 0.5 kg/ha and pendimethalin 1.0 kg/ha (PE) were tested on pearlmillet and compared with farmers' practices where farmer was not applied any herbicide. The dominant weeds on farmers' field were *Cyperus rotundus, Phyllanthus niruri, Echinochloa crus-galli, Commelina benghalensis, Digera arvensis* and *Sateria glauca*. Both the chemical weed management practices gave higher grain yield over farmers' practice. The maximum yield of pearlmillet 2.90 t/ha was obtained with the application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (PoE) *fb* pendimethalin 1.0 kg/ha PE, which was 53.0%, and 37.0% higher than farmers' practices respectively. The B:C ratio (2.34) was also recorded higher with the application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (PoE). It is concluded that at farmer's fields the application of atrazine 0.5 kg/ha + 2, 4-D 0.5 kg/ha (PoE) gave 53.0% increase of pearl millet yield over farmers' practice with BC ratio of 2.34.

At Palampur, four OFTs on rice, four on maize, five on wheat, three on turmeric, three on peas and four in grasslands were undertaken (**Table 4.2 to 4.5**).

Table 4.2 Effect of weed management technologies in rice (N=11)

Treatment	Grain yield (t/ha)
Pretilachlor 0.75 kg/ha	3.5
Pyrazosulfuron 25 g/ha	3.1
Bispyribac 20 g/ha	3.5
Butachlor 1.5 kg/ha	2.7
Hand weeding (Farmers Practice)	2.6.
SE(m±)	0.1
LSD (P=0.05)	0.4

Table 4.3 Effect of weed management technologies in maize (N=12)

Treatment	Grain yield (t/ha)
Tembotrione 120 g/ha	5.3
Atrazine 1.5 kg/ha	4.8
Pendimethalin	4.9
Hand weeding 20 & 45 DAS (Farmers Practice)	4.2
SE(m±)	0.2
LSD (P=0.05)	0.5

Table 4.4 Effect of weed management technologies in wheat (N=15)

Treatment	Grain yield (t/ha)
Clodinafop 60 g/ha + metsulfuron methyl 4 g/ha	3.4
Clodinafop 60 g/ha *fb* 2,4-D 0.5 kg/ha	3.3
Isoproturon 1.25 kg/ha	2.7
SE(m±)	0.2
LSD (P=0.05)	0.6

Table 4.5 Effect of weed management technologies in turmeric (N=4)

Treatment	Yield (t/ha)
Metribuzine 0.7 kg/ha + mulch + HW	24.4
Atrazine 1.0 kg/ha + mulch + HW	23.3
Pendimethalin 1.0 kg/ha + mulch + HW	21.4
Hand weeding (HW) thrice	18.7
SE(m±)	0.9
LSD (P=0.05)	2.7

During 2019-20 Five OFR each in grasslands and soybean were also conducted. OFTs each on the control of *Lantana camara* and *Parthenium* were also undertaken.

WP4.2 Dissemination of weed management technologies through FLDs and capacity building

At Coimbatore, the front line demonstrations were conducted at five farmers' field of Channaur and Thaneerpandal villages, Thondamuthur block of Coimbatore District in turmeric (Variety Erode Local). Due to adoption of improved weed management technology PE oxyfluorfen 0.25 kg/ha *fb* hand weeding at 30-35 DAP the weed density and dry weight recorded lesser than farmer practice (Two hand weedings). The major flora consisted of *Celosia argentea*, *Ageratum conyzoides*, *Acalypha indica*, *Digeria arvensis*, *Cyperus rotundus*, *Echinochloa* spp., *Dinebra retroflexa* etc.

At Gwalior, four demonstration trials were conducted at farmers' fields under FLD programme during *Rabi* 2019-20 in wheat crop. Post-emergence herbicides sulfosulfuron + metsulfuron (30+2) g/ha and clodinafop + metsulfuron (60+4) g/ha were applied to control the weeds in wheat and compared with farmers' practices at three locations of Gwalior district where farmer did not apply any herbicide. The dominant weeds on farmers' fields consisted of *Cyperus rotundus, Anagallis arvensis, Phalaris minor, Convolvulus arvensis, Chenopodium album* and *Spergula arvensis,* etc. It was observed that both herbicide combinations gave lower weed population and higher seed yield over farmers' practices. The maximum yield of 4.29 t/ha was obtained with the application of sulfosulfuron + metsulfuron (30+2) g/ha PoE *fb* clodinafop + metsulfuron (60+4) g/ha PoE (4.25 t/ha) which was 24 and 23% higher over farmers practice (3.46 t/ha). From the above findings it can be concluded that the combination of sulfosulfuron + metsulfuron (30+2) g/ha PoE gave maximum yield (4.29 t/ha) *fb* clodinafop + metsulfuron (60+4) g/ha PoE (4.25 t/ha) in the farmers field, which was 24%, and 23% higher than farmers practice (no herbicide applied) respectively. The BC ratio was also found 2.51 and 2.49 in these weed management practices as compared to 2.45 in farmers' field respectively. Two FLDs were conducted on pearlmillet at farmers' fields in two different villages of Gwalior district to demonstrate the benefit of the application of atrazine 500 g/ha + 2, 4-D 500 g/ha. The dominant weeds on farmers' field were *Cyperus rotundus, Cynodon dactylon, Phyllanthus niruri, Commelina benghalensis, Digera arvensis* and *Echinocloa crus-galli.* Application of atrazine 500 g/ha + 2, 4-D 500 g/ha gave higher grain yield over farmers' practice. The yield of demonstrated plot was recorded 2.89 t/ha which was 49.9% higher than farmers' practice. Similarly higher BC ratio 2.16 was recorded in the field where atrazine 500g/ha PE + 2, 4-D 500 g/ha was applied as PoE. In farmers' fields, application of atrazine 500g/ha + 2, 4-D 500g/ha (PoE) gave 49.9% increase in pearlmillet yield with BC ratio 2.16.

At Palampur sixty-eight demonstrations were conducted during 2019-20. In rice bispyribac 20 g/ha under technological intervention v/s butachlor 1.5 kg/ha; in maize tembotrione 120 g/ha as technological intervention v/s hoeing 20 DAS v/s earthing up 45 DAS and in wheat clodinafop propargyl 60 g/ha + metsulfuron methyl v/s farmers' practice, in fodder pendimethalin + atrazine (variable across villages) were evaluated (**Table 4.6**).

Table 4.6 Demonstrations on weed management technologies in various crops by AICRP-WM Palampur centre

Crop	No of farmers	Average yield (t/ha)		% Yield increase
		Demonstration	Check	
Rice	15	3.2	2.4	33.3
Maize	6	4.2	3.2	31.3
Wheat	25	3.9	2.2	77.3
Turmeric	3	6.6	5.4	22.2
Peas	5	5.5	4.0	44.4
Soybean	6	1.6	1.1	45.5
Fodder sorghum/pearl millet	4	45	35	28.3

At Ludhiana, eight FLDs were conducted during *Rabi*, 2019-20 in wheat on control of *Phalaris minor* in wheat with pre-mix of clodinafop + metribuzin WP at 174 g/ha a new post-emergence herbicide. *P. minor* has developed cross resistance to one or more of currently recommended herbicides like clodinafop, sulfosulfuron and pinoxaden. In such wheat fields, demonstrations of field efficacy of premix of clodinafop + metribuzin, were conducted. It recorded effective control of *P. minor* than clodinafop, sulfosulfuron and pinoxaden and enhanced wheat grain yield by 15%. Herbicide provided relief to farmers facing multiple herbicide resistance problems. Farmers were satisfied with results of this herbicide.

Effective weed control is the key for success of direct seeded rice (DSR). New DSR technique called 'Tar-wattar DSR' saved more than 20% irrigation water compared to puddle transplanted rice and have lesser weed incidence, due to dust mulching. Six demonstrations on tar-wattar direct seeded rice were conducted during *Kharif* 2020 in Fatehgarh Sahib, Moga and Bathinda districts. Tar-wattar field was first laser leveled, then pre-sowing (rauni) irrigation applied and field prepared at tar-wattar (good soil moisture) condition and primed rice sown immediately using 'Lucky seed drill' along with application of pendiemthalin 750 g/ha. First irrigation was applied at three weeks. Post-emergence herbicide bispyribac-sodium/ fenoxaprop-p-ethyl/ chlorimuron + ethoxysulfuron were applied as per weed flora in the field and hand pulling of escaped weeds. In case of transplanted rice, pretilachlor / butachlor was applied as pre-emergence and bispyribac-sodium/fenoxaprop-p-ethyl/chlorimuron + ethoxysulfuron as post-emergence depending on weed flora in the field and hand pulling of escaped weeds. Averaged over locations, tar wattar DSR recorded 87% control of wheat which was comparable to puddle transplanted rice (90%). Rice grain yield under DSR were 0.7% lower, however, net returns from DSR were similar/higher than transplanted rice, as DSR variable costs are up to ₹ 10,000/ha lower. All farmers were fully satisfied with the new technology.

At Hisar, 150 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 78% control of *Orobanche* in mustard with yield gain of 27.3% over untreated control. To show the efficacy of weed management technology in DSR during *Kharif* 2020, 39 DSR demonstrations covering 743.5 acres (297.4 ha) were conducted at farmers' fields in Kaithal, Yamuna Nagar, Sirsa, Fatehabad, Karnal, Jind, Kurukshetra and Hisar districts of state. Grain yield of rice under DSR was 64.0 q/ha as against 62.6 q/ha under puddled conventional method of transplanting. Most of the farmers were of the opinion that in spite of yield reduction or no gain of yield under DSR, this method of sowing resulted in less expenditure, saved cost of transplanting and may help to improve soil structure in the long run.

At Hyderabad, five front line demonstrations were conducted in rice during *Kharif* 2020 to popularize the integrated weed management technology at Badampalle village, Doma Mandal in Vikarabad district respectively with the technology generated at AICRP on Weed Management. IWM involving post-emergence application of pyrazosulfuron-ethyl pretilachlor 0.615 kg /ha *fb* one hand weeding at 35-40 DAT resulted in efficient weed control in early crop growth stages compared to the farmers' method. Further the manual labour requirement was less when the improved practice was adopted by the famer compared to the traditional method. This resulted in higher B: C in the range of 2.6 to 2.91 compared to farmers method where in B: C of 2.37 to 2.6 was recorded. Five front line demonstrations were conducted in cotton crop during *Kharif* 2020 to popularize the selective herbicides and integrated weed management technology in at Kamsanpalle village, Farooqnagar Mandal in Mahabubnagar district. FLDs involved pyrithiobac-sodium 62.5 g/ha + quizalofop- butyl 50 g/ha POE *fb*

intercultivation in comparison with farmers practice (pendimethalin PE followed by intercultivation at 15, 30, 45, 60 DAS). IWM involving post-emergence application of pyrithiobac-sodium 62.5 g/ha + quizalofop- butyl 50 g/ha POE *fb* intercultivation at 35-40 DAS resulted in equally efficient weed control in early crop growth stages compared to the farmers method of pendimethalin PE followed by intercultivation at 15, 30, 45, 60 DAS. Further the manual labour requirement was less when the improved practice was adopted by the famer compared to the traditional method. This resulted in higher B: C in the range of 1.25 to 1.53 compared to farmers' method where in B:C of 1.10 to 1.43 was recorded

At Thrissur, total of four FLDs were conducted at four different locations in farmers' fields on management of broad spectrum weed flora in transplanted rice with the application of ready mix combination of pretilachlor + bensulfuron methyl, 0.6 + 0.06 kg/ha at 0-6 DAT against bispyribac sodium, 25 g/ha, 15-20 DAS as farmers' practice.

At Jammu, 2 front line demonstrations were conducted in *Rabi*, 2019-20 at 8 farmers' fields of different blocks of Jammu region under irrigated conditions. In first front line demonstration, clodinafop-propargyl + metsulfuron (60+4 g/ha) at 30-35 DAS was taken as test treatment and compared farmers' practice (metribuzin 200 g/ha at 30-35 DAS). In second front line demonstration, sulfosulfuron + carfentrazone (25+20 g/ha) at 30-35 DAS was taken as test treatment and compared farmers' practice (Metribuzin 200 g/ha at 30-35 DAS). All the herbicides were applied at 30-35 DAS using 500 L water/ha. In both the front line demonstrations, the lower weed density, higher grain yield and B: C ratio was recorded 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 8.97% and 6.36% higher mean yield as compared to farmers' practice (metribuzin 200 g/ha at 30-35 DAS).

At Bhubaneswar, the study on 'Impact analysis on weed management' was carried out in munida village of sakhigopal block of Puri district. The farmers have mostly marginal holding size with medium family size. The dominant cropping systems practiced are rice - pulses / groundnut, rice - vegetables and rice - rice (irrigated patch - 20%). The major production constraints are lack of exposures, unavailability of inputs in time, weed menace and uncertainty of monsoon. The yields of the crops were low in 60% of the areas and the farmers are spending ₹ 1500 - 2150 /ha more in manual weeding. Most of the farmers are not satisfied with the traditional method of weed management.

At Udaipur, five FLDs on broad spectrum weed control in wheat during *Rabi,* 2019-20 with premix application of sulfosulfuron + metsulfuron (30 + 2 g/ha) at 35 DAS were conducted at Ghagsaand Tikyo ka khedavillage tehsil Chittorgarh and Bhadesar. The farmers' field was infested with *Phalaris minor* among the monocots *Chenopodium album, Chenopodium murale, Convolvulus arvensis, Fumaria parviflora,* 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 12.12 per cent over farmers practice wheat yield (3.96 t/ha).

Five demonstrations on weed management during *Kharif* 2020 in maize through post emergence herbicide tembotrione was conducted at village Kanthoda 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. The major broadleaf weeds in the demonstration fields were

Trianthema pertulacastrum and *Digera arvensis*. The grassy weeds were *Ecinochloa colona, Commelina benghalensis* and *Cyperus rotundus*. 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 10.71% over farmers' practice in respect of grain yield of maize.

Five demonstrations on weed management in soybean through herbicide imazethapyr + propaquizafop 75+75 g/ha PoE at 21 DAS (Tank mix) were conducted at village Ukhliya Tehsil- Nimbahera district Chittorgarh. The treatments included the recommended herbicides and farmers' practice to compare the efficacy over the farmers' practices and weed check. The minimum density and dry matter of total weeds was recorded with the treated plot. The maximum seed (660 kg/ha) and haulm yield (1.71 t/ha) of soybean over farmers practice was observed with tank mix application of imazethapyar + propaquizafop 75+75 g/ha at 21 DAS. The maximum net returns (₹ 20,207/ha) was realized with imazethapyar + propaquizafop.

Five demonstrations on weed management in blackgram through herbicide imazethapyar 100 g/ha PoE at 21 DAS was conducted at village Ukhliya Tehsil - Nimbahera district Chittorgarh. The treatments included the recommended herbicides and farmers practice to compare the efficacy over the farmers' practices and weed check. The minimum density and dry matter of total weeds was recorded with the treated plot. The maximum seed (558 kg/ha) and haulm yield (1.47 t/ha) of blackgram over farmers' practice was observed with tank mix application of imazethapyar + propaquizafop 75+75 g/ha at 21 DAS. The maximum net returns (₹ 22,675/ha) was realized with imazethapyar + propaquizafop.

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 15.3% increase in grain yield due to recommended practice over farmers practice.

At Bengaluru, five front line demonstrations were conducted during *Kharif* 2020 at Doddaballapur on weed management in maize crop by herbicides. FLDs' with respect to use of post-emergence herbicide (Tembotrione 120 g/ha + atrazine 500 g/ha) in maize has been demonstrated on the farmers' field in and around KVK, Hadonahalli, Bangalore rural districts and the beneficiaries were happy with the cost of weed management practices, savings in weeding cost over farmers' practice. Use of herbicides was found better for managing complex weed flora in maize crop. The percent increase in seed yield (6.31% over farmers' Practice) strongly suggests that, it is possible to reduce the gap between potential yield and achievable yield (at the farmers' level) through agronomic interventions, especially weed management by spraying herbicides.

At Anand, five FLDs in groundnut, fifteen in wheat were conducted at farmer fields. Application of premix herbicide clodinafop +metsulfuron-methyl 64 g/ha PoE provided effective control of complex weed flora and resulted in higher grain yield, net profit and B:C as compared to farmers practice (metsulfuron-methyl 4g/ha PoE). In soybean application of propaquizafop + imazethapyr (premix) 125 g/ha provided effective control of weed flora and resulted in higher grain yield, net profit and B:C as compared to farmers practice (Imazethapyr + imazamox (premix) 40g/ha PoE) (**Table 4.7 and 4.8**).

Table 4.7 Treatment details of weed management in soybean on farmers' field

Sl. No.	Treatment	Dose (g/ha)	Application time	Cost of input (₹/ha)
T_1	Propaquizafop 2.5% + imazethapyr (premix)	50+75	PoE	3100
T_2	Farmers practice (Imazethapyr + imazamox (premix)	70	PoE	2763

Table 4.8 Effect of weed management technology in soybean demonstrated on farmers' field

Name of the farmer	Address	Size of holding (ha)	Family size	Education status	Total income		Major cropping pattern followed
					Agriculture (₹/ha)	Other sources	
1	2	3	4	5	6		7
Vasadiya Hitendrasinh Yogendrasinh	At: Jabugam Ta: Bodeli Dist: Chhota-udepur	2.76	5	High school	1,48,000	34,000	Soybean-wheat
Vasadiya Ghanshyamsinh Abhesinh	At: Jabugam Ta: Bodeli Dist: Chhota-udepur	1.10	6	Primary	1,05,000	-	Soybean-wheat
Patel Bharatbhai Naaranbhai	At: Rampura Ta: Pavijetpur Dist: Chhota-udepur	1.60	5	Primary	85,000	-	Soybean-wheat
Patel Neel Bharatbhai	At: Raampura Ta: Pavijetpur Dist: Chhota-udepur	1.72	5	Primary	1.06,000	-	Soybean-wheat
Patel Sanjaybhai Ravjibhai	At: Umarva Ta: Pavijetpur Dist: Chhota-udepur	1.40	4	Primary	75,,000	-	Soybean-wheat

ST Station trials on weed management

AAU, Anand

ST 1 (v) Integrated weed management in summer groundnut (*Arachis hypogaea* L.)

An experiment was conducted to evaluate the efficacy of different weed management practices on weeds and yield of summer groundnut. Application of quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS recorded significantly lower density and dry biomass of monocot weeds (2.95/m^2 and 3.05g/m^2, respectively) while imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS recorded significantly lower density and dry biomass of dicot weeds (2.62/m^2 and 2.97g/m^2, respectively). Further, minimum density and dry biomass of sedges was observed under imazethapyr 150 g/ha PoE and IC *fb* HW at 20 and 40 DAS, respectively. Density and dry biomass of total weed (5.76/m^2 and 4.80 g/m^2, respectively) was recorded under imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS. With respect to weed control efficiency, imazethapyr 100 g/ha EPoE *fb* IC + HW at 40 DAS registered higher WCE of 95.5 % which was closely followed by imazethapyr + imazamox 70 g/ha EPoE (pre mix) *fb* HW at 40 DAS (93.4%), quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS (91.9), oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS (91.8%) and oxyfluorfen 180 g/ha PE *fb* imazethapyr + imazamox 100 g/ha PoE (91.1%).

Significantly higher pod yield of 3.99 t/ha and haulm yield of 5.95 t/ha were achieved under oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS as compared to quizalofop-ethyl 50 g/ha EPoE *fb* IC + HW at 40 DAS. Significantly higher seed index (37.1 g) was recorded under weedy check as compared to oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS. Maximum gross returns (₹ 2, 07,011/ha) and net returns (₹ 2, 02,799/ha) was achieved under oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS followed by oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE. With respect to benefit cost ratio, oxyfluorfen 180 g/ha PE *fb* imazethapyr 100 g/ha PoE and oxyfluorfen 180 g/ha PE *fb* IC + HW at 40 DAS recorded 3.24 and 3.22 of benefit cost ratio, respectively.

Ludhiana

ST 2 Evalaution of new herbicides in direct seeded rice

A field study to manage weeds in direct seeded rice was conducted in summer 2020. Treatment consisted

consisted of pre-mix of triafamone+ethoxysulfuron at 60.75, 67.5 and 74.25 g/ha, penoxsulam + cyhalofop-butyl 5 at 135 g/ha. All plots were sprayed with pendimethalin at 750 g/ha on the day of sowing. *Echinochloa* sp., *Digitaria sanguinalis, Leptochloa chinensis, Ammania baccifera* and *Cyperus iria* were the major weeds in the experimental field. Application of triafamone +ethoxysulfuron at 67.5 g/ha provided effective control of broad spectrum of weeds including *Echinochloa* sp., *Cyperus iria;* it was at par to its higher dose of 74.2 g and penoxsulam cyhalofop -butyl at 135 g/ha. Triafamone 20 + ethoxysulfuron at 74.25 g/ha provided highest rice grain yield which were at par to its lower dose of 67.5 g/ha and penoxsulam+cyhalofop butyl at 135 g/ha (**Table ST 1**).

ST 3 Dissipation of halosulfuron-methyl and its availability to soil enzymes and microorganisms under laboratory conditions

Dissipation, effect of application rate and physiochemical properties of soil were studied in loamy sand, sandy loam and clay loam soils at four application rates of halosulfuron-methyl viz., 67.5, 135, 202.5 and 270 g/ha. The initial residues at 3 hours after herbicide application ranged from 0.032 to 0.039 µg/g and 0.062 to 0.069 µg/g in loamy sand, sandy loam and clay loam at 67.5 and 135 g/ha, whereas, at higher application rate 202.5 and 270 g/ha, the initial residues varied from 0.091 to 0.97 µg/g and 0.122 to 0.129 µg/g, respectively. Halosulfuron-methyl residues decreased significantly over time irrespective of the soil type; and residues were below detectable limit (BDL, < 0.008 µg/g) at 45 and 60 DAA at 67.5 and 135 g/ ha, respectively whereas the residues were found to be < 0.008 µg/g at 90 DAA when applied at 202.5 and 270 g/ ha. DT_{50} for halosulfuron-methyl ranged from 14.4 to 23.3, 16.1 to 26.1 and 19.8 to 33.7 days in loamy sand, sandy loam and clay loam soil, respectively. In initial days, an inhibition was observed in microbial counts from 0 to 30 and 0 to 45 DAT at application rates of 67.5 and 135 g/ha and up to 60 DAT at application rates of 202.5 and 270 g/ha. Additionally with increase in temperature and OM content, microbial population increased significantly ($p < 0.05$) and was highest at 25±2°C as compared to 15±2 and 5±2°C.

Hisar

ST 4 Evaluation of pendimethalin (applied before sowing) in sequence with other recommended herbicides for management of *P. minor* in zero-till sown wheat

An experiment entitled "Evaluation of pendimethalin (applied one week before sowing) in sequence with other recommended herbicides for management of *P. minor* in zero-till sown wheat" was conducted to improve performance and efficacy of post emergence herbicides during *Rabi* 2019-20. Treatments consisted of sequential application of pendimethalin 1500 g/ha (one week before sowing) alone and in sequence with POE herbicides clodinafop 60 g/ha,

Table ST1 Effect of different herbicide treatments on weed density and biomass at 60 DAS in direct seeded rice

Treatment	Dose (g/ha)	Weed density (No./m²)				Weed biomass (g/m²)			Grain yield (t/ha)
		Grasses		Sedge	Broadleaf	Grass	Sedge	Broadleaf	
		E. colona	*D. sanguinalis*	*C. iria*	*A. baccifera*				
Ttriafamone +ethoxysulfuron	60.75	2.20 (4)	3.11 (9)	4.53 (20)	5.38 (28)	9.49 (89)*	9.78 (95)	6.06 (36)	3.19
Ttriafamone +ethoxysulfuron	67.5	1.24 (0.7)	2.63 (6)	2.88 (7)	3.68 (13)	6.94 (48)	4.73 (22)	4.71 (21)	6.58
Triafamone +ethoxysulfuron	74.25	1.00 (0)	2.67 (2)	2.82 (7)	3.41 (11)	6.50 (41)	5.07 (25)	4.75 (22)	6.62
Penoxsulam + cyhalofop butyl	135	1.00 (0)	1.90 (3)	2.58 (6)	1.00 (0)	5.78 (33)	5.49 (29)	4.60 (20)	6.63
Weedy check	-	3.85 (14)	3.86 (14)	4.92 (23)	5.97 (35)	31.26 (978)	10.52 (110)	8.19 (66)	2.66
LCD (P=0.05)	-	0.74	0.60	0.47	0.45	1.40	0.58	0.72	0.15

*Figures in parentheses are original means. Data was subjected to square root transformation √ (X+0.5)

sulfosulfuron 25 g/ha, sulfosulfuron+ metsulfuron (ready-mix) 32 g/ha, mesosulfuron+ iodosulfuron (ready-mix) 14.4 g/ha and pinoxaden 50 g/ha along with alone application of POE herbicides, weed free and weedy checks. Density of *P. minor* was recorded at 75 days after sowing (DAS). Phyto-toxicity in terms of chlorosis, stunting, leaf burning and epinasty was recorded at 30 & 45 DAS.

Pendimethalin applied before (one week) sowing in sequence with other recommended herbicides provided effective control of *P. minor* with lower dry weight (1.0-2.7 g/m^2) in zero till sown wheat as compared to alone application of sequential herbicides viz. clodinafop, sulfosulfuron, sulfosulfuron+ metsulfuron, mesosulfuron + iodosulfuron and pinoxaden with dry weight (12.7-17.0 g/m^2) and weedy check (27.3 g/m^2). *Rumex dentatus* density was also significantly lower with pendimethalin (0.67-2.00) as pre-emergence compared to alone application of post-emergence herbicides. Similarly, grain yield was higher with sequential application of pendimethalin (57.8-59.5 q/ha) as compared to alone applications of PoE herbicides (45.2-50.0 q/ha). No phytotoxicity on wheat crop was found with sequential application of pendimethalin.

Thrissur

ST 5 Efficacy of post emergent herbicides in transplanted rice.

An experiment on comparative efficacy of various post emergent herbicides was conducted during June to November 2020. At 60 DAP, a slight increase in tiller number could be observed and trend in various values was almost similar to that at 30 DAP (**Table ST 1**). Unweeded plot had the lowest and inferior count of 14.7 nos./hill. At 60 DAP sedges can be observed only in unweeded control (7 nos./m^2). Among grasses, *Echinochloa* was only present and BLWs were included of *Ludwigia, Sphenoclea, Hydrolea,* etc. At 60 days, out of the total weed population, 78% was BLWs, 15 % grasses and 7% were sedges. The highest WCE of 91 % was recorded in bispyribac sodium treated plots. Hand weeding, post emergent spray of bispyribac were the superior treatments with grain yield of 5.27 and 5.26 t/ha, respectively. Harvest Index was higher (0.49) and comparable in all treatments except unweeded control, where a lower value of 0.40 was registered, due to poor plant growth and yield (**Table ST 2**).

SKUAST, Jammu

ST 6 (i) Effect of crop residue and weed management practices on weed flora and yield of zero-till wheat

The experiment was conducted to study the effect of crop residue and weed management practices in zero-till wheat on weed flora dynamics and productivity of wheat in *Rabi* 2019-20. After harvesting of rice, standing rice residue was kept in residue plots and nitrogen was applied. The zero-till wheat was sown with zero-till seed cum fertilizer dirll using wheat variety HD 3086. All the herbicides were applied at 33 DAS. The waste decomposer was sprayed after sowing of wheat in respective plots.

Table ST 2 Effect of post emergent herbicide application on yield attributes of rice

Treatments	Dose	Total weeds (no./m^2)	No. of productive tillers/hill	Chaff (%)	Weed index (WI) (%)	1000 grain weight	Grain yield (t/ha)
Hand weeding	-	0.93^{e} (1)	20.2^{a}	8.66^{b}	0.0	26.5	5.27^{a}
Cyhalofop-butyl + penoxsulam	135g/ha,15-20 DAP	2.63^{bc} (7)	16.5^{b}	8.28^{b}	11.2	26.0	4.68^{b}
Butachlor + penoxsulam	2.5 L/ha (Product)	2.09^{cd} (4)	17.5^{b}	8.23^{b}	10.4	25.8	4.72^{b}
Bispyribac-sodium	25g/ha,15-20 DAP	1.63^{de} (3)	17.5^{b}	8.89^{b}	0.04	25.0	5.26^{a}
Bensulfuron methyl + pretilachlor	60g/ha+600g/ha	3.27^{b} (10)	18.2^{ab}	7.96^{b}	13.4	27.0	4.56^{b}
Unweeded control	-	9.87^{a} (97)	11.5^{c}	14.2^{a}	67.9	26.0	1.69^{c}
SD		3.27	2.94	2.40	25.5	0.67	1.34
SEm		1.33	1.19	0.98	10.4	0.28	0.54
LSD (P=0.05)		0.74	2.52	1.20	-	NS	0.44

*In a column values followed by the same alphabets do not differ significantly in DMRT.

The weed flora included *Phalaris minor, Avena spp., Ranunculus arvensis, Medicago spp., Rumex spp.* and *Anagalis arvesnsis* as major weeds and other weeds like *Vicia spp.*, and *Melilotus spp.* etc were observed in wheat. The lowest weed density as well as weed biomass of grassy and broad-leaved were observed in 125% RDN + paddy residue + waste decomposer (WD) which was statistically at par with 125% RDN + paddy residue and significantly lower than 100% RDN + paddy residue and 100% RDN. The higher nitrogen and residue retention significantly influenced the weed density and weed biomass. The higher weed control efficiency was recorded when rice residue was retained on soil surface with higher nitrogen level.

The highest grain yield as well as straw yield were observed in 125% RDN + paddy residue + waste decomposer (WD) which was statistically at par with 125% RDN + paddy residue and significantly lower than 100% RDN + paddy residue and 100% RDN. The higher nitrogen and residue retention both was significantly influenced the yield attributes and yields of wheat. All the weed management treatments recorded significantly higher plant height, number of tillers/m^2, plant dry matter at 60 DAS, yield attributes and yield of wheat as compared to weedy check. The sulfosulfuron + carfentrazone 25+20 g/ha at 30-35 DAS recorded highest grain and straw yield which was statistically at par with clodinafop-propargyl + metsulfuron (60+4 g/ha) and clodinafop-propargyl + metribuzin (54+120 g/ha). The non-significant interactions were found between nitrogen, residue and weed management treatments with growth, yield attributes, grain yield and straw yield of wheat (**Table ST 3**).

Table ST 3 Effect of Nitrogen, residue and weed management practices on yield attributes and yield of wheat (*Rabi*-2019-20)

Treatments	Panicles /m²	WCE	Grains/ panicles	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C
Nitrogen and residue management									
100% RDN* + paddy residue	413	57.0	35	36.7	3.82	5.45	23,752	51,759	2.17
125% RDN + paddy residue	455	60.3	38	38.6	4.27	6.00	24,052	60,325	2.50
125% RDN + paddy residue + Waste decomposer (WD)	461	61.0	38	38.7	4.30	6.04	24,152	60,852	2.51
100% RDN	402	48.6	34	36.5	3.52	5.23	23,752	45,796	1.92
SEm ±	9		1	0.72	0.10	0.13			
LSD (P=0.05)	33		2	NS	0.36	0.47			
Weed management practices									
Sulfosulfuron+carfentrazone (25 + 20 g/ha) at 30-35 DAS	480	76.9	39	39.2	4.37	6.20	24,440	62,019	2.54
Clodinafop-propargyl +metsulfuron (60 +4 g/ha) at 30-35 DAS	472	75.5	37	38.3	4.29	6.05	24,815	60,039	2.42
Clodinafop-propargyl +metribuzin (54 +120 g/ha) at 30-35 DAS	459	74.7	36	37.7	4.16	6.01	24,037	58,242	2.42
Control	321	0.00	32	35.3	3.08	4.47	22,415	38,433	1.71
SEm ±	14		1	0.55	0.06	0.14			
LSD (P=0.05)	49		2	1.92	0.21	0.49			
Interaction	NS		NS	NS	NS	NS			

ST 6(ii) Evaluation of post-emergence herbicides against complex weed flora in summer green gram under different tillage practices

The experiment was conducted to study the effect of tillage and post-emergence herbicides against complex weed flora in summer greengram and their effect on growth and yield of summer greengram in summer 2020. The tillage (Zero-tillage, minimum tillage and conventional tillage) treatments were kept in main plot and weed management treatment (Acifluorfen + clodinafop 245 g/ha at 3-4 leaf stage, imazethapyr 70 g/ha at 3-4 leaf stage and weedy check) were kept as sub-plot treatments. After harvesting of wheat, greengram was sown with different tillage treatments using greengram variety IPM-02-3 on 14 April 2020. The weed flora included *Digitaria sanguinalis, Dactloctenium aegyptium, Cynodon dactylon, Phyllanthus niruri, Physalis minima* and *Cyperus* spp. as major weeds in experiment field in summer greengram. Different tillage treatments had non-significant effect on total weed density and total weed biomass at 50 DAS. A application of acifluorfen + clodinafop 245 g/ha at 3-4 leaf stage recorded significantly lowest total weed density, weed biomass and higher weed control efficiency as compared to weedy check and imazethapyr 70 g/ha at 3-4 leaf stage at 25 DAS and 50 DAS. The acifluorfen + clodinafop 245 g/ha at 3-4 leaf stage recorded significantly highest grain and stover yield than weedy check. However, highest B:C was recorded in acifluorfen + clodinafop 245 g/ha and lowest with weedy check (**Table ST 4**).

Table ST 4 Effect of tillage and weed management practices on yield attributes, yield and economics of summer greengram suring Summer 2020

Treatments	No. of pods/ plant	No. of grains/ pod	1000-grain weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Tillage practice									
Zero-tillage	16.6	5.20	35.1	817	2.10	17,108	58,799	41,691	2.42
Minimum tillage	17.2	5.28	35.2	820	2.14	18,408	58,983	40,575	2.18
Conventional tillage	18.4	5.34	35.5	839	2.23	20,908	60,366	39,458	1.87
SEm ±	0.47	0.12	0.54	23	0.045	-	-	-	-
LSD (p=0.05)	NS	NS	NS	NS	NS	-	-	-	-
Weed management practice									
Acifluorfen + clodinafop 245 g/ha at 3-4 leaf stage	20.4	5.59	36.21	945	2.50	18,735	68,034	49,299	2.66
Imazethapyr 70 g/ha at 3-4 leaf stage	19.0	5.50	35.7	918	2.43	20,430	66,035	45,605	2.25
Weedy check	12.8	4.73	34.1	613	1.55	17,260	44,079	26,819	1.56
SEm ±	0.54	0.09	0.49	18	0.04	-	-	-	-
LSD (P=0.05)	1.67	0.26	1.50	54	0.15	-	-	-	-
Interaction	NS	NS	NS	NS	NS	-	-	-	-

Bhubaneswar

ST 7 Weed management in rainfed transplanted finger millet

An experiemnt was conducted to evaluate effect of pre and post emergence herbicides on growth, productivity and economics of finger millet and its residual effect on succeeding mustard crop. The predominant weed flora in the experimental site was *Echinocloa crusgalli, Dactyloctenium aegyptium* and *Elusine indica* among grasses, *Cyperus rotundus* and *Cyperus iria* among sedges, *Commelina bengalensis, Ageratum conyzoids, Oldendandia*

corymbosa among broad leave weeds. Pre-emergence application of bensulfuron-methyl + pretilachlor 0.660 kg/ha at 2 DAT *fb* 2, 4 D Ethyl Ester 0.50 kg/ha 30 DAT significantly reduced the weed population and dry matter production (g/m^2). The yield of finger millet was higher in case of application of bensulfuron methyl + pretilachlor 0.660 kg/ha at 2 DAT *fb* 2, 4 D Ethyl Ester 0.50 kg/ha 30 DAT in comparison to other treatments (**Table ST 5**).

Udaipur

WP ST 8 Effect of weed management practices on weed dynamic, yield of Isabgol (Plantago ovata Forsk) and germination of succeeding crop

The experiment was conducted to study the bio-efficacy of different herbicides against weeds and their effect on growth and yield of isabgol and to study the phytotoxic effects.

Table ST 5 Effect of different treatments on weeds and yield of finger millet

Treatment	Weed density (g/m^2)			Weed biomass (g/m^2)			Yield (t/ha)	Net returns (₹/ha)	B:C
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
Mechanical weeding at 20 DAS	9.45 (89.0)	13.88 (192.3)	9.15 (83.7)	8.62 (74.0)	8.87 (78.2)	4.21 (17.32)	2.12	18,742	1.49
Pre-eme butaclor 500 g/ha *fb* mechanical weeding at 45 DAS	7.49 (55.7)	10.50 (110.0)	8.19 (66.7)	7.23 (52.0)	5.96 935.1)	3.21 (9.80)	1.88	20,204	1.80
Pre-eme pendimethalin 0.75 kg/ha at 2 DAT *fb* mechanical weeding at 45 DAS	6.91 (47.3)	9.14 (83.3)	7.03 (49.0)	6.22 (38.3)	4.81 (22.7)	2.55 (6.03)	2.44	19,945	1.69
Pre-eme pretilachlor 6.25 g/ha at 2 DAT *fb* mechanical weeding at 45 DAS	8.64 (74.3)	12.06 (145.7)	8.42 (70.3)	7.77 (60.0)	7.72 (59.4)	3.50 (11.75)	2.50	21,245	1.59
Pre-eme bensulfuron methyl + pretilachlor 0.660 kg/ha at 2 DAT	6.03 (36.0)	7.14 (50.7)	6.08 (36.6)	9.30 (86.0)	2.62 (6.38)	1.63 (2.16)	2.64	24,651	1.82
Pre-eme of pendimethalin 0.75 kg/ha at 2 DAT *fb* 2,4 D Ethyl Ester 0.50 kg/ha 30 DAT	5.81 (33.3)	6.65 (44.0)	5.54 (30.3)	8.95 (79.7)	2.42 (5.37)	1.46 (1.64)	2.47	26,351	1.62
Pre-eme pretilachlor 0.625 kg/ha at 2 DAT *fb* 2,4 D Ethyl Ester 0.50 kg/ha 30 DAT	4.69 (21.7)	5.80 (33.33)	4.10 (16.33)	7.00 (49.7)	2.07 (3.81)	1.17 (0.87)	2.74	27,514	1.86
Pre-eme bensulfuron methyl + pretilachlor 0.660 kg/ha at 2 DAT *fb* 2,4 D Ethyl Ester 0.50 kg/ha 30 DAT	4.29 (18.0)	5.36 (28.33)	3.45 (11.67)	5.86 (34.0)	1.88 (3.03)	1.08 (0.67)	2.85	32,654	2.21
Pre-eme butachlor 500 g/ha *fb* 2,4 D Ethyl Ester 0.50 kg/ha 30 DAT	5.58 (30.7)	6.32 (39.7)	4.89 (23.7)	8.03 (64.7)	2.38 (5.19)	1.26 (1.09)	2.76	28,451	2.01
Weed free	3.97 (15.3)	4.65 (21.33)	0.71 (0.00)	2.60 (6.33)	1.59 (2.05)	0.71 (0.00)	2.90	37,452	1.78
SE(m)±	0.11	0.19	0.11	0.08	0.11	0.08	0.25	-	-
LSD (P=0.05)	0.34	0.55	0.33	0.24	0.31	0.24	0.84	-	-

The major weed populations were viz., *Chenopodium album* (34.3%), *Chenopodium murale* (28.2%), *Fumaria parviflora* (10.3%), *Convolulus arvensis* (9.1%) and *Melilotus alba* (9.0%). Whereas, *Phalaris minor* (9.1 %) was the only monocot weed at 30 DAS. Among the various weed control treatments in isabgol, pendimethalin 750 g/ha recorded the lowest density of weeds at 60 DAS as compared to other chemical weed control treatments (**Table ST 6**). At 7 DAHA both levels of pendimethalin gave severe setback to isabgol crop by causing complete destruction of the crop plant at pendimethalin 750 g/ha and very few plants were alive at pendimethalin 500 g/ha under non recovery zone. Oxyfluorfen as PE, oxadiargyl PE and sulfosulfuron PE also gave setback to isabgol crop by causing injury more pronounced but injury was not persisted after 21 DAS.

Table ST 6 Effect of treatments on growth, yield attributes and yield of isabgol

Treatment	Dose (g /ha)	Application stage (DAS)	Plant height (cm)	No. of spikelets per plant	Length of spike (cm)	Grain yield (Kg/ha)	Straw yield (kg/ha)
Pendimethalin	500	PE(0-3DAS	0.00	0.00	0.00	0	0
Pendimethalin	750	PE	0.00	0.00	0.00	0	0
Sulfosulfuron	25	PoE (25 DAS)	32.8	21.0	4.59	608	1.42
Sulfosulfuron	25	PE	30.5	29.1	4.81	464	1.54
Oxadiargyl	100	PoE (25 DAS)	29.6	20.1	4.86	534	1.62
Oxadiargyl	100	PE	33.0	29.7	6.00	738	1.71
Oxyfluorfen	75	PoE (25 DAS)	8.34	19.9	4.19	342	0.95
Oxyfluorfen	75	PE	27.9	23.8	5.13	432	1.01
Weed free	-	(2 HW at 25 & 45 DAS)	34.2	33.2	6.48	782	2.13
Weedy check	-	-	25.0	13.1	3.28	378	0.65
SEm ±			1.29	1.14	0.23	26	0.06
LSD (P = 0.05)			3.83	3.38	0.67	77	0.19

Bengaluru

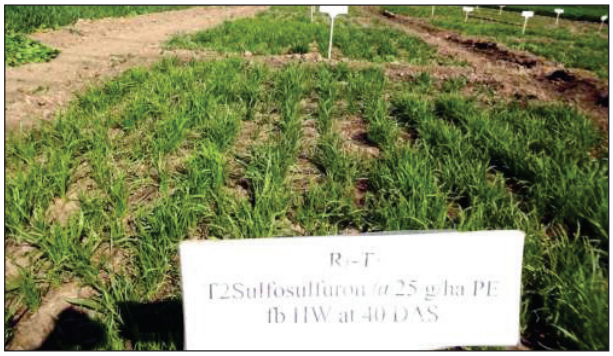
ST 9 (i) Evaluation of pre-emergent herbicides in Kodo millet (*Paspalum scrobiculatum)*

The field experiment was conducted during *Kharif 2020* to know the bioefficacy of pre emergent herbicide against complex weed flora and their effect on growth and yield of Kodo millet. Apart from screening pre-emergent herbicides, phytotoxiciity of the herbicides on weed control and crop toxicity ratings, if any were recorded.

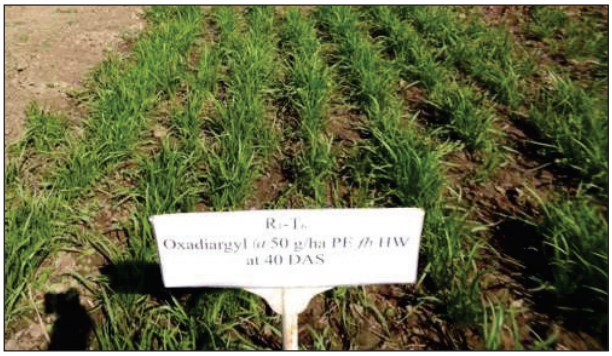
PE application of bensulfuron methyl +pretilachlor at 165 g/ha and 330 g/ha and pendimethalin at 680 g and 1000 g/ha did not cause any crop toxicity. In plots treated with oxadiargyl at both the dose 50 and 75 g/ha there was delay in germination compared to other treatments and crop toxicity was observed only at initial stages, later crop recovered. In butachlor, only 40-50 % germination was recorded and plant stand was very poor. In atrazine treated plot, at higher dose 500 g/ha early crop toxicity (7 DAHS) was observed compared to lower dose 250 g/ha (toxicity was observed at 10 DAHS). Leaf burning was observed which pronounced, became persistent and not recovered and caused destruction of crop or only few plants were survived.

The important weed flora in kodo millet in *Cyperus rotundus*, *Cynodon dactylon, Digitaria marginata, Dactyloctenium egyptium; Eichinocloa colona, Bracheria repen, Elucine indica, Ageratum conyzoides, Alternanthera sessilis, Borreria hispida, Commelina benghalensis*, *Phyllanthus niruri*; *Spilanthes acmella Oldenlandia corymbosa,* etc.

Pre emergence herbicides application of bensulfuron methyl +pretilachlor at both the dosage recorded lower weed count in sedges, grasses and broad leaf weeds and lower total weed dry weight at 30



Sulfosulfuron 25 g/ha PE



Oxadiargyl 100 g/ha PoE

Oxadiargyl 100 g/ha PE

Weedy check

Sulfosulfuron 25 g/ha PoE

Oxyfluorfen 75 g/ha PE

Fig. ST 1 Effect of treatments on weed density and growth of Isabgol

60 and at 90 days of crop and pendimethalin at 680 and 1000 g/ha recorded lower weed count in sedges and grasses which was on par with two hand weeding at 20 and 40 DAS. Highest seed and straw yield was recorded in hand weeding which recorded 2.03 t/ha, which was on par with application bensulfuron-methyl +pretilachlor at both the dosage at 165 g/ha and 330 g/ha and pendimethalin at 680 and 1000 g/ha (**Table ST 7**). Reasonable reduction in the density of weeds and noticeable reduction of weed flora was observed in pre emergence application of bensulfuron methyl + pretilachlor at both the dosage at 165 g/ha and 330 g/ha and pendimethalin at 680 and 1000 g/ha. These herbicides can be recommended for controlling weeds effectively in Kodomillet as pre-emergent herbicides.

Table ST 7 Grain yield as influenced by different pre-emergent herbicides in irrigated Kodo Millet (*Paspalum scrobiculatum*) sown during *Kharif* 2020

Pre-emergence Treatments	Dose g/ha	Formulation (g/ha)	Plant height (cm)	Number of tillers/plant	Number of productive tillers/plant	Grain yield (t/ha)	Straw yield (t/ha)
Oxadiargyl	50	63	64.2	7	6	1.56	2.39
Oxadiargyl	75	94	65.2	6	5	1.71	2.19
Bensulfuron -methyl + pretilachlor	165	2500	75.9	10	10	1.54	2.22
Bensulfuron -methyl + pretilachlor	330	5000	76.3	11	11	1.87	2.43
Butachlor	750	1500	59.8	6	5	0.93	0.50
Butachlor	1000	2000	63.4	6	4	0.92	2.34
Pendimethalin	680	1757	75.6	9	8	1.60	2.04
Pendimethalin	1000	2584	76.2	12	11	1.50	2.67
Atrazine	250	500	53.3	6	5	0.42	0.50
Atrazine	500	1000	54.4	5	4	0.55	0.63
Two hand weeding	NA	20 & 40 DAS	76.6	12	11	2.03	2.73
Weedy check		NA	57.8	5	4	0.73	2.05
SEm ±			3.32	0.89	0.80	0.49	0.37
LSD (P=0.05)			6.94	1.87	1.68	1.02	0.78

NA: Not applicable

ST 9 (ii) Evaluation of post- emergent herbicide in Kodo millet (*Paspalum scrobiculatum)*

This experiment was conducted to study the bio-efficacy of different post emergent herbicides against weeds and their effect on growth and yield of Kodomillet and to study the phytotoxic effects on the crop, if any. All herbicides were applied when the weeds were 2-3 leaf stage, which coincided with 17 days after sowing. The major weed species found were *Cyperus rotundus*, *Cynadon dactylon, Digitaria marginata, Brachiaria ramose, Dactyloctenium aegyptium*, *Elucine indica, Echinochloa colona*, *Ergostris pilosa, Chloris barbata, Borreria hispida, Commelina benghalensis, Mimosa pudica, Oldenlandia corymbosa,* etc.

Among the herbicides, application of tembotrione at both the dosage 60 and 120 g/ha showed slight discoloration of leaves from 3 DAHS. The symptom in both the dosage of herbicide spray persisted up to 30 DAHS. However the crop recovered fully after 30 days after herbicide spray (DAHS). Cyhalofop -butyl at both the dosage exhibited mild wilting symptom for few days after herbicide spray, later the crop recovered. Application of metsulfuron-methyl +chlorimuron-ethyl 4 g/ha gave good control of weeds followed by bispyribac sodium 25 g/ha, 2 4 D sodium salt 750 g/ha and ethoxysulfuron 18.75 g/ha. Post-emergence herbicides application of metsulfuron-methyl +chlorimuron-ethyl 4 g/ha followed by 2, 4-D sodium salt at 750g/ha, bispyribac-sodium at 25 g/ha recorded lower weed count in sedges, grasses and broad leaf weeds at 30 60 and at 90 days of crop which was on par with two hand weeding at 20 and 40 DAS. Cyhalofop-butyl, fenoxaprop-ethyl at both the dosages was not effective in controlling the weed flora. (**Table ST 8**).

Application of tembotrione at both the dosage at 60 and 120 g/ha gave excellent weed control throughout the crop growth and was also significant over weedy check, due to its phytotoxicity on the crop, the herbicide is not considered for recommendation. Weed dry weight as influenced by application of different post emergence herbicides in Kodo millet recorded significantly lower sedges, narrow leaf weeds and broad leaf weeds at 30 DAS. Plots treated with metsulfuron methyl +chlorimuron-ethyl 20 g/ha, 2, 4-D sodium salt at 750 g/ha, bispyribac- sodium at 25 g/ha recorded significantly lower total weed dry weight 1.69, 1.84 and 2.11 g/ m^2 compared to weedy check (3.69 g/m^2). Highest seed yield was recorded in hand weeding which was on par with application of broad spectrum herbicides like metsulfuron-methyl + chlorimuron-ethyl at 4 g/ha (1.79 t/ha), 2,4 D sodium salt 750 g/ha (1.32 t/ha) followed by bispyribac sodium

Table ST 8 Growth parameters at harvest and yield as influenced by different post emergent herbicides in irrigated Kodo Millet (*Paspalu scrobiculatum*) sown during *Kharif* 2020

Treatments	Dose g/ha	Formulation (g/ha)	Plant height (cm)	Number of tillers/plant	Number of productive tillers/plant	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac-sodium	15	150.0	67.3	10	9	0.58	1.25
Bispyribac-sodium	25	250.0	70.8	10	10	1.30	2.09
Cyhalofop-butyl	50	500.0	65.0	10	10	0.68	2.18
Cyhalofop-butyl	75	750.0	68.0	11	10	0.78	1.46
Fenoxaprop-ethyl	30	300.0	70.1	10	9	1.05	1.47
Fenoxaprop-ethyl	60	600.0	67.8	10	9	0.89	0.92
Metsulfuron-methyl + chlorimuron ethyl (2+2)	2	10.0	65.7	10	9	1.23	1.62
Metsulfuron-methyl + chlorimuron (2+2)	4	20.0	73.1	11	11	1.79	2.14
Tembotrione	60	142.9	65.6	11	11	0.84	1.49
Tembotrione	120	285.7	65.7	11	11	0.98	1.57
2 4 D sodium salt	750	937.5	70.4	11	10	1.32	2.08
2 4 D sodium salt	500	625.0	66.7	10	9	0.57	1.29
Ethoxysulfuron	9.5	63.3	68.9	10	9	0.80	1.62
Ethoxysulfuron	18.7	125.0	69.3	10	9	0.96	1.21
Two hand weeding at 20 & 40 DAS	-	-	70.8	11	11	1.70	2.04
Un weeded check	-	-	68.7	11	7	0.54	0.61
SEm ±			1.44	0.73	0.74	0.37	0.39
LSD (P=0.05)			4.16	NS	2.16	0.76	0.79

NA: Not applicable

at 25 g/ha (1.30 t/ha). These herbicides can be recommended for controlling weeds effectively in Kodomillet, at 2-3 leaf stage.

ST 9 (iii) Evaluation of post- emergent herbicide in foxtail millet (*Setaria italic* (L.) P. Beauv

The experiment was initiated during *Kharif* 2020 to study the bio-efficacy of different preemergent herbicides against weeds and their effect on growth and yield of Kodomillet. The major weed species found were *Cyperus rotundus, Cynadon dactylon, Digitaria marginata, Echinochloa colona, Dactyloctenium aegyptium, Elucine indica, Borreria hispida, Commelina benghalensis, etc.* Post emergence herbicides application of metsulfuron-methyl + chlorimuron-ethyl 4 g/ha followed by 2, 4-D sodium salt at 1000 g/ha, bispyribac sodium 10 EC at 20 g/ha recorded lower weed count at 30, 60 and 90 DAS which was found on par with mechanical weeding by cycle weeder at 20 and 40 DAS. Ethoxysulfuron at both the dosages and lower dosage of bispyribac sodium, metsulfuron-methyl +chlorimuron-ethyl and 2, 4-D sodium salt were not effective in controlling the weed flora.

Plots treated with metsulfuron-methyl +chlorimuron-ethyl 4 g/ha, 2, 4-D sodium salt at 1000 g/ha, bispyribac sodium at 20 g/ha recorded significantly lower total weed dry weight, which was on par with two hand weeding and mechanical weeding at 20 and 40 DAS. However at lower dosage of the herbicides and unweeded check recorded higher dry weight over the same herbicides tried at higher dosage, indicating the dosage tried was ineffective in controlling weeds in fox tail millet.

Plant height was significant at harvest. Plots treated with metsulfuron-methyl +chlorimuron-ethyl 4 g/ha (74.8 cm) 2, 4-D sodium salt at 1000 g/ha (73.2 cm), bispyribac- sodium at 20 g/ha (65.2 cm) recorded

highest plant height and found on par with hand weeding (71.5 cm). Plant height (59.1 cm) was lowest in unweeded check (**Table ST 9**).

The number of productive tillers was found high in plots treated with application of post emergence application of with metsulfuron-methyl +chlorimuron-ethyl 4 g/ha and 2, 4-D sodium salt at 1000 g/ha found on par with hand weeding at 20 and 40 Days after sowing in comparison with weedy check. Grain yield and straw yield were found significant, indicating that the herbicides used for screening for fox tail had no adverse effect on yield of grain and straw. Highest grain yield 0.722 t/ha was recorded in hand weeding which was on par with metsulfuron-methyl + chlorimuron-ethyl at 4 g/ha (0.570 t/ha), 2,4-D sodium salt 1000g/ha (0.674 t/ha) followed by bispyribac-sodium at 20 g/ha (0.405 t/ha). The straw yield was also found significant due to application of post emergent herbicides.

From the preliminary screening experiment of the post-emergence herbicides in Foxtail millet, it is understood that reasonable reduction in the density of weeds and noticeable reduction of weed flora was observed in post emergence application of metsulfuron-methyl + chlorimuron-ethyl P at 4g/ha, 2, 4-D sodium salt 1000g/ha followed by bispyribac sodium at 20g/ha. These herbicides can be recommended for controlling weeds effectively in fox tail millet as post emergent herbicide. However, testing bispyribac sodium at 20g/ha may give better weed control, but need to be evaluated for phytotoxicity.

Guntur

ST 10 Evaluation of pre and post-emergence herbicides combinations for selectivity and broad spectrum weed control in bengalgram

Evaluation of pre and post-emergence herbicides combinations for selectivity and broad spectrum weed control in bengalgram was done in *Rabi* 2019-20. Pre-emergence application of pendimethalin + imazethapyr 750 + 50 g/ha alone gave on par grain yield (3.02 t/ha) with hand weeding at 20 & 40 DAS (3.04 t/ha). The grain yield recorded with treatments pendimethalin 0.75 kg/ha PE fb acifluorfen + clodinafop 0.165 + 0.080 kg/ha POE yield (2.88 t/ha) and pendimethalin + imazethapyr 0.56+0.038 kg/ha PE *fb* hand weeding 20 DAS (2.66 t/ha) was also on par with hand weeding treatment (**Table ST 10**).

BUAT, Banda

ST 11 Studies on time of application of imezathapyr and its ready mix combination with imazamox (Odyssey) against weeds in blackgram and their carryover effect on succeeding mustard.

A field experiment was conducted during 2019-20 in blackgram. Carry over effect of herbicides applied in blackgram was visible on succeeding

Table ST 9 Growth parameters at harvest and yield as influenced by different post emergent herbicides in Foxtail millet (*Setaria italica*) sown during *Kharif* 2020

Treatments	Dose g/ha	Formulation (g/ha)	Plant height (cm)	Number of productive tillers/plant	Seed yield (t/ha)	Straw yield (t/ha)
Bispyribac-sodium	15	150	63.5	2	0.09	0.59
Bispyribac-sodium	20	200	65.2	2	0.40	0.51
Metsulfuron + chlorimuron (2+2)	3	15	69.5	1	0.11	0.61
Metsulfuron + chlorimuron (2+2)	4	20	74.8	2	0.50	0.69
2 4-D sodium salt	1000	1250	73.2	2	0.67	0.53
2 4-D sodium salt	500	625	72.6	1	0.07	0.29
Ethoxysulfuron 15	10	67	71.1	1	0.09	0.35
Ethoxysulfuron 15	15	100	67.9	1	0.10	0.40
Two hand weeding at 20 & 40 DAS	-	-	71.5	2	0.72	0.69
Mechanical weeding by cycle weeder at 20 and 40 DAS	-	-	69.0	1	0.70	0.67
Un weeded check	-	-	59.1	1	0.10	0.40
SEm ±	15	150	2.91	0.13	0.03	0.04
LSD (P=0.05)	20	200	8.6	0.40	0.11	0.12

NA: Not Applicable

Table ST 10 Influence of weed control treatments on bengalgram crop and weed parameters during *Rabi* 2019-20

Treatments	Crop injury score				Weed dry weight 30 DAS (g/m²)	WCE (%)	Plant height (cm)	No. of branches /plant	No.of pods/ plant	100 seed weight (g)	Grain yield (t/ha)
	PE herbicides		POE herbicides								
	7 DAS	14 DAS	7 DAS	14 DAS							
Pendimethalin + imazethapyr 0.75+0.050 kg/ha PE	0	0	-	-	4.08 (16.6)	96.7	43.7	2.5	36.0	29.1	3.02
Pendimethalin + imazethapyr 0.56+0.038 kg/ha PE	0	0	-	-	10.4 (110.7)	78.6	42.4	2.1	20.9	26.7	1.50
Pendimethalin + imazethapyr 0.56+0.038 kg/ha PE *fb* quizalofop ethyl 0.05 kg/ha POE	0	0	0	0	10.3 (109.7)	79.1	42.2	2.1	26.7	26.7	1.83
Pendimethalin + imazethapyr 0.56+0.038 kg/ha PE *fb* 20 DAS	0	0	-	-	14.4 (208.0)	60.0	42.4	2.2	27.0	27.9	2.05
Pendimethalin + imazethapyr 0.56+0.038 kg/ha PE *fb* HW 20 DAS	0	0	-	-	4.50 (20.0)	96.1	47.3	2.4	31.5	29.2	2.66
Pendimethalin 0.75 kg/ha PE *fb* quizalofop ethyl 0.05 kg/ha POE	0	0	0	0	14.2 (207.3)	63.2	41.9	1.6	27.8	25.5	1.98
Pendimethalin 0.75 kg/ha PE *fb* acifluorfen + clodinafop 0.165 + 0.080 kg/ha POE	0	0	2	-	4.85 (24.1)	95.8	46.4	2.7	37.8	29.1	2.88
Hand weeding 20 & 40 DAS	-	-	-	-	4.87 (24.6)	95.6	50.1	3.2	47.5	29.5	3.04
Weedy check	-	-	-	-	23.3 (548.0)	-	33.0	1.2	15.5	24.2	1.24
SEm±					1.04	4.451	1.93	0.36	2.42	0.77	0.23
LSD (P=0.05)					3.12	13.5	5.8	1.2	7.3	2.3	0.71

Note: Data on dry weight of weeds was subjected to $\sqrt{x+0.05}$ transformation. Figures in parenthesis are the original values.
DAS: Days after sowing.

mustard crop during crop growth stage. The maximum plant stand (1.6 lakh) and plant height at both stages were recorded with treatment hoeing twice, while minimum plant stand (1.1 lakh), plant height (81.5 cm & 110.9 cm) was recorded from plot treated with imazethypyr + imazamox (RM) 80 g (3-4 leaf stage). Similar trends were followed in case of yield attributes and yield of mustard. Maximum seed yield of 22.9 q/ha obtained from imazethypyr + pendimethalin (RM) 1000 g PE while minimum (13.8 q/ha) from Imazethypyr + imazamox (RM) 80 g (3-4 leaf stage) (**Table ST 11**).

Karaikal

ST 12 Comparative evaluation of different formulations of 2,4- D for brown manuring in rice

A pot culture study was conducted in October 2020 to study the effect of different formulation of 2, 4-D formulation (sodium salt, ethyl ester and methyl amine)

Table ST 11. Effect of weed management practices applied in Blackgram (Preceding Crop) on mustard (Succeeding crop)

Treatments	Dose (g/ha)	Plant population (L/ha) at 60 DAS	Plant height (cm)		Number of primary branches/ plant	Number of secondary branches /plant	Siliquae/ plant	Seed weight (g)/plant	Seed yield (q) /ha
			60 DAS	At harvest					
Imazethypyr	60 g	0.1	125.0	176.9	4.9	13.0	452.6	18.7	18.0
Imazethypyr	50 g	1.4	143.2	177.6	4.9	13.3	476.3	19.7	18.0
Imazethypyr	60 g	1.4	115.0	170.2	5.4	20.5	556.2	21.4	17.9
Imazethypyr	50 g	1.3	132.7	174.3	5.3	20.3	455.1	18.2	18.5
Imazethypyr + Imazamox (RM)	60 g	1.2	117.0	167.2	5.3	19.7	434.8	19.3	15.7
Imazethypyr + imazamox (RM)	50 g	1.2	120.7	161.5	5.9	19.9	417.6	18.2	14.0
Imazethypyr + imazamox (RM)	60 g	116.9	86.2	116.9	4.4	12.3	400.3	17.5	13.9
Imazethypyr + imazamox (RM)	1000 g	110.9	81.5	110.9	4.0	11.7	384.7	16.7	13.8
Pendimethalin	1000 g	1.6	125.0	160.4	5.2	17.3	626.9	21.0	22.5
Imazethypyr + pendimethalin (RM)	-	175.7	133.2	175.7	5.3	18.7	625.1	22.0	22.9
Hoeing (2)	-	1.6	132.5	178.0	5.3	17.0	559.1	20.7	19.6
Weedy check	-	1.4	110.3	149.2	4.3	14.0	387.2	18.8	18.1
Weed free	-	1.5	109.3	159.9	5.8	20.4	579.9	22.3	21.2
SEm ±	-	0.1	6.1	7.8	0.5	2.3	41.9	1.3	0.58
LSD (P=0.05)	-	0.3	18.0	22.9	1.5	6.8	123.0	3.8	1.70

for brown manuring. Rice cultivar (Improved white ponni) was chosen as a research crop in wet seeded method in first week of October. Later, different formulations of 2, 4-D were sprayed at 35 DAS. The total amount of spray fluid used was 375lit. At final stage, the density of weed, *Sesbania aculaeta* (daincha) was observed (55 DAS) and plant height was also taken.

Among the different combinations of herbicide used, 2,4-D ethyl ester showed pronounced symptom on daincha plant from 2nd day onwards after herbicide application. Full efficiency of herbicide on daincha was observed from 20th day onwards. Likewise, 2, 4-D methyl amine started to show symptoms from 4th day onwards, but 2,4 – D sodium salt has less effect on daincha when compared to both 2,4 - D ethyl ester and 2,4 - D methyl amine. Higher daincha plant population (19.7 and 34.5 no./m^2) were observed with 2,4-D sodium salt. Lower weed density under 2,4-ethyl ester resulted in higher plant height (70.8 cm).It can be concluded that 2,4- D ethyl ester and 2,4 - methyl amine at 0.5 kg/ha were found to be more effective for brown manuring in direct seeded rice **(Table ST 12).**

Table ST 12. Effect of different formulations of 2,4-D for brown manuring in DSR

Treatments	*Sesbania aculaeta* density (no./m^2) at 55 DAS	Other weeds density (no./m^2) at 55 DAS	Rice height (cm)
Rice co-culture with sesbania sp.+2,4-D sodium salt 0.5 kg/ha	19.7	15.7 (246.0)	66.7
Rice co-culture with sesbania sp. +2, 4-D ethyl ester 0.5 kg/ha	0	14.5 (211.7)	70.8
Rice co-culture with sesbania sp. +2,4-D methyl amine 0.5 kg/ha	0	15.1(236.3)	64.6
Sesbania sp. alone +2,4-D sodium salt 0.5 kg/ha	34.5	16.5 (275.7)	-
Sesbania sp. alone +2,4- D ethyl ester 0.5 kg/ha	0	14.3(206.7)	-
Sesbania sp. alone +2,4- D methyl amine 0.5 kg/ha	0	15.8(251.0)	-
Rice alone (without 2,4-D spraying)	0	21.8 (482.7)	68.7
LSD (P=0.05)	8.00	3.72	

*Original figures in parenthesis were subjected to square root transformation ($\sqrt{x+0.05}$) before statistical analysis

AAU, Jorhat

ST 13 Monitoring of weed shifts in deepwater paddy under different water regimes

A study was conducted to study the weed shifts under the regime of climate change in collaboration with the Department of Agro-meteorology, AAU, Jorhat to determine the dominance spectrum of weed flora and specific weed flora shifts of weep water paddy in three different water regimes to monitor the location.

Study area as per water regimes:

S.No.	Water level during flood	Districts
1.	Up to 3m	Dhemaji and Lakhimpur
2.	1 to 2 m	Jorhat, Majuli and Sivasagar
3.	70 cm to 1 m	Erstwhile Kamrup

Deep water paddy was surveyed in and around Greater Hajo, where the average ponded water varied between 70cm to 100cm. The study area was a closed ecosystem and not connected to any river system. *Ranga Bao* is one of the most commonly cultivated varieties of deep water paddy in this area. The broadleaved weeds were represented by more than 11 species, including a variety of *Nymphaea* species and *Ceratophyllum-Utriculkaria* complex comprising of species like *Ceratophyllum demersum, Utricularia bifida* and green algae like *Chara* and *Nitella* which possessed vary much vegetative mimicry. Similar study conducted in 2006 recorded four numbers of weeds (all BLWs) in deepwater paddy fields in earstwhile Kamrup district, including the Hajo area, namely *Alternanthera philoxeroides, Ludwigia adscedens, Leersia hexandra* and *Sacciolepis interrupta.* All these species found prevailing in 2020 also. However weed species was found to be increased in the deepwater paddy fields during last 15 years. Presence of *Cyperus esculenta* is another worth mentioning incidence, as this weed has very restricted distribution in Assam.

At Jorhat district, *Ceratophyllum-Utricularia* complex recorded the maximum density followed by *Isachne himalaica* and *Hydrilla verticillata.* The overall dominance in the deepwater paddy fields of Jorhat at post flood situation was shown by the sedge *Acctinoscirpus grossus* (IVI=63.93) followed by *Ceratophyllum-Utricularia* complex (IVI=40.05) and *Isachne himalaica* (IVI=23.35). Major weed shift at Jorhat was appearance of *Butomopsis latifolia* and *Actinoscirpus grossus* as a weed which presence were not recorded in this crop in 2004-05. At Sivasagar district the highest level of ponded water in deepwater paddy fields in Sivasagar district was varied between 150 cm to 200cm. Most of the study area was an open ecosystem and connected to the river Brahmaputra during high flood, although few closed areas were also recorded. *Bodol, Amona, Ranga Bao* etc. were the most commonly cultivated varieties of deepwater paddy in this district.

In Kamrup, Jorhat and Sivasagar districts, *Ceratophyllum-Utricularia* complex represented with the highest density. The dominance pattern of broadleaved and narrow leaved weeds in the deepwater paddy at post flood situation found to be highly influenced by the maximum limit of ponded water. At Jorhat, the importance value index of broadleaved weeds was increased (from 62% to 81%), while that of sedge weeds was declined (from 19% to 3%) along with the increase of ponded water in the deepwater paddy fields (**Fig. ST 1**).

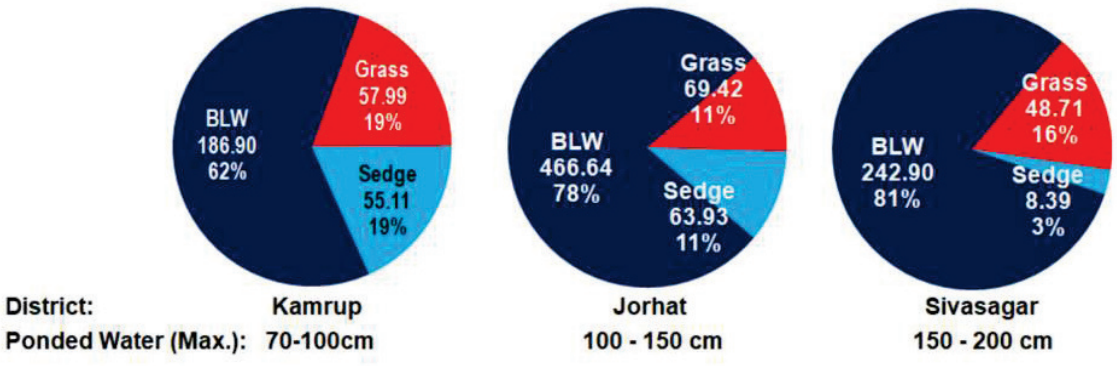


Fig ST 1 Dominance spectrum of grass, sedge and broadleaved weeds in deepwater paddy fields of Kamrup, Jorhat and Sivasagar districts at post flood situation during 2020

4. RECOMMENDATIONS FOR PACKAGE OF PRACTICES

AAU, Anand

- Treatment combination of zero tillage with residue in cotton followed by zero tillage with residue in greengram and application of 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 in cotton and imazethapyr 75 g/ha *fb* HW at 30 DAS in greengram recorded higher seed cotton yield (2.93 t/ha) and recommend under PoP.
- Following technology for management of complex weed flora in summer groundnut is recently included in state package of practices for the groundnut growers of the state.
  - Pre-emergence (2-3 DAS) application of oxyfluorfen 180 g/ha *fb* post-emergence (25-30 DAS) application of imazethapyr 100 g/ha.
  - Pre-emergence (2-3 DAS) application of oxyfluorfen 180 g /ha (15.3 ml/10 litre of water) *fb* post-emergence (25-30 DAS) application of imazethapyr + imazamox (premix) 70 g /ha.
  - Pre-emergence (2-3 DAS) application of oxyfluorfen 180 g/ha (15.3 ml/10 litre of water) *fb* interculturing and hand weeding at 40 DAS.
  - Early post-emergence (10-15 DAS) application of imazethapyr 100 g/ha (20 ml/10 litre of water) *fb* interculturing and hand weeding at 40 DAS.
  - Early post-emergence (10-15 DAS) application of fluazifop-p-butyl + fomesafen (premix) 250 g/ha *fb* interculturing and hand weeding at 40 DAS.
- Application of sulfosulfuron 50 g/ha at 45 DAT *fb* 50 g/ha at 90 DAT in tomato has found effective for the control of *Orobanche* with higher tomato fruit yield (74.7 t/ha) and B:C (1.83).
- Application of glyphosate 25 g/ha at 25 DAT *fb* 25 g/ha at 60 DAT found less phytotoxic (5%) with 62% control of *Orobanche*, higher brinjal fruit yield (42.1 t/ha) and B:C ratio (2.22).
- Application of oxyfluorfen 120 g/ha PE found effective for *Cuscuta* control without any phytotoxicity on onion crop with higher onion bulb yield (45.7 t/ha) and B:C (3.53).

CCSHAU, Hisar

- Application of penoxsulam + butachlor 800 ml/acre at 0-7 DAT as spray in 120 L water under saturated moist field conditions is recommended to control complex weed flora in transplanted rice. Apply irrigation in field one day after herbicide application.

GBPUAT, Pantnagar

- Apply bispyribac-sodium 20 g/ha or penoxsulam 20-22.5 g/ha *fb* almix 4 g/ha as post-emergence to control grassy, sedges and broad leaf weeds or apply penoxsulam + cyhalofop-butyl 120-135 g/ha as early post emergence in DSR and TPR. Cyhalofop-butyl at 80 g/ha as post emergence in direct seeded rice.
- In sugarcane, apply halosulfuron methyl 60-67.5 g/ha as post emergence for control of *Cyperus rotundus*.
- In wheat, apply metsulfuron-methyl 4.0g/ha or carfentrazon-ethyl 20g/ha or 2,4-D DMA salt 0.5-0.75 kg/ha or 2,4-D ethyl ester 0.5 kg/ha or metsulfuron-methyl +carfentrazon-ethyl 50 g/ha

as post emergence or 30-35 days after sowing for control of broad leaf weeds.

PAU, Ludhiana

- In '*Tar wattar*- DSR' technique, field is first laser leveled, then pre-sowing (rauni) irrigation applied and field prepared at tar-wattar (good soil moisture) conditions and rice sown immediately preferably using 'Lucky seed drill' or alternatively with rice seed drill having inclined plate metering mechanism and, which herbicide sprayed immediately. Rice seed (8 to l0 kg /acre) is soaked in water for 8-12 hours, dried in shade and treated with fungicide. This technique is suitable for direct seeding of short and medium duration varieties (parmal and basmati) in medium to heavy textured soils. A major departure from the earlier practice is delayed first irrigation which is applied at 21 days after sowing which results in, 1) more saving in irrigation water, 2) lesser weed problem, 3) reduced incidence of nutrient deficiency, particularly iron, owing to deeper root development, 4) wider adaptability and, 5) comparable rice yield to that of puddle transplanted rice.
- In cotton, post-emergence application of ready-mix of pyrithiobac-sodium + quizalofop at 125 g /ha in moist soil after first irrigation/rainfall, provided effective control of annual grasses and broadleaf weeds.
- In direct seeded rice, post-emrgence application of ready-mix of penoxsulam + cyhalofop butyl at 135 g /ha provided effective control of grass, broadleaf and sedge weeds particularly *Echinochloa-crus-galli*, *E. colona*, *Leptochloa chinensis*, *Caesulia axillaris*, *Cyperus iria* and suppress *Cyperus rotundus* when sprayed at 2-4 leaf stage of weeds.
- In wheat, super seeder is a tractor mounted machine and it incorporates straw and directly drill/sows the seed provides comparable grain yield to happy seeder wheat. Field capacity of super seeder and Happy Seeder were 0.24 and 0.32 ha/h, respectively. Average straw load was 6.2 t/ha. Weed dry biomass in super seeder and happy seeder were 225 g and 188 g/m^2, respectively.
- In cotton, post-emergence directed application of glufosinate ammonium (13.5 SL), a non selective herbicide at 304 g/ha in inter-row spaces at 45-50 days after sowing provided effective control of broad-spectrum of weeds in cotton.

PDKV, Akola

- Post emergence application of imazethapyr + imazamox 0.070 kg/ha PoE 15 DAS was the most remunerative and effective herbicide for controlling the weed flora and getting higher yield and economic returns in soybean/ groundnut.
- In cotton, pre emergence application of pendimethalin 1.00 kg /ha followed by directed spray (by using protective shield) of non-selective herbicide paraquat 0.60 kg/ha at 45 days after sowing is recommended for controlling weeds 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 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.
- 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.

PJTSAU, Hyderabad

- Inter-row rice straw mulch (5 tons/ha) *fb* intra row weeding at 30 DAS or mulching with polysheet (250 micrometers) *fb* intrarow HW at 30 DAS or cultural practice involving mechanical weeding at 20 & 40 DAS can be recommended for efficient weed control and higher yield in okra.
- Straw mulch 5 tons/ha followed by intra-row weeding at 30 DAS or rice husk at 3 t/ha *fb* intra-row weeding at 30 DAS proved effective and recommended for efficient weed control and higher root yield of carrot.
- IWM involving post-emergence application of penoxsulam + cyhalofop –butyl (120 g/ha) or penoxsulam 25 g/ha *fb* hand weding/ mechanical weeding resulted in efficient weed control and increase in yield ranged from 8.1 to 13.5% compared to PE application of pretilachlor 500 g/ha followed by hand weeding. Mean reduction of 15-18% in the cost of cultivation with adoption of improved practice over the farmers' practice due to adoption of new IWM practice.

TNAU, Coimbatore

- In transplanted rice-rice cropping system early post emergence application of bispyripac-sodium 40 g/ha (2-3 leaf stage of weeds) + hand weeding on 45 DAT provide effective control of weeds.
- In black gram and green gram 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.
- 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.
- Apply post-emergence tank mix directed application of glyphosate 10 ml/ha + 2, 4-D sodium salt 5g / lit to control *Portulaca quadrifida* in cropped fields.

5. SCHEDULED CASTE SUP PLAN PROGRAMME

Coimbatore

Two hands on training programmes for 85 farmers "Integrated weed management in coconut and paddy fields" were conducerd at Ramanamudha-lipudur, Annamalai Block on 23.10.2020 and Valayapalayam, Udumalpet Taluk on 30.09.2020. Inputs were distributed to the Scheduled Caste farmers and importance of herbicides for weed management in different crops and their safe usage, the selection, time of application and method of application were explained. The ill-effects of parthenium and its management were also explained.

Gwalior

The schedule cast sub plan (SCSP) was started in the financial year 2019-20. The agriculture materials i.e. seed (wheat and chickpea), urea, SSP,herbicides and *Rhizobium* culture were purchased and distributed among 51 Scheduled cast farmers of different villages. The selected farmers were very poor and lived-in below poverty line. One krishak sangoshthi was also organized in the village *Gowai* to introduce about the SCSP programme and for the upgradation of the social economic condition of the farmers

Palampur

Eight training programmes were conducted in different villages of the Kangra district and more than four hundred famers were made aware of the losses caused by the weeds in commercial crops, field crops and as well as in grassland/pastures. Four trainings programmes were conducted in the month of February and four were conducted in the month of November and December.

Hisar

A training was organized on herbicide spray training techniques in Village Dher (Jakhal) of Fatehabad district on 30.12.2020. Distributed pinoxaden and Atlantis herbicides among beneficiaries for weed management in wheat.

Thrissur

The activities undertaken under SCSP Programme 2020-21 included FLDs on weed management in rice, distribution of fertilizers and plant protection chemicals as well as spraying equipment. 15 FLDs on herbicidal weed management in rice are planned. Four locations vix, 1. Nchery, Thrissur 2. Kattoor Thekkumpadam, Padiyur, Irinjalakuda, Thrissur 3. Vavanoor Padashekharam, Nagalassery Panchayath, Koottanadu, Palakkad and 4. Aanuruli Harijan Kole Padavu, Muriyad Panchayath, Mala Block, Thrissur were selected for demonstration of weed management in rice. Five farmers field were selected in each location and demonstrated application of ready mix combination of pretilachlor + bensulfuron methyl, 0.6+0.06 kg/ha at 0-6 DAT and bispyribac sodium, 25g/ha, 15-20 DAS in rice.

SKUAST, Jammu

Blackgram seeds and fertilizer distributed to 200 SC farmers at New Salehare on 14 March, 2020. Wheat seeds distributed to 200 SC farmers at Chak Jagtu village on 05 November, 2020. Herbicide clodinofop+ metsulfuron was distributed to 150 SC farmers and knapsack sprayers were distributed to 8 farmers at Chak Jagtu village on 16 December, 2020. Training cum demonstration on safe use of herbicide was conducted at Chak Jagtu village on 16 December, 2020.

Udaipur

The following one day training programmes were conducted under SCSP activities.

Training porgamme	Date	Location	Number of farmers'
Improved production technologies for summer moong cultivation	16.02.2020	Jhadol	50
Calibration of sprayer, preparation of herbicide solution and method of herbicide spray	28.02.2020	Visma village	20
Integrated weed management in *Rabi* crops	16.01.2020	Judali village Tehsil Jhadol	60
Chemical weed management in *Kharif* crops	28.07.2020		20

Kalyani

Work was undertaken during 2019-20 in the jute crop season initially in two villages namely Sridharpur and Gopinagar under Ranaghat-II Block in the District Nadia, West Bengal. Initially, *Kharif* rice and jute were covered for conducting demonstration in farmers' fields in the villages under the scheme. However, all the crops taken by the beneficiary farmers under production like vegetables (pointed gourd, brinjal, tomato etc) oilseed (sesame, rapeseed and mustard etc) and pulse crops have been covered for giving advisory for plant protection and better production. Number of beneficiaries were 83 including 19 women farmers. Various inputs like seed, fertilizers, herbicides, insecticides, etc were distributed among the selected beneficiary farmers of the villages taken under SCSP that included 04 Seed drill, 08 Knapsack sprayer and 06 Nail weeder.

Soil testing was done of the farmers' plot to have initial status of physico-chemical characteristics in the adopted villages for the new beneficiary farmers under SCSP. Farmers' awareness cum training meetings were organized on weed management and plant protection in the villages. Six trainings and; 10 demonstrations were conducted.

JRO 204 (Suren), attaining traits of high yield (36-38 qtl/ha), green stem, good plant height (4.0 m - 4.3 m), non-branching was taken as component of demonstration with JRO 524 as check. Same practice was applied in both the villages along with use of implements like seed drill, nail weeder. Fifteen farmers covering 2.0 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) as and when required (**Table 5.1 to 5.4**). Adjacent check plot (with farmers' practice) was maintained for each demonstration plot in order to differentiate the practice of improved technology from the traditional one. Improved production practice viz line sowing, chemical weed control with quizalofop-ethyl 1.5ml/L at 20 DAS +1 hand weeding after 20 days of herbicide application, plant protection measures against damage by insect pests were taken in practice all together.

Table 5.1 Economics of the trial in farmers' field in Jute at Sridharpur village

Treatment	Crop yield (q/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)
Line sowing + chemical weed control with quizalofop ethyl 1.5ml/L at 20 DAS + one hand weeding after 20 days of herbicide application + Cypermethrin against semilooper and hairy caterpillar + traditional retting	28.9	47,150	71,803
Farmer's practice (broadcasting + two HW + traditional retting)	26.9	53,880	56,488

Table 5.2 Economics of the trial in farmers' field in Jute at Gopinagar village

Treatment	Crop yield (q/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)
Line sowing + chemical weed control with quizalofop ethyl 1.5ml/L at 20 DAS + one hand weeding after 20 days of herbicide application + cypermethrin against semilooper and hairy caterpillar + traditional retting	29.8	47,640	74,599
Farmers' practice (broadcasting + two HW + traditional retting)	26.9	54,427	55,943

*** Sale price of fibre for T_1: ₹ 4050 per quintal, for jute stick: ₹ 1525 per hectare.

Demonstration on advance production technology in rice were conducetd in succeeding jute crops in both the villages during *Rabi* ₹ 2019-20.

Table 5.3: Economics of the trial in farmers' field in rice crop at Sridharpur village

Treatment	Replication	Crop yield (q/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)
New variety (Pratiksha) + 100% RDF (80:40:40 kg/ha N-P_2O_5-K_2O) pretilachlor 750 g/ha PE *fb* bispyribac-Na25 g/ha at 25 DAT	9	57.7	75,509	37,932
Farmers' practice : Existing old variety (MTU7029) + 80:40:40 kg/ha N-P_2O_5-K_2O + one hand weeding at 25DAT	10	49.6	68,909	30,745

Table 5.4 Economics of the trial in farmers' field in rice crop at Gopinagar village

Treatment	Replication	Crop yield (q/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)
New variety (Pratiksha) + 100% RDF (80:40:40 kg/ha N- P_2O_5-K_2O) pretilachlor 750 g/ha PE *fb* Bispyribac-Na25 g/ha at 25 DAT	11	52.8	75,509	29,866
Farmers' practice : Existing old variety (MTU7029) + 80:40:40 kg/ha N-P_2O_5-K_2O + one hand weeding at 25DAT	11	44.9	68,909	21,982

* Sale price of paddy: ₹ 1700 per quintal, for paddy straw: ₹ 15000 per hectare.

Raipur

Training were conducted for the farmers on weed management before the conduction of FLD's under SCSP. Distribution of chickpea seed cultiver JG-14 and wheat seed along with herbicides pendimethlin and metsulfuron were done. During *Rabi* 2019-20 front line demonstrations were laid down in schedule caste dominated villages Pendri, and Village Godhi block Tilda, district Bhatapara in wheat in an area of 40 acres of 40 farmers' having one acre each,. Out of 40 acres, demonstrations on wheat 'Ratan' were conducted in 30 acres on weed management by chemical weed control under irrigated condition. Treatments were PE application of pendimethalin 1000g/ha+ PoE of metsulfuron 4g/ha and farmers practice i.e. one HW at 30-40 DAS. The average yield increase in technology given by the project was 39.5% over farmers' practice. While, demonstrations on chickpea 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 **(Table 5.5).** The demonstrations were conducted with the help of KVK, Bhatapara during *Rabi* 2019-20. The overall yield was badly affected due to adverse weather conditions including untimely rains and hailstorm in the area especially during last week of February and 3rd week of March 2020.

Table 5.5 Performance of recommended practice over farmers practice in chickpea during *Rabi* 2019-20

Sl. No.	Name of Farmers at village Godhi (T)	Caste	Farmer practice yield (q/ha)	Demonstration yield (q/ha)	Percent increase over farmers practice
1	Mrs Kajla Bai C/o Babulal	SC	653	948	45.1
2	Babulal C/o Mangalu	SC	1120	1520	35.7
3	Kunwar Singh C/o Khorbahra	SC	480	668	39.1
4	Indal C/o Sonechand	SC	843	1240	47.1
5	David C/o Tirith	OBC	457	672	47.0
6	Lekhram C/o Mansharam	SC	1240	1712	38.0
7	Sahasram C/o Dhallu	SC	364	428	17.5
8	Satyalal C/o Dashru	SC	750	908	21.0
9	Mansharam C/o Babulal	SC	545	760	39.4
10	Tirithram C/o Bhagau	OBC	653	884	35.3

Bengaluru

The program under Shedule Caste sub-plan was not assigned to UAS, Bengaluru during 2020. However, in selected villages finger millet, groundnut, horse gram, cowpea and avare crops were grown under rainfed situation.

Tomato and beans were grown under irrigated situation. Predominant weed species observed in the farmers' field were *Cyperus rotundus, Parthenium hysterophorus, Stachytarpheta indica, Acanthospermum hispidum, Celosia argentea, Argemone mexicana, Borreria articularis,* etc. Sixty eight families were identified for distribution of weed management tools / equipments distribution to *C. hosahalli* people on 28th of August 2020. Distributed 15- Cycle weeders, 68- Sickles, 10- Rakes, 25-Varavari and 65- Spade local hand weeding tools of the needy farmers and beneficiaries in Hosahalli in Mulabagilu Taluk of Kolar district. Farmers were aware of weed control implements *viz.* Animal drawn kunte and request for sickle, Varavari, Cycle weeder came from them. Information on integrated weed management strategies in various crops through use of various pre- and post-emergence herbicides were given.

Demonstrations on weed management in crops and distribution of agricultural inputs









6 . LINKAGES AND COLLABORATION

AICRP-WM, BCKVV, Kalyani

Research works are being undertaken on weed management in collaboration with the AICRPs running in university namely AICRP in Agro-meteorology and AINP Agro-chemicals, BCKV, Kalyani centre.

CCSHAU, Hisar

AICRP-WM, Hisar centre 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. Centre has developed linkage with State Department of Agriculture, Haryana. All the recommendations are tested at farmers' fields by extension officers of KVK's and Department of Agriculture, Haryana before their inclusion in package of practices.

CSKHPKV, Palampur

Three irrigation levels and four weed management practices were evaluated in collaboration with AICRP-Water management in cauliflower at Palampur during the winter seasons of 2019-20. Irrigation at 0.5 PE resulted in significantly lower total weed count and weed dry weight at all the stages of observation. It was followed by irrigation at 0.7 PE **(Table 6.1)**.

Table 6.1 Effect of irrigation levels and weed management practices on weed count and dry weight in cauliflower

Treatment	Weed count (Number/m^2)			Weed dry matter (g)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Irrigation level						
0.9 PE	(42)5.90	(41)5.81	(58)6.93	(26)4.56	(25)4.83	(49)6.34
0.7PE	(32)5.07	(34)5.26	(40)5.77	(22)4.37	(22)4.42	(43)6.00
0.5PE	(25)4.47	(26)4.62	(34)5.17	(17)3.76	(15)3.71	(36)5.38
SE±	0.18	0.11	0.09	0.12	0.08	0.07
LSD (P=0.05)	0.72	0.44	0.40	0.47	0.34	0.31
Weed management						
W_1	(1)1.25	(4)2.0	(3)1.88	(0)0.92	(5)2.3	(4)2.04
W_2	(36)5.95	(25)5.0	(47)6.79	(22)4.69	(14)3.8	(43)6.54
W_3	(26)5.12	(23)4.8	(29)5.40	(25)5.02	(26)5.1	(27)5.21
W_4	(68)8.27	(84)9.2	(96)9.76	(40)6.29	(37)6.1	(97)9.85
SE±	0.12	0.18	0.17	0.17	0.13	0.16
LSD (P=0.05)	0.37	0.55	0.51	0.50	0.40	0.48

Data subjected to $\sqrt{x+0.5}$ transformation: figures in parentheses are original values.

I_1: Irrigation at 0.9 PE **I_2:** Irrigation at 0.7 PE **I_3:** Irrigation at 0.5 PE

W_1: Black polythene mulch **W_2:** pendimethalin at 1.5 kg ha^{-1} followed by one hand weeding at 40-45 DAT **W_3:** pendimethalin at 1.5 kg ha^{-1} followed by straw mulching **W_4**: Weedy check

Black polythene mulch resulted in lowest total weed count and weed dry weight at all the stages of observation. Pendimethalin at 1.5 kg/ha followed by straw mulching was superior to pendimethalin *fb* hand weeding for reducing weed count at 30 and 90 DAS and dry weight at 90 DAS. It was concluded that for minimizing weed menace in cauliflower, the crop should be irrigated at 0.8 PE irrigation level and mulched with popythene sheets or pendimethalin 1.5 kg/ha + straw mulch or pendimenthalin 1.50 kg/ha + hand weeding must be done.

PAU, Ludhiana

Two sponsored projects 'Managing herbicide resistance in *Phalaris minor* in wheat through popularization of pre-emergence weed control using lucky seed drill and cereal early stage establishment program through in-situ crop residue management in rice-wheat production systems in Punjab for the development and advocacy of an integrated approach' financed by Bayer Crop Science and Syngenta India Ltd. were undertaken in collaboration with KVKs.

PJTSAU, Hyderabad

Centre has effective collaboration with State Agriculture departments, CRIDA and KVKs. Scientists are participating in Zonal Research and Extension Advisory Council (ZREAC) meeting before *Kharif* and *Rabi* seasons every year for formulating the research programmes pertaining to farmers problems by taking feedback from farmers and departmental officers. Lecture were also given in the training programmes organized at SAMETI (State Agricultural Management and Extension Training Institute), Department of Agriculture, District Agricultural Advisory and Transfer of Technology Centers (DAATT Centers) and *KrishiVignanKendras* on Weed Management.

TNAU, Coimbatore

An investigation was carried out to study the weed dynamics in collaboration with Integrated Farming System (IFS) Research in Irrigated Upland, Coimbatore centre. The Integrated Farming System was imposed in an area of 0.85 ha apportioned with the following cropping system in order to study the system productivity.

Cropping system followed in IFS in Irrigated Upland, Coimbatore

Cropping system	Area (ha)
1. Cowpea (G) - Ragi –Dhaincha	0.15
2. Maize - Sunflower -Dhaincha	0.15
3. Prosomillet - Chillies - Dhaincha	0.15
4. Pearlmillet - Cotton –Dhaincha	0.15
5. BN hybrid grass and *Desmanthus* Silvipasture (Cenchrus + fodder trees)	0.25
Total area	**0.85**

Study was initiated from June, 2019 with the objective to study the weed dynamics in the on station Integrated Farming System Research in Irrigated Upland of AICRP IFS, Coimbatore centre. The weed observations were made four times in a year from the cropping system. (January, April, July and October) (**Table 6.2**). Major weed species were *Dactyloctenium aegyptium, Dinebera reteroflxa, Echinochloa colonas*, *Chloris barbata* under grasses and *Cyperus rotundus* under sedge and *Trianthema portulacastrum, Digera arvensis, Portulaca quadrifida, Euphorbia prostrate, Parthenium hysterophorus* under broad leaved weed (BLW).

System I (Cowpea (G) - Ragi–Dhaincha)

For weed management, pendimethalin 1.kg/ ha was applied. Hand weeding was carried out on 35 DAS. In general, broad leaved weeds dominated in cowpea (veg.) - ragi - dhaincha cropping systems. The relative density of BLW was 60.8, 54.8, 65.3 and 56.6 % at January, April, July and October months of observations.

Table 6.2 Details of cropping in different systems

Crop	Date of sowing	Date of harvest	Yield (kg/ha)
System I Cowpea (G) - Ragi –Dhaincha			
Cowpea (0.15)	21.06.2019	19.09.2019	208 (306)
Ragi (0.15)	05.11.2019	26.02.2020	432 (1036)
Daincha (0.15)	29.02.2020	07.04.2020	2156
System II Maize - Sunflower –Dhaincha			
Maize(0.15)	20.06.2019	12.10.2019	Green cob (4156) & Grain 376 (11244)
Sunflower (0.15)	31.10.2019	12.02.2020	264 (874)
Daincha (0.15)	29.02.2020	07.04.2020	1984
System III : Prosomillet - Chillies - Dhaincha			
Prosomillet (0.15)	18.06.2019	03.10.2019	375 (826)
Chillies (0.15)	09.11.2019	19.03.2020	288 (Green) 136 (1578) (Red)
Daincha (0.15)	22.03.2020	30.04.2020	2580
System IV Pearlmillet - Cotton –Dhaincha			
Pearlmillet (0.15)	17.06.2019	30.09.2019	435 (1243)
Cotton (0.15)	30.10.2019	16..04.2020	256 (5287)
Daincha (0.15)	24.04.2020	30.05.2020	2320
System V BN hybrid grass and *Desmanthus* Silvipasture (Cenchrus + fodder trees) (0.25)	07.07.2018, 12.08.2016, 17.05.2019	Staggered daily harvest depending on requirement	53456 + 5982 + 5863 65301

System II (Maize - Sunflower -Dhaincha)

Maize – sunflower – dhaincha cropping system was raised with application of PE atrazine 0.5 kg/ha for maize and pendimethalin 1.0 kg/ha in sunflower along with hand weeding on 45 DAS for both the crops. Broad leaved weeds dominated with higher relative density of 55 % with higher dry weight (44.6 g/ha) during January followed by grassy weeds (relative density - 40% and dry weight – 7.4 g/ha).

System III (Prosomillet - Chillies – Green manure)

Prosomillet - chillies – green manure cropping system was raised with application of PE atrazine 0.5 kg/ha for maize and without herbicide application for daincha and chillies. In prosomillet - chillies – green manure cropping system, *Amaranthus viridis* was the dominating BLW at all the stages of observationand was followed by another BLW *Trianthima portulacastrum*.

System IV (Pearlmillet - Cotton - G.Manure)

Pearlmillet crop was applied with atrazine 0.25 kg/ha as pre-emergence. *Amaranthus viridis* (relative density of 33.1, 31.3, 33.3 and 34.2%) was dominant BLW irrespective of the time of observation.

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8. AWARDS AND RECOGNITIONS

AAU, Anand

- Dr. B. D. Patel was awarded with Best Oral Presentation Award at National Symposium on Cotton Production Technologies in the Next Decade: Problems & Perspectives, Organized by Cotton Research & Development Association (CRDA), CCS HAU, Hisar at OUAT, Bhubaneshwar during 22-24 January, 2020.
- Dr. B. D. Patel was awarded with Life Time Achievement Award by Society for Biotic and Environmental Research for Outstanding Contribution towards Weed Science on 15-10-2020.

CCSHAU, Hisar

- Dr. S.S. Punia was awarded Best Extension Scientist Award by Haryana Agronomists Agronomy and IWSS on 31.01.2020.
- Dr. S.S. Punia was awarded Lifetime Achievement Award by Indian Society of Genetics, Biotechnology research and Development.
- Dr. Sushil Kumar Singh was awarded with Best Researcher Award by Indian Society of Genetics, Biotechnology research and Development.
- Dr. Todar Mal was awarded with Young Scientist Award by Haryana Agronomists Agronomy and IWSS on 31.01.2020.

MPUAT, Udaipur

- Dr Roshan Choudhary Awarded as 'Woman Scientist Award' during International Conference on Innovative and Current Advances in Agriculture and Allied Sciences (ICAAAS-2020) held at Bangkok, Thailand from 27 January – 01 February, 2020.
- Dr. Roshan Choudhary, Junior Agronomist, participated in 27th Asian-Pacific Weed Science Society Conference and presented oral presentation on 'three tier management practices for effective organic weed management in sweet corn' during 3-6 September, 2019 at Riverside Majestic Hotel, Kuching, Sarawak, Malaysia.

TNAU, Coimbatore

- Dr. P. Murali Arthanari received Best edited book award in weed science (Tamil).
- Received Best Centre Award to AICRP Weed Management Unit, by Agricultural Scientific Tamil Society, New Delhi

PJTSAU, Hyderabad

- Dr. T Ramprakash, received ICAR-IIOR-ISOR Fellow award in the ISOR national conference organized during 6-8 February 2020 at University Auditorium, PJTSAU, Hyderabad.

9. RECOMMENDATIONS OF XXVI ANNUAL REVIEW MEETING

Recommendations of XXVII Annual Review Meeting of All India Coordinated Research Project On Weed Management was organized at ICAR-DWR, Jabalpur during 8-10 June, 2020 through video conferencing are given below:

- All the centre must follow the guideline provided from the head quarter while submitting the information, data, annual report etc.
- Strictly record all the observations in all experiments as per protocols and approved technical program.
- Use of mechanical tools/gadgets and observations on bio-engineering, ergonomics, performance indicator, drudgery reduction all these parameters need to take by all centres in organic agriculture
- GPS system based information along with good quality photograph should be given while collecting weed shift and monitoring of quarantine weeds/new weeds
- Follow the safety precaution while spraying herbicide in the field.
- Herbicide resistance biotypes may be collected, screened at various doses and information may be disseminated for better management.
- Facility needs to be developed for rearing of bioagent at the centre itself in order to cater the need of the centre
- Collect herbicide consumption data from agriculture department, industries persons or pesticide distributors or dealers and submit to the PC unit.
- Follow the standard guidelines while conducting OFR and FLD.
- All the centre should develop weed control mobile apps (Weed manager) in regional language.
- All the centres should prepare a short high quality video film on the success story and that can be submitted to the ICAR-DWR, Jabalpur to make these success stories available in public domain.
- There is a need to harness the benefits of ICT modules (Facebook, WhatsApp, YouTube etc.) at the maximum extent so as to disseminate the technologies to the mass of the farmers. While using social media for demonstration of technology/success story acknowledge ICAR-DWR, Jabalpur name properly.

10. STATUS OF EXPERIMENTS

Sl. No.	Centres	WP 1 Development of location specific sustainable weed management practices	WP 2 Management of weeds in non-cropped and aquatic areas	WP 3 Fate of herbicide residues in different agroecosystem	WP 4 WP1.1 Demon stration and impact assessment of weed management technologies	ST Station trials on weed management	Total no. of experiments
1.	PAU, Ludhiana	WP1.1.2.4, WP1.2.1.1.7, WP1.3.10, WP1.4.2(i), WP1.4.2(ii)	WP2.1, WP2.1.2, WP2.2 WP2.3.1	WP3.1.1, WP3.2, WP3.3, WP3.4	WP4.1.7(i), WP4.1.7(ii), WP4.2.13(i), WP4.2.13(ii)	-	17
2.	UAS, Bengaluru	WP1.1.14, WP1.2.2.2.1, WP1.3.15, WP1.5.3*	WP2.1*, WP2.1.2, WP2.2*	-	WP4.1.2*, WP4.2.4*	ST4(i), ST4(ii), ST4(iii)	12
3.	RVSKKV, Gwalior	WP1.2.2.3.1, WP1.3.9, WP1.5.2	WP2.1, WP2.1.2, WP2.1.3*, WP2.2, WP2.3.1	-	WP4.1.3(i), WP4.1.3(ii), WP4.1.3(iii)*, WP4.2.11	-	12
4.	GBPUAT, Pantnagar	WP1.1.9, WP1.1.12, WP1.2.1.1.6, WP1.3.4	WP2.1.1.2, WP2.1.2, WP2.2*	-	WP4.1.10, WP4.2.8	ST8*	10
5.	CSKHPK, Palampur	WP1.2.1.1, WP1.3.7	WP2.1.1, WP2.1.2, WP2.2	WP3.1.1, WP3.2, WP3.3, WP3.4	WP4.1.9, WP4.2.7	-	11
6.	AAU, Jorhat	WP1.1.1.2, WP1.1.1.3, WP1.1.2.1, WP1.2.1.1.3	WP2.1.1.4, WP2.1.1.5, WP2.1.2, WP2.2	-	WP4.1.14(i)*, WP 4.1.14(ii)*, WP4.2.14	ST6	12
7.	AAU, Anand	WP1.1.1.4, WP1.2.1.5.3, WP1.3.1, WP1.5.1	WP2.1, WP2.1.2, WP2.2, WP2.3.1 WP2.4.1	-	WP4.1.1(i)*, WP4.1.1(ii), WP4.2.1(i), WP4.2.1(ii)	ST2(i), ST2(ii)*, ST2(iii), ST2 (iv)	17
8.	TNAU, Coimbatore	WP1.1.1.1, WP1.2.1.5.1, WP1.5.3	WP2.1, WP2.1.2, WP2.2, WP2.3.1	WP3.1.1, WP3.2, WP3.3, WP3.4	WP4.1.12, WP4.2.16	-	13
9.	KAU, Thrissur	WP1.1.3.7, WP1.3.12(i), WP1.3.13(ii), WP1.3.14(iii)	WP2.1.1*, WP2.1.1.1, WP2.2*	-	WP4.1.11, WP4.2.10	ST5	10
10.	OUAT, Bhubaneshwar	WP1.1.2.3, WP1.1.4.1, WP1.2.1.1.1, WP1.3.5, WP1.5.6	WP2.1, WP2.1.2, WP2.1.3*, WP2.2, WP2.3.1	-	WP4.1.15, WP4.2.15*	ST7	13

Table contd...

11.	PJTSAU, Hyderabad	WP1.1.5.1, WP1.1.6.1, WP1.2.1.5.2, WP1.3.2	WP2.1.1*, WP2.1.2*, WP2.2, WP2.1.3* WP2.3.1	WP3.1.1, WP3.2, WP3.3, WP3.4	WP4.1.5*, WP4.2.5	-	15
12.	CCSHAU, Hisar	WP1.1.3.8, WP1.2.1.1.5, WP1.4.1(i), WP1.4.1(ii)*, WP1.4.4*, WP1.5.6	WP2.1, WP2.1.2, WP2.2	-	WP4.1.4(i), WP4.1.4(ii), WP4.2.3(i), WP4.2.3(ii)	-	14
13.	IGKVV, Raipur	WP1.1.1.10, WP 1.1.1.11, WP1.2.1.1.4, WP1.3.11, WP1.5.2	WP2.1.1*, WP2.1.1.3, WP2.1.2, WP2.1.3, WP2.2, WP2.3.1	-	WP4.1.6, WP4.2.12	-	13
14.	SKUAST, Jammu	WP1.1.1.7 (i), WP1.1.1.7 (ii), WP1.1.2.2, WP1.1.11*, WP1.2.1.1.2, WP1.3.3, WP1.4.3(i), WP1.4.3(ii)*	WP2.1, WP2.1.2, WP2.2, WP2.3.1	-	WP4.1.16, WP 4.2.2	-	14
15.	MPUAT, Udaipur	WP1.1.3.1, WP1.1.4.2, WP1.2.2.2.2, WP1.3.8, WP1.5.5	WP2.1.1, WP2.1.2, WP2.1.3, WP2.2, WP2.3.1	WP3.1.1,	WP4.1.8, WP 4.2.6	ST3(i), ST3(ii)	15
16.	PDKV, Akola	WP1.1.1.12*, WP1.2.1.4.1, WP1.3.16*, WP1.5.2*	WP2.1, WP2.1.2*, WP2.1.3*, WP2.2	-	WP4.1.13*, WP4.2.9*	ST1	11
17.	BCKV, Kalyani	WP1.1.1.9*, WP1.1.7*, WP1.1.13, WP1.2.1.1.8, WP1.3.6(i), WP1.3.6(ii)	WP2.1*, WP2.1.2*, WP2.2*	-	WP4.1.17(i)*, WP4.1.17(ii)*,	-	11

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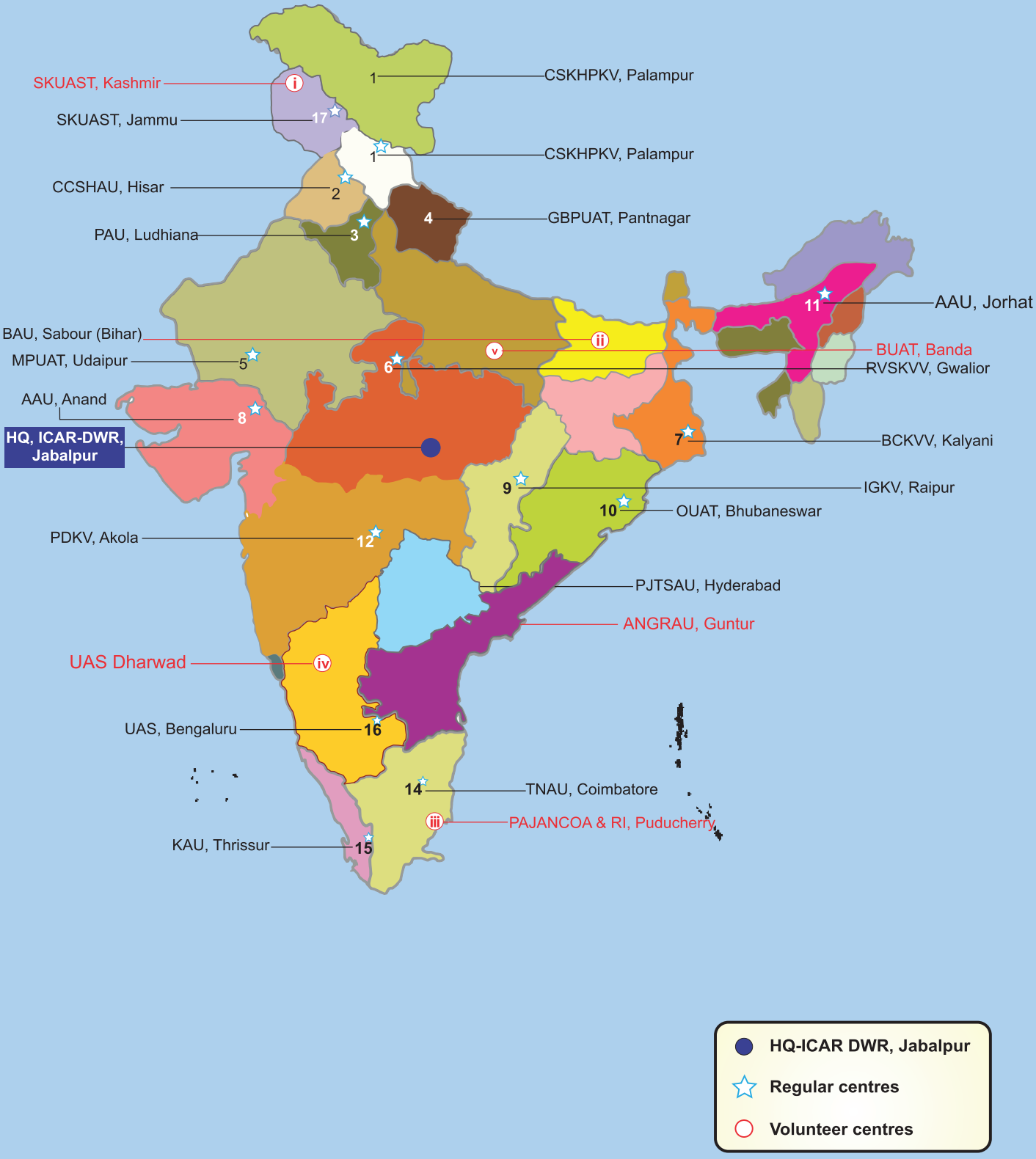
12. STATUS OF SUBMISSION OF ANNUAL REPORT 2020

Sl No.	Centre's name	Received	
		Before due date (10.01.2021)	After due date
Regular centres			
1.	PAU, Ludhiana	-	15.01.2021
2.	UAS, Bengaluru	07.01.2021	-
3.	RVS KVV, Gwalior	08.01.2021	-
4.	GBPUAT, Pantnagar	-	24.01.2021
5.	CSKHPKVV, Palampur	-	11.01.2021
6.	AAU, Jorhat	-	28.01.2021
7.	AAU, Anand	06.01.2021	-
8.	TNAU, Coimbatore	07.01.2021	-
9.	KAU, Thrissur	07.01.2021	-
10.	OUAT, Bhubaneswar	-	19.01.2021
11.	PJTSAU, Hyderabad	-	17.01.2021
12.	CCSHAU, Hisar	-	15.01.2021
13.	IGKVV, Raipur	07.01.2021	-
14.	SKUAST-Jammu	-	16.02.2021
15.	PDKV, Akola	08.01.2021	-
16.	MPUAT, Udaipur	-	20.01.2021
17.	BCKV, Kalyani	-	17.01.2021
Volunteer centres			
1.	SKUAST-Kashmir	-	27.01.2021
2.	PJNCA&RI, Karaikal	-	10.01.2021
3.	BAU, Sabour	-	-
4.	UAS, Dharwad	-	-
5.	BUAT, Banda	-	15.01.2021
6.	ANGRAU, Guntur	-	12.01.2021

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


SKUAST, Kashmir
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CSKHPKV, Palampur
SKUAST, Jammu
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CSKHPKV, Palampur
CCSHAU, Hisar
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GBPUAT, Pantnagar
PAU, Ludhiana
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AAU, Jorhat
BAU, Sabour (Bihar)
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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
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12
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UAS Dharwad
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UAS, Bengaluru
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PAJANCOA & RI, Puducherry
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Regular centres
Volunteer centres