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अखिल भारतीय समन्वित खरपतवार नियंत्रण अनुसंधान परियोजना

All India Coordinated Research Project on Weed Control

वार्षिक प्रतिवेदन
Annual Report
2013-14

खरपतवार विज्ञान अनुसंधान निदेशालय
Directorate of Weed Science Research
Jabalpur (M.P.)

Correct citation :

Annual Report 2013-14. AICRP-Weed Control, Directorate of Weed Science Research, Jabalpur, (M.P.), 126 p.

Published by

Director
Directorate of Weed Science Research
Maharajpur, Jabalpur 482 004 (M.P.)

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Published in

April, 2014

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Cover Page Photograph

Map of Coordinating Centres of AICRP on Weed control

Acknowledgement

I express my sincere gratitude to Dr. S. Ayyappan, Secretary (DARE) and Director General (ICAR) for providing constant encouragement and guidance for improvement and strengthening the research and extension activities of AICRP on Weed Control. I am equally grateful to Dr. A.K. Sikka, Deputy Director General (NRM) for his constant encouragement, guidance and support in carrying out the various activities of the AICRP on Weed Control. Thanks are also due to Dr. B. Mohan Kumar, Assistant Director General (Agronomy & Agroforestry) for his keen interest and support in running this project.

The research work carried out in the project is the outcome of the commitment and hard work of the scientists and staff of all the Coordinating Centres. I would like to thank all of them for their active participation. My special thanks are due to all the Principal Investigators of Coordinating Centres, viz. Drs. M.S. Bhullar, PAU, Ludhiana; B. Duary, V.B., Sriniketan; R. Devendra, UAS, Bengaluru; R.A. Yadav, CSAUAT, Kanpur; S.S. Punia, CCSHAU, Hisar; N.K. Prabhakaran, TNAU, Coimbatore; M.M. Mishra, OUAT, Bhubaneshwar; V. Pratap Singh, GBPUAT, Pantnagar; J.P. Dixit, RVSKVV, Gwalior; J. Deka, AAU, Jorhat; D.K. Roy, RAU, Pusa; M. Yakadri, ANGRAU, Hyderabad; B.D. Patel, AAU, Anand; A.S. Jadhav, VNMKV, Parbhani; C. T. Abraham, KAU, Thrissur; Dinesh Badiyala, CSKHPKV, Palampur; Jaidev Sharma, NDUAT, Faizabad; R.R. Upasani, BAU, Ranchi; M.J. Mane, DBSKKV, Dapoli; A.P. Singh, IGKVV, Raipur; Ramesh Babu, UAS, Dharwad; and R.S. Yadav, SKRAU, Bikaner for their help and cooperation in implementing the technical programme of the project. Thanks are also due to the PIs of the volunteer centres, viz. Dr. Anil Kumar, SKUAST, Jammu, J&K; Dr. Raghuvir Singh, SVBPUAT, Meerut; Dr. J.P. Deshmukh, DPDKV, Akola; Dr. Purshotam Singh, SKUAST-Kashmir and; Dr. P. Saravanane, PJNCA&RI, Karaikal for their association and contributions in this project.

I express my sincere thanks to Incharge, AICRP-WC, Dr. R.P. Dubey, Principal Scientist (Agronomy), and Nodal Officers, viz. Dr. V.P. Singh, Principal Scientist (Agronomy); Dr. P.K. Singh, Principal Scientist (Agricultural Extension); Dr. D.K. Pandey, Principal Scientist (Plant Physiology); Dr. Sushilkumar, Principal Scientist (Entomology); Dr. Shobha Sondhia, Senior Scientist (Organic Chemistry); Dr. C. Kannan, Senior Scientist (Plant Pathology); and Dr. Bhumesh Kumar, Senior Scientist, (Plant Physiology) for compiling and editing this report. Thanks are also due to Technical Officers, viz. Mr. O.N. Tiwari, Mr. Pankaj Shukla and Mr. Sandeep Dhagat for providing technical help in bringing out this report.

Date : 12.04.2014

Place : Jabalpur

(A.R. Sharma)
Jabalpur

Contents

कार्यकारी सारांश

निदेशालय के अंतर्गत 22 समन्वित और 06 स्वैच्छिक केन्द्र जो कि देश के विभिन्न राज्यों में स्थित कृषि विश्वविद्यालयों के माध्यम से विभिन्न फसलों, फसल प्रणाली और गैर फसलीय क्षेत्रों मे खरपतवार प्रबंधन हेतु अनुसंधान कार्य कर रहे हैं ।

वर्ष 2013-14 के दौरान किये गये मुख्य अनुसंधानीय उपलब्धियां निम्नानुसार हैं :-

खरपतवार निगरानी

- गुजरात के साबरकांठा, मेहशना, पाटन, गांधीनगर, अहमदाबाद, खेड़ा, आनंद, पांचमहल और दाहोद जिलों मे गेहूं में *फैलेरिस माइनर* की बढ़त दर्ज की गई है ।
- *मिकानियां मिकरांथा, एम्ब्रोसिया अर्टीमिशिफोलिया, अबुटिलन हिंटिम, बरबेशिया एन्सीलाइडिश, सोलेनम इलाग्नीफोलियम, पिस्टिया स्ट्रेटिट्योस और एम्ब्रोशिया साइलोस्टीका* आदि नये खरपतवारों का फैलाव दक्षिण कर्नाटक में दर्ज किया गया ।
- ओडीशा के कटक और खुर्दा जिलो में बैंगन और टमाटर की फसलों में भुईफोड विरल रूप से पायी गई ।
- राजस्थान के बीकानेर जिले में *फैलेरिस माइनर* और *कनवानबुलस अरबेन्सिस* गेहूं की फसल में फैल रहा हैं।
- तमिलनाडू में फसलीय क्षेत्र में गाजरघास को प्रभावकारी खरपतवार के रूप में दर्ज किया गया ।
- कर्नाटक के गदाग जिले के मुंदार्गी तालुक में *सोलेनम इलाग्नीफोलियम* खरपतवार की प्रमुखता पायी गई है ।
- घास कुल के खरपतवारों के नियंत्रण हेतु शाकनाशी का निरंतर प्रयोग करने के कारण संकरी और चौड़ी पत्ती वाले खरपतवार *एकलिप्टा एल्बा, अमानिया बेसीफेरा, कुकुमिस मिल्लो* और *स्किरपस ट्यूबरोसस* इत्यादि पूर्वीय उत्तर प्रदेश क्षेत्र में बढ़ रहे हैं ।
- हरियाणा के भिवानी जिले के अनेक क्षेत्रों में टमाटर की फसल में भुईफोड़ की संक्रामता गंभीर रूप से होने के कारण टमाटर की उपज में 15 से 70 प्रतिशत तक हानि दर्ज की गई ।
- असम में गाजरघास का ग्रसन देशी वनस्पति को विस्थापित कर रहा है।
- पंजाब के कपूरथला, जालंधर, भटिण्डा और होशियारपुर के जिलों में मक्का की फसल में एट्राजिन का निरंतर उपयोग करने से सकरी और चौड़ी पत्ती वाले खरपतवार घास कुल के खरपतवारों में विस्थापित हो रहे है । कपास में आइपोमिया खरपतवार के ग्रसन के कारण आर्थिक क्षति हो रही हैं ।
- छत्तीसगढ़ के बिलासपुर जिले में *अल्टरनेन्थेरा ट्राईन्ड्रा* की संक्रामकता सीधी बुवाई वाली धान के खेत के मेड़ो और सड़क के किनारे देखी गई है ।

खरपतवारों का जीव एवं क्रिया विज्ञान

- जोरहट में *इकानोक्लोवा* प्रजातियों के 14 टैक्सा एवं 11 अंत:विशिष्ट प्रजातियों की पहचान की गई है ।
- भुवनेश्वर में *ई. कोलोना* और *ई. क्रसगाली* का दैहिक पराभावी अध्ययन किया गया ।

***इकाईनोक्लोवा* प्रजाति का दैहिक पराभावी**

दैहिक लक्षण	*ई. कोलोना*	*ई. क्रसगाली*
अंकुरण प्रतिशत	72	64
निर्गमन (दिन)	4.5	3-4
शुष्क भार 25 दिनों के निर्गमन पश्चात् (ग्रा./पौध)	0.27	0.32
पुष्पण (दिन)	28	31
बीजों की संख्या/पौध	568	641
बीजों की संख्या/मी.2	2800	6250
1000 बीजों का भार (ग्रा.)	0.031	0.039

- असम में रोपित धान में जंगली धान की समस्या कम पायी गई ।
- करनाल में किसानों के खेत में किये गये अनुसंधान से यह ज्ञात हुआ है कि गेहूं में क्लोडिनाफाप 75 ग्रा., सल्फोसल्फयूरान 30 ग्रा. एवं मेजो + आइडोसल्फयूरान 14+4 ग्रा./हे. का प्रयोग करने पर *फेलेरिस माइनर* का पूर्ण रूप से नियंत्रण नहीं किया जा सका । मैट्रीब्यूजिन 105 ग्रा. एवं क्लोडिनाफाप 60 ग्रा./हे. /सल्फोसल्फयूरान 25 ग्रा./पिनाक्साडेन 50 ग्रा./हे. के टेंक मिश्रण द्वारा *फैलेरिस माइनर* पर प्रभावी नियंत्रण पाया गया । पंजाब राज्य में मैट्रीब्यूजिन+फेनोक्साप्राप के मिश्रण द्वारा *फैलेरिस माइनर* पर प्रभावकारी नियंत्रण

पाया गया ।

- ग्लायफोसेट के साथ गुड़ मिलाने पर *साइप्रस रूटेन्डस* के नियंत्रण में जोरहट, आंनद, लुधियाना, बैगुलुरू में कोई वृद्धि दर्ज नहीं की गई। हालांकि इस मिश्रण का लाभकारी प्रयोग पंतनगर एवं कोयम्बटूर में पाया गया ।

फसल एवं फसल प्रणालियों में खरपतवार प्रबंधन

- बिसपायरीबेक + इथाक्सीसल्फयूरान/अलमिक्स के टेंक मिश्रण के अंकुरण पश्चात् उपयोग से लुधियाना, हिसार, भुवनेश्वर, पंतनगर एवं रायपुर केन्द्रों में रोपित धान में खरपतवारों का प्रभावी नियंत्रण पाया गया ।
- भुवनेश्वर, हैदराबाद, रांची, रायपुर, कोयम्बूटर, बैंगलुरू, फैजाबाद, पालमपुर एवं पूसा केन्द्रों में सीधी बुवाई वाली धान में पेन्डीमिथलिन तत्पश्चात् बिसपायरीबेक + 1 निंदाई का प्रयोग करने पर खरपतवारों का प्रभावी नियंत्रण पाया गया ।
- हल्दी की फसल में हिसार, लुधियाना, रांची, परभनी एवं फैजाबाद केन्द्रो में मैट्रीब्यूजिन 0.7 कि.ग्रा./हे.तत्पश्चात् मल्चिंग + निंदाई खरपतवारो के नियंत्रण हेतु प्रभावी पाया गया ।
- ग्वालियर, हिसार, लुधियाना, बीकानेर, पालमपुर, पंतनगर, श्रीनिकेतन एवं मेरठ केन्द्रों में मूंग/उड़द की फसल में प्रभावी खरपतवार नियंत्रण हेतु इमाजेथापायर + पेन्डीमीथेलिन का उपयोग लाभप्रद पाया गया । संरक्षित खेती के अंतर्गत धान-गेहूं फसल प्रणाली में लुधियाना, पूसा, कानपुर एवं फैजाबाद केन्द्रों में बिना जुताई वाली धान में खरपतवारों की संख्या अभिसामयिक भू-परिष्करण से अधिक पायी गई। जबकि पंतनगर में, अभिसामयिक भूपरिष्करण के अंतर्गत खरपतवारों की संख्या अधिक पायी गई।
- बैंगलुरू में धान-चना फसल प्रणाली, में भूपरिष्करण एवं अवशेष प्रबंधन का खरपतवारों की संख्या पर कोई प्रभाव नहीं पाया गया ।
- धान-सरसों चक्र में श्रीनिकेतन एवं जोरहट केन्द्रों में अभिसामयिक भूपरिष्करण द्वारा प्रभावी खरपतवार नियंत्रण पाया गया ।

दीर्घकालीन शाकनाशी प्रयोग

- लुधियाना केन्द्र में ब्यूटाक्लोर तत्पश्चात् मेटसल्फयूरान धान की फसल में तथा क्लोडिनाफाप तत्पश्चात् मेटस्ल्फयूरान का प्रयोग गेहूं में खरपतवारों के नियंत्रण हेतु प्रभावकारी पाया गया।
- भुवनेश्वर में धान-मूंगफली फसल चक्र में, बूटाक्लोर + 2,4-डी धान में एवं अलाक्लोर मूंगफली में खरपतवार नियंत्रण हेतु लाभप्रद पाया गया ।
- रायपुर केन्द्र में धान-चना फसल चक्र में आक्साडायरजिल 80 ग्रा./हे. तत्पश्चात् बिसपायरीबेक 25 ग्रा./हे. धान में एवं चने में पेन्डीमीथेलिन 1 कि.ग्रा./हे. का उपयोग खरपतवारों के नियंत्रण हेतु प्रभावकारी पाया गया ।

चने में संरक्षित खेती द्वारा खरपतवार घनत्व, शुष्क भार 60 दिनों पर और दानों की उपज पर प्रभाव

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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

( ) में मौलिक संख्या दर्शाई गई है

समस्याकारी/आक्रामक/परजीवी/जलीय खरपतवारों का प्रबंधन

- हरियाणा में सरसों की फसल में, ग्लाइफोसेट 25 ग्रा./हे. + 1 प्रतिशत अमोनियम सल्फेट बुवाई के 55 दिन बाद प्रयोग करने पर भुईफोड़ का 80-90 प्रतिशत नियंत्रण पाया गया। जबकि ग्वालियर में ग्लाइफोसेट 50 ग्रा./हे. का प्रयोग भुईफोड़ के नियंत्रण हेतु प्रभावी पाया गया ।
- तामिलनाडू में तंबाखू की फसल में नीम की खली 200 कि.ग्रा./हे. की दर से या इमाजेथापयर 30 ग्रा./हे. बुवाई के 55 दिन बाद प्रयोग करने पर *औरोबेंकी* का प्रकोप कम पाया गया और तंबाखू की अधिक उपज दर्ज की गई ।
- कोयंबटूर में गन्ने की फसल में, *स्ट्राइगा* नियंत्रण हेतु अट्राजिन 1 कि.ग्रा./हे. + 1 निंदाई 45 दिन पर + 60 दिन पर मिट्टी चढ़ाना+ 2,4-डी 5 ग्रा. + यूरिया 20 ग्रा./लि. 90 दिनों के बाद तत्पश्चात् ट्रेश मलचिंग 5 टन/हे. की दर से 120 दिन बाद खरपतवार नियंत्रण हेतु प्रभावकारी पाया गया ।
- बैंगलुरू में सपोटा पर *डेनड्रोफथी* नियंत्रण हेतु 4 ग्रा. कापर सल्फेट + 0.5 ग्रा. 2,4-डी सोडियम साल्ट के मिश्रण की पट्टी बांधने पर *डेनड्रोफथी* की 100 प्रतिशत पत्तियां झड़ गई एवं 6 महीने तक इनमें वृद्धि नहीं पायी गई ।

जैविकीय खरपतवार नियंत्रण

- *जाइगोग्रामा* कीट के प्रयोग से आनंद, हिसार, पालमपुर, पंतनगर, लुधियाना, परभनी, भुवनेश्वर, कानुपर, फैजाबाद, पूसा, ग्वालियर, बीकानेर एवं श्रीनिकेतन केन्द्रो में गाजरघास का 7-75 प्रतिशत नियंत्रण पाया गया। कीट की संख्या अगस्त से सितम्बर के मध्य श्रीनिकेतन, पालमपुर, फैजाबाद एवं बीकानेर में अधिक पायी गई ।
- *केशिया तोरा* के बीजों के छिड़काव से सितंबर-अक्टूबर के मध्य आनंद, जोरहट, रांची, हिसार, कानपुर, फैजाबाद, पालमपुर पंतनगर, लुधियाना, भुवनेश्वर, कानपुर, मुज्जफरपुर, ग्वालियर एवं श्रीनिकेतन केन्द्रों में गाजरघास का प्रतिस्थापन दर्ज किया गया ।
- हैदराबाद, त्रिशूर, हिसार एवं फैजाबाद केन्द्रों में नियोकेटिना वीव्हिल द्वारा जलकुंभी पर प्रभावी नियंत्रण पाया गया। हालांकि जलकुंभी द्वारा खाली किये गये स्थान पर एलिगेटर खरपतवार का प्रकोप पाया गया ।

शाकनाशी अवशेष और पर्यावरण गुणवत्ता

- धान-गेहूं फसल चक्र में बूटाक्लोर, प्रीतलाक्लोर और एनिलोफास के अवशेष हिसार ओर लुधियाना में, बूटाक्लोर और आइसोप्रोटूरान के अवशेष पालमपुर और पंतनगर में मृदा, बीज और भूसा में अपेक्षित स्तर से कम पाया गया ।
- मक्का-मटर फसल चक्र में, पालमपुर में पेंडीमिथलिन शाकनाशी के अवशेष अपेक्षित स्तर से कम (0-001µg/g) फसल की कटाई के बाद मृदा, दानों और भूसा में पाये गये। चना, मटर और सरसों के खेतों से फसल की कटाई के उपरांत लिये गये मृदा के नमूनों में पेंडीमिथलिन के अवशेष अपेक्षित स्तर से कम दर्ज किये गये। यद्यपि सरसों की कटाई के समय 0.095 µg/g अवशेष दर्ज किया गया ।
- हैदराबाद मे मक्का की फसल में बिना जुताई के किये गये खेत से मृदा के नमूनों में अट्राजीन का अवशेष मृदा में इसके संस्तुत मात्रा का उपयोग करने पर या पैराक्वाट के साथ इसका संयोजन करने पर इसके अवशेष उपयोग करने के 60 दिनों बाद तक दर्ज किये गये । मक्का के अंकुरण के बाद इसका छिड़काव करने पर इसके अवशेष 45 दिन तक दर्ज किये गये। बूटाक्लोर का अवशेष कटाई के बाद दानो और भूसा में नहीं पाया गया
- हिसार में, किसानों के खेतों के नलकूपों से पानी के नमूने शाकनाशी का प्रयोग करने के 45 दिन बाद एकत्र किये गये । परीक्षण उपरांत यह पाया गया कि 21 स्थानों में से एकत्रित 5 स्थानों में प्रीतलाक्लोर शाकनाशी का अवशेष 0.21-1.30 µg/g दर्ज किया गया ।
- हरियाणा में हिसार केन्द्र द्वारा किसानों के खेतो से जहां धान और गेहूं की खेती की जाती है, गेहूं के दानों और भूसा के नमूने एकत्रित किए गए। फसल की कटाई के समय एकत्र किए गए नमूनों मे से 4 नमूनों में सल्फोसल्फयूरान के अवशेष 0.11-0.028 µg/g दर्ज किए गए । पांच नमूनों से सल्फोसल्फयूरॉन या मीजो + आइडोसल्फयूरान के अवशेष पाये गये बाकी नमूनों में गेहूं के दानों और भूसा में शाकनाशी अवशेष नहीं पाये गये ।

तकनीकी स्थानान्तरण

- वर्ष 2013 के दौरान अखिल भारतीय समन्वित खरपतवार नियंत्रण अनुसंधान परियोजना के केन्द्रो में 843 फ्रंट लाइन प्रदर्शन, खरपतवार प्रबंधन तकनीकों के प्रदर्शन हेतु किये गये, 29 रेडियो द्वारा प्रसारण ओर 27 दूरदर्शन द्वारा वार्तालाप के माध्यम से जानकारी दी गई । इसके अलावा 80 प्रशिक्षण कार्यक्रम भी किये गये। 20 हैण्ड आउट, फोल्डर, पंपलेट, बुलेटिन्स/बुकलेट विभिन्न भाषाओं में प्रकाशित कर किसानों को बांटे गये।
- हिसार में प्रीतलाक्लोर + बेनसल्फयूरान के तैयार मिश्रण का संयोजन जटिल खरपतवारों के नियंत्रण हेतु हरियाणा के 17 विभिन्न भागों में जांचे गये । जांच द्वारा पाया गया कि जटिल खरपतवारों का नियंत्रण 94.2% शाकनाशी प्रीतलाक्लोर के 84.7% की अपेक्षा ज्यादा नियंत्रण हुआ ओर उपज में वृद्धि 157 कि.ग्रा./हे. दर्ज की गई ।
- भुवनेश्वर में, 6 ओ एफ टी रोपित धान मे किये गये परिणाम द्वारा पाया गया कि अधिकतम उपज (4.21 ट./हे.) आक्साडायरजिल 0.065 कि.ग्रा./हे तदुपरांत पायराजूसलफ्यूरान -इथाईल 0.02 कि.ग्रा./हे. (4.02 ट./हे.) में प्राप्त की गई एवं ₹ 2150-2654/हे. की बचत दर्ज की गई ।

जनजाति उपयोजना

- वर्ष 2013-14 के दौरान आनंद, जोरहट, रांची, पालमपुर, रायपुर, भुवनेश्वर, बीकानेर, कोयंबटूर, बेंगलुरू, धारवाड़ ओर दपोली केन्द्रों द्वारा जनजाति उपयोजना को कार्यान्वित किया गया ।
- आनंद केन्द्र द्वारा, शाकनाशी स्प्रे उपकरण, हाथ द्वारा संचालित हो-यंत्र दाहोद जिले के 50 जनजाति कृषकों को वितरित कये गये । ओ एफ टी भी खरपतवार प्रबंधन तकनीकी के प्रदर्शन हेतु किये गये।
- जोरहट केन्द्र द्वारा कार्बीआंग और कोकराझार जिलों में प्रक्षेत्र प्रदर्शन, फील्ड दिवस एवं प्रशिक्षण कार्यक्रम बोरोधान में खरपतवार प्रबंधन संचालित किये गये । 80 जनजाति कृषकों को खरपतवार प्रबपंधन से संबंधित उपकरण वितरित किये गये ।
- रांची केन्द्र द्वारा रांची, पश्चिम सिंहभूम, लोहरदग्गा और गुमला जिले में जनजाति कृषकों के लिए अनेक प्रशिक्षण कार्यक्रम संचालित किये गये । केन्द्र द्वारा उपकरण जैसे कोनो वीडर, ग्रबर, डच-हो, भी जनजाति कृषकों को वितरित किये गये ।


रांची केन्द्र द्वारा प्रशिक्षण कार्यक्रम और उपकरण वितरण

- पालमपुर केन्द्र द्वारा 500 जनजाति कृषकों को प्रशिक्षित करने हेतु प्रशिक्षण कार्यक्रम संचालित किये गये । कृषकों को नापसेक स्प्रेयर्स भी वितरित किये गये ।
- रायपुर केन्द्र द्वारा छत्तीसगढ़ के 26 जनजाति जिलो में कृषकों के 318 खेतों में मक्का, धान और गेहूं में फ्रंट लाइन प्रदर्शन संचालित किये गये ।
- भुवनेश्वर केन्द्र द्वारा क्यौझर, देवगढ़, सुन्दरगढ़ और मयूरगंज जिलों के जनजाति कृषकों को खरपतवार नियंत्रण उपस्कर वितरित किये गये ।
- बीकानेर केन्द्र द्वारा दुनगारपुर, बनासवाड़ा जिले में जनजाति कृषकों हेतु 3 प्रशिक्षण कार्यक्रम संचालित किये गये । केन्द्र द्वारा 90 कृषकों को स्प्रेयर्स ओर शाकनाशी रसायन भी वितरित किये गये ।
- बैंगलुरू, कोयम्बटूर, धारवाड़ और दपोली केन्द्रों द्वारा जनजाति कृषकों के लाभ हेतु खरपतवार नियंत्रण प्रशिक्षण कार्यक्रम ओर उपस्कर वितरित किये गये ।

Executive summary

AICRP on Weed Control has 22 regular centres and 6 volunteer centres located at different state agricultural universities for carrying out network research and generating location specific technologies on weed management in different crops, cropping system and non-cropped situations.

Salient research findings of 2013-14 are presented below:

Weed surveillance

- Increasing density of *Phalaris minor* in wheat field was recorded in Sabarkantha, Mehsana, Patan, Gandhinagar, Ahmedabad, Kheda, Anand, Panchamahal and Dahod districts of Gujarat.
- Spread of new weeds like *Mikania micrantha, Ambrosia artemisiifolia, Abutilon hirtum, Verbesia encelioides, Solanum elaegnifolium, Pistia stratiotes* and *Ambrosia psilostachya* in South Karnataka has been noticed.
- In Odisha, sporadic incidences of *Orobanche aegyptiaca* were observed in brinjal and tomato crops at Cuttack and Khurda districts.
- In Rajashtan, *Phalaris minor* and *Convolvulus arvensis* in wheat are spreading in Bikaner district.
- *Parthenium hysterophorus* was dominant weed in cropped areas of Tamil Nadu.
- Incidence of *Solanum elaegnifolium* infestation in Gadag district (Mundargi taluk) in Karnataka was prominent.
- Due to continuous use of grassy killers, infestation of sedges, and broadleaf weeds e.g. *Eclipta alba*, *Ammania baccifera*, *Cucumus mello* and *Scirpus tuberosus* etc. is increasing in eastern U.P.
- Tomato crop in several areas of Bhiwani district of Haryana, was severely infested with *Orobanche aegyptiaca* causing 15-70% loss in fruit yield.
- In Assam, infestation of *Parthenium* is threatening the indigenous vegetation.
- In maize, there was a shift in weed flora from broadleaf and sedges towards grasses due to continuous use of atrazine in Kapurthala, Jalandhar, Bathinda, Hoshiarpur districts of Punjab. *Ipomoea* sp in cotton is also causing economic losses.
- *Alternanthra triandra* had heavily infested direct seeded rice and was rampant along road side , bunds etc. in Bilaspur district of Chhattisgarh.

Weed biology and Physiology

- As many as 14 taxa of *Echinochloa* species and intra-specific ranks under altogether 11 species have so far been identified by the Jorhat centre.

  Morphological parameters of *E. colona* and *E. crus-galli* were studied. Effect of tillage and weed management practices on weed density, weed dry weight at 60 DAS, and grain yield of chickpea under conservation agriculture (Bengaluru)

Morphological parameters of *Echinochloa* species

Morphological characters	*E. colona*	*E. crus-galli*
Germination (%)	72	64
Emergence (days)	4-5	3-4
Dry weight at 25 DAE (g/plant)	0.27	0.32
Flowering (days)	28	31
No. of seeds/plant	568	641
No. of seeds/m^2	5800	6250
1000 seed weight (g)	0.031	0.039

- Weedy rice possessing affinity to *Oryza rufipogon* and *Oryza nivara,* are extremely scarce in transplanted *kharif* and autumn rice of medium land situation of Assam.
- Results from farmer's fields at Karnal indicated that clodinafop 75 g, sulfosulfuron 30 g and meso+iodosulfuron 14.4 g/ha did not provide effective control of *P. minor* in wheat. Tank mix of metribuzin 105 g with clodinafop 60 g/ha or sulfosulfuron 25 g/ha or pinoxaden 50 g/ha provided effective control of *P. minor*. In Punjab, metribuzin + fenoxaprop-p-ethyl was most effective against *P. minor*.
- Addition of jaggery to glyphosate application for control of *C. rotundus* did not show added advantage at Jorhat, Anand, Ludhiana, Bengaluru however, it was beneficial at Pantnagar and Coimbatore.

Weed management in crops and cropping systems

- Herbicide combinations for control of complex weed flora in transplanted rice were evaluated. Post-emergence application of tank mix bispyribac+ ethoxysulfuron/Almix was found most effective at Ludhiana, Hisar, Bhubaneswer, Pantnagar and Raipur.

- In direct seeded rice, application of pendimethalin *fb* bispyribac+1 mannual weeding was most effective for weed control at Bhubaneswer, Hyderabad, Ranchi, Raipur, Coimbatore, Bengaluru, Palampur, Faizabad and Pusa.
- Weed management in turmeric by application of metribuzin 0.7 kg/ha *fb* mulching + 1 hand weeding was found best at Hisar, Ludhiana, Ranchi, Parbhani and Faizabad.
- Application of imazethapyr + pendimethalin 800-1000 g/ha was most effective and economical for weed control in blackgram/greengram at Gwalior, Hisar, Ludhiana, Bikaner, Palampur, Pantnagar, Sriniketan and Meerut.
- Experiments conducted in rice-wheat system under conservation agriculture system revealed that higher weed densities in DSR were observed with ZT compared to CT at Ludhiana, Pusa, Kanpur and Faizabad, while CT recorded higher weed density at Pantnagar. In wheat, CT-CT method recorded reduced density of weeds at Ludhiana and Pusa, while it favored higher weed growth at Pantnagar and Kanpur. Integrated weed management was most effective for weed control at all the places.
- The weed density was not significantly influenced due to tillage and residue management practices in rice –chickpea system at Bengaluru.
- In rice-mustard system, at Sriniketan and Jorhat conventional tillage in transplanted rice was found most effective in controlling weeds. In mustard also, lowest weed density was recorded under CT-CT method.

Long-term herbicide trials

- Sequential application of pre and post-emergence herbicides (clodinafop *fb* metsulfuron) against grasses and broadleaf weeds in wheat, and butachlor *fb* metsulfuron in rice were most effective for weed control on long-term basis at Ludhiana.
- In long-term herbicide trial in rice-groundnut at Bhubaneswar, application of butachlor+2,4-DEE, without organic matter to rice and alachlor to groundnut was found to be the best practice for weed management with high B:C ratio.
- In rice-chickpea system at Raipur, application of oxadiargyl 80 g/ha *fb* post-emergence bispyribac 25 g/ha in rice and pendimethalin 1.0 kg/ha in chickpea was the most effective for weed management and higher crop yields.

Effect of tillage and weed management practices on weeds and chickpea under conservation agriculture (Bengaluru)

Treatments	Total Weed density* (no./m^2)	Total Weed dry weight* (g/m^2)	Yield (t/ha)
Crop establishment technique			
CT - CT -	1.7(60.8)	1.3(31.2)	1.51
CT – ZT - ZT	1.7(60.0)	1.3(29.2)	1.52
CT – CT - ZT	1.7(60.1)	1.3(30.1)	1.50
ZT – ZT -ZT	1.8(73.3)	1.4(38.3)	1.33
ZT+R-ZT+R-ZT	1.7(70.9)	1.4(37.8)	1.36
CD (P=0.05)	NS	NS	NS
Weed control			
Recommended herbicide	1.7(56.0)	1.3(21.4)	1.6 5
IWM (herbicide + mechanical weeding + intercrop)	1.3(19.7)	0.8(3.9)	1.91
Unweeded	2.1(119.3)	1.9(74.7)	0.77
LSD (P=0.05)	0.11	0.11	0.16

Original values are given in ( )

* $\sqrt{x + 0.05}$ transformed values

Management of problematic / invasive / parasitic/aquatic weeds

- Application of glyphosate @ 25 g/ha on 55 DAS alone or with 1% $(NH_4)_2SO_4$ provided about 80-90% control of *Orobanche* in mustard in Haryana. Whereas, at Gwalior, lowest *Orobanche* shoot population was recorded with glyphosate @ 50 g/ha after emergence of *Orobanche* in mustard.
- In tobacco crop in Tamil Nadu, it was reported that plant hole application of neem cake at 200 kg/ha on 30 DAT or imazethapyr at 30 g/ha on 55 DAT recorded *Orobanche* shoot with higher tobacco leaf yield.
- Pre-emergence application of atrazine at 1.0 kg/ha on 3 DAP + HW on 45 DAP + earthing up on 60 DAP + POE 2,4-D Na salt 5 g/l + urea 20 g/l on 90 DAP *fb* trash mulching at 5 t/ha on 120 DAP was found most effective to control *Striga* in sugarcane at Coimbatore.

- The germination of *Cuscuta* was less in stale seedbed *fb* pre-emergence application of pendimethalin 1.0 kg/ha which resulted in the highest seed yield of niger at Bhubaneswar.
- In Bengaluru, for management of *Dendrophthoe* in sapota, padding of cotton with the paste made of 4 g copper sulphate + 0.5 g 2,4-D sodium salt 80 WP on the wounds of *Dendrophthe* shoots caused 100% defoliation after 2 months, without regeneration up to 6 months.

Biological weed management

Biological control of *Parthenium* by *Zygogramma bicolorata*

- Use of bioagent, *Zygogramma bicolorata* against resulted in significant control of *Parthenium* at Anand, Hisar, Palampur, Pantnagar, Ludhiana, Parbhani, Bhubaneswar, Kanpur, Faizabad, Pusa, Gwalior, Bikaner and Sriniketan centres with its effect ranging from 07-75%. Larval population, eggs and adults of *Zygogramma* beetles were highest during August to September at Sriniketan, Palampur, Faizabad and Bikaner.
- Broadcasting of seeds of *Cassia tora* was done during February-May in the pre-marked *Parthenium* infested sites. *Cassia tora* successfully replaced *Parthenium* by September-October at Anand, Jorhat, Ranchi, Hisar, Kanpur, Faizabad, Palampur, Pantnagar, Ludhiana, Raipur, Bhubaneswar, Muzaffarpur (Bihar), Gwalior and Sriniketan. At Coimbatore, *C. tora* did not germinate well due to scanty rainfall.
- *Neochetina* spp. weevils multiplied and caused excellent control of water hyacinth at Hyderabad, Thrissur, Hisar and Faizabad centre. Alligator weed replaced the niche vacated by water hyacinth.

Herbicide residues and environmental quality

- In long-term herbicide trial in rice-wheat cropping system, the residues of butachlor, pretilachlor and anilophos at Hisar and Ludhiana; butachlor and isoproturon at Palampur and Pantnagar were found below detectable level (0.01 ppm) in soil, grain and straw.
- In maize-pea cropping system at Palampur, pendimethalin residues were below detectable limits (0.001 µg/g) in post-harvest soil, grain and straw samples. Soil samples from chickpea, peas and mustard crops also showed residues of pendimethalin below detectable level. However, 0.095 µg/g residue was detected in mustard at the time of harvest of crop.
- At Hyderabad, in no-till maize soils, atrazine residues in soil could be detected upto 60 days after application at recommended dose of application either in combination with the paraquat or sole application. In post-emergence application, residues could be detected upto 45 days. No residues of butachlor could be detected in the rice grain or straw samples collected at harvest.
- At Hisar, the water samples from the tube-wells from farmers' fields were collected after 45 days of application of herbicide. Results revealed that 5 out of 21 sites were having pretilachlor residues ranging between 0.21–1.30 µg/g.
- At Hisar, soil, wheat grain and straw samples were collected from farmers' field at harvest from different rice-wheat growing regions of Haryana. The samples were taken from the sites where farmers were continuously using the pretilachlor for many years. At harvest, four samples were found to contain sulfosulfuron with in rage of 0.011-0.028 µg/g. Five soil samples were having either sulfosulfuron or meso+iodosulfuron. No other herbicides residues were detected in wheat grain and straw in the framer's fields.

Transfer of technology

- During 2013, AICRP-WC centres conducted 843 frontline demonstrations on location-specific weed management technologies, and broadcast 29 radio and 27 TV talk-shows. In addition to this, 80 training programmes were conducted, 20 handouts, folders, pamphlets, bulletins/booklet in various languages were published and distributed to the farmers and other end-users.
- At Hisar, ready mix combination of pretilachlor +bensulfuron was tested against complex weed flora in transplanted rice at 17 locations in various parts of Haryana and compared with existing herbicide pretilachlor. Results showed that 94.2% control of complex weed flora with tested new herbicide against 84.7% with pretilachlor and also yield increase of 157 kg/ha.
- At Bhubaneswar, 6 OFT wewe conducted in transplanted rice, results revealed that maximum yield of 4.21 t/ha was recorded with application

of oxadiargyl 0.065 kg/ha *fb* pyrazosulfuron-ethyl 0.02 kg/ha (4.02 t/ha) and net saving of ₹2150 - 2654/ ha was recorded.

Tribal Sub Plan

- Tribal sub plan was implemented at Anand, Jorhat, Ranchi, Palampur, Raipur, Bhubaneswar, Bikaner, Coimbatore, Bengaluru, Dharwad and Dapoli centres during 2013-14.
- Anand centre distributed herbicide spray equipments, hand hoes etc. to 50 tribal farmers of Dahod districts. OFTs were also conducted to demonstrate weed management technologies.
- FLDs, field day, training on weed management in *boro* rice were conducted by Jorhat Centre at Karbi Anglong, Kokrajhar districts. Inputs related to weed management were distributed to 80 tribal farmers.
- Ranchi centre conducted several training programmes for tribal farmers of Ranchi, West Singhbhum, Lohardaga and Gumla districts. Implements like cono weeder, grubber, dutch-hoe were also distributed to tribal farmers.


Training and distribution of inputs to tribal farmers by Ranchi centre

- Palampur center conducted 5 training programmes for 500 tribal farmers. Knapsack sprayers were also distributed to the farmers.
- Frontline demonstrations on weed management in maize, rice and wheat were conducted in 26 tribal districts at 318 farmer's fields in Chhattisgarh state by Raipur centre.
- Bhubaneswar center distributed implements and other inputs to tribal farmers in Keonjhar, Deogarh, Sundergarh and Mayurbhanja districts.
- Bikaner center organized 3 training programmes at Dungarpur, Banswara districts. Sprayers and herbicides were supplied to 90 tribal farmers.
- Training on weed management and distribution of implements was also under taken by coordinating centres at Bengaluru, Dharwad and Dapoli for the benefit of tribal 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 Control by the ICAR in collaboration with the United States Department of Agriculture (FERRO) at six locations, viz. Punjab Agricultural University, Ludhiana (Punjab); University of Agricultural Sciences, Bangalore (Karnataka); Indian Institute of Technology, Kharagpur (West Bengal); Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.); Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (U.P.); and Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur (H.P.). The project came into operation in April, 1978 with the financial outlay of ₹ 42.97 lakhs for five years. The tenure of the project was, however, extended for one more year till March, 1984 with the savings. Further work was continued at these centres with the AP Cess fund of ICAR till the implementation of VII Plan in April, 1986.

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

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

In the VIII Plan, 4 new centres, viz. 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 per cent 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) and XI plan (2007-2012) the total expenditure incurred under AICRP-WC was ₹ 823.79, 1696.57 and 3578.0 lakhs, respectively.

The coordinating unit of the project was located initially at CRRI, Cuttack, and shifted to NRC for Weed Science in 1989. Later in 2009, NRC for Weed Science was upgraded to Directorate of Weed Science Research.

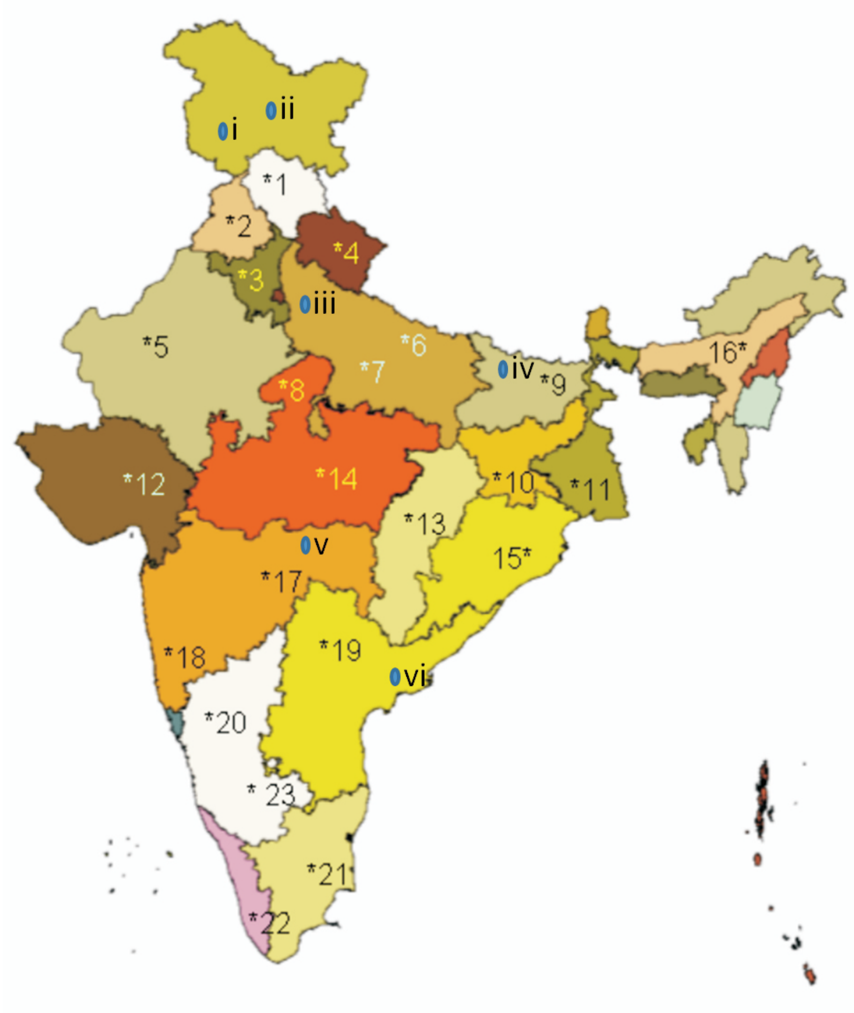
1.2 Mandate

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

1.3 Objectives

- To survey and surveillance of weed flora, mapping their distribution, ecology and habitat
- To evaluate new herbicides and working out the residual effect on non-targeted organisms
- To work out effective and economic weed management modules for field and horticultural crops and in different aquatic situations
- To study biology and control of problem weeds including aquatic and parasitic weeds

- To study long-term residual and cumulative effects, if any, of herbicides
- To standardize techniques for herbicide residues in soil, water and food chain
- To carry out basic research at different centres having adequate laboratory facilities for rendering support to adaptive research
- To test available tools/ implements for weed management under various agro-ecosystems; and To transfer weed management technologies on farmers' fields through OFT and FLDs their impact assessment and training.



AICRP-Weed Control

Regular Centres

1 CSKHPKV, Palampur
2 PAU, Ludhiana
3 CCSHAU, Hisar
4 GBPUAT, Pantnagar
5 SKRAU, Bikaner
6 NDUAT, Faizabad
7 CSAUAT, Kanpur
8 RVSKVV, Gwalior
9 RAU, Pusa
10 BAU, Ranchi
11 VB, Sriniketan
12 AAU, Anand
13 IGKV, Raipur
14 **HQ, DWSR, Jabalpur**
15 OUAT, Bhubaneswar
16 AAU, Jorhat
17 VNMKV, Parbhani
18 DBSKKV, Dapoli
19 ANGRAU, Hyderabad
20 UAS, Dharwad
21 TNAU, Coimbatore
22 KAU, Thrissur
23 UAS, Bengaluru

Volunteer Centres

i SKUAST, Jammu
ii SKUAST, Kashmir
iii SVBPUAT, Meerut
iv RAU, Sabour
v PDKV, Akola
vi PAJANCOA & RI, Puducherry

2. STAFF POSITION AND EXPENDITURE

AICRP on Weed Control is presently under operation in 22 State Agricultural Universities in 19 different states of the country. These centres represent 19 agro-ecological regions. Altogether, 72 scientists of different disciplines (Agronomy, Plant Physiology, Taxonomy, Residue Chemistry, Microbiology and Agricultural Economics) are working in inter-disciplinary mode. Besides 22 main centres, 8 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2013-14 are given below:

Staff position at different coordinating centres during 2013-14

Centre	Scientific		Technical (Including Driver)		Administrative		Supporting	
	Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled
PAU, Ludhiana	4	4	3	3	1	1	2	2
UAS, Bengaluru	4	4	3	2	1	-	2	2
JNKVV, Gwalior	4	3	2	2	1	1	2	2
GBPUAT, Pantnagar	4	4	3	3	1	1	2	2
CSKHPKV, Palampur	4	4	3	3	1	1	2	2
AAU, Jorhat	4	4	3	3	1	1	2	1
VNMKV, Parbhani	4	3	3	3	1	1	2	1
AAU, Anand	4	3	3	3	1	-	2	2
TNAU, Coimbatore	4	4	3	3	1	1	2	2
NDUAT, Faizabad	4	4	2	2	1	-	2	2
VB,Sriniketan	3	3	2	2	1	1	1	1
BAU, Ranchi	3	2	2	2	1	1	1	1
CSAUAT,Kanpur	3	3	1	1	1	1	1	1
KAU, Thrissur	3	3	2	1	1	1	1	-
OUAT, Bhubaneshwar	3	3	2	2	1	1	1	1
ANGRAU, Hyderabad	3	3	1	1	1	1	1	1
CCSHAU, Hisar	3	3	2	2	1	-	1	-
RAU, Pusa	3	3	2	-	1	-	1	1
DBSKKV, Dapoli	2	2	1	1	1	1	1	1
IGKVV, Raipur	2	2	1	1	1	1	1	1
UAS, Dharwad	2	2	1	1	1	1	1	1
SKRAU, Bikaner	2	2	1	1	1	-	1	1
Total	**72**	**68**	**46**	**42**	**22**	**16**	**32**	**28**

Funds released to different coordinating centres during the financial Year 2013-14

(₹ in lakhs)

Sl. No.	Centre name	Pay & Allowances	TA	Recurring Contingency	IT	TSP	Total (ICAR share)
1	PAU, Ludhiana	32.77	0.60	2.78	0.00	0.00	36.15
2	UAS, Bengaluru	36.74	0.45	1.80	0.00	0.00	38.99
3	RVSKVV, Gwalior	35.94	0.60	2.78	0.00	7.70	47.02
4	GBPUAT, Pantnagar	31.09	0.60	2.78	0.00	0.00	34.47
5	CSKHPKV, Palampur	42.52	0.60	2.40	0.00	5.50	51.02
6	AAU, Jorhat	54.88	0.60	19.40	2.00	7.70	84.58
7	VNMKV, Parbhani	27.29	0.45	1.80	0.00	0.00	29.54
8	AAU, Anand	30.06	0.45	1.80	0.00	13.20	45.51
9	TNAU, Coimbatore	35.55	0.60	2.40	0.00	0.00	38.55
10	NDUAT, Faizabad	40.90	0.60	2.78	0.00	0.00	44.28
11	V.B.Sriniketan	14.97	0.60	2.40	0.00	0.00	17.97
12	BAU, Ranchi	22.79	0.30	1.58	0.00	13 .20	37.87
13	CSAUAT,Kanpur	20.19	0.45	2.18	0.00	0.00	22.82
14	KAU, Thrissur	36.40	0.45	1.80	0.00	0.00	38.65
15	OUAT, Bhubaneshwar	25.60	0.30	1.20	0.00	23.10	50.20
16	ANGRAU, Hyderabad	26.25	0.45	2.18	0.00	0.00	28.88
17	CCSHAU, Hisar	25.76	0.45	1.80	0. 00	0.00	28.01
18	RAU, Pusa	11.89	0.45	1.80	0.00	0.00	14.14
19	DBSKKV, Dapoli	16.25	0.30	1.58	0.00	2.20	20.33
20	IGKVV, Raipur	29.78	0.30	1.58	0.00	18.70	50.36
21	UAS, Dharwad	14.81	0.30	1.58	0.00	0.00	16.69
22	SKRAU, Bikaner	11.95	0.30	1.58	0.00	7.70	21.53
	Total	**624.38**	**10.20**	**61.98**	**2.00**	**99.00**	**797.56**
	Volunteer Centres						
23	DPDKV, Akola	0.00	0.00	0.20	0.00	0.00	**0.20**
24	SKUAST, Kashmir	0.00	0.00	0.30	0.00	0.00	**0.30**
25	PJNCARI, Karaikal	0.00	0.00	0.10	0.00	0.00	**0.10**
26	ACRI, Madurai	0.00	0.00	0.10	0.00	0.00	**0.10**
	Total	**0.00**	**0.00**	**0.70**	**0.00**	**0.00**	**0.70**
	Total ICAR share	**624.38**	**10.20**	**62.68**	**2.00**	**99.00**	**798.26**

3. RESEARCH ACHIEVEMENTS

WS 1: Weed surveillance

Different centres undertook weed surveillance in their respective areas during different seasons and in cropped and non-cropped areas as well as in aquatic and other habitats. The salient findings have been summarised centrewise.

1.1. AAU, Anand

1.1.1. Weeds of rainy season crops

Weed survey in North Gujarat agro-climatic zone elicited that cluster bean, cotton, castor, pearlmillet, sorghum and maize were major crops grown in the region. The crops were mainly infested with dominant weeds, *viz. Cyperus rotundus, Eragrostis major, Eleusine indica, Echinochloa crus-galli,* and *Commelina forskalaei* as narrow leaved weeds. While *Phyllanthus niruri, Digera arvensis, Trianthema monogyna, Euphorbia hirta* and *Vernonia cinerea* were broad leaved weeds in the winter season crops. Weedy rice was recorded in the field and non cropped areas at Tarapur, Petlad, Matar, Khambhat, Sojitra, Bareja, Nadiad, Vadodara, Dabhoi and Karjan in middle Gujarat.

Major grass weeds in clusterbean were *Eragrostis major, Eleusine indica*, *Commelina forskalaei* and *Dactyloctenium aegyptium*. Prominent broadleaf weeds were *Phyllanthus niruri*, *Digera arvensis*, *Euphorbia hirta* and *Trianthema monogyna*. Sedges invading the crop fields were *Cyperus rotundus* and *Cyperus iria*.

1.1.2. Weeds of winter season crops

Density of *Phalaris minor* was recorded in various wheat fields in Sabarakantha, Mehsana, Patan, Gandhinagar, Ahmedabad, Kheda, Anand, Panchamahal and Dahod districts.

1.2. UAS, Bengaluru

1.2.1. New weeds/spread of weeds

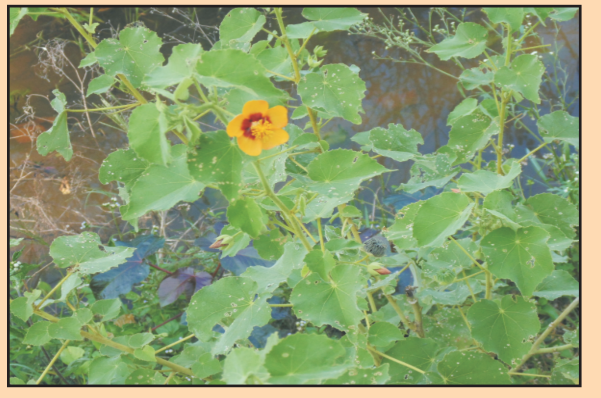
New weeds noticed in different parts of southern Karnataka were recorded and fear was expressed on their probable spread with time likey to pose problem in crops.

i. ***Mikania micrantha***–The weed spread has been reported to many areas on road sides and valleys in Ponnampet area of Kodagu district in hilly zone (851-909 m elevation, 12º2″ N, 75º8″ to 75º9″ E) during *Kharif* 2012. Spread of the weed was also noticed in Turuvekere (795 m, 13º09'384″ N, 76º40'0001″ E), Tumkur district. The weed has been reported to cover trees and road side plants in many places in the valleys.

ii. ***Ambrosia artemisiifolia*** **–** The species which is similar to *Parthenium hysterophorus* was found in Krishna Raja Puram Railway station near track leading to Food Corporation of India Godown.

Ambrosia artemisiifolia

iii. ***Abutilon hirtum*** **–** This weed was observed in Turuvekere (795m, 13º 09' 384″ N, 76º 40' 0001″ E), Tumkur district near water source and irrigation canal in Amanikere. The weed (also known as Indian mallow), native of Florida, was a perennial dicot species. The species was also found in Turuvekere.



Abutilon hirtum

Mikania micarnatha

Pistia stratiotes

iv. ***Verbesia encelioides var.*** encelioides (Wild sunflower) – The species had invaded certain areas in the southern Karnataka.

Verbesia encelioides Var. encelioides wild sunflower observed in Turuvekere, Tumkur district.

v. ***Solanum elaegnifolium*** **–** The weed occurred around automobile servicing areas suggesting that this was probably spread by vehicular movement in the infested areas and washing led to fresh infestations.

Solanum elaegnifolium observed in Turuvekere city

vi. ***Pistia stratiotes*** – An aquatic weed (Araceae) commonly called as water lettuce, water cabbage, was found in Dwaranahally village of Turuvekere taluk**.**

vii. ***Ambrosia psilostachya***, a quarantine weed had infested 138 farmer's fields in 9 villages of Turuvekere. The weed occurred along road sides, irrigation canals extending to 185 acres and 7.5 guntas.

1.3. OUAT, Bhubaneswar

1.3.1. Weeds of rainy season crops

The weed survey has been conducted in the irrigated tracts along the national highway no. 203 from Bhubaneswar to Puri under East and South Eastern Coastal Plain Agro-climatic Zone of the state during *kharif* 2013. The covered locations were Pipli and Nimapara of Puri district.

In North-Central plateu Zone, *Celosia argentea* was observed to be a severe problem in upland rice and *Rabi* pulses in the districts of Keonjhar. The weed was invading mostly the upland areas nearer the foothills with light textured red soils. The yield loss in rice and pulses due to *Celosia argentea* was to the tune of 40 and 35%, respectively. *Echinochloa colona* and *Digitaria sanguinalis* were the major grassy weeds found in *kharif* ground nut in this zone. In East and South Eastern Coastal plain zone, *Alternanthera philoxeroides* (alligator weed) was observed in low land paddy areas and lowlying swampy areas along the road sides of coastal districts (Jagatsinghpur, Kendrapara, Puri, Khurda and Jajpur). A shift from *Alternanthera sessilis* to *Alternanthera philoxeroides* was recorded in several low-lying rice areas in these regions. Sporadic incidences of *Orobanche aegyptica* **were** observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda district along river Mahanadi.

1.3.2. Weeds of winter season crops

The weed survey had been conducted in the rainfed tracts along the state highway no. 215 from Jajpur to Keonjhar via Anandpur under North central plateu zone of the state during *rabi*, 2012-13. The locations covered were Ghatagaon, Gopapur, and Poipani of Keonjhar district.

Weed flora in pulses was dominated with grasses like *Cynodon dactylon*, *Echinochloa colona* and *Digitaria ciliaris*, and broad leaf weeds like *Ageratum conyzoides*, *Amaranthus viridis* and *Spaeranthus indicus*, and sedges like *Cyperus rotundus*. The dominant weeds observed in non-cropped areas were *Cynodon dactylon*, *Sporobolus diander*, *Ageratum conyzoides*, *Achyranthus aspera*, *Spaeranthus indicus* and *Cyperus rotundus*.

1.3.3. Weeds of non-cropped lands

In non-cropped area, *Ipomoea aquatica, Mimosa pudica, Parthenium hysterophorus, Saccharum spontaneum* and *Eichhornia crassipes* were prominent weeds in North central plateau Zone of Odisha. The results of weed survey in non-cropped area at Ghatagaon revealed the dominance of *Cynodon dactylon* (IVI 48.6) and *Digitaria ciliaris* (17.0) among grasses. The dominant broad leaf weeds were *Ipomoea aquatica* (40.8), *Ageratum conyzoides* (36.7) and *Amaranthus viridis* (22.2). Major sedge observed was *Cyperus iria* (14.0).

1.3.4. Aquatic weeds

Water hyancith was confined to particular locations like ponds, ditches, etc. but now it was widely seen in the new areas like low land paddy of coastal districts of Cuttack, Puri, Ganjam and Balasore. Surveillance of *Phragmites karaka* was carried out in Chilika Lagoon. Chilika, the largest brackish water lagoon of Asia, is a naturally formed wet land with water spread over an area of 1165 sq km during monsoon and 906 sq km during summer. It is a hot spot of biodiversity.

Phragmites karka, covered one tenth area of the lake, posing a serious problem in navigation and fishing. This weed was confined to a particular area of the lake earlier, but now it has spread towards the bank posing serious problem.

1.4. SKRAU, Bikaner

1.4.1. Weeds of rainy season crops

Dactyloctenium aegyptium dominated in goundnut and *Digera arvensis*, in moth bean. In cluster bean and greengram, *Chorcorus tridense* dominanted the fields.

1.4.2. Weeds of winter season crops

Prominent weeds of *rabi* were *Chenopodium album, Melilotus indica* and *Rumex dentatus* in wheat and barley; *Chenopodium album* and *Asphodelus tenuifolius* were the most prevalent weeds in mustard. In chickpea, *Chenopodium album* and *Convolvulus arvensis* were dominant weeds. In fenugreek, *Melilotus indica* and *Chenopodium album* dominated the fields while *Fumaria parviflora* also showed its presence.

1.4.3. Shift in weed flora

In wheat, *Phalaris minor* and *Convolvulius arvensis* were spreading alarmingly in the Bikaner district. Previously, the Bikaner district was dominated by broad leaved weeds in *rabi* season with poor or no population of grassy weeds.

In *kharif* season, groundnut is cultivated as irrigated crop in the region and therefore, weed flora was shifted to weeds like *Dactyloctenium aegyptium*, *Eleusine verticillata* and *Digera arvensis* from dry land weeds like *Gisekia pharnaceoides* and *Tribulus terristris.* Another weed, *Crotolaria medicaginea* was also noticed in groundnut. In cluster bean, new weed *Cleome viscosa* was apparent mainly in Dungergarh tehsil of the district. Water hyacinth was also noticed in the water bodies of the Thar Desert.

1.5. TNAU, Coimbatore

1.5.1. Crop weeds

Parthenium hysterophorus was dominant broad leaved weed (SDR, 19.9) as compared to *Trianthema portulacastrum* (SDR, 12.1) in 2008 in cropped area. However, the incidence of *Cyperus rotundus* had come down (SDR, 19.9) from 2008 (SDR, 26.1).

Cynodon dactylon which was dominant (SDR, 12.4) among grasses during 2008 in cropped area had been replaced by *Dactyloctenium aegyptium* (SDR, 14.6).

1.5.2. Weeds in non-cropped areas

Gomphrena decumbens was dominant (SDR, 11.2) among broad leaved weeds during 2008 was replaced by *Parthenium hysterophorus* during 2013 (SDR, 20.3). In cropped area, incidence of *Cyperus rotundus* had also come down during 2013 (SDR, 12.9) as compared to the situation in 2008. During 2013, among the grass weeds, *Cynodon dactylon* (SDR, 19.8) incidence was higher as compared to the status brought out in 2008 (SDR, 14.3) survey.

1.5.3. Weeds in garbage areas

High intensity of *Parthenium hysterophorus* (SDR, 21.4) among broad leaved weeds under garbage area was prominent during 2013. The weed had lower density (SDR, 10.6) during 2008 survey. Invasion of *Cyperus rotundus* was observed during 2013, which was not so in 2008. Among the grass weeds, the predominant weed *Cynodon dactylon* population had decreased during 2013 (SDR, 16.0) when compared to 2008.

1.6. DBSKKV, Dapoli

1.6.1. Weeds of rainy season crops

Weed survey was conducted in different tahsils of Ratnagiri district Dapoli, Guhagar, Ratnagiri, Lanja, Sangmeshvar, Deorukh, Chiplun and Khed during *Kharif* 2013. In Dapoli, Guhagar, Ratnagiri, lanja and Rajapur tahsil, *Isachanae globosa, Leptochloa chinensis, Ischaemum rugosum, Blumea lacera, Eriocaulon hexangularis* and *Ehinochloa colona* were most dominant weeds in *kharif* rice. While in groundnut *Mimosa pudica, Ludwigia octovalvis, Blumea lacera, Ehinochloa colona, Ageratum conyzoides, Isachnae globosa* and *Alternanthera sessilis* were dominant species.

1.6.2. Weeds in orchards

In orchard crops like mango and coconut, *Themeda quadrivolvis, Celosia argentea, Urena lobata, Blumea lacera, Ludwigia octovalvis* and *Ageratum conyzoides* were prominent weeds.

1.7. UAS, Dharwad

1.7.1. Weed survey

Incidence of *Solanum elaegnifolium* infestation in Gadag district (Mundargi taluk) was prominent. During 2012, this weed was noticed in Hukkeri block of Belgaum district and during 2010 in Khyad village of Badami block in Bagalkot district.

1.7.2. Monitoring of weed shift / appearance of new weeds

Weed shift was not apparent in the cropping system. Due to continuous and more amount of rains during July, the incidence of *Mollugo* sp. was relatively more during the year in the experimental plots as compared to previous years.

1.8. NDUAT, Faizabad

1.8.1. Weeds of rainy season crops

Weed surveillance studies conducted in *kharif* crops revealed no new weed appearance in any crop including rice. Wild rice (*Oryza sativa f. rufipogon* and *Oryza sativa f. spontanea*) was observed in low lying rice growing areas in Varanasi and Jaunpur districts to a considerable extent but was not dominating in uplands. Poor efficacy of all the pre-emergence herbicides used by the farmers (butachlor, pretilachlor and oxadiarzgyl) was observed against *Dactyloctenium aegyptium* in transplanted and direct seeded rice crop.

Due to continuous use of grassy weed killer herbicides, infestation of sedges and broad leaved weeds e.g. *Eclipta alba, Ammania baccifera, Cucumus mello* and *Scirpus tuberosus* was increasing in rice every year.

1.8.2. Weeds of winter-season crops

Phalaris minor was most dominating grassy weed in wheat in all the districts surveyed while in some pockets of Sonebhdra, infestation of *Avena ludoviciana* was observed. In *rabi* season, especially in wheat, infestation of broad leaved weeds had been increasing. It was contemplated that it might be due to more use of grass killers. In some wheat growing areas, dominance of *Medicago denticulata* and *Lathyrus aphaca* and *Convolvulus arvensis* was observed.

1.9. RVSKVV, Gwalior

1.9.1. Weeds of rainy season crops

Rainy season weeds were surveyed in *kharif* crops of Tikamgarh and Sagar district of M.P. The weed survey work was done in soybean, paddy, blackgram, green gram, sesamum and groundnut crops in Tikamgarh and Sagar districts of the state. On the basis of IVI values and relative density, major weeds *Echinochloa crus-galli, Commelina benghalensis* and *Eragrostis pilosa* were found dominant in *kharif* season in these districts.

1.9.2. Weeds of winter season crops

The survey covered Gwalior and Chambal Divisions, involving Gwalior, Datia, Morena and Bhind districts of Madhya Pradesh. Major weeds were *Chenopodium album, Anagallis arvensis, Asphodelus tenuifolius, Orobanche* sp. and *Convolvulus arvensis* dominant in wheat, gram and mustard crops.

1.10. CCSHAU, Hisar

1.10.1. Weeds of rainy season crops

Direct seeded rice was heavily infested with grassy weeds like *Dactyloctenium aegyptium, Eleusine indica, Panicum* spp. and *Leptochloa chinensis* responsible for heavy yield reductions in the fields in Fatehbad, Sirsa, Ambala, Karnal and Kurukshetra districts of the Haryana state.

1.10.2. Weeds of winter season crops

Avena ludoviciana was observed as one of the major weeds of wheat in Farook Nagar, Heli Mandi, Patoudi, Bilaspur, Dighawa, Loharu, Badhra, Siwani and Tosham areas. This weed had not been observed in these areas earlier.

None of the mustard genotypes grown in the region was tolerant to infestation of *Orobanche* sp.

In February and March, even perennial sedge *Scirpus tuberosus* showed infestation in wheat sown under zero till conditions in Naggal (Ambala), Cheeka, Bainsi (Rohtak), Satrod and Ladwa areas of Hisar.

Tomato crop in Nuh and Ferozepur Jhirka areas of Mewat and Dadri tehsil of Bhiwani district was severely infested with parasitic weed *Orobanche aegyptiaca* causing 15-70 % decrease in fruit yield in the crop. Even cauliflower and cabbage were infested with *Orobanche* sp. in Mehra village of Dadri tehsil.

Sporadic infestation of parasitic weed *Cuscuta chinensis* was observed in berseem crop in Assandh, Safidon, Ambala, Karnal, Kaithal, Tohana, Kurukshetra and Kaithal areas of the state. *Coronopus didymus, Polypogon monspliensis* and *Poa annua* had become dominant weeds of berseem crop.

Infestation of *Euphorbia dracunculoides* had increased in mustard and chickpea crops planted under rainfed conditions.

Wheat and mustard crops in Gurgaon, Mewat, Rewari and Narnaul areas were severely infested with thorny weed (*Carthamus oxycantha)* and deep rooted perennial weed (*Pluchea lanceolata)*.

Ratoon sugarcane crop mulched with sugarcane trash was heavily infested with *Ipomoea* spp. causing huge losses in Yamuna Nagar, Palwal, Ambala and some parts of Karnal and Kurukshetra districts. Infestation of *Poa annua* was increasing in berseem, wheat and vegetable crops.

1.10.3. Weeds of non-cropped lands

In North-Western Haryana, weed flora in non cropped areas and along roadsides have shifted to *Cassia occidentalis, Chenopodium ambrosoides, Cassia tora* and *Cannabis sativa*.

1.11. ANGRAU, Hyderabad

1.11.1. Weeds in maize crop

Weed flora in maize crop included *Cyperus rotundus, Cynodon dactylon, Hyptis sauveolens, Celosia argentea, Commelina benghalensis, Tridex procumbense, Cleome viscosa, Croton sparsiflorus, Euphorbia hirta, Leucas aspera, Ipomoea pestigridis* and *Acanthospermum hispidum*. Out of all the species, *Cyperus rotundus* was the most dense and frequently invading species.

1.11.2. Weeds in cotton crop

Predominent weed flora in cotton in Karimnagar district was *Cyperus rotundus, Parthenium hysterophorous, Cynodon dactylon, Tridex procumbense, Leucas aspera, Euphorbia hirta* and *Amaranthus spinosus*. Among the broad leaved weeds, *Parthenium hysterophorous* was the most densly and frequently appearing weed in cotton. The relative density of *Cyperus rotundus* was lesser than *Parthenium hysterophorus*. But frequency of its occurrence was equal to that of *Parthenium hysterophorus*.

1.12. AAU, Jorhat

1.12.1. Infestation of *Parthenium hysterophorus*

Infestation of the weed was severe as altogether 95 species of indigenous vegetation of Assam were more or less severely affected and gradually eliminated by *Parthenium hysterophorus*. Of these, about 85% were broadleaved species, 13% grasses and rest 2% sedges. Broadleaved species included edible ferns like *Diplazium esculentum* (*Dhekia sak*) and two species of *Lygodium* (*Kopou dhekia*). *Parthenium hysterophorus* was first recorded as an invasive weed in and around Guwahati city during 1980. It had now become one of the top three invasive weeds in the Hill zone of Assam.

1.12.2. Infestation of *Cuscuta campestris*

Cuscuta campestris, the yellow dodder, was a common stem parasite occurring in areas of North East India at nearly 80 m to 1300 m altitude from MSL. As many as 23 crops and non-crop species of Assam were more or less severely infested by *Cuscuta campestris*.

1.12.3. Weeds of non-cropped lands

The playground was infested mostly by *Imperata cylindrica* coupled with *Eleusine indica.* Damp areas were originally rice fields and hence possessed lots of sedges. The sedge species like *Cyperus iria, Cyperus difformis, Cyperus brevifolius, Cyperus flavidus,* several species of *Fimvristylis, Pycreus macrostachys,* etc. were the most common species in these areas.

1.13.4 Aquatic weeds

1.13.4.1. Aquatic weeds of Nagaon district

The aquatic weeds of southern part of Nagaon district consisted of altogether 44 species, which included 30 broadleaved species, 1 fern (*Sphaerostephanos unitus*), and monocots. Most of the species of aquatic situations were anchored, emerged and marginal plants.

1.13.4.2. Aquatic weeds of Karbi Anglong district

The aquatic weeds of Karbi Anglong district (Diphu and Bokajan subdivisions) consisted of altogether 50 species, which included 33 broadleaved plants comprising of 2 ferns, 5 monocots and 26 dicot species, and 17 narrow leaved species belonged to 10 grasses and 7 sedges. Amongst these, the perennial bushy weed, *Ludwigia peruviana,* showed the maximum density, frequency of occurrence, area coverage and ultimately the importance value index and sum dominance ratio, which were quite higher than other plant species recorded during the study.

1.14. CSAUAT, Kanpur

1.14.1. Weeds of rainy season crops

Weed surveillance was conducted in *kharif* season of central plain zone of U.P. In Fatehpur district, in pigeon pea crop, the major weeds were *Digera arvensis* and *Dactyloctenium aegyptium* (IVI, 73.3 and 69.9, respectively). In pearlmillet, the major weeds were *Achyranthus aspera* and *Euphorbia hitra* (IVI, 41.2 and 37.3, respectively). In rice, major weeds were *Commelina benghalensis* and *Echinochloa colona* (IVI, 74.1 and 77.5, respectively).

There were shifts in *Corchorus acutangulus, Dinebra arabica, Erigeron asteroids* and *Ipomoea hederacea* leading to emergence of weeds, *viz. Vernonia cinerea, Alternanthera sessilis Leptochloa chinensis, Dactyloctenium aegyptium, Celosia argentea, Ceasulia axillaris, Zizyphus rotundifolia* and *Fimbristyllis milliacea.*

In Kaushambi district, under sorghum + pigeonpea cropping system, major weeds were *Dactyloctenium aegptium* and *Digera arvensis* (IVI 27.2). In pigeonpea crop, major weeds were *Parthenium hysterophorus* with IVI value of (50.8), *Digera arvensis* and *Eclipta alba* (42.0 each).

In Allahabad district, in rice major weed was *Echinochloa colona* (IVI 118.8). In non-cropped area major weeds were *Xanthium strumarium* and *Achranthus aspera* (IVI 33.02 and 36.6, respectively). Species like *Digera arvensis, Achyranthus aspera, Lantana camera, Celosia argentea, Dinebra arabica, Trianthema monogyna, Setaria verticillata, Euphorbia hirta* and *Phyllanthus niruri* shifted and new weeds, *viz. Echinochloa crus-galli, Xanthium strumarium, Zizyphus rotundifolia, Cassia tora, Corchorous acutangulus* and *Achyranthus aspera* occupied their place.

1.14.2. Weeds of winter season crops

Weed surveillance during *rabi* season in Central Plain Zone revealed that in Kanauj district, in wheat new emerging weeds, *viz., Parthenium hysterophorus, Argemone mexicana, Rumex dentatus, Avena ludoviciana and Asphodelus tenuifolious* were observed.

In Mainpuri district, in wheat, major weeds were *Chenopodium album* and *Phalaris minor* (IVI 83.9 and 75.0, respectively). In Etawah district, in wheat major weeds were *Avena ludoviciana* and *Phalaris minor* (IVI 96.6 and 103.3, respectively).

1.15. PAU, Ludhiana

1.15.1. Weeds of rainy season crops

Monitoring of weed shift / appearance of new weeds due to weed management practices, changes in cropping systems and climatic parameters were undertaken in *kharif* 2013 in Kapurthala, Jalandhar, Bathinda, Hoshiarpur and Nawanshahr and Roopnagar districts. In rice, *Echinochloa crus-galli* still dominated the weed flroa in transplanted crop. Infestation of *Oryza* sp. was on the increase in transplanted rice. *Dactyloctenium* and *Leptochloa* infestation had been recorded in transplanted rice, in areas having shortage of irrigation water, and with intermittent flooding of the rice fields. *Dactyloctenum and Leptochloa* sp. intensity had increased in direct seeded rice and these weeds were likely to dominate *Echinochloa* sp.

In maize, there was a shift in weed flora from broadleaves and sedges to grass weeds which had become dominant, due to continuous use of atrazine. Atrazine had poor response against hardy grasses like *Acrachne racemose, Brachiaria reptans* and *Commelina benghalensis*. These dominated the fields in the absence of broadleaved weeds and also suppressed *Cyperus rotundus*.

1.15.2. Weeds of winter season crops

In *rabi* 2012-13, in Kapurthala, Jalandhar, Bathinda, Hoshiarpur and Nawanshahr and Roopnagar districts. *Phalaris minor* dominated the weed flora in rice-wheat cropping areas. The intensity of *Poa annua* was increasing, particularly in heavy textured soils which retained more moisture. *Solanum nigrum* was coming up as troublesome weed of wheat and spring crops. In maize-wheat cropping areas, *Avena ludoviciana* dominated the weed flora followed by *umex dentatus*.

In Malwa belt of Punjab, *Ipomoea* sp. started infesting cotton crop and the infestation was increasing every year causing economic losses to the cotton growers.

1.15.3. Weeds of non-crop lands

Parthenium hysterophorus and *Cannabis sativa,* which were earlier weeds of non-cropped areas, have started infesting berseem and maize. *Cuscuta* sp. which was earlier infesting trees along roadsides had started infesting berseem crop also.

1.16. CSKHPKV, Palampur

1.16.1. Weeds of rainy season crops

In Kangra district, in maize crop, increasing dominance of *Ageratum conyzoides* at silking stage was prominent. Other major weeds in the crop were *Commelina benghalensis* and *Brachiaria* sp. *Parthenium hysterophorus* was reported to invade the upland *kharif* crops adjoining roads, railway tracks and sides of nalas.

1.16.2. Weeds of non-crop lands

Spread of *Cassia tora* and *Zygogramma bicolorata* beetle on large scale were observed in some localized pockets of the district.

1.17. GBPUAT, Pantnagar

1.17.1. Weeds of rainy season crops

The survey was undertaken along Rudrapur–Gadarpur–Gularbhoj area. Five locations in the Rudrapur-Gadarpur-Gularbhoj area were surveyed where rice and sugarcane were major crops. Among grasses, *Echinochloa cruss-galli* was the major weed (IVI 20.0) followed by *Echinochloa colona* (16.0) and the broadleaf weeds *Ammannia baccifera* (20.1). Other major broadleaf weeds were *Commellina diffusa* and *Commelina axillaries*. *Cyperus difformis* was the only sedge (with an IVI of 8.1). In the Nainital-Bhimtal-Jeolikote area, a total of six locations were surveyed. Rice was the major crop with both transplanting and broadcasting methods of growing. In the Jeolikote area, mixed cropping of soybean and finger millet was observed. In the Nainital area, *Ageratum conyjoides* was the major species (IVI 27.0) followed by *Lindernia cristaceae* (IVI 24.1) and *Oxallis latifolia* (IVI 14.2). *Echinochloa colona* and *Echinochloa crus-galli* were the major grasses. In the Jeolikote area, among the grasses, *Echinochloa crus-galli*, and *Echonochloa colona* were apparent at most of the locations. In this route, *Oxallis latifolia, Ageratum conyzoides, Galingsoga parviflora, Lindernia cristaceae, Eclipta alba* and *Ammania baccifera* were the major broad leaf weeds.

1.17.2. Weeds of winter season crops

The survey was undertaken in the fields of farmers along Kichha - Sitarganj- Khatima area during the winter season. Total nine fields were surveyed. The major crops and cropping systems were rice-wheat, sugarcane-ratoon, wheat + poplar, vegetable pea, maize and green gram. *Phalaris minor* was the major weed in wheat. The population of this weed ranged between 120-168/m^2 at different locations. Other weed species in wheat crop included *Chenopodium album* (48/m^2), *Avena* sp. and *Melilotus alba*. In sugarcane ratoon, the population of *Chenopodium album* was 128/m^2 followed by that of *Ageratum conyzoides.* In sugarcane, major problem weed was *Cyperus rotundus*.

1.18. VNMKV, Parbhani

1.18.1. Weeds of rainy season crops

Weed survey was undertaken in *kharif* in Jalna, Aurangabad and Beed districts of Maharashtra state. In Jalna district, *Parthenium hysterophorus, Euphorbia geniculata, Commelina benghalensis* and *Cynodon dactylon* were dominent weed species in sorghum, soybean and pigeon pea. In non-cropped area, *Pathenium hysterophorus, Cassia tora* and *Althernanthera sessiles* were dominent. In Aurangabad district, *Parthenium hysterophorus, Commelina benghalensis, Euphorbia geniculata* were dominant weed species in soybean, cotton and maize. In non-cropped area, *Parthenium hysterophorus, Cassia tora* and *Achyaranthus aspera* were dominant. In Beed district, *Euphorbia geniculata, Parthenium hysterophorus, Commelina bengalensis, Cynodon dactylon* were dominant weed species in soybean, cotton and sorghum.

1.18.2. Weeds of winter season crops

Weed survey was conducted in cropped as well as non cropped areas during *rabi* season in Latur, Nanded and Hingoli districts of Maharashtra state. In Latur district, *Parthenium hysterophorus, Convolvulus arvensis, Euphorbia geniculata* and *Cynodon dactylon* were dominant in wheat and gram. In non-cropped area, *Alternanthera sessilis* and *Parthenium hysterophorus* were dominant. In Nanded district, *Parthenium hysterophorus, Euphorbia geniculata, Chenopodium album* and *Cynodon dactylon* were dominant in wheat and gram. In non-cropped area, *Parthenium hysterophorus* and *Alternanthera sessilis* were dominant. In Hingoli district, the dominant weeds were *Parthenium hysterophorus, Chenopodium album, Euphorbia geniculata* and *Cynodon dactylon* in wheat and gram. In non-cropped area, *Parthenium hysterophorus, Celosia argentea* and *Alternanthera sessilis* were dominant.

1.19. RAU, Pusa

1.19.1. Weeds of rainy season crops

Survey of weed flora was conducted during *kharif* season of 2013. In direct-seeded upland rice, 16 weed species were observed, out of which, 5 were grasses, 2 sedges and 9 broadleaved weed speices. Among the grasses and sedges, highly dominant weed species were *Cynodon dactylon* followed by *Echinocloa colona, Cyperus rotundus* and *Cyperus diformis*. Among the broad leaved weeds, prevalent species were *Cleome viscosa, Caesulia axillaris* and *Amaranthus spinosus*.

Transplanted rice was infested with 14 weed species. These comprised of four grasses, four sedges and six broad leaved species. Among grasses, dominant weed *species* were *Echinocloa colona* (IVI 22.2) followed by *Cynodon dactylon* (18.4) and *Dactyloctenium aegyptium* (17.6), and amongst sedges the dominant weed species were *Cyperus rotundus* (18.6) followed by *Cyperus iria* (17.3) and *Cyperus difformis* (16.7). Under broad-leaved weeds, the dominant species were *Amaranthus viridis* (15.3), *Caesulia aixilaris* (13.4) and *Lippia nodiflora (10.9).*

In *kharif* arhar, there were 13 weed species infesting the crop. Among them, three were grasses, three sedges and seven broad leaved species. Among grasses, the dominant weed was *Cynodon dactylon* (20.4) followed by *Dactiloctenium aegyptium* (19.2). Among sedges the dominant weed was *Cyperus rotundus* (21.5) followed by *Cyperus scleriosus* (14.4). Among broad leaved weeds, the dominant species was *Ageratum conyzoides* (18.3) followed by *Blumea lacera* (18.1) and *Anagallis arvensis* (13.7).

Sugarcane was infested by 10 weed species. Among them, one was grass, two sedges and seven broadleaved species. Among grasses, dominant weed was *Cynodon dactylon* (IVI, 23.5). Among sedges, dominant weed was *Cyperus iria* (29.8). Among broad leaved species, dominant weed was *Abutilon indicum* (24.1) followed by *Physalis minima* (24.1) and *Solanum nigrum* (18.5).

1.20. BAU, Ranchi

1.20.1. Weeds of rainy season crops

On Ranchi-Daltonganj route, *Fimbrysthylis miliacea* recorded maximum IVI followed by *Cyperus iria* (15.1), *Spillanthus acmella* (11.3), *Echinochloa crus-galli* (7.7), *Commelina nudifolia, Mollugo disticha* and *Cynodon dactylon* (6.2 each) in *kharf* season. In fingermillet, maximum IVI values were recorded by *Eleusine indica* (35.2) followed by *Echinochloa crus-galli, Digitaria sanguinalis* (30.6 each), *Stellaria media* and *Vernonia cinerea* (21.5 each). In sugarcane, mimum IVI values were recorded by *Spilanthes calva* (66.8) followed by *Ageratum conyzoides* (43.4), and *Commelina nudifolia* (38.7).

On Ranchi-Gumla route, 24 species of weeds infested rice crop. The maximum IVI value was recorded by *Cyperus iria* (16.4), *Fimbristylis argentea* (15.9), *Ludwigia parviflora* (12.4) and *Ammania baccifera* (8.7). The IVI values of other weeds ranged from 5 to 1.

In maize, 6 weeds were identified. Among them, maximum IVI value was recorded by *Commelina benghalensis* (60.4) followed by *Kyllinga brevifolia* (35.4), *Stellaria media* and *Cynodon dactylon* (29.1 each) and *Eleusine indica* (22.9). In ginger crop, maximum IVI value was recorded by *Ageratum conyzoides* (41.4). In brinjal, *Agropyron repens* (45.5), in okra *Cynotis cristata* (47.0) and *Echinochloa crus-galli* (43.4), in sweet potato *Cyperus iria* (33.3) and *Agropyron repens* (20.7) were predominant weeds.

Under intercropping system, cow pea + ridge gourd, *Mollugo* recorded maximum IVI value (63.1) followed by *Digitaria sanguinalis* (58.3) and *Commelina nudifolia* (48.1). In cow pea + black gram intercropping, *Setaria* spp. recorded maximum IVI value (39.2) followed by *Digitaria sanguinalis* (32.9) and *Commelina benghalensis* (20.4). While in upland rice + pea, horsegram + niger, blackgram + pearlmillet, chilli + radish and colocacia, the maximum IVI values were recorded by *Setaria glauca* (37.2), *Cynodon dactylon* (46.1), *Digitaria sanguinalis* (46.0), *Cynodon dactylon* (49.4) and *Digitaria sanguinalis* (44.4), respectively.

The weed survey on Ranchi Lohardaga route via Kathitanr revealed that under transplanted rice *Fimbristylis milliacea* recorded maximum IVI (38.5) followed by *Ludwigia parviflora* (23.3), weedy rice (22.0), *Spilanthes calva* (14.3), and *Cyperus iria* (10.3). While under upland rice, the maximum IVI value was registered by *Stellaria media* and *Ageratum conyzoides* (17.6 each). This was followed by *Setaria glauca* (15.6) and *Xanthium* spp. (9.6). In maize, maximum IVI value was registered by *Kyllinga brevifolia* (3,5.6) followed by *Mollugo nudicaulis* (28.9), *Digitaria sanguinalis* (15.6), *Commelina nudifolia* (15.1) and *Spilanthes calva* (11.1).

1.21. IGKV, Raipur

1.21.1. Weeds of rainy season crops

In a weed survey done in Guarella Pendra block of district Bilaspur, the dominant weeds of the cropped area of transplanted rice were *Cyperus rotundus, Echinochloa crus-galli and Fimbristyllis miliaceae* (IVI 46.9, 28.9 and 26.4, respectively). The *Alternanthera triandra* had heavily infested crop field especially direct seeded rice, and was rampant along road sides, bunds, etc.

1.21.2. Weeds of non-cropped lands

In non cropped area, dominant weeds in rice fallow were *Cynodon dactylon, Heliotropium indicum* and *Cassia tora* (IVI 20.0, 20.0 and 19.6, respectively). Other weeds on increase in the non-cropped area were *Malwa pusila, Cenchrus ciliaris* and *Chromolaena odorata*. These weeds have been reported replacing *Parthenium hysterophorus.*

1.22. VB, Sriniketan

1.22.1. Weed survey and surveillance in different crops

Weed survey was undertaken in the district Birbhum and Purulia in vegetables (pointed gourd, pumpkin), sesame, boro rice, cowpea, maize - ladies finger intercropping and sesbania. Prominent weeds in different crops were species of *Cyperus, Croton, Trianthema* in pointed gourd; *Gnaphalium* sp., *Polygonum* sp. and *Digitaria* sp. in pumpkin; *Cyperus difformis, Echinochloa glabrescens* and *Marsilea* sp. in boro rice; *Cyperus* sp., *Cynodon* sp. and *Paspalum* sp. in cowpea; and *Cynodon* sp., *Paspalum* sp. and *Digitaria* sp. in maize - ladies finger intercropping as well as *Sesbania* sp. were predominant weed species.

Weed surveillance in rice, maize and pigeonpea was done in Purulia district for major weed flora, dominant species and change of species compared to that of 2006. Total number of weed species which were eight in 2006, increased to 16 in 2013 in maize. In pigeonpea it was 21 in 2013 as compared to 9 in 2006. In rice, numbers of weed species were more or less same in 2013 and 2006. In maize, relative density (RD) and frequency (% F) were increased in 2013. In pigeonpea, RD and %F were decreased in *Echinochloa* sp. and *Cyperus iria.* In rice, RD and % F increased in *Cynodon dactylon, Digitaria* sp., *Echinochloa* sp., *Eclipta* sp., *Marsilea* sp. and decreased in *Cyperus* sp. and *Fymbristlis* sp. in 2013 as compared to 2006.

WS 2.0 Weed biology and physiology

WS 2.1. Biology of importat weeds

For successful management of weed problem in different cropping system, it is necessary to study biology and physiology of different weed species with respect to prevailing cropping system and practices. Efforts have been made to study different biological and physiological characteristics of important weed species depending upon their importance in different regions.

WS 2.1a. *Echinochloa* species

Echinochloa species frequently occurred in *kharif* season leading to variable losses in different crops. Species of *Echinochloa* have been reported to possess huge variation in their morphology and physiology, particularly at its blooming period.

AAU, Jorhat

During last couple of years as many as 14 taxa of species and intra-specific ranks under altogether 11 species which include *Echinochloa colona* (Linn.) Link, *Echinochloa crus-galli* subsp. *crus-galli* var. *crus-galli, Echinochloa crus-galli* (Linn.) Beauv. subsp. *hispidula*

(Retz.) Honda var. *hispidula, Echinochloa crus-galli* (Linn.) Beauv. subsp. *hispidula* (Retz.) Honda var. *austro-japonensis* Ohwi, *Echinochloa crus-galli* subsp. *crus-galli* var. *practicola* Ohwi, *Echinochloa crus-pavonis* (H.B.K.) Schult, *Echinochloa frumentacea* Link, *Echinochloa glabrescens* Kossenko, *Echinochloa inundata* Michael et Vickery, *Echinochloa muricata* (Beauv.) Fern., *Echinochloa oryzoides* (Ard.) Fritsch, *Echinochloa stagnina* (Retz.) Beauv., *Echinochloa subverticellata* Pilger and *Echinochloa ugandensis* Snowden et C. E. Hubbard have so far been identified. Out of all these taxa, *E. stagnina* (Retz.) Beauv. was the only perennial species found in this region. The phyllatic relationship of awnless germplasm of *Echinochloa* revealed the similarity index values ranged from 1.22 to 10.11 indicating the presence of high morphological diversity amongst the germplasm.

ANGRAU, Hyderabad

Emergence of *E. colona* was observed at 10 DAS when placed in 2.5 cm depth and no germination was observed when seeds were kept at 5 cm depth. The plant height was around 13 cm with 22 leaves and 6 tillers/plant observed at 30 DAE. *E. crus-galli* emerged at 9 and 10 DAS when seeds were kept at 2.5 cm and 5 cm depth, respectively. Plant height, number of leaves and number of tillers per plant at 30 DAE were recorded higher in seeds sown at 2.5 cm as compared to those at 5 cm depth.

OUAT, Bhubaneshwar

Morphological parameters of *E. colona* and *E. crus-galli* were studied in order to develop management practices. The study has been undertaken in the *kharif* season of 2013 and observations recorded are presented in Table 2.1a.1.

Table 2.1a.1: Morphological parameters of *Echinochloa* species

Morphological characters	*E. colona*	*E. crus-galli*
Germination (%)	72	64
Emergence (days)	4-5	3-4
Dry weight at 25 DAE (g/plant)	0.27	0.32
Flowering (days)	28	31
No. of seeds/plant	568	641
No. of seeds/m^2	5800	6250
1000 see d weight (g)	0.031	0.039

TNAU, Coimbatore

A study in pots revealed germination of *E. colona and E. crus-galli* upto 92 and 90%, respectively. *E. colona and E. crus-galli* recorded a height of 156.5 cm and 149.3 cm, total biomass 205.3 and 197.5 g/pot, tillers/plant 19.9 and 14.5 and number of grains/plants 6250 and 4756 seeds, respectively at 45 DAS. From four field samples collected, average population of *E. colona* and *E. crus-galli* was found to be 6.0 and 5.5/m^2, respectively and grain production of 7746 and 4825 kg/ha, respectively were obtained. Results indicated that *E. colona* have higher seed production capacity in shorter period and able to record more dry matter production.

VB, Srinikatan

Out of five identified species of *Echinochloa* namely, (*E. colona, E. crus-galli, E. glabrescens, E. cruspavonis* and *E. frumentacea*), *E. crus-galli* and *E. glabrescens* were dominant grassy weeds in rice-rice system in lateritic region of West Bengal. With this view different parameters of *E. glabrescens* and *E. crus-galli* were studied in *kharif,* 2013 in field conditions (Table 2.1a.2).

Table 2.1a.2: Variation in emergence and morphological characters of *E. glabrescens* and *E. crus-galli*

Weed species/parameters		*E. glabrescens*	*E. crus-galli*
Emergence (%)		46	44
Days required for emergence		9	8
Height (cm)	30 DAT	49	37
	60 DAT	70	55
	90 DAT	83	63
Tillers (No./hill)	45 DAT	6	8
	60 DAT	7	12
	90 DAT	10	29
Leaves (No./hill)	30 DAT	24	32
	60 DAT	35	60
Leaf area/hill (sq.cm.)	30 DAT	480	395
	60 DAT	910	1200
Leaf area index	30 DAT	0.98	0.80
	60 DAT	1.85	2.44
Effective tillers/hill	90 DAT	9	6

WS 2.1b Biology of weedy rice

Weedy rice differ from the pure lines, and land races morphologically and physiologically and can be characterized by non-synchronized flowering and fruiting behavior. Weedy rice are largely result of spontaneous hybridization between cultivated *Oryza sativa* and wild rice or of de-domestication of rice or genetic mutation or combination of all. Studies were carried out to see the available variations among various biotypes of weedy rice.

AAU, Jorhat

There are lot of intermediate forms between *Oryza sativa* and *O. rufipogon,* as well as *O. sativa* and *O. nivara* which might be due to natural out crossing. The most interesting ecological observation is that the weedy rice possessing affinity to *O. rufipogon* and *O. nivara,* are extremely scarce in transplanted *kharif* and autumn rice of medium lowland situations. Places of their occurrence were the much deeper regions, either in association with deep water paddy or in the non-cropland situations of jheels or ditches, neighbouring rice fields and tea gardens and road-sides in foothills to river beds.

BAU, Ranchi

In upland ecosystem with dry seeding of rice, occurrence of weedy rice in this ecosystem is rare. In wet land ecosystem where rice is grown as transplanted as well as direct seeded methods, varying degree of weedy rice was found depending upon the method of sowing. The occurrence of weedy rice in transplanted rice is lower as compared to direct seeded as the farmers get opportunity to weed out prior to flowering and seed setting, infestation of weedy rice is reducing. However, in fields where the weeding has not been performed due to unavailability of labor, the infestation of weedy rice varies from 20 - 45 plants/m^2. Whereas, under direct seeded, majority of farmers grow rice by broadcasting the rice seed few days ahead of onset of monsoon and as soon as monsoon rain starts weedy rice as well as rice seeds germinate simultaneously and infest the whole field posing difficulty in controlling. Weedy rice infestations have also been observed in low lying ditches having ponded water adjoining to rice fields.

CSKHPKV, Palampur

Survey on weedy rice was conducted in Kangra and Hamirpur districts in rice growing areas to assess the extent of infestation of weedy rice. It is commonly known as *bhrin, bihrni, rissa* and *rohdua* in Himachal Pradesh. Its infestation was highest in direct seeded rice (18-58 %) followed by direct seeded puddled rice and very less in transplanted rice.

NDUAT, Faizabad

Three species of weedy rice viz. *Oryza nivara, O. sativa f. spontanea* and *O. rufipogon* were found in the phyto-sociological survey of weedy rice in rice fields in Amethi, Basti and Barabanki districts of eastern Uttar Pradesh. Among the three weed species of weedy rice, *Oryza sativa* f. *spontanea* was the most dominant species in Amethi and Barabanki districts with a density of 24.2-32.2 plants/m^2 with a relative density of 44-54% and IVI values ranging from 102-104%. But in Basti district, *O. rufipogon* was found most dominant species followed by *O. sativa f. spontanea.* The *O. nivara* and *O. rufipogon* species of weedy rice were also found in non-crop land low lying areas also. Farmers also explained the severity of these weed species and told that *O. rufipogon* and *O. spontanea* are being observed in the crop fields only from last 3-4 years in an invasive form.

OUAT, Bhubaneswar

On the basis of morphological characters of the plants collected from different places of Puri, Khorda, Cuttack, Kendrapada (East & South eastern zone) as well as Sambalpur, Baragarh, Sonepur and Bolangir district (west central table land) two species of weedy rice have been identified namely *O. rufipogon* and *O. nivara.* In pot experiment, higher emergence was recorded in *O. rufipogon* than *O. nivara* which was adversely affected by the depth of the sowing in both the species. More height was recorded in *O. nivara* than *O. rufipogon* irrespective of depth of sowing, however, height of plant decreased in both the species with increasing depth of sowing. Significantly more number of tillers/hill as well as number of effective tillers was recorded in *O. rufipogon* than *O. nivara*.

RAU, Pusa

In North Bihar, infestation of weedy rice (locally known as Jharang or Lalsar) was found in direct seeded deep water rice in Darbhanga and Madhubani districts causing significant yield losses. Plant height, number of tillers/plant, effective tillers/plant, length of panicle and reduction in grain yield of rice varied from 86-93 cm, 14-22, 5-11, 11-19 cm and 25-46%, respectively. All the weedy rice found were awned. Farmers were in the opinion that control of weedy rice is very difficult due to its resemblance with rice.

WS 2.1c: *Phalaris minor* (Resistance to isoproturon, inheritance of resistance and management)

Herbicides clodinafop, sulfosulfuron and fenoxaprop were recommended to control isoproturon resistant population of *P. minor* during 1997 in states like Haryana and Punjab. These herbicides provided effective control of this weed up to 2007. Based on the observations recorded from farmers' interviews and experiments conducted at farmer's fields, bioassay studies, it seems that *P. minor* has also developed resistance against herbicides like clodinafop-propargyl and fenoxaprop. Keeping this in mind, experiments were planned to evaluate the efficacy of herbicides found promising during previous years for management of the resistance in *P. minor*. Work done at different centres is being summarized below.

CCSHAU, Hisar

Results of field experiment on cross resistance against *P. minor* conducted at farmers' fields in Kaithal district revealed that clodinafop 60-120 g/ha and fenoxaprop at 120 g/ha exhibited only 30-45% control of *P. minor* in wheat (30-45%). Sulfosulfuron 25 g/ha gave only 70% control of *P. minor* with 65% control of broadleaf weeds. Mesosulfuron+ iodosulfuron (RM) provided 85% control of *P. minor* but with slight crop suppression. Sulfosulfuron+metsulfuron (R.M.) at 40 g/ha provided 92% control of *P. minor* resulting in highest yield (4.90 t/ha) which was at par with farmer's practice of applying this herbicide twice (before and after first irrigation). Pinoxaden at 50 g/ha although provided 55% control of *P. minor* at 15 DAT but regeneration was observed at 30 DAT with grain yield of 4.40 t/ha.

Results from farmer's field trial conducted at Karnal indicated that clodinafop 75 g/ha, sulfosulfuron 30 g/ha and mesosulfuron+ iodosulfuron 14.4 g/ha did not provide effective control of *P. minor* in wheat. Tank-mix of metribuzin 105 g/ha with clodinafop 60 g/ha, sulfosulfuron 25 g/ha or pinoxaden 50 g/ha provided effective control of *P. minor* resulting in similar grain yields (5.52-5.65 t/ha), which were higher than the grain yields obtained under their alone applications. None of the herbicidal treatments showed any phytotoxic effects on the crop. Lowest grain yields were obtained with sulfosulfuron 25 g/ha (4.23 t/ha). Combination of herbicides also improved the control of broadleaf weeds. Thus, combination of herbicides provides an effective management strategy against resistant *P. minor* in wheat.

Pot-culture studies with nine biotypes from farmers' fields/ research farms (Uchana, Kalwehri-1, Kalwehri-2, Bawal, HAU, Pipalthah-1, Pipaltha-2, Radaur, Jakholi, Uchani) indicated that clodinafop at X dose did not provide effective control of five biotypes with <10% control (Uchana, Kalwehri-2, HAU, Pipalthah-1, Pipalthah-2). However, there was >75% control of other biotypes of *P. minor*. Similarly sulfosulfuron at X dose was quite ineffective against three biotypes (Uchana, HAU, Pipalthah-2) with <20% control, medium efficacy (60-70%) against two biotypes (Kalwehri-1, Bawal), and good efficacy against rest of the biotypes. Mesosulfuron+ iodosulfuron at X dose was quite effective (>85% control) against all biotypes, except Pipalthah-2 biotype with 70% efficacy. Pinoxaden at X dose provided effective control of all biotypes. This indicated the suitability of mesosulfuron + iodosulfuron and pinoxaden in management of cross resistance in *P. minor*.

GBPUAT, Pantnagar

Resistance of *P. minor* to isoproturon was tested during the winter season of 2012-2013. Seeds collected from farmers' fields from different areas of Udham Singh Nagar and Nainital districts of Uttarakhand and adjoining areas of Uttar Pradesh were sown in pots. Isoproturon was applied at 0.5, 1.0 and 2.0 kg/ha at 39 DAS. In order to check the bioefficacy of sulfosulfuron and clodinafop in controlling isoproturon resistant *Phalaris minor*, these two herbicides were sprayed at their recommended doses at 39 DAS. All the treatments were replicated thrice. Further, to find out the effect of date of sowing on the efficacy of the clodinafop, a late sowing was done on 15th December. Observation on per cent mortality and survival of *P. minor* plants was recorded at 30 days after spray. Seeds of *P. minor* were collected from following sources (Table 2.1c.1).

Table 2.1c.1: Sources of *P. minor* seeds in Uttarakhand

S1 Dibdiba-1 (Rudrapur area)	S2 Dibdiba-2 (Rudrapur area)	S3 Dibdiba-3 (Rudrapur area)
S4 Kaushalganj	S5 Jaffrabad (Rampur, UP)	S6 Sajapuri (US nagar)
S7 Gadarpur-Bajpur area	S8 Bazpur-Kaladhungi area	S9 Bazpur-Kaladhungi area
S10 Namuna circle	S11 Namuna-Bhattpuri	S12 Hussainganj area
S13 Lamachaur	S14 Kamluaganja	S15 Kusumkhera

In isoproturon treatments, mortality of *P. minor* ranged from 11.9% at 0.5 kg to 57.3% at 2.0 kg/ha. Plants raised from different seed sources (localities) showed variable mortality due to isoproturon treatments varied from nil to 55.6% at 0.5 kg/ha, 8.9- 60.0% at 1.0 kg/ha and 8.9-88.9% at 2.0 kg/ha. In the sulfosulfuron treatment, the plants from locations S1 and S3 to S10 were completely killed. In rest of the locations, the mortality ranged between 42.2-95.6%. Effect of isoproturon on dry matter production by *P. minor* plants is presented in Fig 2.1c.1.

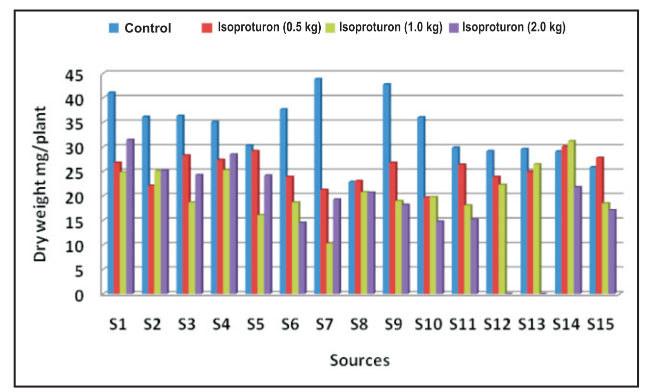


Fig. 2.1c.1. Effect of isoproturon on dry weight of *P. minor* collected from different locations

As an alternate herbicide, clodinafop was found very effective. At the recommended dose of clodinafop, all the *P. minor* plants from all the sources were killed at 20 days after the herbicide application irrespective of date of sowing (data not given).

Regeneration of *P. minor* in sulfosulfuron treatment: *P. minor* plants from few sources exhibited regeneration in the sulfosulfuron treatment. Sources S7, S9, S13 and S14 showed higher levels of regeneration. (Fig. 2.1c.2)

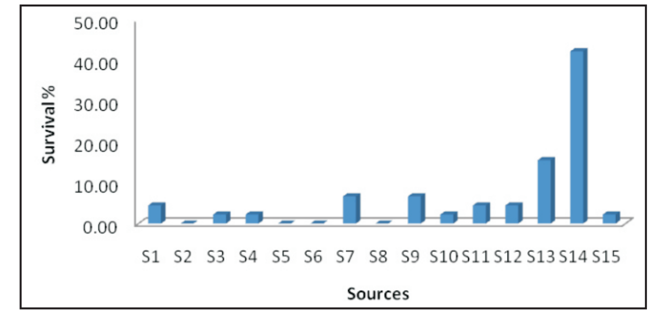


Fig. 2.1c.2. Regeneration of sulfosulfuron-treated *P. minor*

Inheritance of resistance: Inheritance of resistance to isoproturon was verified for all the sources. Seeds from the previous year experiment were collected from the pots where *P. minor* plants had survived at normal dose of isoproturon. These seeds were again sown and the plants were treated with 1.0 kg isoproturon. The survival of plants was recorded for all the sources. It was observed that resistance was inherited in plants from all the sources (50-100%) except S15 (Fig.2.1c.3)

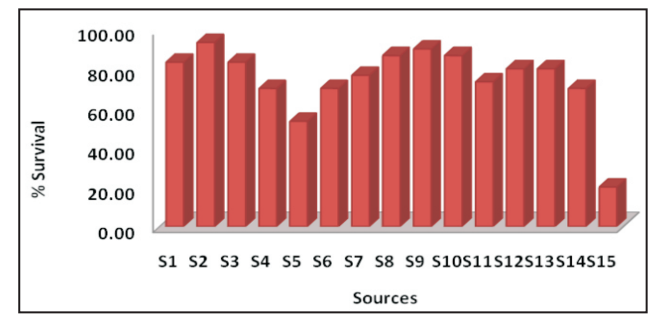


Fig.2.1c.3: Inheritance of resistance to isoproturon (survival at 1.0 kg isoproturon)

PAU, Ludhiana

After development of resistance in *P. minor* against isoproturon, some alternate herbicides namely clodinafop, sulfosulfuron and fenoxaprop were recommended. To monitor the response of *P. minor* to these herbicides, seeds of ten *P. minor* populations escaped after the application of different herbicides at farmers' field were collected during *rabi* 2011-12 and were sown in rows during *rabi* 2012-13. Isoproturon, clodinafop, sulfosulfuron, fenoxaprop-p-ethyl, pinoxaden, mesosulfuron+iodosulfuron and metribuzin+fenoxaprop-p-ethyl were sprayed at their recommended doses at 30 DAS. Data were recorded on mortality, dry weight and chlorophyll 'a' fluorescence (Fv/Fm) (Table 2.1c.2).

Table 2.1c.2: Per cent mortality, dry matter and chlorophyll 'a' fluorescence of *P. minor* populations under different herbicides. Data are mean of ten populations.

Herbicide dose (g/ha)	% mortality (20 DAS)	Dry matter(mg/plant)		Fv/Fm	
		20 DAS	40 DAS	After 24 h	5 DAS
Pinoxaden (50)	35.4	46.9	589.2	0.611	0.577
Clodinafop (60)	30.7	50.2	1300.2	0.691	0.680
Fenoxaprop –p-ethyl (100)	19.7	44.4	1255.1	0.712	0.624
Sulfosulfuron (25)	82.8	2.7	0.0	0.617	0.588
Mesosulfuron + iodosulfuron (14.4)	66.5	40.2	267.1	0.709	0.598
Isoproturon (980)	6.4	56.4	1201.9	0.695	0.674
Metribuzin+fenoxaprop-p-ethyl (275)	87.4	27.1	357.4	0.257	0.159
Control	7.2	91.8	1419.2	0.722	0.698
SEm±	103.4	80.1	1759.3	0.021	0.031
LSD (P = 0.05)	3.9	9.3	202.7	0.055	0.081

Results obtained during study can be summarized as follows:-

- Clodinafop, fenoxaprop-p-ethyl and sulfosulfuron at field doses recorded <40% control of *P. minor* biotypes indicating the development of cross resistance to these herbicides.
- Sulfosulfuron and metribuzin + fenoxaprop-p-ethyl significantly reduced Fv/Fm ratio indicating damage to PSII and photoinhibition that consequently resulted in mortality of *P. minor* plants.
- In another study, GR_{50} values for sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron and metribuzin + fenoxaprop-p-ethyl were lower than their recommended doses indicating that these herbicides were still effective.
- Pinoxaden caused considerable damage to PSII only at 2x and 4x doses. Metribuzin + fenoxaprop-p-ethyl caused 21, 53, 56 and 78% reduction in Fv/Fm ratio at 0.5x, 1x, 2x and 4x doses, respectively. Thus, metribuzin + fenoxaprop-p-ethyl was the most effective against *P. minor*.

2.1d Biology of *Orobanche*

CCSHAU, Hisar

In Haryana, *Orobanche* is causing huge losses in mustard and tomato. During April, 2012 mature seeds of *Orobanche* were collected from highly infested mustard and tomato fields across various soil types and sources of irrigation. To study the biology of these seeds, pot experiments were initiated during *Rabi* 2012-13. Seeds collected from six locations were grown in pots mixed with mustard seeds. In mustard Var. RH 30 was planted on the 16.10.2012 in 6 pots /biotype and these pots were irrigated before sowing. Out of six locations, only 4 biotypes (Bidhwan, Obera, Budhera and Hasan) could germinate. In tomato seeds from three locations from Dadri and Nuh areas were collected and tomato seedlings were planted in January 2013 but none of seed collected from tomato fields could germinate in pot due to frequent irrigations applied in tomato. Number of seeds per capsule were counted with the help of microscope. Results obtained during study are given in Table 2.1d.1.

Table 2.1d.1: Various phenological parameters of *Orabanche* in mustard

Parameters	Location (source) of seeds			
	Bidhwan	Obera	Budhera	Hasan
Days to appearance of shoot	55.0	52.0	60.0	58.0
Fresh wt./plant	40.2	36.6	35.8	30.9
Dry wt./plant	4.60	3.86	3.60	3.56
No of shoots/plant	4.5	2.6	3.5	2.5
Flower initiation (Days after emergence)	12.0	10.0	11.0	12.0
Capsules (no./shoot)	46.0	40.0	45.0	42.0
Capsule wt./plant(g)	0.132	0.084	0.098	0.0128
No. of seeds/capsule	5625	4580	3690	3944

SKRAU, Bikaner

Observations at farmers' field in mustard crop indicated that *Orobanche* germination process is temperature dependant and severity was noticed in those years in which the temperature of Nov-Dec months was higher than normal. It was also observed that during *rabi* 2012-13, *Orobanche* infestation was noticed in February month. Late sown mustard had lower *Orobanche* infestation than early sown at farmers' field.

TNAU, Coimbatore

Results of pot culture study showed that *Orobanche cernua* seeds (collected from four different locations) germinated on an average of 51.3 days after tobacco transplanting. The fresh and dry shoot weights at 15 days after emergence (DAE) were in the range of 39.3 - 43.9 and 3.7 - 4.3 g/shoot, respectively. The shoot production (no. of tillers/plant) varied from 9 - 17. In general, flower initiation was recorded between 10 - 13 DAE with capsule number per shoot 46 - 52. Average capsule weight was observed to be 0.1 g, while number of seeds per capsule varied from 3897 - 4325.

WS 2.1.e. Biology of *Striga*

Striga is becoming a notorious weed of sugarcane in southern part of India. The practice of continuous mono cropping is the main reason for the buildup of *Striga* population in the cane fields. Detailed study on the biology of *Striga* would pave way for the planning of effective weed management strategies. Research work carried out at different centers is given below.

TNAU, Coimbatore

A pot experiment was conducted to study various biological characteristics of *Striga* infestation in sugarcane using soil collected from ten different infested locations. Results revealed that *Striga asiatica* seeds took an average of 46 days for emergence after cane planting with an average dry weight of 1.6 g/plant. At 30 days after emergence *Striga* plants attained the fresh weight ranging from 2.3 to 3.8 g/plant, dry weight ranging from 0.56 to 0.65 g/plant, shoots from 4 to 6 shoots/plant with an average of 3.7 branches/shoot. Flower initiation of *Striga* varied from 26 to 35 days after emergence. The reproduction capacity varied from 285 to 375 capsules/plant with an average dry weight of capsules was 0.4 g/plant. Each capsule has thousands of seeds which shows seed production potentiality of *S. asiatica* alongwith high biomass potential in sugarcane under red sandy loam soils.

UAS, Dharwad

Several sugarcane fields were surveyed. In most of the fields, *Striga* emergence was noticed during the period of 100-120 days after cane planting. In few fields, it is also seen in 60 days old crop. Accordingly, the experiments were planned to develop strategies to contain its incidence.

WS 2.1f. *Mimosa diplotricha*

Mimosa diplotricha is one of the most problematic weeds in forest, non-crop land and plantation crop ecosystems of north-eastern part of India including Kaziranga National Park and Rajib Gandhi Wild Life Sanctuary. The weed has also been extended to many tea gardens, sugarcane fields, roadsides, railway tracts and home-stead woodlands of Upper Brahmaputra Valley zone.

AAU, Jorhat

The species is a straggling shrub, its branches may climb nearly up to 12 m high on associating tree species; however, in open areas the plant forms compact thickets of 2-3m stature. Stems are quadrangular and densely prickly along the ridges in the variety *diplothricha*. Leaves of *Mimosa diplotricha* are peri-pinnately bi-compound. The average number of leaflets (and the range) per pinnate was 26 (18-32) and 42 (40-48) pairs in *M. diplotricha* var. *diplotricha* and *M. diplotricha* var. *innermis*, respectively. Pulvinous size of var. *diplotricha* was 1.19 (0.21) x 0.67 (0.18) mm, a little bigger than var. *innermis*.

The average number of pods per inflorescence of *M. diplotricha* has been found to be 25 or more and that of the number of lomentum (or seed) per pod 41. Seeds of all the studied taxa were laterally ovoid to slight obliquely ovoid, 2.78 (0.13) x 2.08 (0.12) x 0.42 (0.08) mm in size, reddish black to reddish brown in colour. However, in its variety *innermis* seeds were ovoid to obtusely rhomboid in lateral view, slightly bigger in size and yellowish brown in colour. Round shaped sub-apical depression was characteristic feature of var. *diplotricha*, whereas, no such depression was observed in var. *innermis*. Test weight of the seeds of both the taxa varied between 3.2 to 3.7 g.

WS 2.1g. *Mikania micrantha*

Mikania micrantha is one of the most serious invasive weeds in NE India as well as southern part of India. Tremendous seed production and air dispersal capacity as well as fast spreading vegetative branches are the key factors of the weed in establishing itself. Work carried out at different centres is summarized below.

AAU, Jorhat

Mikania micrantha preferred to grow in moist and fertile places. It is more prevalent in high rainfall areas of Assam, and accordingly more infestation was noticed in the Upper Brahmaputra Valley zone comparing to the Lower Brahmaputra Valley. The lower portion of the stem with numerous adventitious fibrous roots was found to be of several meters long, leafless, runner like and prostrate, usually remained hiding amidst the litter or moss cover. The branches formed cushions on ground, roofs of houses and canopies of associated trees and bushes. In aquatic ecosystem also, the branches usually formed cushions over the canopies of water hyacinth, reed grasses and other suitable plants.

The number of photosynthetically functional leaves of *M. micrantha* varied from 2106 to 5061 with a mean of 3876 ± 1076 in the month of December, which is reduced to 126 to 266 (mean 179 ± 39) at 60 to 75 days after infestation by *C. campestris*. Similarly, in *Cuscuta* infested area, blooming of *Mikania* was restricted to a great extent preventing seed production. However, in non-infested area the extent of seed production might go up to over 6 lakhs seeds/m^2 area. The growth rate of *M. micrantha* varied from 1.3 to 4.4 g/m^2/day, which was at an average of (-)0.6 ± 0.2 g/m^2/day under *Cuscuta* infestation (Fig. 2.1g.1).

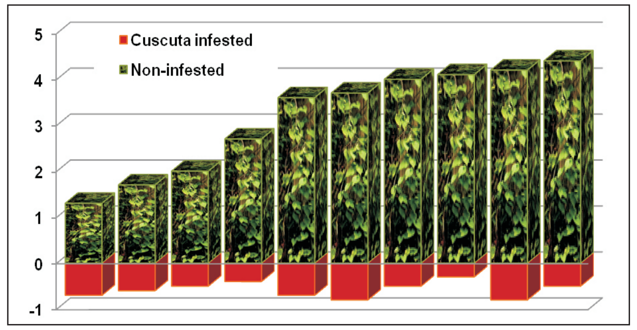


Fig 2.1g.1 Effect of *C. campestris* infestation on growth rate of *M. micrantha* at 10 locations in Assam

OUAT, Bhubaneswar

Mikania micrantha affects most crops but was most severe in banana, coconut and mango in the state. Seeds were collected from affected fields of banana during December, 2012 from Jagatsinghpur and Puri district. hundred seeds were collected and made into 5 groups of 20 each and were grown in earthen pots of 20 cm diameter in three different depths (0.5, 2 and 4 cm). Germination of *Mikania* species was around 65% at sowing depth of 0.5 cm but very less germination was observed in deeper sowing. The emergence of seedlings took 7-8 days. The average number of seeds/plant was 3200 with test seed weight (1000 seeds) 0.085 g.

WS 2.1i. *Cyperus rotundus*

Cyperus rotundus (purple nut-sedge), is one of the world's worst weeds occurring in almost all over India. It competes with almost all upland and medium low land crops and its large colonies are common in roadsides and open grounds. Its presence causes yield loss of seasonal and annual crops to a great extent. Experiments were conducted at different centres to study its biology and results are summarized below.

AAU, Jorhat

Different biological features were studied in *C. rotundus* which are summarized in Table 2.1i.1.

Table 2.1i.1: Morphological features of *C. rotundus*

Habit	Perennial herb, nearly up to 16 cm high.
Root	Fibrous.
Stem	Solitary or 2-3 together, compressed-trigonous, sometimes tortuous, 1-2 mm in diam., base tuberous, with long slender stolons and ellipsoid aromatic tubers.
Leaf	Several, usually shorter than or sometimes sub-equaling the stem, 2-4 mm broad.
Inflorescence	Anthela, usually simple, sometimes compound and lax; involucral bracts 2-4, foliaceous, spreading, lowest 4-15 cm long; rays 3-9, slender, spreading, longest 3-10 cm long; secondary rays, if present, few.
Spikelets	3-10 together, linear lanceolate, 10-35 x 1.5-2.0 mm, curved, rachila wings lanceolate, hyaline or red streaked. Glumes tightly imbricating, broadly ovate, 3.0-3.5 mm long, muticous or mucronulate, keeled, red or deep brown, 3-5 nerved.
	Stamens 3; anthers 2 mm long, crest ovate, red, style long, ovary hypogynous.
Fruits & seeds	Ttrigonous nut with erect solitary seed, fusiform in lateral view, brownish black, presence of 3 ridges on seed surface, 1000 seed weight 10.47 (±0.78) g.
Phenology	Flowering and fruiting: May to September
Tuber	Modified underground stolon tips

UAS, Bengaluru

Tubers were planted in pots to take periodic observations during different growth stages viz., 25,50,75,100,125,150,175 and 200 DAS. Observation viz. leaf area, biomass of different plant parts, number of tubers/seeds per plant were recorded. Tubers produced were separated based on their origin in the tuber chain. Initially, newly formed tubers were designated as "primary", from primary tubers new tubers formed were denoted as "secondary" and from secondary tubers new tubers formed designated as "Tertiary". Different parameters studied are given in Table 2.1i.2. Strong correlation between total biomass with number of tertiary tubers was noticed with a correlation coefficient (r) 0.868, as compared to that with primary and secondary number of tubers (r = 0.807 and 0.518, respectively).

Table 2.1i.2: Periodic biomass (g/plant) distribution in different plant parts of *Cyperus rotundus*

DAS	Shoot	Tuber weight (g/plant)					Stolon	Root	Inflores-cence	Total biomass
		Planted	Primary	Secon-dary	Tert-iary	Total				
25	0.44	0.60	0.25	-	-	0.85	-	0.06	-	1.35
51	12.00	8.22	4.58	-	-	12.80	-	7.34	-	32.14
75	20.34	0	7.14	7.17	3.64	17.95	2.59	20.50	3.06	64.44
100	10.53	0	5.13	3.65	2.33	11.11	1.11	7.44	0.05	29.76
125	14.37	0	8.73	7.5	5.03	21.26	3.30	13.87	0.40	53.20
209	22.87	0	18.53	9.9	5.97	34.4	3.3	18.07	0.9	78.64
260	15.00	0	16.63	11.60	7.47	35.7	4.3	15.93	0.0	70.93
285	11.97	0	24.73	10.63	8.13	43.49	5.87	20.93	0.0	82.27

TNAU, Coimbatore

An experiment was conducted with the objective to quantify the biological characteristics of *C. rotundus* and to study the regeneration potential in vertisols under irrigated upland condition. Germination percent of secondary tubers of *C. rotundus* was upto 86%. It recorded a height of 59.2 cm and total biomass 163.9 g/pot at 60 days after innoculation. *Cyperus rotundus* showed quick multiplication rate in shorter period (e.g. 9 weeks) and was able to record more dry matter production and tubers. The tuber production rate is 9 times more than that of the initial inoculation of tubers.

WS 2.2. Viability / regeneration potential of glyphosate-treated *Cyperus rotundus*

The systemic herbicide glyphosate may play important role in controlling the weed. However, appropriate technique of application as well as the dose of the herbicide is to be developed to destroy the underground network of tubers for effective control of the species. Different concentration of glyphosate (0.5, 1.0 kg and 1.5 kg/ha) applied twice at an interval of 48h with or without additives like jaggery (2%) or soap nut dry fruit extract were applied twice at 48 h interval. Experiments were conducted in 2x2 m^2 plots at different centres and results obtained are summarized as below.

AAU, Jorhat

All the treatments controlled *C. rotundus* and no regeneration of *C. rotundus* from the herbicide treated tubers was observed up to 60 days after application of herbicides both in the pots as well in field conditions. Results of the years 2012 and 2013 revealed that number of tubers varied from 1029 to 1165 in the month of June in 2012, and 747 to 823 in February, 2013. The tuber population was increased to 5.75 to 12.30% in the year 2012 (June) and 2013 (February), respectively, within a span of two months in the untreated plots. All sprouted tubers with green leaves were damaged by application of glyphosate, with or without mixing with jaggery. However, unsprouted tubers, remained under soil surface at the time of herbicide application, were escaped, as noticed after 3 to 4 months of application of herbicides.

AAU, Anand

Visual observations on growth and mortality were recorded 30 days after herbicide application. All concentrations of glyphosate herbicides reflected their effect in terms of phytotoxicity on *C. rotundus*. There was consistent increase in the efficacy of glyphosate with increasing concentration and control of *C. rotundus* ranged from 33 to 93 %. However, no additional benefit was observed with the additives like jaggery and soap nut extract.

GBPUAT, Pantnagar

Shoot mortality of the *C. rotundus* populations were estimated at 20 days after treatments. It ranged from 11.83 % at 0.5 kg to 28.43 at 1.5 kg of glyphosate. Addition of jaggery improved effectiveness of the chemical at all the doses. The mortality, with jaggery, ranged from 17.30 % to 37.81 % (Fig. 2.2.1).

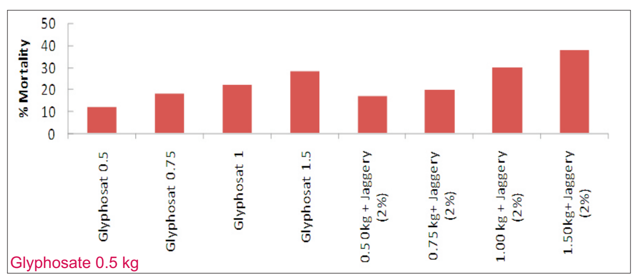


Fig. 2.2.1: Mortality of *Cyperus* at different doses of glyphosate as compared to control (20 days after treatment)

The number of tubers produced in the treated plots was estimated 20 days after herbicide application. Tubers were dug out from 15 cm depth from an area of 100 cm^2. It was lowest (12.0- 13.3) at 1.0 -1.5 kg glyphosate. Lower doses of the herbicide (0.5-0.75kg) recorded higher number of tubers similar to that in control (17.3). Regeneration of *C. rotundus* was recorded in the treated plots 60 days after treatment. Regeneration was lowest in the control (26.5 %) as well as at 0.5 kg treatment (28.2%). Highest regeneration (40-42%) was recorded in the plots treated with 0.75 and 1.0 kg glyphosate along with jaggery.

Viability of tubers was assessed by taking 10 tubers from the plots (after 20 days of spray) and planting them in pots. The sprouting per cent was higher in control (40%) followed by that in 1.0 kg glyphosate (33.0%), with or without jaggery. It was lowest in the treatments 1.5 kg, 0.5 kg + jaggery and 0.75 kg glyphosate (Fig. 2.2.2).

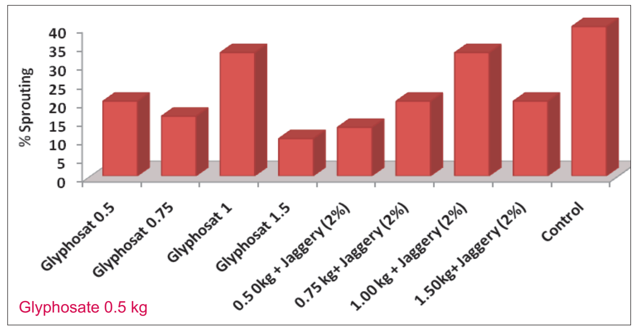


Fig.2.2.2 Viability of tubers in pots at different doses of glyphosate.

PAU, Ludhiana

Results revealed that all glyphosate treatments significantly reduced *Cyperus* populations due to its effects on shoot mortality, tuber number and tuber weight. Glyphosate @ 1.5 kg/ha was most effective in controlling *C. rotundus*. Addition of 2% jaggery had no added advantage on shoot mortality, tuber number and tuber weight over glyphosate alone. To assess regeneration potential, ten tubers were dug out 30 days after spray from 0-15 cm depth and were planted into pots. Number of shoots per pot (20 days after planting into pots) significantly reduced due to all glyphosate treatments except @ 0.5 kg/ha with or without jaggery. There was significant reduction in tuber sprouting (10 days after planting into pots) and tuber weight per pot (45 days after planting into pots) due to all glyphosate treatments. Minimum tuber weight per pot was observed due to glyphosate @ 1.5 kg/ha and addition of 2% jaggery had no added advantage in reducing the tuber weight.

TNAU, Coimbatore

In the experimental field, mortality of *C. rotundus* was found to be higher with the application of glyphosate at 1.5 kg/ha + jaggery 2% and it was followed by the application of glyphosate at 1.0 kg/ha + jaggery 2%. Higher population of *Cyperus rotundus* was recorded with lower dose of glyphosate at 0.5 kg/ha treated plot. Application of glyphosate at 1.5 kg/ha + 2% jaggery was found to be effective in reducing density and dry weight of *Cyperus rotundus* and with no regeneration even after 60 days after herbicide application.

UAS, Bengaluru

Glyphosate 1.5 kg/ha showed significant reduction in total biomass, number of total tuber and tertiary tuber, however not much effect on medium and large size tuber numbers. Results also showed that addition of jaggery did not significantly alter the glyphosate efficacy in controlling *C. rotundus*.

WS 2.3 Physiological studies in long-term trials on tillage and herbicide

Weeds persist in soil mostly with their dormant seeds, which may remain viable for several years. The assessment of dormant seed in a particular land area is required to predict the probable pattern of weed vegetation in the area in near future, for adoption of timely, eco-friendly and effective management practices. Hence efforts have been made to quantify the seed bank of different weed species and different long term herbicide trials and under different cropping system with prevalent weed management practices. Results obtained at different centres are being summarized here under.

AAU, Jorhat

(a) Rice (winter) -wheat sequence

The experiment was started in the month of July, 2008. During 2012-13, the highest number of germinated seed was of the weed *Ludwigia adscendens* (250) and emerged during the winter rice cropping, followed by *Echinochloa crus-galli* (124) that emerged during the wheat cropping and fallow period, out of the total 17 species. New broadleaved weed species viz. *Hydrolea zeylanica, Ludwigia adscendens and Oldenlandia corymbosa* appeared this year in the study area for the first time since initiation of the study. From 2008 to 2013, as many as 12097 numbers of weed seeds/m^2 area had emerged under rice-wheat cropping sequence; out of which 81.7% (9887 numbers) were of broadleaved species, 17.9% (2176 numbers) of grasses and rest 0.28% (34 numbers) of sedges. Amongst these, only *Marsilea minuta* belonged to Pteridophytic species and rests Angiospermic. The highest number of germinated seed was of the weed *Stellaria media* and till 2013, as many as 3888 numbers of seeds/m^2 were emerged from the soil seed bank.

(b) Rice (autumn)–rice (w) sequence:

Since initiation of the study till the end of the *kharif* season of 2013 as many as 4193 number of weed seeds/m^2 have been germinated and emerged in the rice-rice sequence. Total weed species so far recorded were of the ratio of 19:11:9 broadleaved, grassy and sedge weeds, respectively. Amongst these, seedlings of *Ludwigia adscendens* and *Marsilea minuta* have been recorded in the study area for the first time during this year. Out of the total weeds emerged in this area, 82.56% were broadleaved weeds, 2.44% sedges and 15.01% grasses.

Total density of *Psedognaphalium luteoalbum* was the highest (1304) amongst the weeds. This weed was found to appear in the field at the harvest time of *kharif* rice and rather vigorously in winter fallow period in 2012-13. Other species shown high seed densities in the study area were *Ceraophyllum demersum* (464), *Mollugo pentaphylla* (308), *Wehlandbergia gracilis* (268), *Panicum repens* (247), *Digitaria setigera* (212), *Monochoria vaginalis* (196), *Sagittaria guayanensis* (187). Results also revealed that the rate of increase of emergence was varied from 1.3 to 114.2%, and the maximum seed germination was recorded during 2011-12, i.e. in the fourth year after initiation of the study.

AAU, Anand

Weed seed bank studies in tillage trial (Pearlmillet –wheat cropping System)

Soil samples from different treatments were collected after harvesting of *kharif* pearlmillet in 2012. Data on weed emergence/m^2 (Table 2.3.1) was recorded at monthly interval from June-2013 to September-2013.

Treatments:

Main plot:		Sub plot: Weed management practices	
T_1	Zero tillage	W_1	Hand weeding
T_2	Zero tillage	W_2	Atrazine 0.50 kg/ha
T_3	Conventional tillage	W_3	Weedy check
T_4	Conventional tillage		

During the course of seed bank studies, the predominant weed species of grasses were *Eragrostis major, Eleusine indica. Digitaria sanguinalis, Commelina benghalensis, Dactyloctenium aegyptium* and *Chloris barbata*. The major dicot weeds were *Euphorbia hirta, Boerhavia diffusa, Mollugo nudicaulis, Digera arvensis, Oldenlandia umbellata, Phyllanthus niruri, Trianthema monogyna, Tridex procumbens* and *Amaranthus spinosus. Cyperus rotundus* and *C. iria* were recorded as sedges.

Table 2.3.1. Weed seed bank under tillage and weed management treatments at Anand

Soil depth (cm)	Weed species	Treatments											
		1	2	3	4	5	6	7	8	9	10	11	12
0 -5	Grasses	04	15	20	02	02	22	04	04	14	01	04	15
	Sedges	02	02	03	00	03	02	00	03	02	00	02	02
	Others	06	08	24	01	05	11	04	04	15	02	03	21
	Total	12	25	49	03	10	35	08	11	31	03	09	38
5-10	Grasses	03	02	13	03	04	13	01	01	13	03	02	11
	Sedges	01	00	03	00	00	02	00	02	03	00	00	01
	Others	04	03	15	03	03	19	02	02	10	04	02	11
	Total	08	05	31	06	07	34	03	05	26	07	04	23
10-15	Grasses	00	01	04	00	00	02	01	02	01	00	01	02
	Sedges	01	00	02	00	00	01	00	00	00	01	00	02
	Others	00	02	10	00	01	06	00	00	02	00	00	06
	Total	01	03	16	00	01	09	01	02	03	01	01	10

During the course of seed bank studies, the predominant weed species of grasses were *Eragrostis major, Digitaria sanguinalis, Eleusine indica, Dactyloctenium aegyptium, Commelina benghalensis* and *Echinochloa crus-galli*. The major species of weeds as dicot were *Phyllanthus niruri, Mollugo nudicaulis, Digera arvensis, Oldenlandia umbellata, Amaranthus spinosus, Euphorbia hirta, Boerhavia diffusa*, *Trianthema monogyna* and *Amaranthus viridis. C. rotundus* and *C. iria* were recorded as sedges.

BAU, Ranchi

Physiological observations on weed seed bank and weed seed longevity were recorded from soil (0-15 cm) along with periodicity of weed emergence at different interval.

Long-term tillage trial (rice-wheat)

It was observed that Z-Z, Z–C, C–Z and C–C recorded 137, 99, 59, 117 grassy and 17, 20, 24 and 10 broad leaved weeds indicating that zero tillage recorded more weed seed bank compared to conventional tillage.

Among weed control methods application of recommended herbicides in rice and wheat recorded 43 grassy and 6 broad leaved weed's in seed bank while hand weeding performed in both the season recorded 78 and 14 grassy and broad leaved weed emergence. These were 39.2 and 57.5% under hand weeding and 77.2 and 81.8% under recommended herbicide.

Long-term herbicide trial (rice-wheat)

Hand weeding performed in both the seasons recorded reduced weed seed bank of grassy (27/m^2) and broad leaved weeds (29/m^2). The maximum weed seed bank of grassy (124/m^2) and broad leaved weeds (62/m^2) were recorded by weedy check. While application of herbicides showed reduced weed seed bank as compared to weedy check.

CCSHAU, Hisar

The trial on long-term effect of green manuring and herbicide use on weed dynamics, herbicide efficacy, cross-resistance development and crop productivity in rice-wheat system has been conducted continuously since 1999.

In *rabi* 2012-13 season, *P. minor, Coronopus didymus, Anagallis arvensis, M. indica, V. sativa, C. album* were observed along with some other broadleaf weeds in soil from different treatments. Emergence of *P. minor* was almost similar under green manuring and non-green manuring. *P. minor* emergence in soil from weedy check plots was significantly higher than other treatments.

In *kharif* 2013, *E. crus-galli, E. colona, D. aegyptium, B. reptans, L. chinensis* among grasses; *T. portulacastrum, P. niruri, A. baccifera* among broadleaf weeds were recorded.

GBPUAT, Pantnagar

Winter season 2012-13 : Weed seed longevity was assessed in the long-term trials on rice-wheat and soybean-wheat cropping systems. In the rice-wheat cropping system, *P. minor* and *C. rotundus* were the only grasses and sedge observed throughout the cropping season with their number declining at later stages. Among the 11 species of BLWs observed, maximum population was for *Gnaphalium spp.* (13.3/m^2) followed by *A. arvensis* and *M. sativa* (10 each).

Rainy season, 2013: During the rainy season, there was heavy infestation of weeds in both the cropping systems as compared to earlier years. In the rice-wheat cropping systems, four grassy weeds, five BLWs and the sedge *C. rotundus* were observed. Among all the species, maximum population was that of *C. rotundus* (348/m^2) with much higher population observed at 30 DAT and but absent at the final stage. Among grasses, *E. crus-galli* and *D. aegyptium* had maximum population while among BLWs, *Mollugo sp.* had the maximum population (66/m^2). All the grasses and BLWs except *Mollugo sp.* were absent at later stages.

Weed seed bank in long-term trial on conservation agriculture

Weed seed bank was estimated in the long term trial on conservation tillage in rice-wheat cropping system. Soil samples from 0-15 cm soil depth were collected after harvest of the crop.

Treatments:

Main Plot : Tillage and residue management

M1: TPR (CT)-wheat (CT)

M2: TPR (CT)- wheat (ZT)+*Sesbania* (ZT)

M3: DSR (CT) - wheat (CT) + *Sesbania* (ZT)

M4: DSR (ZT) - wheat (ZT) + *Sesbania* (ZT)

M5: DSR (ZT)+crop residue-wheat (ZT) + crop residue + *Sesbania* (ZT)

Sub-Plot : Weed management

S1: Recommended herbicide

S2: IWM

S3: Weedy

***Rabi* 2012-13:** During the winter season, maximum number of seeds were recorded in the treatments M3S1, M1S1 and M1S3 (12.0-14.0/100 g of soil) while lowest number of seeds were recorded in M5S1and M5S2 (5.3-6.3/100 g of soil). Among the weed species, *P. minor* was maximum in the M2 and M3 treatments followed by *C. album* in M1 and M4 treatments. Among the tillage systems, maximum weed seed bank was recorded in M1while M2, M3 and M4 had similar weed seed bank.

***Kharif* 2013:** During the rainy season, maximum weed seeds were recorded in M4S2 (15.3) while lowest number of seeds were recorded in M5 S1 (7.3/100 g of soil). In rest of the treatments number of seeds were almost similar. Among the weed species, *L. chinenesis* was maximum in M4 while *C. rotundus* was maximum in M1 and M3 treatments. *A. baccifera* recorded lowest number of seeds in all the tillage systems. Among the tillage systems, maximum weed seed bank was recorded in M1, M2 and M4 (36.7-37.4/100 g of soil).

IGKV, Raipur

Physiological studies in long term tillage/ herbicides trials in rice-chickpea cropping system

Medicago denticulata was the most dominant weed emerged. Weeds like *C. album, C. iria* and others were also recorded in small and irregular number. Among two tillage systems, *M. denticulata* was higher by 61% in conventional over zero tillage. It was also noticed that *M. denticulata* was slightly higher under manually weeded plots i.e. farmer's practice than plots applied with pendimethalin @ 1.0 kg/ha as pre-emergence under both conventional as well as zero tillage.

NDUAT, Faizabad

Soil weed seed bank dynamics in long-term trial on tillage in rice-wheat cropping system

Studies on soil weed seed dynamics in rice-wheat system was initiated in the year 2007 from the on going long term experiment on tillage in rice-wheat systems. The soil samples (150g) from the experimental plots were collected from 0-10 cm depth from all the treatments after harvest crops.

Treatments

T_1: Conventional rice-conventional wheat

T_2: Conventional rice-zero tillage wheat

Wheat	**Rice**
W_1: Weedy check;	S_1: Weedy
W_2: Hand weeding	S_2: Hand weeding
W_3: Recommended herbicide	S_3: Recommended herbicide

During the *rabi* season, the treatment $T_1W_1S_1$ recorded the highest number of weed seeds (18.5/ 100 g soil) followed by almost equal population in $T_1W_2S_1$ and $T_1W_3S_1$, but $T_2W_1S_1$, $T_2W_2S_1$ and $T_2W_3S_1$ recorded the less weed seed population.

During the *kharif* season, higher weed seed population was recorded with conventional rice-conventional wheat (T_1) system with weedy check (W_1) over rest of the treatments. Weed control treatments applied in wheat did not have the much impact though S_1 (Weedy check in wheat) recorded higher weed seed population.

/ ha) increased the weed population by 12.7 % over the treatments without organic matter.

***Kharif* 2013:** Major grasses observed in the experimental site were *E. colona, Digitaria ciliaris, Eleusine indica, E. crus-galli, Cynodon dactylon*. Major broad leaf weeds were *Celosia argentea, Cleome viscosa, Acanthospermum hispidum, Spilanthus acmella*. Dominant sedges noticed were *C. rotundus, C. iria* and *Fimbristylis miliaceae*. Application of butachlor + 2,4-D EE rotated with pretilachlor without organic manure in *kharif* rice recorded the lowest weed density (127 /m^2) at 25 DAS of *rabi* groundnut. Incorporation of *Dhaincha* in rice increased the weed densities in the tune of 21% in succeeding groundnut during initial stages. Application of herbicides in groundnut significantly reduced the weed density (65%) over the treatment of hand weeding at 25 DAS.

PAU, Ludhiana

Soil weed seed bank studies in long term rice-wheat system

Studies on soil weed seed dynamics in rice-wheat system was initiated in year 2002. The soil samples from the experimental plots were taken in the month of Nov. 2012 and again in June 2013. The soil was washed through a mesh and placed in Petri dishes which were kept under the laboratory conditions. The seedlings were counted and the seed number was worked out.

Phalaris minor, *Poa annua* and *Rumex dentatus* were the major weeds in wheat during *rabi* 2012-13. Significant differences were observed in weed seed bank of *P. minor*, *P. annua* and *R. dentatus* in different treatments than control and their seed bank had increased as compared to previous season. Minimum seed bank of *P. minor* was observed in clodinafop *fb* metsulfuron which was at par with clodinafop *fb* 2,4-D. Rotational herbicide treatment recorded minimum weed seed bank of *P. annua*. Amongst the broad leaf weeds, the *R. dentatus* had the highest weed seed bank. All weed control treatments had significantly lowered weed seed bank of *R. dentatus* than control. Minimum weed seed bank of *R. dentatus* was observed in clodinafop *fb* 2,4-D treatment.

During *kharif* 2013 in rice, *E. crus-galli, I. rugosum* and *Leptochloa chinensis* were the major weeds. The seed bank of *E. crus-galli* had decreased as compared to previous season, whereas that of *I. rugosum* and *Leptochloa chinensis* had increased from previous year in all treatments. Minimum weed seed bank of *E. crus-galli* was observed in rotational herbicide treatment which was at par with butachlor *fb* metsulfuron. Anilofos treatment recorded minimum weed seed bank of *I. rugosum*. Minimum seed bank of *L. chinensis* was observed in pretilachlor *fb* metsulfuron treatment. Weed survival ratio (no. of weeds at harvest/total seedling emergence) of major weeds occurring in rice was calculated. Highest weed survival ratio of *E. crus-galli, I. rugosum*, and *Caesulia axillaris* was observed in pretilachlor *fb* metsulfuron, butachlor and rotational herbicide treatments, respectively.

RAU, Pusa

Soil weed seed bank studies (0-15 cm) before rice sowing/transplanting in long-term tillage methods

It was observed that before sowing/ transplanting of rice ZT(DS)-ZT-ZT recorded highest weed seed bank compared to rest of the treatments and the lowest weed seeds bank recorded in CT (TP)-CT. Among weed control methods, integrated weed management recorded the lowest weed while the highest weed seed bank was recorded under weedy plots.

Soil weed seed bank studies (0-15 cm) before wheat sowing

It was observed that before sowing of wheat, ZT(DS)-ZT-ZT recorded highest weed seed bank compared to rest of the treatments and the lowest weed seed bank recorded in CT (T)-CT-. Among weed control methods, integrated weed management recorded the lowest weed seeds while the highest weed seed bank was recorded under weedy plots.

Soil weed seed bank studies (0-15 cm) before greengram sowing

It was observed that before sowing of greengram ZT(DS)-ZT-ZT recorded highest weed seed bank compared to rest of the treatments and the lowest weed seed bank recorded in CT(T)-ZT-ZT. Among weed control methods, integrated weed management recorded the lowest weed seed bank while the highest weed seed bank was recorded under weedy plots.

SKRAU, Bikaner

Studies on soil weed seed dynamics in clusterbean-wheat system were recorded. The soil samples were taken in the month of November 2012 and again in July 2013. During *rabi*, *R. dentatus, C. album, M. indica* were the major weeds in wheat. Higher number of weeds was observed in weedy check than metsulfuron treated plots. Lowest weed seedlings were observed in integrated weed management treatments. *Rumex dentatus* seed bank increased during *rabi* 2012-13 compared to previous season. Another important observation was that *Asphodelus tenuifolius* seedlings were not observed in wheat.

During *kharif* 2013, clusterbean was dominated by weeds like *Corchorus tridense, Gisekia pharnaceoides, Digera arvensis* and *Mullugo cerviana*. The seed bank of *Gisekia pharnaceoides, Corchorus tridense* and *Digera arvensis* increased in this season compared to the previous years in weedy check plots. In imazethapyr treated plots minimum seed bank of *Digera arvensis* was observed while *Gisekia pharnaceoides* and *Corchorus tridense* had higher weed seed banks. *Digiteria* sp. was not observed in *kharif* 2013 while it was noticed in *kharif* 2012 in weedy check plots.

In pearlmillet-chickpea cropping system during *rabi* 2012-13 the weed seed bank studies revealed that predominant weeds as *A. tenuifolius*, *R. dentatus, C. album, M. indica* in chickpea. It was also observed that *M. indica* and *A. tenuifolius* weed seed bank was increased in pendimethalin treated plots compared to pendimethalin + 1 hand weeding. All the major weeds were on increasing trend during *rabi* 2012-13 than previous years. *Rumex dentatus* became dominant weed of weedy check plots while *M. indica* dominated the pendimethalin treated plots.

TNAU, Coimbatore

Physiological studies in long-term trials on tillage methods

Before sowing of maize: Lower density of grasses was recorded in CT while higher grass weed density was observed in ZT. Among weed management treatments, PE herbicides with HW on 45 DAS recorded significantly lower density of weeds than weedy check.

Before sowing of sunflower: Density of grasses, sedges, broad leaved weeds and total weeds were significantly lower in CT than ZT. Among the weed management treatments, the density of grasses, sedges, BLWs were less in PE herbicides with HW at 45 DAS.

Long- term trial on weed management in rice-based conservation agriculture system

Predominant weed species were *E. crus-galli* (L.) and *E. colona* among grasses, *C. difformis* under sedges and *E. prostrata, Marsilia quadrifoliata* and *Monochoria vaginalis* among BLWs. Significantly lower grassy weeds observed in transplanted rice with CT-CT-Fallow system at 7th, 15th and 21st day. The higher grassy weeds germination was observed in direct seeded ZT-ZT +crop residue (CR) - ZT+CR- ZT. At 7th day lower germination of BLWs was registered with transplanted CT-CT- Fallow system as compared to direct seeded ZT+CR - ZT +CR - ZT system. At 15th and 21st days, low germination of BLWs was registered with direct seeded rice with CT-CT-ZT. Integrated weed management method recorded lower grassy weed seed germination which was at par with chemical method of weed control.

UAS, Bengaluru

Weed seed longevity associated with major cropping systems

Finger millet- groundnut and maize-sunflower

Seven predominant weed species viz. *C. rotundus* among sedge; *D. aegyptium, Digitaria marginata* and *Chloris barbata* amongst grassy weeds; *Borreria articularis*, *Ageratum conyzoides* and *Spilanthus acmella* amongst broad leaved weeds were recorded. *C. rotundus* population significantly increased in maize-sunflower cropping system compared to finger millet-groundnut cropping system; however, such a trend was not observed in *Ageratum conyzoides, Dactyloctenium aegyptium* and *Spilanthus acmella*.

UAS, Dharwad

Weed seed bank in long-term trials on tillage and herbicide

Weed seed bank study in long-term trial on tillage in maize-chickpea revealed that emergence of weed seedlings per 100 g of soil was almost similar (3.7 to 3.9) in the main plots irrespective of tillage practices (CT or ZT). Weed emergence was highest in weedy check (5.8) and the lowest in HW (2.1) followed by recommended herbicides (3.5). Similarly, weed management in conservation agriculture system, weed emergence in the main plots (tillage practices) did not vary much. With respect to weed control treatments, the weed emergence was highest in weedy check (9.2) followed by IWM (4.1) and recommended herbicide (3.9). Long-term trial groundnut-wheat sequence, weed seed emergence was lower in weed free check (2.2), oxyfluorfen (2.5), imazethapyr (2.6). It was 4.1 in farmer's practice and 9.7 in weedy check.

VB, Sriniketan

Weed seed bank studies in long-term herbicidal trial (Rice – mustard)

The highest emergence was recorded under farmer's practice (FP) in *rabi* followed by FP in *kharif* and lowest emergence in pendimethalin (repeated) + fertilizer (100%) followed by butachlor (repeated) + 2,4-D + fertilizer (100%). Repeated application of pendimethalin followed by repeated application of butachlor was more effective than rotational application of isoproturon/pendimethalin in mustard followed by rotational application of pretilachlor / butachlor in rice in reducing total weed emergence during *rabi* 2012-13. During *kharif*, 2013, repeated application of butachlor in rice followed by repeated application of pendimethalin in mustard recorded the lowest emergence of weed seeds.

Periodicity of weed emergence in long-term herbicidal trial

***Rabi* 2012-13:** Early emergence was recorded in *Polygonum plebeium* (within 3-4 days after first watering) followed by *Gnaphalium purpureum* (6-7 days), *Digitaria, Chenopodium* and *Spilanthus* (10-12 days), *Anagallis,* and *Spergula Echinochloa* (after two weeks). Emergence was higher in number in 0-5 cm depth followed by 5-10 and 10-15 cm.

***Kharif* 2013:** Early emergence was recorded in *Fimbristylis miliacea* and *Cyperus iria* (3 days) followed by *Lindernia ciliata, Ludwigia parviflora, Digitaria sanguinalis, E. colona* and *Spilanthus acmella* (7-8 days), *Fimbristylis dichotoma, C. diffusa* and *Mollugo stricta* (14-15 days). Number of emerged weeds were recorded higher in first flush followed by second and third.

WS 2.4 Weed seedling identification method

AAU, Jorhat

Amongst the species studied, *Digitaria setigera*, *Eleusine indica*, *Imperata cylindrica* and *Paspalum conjugatum* facultative upland weeds, while *Isachne himalaica* is a common aquatic weed of transplanted rice and *Panicum repens* possesses very good adaptation in both upland and medium lowland situations. All these species, except *Eleusine indica,* are perennial in habit and highly troublesome in crop land situations. Though annual, *E. indica* occurs almost round the year and is rather problematic in wheat, jute, upland rice and vegetables.

At the developing stage, most of the morphological characters were highly variable and, therefore, more importance was given on leaf characteristics like the length, width, L-W ratio and colour of the lamina. A taxonomic key for identification has also been developed based on the characters studied for easy reorganization of the species (Table 2.4.1).

Table 2.4.1 Morphological characters of primary leaves of weed seedlings

Species	*Digitaria setigera*	*Eleusine indica*	*Imperata cylindrica*	*Isachne himalaica*	*Panicum repens*	*Paspalum conjugatum*
Shape	Narrow ovate to Lanceolate	Narrow oblong	Linear	Ovate – lanceolate	Linear	Linear
Surface	Pubescent	Glabrous	-	Pubescent	Glabrous	Glabrous
L:B ratio	2-4 : 1	4 : 1	18 : 1	1.0–1.6 : 1	20 : 1	10-20 : 1
Apex	Acute	Acute	Pointed	Subacuminate	Acute to pointed	pointed
Base	Acute	Rounded	Acute	Acute	Rounded	Rounded
Margins	Entire	Wavy (plicate) & ciliate	Entire & glabrous	Entire	Entire & glabrous	Entire & glabrous
Lamina colour	Green	Green	Yellowish green	Green	Green with bluish and glaucous tinge	Green tinged reddish purple
Mid vein colour	No colour variation	No colour variation	Deep green	No colour variation	Much lighter than lamina	No colour variation
Texture	M	M	M	F	F	M
Venation	P	P	P	P	P	P
Primary basal nerves	Many	1	1	Many	1	Many
Phyllotaxy	Alternate, falsely opposite	Spiral	Alternate, falsely opposite	Alternate, falsely opposite	Alternate, falsely opposite	Alternate, falsely opposite
Young leaf (no.)	1	1	1	1	1	1

WS 3: Weed management in crops and cropping systems

WS 3.1: Herbicide combinations for control of complex weed flora in transplanted rice

Due to scarcity of rains, irrigation water, efficacy of herbicides is affected and diverse flora of weeds emerge in rice. Hence, there is need for evaluation of combination of different herbicides for control of complex weed flora in transplanted rice. An experiment was conducted to study the bio-efficiency of combination of herbicides against complex weed flora, and their effect on growth and yield of transplanted rice. Different herbicides were applied either singly or in combination. Observations were recorded on weed population and dry matter at 60 DAT, crop growth parameters, yield attributes and yield, phytotoxicity on crop and economic analysis. Salient findings obtained at different centres are presented below:

PAU, Ludhiana

Echinochloa sp, *Ischaemum rugosum*, *Cyperus iria*, *Caesulia axilaris* and *Ammania baccifera* were the major weeds. Tank-mix application of bispyribac with ethoxysulfuron/Almix provided complete control of grasses, broadleaved and sedges weeds and recorded the highest rice grain yield (Table 3.1.1). Bispyribac alone and integrated use of pyrazosulfuron with one hand weeding were at par with these two treatments. Bispyribac alone and as tank-mix with Almix recorded the highest net returns and B:C ratio. All the herbicides were safe to the rice crop. Post-emergecne application of bispyribac alone and as tank-mix with ethoxysulfuron/Almix or pre-emergecne pyrazosulfuron + one hand weeding seems to be the best way of controlling complex weed flora and enhancing productivity and profitability from transplanted rice.

Table 3.1.1: Effect of weed control treatments on weed growth, yield and economics in transplanted rice during *kharif* 2013 at Ludhiana

Treatment	Dose (g/ha)	Weed dry matter at 60 DAT (g/m^2)			Grain yield (t/ha)	Net returns ($x10^3$ ₹/ha)	B:C ratio
		Grass	BLW	Sedges			
Bispyribac-Na	25	1.0 (0)	1.0 (0)	3.4 (22)	7.13	48.12	2.55
Pretilachlor	1000	4.4 (25)	2.4 (9)	3.6 (15)	6.05	36.89	2.22
Penoxsulam	22.5	6.3 (41)	3.9 (20)	5.1 (36)	5.35	29.12	1.96
Pyrazosulfuron	20	11.1 (137)	2.2 (7)	1.9 (4)	3.29	6.40	1.21
Bispyribac + ethoxysulfuron	25+18.7575	1.0 (0)	1.0 (0)	1.0 (0)	6.52	40.78	2.29
Bispyribac + Almix	20+4	1.0 (0)	1.0 (0)	1.0 (0)	7.33	48.60	2.48
Pretilachlor *fb* ethoxysulfuron	750/18.75	8.3 (94)	2.3 (8)	2.8 (13)	5.87	34.87	2.15
Pretilachlor *fb* Almix	750/4	9.8 (98)	1.0 (0)	1.0 (0)	5.97	34.35	2.08
Pyrazusulfuron *fb* manual weeding	20 *fb* HW	8.6 (75)	1.0 (0)	4.5 (21)	6.68	40.41	2.20
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660	11.5 (137)	1.9 (4)	1.8 (3)	4.75	21.90	1.71
Weed free (HW at 25, 45d)	-	2.3 (8)	2.8 (8)	1.9 (4)	5.89	28.72	1.78
Weedy check	-	23.1 (534)	3.9 (14)	5.8 (39)	3.21	6.15	1.21
SEm±	-	1.6	0.9	1.3	0.59		
LSD (P=0.05)	-	4.8	NS	NS	1.77		

Data subjected to square root transformations, in parentheses are original values

CCSHAU, Hisar

Weed flora was dominated by *Echinochloa crus-galli* along with broadleaved *Ammania baccifera* and sedges like *Cyperus difformis*. All the herbicide except pyrazosulfuron 20 g/ha provided effective control of *Echinochloa crus-galli* (Table 3.1.2). Addition of ethoxysulfuron and chlorimuron+ metsulfuron as tank-mix or as sequence improved the control of broad leaf weeds and sedges. There was no phyto-toxicity of different herbicidal treatments on the crop. All the herbicidal treatments except pyrazosulfuron 20 g/ha produced effective tillers and grain yields similar to weed-free check. Similarly, all herbicidal treatments except pyrazosulfuron alone and in combination with hand weeding resulted in higher net returns and B:C ratio than other treatments.

OUAT, Bhubaneswar

Major weed flora were: grasses like *Digitaria ciliaris, Cynodon dactylon, Echinochloa colona,* and broad leaf weeds like *Ageratum conyzoides, Cleome viscosa, Ludwigia parviflora, Physalis minima, Chrozoffera rottleri and Monocharia vaginalis*. The dominant sedges observed was *Cyperus rotundus* and *Cyperus iria*. Other weeds observed in lower density were *Panicum repens, Sporobolus diander, Alternanthera sessilis, Eclipta alba* and *Cyperus difformis*.Weed free treatment recorded significantly lowest weed density and biomass of at 60 DAP. Post-emergence application of bispyribac + Almix recorded significantly higher yield of 3.02 t/ha which was at par with post- emergence application of bispyribac + ethoxysulfuron (2.98 t/ha). Weed free plots recorded rice yield of 3.63 t/ha where as weedy treatment recorded the lowest yield(1.60 t/ha). Highest net returns of Rs. 21478/ha was obtained from post emergence application of bispyribac + Almix followed by bispyribac + ethoxysulfuron Rs 20713/ha, also the highest B:C ratio of 1.85 was observed with bispyribac + almix treated plots and the best B:C ratio in order was bispyribac + ethoxysulfuron (1.79).

Table 3.1.2: Effect of different herbicides alone or in combination on weed growth, yield and economics of transplanted rice during *Kharif* 2013 at Hisar

Treatment	Dose (g/ha)	Time (DAT)	Dry weight of weeds at 60 DAT (g/m^2)			Grain yield (t/ha)	Net returns Over VC ($x10^3$ ₹/ha)	Net returns Over VC ($x10^3$ ₹/ha)
			Grass weeds	Sedges	Broad-leaved weeds			
Bispyribac	25	20	0.0	0.4	1.0	6.66	51.50	2.27
Pretilachlor	1000	3	0.0	0.0	0.5	6.78	54.34	2.39
Penoxsulam	22.5	8-12	0.0	0.0	0.0	6.39	47.94	2.18
Pyrazosulfuron	20	3	92.7	0.0	0.7	5.60	38.43	1.97
Bispyribac+ ethoxysulfuron	25+18.8	20	0.0	0.0	0.2	6.92	54.51	2.33
Bispyribac + chlorimuron+ metsulfuron(RM)	25+4	20	0.0	0.0	0.0	6.88	54.03	2.32
Pretilachlor *fb* ethoxysulfuron	750 *fb* 18.8	3/20	0.0	0.0	0.0	6.79	53.69	2.34
Pretilachlor *fb* chlorimuron+ metsulfuron(RM)	750 *fb* 4	3/20	0.0	0.0	0.0	6.82	54.08	2.35
Pyrazosulfuron *fb* hand weeding	20	3/25	19.0	0.0	0.3	6.50	45.35	2.01
Pretilachlor + bensulfuron (RM)	660	5	7.7	0.0	0.0	6.87	55.22	2.40
Weed free			0.0	0.0	0.0	7.02	47.81	1.96
Weedy check			200.3	1.2	1.0	4.88	29.53	1.75
SEm±			11.8	0.1	0.2	0.181		
LSD (P=0.05)			34.5	0.2	0.7	0.530		

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

ANGRAU, Hyderabad

Weed flora observed in experimental field consisted of *Cyperus difformis, Cyperus spp, Scirpus supinus, Eclipta alba, Ammania baccifera, Panicum repenns, Echinocloa colona and Echinochloa crus-galli* and *Bacopa monneri*. Lowest weed dry matter (18.8 g/m^2) was recorded with weed free treatment i.e hand weeding at 25 and 45 DAT and was on par with pyrazosulfuron ethyl @ 20 g/ha (PE) *fb* manual weeding (19.1g/m^2), pretilachlor 750 g/ha (PE) *fb* Almix @ 4 g (POE) (20.8 g/m^2), pretilachlor 750 g/ha (PE) *fb* ethoxysulfuron @ 18.75 g/ha (POE) (22.667 g/m^2), bispyribac sodium 20 g/ha + Almix @ 4 g (POE) (23.6 g/m^2). Significantly higher grain yield was recorded with hand weeding twice at 25 and 45 DAT (7353 kg/ha), and was on par with the grain yield obtained with sequential application of pre and post emergence herbicides, *viz.* pyrazosulfuron ethyl @ 20 g/ha (PE) *fb* manual weeding (7338 kg/ha), pretilachlor (PE) *fb* ethoxysulfuron (7090 kg/ha), pretilachlor *fb* Almix (POE) (7050 kg/ha), and all these treatment were significantly superior to grain yield obtained from lone application of bispyribac sodium or pretilachlor or pyrazosulfuron or pretilachlor + bensulfuron methyl. Hand weeding at 25 and 45 DAT, pyrazosulfuron ethyl @ 20 g *fb* manual weeding though was effective in efficient weed control and higher yield but its higher cost (₹ 42350/ha), (₹ 39875/ha) respectively, pulled down the profit with low B.C ratio of 2.27 and 2.41.

AAU, Jorhat

Like the previous year's results, in 2013 also the early emerged weed species in the experimental site were *Monochoria vaginalis, Sagittaria guayanensis, Cyperus iria and Fimbristylis littoralis*. Grasses dominated the ground vegetation after 60 DAT; the most frequently occurred grass species were *Echinochloa crus-galli, Isachne himalaica, Leersia hexandra, Sacciolepis interrupta and Paspalum scorbiculatum*. The weed density was lowest at 60 DAT due to weed free (2 hand weedings), closely followed by pretilachlor (6%) + bensulfuron (0.6%) 6.6% 660 g/ha and pretilachlor 1000 g/ha followed by Almix 4 g/ha. In respect of weed dry weight, two hand weedings (weed free), pretilachlor 1000 g/ha, pretilachlor 1000 g/ha followed by ethoxysulfuron

18.75 g/ha and pretilachlor 1000 g/ha followed by Almix 4 g/ha recorded considerably lower values throughout the growing season of the crop. Pretilachlor 1000 g/ha followed by almix 4 and pretilachlor 1000 g/ha followed by ethoxysulfuron 18.75 g/ha were at par with weed free treatment in respect of grain yield (Table 3.1.3).

Table 3.1.3: Effect of weed management practices on weed growth and yield of rice at Jorhat

Treatment	Weed density at 60 DAT (no./m²)	Weed dry weight at 60 DAT (no./m²)	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac-Na 25 g/ha	59.3	34.2	3.05	5.06
Pretilachlor 1000 g/ha	32.7	27.5	3.74	6.10
Pyrazosulfuron 20 g/ha	43.3	29.6	3.45	5.64
Bispyribac-Na 25 g/ha + ethoxysulfuron 18.75 g/ha	56.7	35.9	3.17	5.13
Bispyribac-Na 25 g/ha + Almix 4 g/ha	45.7	37.8	3.30	5.37
Pretilachlor 1000 g/ha followed by ethoxysulfuron 18.75 g/ha	29.7	33.0	3.80	6.10
Pretilachlor 1000 g/ha *fb* Almix 4 g/ha	27.3	34.7	4.05	6.14
Pyrazosulfuron 20 g/ha followed by manual weeding 30 DAT	40.7	33.2	3.75	6.28
Pretilachlor (6%) + bensulfuron (0.6%) 6.6% 660 g/ha	24.7	29.5	3.50	5.62
Weed free	19.0	23.7	4.14	6.13
Weedy	82.3	98.9	2.78	4.23
LSD (P=0.05)	9.0	5.8	0.36	0.69
CV (%)	14.8	10.5	0.71	0.86

VB, Sriniketan

During 2012, the experimental rice field was infested with 18 weed species out of which 4 grasses, 12 broad leaved and 2 sedges but in *kharif* 2013, there were all together 17 weeds species in the experimental field out of which 4 grasses, 11 broad leaved and 2 sedges. Pretilachlor + bensulfuron, bispyribac + Almix and pyrazosulfuron followed by manual weeding also showed best performance in controlling grassy weeds. Regarding suppression of total weed population post-emergence application of bispyribac + Almix was found to be most effective and this was closely followed by bispyribac + ethoxysulfuron as post-emergence and pretilachlor *fb* Almix. Post-emergence application of bispyribac + Almix recorded the highest grain yield (5.11 t/ha) and it was at par with that of post-emergence application of bispyribac + ethoxysulfuron (4.82t/ha), pretilachlor *fb* Almix (4.81 t/ha), pyrazosulfuron *fb* manual weeding (4.76 t/ha), pretilachlor + bensulfuron (4.70 t/ha) and weed free (4.79 t/ha) check. The highest net return (₹ 41092/ha) and B:C ratio (1.54) was recorded under bispyribac + Almix. Pretilachlor *fb* Almix also recorded higher net return (₹ 38998/ha) and B:C ratio (1.54).

GBPUAT, Pantnagar

The experimental area was mainly infested only with *E. colona* (66.5%) and *E. crus-galli* (33.5%) among the grassy weeds. At 60 DAT, the maximum density and dry matter of weeds was found in weedy plot and lowest with hand weeded twice (25 and 45 DAT). Among the herbicidal treatments lowest density of total weeds was recorded with application of pretilachlor (750 g/ha) followed by combination of chlorimuron ethyl 10%+ metsulfuron methyl 10% (4 g/ha) being on par with combination of bispyribac-Na 20 g + chlorimuron ethyl 10% + metsulfuron methyl 10% (4 g/ha), pretilachlor 750 + ethoxysulfuron 18.7 g/ha, bispyribac-Na 25 g/ha being at par with application of pyrazosulfuron (22.5 g/ha) and all these proved most effective herbicides in reducing the density of total weed density (Table 3.1.4). Weedy check resulted in 34.3% reduction in grain yield of rice over weed free treatments. Hand weeding yielded highest grain yield, followed by the application of bispyribac-Na (25 + ethoxysulfuron 18.75 g/ha) yielded 6.51 t/ha, pretilachlor 750 g/ha+ chlorimuron ethyl 10%+ metsulfuron-ethyl 10% 4 g/ha bispyribac-Na 20 g/ha followed by chlorimuron-ethyl 10% + metsulfuron-ethyl 10% 4g/ha, pretilachlor (750 g/ha) followed by ethoxysulfuron (18.75 g/ha). Combined application of bispyribac-Na 25g + ethoxysulfuron 18.75 g/ha significantly yielded over the application of pretilachlor 1000 g/ha and pyrazosulfuron 20 g/ha.

Table 3.1.4: Effect of herbicides on weed growth and yield of transplanted rice during *kharif* 2013 at Pantnagar

Treatment	Dose (g/ha)	Total weed density (g/m²)	Total weed dry weight (g/m²)	Grain yield (t/ha)
Bispyribac –Na	25	1.8 (5.4)	2.7(13.9)	6.05
Pretilachlor	10.0	2.5(12.0)	3.2(23.6)	5.83
Penoxsulam	22.5	2.0(6.7)	3.0(19.8)	6.02
Pyrazosulfuron	20	2.8(16.0)	3.5(34.6)	5.55
Bispyribac-Na - ethoxysulfuron	25+18.75	0.8(1.3)	0.3(0.5)	6.51
Bispyribac-Na - chlorimuron-ethyl 10% + metsulfuron-methyl	20+4	1.3(2.6)	1.4(3.1)	6.38
Pretilachlor *fb* ethoxysulfuron	750/18.75	1.6(4.0)	2.2(8.7)	6.22
Pretilachlor *fb* CME 10% + MSM10%	750/4	0.8(1.3)	0.9(1.7)	6.39
Pyrazosulfuron *fb* manual weeding at 25 DAT	20	1.8(5.4)	2.9(19.1)	6.05
Pretilachlor (6%) + bensulfuron (0.6%) 6.6GR	660 (10 kg/ha)	2.3(9.4)	3.1(20.8)	5.96
Hand weeding	25 & 45 DAT	0.0(0.0)	0.0(0.0)	6.74
Weedy check	-	3.0(20.0)	3.8(44.2)	4.38
SEm+	-	0.11	0.12	0.203
LSD(P=0.05)	-	0.33	0.37	0.595

Value in parentheses were original and transformed to log (X+1) for analysis

IGKV, Raipur

Weed flora of the experimental field consisted of *Echinochloa colona, Cyperus iria, Fimbristyllis miliaceae, Alternanthera triandra and Ludvigia parviflora*. The lowest weed count was recorded under weed free (hand weeding at 25 and 45 DAT), bispyribac + ethoxysulfuron @ 25 + 18.75 g/ha, and bispyribac + (chlorimuron + metsulfuron) @ 25 + 4 g/ha, in order and this was closely followed by pretilachlor *fb* (chlorimuron + metsulfuron) @ 750 + 4 g/ha, pretilachlor *fb* ethoxysulfuron @ 750 + 18.75 g/ha, pyrazosulfuron @ 20 *fb* manual weeding and pinoxsulam @ 22.5 g/ha. Significantly higher seed yield was recorded under hand weeding twice than weedy check, but it was statistically at par with herbicide combinations such as bispyribac + (chlorimuron + metsulfuron) @ 25 + 4 g/ha, bispyribac + ethoxysulfuron @ 25 + 18.75 g/ha, pyrazosulfuron @ 20 *fb* manual weeding and Pretilachlor (6%) + bensulfuron (0.6%) GR@ 660 g/ha, in order. Though the gross return was maximum under weed free (hand weeding at 25 and 45 dat) treatment followed by bispyribac + (chlorimuron + metsulfuron) @ 25 + 4 g/ha, but benefit-cost ratio was highest under the treatment of pretilachlor(6%) + bensulfuron (0.6%) 6.6% GR @ 660 g/ha narrowly followed by bispyribac + (chlorimuron + metsulfuron) @ 25 + 4 g/ha.

TNAU, Coimbatore

The common weed flora during *rabi*, 2012-13 consisted of grasses, sedges and broad leaved weeds. Among the grasses, *Echinochloa colona* was a dominant one and the major sedge was *Cyperus difformis*. Among the broad leaved weeds, *Ammania baccifera* was the dominant species. During *kharif*, 2013 pre-dominant grassy weeds were *Echinochloa crus-galli* and *Echinochloa colona* and the dominant sedge was *Cyperus difformis*. Among the broad leaved weeds, *Ammania baccifera* and *Marsilea quadrifoliata* were the dominant species. At 60 DAT, there was remarkable reduction in total weed density with hand weeding twice at 25 and 45 DAT and it was on par with the application of PE pretilachlor 750 g/ha + POE admixture of chlorimuron + metsulfuron 4 g/ha during *rabi*, 2012-13. During *kharif* 2013, PE pretilachlor 750 g/ha *fb* POE chlorimuron + metsulfuron 4 g/ha recorded considerably lower total weed density and it was closely followed by PE pretilachlor 750 g/ha *fb* POE ethoxysulfuron 18.75 g/ha. PE pyrazosulfuron-ethyl 20 g/ha recorded significantly higher weed density at 60 DAT. The grain yield was conspicuously higher in hand weeding twice at 25 and 45 DAT and it was comparable with PE pretilachlor 750 g/ha + POE admixture of chlorimuron + metsulfuron 4 g/ha during *rabi,* 2012-13. The lower yield was obtained in PE pretilachlor 1000 g/ha. During *kharif* 2013, grain yield was conspicuously higher in PE pretilachlor 750 g/ha *fb* POE chlorimuron + metsulfuron 4 g/ha and it was on par with PE pretilachlor 750 g a.i./ha *fb* POE ethoxysulfuron 18.75 g/ha and hand weeding twice at 25 and 45 DAT. Higher gross return, net return and B:C ratio was obtained with application of PE pretilachlor 750 g/ha + POE admixture of chlorimuron and metsulfuron 4 g/ha and it was followed by application of PE pretilachlor 750 g/ha + POE ethoxysulfuron 18.75 g/ha.

NDUAT, Faizabad

The experimental field was infested with natural population of grassy, BLWs and sedges. The dominant weeds in the weedy check plot, *viz.*, *Echinochloa colona* and *E. crus-galli* (22.3%) among the grassy, *Eclipta alba, Caesulia alxillaris* and *Ammania baccifera* among BLWs and *Cyperus* spp and *Fimbristyllis* spp. among sedges were recorded. Bispyribac-Na provided control of almost all type of the weeds but it was excellent against *Echinochloa colona* and *E. crus-galli*. Pretilachlor 1000 g/ha applied at 0-3 DAT also controlled the grassy weeds very effectively but *C. axillaris* was controlled moderately. The grain yield was recorded at par due to bispyribac-Na, penoxsulam and pyrazosulfuron, along with the either tank mixing or sequential application of ethoxysulfuron with pretilachlor or bispyricbac. However, bispyribac + Almix, Pretilachlor *fb* Almix and pyrazosulfuron *fb* manual weeding at 25 DAT recorded fairly better grain yield which were comparable to weed free treatments. Net returns and BCR values affected substantially due to different weed control treatments. Though weed free treatment recorded maximum grain yield but due to higher cost of cultivation, values of net returns and BCR were lower than other many weed control treatments. Among the different weed control treatments, *viz.* pretilachlor *fb* Almix recorded higher value of net returns and BCR followed by bispyribac-Na+ethoxysulfuron and pretilachlor *fb* ethoxysulfuron, respectively.

UAS, Bengaluru

Major weed flora observed in the experimental plots were: *Cyperus difformis, Scirpus* sp, *Fimbristylis miliacea* (among sedges), *Paspalum distichum, Echinochloa colona* (among grasses). Where as among broad leaf weeds, major weeds were *Spilanthus acmella, Ludwigia parviflora, Rotala verticillaris, Eclipta alba (from initial stage), Dopatrium junceum* (from 60 DAP). Other weeds observed in lower densities were *Cyperus iria* (among sedges), *Echinochloa glabrescens* (among grasses), *Marselia quadrifoliata, Alternanthera sessilis and Gnaphalium polycaulon* (among broad leaf weeds). Among the weed species, the density of *Scirpus* sp, *Fimbristylis miliacea, C. difformis, E. colona, P. distichum, Spilanthus acmella* and *L. parviflora* were higher than other weed species, indicating their dominance from the beginning of the crop cycle. At 60 DAP, herbicide treatments were significantly superior to unweeded with regards to weeds density and dry weight. The plots treated with herbicide combinations such as pyrazosulfuron ethyl 20 g/ha – 3 DAP *fb* manual weeding (45 DAP), pretilachlor 750 g/ha – 3 DAP *fb* ethoxysulfuron 18.75 g/ha – 25 DAP or chlorimuron ethyl + metsulfuron methyl 20 WP 4 g/ha – 25 DAP, bispyribac sodium 25 g + ethoxysulfuron 18.75 g/ha – 25 DAP and bispyribac sodium 25 g + chlorimuron ethyl + metsulfuron methyl 20 WP at 4 g/ha – 25 DAP recorded lower weeds' density and dry weight compared to application of single herbicides like pretilachlor + bensulfuron methyl 6.6% G 660 g/ha – 3 DAP, penoxsulam 22.5 g ai/ha – 12 DAP, pyrazosulfuron ethyl 20 g/ha – 3 DAP and pretilachlor 1000 g/ha – 3 DAP indicating the necessity of combination of herbicides to manage complex weed flora in transplanted rice. The plot treated with pyrazosulfuron ethyl 20 g/ha – 3 DAP *fb* manual weeding (45 DAP) recorded significantly higher paddy yield compared to all other treatments except pretilachlor 750 g – 3 DAP *fb* chlorimuron ethyl + metsulfuron methyl 20 WP 4 g ai/ha – 25 DAP, pretilachlor 750 g – 3 DAP *fb* ethoxysulfuron 18.75 g/ha – 25 DAP and two hand weedings (25 and 45 DAP) with which it was at par. Unweeded control gave the lowest paddy yield, owing to severe competition from weeds of all types as revealed from weed index (60.2%).

RAU, Pusa

Weed flora found in the experimental field were: Grasses : *Echinocloa crus-galli, E. colona, Digitaria sanguilis, Dactyloctenium aegyptium, Cynodon dactylon.*; Sedges: *Cyperus rotundus, Cyperus diformis, Fimbristylis milliaceae;* Broad leaf weeds: *Caesulia axillaris, Lippia nodiflora, Ammania baccifera, Eclipta alba, Phyllanthus niruri*. The lowest weed population and weed dry weight were recorded in weed free (hand weeding at 25 and 45 DAS) which were significantly superior over rest of the treatments. The highest grain yield of rice (4.60 t/ha) was recorded by the treatment weed free (hand weeding at 25 and 45 das) which was statistically at par with pyrazosulfuron *fb* manual weeding, pretilachlor *fb* ethoxysulfuron.

SKUAST, Kashmir

Control of complex weed flora in transplanted rice

A field experiment was carried out during *kharif*, 2013 at Research Farm of SKUAST-Kashmir, Shalimar to evaluate the effect of Brown sarson extracts in different dilutions on transplanted rice and associated weeds. Weed flora in weedy check at 60 DAT mainly comprised of *Echinochloa crus-galli* (25.5%), among grassy weeds *Ammania baccifera* (15.2%), *Gratula japonica*(12.3%), *Monochoria vignalis* (6.1%), *Aeschynomene indica* (10.2%), and *Polygonum hydropiper* (10.7%) among broadleaf weeds and *Cyperus difformis* (8.3%) and *Cyperus iria* (4.3%) among sedges. At 60 DAT the maximum density of total weeds was found in weedy check control plot.

Among treatment combinations the lowest density was observed with the application of 100% brown sarson extract of 36 and 24 hrs soaking at 5 and 10 DAT followed by 1:10 dilution brown sarson extract of 36 and 24 hrs soaking at 5 and 10 DAT which in turn is followed by100% brown sarson extract of 12 hrs soaking at 5 and 10 DAT and then by 1:10 dilution. Uncontrolled growth of weeds (weedy check) resulted in 75% reduction in grain yield of rice. The highest recorded yield of rice due to influence of most effective weed control treatment combinations was in the order of Brown sarson extracts (100%) of 36 hrs sprayed at 5 DAT (8.67 t/ha) > Brown sarson extracts (100%) of 36 hrs sprayed at 10 DAT (8.12 t/ha) > 1:10% dilution of 36 hr at 5 DAT (7.83 t/ha) >100 percent concentrates of brown sarson extracts of 24 hr at 5 DAT (7.67 t/ha) > 1:10 percent dilution of 36 hr at 15 DAT (7.17 t/ha) > 1:10 percent dilution of 24 hr at 5 DAT (7.00 t/ha).

WS 3.2: Herbicides combinations for control of complex weed flora in direct-seeded rice

An appropriate weed management strategy has always been a major focus and key element to make direct seeded rice a success. Heavy weed infestation and shifts in weed population are major constrains in the sustainability of direct seeded rice. Manual weeding though effective is getting increasingly difficult due to many reasons. Thus, herbicide usage seems indispensible for weed management in direct seeded rice. The present investigation was planned to decide the efficacy of sole and sequential application of pre and post emergence herbicides and integration with manual/mechanical weeding for selective and long lasting weed control in direct seeded rice.

The experiment was conducted on dry-seeded rice at was conducted different centres and data were recorded on weed population (no./m^2) and dry matter (g/m^2) at 60 DAS, crop growth parameters, yield attributes and yield, phytotoxicity on crop and economics analysis. Salient findings are presented below:

OUAT, Bhubaneswar

Major weed flora were grasses like *Digitaria ciliaris, Cynodon dactylon, Echinochloa colona* and broad leaf weeds like *Ageratum conyzoides, Cleome viscosa, Celosia argentea Oldenlandia corymbosa, Ludwigia parviflora, Physalis minima and Amaranthus viridis*. The dominant sedges observed was *Cyperus rotundus* and *Cyperus ira*. Other weeds observed in lower density were *Panicum repens, Sporobolus diander, Alternanthera sessilis, Eclipta alba*. Significant difference in weed densities was observed at 60 DAS. Weed free treatment recorded significantly lowest weeds. Among different weed control treatments, application of pendimethalin *fb* bispyribac *fb* manual weeding recorded significantly lowest density at 60 DAS. Weed free treatment recorded significantly lowest weed biomass. Among different herbicide combinations, application of pendimethalin *fb* bispyribac *fb* manual weeding exhibited significantly lowest weed biomass, followed by oxadiargyl *fb* bispyribac treatment. Weed free treatment recorded significantly highest yield of 4.47 t/ha where as weedy check treatment recorded the lowest yield (1.84 t/ha). Among different herbicide combinations, significantly higher grain yield of 4.40 t/ha was obtained with application of pendimethalin *fb* bispyribac *fb* manual weeding which was at par with oxadiargyl *fb* bispyribac (4.32 t), pyrazosulfuron *fb* bispyribac (4.27 t), pendimethalin fb bispyribac (4.10 t) and pendimethalin* *fb* manual weeding (4.0 t/ha). Highest net return and B:C ratio of ₹ 18900/ha and 1.78 were obtained respectively from application of pendimethalin fb bispyribac *fb* manual weeding followed by oxadiargyl *fb* bispyribac.Weedy check recorded the (-ve) value of ₹ 1300 with respect to net return/ha with B:C ratio of 1.04.

ANGRAU, Hyderabad

Weed flora consisted of *Trianthema portulacastrum, Digera arvensis, Alternanthera phylloxirolides, Echinochloa colonum, Echinochloa crus-galli, Dactyloctenium aegyptium, Dinebra arabica, Cyperus rotundus* and *Cynodon dactylon*. Weed dry matter was significantly affected due to imposition of different weed control treatments. Obviously highest weed dry matter was recorded in weedy check (14.2 g/m^2) compared to other treatments indicating the necessity of weed control in direct seeded rice. Significantly lowest weed dry matter (3.97 g/m^2) was noticed in weed free situation (HW at 20, 40 and 60 DAS) and differed significantly from the remaining treatments. Grain yield was highly influenced by various weed control treatments in direct seeded rice. Significantly highest grain yield was achieved in weed free situation) and it was on par with grain yield realized under T8 (Three mechanical weedings at 20, 40 and 60 DAS). Lowest grain yield of 1.54 t/ha was observed in weedy check indicating the importance of weed control. Among the treatments involving sequential application of herbicides, pendimethalin *fb* bispyribac-sodium (POE) *fb* manual weeding) gave higher yield that surpassed yields obtained under remaining pre and post-emergence or their lone application or along with manual weeding. Highest gross returns were realized due to maintenance of weed free situation at 20, 40 and 60 DAS, followed by three mechanical weedings and pendimethalin *fb* bispyribac *fb* manual weeding. Oxadiargyl *fb* bispyribac and pyrazosulfuron *fb* bispyribac also performed better, registering a BC ratio of 2.0 each. Pre-emergence application of pendimethalin *fb* bispyribac-sodium along with one manual weding at 45 DAS is recommended for efficient weed management and good profit in aerobic rice cultivation (Table 3.2.1).

Table 3.2.1: Effect of weed management practices on weed growth, yield and economics of aerobic rice during *kharif*, 2013 at Hyderabad

Treatment	WDM (g/m^2)	Grain Yield (t/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
Bispyribac-Na	11.4 (129.2)	2.29	8.74	1.5
Pendimethalin* *fb* bispyribac	10.1 (101.0)	3.11	16.85	1.8
Oxadiargyl *fb* bispyribac	9.2 (84.7)	3.4	20.92	2.0
Pyrazosulfuron *fb* bispyribac	9.1 (82.2)	3.81	25.31	2.3
Pendimethalin* *fb* bispyribac *fb* manual weeding	7.3 (53.3)	4.54	32.26	2.5
Pendimethalin* *fb* manual weeding	10.0 (99.9)	3.21	14.89	1.6
Bispyribac + (chlorimuron + metsulfuron)	10.3 (105.6)	3.18	17.53	1.9
Three mechanical weedings (cono / rotary weeder)	6.1 (37.2)	4.74	33.19	2.5
Weed free	3.9(14.8)	4.98	29.08	2.0
Weedy check	14.2 (200.8)	1.54	1.69	1.0
LSD (P=0.05)	0.61	0.33		
CV (%)	3.8	5.6		

BAU, Ranchi

Application of pyrazosulfuron 3DAS *fb* bispyribac 25 DAS recorded practically no broad leaved weeds as similar to three weeding. At 60 Days after sowing application of oxadiargyl 3DAS *fb* bispyribac 25 DAS being similar to bispyribac + Almix 20 DAS showed an edge over rest of the treatments. Application of pyrazosulfuron 3DAS *fb* bispyribac 25 DAS did not record dry matter by broad leaved weeds at 30 and 60 DAS, while pendimethalin 3 DAS *fb* bispyribac 20 DAS *fb* manual weeding at 25 DAS being similar to rest of the treatments recorded reduced weed dry matter compared to weedy check. Application of pendimethalin 3 DAS *fb* bispyribac 20 DAS *fb* manual weeding at 25 DAS recorded grain yield and straw yield similar to weed free and was 40.6 and 40.1% respectively significantly higher compared to rest of the treatments. Three MW 20, 40, 60 DAS recorded significantly higher net return (₹ 42508) and B:C ratio (2.76) as compared to rest of the treatments. However among herbicides application of Pendimethalin 3 DAS *fb* bispyribac 20 DAS *fb* manual weeding at 25 DAS recorded significantly higher net return (₹ 38794) and B:C ratio (2.10).

AAU, Jorhat

The early emerged weeds in the field were *Cynodon dactylon* among the grasses and *Mimosa pudica* among the broadleaves. The most troublesome weeds in the critical crop growth period were grasses like *Digiteria setigera* and *Eleusine indica*, broadleaved species like *Ageratum houstonianum*, *Borreria articularis, Ludwigia linifolia, Melochia corchorifolia,* etc. and sedges like *Cyperus iria,* a number of species of *Fimbristylis* and *Scirpus*. Out of these the *Digitaria-Eleusine-Ageratum* and *Melochia* formed a complex to dominate the field during active crop growth period to blooming period. *Ludwigia-Melochia-Mimosa* and *Cuphea balsamona* complex, on the other hand created problem in the later part of crop stand. Application of oxadiargyl 100 g/ha *fb* bispyribac-Na 25 g/ha recorded significantly lowest weed density. However, at 60 DAS, weed-free resulted in significantly lowest weed density followed by pendimethalin 1000 g/ha *fb* bispyribac-Na 25 g/ha + manual weeding (45 DAS). Regarding weed dry weight at 20 and 40 DAS, pendimethalin 1000 g/ha *fb* manual weeding (25 DAS) and oxadiargyl 100 g/ha *fb* bispyribac-Na 25 g/ha resulted in significantly lowest weed dry weight. The Weed free (hand weeding 20, 40 and 60 DAS) treatment recorded significantly lowest false grain followed by mechanical weeding 20, 40 and 60 DAS. The weed free treatment recorded significantly highest grain and straw yield followed by mechanical weeding (Table 3.2.2).

IGKV, Raipur

Weed flora of the experimental field consisted of *Echinochloa colona* among grasses, *Cyperus iria* among sedges and *Alternanthera triandra, Spilanthes acmella, Cynotis axillaris* among broad leaf weeds. Broad leaf weeds and Sedges dominated the weed flora at 60 DAS and harvest as compared to grasses and other weeds. The lowest weed count at 60 DAS was recorded under pendimethalin *fb* bispyribac–Na @ 1000 g/ha *fb* manual weeding 45 DAS and this was closely followed by hand weeding twice, pyrazosulfuron *fb* bispyribac –Na @ 100/25 g/ha, bispyribac –Na + (chlorimuron + metsulfuron) @ 20 + 4 g/ha and oxadiargyl *fb* bispyribac –Na @ 100/25 g/ha, in order. It is obvious from the data on weed dry matter that significantly lowest dry matter was recorded under pendimethalin *fb* bispyribac–Na @ 1000 g/ha *fb* manual weeding 45 DAS but it was statistically at par with weed free (hand weeding at 20, 40 and 60 DAS) and pendimethalin @ 1000 g/ha *fb* manual weeding at 60 DAS, in order. Seed yield of direct-seeded rice varied significantly due to different weed control measures and was significantly superior over weedy check. Significantly higher seed yield was recorded under pendimethalin *fb* bispyribac–Na @

Table 3.2.2: Weed density at 60 DAS, and yield of rice as influenced by different treatrments at Jorhat

Treatment	Weed density at 60 DAS (no/m^2)	Weed dry weight at 60 DAS (g/m^2)	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac-Na 25 g/ha	10.5 (109.0)	9.57 (91.0)	0.68	1.04
Pendimethalin 1000 g/ha *fb* bispyribac-Na 25 g/ha	7.9 (62.7)	6.92 (47.4)	1.18	1.85
Oxadiargyl 100 g/ha *fb* bispyribac-Na 25 g/ha	7.1 (50.0)	6.35 (39.8)	1.46	2.08
Pyrazosulfuron 20 g/ha *fb* bispyribac-Na 25 g/ha	8.8 (76.7)	7.18 (51.0)	1.37	1.93
Pendimethalin 1000 g/ha *fb* bispyribac-Na 25 g/ha + manual weeding (45 DAS)	6.8 (45.7)	6.19 (37.8)	1.45	1.89
Pendimethalin 1000 g/ha *fb* manual weeding (25 DAS)	7.8 (59.7)	6.98 (48.1)	1.67	2.34
Bispyribac-Na 25 g/ha + Almix 4 g/ha	10.7 (114.0)	9.24 (84.7)	0.73	1.08
Mechanical weeding	7.2 (50.7)	5.81 (33.2)	1.92	2.95
Weed free	6.5 (41.7)	5.49 (29.5)	2.01	3.04
Weedy	12.4 (152.3)	10.79 (115.9)	0.050	0.72
LSD (P=0.05)	0.8	0.60	0.11	0.15
CV (%)	6.0	5.36	5.7	5.3

*Square root ($\sqrt{}$ (V +0.5), V is observed value) transformed data, original value in the parentheses

1000/25 g/ha *fb* manual weeding 45 DAS, however, it was statistically at par with rest of the treatments except bispyribac–Na @ 25 g/ha applied alone as post emergence, bispyribac–Na + (chlorimuron + metsulfuron) @ 20 + 4 g/ha, three mechanical weedings and weedy check. Though the gross retun is maximum under pendimethalin *fb* bispyribac–Na @ 1000 g/ha *fb* manual weeding 45 DAS treatment followed by pendimethalin *fb* bispyribac –Na @ 1000 fb 25 g/ha, but, benefit-cost ratio was highest under the treatment of pendimethalin *fb* bispyribac– Na @ 1000 *fb* 25 g/ha and three mechanical weedings (Table 3.2.3).

GBPUAT, Pantnagar

Application of pendimethalin *fb* bispyribac supplemented with one hand weeding recorded the lowest weed dry weight which was at par with spray of other combination of herbicides except alone application of bispyribac-Na and mechanical weeding(thrice). Application of pendimethalin *fb* bispyribac supplemented with one hand weeding recorded 44.5% lower weed dry matter production over the application of pendimethalin followed by bispyribac-Na. Highest grain yield was obtained with application of pendimethalin *fb* bispyribac at (1000 *fb* 25 g/ha) followed by same combination of herbicide supplemented with one hand weeding and oxadiargyl followed by bispyribac (100 *fb* 25) which were at par with each other. Application of pendimethalin followed by bispyribac recorded 9.9, 32.2 and 75% higher grain yield over the hand and mechanical weeding (thrice) and weedy check. Highest B: C was obtained with application of bispyribac-Na (3.4) followed by oxadiargyl *fb* bispyribac (3.2) and pendimethalin followed by bispyribac (3.2) while lowest B:C ratio was observed with weedy check followed by hand weeding (Table 3.2.4).

Table 3.2.3: Effect of herbicide combination on weed growth, yield and economics of rice at Raipur

Treatment	Weed dry matter at 60 DAS (g/m²)	Grain yield (t/ha)	Net returns (x10³ ₹/ha) (pooled)	B:C ratio
Bispyribac –Na @ 25 g/ha	7.83(61.2)	4.27	41.71	3.10
Pendimethalin* *fb* bispyribac –Na @ 1000 *fb* 25 g/ha	6.16(37.6)	5.03	50.01	3.35
Oxadiargyl *fb* bispyribac –Na @ 100/25 g/ha	6.35(40.0)	4.98	48.43	3.33
Pyrazosulfuron *fb* bispyribac –Na @ 20/25 g/ha	4.47(19.7)	4.63	43.55	3.11
Pendimethalin* *fb* bispyribac–Na @ 1000 g/ha *fb* manual weeding 25 DAS	3.68(13.1)	5.16	49.94	3.11
Pendimethalin* @ 1000 g/ha *fb* manual weeding	4.65(21.1)	4.58	42.15	2.86
Bispyribac –Na + (chlorimuron + metsulfuron) @ 20 + 4 g/ha	6.65(43.8)	4.33	42.86	3.12
Three mechanical weedings	8.30(68.4)	4.30	44.03	3.35
Weed free	3.79(14.0)	4.86	38.18	2.28
Weedy check	12.12(147.3)	0.89	7.17	1.40
SEm±	0.305	0.281		
LSD (P=0.05)	0.91	0.81		

Figures in the parentheses are original values; data were transformed through $\sqrt{x + 0.5}$

TNAU, Coimbatore

The common weed flora of the experimental field consisted of grasses, sedges and broad leaved weeds which were observed from the unweeded check plot at flowering stage of rice. The pre-dominant grassy weeds were *Echinochloa crus-galli* and *Echinochloa colona* and the dominant sedge was *Cyperus difformis*. Among the broad leaved weeds, *Eclipta alba, Ludwigia parviflora* and *Ammania baccifera* were the dominant species. During *rabi* 2012-13, at 60 DAS there was remarkable reduction in total weed density with the application of PE pendimethalin at 1000 g a.i./ha *fb* EPOE bispyribac sodium at 25 g a.i./ha *fb* HW on 45 DAS and it was on par with PE pyrazosulfuron at 20 g/ha *fb* EPOE bispyribac sodium at 25 g a.i./ha. During *kharif* 2013, the total weed density was lower with the application of PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac-sodium at 25 g/ha *fb* hand weeding on 45 DAS. This treatment was comparable with PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha (14.00 No./m²) and EPOE bispyribac sodium at 20 g/ha + (chlorimuron + metsulfuron) at 4 g/ha. At 60 DAS, during *rabi* 2012-13, the total weed dry weight was significantly lower with the application of PE

Table 3.2.4: Effect of treatments on weed growth, yield and economics of direct dry-seeded rice at Pantnagar

Treatment	Dose (g/ha)	Total weed density (no/m²)	Total weed dry weight (g/m²)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (x10³ ₹/ha)	B:C ratio
Bispyribac-Na	25	70.7	78.9	5.20	9.43	52.71	3.4
Pendimethalin *fb* bispyribac	1000 *fb* 25	212.0	49.0	5.68	9.56	56.94	3.2
Oxadiargyl *fb* bispyribac	100 *fb* 25	148.0	29.9	5.54	9.70	55.83	3.2
Pyrazosulfuron *fb* bispyribac	20 *fb* 25	76.0	51.7	5.20	9.64	46.92	2.2
Pendimethalin *fb* bispyribac+HW (45 DAS)	1000 *fb* 25	54.7	27.2	5.67	10.07	48.35	1.8
Pendimethalin *fb* HW (30 DAS)	1000	30.7	46.2	4.53	8.60	35.69	1.5
Bispyribac + Almix	20+4	32.0	40.8	4.84	7.54	43.94	2.2
Mechanical weeding	20, 40 & 60 DAS	42.7	179.6	3.85	7.81	28.15	1.2
Hand weeding	20, 40 & 60 DAS	16.0	27.2	5.12	8.95	29.40	0.8
Weedy check	-	157.3	495.0	1.41	3.29	4.91	0.3
SEm±	-	17.7	39.2	0.306	0.579		
LSD (P=0.05)	-	52.5	116.4	0.991	1.720		

pendimethalin at 1000 g/ha *fb* EPOE bispyribac-sodium at 25 g/ha *fb* HW on 45 DAS. This treatment was followed by EPOE bispyribac 20 g/ha + (chlorimuron + metsulfuron) at 4 g/ha. During *kharif* 2013, the grain yield was conspicuously higher with the application of PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha *fb* hand weeding on 45 DAS and it was on par with PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha and hand weeding. Lower grain yield was obtained in three mechanical weeding. During *rabi* 2012-13, higher net returns were observed with the application of PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha. PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha recorded higher B:C ratio of 2.27 and it was followed by PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha *fb* hand weeding on 45 DAS. During *kharif* 2013, higher gross returns were observed with PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha and it was followed by PE pendimethalin at 1000 g/ha *fb* EPOE bispyribac sodium at 25 g/ha fb hand weeding on 45 DAS.

UAS, Bengaluru

Major weed flora observed in the experimental plots was *Cyperus rotundus* (sedge), *Digitaria marginata, Echinochloa colona* (among grasses). Whereas among broad leaf weeds, major weeds were *Borreria articularis, Spilanthes acmella, Commelina benghalensis, Ageratum conyzoides, Euphorbia geniculata and Euphorbia hirta*. Among the weed species, the densities of *C. rotundus, D. marginata, E. colona, S. acmella, E. geniculata and A. conyzoides* were more than other weed species, indicating their dominance and competitiveness with the direct seeded rice. At all stages, all these herbicide mixtures were superior to unweeded control in having lower weeds' density and dry weight. Three hand weedings ecorded significantly higher paddy grain and straw yield compared to all other treatments except pendimethalin 1.0 kg/ha – 2 DAS *fb* bispyribac-sodium 25 g/ha – 20 DAS with manual weeding - 45 DAS, pendimethalin 1.0 kg/ha – 2 DAS *fb* bispyribac sodium 25 g/ha – 20 DAS and passing cono-weeder with which it was at par. The herbicides alone or mixtures were cheaper than manual weeding or passing cono-weeder. The plots treated with herbicides/herbicide mixtures saved the weeding cost as compared to three times manual weeding (Table 3.2.5).

CSKHPKV, Palampur

The major weeds were: *Echinochloa colona, Digitaria sanguinalis, Panicum dichotomiflorum, Commelina benghalensis, Aeschynomene indica, Ageratum conyzoides* and *Cyperus iria*. All the

Table 3.2.5: Effect of herbicide mixtures on weed growth, yield and economics of direct-seeded rice at Bengaluru

Treatment	Total weed density at 90 DAS (no./m²)	Total weed dry weight at 90 DAS (g/m²)	Rice grain yield (t/ha)	Cost of weed management (x10³ ₹/ha)	Saving in weeding cost over HW (x10³ ₹/ha)
Bispyribac-sodium 10% SC	2.12(136.1)	2.11(133.4)	2.13	2.28	5.72
Pendimethalin* *fb* bispyribac	2.00(100.6)	1.90(80.6)	3.08	4.48	3.52
Oxadiargyl *fb* bispyribac	2.07(119.6)	2.04(112.5)	2.47	3.75	4.25
Pyrazosulfuron *fb* bispyribac	2.05(112.3)	1.98(94.9)	2.64	3.50	4.49
Pendimethalin* *fb* bispyribac *fb* manual weeding	1.86(77.8)	1.75(61.1)	3.19	5.98	2.02
Pendimethalin* *fb* manual weeding	2.07(116.7)	2.04(109.9)	2.24	2.20	5.80
Bispyribac + (chlorimuron + metsulfuron)	2.06(120.2)	2.02(108.3)	2.58	3.23	4.77
Three mechanical weedings	1.97(97.2)	1.88(79.9)	2.97	6.00	2.00
Weed free	1.84(67.2)	1.72(50.6)	3.26	8.00	-
Weedy check	2.25(179.0)	2.28(190.7)	0.41	-	-
SEm ±	0.09	0.09	0.137	-	-
LSD (P=0.05)	0.26	0.28	0.406	-	-

Data within the parentheses are original values; Transformed values - # = log (X+2), + = square root of (X+1); DAS = Days after sowing

herbicides behaving statistically similar among them and with weed free resulted in significantly lower density of *Echinochloa* as compared to three mechanical weedings with cono/rotary weeder and weedy check at both the stages of observations. Similarly, all the weed control teatments behaving statistically similar except three mechanical weedings with cono/rotary weeder and bispyribac 25 g/ha (20 DAS) resulted in significantly lower density of *Panicum dichotomiflorum* at 60 DAS as compared to weedy check. Pendimethalin *fb* bispyribac 1000 *fb* 25 g/ha (0-2 *fb* 25 DAS) or pendimethalin *fb* manual weedy 1000 g/ha (0-2 *fb* 25-30 DAS) behaving statistically similar were the effective treatments in reducing the count of *Panicum dichotomiflorum* at 60 DAS. All the weed control teatments except three mechanical weedings with cono/rotary weeder and pendimethalin *fb* manual weedy 1000 g/ha (0-2 *fb* 25-30 DAS) at 60 DAS and except three mechanical weedings with cono/rotary weeder at harvest behaving statistically similar resulted in significantly lower dry weight of *Echinochloa* at both the stages of observations. Weeds in unweeded check reduced the grain yield of paddy by 54.9% over pendimethalin *fb* bispyribac *fb* manual weed 1000 *fb* 25 g/ha (0-2 *fb* 20 DAS *fb* 45 DAS) (Table 3.2.6). However, pendimethalin *fb* bispyribac *fb* manual weed 1000 *fb* 25 g/ha (0-2 *fb* 20 DAS *fb* 45 DAS) behaved statistically alike with all the weed control treatments except three mechanical weedings with cono/rotary weeder and pendimethalin *fb* manual weedy 1000 g/ha (0-2 *fb* 25-30 DAS) and resulted in significantly higher grain yield by effective control of weeds. It was followed by pyrazosulfuron *fb* bispyribac 20 *fb* 25 g/ha (0-3 *fb* 25 DAS).The lowest grain yield was recorded in weedy check treatment (Table 3.2.6).

Table 3.2.6: Effect of different treatments on weed growth and yield of direct-seeded rice at Palampur

Treatment	Total weed count 60 DAS (no./m²)	Total weed dry weight at 60 DAS (g/m²)	Grain yield (t/ha)
Bispyribac 25g/ha (20 DAS)	4.17 (16.4)	3.35 (10.2)	2.79
Pendimethalin *fb* bispyribac 1000 *fb* 25g/ha (0-2 *fb* 25 DAS)	2.4 (5.0)	2.77 (6.7)	3.02
Oxadiargyl *fb* bispyribac 100 *fb* 25g (0-2 fb25 DAS)	3.16 (9.0)	2.44 (5.0)	3.08
Pyrazosulfum *fb* bispyribac 20 *fb* 25g/ha (0-3 *fb* 25 DAS)	2.7 (6.4)	2.48 (5.2)	2.79
Pendimethalin *fb* bispyribac *fb* manual weeding 1000 *fb* 25g/ha (0-2 *fb* 20 DAS *fb* 45 DAS)	3.0 (8.7)	2.48 (7.12)	3.14
Pendimethalin *fb* manual weeding1000g/ha (0-2 *fb*-25-30 DAS)	3.47 (11.9)	3.35 (10.26)	1.96
Bispyribac + (chlorimuron + metsulfuron-methyl) 20+ 4g/ha (20 DAS)	3.61(12.1)	3.83 (13.72)	2.65
Three mechanical weedings	5.35 (27.7)	2.20 (3.88)	2.23
Weed free	2.51 (5.35)	3.60 (12.0)	2.79
Weedy check	4.33 (17.8)	5.76 (32.2)	1.11
SEm±	0.21	0.40	0.125
LSD (P=0.05)	0.62	1.18	0.371

Values given in the parentheses are the original means.

NDUAT, Faizabad

The major weed species were: *Echinochloa colona* (12.4%), *Echinochloa crus-galli* (4.7%), *Panicum maximum* (7.8%) among grassy while *Caesulia axillaris* (5.2%) and *Eclipta alba* (2.8%) in BLWs and *Fimbristyllis miliaceae* (8.2%) and *Cyperus difformis* (5.2%) in sedges. Different weed control treatments affected the species wise as well as total weed density significantly. When the bispyribac 25 g/ha was applied as superimposed for follow up as post emergence at 25 DAS after the pre-emergence application of oxadiargyl or early post emergence of pendimethalin being at par recorded significantly less number of weeds in almost all the grassy as well as non grassy as compared to bispyribac alone. Combination of two herbicides or along with manual weeding (MW) recorded significantly lower values of weed dry weight and higher values of WCE. A combination of pendimethlin *fb* bispyribac being at par with pendimethalin + bispyribac + MW recorded significantly less weed dry weight (13.6 g/m^2) and highest value of WCE (95.6%) followed by oxadiargyl *fb* bispyribac) and bispyribac + Almix, respectively. All the weed control treatments significantly yielded higher than the weedy check. Among the herbicidal treatments, the combined application of pendimethalin 1000 g/ha applied as pre-emergence followed by bispyribac-Na 25 g/ha + one hand weeding at 45 DAS recorded the maximum grain and straw yield, which was at par with application of pendimethalin *fb* bispyribac-Na (1000 + 25 g/ha) and oxadiargyl *fb* bispyribac-Na (100g *fb* 25 g/ha). Pendimethalin 1000 g/ha as PE *fb* bispyribac –Na 25 g/ha as POE *fb* manual weeding (45 DAS) recorded highest gross returns (₹ 57850.0/ha), net returns and benefit : cost ratio (₹ 1.69) followed by pendimethalin 1000 g/ha as PE *fb* bispyribac 25 g/ha POE treatments.

RAU, Pusa

Weed flora found in the experimental field were: grasses: *Echinocloa crus-galli, E. colona, Digitaria sanguinalis, Dactyloctenium aegyptium, Cynodon dactylon;* sedges: *Cyperus rotundus, Cyperus difformis, Fimbristylis miliaceae;* broad leaved weeds : *Caesulia axillaris, Lippia nodiflora, Ammonia baccifera, Eclipta alba, Phyllanthus niruri.* The lowest weed count and weed dry weight were recorded under three mechanical weedings (cono/ rotary weeder) which was statistically at par with weed free and pendimethalin *fb* bispyribac *fb* manual weeding which were significantly superior over rest of the treatments. However, weed free was significantly superior to pendimethalin *fb* bispyribac *fb* manual weeding with respect to weed count. The highest grain yield of rice (3.96 t/ha) was recorded under treatment three mechanical weedings (cono/rotary weeder) which was statistically at par with weed-free and pendimethalin *fb* bispyribac *fb* manual weeding and which were significantly superior over rest of the treatments (Table 3.2.7).

Table 3.2.7: Herbicides combinations for control of complex weed flora in direct seeded rice under wet-condition at Pusa

Treatment	Weed population at 60 DAS (no./m²)	Weed dry weight at 60 DAS (g/m²)	Grain yield (t/ha)	WCE (%)
Bispyribac 25g/ha (20 DAS)	16.0	36.0	3.04	45.0
Pendimethalin *fb* bispyribac 1000 *fb* 25g/ha (0-2 *fb* 25 DAS)	10.2	21.7	3.15	66.9
Oxadiargyl *fb* bispyribac 100 *fb* 25g(0-2 fb25 DAS)	15.4	32.3	2.79	50.6
Pyrazosulfum *fb* bispyribac 20 *fb* 25g/ha (0-3 *fb* 25 DAS)	9.6	19.5	3.30	70.1
Pendimethalin *fb* bispyribac *fb* manual weeding 1000 *fb* 25g/ha (0-2 *fb* 20 DAS *fb* 45 DAS)	4.9	11.9	3.71	81.8
Pendimethalin *fb* manual weeding1000g/ha (0-2 *fb* 25-30 DAS)	7.9	17.8	3.33	72.8
Bispyribac + (chlorimuron + metsulfuron-methyl) 20+ 4g/ha (20 DAS)	13.1	30.6	3.04	53.2
Three mechanical weedings	3.9	8.6	3.96	86.8
Weed free	4.2	9.5	3.95	85.5
Weedy check	33.2	65.6	2.27	-
SEm±	0.19	1.15	0.11	
LSD (P=0.05)	0.58	3.43	0.33	-

WS 3.3: Weed management in turmeric

Turmeric is an important spice crop. Due to wide spacing of planting and long duration of the crop, weeds pose a big problem in turmeric particularly during initial phase of growth during *kharif* season. Diverse weed flora infest the turmeric crop which are hard to be controlled with a single herbicide. Weed control part is still lacking in turmeric. There is need for combination of different herbicides with cultural practices for management of different type of weeds in turmeric. Hence, this experiment was planned to study the bio-efficacy of different herbicides against weeds and their effect on growth and yield of turmeric. Salient findings recorded at different centres are presented below:

CCSHAU, Hisar

The weed flora of the field consisted of *Cynodon dactylon, Dactyloctenium aegyptium, Brachiaria reptans, Leptochloa chinensis, Eragrostis tenella* among grasses; *Ammania baccifera, Euphorbia hirta, Phyllanthus niruri* among broadleaf weeds (BLW); and *Cyperus rotundus* among sedges. All the treatments except the treatments with fenoxaprop + metsulfuron provided effective control of all type of weeds in turmeric. The treatments with straw mulch were found most effective against all type of weeds including *Cynodon dactylon* and *Cyperus rotundus*. The treatments with straw mulch + hand weeding resulted in maximum number of surviving plants/ha, plant height and number of tillers/plant (Table 3.3.1). The next best treatments were metribuzin or pendimethalin or atrazine *fb* two hoeing. The fenoxaprop + metsulfuron resulted in marked effects on all the above growth parameters. Based on the data received so far, metribuzin 700 g/ha or pendimethalin 1000 g/ha or atrazine 750 g/ha *fb* mulching + hand weeding at 50 DAS were realized to be the best options for effective weed control in turmeric with improved crop growth.

Table 3.3.1: Effect of different treatments on weed growth and tillers of turmeric at Karnal during *kharif* 2013

Treatment	Dose (g/ha)	Time (DAS)	Dry weight of weeds (g/m²)			Tillers/ plant
			Grass weeds	Sedges	BLW	
Metribuzin *fb* hoeing *fb* hoeing	700	0-3/40/70	0.0	2.9	3.9	4.07
Metribuzin *fb* fenoxaprop+ metsulfuron	700 *fb* 67+4	0-3/2-4LS	8.6	10.4	2.1	3.67
Metribuzin *fb* mulching + hand weeding	700	0-3/50	0.0	0.0	0.0	5.33
Pendimethalin *fb* hoeing *fb* hoeing	1000	0-3/40/70	0.0	2.7	4.3	4.07
Pendimethalin *fb* fenoxaprop+ metsulfuron	1000 *fb* 67+4	0-3/2-4LS	11.3	9.5	2.1	3.40
Pendimethalin *fb* mulching + hand weeding	1000	0-3/50	0.0	0.0	0.0	4.80
Atrazine *fb* fenoxaprop+ metsulfuron	750 *fb* 67+4	0-3/2-4LS	14.6	8.6	2.3	3.60
Atrazine *fb* mulching + hand weeding	750	0-3/50	0.0	0.0	0.0	5.07
Weed free			0.0	0.0	0.0	4.53
Weedy check			81.8	3.8	4.6	3.80
SEm±			4.0	0.7	0.4	0.25
LSD (P=0.05)			11.8	2.2	1.2	0.75

PAU, Ludhiana

Cyperus rotundus, Dactyloctenum aegyptium, Digitaria ciliaris, Eleusine indica and Commelina benghalensis were the major weeds. The sequential application of pendimethalin 1.0 kg, metribuzin 0.7 kg and atrazine 0.75 kg/ha as pre-em immediately followed by paddy straw mulch 10 t/ha *fb* one hand weeding kept majority of the grass weeds under check; *C. rotundus* and a few *Commelina* and *Dactyloctenium* plants emerged out of the straw mulch which were uprooted by hand weeding/pulling (Table 3.3.2). The sequential combination of any of the three pre-herbicides, paddy straw much and hand weeding recorded the highest turmeric rhizome yield, net return and B:C ratio and were significantly better than the weed free check, weedy check and other weed control treatments.

Table 3.3.2: Effect of weed control treatments on weed growth and rhizome yield of turmeric during 2013 at Ludhiana

Treatment	Dose (g/ha)	Weed dry matter (g/m²)		Fresh rhizome yield (t/ha)	Net returns (x10³ ₹/ha)	B:C ratio
		Grasses	Sedges			
Metribuzin *fb* 2 hoeings at 30 and 60 days	70	2.5 (7)	6.6 (43)	5.08	0.76	1.01
Metribuzin *fb* fenoxaprop (with safener) + metsulfuron at 45-60d	70 & 67 + 4	13.4 (208)	12.6 (160)	4.64	0.79	1.01
Metribuzin *fb* PSM 9 t/ha *fb* one HW	70	15.5 (276)	8.4 (76)	19.65	162.85	3.99
Pendimethalin *fb* 2 hoeings at 30 and 60days	1000	1.8 (3)	8.0 (64)	9.11	44.78	1.80
Pendimethalin *fb* fenoxaprop (with safener) + metsulfuron at 45-60d	1000 & 67 + 4	6.0 (41)	14.7 (216)	5.21	6.60	1.13
Pendimethalin + PSM 9 t/ha *fb* one HW	1000	7.4 (55)	13.4 (178)	23.95	209.87	4.82
Atrazine *fb* fenoxaprop (with safener) + metsulfuron at 45-60 days	750 & 67 + 4	10.9 (156)	12.0 (175)	3.77	-9.38	0.81
Atrazine + PSM 9 t/ha *fb* one HW	750	15.5 (267)	8.4 (71)	19.43	159.76	3.90
Weed free check	-	1.0 (0)	7.8 (65)	6.29	-2.57	0.96
Weedy check	-	19.3 (388)	9.0 (80)	1.90	-27.39	0.43
SEm±	-	2.9	1.6	1.18		
LSD (P=0.05)	-	8.7	4.8	3.51		

BAU, Ranchi

The major weed flora found in experimental plot among grasses were: *Digitaria sanguinalis, Cynadon dactylon, Paspalam distichum, Dectyloctanium aegiptium, and Commelina nudifolia* broad leaved weeds were: *Ageratum conyzoides, Stellaria media, Heliotropium esculentum, Sphyllanthus acmella, Ludvigia parviflora* and *Tridex procumbens*. At 60 DAS, hand weeding at 25 and 45 DAS recorded reduced weed density of grassy and sedges weeds which was similar to metribuzin 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* One HW at 30 DAS., pendimethalin 1.0 kg/ha *fb* two hoeings, pendimethalin 1.0 kg/ha *fb* straw mulch 10 t/ha *fb* one hand weeding. Application of metribuzin 0.7 kg/ha *fb* by two hoeing recorded significantly reduced weed dry matter accumulation similar to hand weeding at 30 DAS. While at 60 DAS, these were also on par with application of metribuzin 0.7 kg/ha *fb*. straw mulch 10 t/ha *fb* one HW. The pooled data of two year revealed that hand weeding at 25 and 45 DAS recorded reduced weed dry matter accumulation as compared to rest of the treatments and was similar to application of pendimethalin 1.0 kg/ha *fb* two hoeings.

VNMKV, Parbhani

Among broad-leaved weeds *Digera arvensis, Parthenium hysterophorus, Euphorbia geniculata and Acalypha indica* were found to be dominant species. The dominant grassy weeds were *Cynodon dactylon, Bracheria eruciformis* and *Commelina bengalensis* during both the seasons. The lowest weed population of grassy weed was recorded with treatment metribuzin 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW at 30 DAS during both the year of experiment and weed free, whereas broadleaved weed population was lowest in weed free. At 60 DAS the lowest dry weed weight was recorded in treatment pendimethalin PE 0.7 kg/ha *fb* fenoxaprop @ 67 g /ha + metsulfuron 4 g/ha followed by weed free, atrazine 0.75 kg/ha PE *fb* Fenoxaprop @ 67 g /ha + metsulfuron 4 g/ha than rest of the treatments (Table 3.3.3). The turmeric yield was significantly influenced due to various weed control treatments during both the years. Highest rhizome yield, finger number, finger weight and rhizome weight was recorded with metribuzion 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW, which was on par with metribuzion 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW, pendimethalin PE 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW and atrazine 0.75 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW and significantly superior to rest of the treatments. Significantly highest net monetary returns and B:C ratio was recorded in treatment of metribuzin 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW as compared to all other weed control treatments except treatments of weed free, metribuzin 0.7 kg/ha PE *fb* two hoeings, pendimethalin PE 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW and atrazine 0.75 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW.

Table 3.3.3 Weed growth, productivity and economics of turmeric as influenced by different treatments during 2012

Treatments	Weed dry mater at 60 DAS (g/m²)	Rhizome yield (t/ha)	Net monetary returns (x10³ ₹/ha)	B:C ratio
Metribuzin 0.7 kg/ha PE *fb* two hoeings	14.1	10.16	120.64	1.46
Metribuzin 0.7 kg/ha PE *fb* fenoxaprop @ 67 g /ha + metsulfuron 4 g/ha	18.6	8.11	80.96	0.99
Metribuzin 0.7 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW	18.2	12.16	144.63	1.47
Pendimethalin PE 0.7 kg/ha *fb* two hoeings	24.8	9.75	111.76	1.34
Pendimethalin PE 0.7 kg/ha *fb* fenoxaprop @ 67 g /ha + metsulfuron 4 g/ha	26.4	8.06	78.85	0.95
Pendimethalin PE 0.7 kg/ha *fb* straw mulch 10 t/ha *fb* one HW	20.8	10.28	105.88	1.06
Atrazine 0.75 kg/ha PE *fb* fenoxaprop @ 67 g /ha + metsulfuron 4 g/ha	14.3	7.66	71.56	0.87
Atrazine 0.75 kg/ha PE *fb* straw mulch 10 t/ha *fb* one HW	14.6	9.74	97.88	0.96
Weed free	11.2	10.94	118.45	1.18
Weedy check	25.1	3.02	-19.10	-0.24
SEm±	1.95	0.94	18.14	0.21
LSD (P=0.05)	5.80	2.79	53.81	0.63

TNAU, Coimbatore

Weed flora of the experimental field predominantly consisted of six grass species, seven species of broad leaved weeds and a sedge weed. The grass weeds present in the experimental field were *Echinochloa colonum, Digitaria bicornis, Panicum repens*. *Cyperus rotundus* was only sedge and *Amaranthus viridis, Boerhaavia diffusa, Parthenium hysterophorus, Phyllanthus niruri, Eclipta prostrata* were the broad leaved weeds. Pre-emergence application of metribuzin at 0.7 kg/ ha + two hand weeding on 45 and 75 DAP was recorded lower total weed density, dry weight and higher weed control efficiency. The higher plant height and dry matter production was observed in PE application of metribuzin at 0.7 kg/ ha + two hand weedings.

NDUAT, Faizabad

Weed flora consisted of *Echinochloa* sp., *Dactyloctenium aegyptium, Elusine indica and Poa annua* among grasses, *Ludvigia crustacae, Commelina benghalensis, Ammania beccifera, Ageratum conyzoides and Solanum nigrum* among broad leaf weeds and *Cyperus rotundus and Fimbristylis* among sedges. At 60 DAP, all the treatments, except in treatments with fenoxaprop + metsulfuron provided very good control of all type of weeds in turmeric (Table 3.3.4). However, the treatments with fenoxaprop + metsulfuron also provided effective control of weeds but it showed the phytotoxicity on the crop. Metribuzin 700 g with rice straw mulch 10 t/ha *fb* one hand weeding being at par with pendimethalin 1000 g with straw much 10t/ha *fb* one hand weeding recorded significantly higher values of plant height, plant dry weight, weight of rhizomes per plant as well as fresh rhizome yield as compared to atrazine 750 g along with straw mulch *fb* hand weeding treatment. However, metribuzin and pendimethalin supplemented with hoeing twice being at par recorded significantly lower values of all the growth and yield attributes as well as fresh yield of the rhizomes as compared to all the three treatments of metribuzin, pendimethalin and atrazine as supplemented with straw mulch *fb* one hand weeding. Application of metribuzin 700 g *fb* straw mulch 10 t/ha *fb* one hand weeding treatment achieved the substantially higher values of net returns and B:C ratio, followed by pendimethalin 1000 g and atrazine 750 g/ha supplemented with straw mulch 10 t/ha followed by one hand weeding and B: C ratio.

Table 3.3.4: Effect of weed control treatments on weed growth, yield and economics of turmeric at Faizabad

Treatments	Total weeds at 120 DAP (no./m²)	Total dry weight at 120 DAP (g/m²)	Fresh Rhizomes yield (t/ha)	Curcumin (%)	Net return (x10³ ₹/ha)	B : C ratio
Metribuzin at 700 g/ha *fb* 2 HW	6.8 (45.7)	12.0 (143.8)	26.8	7.3	312.26	3.48
Metribuzin at 700 g/ha *fb* fenoxaprop at 67 g/ha + MSM at 4.0 g/ha	8.3 (67.7)	13.6 (184)	18.1	7.1	184.08	2.08
Metribuzin at 700 g/ha *fb* SM at 10 t/ha *fb* 1HW	4.9 (23.4)	10.5 (109.8)	35.6	7.7	423.96	3.85
Pendimethalin at 1000 g/ha *fb* 2 HW	6.5 (42.5)	11.4 (130.4)	27.9	7.5	328.16	3.63
Pendimethalin at 1000g ha⁻¹ *fb* fenaxaprop at 67 g ha⁻¹ + MSM at 4.0 g/ha	8.1 (63.4)	13.0 (168.8)	20.8	7.3	253.88	2.80
Pendimethalin at 1000 g ha *fb* SM at 10 t/ha *fb* 1 HW	5.3 (27.9)	10.6 (112.8)	33.7	8.0	395.61	3.57
Atrazine at 750 g/ha *fb* fenaxaprop at 67 g/ha + MSM at 4.0 g/ha	8.0 (63.3)	13.6 (185.3)	21.3	7.0	235.36	2.67
Atrazine at 750 g/ha *fb* SM at 10 t/ha *fb* 1 HW	5.9 (34.0)	10.9 (118.9)	32.5	7.5	377.09	3.40
Weed free	9.2 (85.7)	12.3 (150)	28.6	7.4	351.16	3.78
Weedy check	11.9 (141.7)	26.8 (720)	11.2	6.9	81.16	0.93
SEm±	0.4	0.2	1.0	-	-	-
LSD (P=0.05)	1.2	0.5	3.0	-	-	-

Fb: Followed by, H: Hoeing. SM= rice straw mulch, HW: Hand weeding, MSM: Metsulfuron-methyl, WCE: Weed control efficiency, DAP: Days after planting

WS 3.4: Weed management in blackgram / greengram and its residual effect on succeeding mustard

Greengram is the important crop in low rainfall rainfed areas. Weed emergence begins almost with the crop emergence leading to crop-weed competition from initial stages. The magnitude of loss as a result of crop-weed competition depends upon type of weed species, associated with crop, their densities and duration of competition with crops.

Crop type and soil properties have greatest influence on the occurrence of weed species. The type of irrigation, cropping pattern, weed control measures and environmental factors had a significant influence on the intensity and infestation of weeds. An experiment was conducted to study the bioefficacy of different herbicides against weeds and their effect on growth and yield of blackgram / greengram, and residual effect of herbicides applied in blackgram/ greengram on succeeding mustard crop. Salient research achievements at different centres are presented below:

RVSKVV, Gwalior

The major weed flora of the experimental field consisted of sedges *Cyperus rotundus* grasses *Echinochloa crus-galli, Commelina benghalensis, Eragrasstis tenella, Digitaria sanguinalis* and *Digera arvensis* and *Phylanthus niruri* but *Eragasstis tenella* and *Digitaria sanguinalis* were not recorded during second year. All the weed species were effectively controlled by pre mix herbicides i.e. imazethapyr + imazamox and pendimethalin + imazethapyr as compared to alone application of pendimethalin as PE and imazethapyr as PoE. Application of imazethapyr @ 70 g/ha as PoE recorded highest seed yield (643 kg/ha) followed by pendimethalin @ 1.0 kg/ha as PE (537 kg/ha) and imazethapyr @ 50 g/ha (527 kg/ha). Hand weeding twice recorded highest grain yield of 893 and 895 kg/ha in the consecutive years on account of respected removal of weeds followed by pre mix herbicide imazethapyr + imazemox @ 50 g/ha as PoE (833 and 841 kg/ha). Among the weed control treatments highest net return and BCR was obtained with 2 hand weeding followed by pre-mix herbicides i.e. imazethapyr + imazamox @ 50 g/ha as PoE and pendimethalin + imazethapyr @ 1000 g/ha as PE application.

CCSHAU, Hisar

Weed flora of the field was dominated by *Trianthema portulacastrum* constituting 99% of total weed flora. Other weeds present in experimental field were *Cyperus rotundus* and *Convolvulus arvensis*. All pre-emergence herbicides treatments proved very effective against predominant weed *T. portulacastrum* and population of this weed in these treatments was at par with weed free check. None of the treatment proved effective against *C. rotundus and C. arvensis*. Post-emergence application of imazethapyr at 50-70g/ha and imazethapyr + imazamox (RM) at 60, 70 and 80 g/ha proved less effective in minimizing density and dry weight of weeds. Although pre-emergence application of pendimethalin proved very effective and gave 90% control of weeds up to 15 DAS but per cent control decreased with time and it remained 70% up to 45 DAS. Seed yield was maximum (1584 kg/ha) in weed free treatment which was significantly higher than all treatments except two hoeing at 20 and 40 DAS. In herbicidal treatments maximum grain yield (1500 kg/ha) was obtained with premergence use of pendimethalin + imazethapyr which was at par with its lower dose of 900 g/ha but higher than all post emergence treatments. All herbicide treatments except imazethapyr at 70 g/ha and its ready-mix combination with imazamox did not cause any phytotoxic effect on mustard. Mustard crop in these treatments showed only 5% toxicity up to 15 DAS due to residues of these herbicides applied in green gram which mitigated within one month after planting.

Effect of pendimethalin + imazethapyr (RM) in greengram at 30 DAS

PAU, Ludhiana

Major weeds in the experimental field included *Dactyloctenum aegyptiacum, Commelina benghalensis, Digitaria sp and Acrachne racemose*. All the post-emergecne herbicides treatments provided effective control of all the grass weeds and created weed free conditions till first 40 days of sowing. Imazethapyr at its both levels and imazethapyr+ imazamox were relatively poor on *Acrachne* and *Commelina* as compared to imazethayr + pendimethalin. Pendimethalin was effective against *Dactyloctenum, Acrachne* and *Digitaria* till first 40 days; higher pressure of *Commelina benghalensis* in pendimethalin treated plots increased weed dry matter which reduced the greengram seed yield significantly as compared to the post emergence herbicides treatments. All the post-emergence herbicides treatments recorded significantly higher greengram seed yield as compared to weedy check and were at par to weed free treatment. Imazethapyr+ pendiemthalin at 1000 g/ha recorded the highest net returns and B:C ratio; net returns and B:C ratio in all the other weed cotnrol treatments were lower than weed free check. All the herbicides were safe to the crop. All the weed control treatments used in greengram did not show any residual effects on the germination, growth and yield of succeeding raya (*Brassica juncea*) crop, indicating that all these herbicides could be adopted for weed control in greengram in raya based cropping sequences. Hence, post-emergence application of imazethapyr alone or its pre-mix with pendimethalin/imazmox can be adopted for effective control of weeds in greengram.

SKRAU, Bikaner

The major weed flora consisted of *Digera arvensis, Gisekia pharnaceoides, Corchorus tridense, Cenchrus biflorus, Eragristis pilosa* and *Eragristis tennela*. Imazethapyr+ pendimethalin (pre-mix) at 800 g/ha as pre-emergence provided effective control of both grassy and broad leaved weeds and created weed free conditions throughout the growing season and recorded significantly higher yield attributes and yield of greengram, which were statistically at par with its higher doses. Imazethapyr alone at 50 g/ha applied at 3-4 leaf stage significantly reduced the density and dry weight of broad leaf weeds as compared to weedy check and pendimethalin 1000 g/ha as pre emergence while imazethapyr + imazamox at 60 g/ha significantly controlled both grassy and broad leaved weeds (Table 3.4.1). Application of imazethapyr + imazamox at 60 g/ha and imazethapyr alone at 50 g/ha significantly increased the yield attributes and seed yield of greengram compared to weedy check but statistically at par with pendimethalin at 1000 g/ha. Higher net returns and B:C ratio was also obtained in imazethapyr+ pendimethalin (pre-mix) at 800 g/ha as pre-emergence followed by weed free and imazethapyr+imazamox at 60 g/ha at 2-3 leaf stage.

Table 3.4.1: Effect of different weed control treatments on weed growth, yield and economics of greengram during *kharif*, 2013 at Bikaner

Treatment	Dose (g/ha)	Total weed count (no./m²)	Weed dry weight (g/m²)	Yield (t/ha)		Net returns (x10³ ₹/ha)	B:C ratio
				Seed	Straw		
Pendimethalin	1000	5.3 (27.9)	31.0	0.74	1.39	19.50	2.17
Imazethapyr	50	4.4 (19.1)	24.6	0.75	1.42	20.63	2.27
Imazethapyr	70	3.0 (8.0)	3.87	0.74	1.41	19.78	2.19
Imazethapyr + pendimethalin (Pre-mix)	800	1.3 (0.7)	0.33	0.85	1.56	24.55	2.43
Imazethapyr + pendimethalin (Pre-mix)	900	1.4 (0.9)	0.02	0.82	1.46	22.76	2.31
Imazethapyr + pendimethalin (Pre-mix)	1000	1.2 (0.5)	2.23	0.81	1.48	22.12	2.26
Imazethapyr + imazamox (Pre-mix)	60	2.2 (3.9)	9.40	0.75	1.43	21.05	2.34
Imazethapyr + imazamox (Pre-mix)	70	1.6 (1.7)	0.90	0.73	1.40	19.91	2.26
Weed free	-	1.0 (0)	0.0 (0)	0.86	1.50	24.12	2.36
Weedy check	-	7.9 (61.5)	49.07	0.62	1.18	15.60	2.05
SEm±		0.23	3.34	0.012	0.018		
LSD (P=0.05)		0.68	10.01	0.035	0.055		

CSKHPKV, Palampur

Major weeds of the experimental field were: *Cyperus rotundus, Dactyloctenum aegyptium, Echinochloa colona, Commelina benghalensis, Digitaria sanguinalis, Eleusine indica* and *Setaria spp*. All the weed control treatments recorded significantly lower total weed count and total weed dry weight as compared to unweeded check. At 40 days after sowing, the minimum weed count and dry weight was recorded with application of imazethapyr+ pendimethalin (pre-mix) @ 800g/ha which was significantly similar to pendimethalin @1000 g/ha and imazethapyr+ pendimethalin (pre-mix) @ 900 g/ha. Weeds in unweeded check reduced the seed yield of blackgram by 70.6% over the best treatment i.e. imazethapyr + pendimethalin (Pre-mix) 900 g/ha (Table 3.4.2). However, imazethapyr + pendimethalin (pre-mix) 1000 g/ha and 800 g/ha pendemethlin 1000 g/ha and imazethapyr 50 and 70 g/ha(pre emergence) behaving statistically similar with pendimethalin 1000 g/ha (pre-emergence) and weed free resulted in significantly higher seed yield of blackgram over weedy check treatments by effective control of weeds. The residual effects of herbicide treatments on succeeding mustard crop were being studied during this *rabi* season and no phytotoxic effects of herbicides were observed on mustard crop till 60 days after sowing.

Table 3.4.2: Effect of different treatments on weed growth and yield of blackgram at Palampur

Treatment	Dose (g/ha)	Time (DAS)	Total weed count at 40 DAS (No/m²)	Total weed dry weight at 40 DAS (g/m²	Seed yield (t/ha)
			6.0	11.6	1.25
Imazethapyr	50	20 DAS (3-4 leaf stage)	8.3	11.0	1.21
Imazethapyr	70	20 DAS (3-4 leaf stage)	9.7	13.0	1.13
Imazethapyr + pendimethalin (Pre-mix)	800	Pre-emergence	3.3	8.9	1.16
Imazethapyr + pendimethalin (Pre-mix)	900	Pre-emergence	5.0	3.0	1.32
Imazethapyr + pendimethalin (Pre-mix)	1000	Pre-emergence	12.0	7.6	1.29
Imazethapyr + imazamox(Pre-mix)	40	20 DAS (3-4 leaf stage)	24.3	15.0	1.20
Imazethapyr + imazamox(Pre-mix)	50	20 DAS (3-4 leaf stage)	31.7	14.2	1.18
Weed free (2HW)	20 & 40 DAS	-	4.0	3.1	1.33
Weedy check	-	-	42.0	23.8	0.38
SEm±			0.94	1.9	0.08
LSD (P=0.05)			2.8	5.6	0.26

Values given in the parentheses are the original means

AAU, Anand

Major monocot weeds were: *Eragrostis major, Eleusine indica, Digitaria sanguinalis, Cyperus rotundus, Cyperus iria* and *Cynodon dactylon*. The dicot weeds were: *Euphorbia hirta, Amaranthus spinosus* and *Phyllanthus niruri* in blackgram. Weed dry matter recorded at 40 DAS and at harvest were significantly influenced by weed management practices. Significantly the lowest weed dry matter was recorded at 40 DAS and at harvest in hand weeding carried out at 20 and 40 DAS treatment. Among herbicides, significantly lower weed dry matter was recorded in application of imazethapyr + pendimethalin @ 1000 g/ha as PE at 40 DAS which was at par with pre emergence application of pendimethalin @ 1000 g/ha and application of imazethapyr + pendimethalin @ 800 and 900 g/ha. Seed and haulm yield of blackgram recorded at harvest showed significantly higher in hand weeding carried out at 20 and 40 DAS treatment which was at par with pre emergence application of pendimethalin @ 1000 g/ha, pre emergence application of imazethapyr + pendimethalin @ 800, 900 and 1000 g/ha and post emergence application of imazethapyr @ 50 g/ha (Table 3.4.3).

In succeeding crop, seed and straw yield of mustard recorded at harvest showed non-significant effect of different weed management practices of blackgram on succeeding mustard crop. There was no any carry over /residual phytotoxic effect observed on succeeding mustard crop.

Table 3.4.3: Effect of weed management treatments on weed growth and yield of blackgram-mustard cropping system at Anand

Treatment (g/ha)	Blackgram			Mustard	
	Dry matter of weeds at 40 DAS (g/m²)	Seed yield (t/ha)	Haulm yield (t/ha)	Seed yield (t/ha)	Straw yield (t/ha)
Pendimethalin @ 1000 as PE	13.5	1.57	2.71	1.16	5.13
Imazethapyr @ 50 at 20 DAS (3-4 leaf stage)	31.5	1.45	2.69	1.10	5.55
Imazethapyr @70 at 20 DAS (3-4 leaf stage)	26.7	1.19	2.38	1.19	5.48
Imazethapyr + pendimethalin @ 800 as PE	19.0	1.41	2.44	1.13	5.97
Imazethapyr + pendimethalin @ 900 as PE	16.5	1.50	2.51	1.11	5.34
Imazethapyr + pendimethalin @ 1000 as PE	12.5	1.58	2.69	1.12	5.10
Imazethapyr + imazamox @ 60 at 20 DAS (3-4 leaf stage)	24.2	1.19	2.29	1.09	5.41
Imazethapyr + imazamox @ 70 at 20 DAS (3-4 leaf stage)	20.5	1.19	1.91	1.14	5.31
HW at 20 and 40 DAS	3.8	1.58	2.73	1.20	5.09
Weedy check	112.2	0.91	1.33	1.11	5.27
SEm ±	2.28	0.101	0.101	0.025	0.197
LSD (P=0.05)	6.63	0.294	0.293	NS	NS
CV (%)	16.3	14.8	8.5	4.4	7.4

VB, Sriniketan

The pre-dominant weed species were: *Melochia corchorifolia, Ludwigia parviflora, Murdania nudiflora* and *Lindernia ciliata* during both the years. Regarding the suppression of grassy weed pre-emergence application of pendimethalin and post emergence application imazethapyr and pre-mix of imazethapyr + imazamox with their two different doses were found most effective which kept the field free from grassy weeds. Pre-emergence application of imazethapyr + pendimethalin (pre-mix) was found comparatively less effective in controlling grassy weeds. Pre-emergence application of imazethapyr + pendimethalin (pre-mix) at 1000 g/ha recorded the highest seed yield of blackgram during both the years. Pre-emergence application of pendimethalin at 1000 g/ha and weed free check produced more seed yield which were closely followed by the best treatment. Due to phyto-toxicity effect of imazethapyr and imazethapyr + imazamox (pre-mix) the seed yield was very low as compared to other herbicidal treatments. Post-emergence application of imazethapyr alone and pre-mix of imazethapyr + imazamox with different doses showed phyto toxicity on crop. Pre-emergence application of imazethapyr + pendimethalin (pre-mix) at 1000 g/ha gave the highest net returns and wider

Table 3.4.4: Residual effect of treatments on mustard and direct effect on blackgram at Sriniketan

Treatment	Dose (g/ha)	Seed yield of mustard (t/ha)	Total weed dry weight (g/m²)	Seed yield of blackgram (t/ha)
Pendimethalin	1000	1.06	39.3	0.82
Imazethapyr	50	1.21	52.3	0.67
Imezathapyr	70	1.16	43.3	0.73
Imezathapyr +pendimethalin	800	1.23	40.5	0.82
Imezathapyr + pendimethalin	900	1.23	36.5	1.08
Imezathapyr + pendimethalin	1000	1.20	32.4	1.09
Imezathapyr + imazamox	60	1.19	46.6	0.80
Imezathapyr + imazamox	70	1.28	36.3	0.90
Hand weeding (twice)	20 and 40	1.30	20.9	1.24
Weedy	-	1.12	87.4	0.44
SEm±	-	0.082	2.16	0.046
LSD (P=0.05)	-	NS	6.40	0.135

B:C ratio. The lower doses of the same herbicides mixtures also registered higher net returns and B: C ratios (Table 3.4.4).

It was observed that all the herbicides / herbicides mixture had some residual effect on mixed weed flora in succeeding mustard. The persistence of imazethapyr, imazethapyr + pendimethalin and imazethapyr + imazamox in the soil was present long time. The germination and emergence of mustard seed occurred but after a few days the seedlings became yellowish and died in imazethapyr, imazethapyr + pendimethalin and imazethapyr + imazamox treated plots. Ultimately, there was no crop stand in the plots under above-mentioned treatments.

SVBPUAT, Meerut

The major weeds were: *Trianthema portulacastrum, Parthenium hysterophorus, Digera arvensis, Echinochloa colona, Commelina benghalensis* and *cyperus spp*. All the weed control treatments were found superior than weedy check. Among the weed control treatments the lowest weed density was recorded in treatment weed free (two hand weeding at 20 and 40 DAS) followed by application of Odissey @ 70 g a.i/ha and Valor @ 1000 g a.i/ha. Similar results were also obtained in weed dry weight. The maximum weed control efficiency (93.0%) was recorded in treatment weed free (two hand weeding at 20 and 40 DAS) followed by Odissey @ 70 g a.i/ha and Valor @ 900 & 1000 g a.i/ha. respectively. As far as grain yield is concerned, all the weed control treatments maintained their superiority over weed check. The highest grain yield was recorded in weed free, closely followed by the application of Valor @ 900 g/ha and Valor @ 800 g/ha and pre-emergence and imazethapyr @ 70 g/ha. Residual effect on following mustard showed that the reatment weed-free gave higher yield than rest of the treatments except treatment pendimethilin @ 1 kg a.i/ha, imazethapyr @ 60 g a.i/ha and Valor @ 800 g a.i/ha.

WS 3.5: Long-term trial on tillage in different cropping systems

A long-term experiment on the effect of tillage and weed control measures was initiated in 2002-03 to monitor weed dynamics, crop productivity, herbicide residues, and to study C-sequestration, changes in physico-chemical and biological properties of soil health under rice-based and non-rice-based cropping systems. Eight treatments consisting of five establishment methods, viz. T_1 - zero tillage - zero tillage (ZT-ZT), T_2 - zero tillage- conventional tillage (ZT-CT), T_3 - conventional tillage - zero tillage (CT-ZT), T_4 - conventional tillage - conventional tillage (CT-CT) as main plots; and three weed control measures, *viz.* W_1 - HW on 25 and 45 DAS, W_2 – recommended herbicide, W_3 - weedy check (control) in subplot was laid out in split-plot design with three replications. The experiment was conducted at Faizabad, Coimbatore, Bengaluru, Dharwad, Anand, and Ranchi centres during 2012-13.

Rice-wheat cropping system (Ranchi, Kanpur and Faizabad)

The major weed flora observed in experimental plot in wheat at 60 DAS and at harvest stage were *Phalaris minor (45.3%), Chenopodium album (10.8%), Anagallis arvensis (13.8%),* and *Melilotus alba(17.8%) at* Faizabad and Kanpur. Density of *P. minor, Melilotus alba, Medicago denticulata, Chenopodium album* and *Rumex* sp. was much lower in ZT- wheat as compared to that of conventional tillage at Faizabad. While in rice, at 60 DAS *Echinochloa crus-galli, E. colona, Dactyloctenium aegyptium* among grasses, *Cyperus* sp. and *Fimbristyllis miliaceae* among sedges, and *Caesulia axillaris, Eclipta alba, Lindernia* spp among broad-leaved weeds were dominant at all the coordinating centres.

Rice: The tillage methods did not show any definite trend on weed population and weed dry biomass across the coordinating centres. ZT-ZT method of tillage provided significantly higher total weed density and weed dry matter accumulation as compared to continuous CT-CT method at Faizabad and Kanpur centres. Significantly lowest weed dry matter accumulation was recorded with CT-CT method of tillage at Faizabad and CT-ZT method at Kanpur. Amongst the weed control treatments, application of recommended herbicides in rice recorded significantly reduced density and dry weight of all categories of weeds at Ranchi.However, significantly lowest total weed density and weed dry weight was recorded under 2 hand weeding given at 25 and 45 DAS over herbicide treated plot and unweeded check at Faizabad and Kanpur.

There were vast differences across the coordinating centres in respect to grain yield of rice. Continuous conventional tillage in both *kharif* and *rabi* season recorded significantly higher grain yield over continuous zero tillage at Faizabad and Kanpur. While at Ranchi, the different tillage combinations did not influence the grain yield of rice, but ZT-CT method of tillage recorded higher grain yield of rice. In case of weed control treatments, 2 hand weeding at 25 and 45 DAS during both the seasons being at par with recommended herbicide provided highest grain yield of rice over weedy check at all the cooperating centres. There was more than 50 per cent increase in grain yield over weedy check.

Wheat: Lowest density and dry biomass of *Phalaris minor* was recorded under continuous ZT-ZT tillage system. Whereas, lowest density of *Chenopodium album, Anagallis arvensis, Melilotus alba, Rumex* spp and *Carthamus didymus* were observed in conventional-conventional tillage at 60 DAS and harvest of the crop at Faizabad and Kanpur centres. Different tillage systems did not influence the total density and dry weight of weeds. But reduced dry biomass of weeds was recorded with continuous zero tillage during both the seasons. Among the weed control practices, the weeds of all category were absolutely controlled by hand weeding (twice) followed by sulfosulfuron (25g a.i./ha) as compared to weedy check at Kanpur. Whereas, at Faizabad centre, isoproturon+ 2,4-D, being at par with hand weeding (twice) provided significant reduction in the growth of *Chenopodium album, P. minor, Melilotus* sp., *Rumex spp*. and *Anagallis arvensis*.

Different tillage systems influenced significantly the effective tillers and grain yield of wheat at both the centres. Significantly higher effective tillers/running meter row (74) was recorded under CT-ZT method of tillage over CT-CT tillage method (66) at Faizabad, while at Kanpur, CT-CT or ZT-ZT system produced highest effective tillers. Continuous conventional tillage during both the season produced significantly higher grain yield (4.5 t/ha) of wheat at Kanpur. The yield reduction in zero-zero tillage sowing was in the tune of 19.0% as compared to conventional-conventional tillage. While at Faizabad, different tillage treatments had no effect on the grain yield of wheat but, 15% higher grain yield of wheat crop was noticed under ZT-ZT or CT-ZT system over zero tillage during both the season. Among the weed control practices, the highest grain yield of wheat (5.4 t/ha at Faizabad) and (4.7 t/ha at Kanpur) was obtained under two hand weeding at 25 and 45 DAS at), which was at par with the grain yield produced in herbicide treated plots.

Economics

All the tillage and weed control treatments influenced significantly the net return and B:C ratio in rice as well as in wheat crop. Among different tillage treatments, significantly highest net return (₹ 10623/ha) and B: C ratio (2.9) was obtained under ZT-CT system followed during both the season in rice at Ranchi. However, at Faizabad and Kanpur centres, continuous conventional tillage system during both the season provided significantly highest net return (₹ 39867/ha and ₹ 22174/ha). In wheat crop, significantly highest net return and B: C ratio was recorded under continuous conventional tillage in both the season over rest of the tillage combinations at Kanpur. While at Faizabad, highest net return (₹ 47884/ha) and B:C ratio (3.2) was recorded under ZT-CT system of tillage. Among weed control measures, significantly higher net return and B:C ratio was obtained in both rice and wheat crop with the application of recommended herbicide in both the seasons.

After completion of cycle, soil of different plots was collected for studying the impact of different treatments on physic-chemical *viz.* bulk density, pH, organic content, dehydogenase and acid-phosphatase content. Results revealed that higher values of above mentioned properties of soil was noticed under continuous zero tillage during both the season at Ranchi and Faizabad centre. Among weed control practice, the higher values were recorded with hand weeding (twice) and unweeded control.

Maize-sunflower cropping system (TNAU and UAS (B)

Predominant weeds in maize were *Dactyloctenium aegyptium, Cynodon dactylon, Chloris barbata, Dinebra retroflexa* and *Setaria verticiliata among grasses; Trianthema portulacastrum, Digeria arvensis, Boerhaavia diffusa, Amaranthus viridis, Datura metal, Corchorus olitorius, Portulaca oleracea* and *Parthenium hysterophorus* among broad-leaved weeds; and *Cyperus rotundus* among sedges. While in sunflower, the major broad leaved weeds were *Trianthema portulacastrum, Digera arvensis, Amaranthus viridis, Portulaca oleracea, Corchorus olitorius* and *Parthenium hysterophorus*. Predominant grassy weeds were *Dactyloctenium aegyptium* and *Echinochloa colonum* at

Coimbatore centre. Whereas, at Bengaluru centre, the sunflower field was infested mainly with *Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium, Echinochloa colona* (among grasses); *Commelina benghalensis, Euphorbia geniculata* and *Borreria articularis* among broad-leaved weeds; and *Cyperus rotundus* as sedge.

Maize: Among different tillage combinations, significantly lower density of all weed species and dry biomass of weeds were recorded in CT-CT system, closely followed by CT-ZT method of tillage at Coimbatore centre. Higher weed control efficiency (76.3%) was registered under CT-CT tillage system compared to others. However, among the weed management methods, the lower density and dry weight of weeds were recorded with the pre-emergence application of pendimethalin 1.0 kg a.i./ha *fb* hand weeding on 45 DAS. There was significant effect on yield attributes and grain yield of maize due to different tillage and weed management practices. Significantly higher yield attributes like cob length, cob girth, cob weight, No. of rows/cob, no. of grains/row and 100 grain weight and grain yield were recorded in CT-CT (5.04 t/ha) among different tillage combinations and with the pre-emergence application of pendimethalin 1.0 kg a.i./ha *fb* hand weeding on 45 DAS at Coimbatore centre. Similar trend was also noticed for higher net return and B:C ratio owing to higher grain yield.

Sunflower: Continuous conventional tillage in both seasons provided reduced total weed density and dry biomass accumulation; and higher weed control efficiency (74%) and seed yield (2.15 t/ha) of sunflower at Coimbatore centre. While at Bengaluru centre, continuous zero tillage favoured the dominance of sedge, grasses and broad leaf weeds as compared to conventional tillageduring both the season. The digging of soil and exposing the *Cyperus rotundus* tubers and other weed seeds in conventional tillage practice resulted in reduction in their emergence compared to zero tillage treatment. However the different tillage systems did not had significant influence on the weed density and dry weight at any of the growth stages of sunflower crop. However, significantly higher sunflower seed yield (1325 kg/ha) and head diameter (12.9 cm) was recorded in continuous conventional tillage practice compared to continuous zero tillage (870 kg/ha) during both the season.

The density of grasses was more during 2005 summer followed by broad leaved weeds and sedge at Bengaluru centre. Similar trend was also noticed even after eight years of experimentation. During 2013 summer, dominance of *Euphorbia geniculata* and *Commelina benghalensis* was noticed, which was a minor weed during 2005. The density of grasses slightly decreased particularly with *C. dactylon*. Under weed management practices in general weeds density of all categories decreased from 2005 to 2013.

Maize-chickpea cropping system (Dharwad)

The major weed flora present in the experimental field was *Commelina benghalensis, Digera arvensis, Dinebra retroflexa and Mollugo sp. among annual weeds; Cyperus rotundus* and *Cynodon dactylon* among perennial weeds.

Maize: There was no significant difference between the main plots i.e. Tillage (only conventional tillage was followed for *kharif* maize). The weed control treatments differed significantly. The maize yields obtained with HW (4941 kg/ha) were significantly higher than RH i.e. atrazine 1.0 kg ai/ha (4661 kg/ha). The weed density and weed dry matter at 60 DAS were significantly lower with HW (25.5 /m^2 and 4.1 g/m^2 respectively). The net returns were significantly higher with HW (₹ 35781/ha) and RH (₹ 34879/ha) over weedy check (₹ 24470/ha).

Highest population of N_2 fixers and P-solubilizers were recorded with CT-ZT (73.87 and 39.77 x10^4 CFU /g of soil) at on 30th day. Among the weed control methods, hand weeding during both the season recorded highest number of N_2 fixers and lowest was recorded with RH-RH on (79.55 and 62.56 X10^4 CFU / g of soil). Highest soil enzyme activity viz., dehydrogenase, phosphatase and urease was recorded with CT-ZT tillage system(3.21 µg TPF formed / g soil / d , 2.20 µg pnp released / g soil / h and 0.95 µgNH^+ N / g soil day^{-1}) at 30 DAS.

Chickpea: chickpea yields were significantly higher in conventional tillage (CT) compared to zero tillage (ZT). Among weed control treatments, seed yield of chickpea produced with hand weeding (1094 kg/ha) was significantly higher over RH (967 kg/ha) and weedy check (774 kg/ha). The total weed dry weight differed significantly and it was significantly lower with CT among different tillage practices and with HW among weed control practices.

Beneficial microflora viz., N_2 fixers and mineral phosphate solubilizing (MPS) micro-organisms recorded highest with CT-ZT system (45.67 and 38.78 X10^4 CFU /g of soil respectively) on 30 DAS, while CT-CT method of tillage recorded lowest populations of these microorganisms (27.33 and 15.78 X10^4 CFU /g of soil respectively). Among the different weed control methods, HW-HW recorded highest populations of N_2 fixers on 30, 60 and 90 DAS (42.17, 42.08 and 57.83 X10^4 CFU /g of soil respectively). Similarly higher population of MPS microflora at 30, 60 and 90 DAS (30.17, 23.08 and 32.83 X10^4 CFU /g of soil respectively) was recorded with hand weeding (twice). Highest per cent root colonization was recorded with CT-ZT among tillage systems and HW-HW (67 per cent and 20.67 per cent). Among weed control, highest dehydrogenase and phosphatase activity was also recorded with CT-ZT (35.04 µg TPF formed / g soil / d and 23.52 µg pnp released / g soil / hrespectively).

Pearlmillet-wheat cropping system (Anand)

Eragrostis major, Eleusine indica, Digitaria sanguinalis, Cyperus rotundus, Cynodon dactylon and *Echinochloa colona* among monocots and *Euphorbia hirta, Spergula arvensis, Mollugo nudicaulis, Boerhavia diffusa, Amaranthus spinosus, Tridax procumbens* and *Phyllanthus niruri* among dicot weeds were observed in pearlmillet. While, in wheat, the major monocot weeds viz. *Cynodon dactylon, Cyperus rotundus, Eleusine indica* and *Cyperus iria* and dicot weeds viz. *Chenopodium album, Chenopodium murale, Amaranthus viridis, Oldenlandia umbellata, Portulaca quadrifida* and *Digera arvensis* were dominant in the experimental fields.

Pearlmillet : Different tillage practices and weed control treatments influenced significantly the weed dry biomass accumulation in pearlmillet. Significantly lowest weed dry matter accumulation and higher weed control efficiency was recorded with continuous zero tillage during both the season. Similarly, different weed control measures also influenced the weed growth. Among weed management practices hand weeding at 30 DAS showed significantly reduced weed dry bio-mass accumulation (25.1 g/m^2) over rest of the treatments. The maximum weed control efficiency was noticed with HW treatment (83.0%), closely followed by pre-emergence application of atrazine @ 0.5 kg/ha (76.9%). Significantly higher grain and straw yield was recorded with ZT-ZT method among different tillage practices and hand weeding at 30 DAS among weed control practices.

Wheat: Dry weed bio-mass recorded at harvest showed significant difference due to different tillage and weed management practices. Significantly lower weed dry weight was recorded in ZT-CT tillage system over continuous conventional tillage followed during both the season. Among weed management practices, the treatment hand weeding carried out at 20 DAS resulted in reduced weed dry weight (25.4 g/m^2) and higher WCE (82.0%), which was at par with pre-emergence application of pendimethalin @ 0.5 kg/ha. Tillage treatments had no significant effect on grain and straw yield of wheat. However, significantly highest grain (4077 kg/ha) and straw (8909 kg/ha) yields were recorded with hand weeding at 20 DAS.

WS 3.6: Weed management in conservation agriculture systems

Weeds are major constraints in conservation agriculture. Any reduction in tillage intensity or frequency may, therefore, influence the weeds infestation. The composition of weeds species and their relative time of emergence differ between conservation agriculture system (CAs) and soil inverting conventional tillage system (CTs). Keeping in view of these facts, a long-term experiment on the effect of crop establishment techniques and weed control measures under conservation agriculture system has been initiated from 2012 to monitor weed dynamics, crop productivity, herbicide residues, and to study C-sequestration, changes in physico-chemical and biological properties of soil health under rice-based and non-rice-based cropping systems. Total eight treatments consisting of five establishment methods viz., (i) CT(TPR)-CT(wheat/mustard/ chickpea/winter maize), (ii) CT(TPR)-ZT (wheat/mustard/ chickpea/winter maize)-ZT (cowpea/greengram), (iii) CT(DSR)–CT (wheat/ mustard/chickpea/ winter maize)-ZT (cowpea/ greengram), (iv) ZT(DSR)-ZT (wheat/ mustard/chickpea/ winter maize)-ZT (cowpea/ greengram), and (v) ZT (DSR)+R–ZT+R (wheat/mustard/chickpea/winter maize)-ZT (cowpea/greengram), as main plots, and three weed control measures *viz.,* recommended herbicides, integrated weed management (herbicide + mechanical weeding) and unweeded (control) as sub plots were laid out in strip plot design with three replications. The experiment was conducted at Faizabad, Ludhiana, Pantanagar, Pusa, Hyderabad, Bhubaneswar, Kanpur, Coimbatore, Bengaluru, , Sriniketan, and Jorhat in rice based cropping systems; and Ranchi, Dharwad, Parbhani, Anand and Bikaner in non-rice based cropping systems

Rice-wheat cropping system (Ludhiana, Pusa, Pantnagar, Faizabad, Kanpur)

Dominant weed flora in rice were *Echinochloa colona*, *Echinochloa crus-galli*, *Leptochloa chinensis* and *Panicum maximum* among grasses; *Alternanthera sessilis, Caesulia axillaris, Ammania baccifera* among broad leaved weeds; and *Cyperus iria, Cyperus difformis, Fimbristylis milliacea, S. junicoides* and *Cyperus rotundus* among the sedges at Pantnagar; *Echinocloa crusgalli, E. colonum, Dactyloctenium aegyptium, Digitaria sanguinalis, Cynodon dactylon* among grasses; *Cyperus rotundus, Cyperus difornis, Fimbristylis miliaceae* among sedges; and *Caesulia axillaris, Lippia nodiflora, Ammania baccifera, Eclipta alba* and *Phyllanthus niruri, Ipomoea aquatica* among broad-leaved weeds at Pusa; *Echinochloa crus-galli, Dactyloctenum aegyptiacum, Eleusine indica, Digitaria ciliaris* among grasses; *Cyperus iria, Digera arvensis, Cyperus compressus* among sedges; and *Euphorbia microphylla, Commelina benghalensis, Phyllanthus niruri* among broad-leaved weeds at Ludhiana; *Echinochloa colona, Leptochloa chinensis, Dactyloctenum aegyptiacum* and *Echinochloa crus-galli* among grasses, *Caesulia axillaris, Alternanthera sessilis* and *Eclipta alba* among broad-leaved weeds and different species of *Cyperus* and *Fimbristyllis* at Faizabad; and *E. colona, D. aegyptium,* and *L. chinensis* among grasses; and *S. nigrum, D. arvensis P. Niruri, C. argentea* among broad-leaved weeds at Kanpur

Dominant weed flora in wheat were *P. minor, M. denticulata, P. plebejum, C. didymus, R. acetosella , M. alba, M. stricta, C. album, V. sativa and F. parviflora* at Pantnagar; *Phalaris minor, Rumex dentatus, Medicago denticulata, Anagallis arvensis, Chenopodium album, Coronopus didymus, Malva parviflora, and Fumaria parviflora* at Ludhiana; *Avena fatua, Cynodon dactylon, Phalaris minor, Cyperus rotundus, Anagalis arvensis, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Eclipta alba, Fumaria purviflora, Lathyrus aphaca, Launia pinnatifida, Melilotus alba, Physalis minima, Rumex dentatus and Vicia hirsuta* at Pusa; and *P. minor, M. alba, A. arvensis, C. didymus,* and *C. arvensis* at Kanpur centre.

Rice: Different crop establishment techniques influenced significantly the total weed population and dry matter accumulation at all the coordinating centres. Lowest total weed density and dry biomass was recorded under transplanted rice compared to direct seeded rice under either CT or ZT tillage systems at all the centres except Faizabad centre (Table 3.6.1). Among crop establishment techniques, significantly higher weed population and weed dry matter was recorded under ZT (Direct seeded) over CT (Direct seeded) at Ludhiana, Pusa, Kanpur and Faizabad centre. While, CT (Direct seeded) recorded significantly higher population and dry biomass of weeds at Pantnagar. Lowest weed count (25.7 /m^2) and weed dry weight (36.7 g/m^2) were recorded at 60 DAS under CT (Transplanted)-CT being statistically at par with CT (Transplanted)-ZT-ZT, was significantly superior over rest of the treatments at Ludhiana, Faizabad, Pusa and Pantnagar centre. Residue retention of previous crop caused more weed infestation at Ludhiana and Faizabad centre. Amongst weed control measures, integrated weed management was found effective in reducing the weed density and weed dry matter production at 60 DAS at all the coordinating centres.

Adopting conventional tillage for transplanting (4.10 to 5.30 t/ha) or direct seeding of rice (2.51 to 4.30 t/ha) gave significantly higher yields than direct seeded rice (0.90 to 3.98 t/ha) under zero tillage at Ludhiana, Pusa, Pantnagar and Kanpur. However, different crop establishment techniques did not cause any significant difference in grain yield of rice at Faizabad centre. Residue retention under ZT (Direct seeded)-ZT technique produced statistically at par grain yield of rice (4.90 t/ha) with CT (Transplanted)-ZT or CT (5.30 t/ha) at Pantnagar. Whereas, lowest grain yield of rice (0.90 t/ha) recorded under ZT (Direct seeded) +R-ZT+R-ZT at Ludhiana centre. Under different weed control methods, integrated weed management practice produced the maximum grain yield (3.17 - 5.8 t/ha) followed by recommended herbicides (2.74 - 5.30 t/ha) at all the coordinating centres. Among all the coordinating centres, highest grain yield of rice was

noticed with integrated weed management at Pantnagar, closely followed by Faizabad centre. However, lowest grain yield of rice (1.72 - 3.37 t/ha) under unweeded control at all the coordinating centres. Lowest net return and B:C ratio was obtained under CT (Transplanted)-CT method of crop establishment over rest of the treatments (Table 3.6.2).

Wheat: Different crop establishment techniques influenced the total weed density and weed dry weight in wheat at different coordinating centres except at Ludhiana centre. CT (Transplanted)-CT method recorded reduced density and dry weight of weeds at Ludhiana and Pusa centre, while it favoured significantly higher weed growth at Pantnagar and Kanpur centre (Table 3.6.3). At Pantnagar, significantly lowest weed density was recorded due to retention of previous crop residues under ZT (Direct seeded)-ZT-ZT method of crop establishment. Amongst weed control measures, integrated weed management was found effective in reducing the weed density and weed dry matter production at 60 DAS at all the coordinating centres.

Adopting conventional tillage for wheat sowing (4.20 to 6.45 t/ha) gave higher yields than direct seeded wheat (3.90 to 6.17 t/ha) under zero tillage at Ludhiana, Pusa, Pantnagar and Kanpur centres. Amongst weed control measures, integrated weed management produced significantly higher grain yield of wheat over recommended herbicide at Pusa and Pantnagar centre. Lowest grain yield was recorded under unweeded control at all the coordinating centres. However, no definite trend was obtained in respect to net return and B:C ratio at all the coordinating centres.

Table 3.6.1: Effect of tillage and weed management practices on weed growth in rice at 60 DAS under conservation agriculture

Treatment	Weed density (No./m²)					Weed dry biomass (g/m²)				
	Ludhiana	Pusa	Faizabad	Pantnagar	Kanpur	Ludhiana	Pusa	Faizabad	Pantnagar	Kanpur
Establishment techniques										
CT (Transplanted)-CT	0.7 (0.0)	12.5	48.0	4.5 (19.6)	4.8 (22.5)	0.7 (0.0)	24.5	52.5	5.8 (33.1)	10.7 (114.5)
CT (Transplanted)-ZT-ZT	0.7 (0.0)	11.5	52.4	2.9 (7.6)	6.4 (39.7)	0.7 (0.0)	22.8	48.5	4.3 (17.9)	10.4 (107.0)
CT (Direct-seeded)-CT-ZT	5.52 (30.0)	20.7	35.0	8.6 (73.3)	6.8 (45.1)	9.8 (96.0)	39.1	61.4	8.4 (70.0)	10.6 (115.2)
ZT (Direct-seeded)-ZT-ZT	5.34 (28.0)	25.4	40.1	7.8 (59.5)	7.2 (50.8)	13.2 (174.0)	47.2	67.5	10.5 (109.5)	11.8 (139.6)
ZT (Direct-seeded)+R-ZT+R-ZT	5.7 (32.0)	23.0	58.6	7.6 (57.3)	7.1 (49.2)	12.3 (150.0)	45.6	53.3	10.2 (103.4)	10.9 (120.4)
LSD(P=0.05)	0.43	1.02	-	0.6	0.42	4.25	1.72	-	0.7	0.64
Weed control measures										
Recommended herbicides	4.42 (19.0)	14.7	51.3	4.9 (23.3)	6.5 (41.3)	8.8 (76.0)	29.7	51.1	7.1 (50.2)	10.9 (118.8)
IWM (herbicide + mechanical weeding+intercrop)	3.8 (13.0)	13.7	35.1	2.8 (7.4)	5.6 (30.4)	7.4 (54.0)	26.9	41.7	2.9 (8.4)	9.5 (89.3)
Unweeded	4.5 (20.0)	27.9	65.7	10.6 (111.7)	7.4 (53.6)	11.0 (121.0)	52.0	83.6	11.8 (138.7)	12.4 (153.0)
LSD (P=0.05)	NS	1.3	-	NS	0.40	NS	1.94	-	NS	0.42

"Original values are given in parentheses

Table 3.6.2: Effect of tillage and weed management practices on grain yield and economics of rice under conservation agriculture

Treatment	Grain yield(t/ha)					Net returns (x10³ ₹/ha)			B:C ratio		
	Ludhiana	Pusa	Faizabad	Pantnagar	Kanpur	Ludhiana	Pantnagar	Kanpur	Ludhiana	Pantnagar	Kanpur
Establishment techniques											
CT (Transplanted)-CT	4.23	4.78	4.70	4.60	4.09	47.79	59.94	33.87	2.9	2.7	2.3
CT (Transplanted)-ZT-ZT	4.11	4.45	4.90	5.30	4.03	48.54	68.45	30.04	3.1	3.4	2.2
CT (Direct-seeded)-CT-ZT	2.51	4.02	4.30	4.00	3.02	49.88	52.20	20.80	3.0	2.8	1.9
ZT (Direct-seeded)-ZT-ZT	0.97	3.48	4.70	3.70	2.69	48.19	48.52	17.81	3.1	2.9	1.8
ZT (Direct-seeded)+R-ZT+R-ZT	0.90	3.98	5.10	4.90	2.84	49.13	64.27	20.15	3.1	3.9	1.9
LSD(P=0.05)	0.68	0.16	-	0.56	0.18			2.21			0.1
Weed control measures											
Recommended herbicides	2.74	4.46	5.20	5.30	3.56	51.19	68.97	27.90	2.9	3.1	1.9
IWM (herbicide + mechanical weeding+intercrop)	3.17	4.60	5.60	5.80	3.86	45.33	75.04	28.98	2.5	3.2	2.3
Unweeded	1.72	3.37	3.20	2.50	2.63	39.25	32.01	18.52	2.6	1.9	1.9
LSD (P=0.05)	0.03	0.22	-	0.25	0.16			1 59			0.06

Table 3.6.3: Effect of tillage and weed management practices on weed growth and Weed dry matter in wheat at 60 DAS under conservation agriculture

Treatment	Weed density (no/m²)				Weed dry biomass (g/m²)			
	Ludhiana	Pusa	Pantnagar	Kanpur	Ludhiana	Pusa	Pantnagar	Kanpur
Establishment techniques								
CT (Transplanted)-CT	13.6 (184.4)	22.5	11.6 (133.5)	4.6 (10.2)	2.3 (4.9)	12.3	4.5 (34.5)	2.9 (7.9)
CT (Transplanted)-ZT-ZT	15.3 (233.4)	27.6	6.9 (47.0)	3.2 (9.5)	2.8 (7.2)	15.7	5.6 (49.0)	3.1 (8.6)
CT (Direct-seeded)-CT-ZT	17.2 (293.6)	30.6	9.3 (86.1)	3.3 (10.5)	2.7 (6.5)	16.5	4.0 (24.9)	3.1 (8.6)
ZT (Direct-seeded)-ZT-ZT	18.8 (352.1)	38.4	9.4 (87.2)	3.2 (9.6)	2.7 (6.5)	20.8	3.1 (6.6)	2.9 (8.2)
ZT (Direct-seeded)+R-ZT+R-ZT	19.7 (389.1)	35.1	6.0 (35.6)	3.2 (9.7)	2.5 (5.7)	19.0	3.5 (10.3)	2.9 (8.0)
LSD(P=0.05)	NS	2.4	0.6	0.5	NS	1.7	1.1	0.4
Weed control								
Recommended herbicides	10.6 (111.4)	22.2	6.5 (41.4)	3.0 (8.6)	2.1 (4.1)	12.2	2.5 (7.0)	2.2 (4.3)
IWM (herbicide + mechanical weeding+intercrop)	22.4 (499.0)	16.9	5.3 (27.7)	2.7 (6.7)	2.7 (6.8)	9.6	1.7 (2.2)	2.7 (6.6)
Unweeded	16.2 (262.2)	53.4	12.8 (164.3)	4.1 (16.0)	2.9 (7.6)	28.8	8.2 (72.1)	4.1 (16.5)
LSD (P=0.05)	NS	1.03	NS	0.4	NS	1.00	NS	0.3

• Original values are given in parentheses

Table 3.6.4: Effect of tillage and weed management practices on grain and economics of wheat under conservation agriculture

Treatments	Grain yield (t/ha)				Net return (x 10³ ₹/ha)			B:C		
	Ludhiana	Pusa	Pantnagar	Kanpur	Ludhiana	Pantnagar	Kanpur	Ludhiana	Pantnagar	Kanpur
Establishment techniques										
CT (Transplanted)-CT	6.27	4.59	4.30	4.50	47.79	37.05	32.62	2.9	1.6	2.2
CT (Transplanted)-ZT-ZT	6.12	4.46	4.10	4.24	48.54	39.69	29.98	3.1	2.2	2.0
CT (Direct-seeded)-CT-ZT	6.45	4.37	4.20	4.33	49.88	36.1	30.86	3.0	1.6	2.1
ZT (Direct-seeded)-ZT-ZT	6.09	4.05	3.90	3.89	48.19	36.94	26.36	3.1	2.2	2.0
ZT (Direct-seeded)+R-ZT+R-ZT	6.17	4.20	4.20	4.02	49.13	42.77	27.80	3.1	2.6	2.0
LSD (P=0.05)	NS	0.08	0.24	0.10			1.37			0.1
Weed control										
Recommended herbicides	6.67	47.2	4.30	4.37	51.19	36.40	31.63	2.9	1.7	2.1
IWM (herbicide + mechanical weeding+intercrop)	6.47	48.7	4.80	4.69	45.33	41.84	33.75	2.5	1.7	2.3
Unweeded	5.53	3.39	3.40	3.55	39.25	29.22	23.19	2.6	1.6	1.9
LSD (P=0.05)	0.90	0.07	0.31	0.09				2.9		0.03

Rice-rice cropping system (Coimbatore)

Predominant weed species were *Echinochloa crus-galli* (L.) and *Echinochloa colona* among grasses, *Cyperus difformis* under sedges and *Eclipta prostrata Marsilia quadrifoliata* and *Monochoria vaginalis* under broad leaved weeds in both seasons of rice. While, *Ammania baccifera and Ludwigia parviflora* among broad-leaved weeds were dominant only in *kharif* rice.

There was significant effect on weed growth due to different tillage methods at 30, 60 DAS/T and at harvest. Significantly lower total weed density and weed dry weight was observed with adoption of conventional tillage for transplanting or direct seeding of rice during both the season. However, significantly highest weed population and weed dry matter accumulation was recorded in rice grown under ZT(Direct seeded)+R-ZT+R-ZT method of establishment during both the season. Significantly highest grain yield of both viz. *kharif* rice (5.8 t/ha) and *rabi* rice (5.9 t/ha) was recorded under CT (Transplanted)-CT over rest of the treatments. Similarly, highest net return (₹ 48700/ha and ₹ 51640/ha) as well as B:C ratio (2.3 and 2.4) were obtained under CT (Transplanted)-CT in *kharif* and *rabi* rice, respectively. However, lowest net return and B:C ration were recorded under ZT (Direct seeded)+R-ZT+R-ZT method of crop establishment in both the season. Amongst weed control measures, integrated weed management produced significantly higher grain yield, net return and B:C ratio over recommended herbicide.

Significantly higher total population of bacteria was observed under CT (Transplanted)-CT method of crop establishment during *kharif* season. While, highest population of total bacteria, fungi and actinomycetes was recorded with ZT (Direct seeded) +R-ZT+R-ZT system of crop establishment during *rabi* season. Under different weed control methods, highest population of total bacteria, fungi and actinomycetes was highest population of total bacteria, fungi and actinomycetes was notice with pre-emergence application of butachlor @ 1.0 kg/ha (Transplanted rice) or pretilachlor @ 0.45 kg/ha(DSR) + dhaincha (*Sesbania* sp) intercropping followed by mechanical incorporation at 35 DAS/T over rest of the treatments.

Rice-maize cropping system (Bhubaneswar)

P. repens, E. crus-galli, E.colona, P. scorbiculatum, C. dactylon, among grasses; *M.quadrifolia, A. sessilis, L. parviflora* among broad-leaved weed; and *C. difformis, C. iria, C. rotundus* and *F. miliacea* among sedges were dominant flora in rice experiment.

Adopting conventional tillage for transplanting recorded significantly reduced total weed density and weed dry matter accumulation, this was closely followed by conventional tillage for direct seeding of rice. Significantly highest total weed population and dry weight were recorded under ZT (Direct seeded rice) +R-ZT+R-ZT system of crop establishment. Amongst weed control treatments, pre-emergence application of butachlor @ 1.5 kg/ha *fb* mechanical weeding gave lowest weed density, which was statistically at par with application of recommended herbicide. Similar trend was also noticed in respect to weed dry matter accumulation. There was no significant difference in grain yield of rice, net return and B:C ratio due to different tillage practices. However, highest grain yield (3.23 t/ha), gross return (₹ 48213/ha) and B:C ratio (1.7) were obtained under CT (Transplanted)-ZT-ZT system.

Rice-chickpea (Bengaluru)

Major weed flora observed in the experimental plots were *Cyperus rotundus, and Fimbristylis miliacea* among sedges; *Echinochloa colona, Digitaria marginata and Chloris barbeta* among grasses; *Spilanthus acmella, Eclipta alba, Alternanthera sessilis, Portulaca oleracea, and Commelina benghalensis* among broad-leaved weeds. Among the weed species, the density of *Fimbristylis miliacea, Digitaria marginata, Spilanthus acmella, Eclipta alba* and *Portulaca oleracea* were higher than other weed species, indicating their dominance from the beginning or at any stage of the crop cycle. The weed density and dry weight recorded at 30, 60 DAS and harvest were not influenced significantly due to tillage and residue management practices. Weed management practices significantly influenced the weed density and weed dry weight at all the stages of crop growth. Integrated weed management practice included pre-emergence application of pendimethalin @ 750 g/ha followed by passing cycle weeder at 30 DAS recorded reduced weed density and dry weight of weeds over application of pendimethalin @ 750 g/ha alone.

The tillage practices and residue management practices did not influence grain, stover yield, number of branches and pods per plant in chickpea. While, weed management practices significantly influenced the yield and yield attributes of chickpea. Pre-emergence application of pendimethalin at 750 g ai/ha followed by passing cycle weeder at 30 DAS recorded significantly higher grain yield (1.91 t/ha), branches per plant (3.8) and pods per plant (31) compared to pendimethalin 750 g ai/ha alone and unweeded control. Unweeded check recorded highest weed index (59.3) due to severe weed competition which had detrimental effect on the yield and yield attributes of chickpea (Table 3.6.5).

Table 3.6.5: Effect of tillage and weed management practices on weed growth at 60 DAS, and yield of chickpea under conservation agriculture (Bengaluru)

Treatment	Total weed density (no./m²)	Total weed dry weight (g/m²)	Yield (t/ha)
Crop establishment technique			
CT- CT-	1.7(60.8)	1.3(31.2)	1.51
CT – ZT- ZT	1.7(60.0)	1.3(29.2)	1.52
CT – CT- ZT	1.7(60.1)	1.3(30.1)	1.50
ZT – ZT-ZT	1.8(73.3)	1.4(38.3)	1.33
ZT + R- ZT + R- ZT	1.7(70.9)	1.4(37.8)	1.36
LSD (P=0.05)	NS	NS	NS
Weed control			
Recommended herbicide	1.7(56.0)	1.3(21.4)	1.65
IWM (herbicide + mechanical weeding + intercrop)	1.3(19.7)	0.8(3.9)	1.91
Unweeded	2.1(119.3)	1.9(74.7)	0.77
LSD (P=0.05)	0.11	0.11	0.16

Rice-mustard cropping system (Sriniketan and Jorhat)

Pre-dominant weed species in rice field were *Echinochloa colonum, Digitaria sanguinalis,* and *Cynodon dactylon,*among grasses; *Ageratum conyzoides, Ludwigia parviflora, Linder crustacea, Commelina diffusa,* and

Spilanthes acmella among broad-leaved weeds and *Fimbristylis miliacea* among sedges at Sriniketan; *Cyperus iria, Fimbristylis littoralis* and *Scirpus juncoides* among sedges; *Ludwigia linifolia among broad-leaved; and Echinochloa crusgalli* among grasses at Jorhat.

Five most dominant weed species in mustard crop were *Stellaria media, Oxalis debilis* var. *crymbosa* and *Leucas indica* among broadleaved group; *Cynodon dactylon* as grassy and sedge *Cyperus rotundus* as sedge at Jorhat.

Rice: Conventional tillage in transplanted rice culture was found most effective in reducing the number as well as the dry matter of total weed flora. In direct seeded rice, there were no significant differences between conventional tillage and zero tillage at Sriniketan. However, data on weed density and dry weight in winter rice showed that the lowest values were recorded due to CT-ZT-ZT and CT-CT-CT at Jorhat centre. Among the weed control measures integrated weed management practices significantly lowered down the number as well as dry matter of total weed at both the centre.

At Sriniketan, among the yield attributes number of effective tillers and test weight differed significantly among the different tillage operations but there was no significant difference in number of grains/panicle. On the other hand, number of effective tillers and number of grains/panicle differed significantly among the weed control measures but, there was no such difference in test weight. The conventional tillage in transplanted rice recorded the highest grain yield (3.99 t/ha) but the conventional tillage did not produce more yield than that of zero tillage in direct seeded rice. However, the number of tillers and panicle length as well as grain yield of rice were significantly affected by tillage methods and highest values were obtained under CT-CT-CT and CT-ZT-ZT at Jorhat. Among the weed control measures integrated weed management system produced the highest grain yield (4.32 t/ha) and this was statistically at par with the recommended herbicide at both the centre.

Mustard: The lowest weed density and dry weight in rapeseed were recorded under CT (Transplanted)-CT-CT method. The weed density and dry weight increased when zero tillage was followed. Pant height, total branches and siliqua/plant were also significantly better under under CT (Transplanted)-CT-CT method. It was closely followed by CT(Direct seeded)-CT-ZT method. Seed yields obtained under these 2 methods were at par and significantly higher than other treatments. Amongst weed control, highest seed yield was recorded with herbicide + hand weeding which was closely followed by recommended herbicide alone.

Maize-wheat cropping system (Ranchi)

The experimental field of maize was mainly infested with *Cyperus rotundus, Stellaria media, Digitaria sanguinalis, Alternanthera sessilis, Commelina nudifolia, Paspalam distichum, Ageratum conyzoides Celosia argentea.*

Among various tillage methods, conventional method recorded reduced weed density of grassy and sedges as well as total weeds at 30 DAS in maize. However at 60 DAS, different crop establishment techniques did not influence the total density and dry matter accumulation of weeds. Amongst weed control, integrated weed control treatment viz. pre-emergence application of atrazine @ 1.0 kg/ha + HW recorded significantly reduced total density of weeds at 60 DAS. Similarly, integrated weed management reduced weed dry matter to the extent of 68.49 and 75.46% compared to weedy check.

Different crop establishment techniques in maize did not influence grain yield, net return and B:C ratio. However, highest grain yield of maize and net return were obtained under adoption of continuous conventional tillage during both the season. Amongst weed control, integrated weed control being at par with recommended herbicide application provided significantly higher grain yield of maize than unweeded control.

Maize-chickpea cropping system (Dharwad)

The weed flora in the experimental plot were *Commelina benghalensis, Digera arvensis, Dinebra retroflexa, Mollugo pentaphylla, Ageratum conyzoides, Corchorus spp* among annuals; *Cyperus rotundus* and *Cynodon dactylon* among perennial weeds.

Different tillage methods did not influence total density of weeds. Whereas, total weed dry matter accumulation was significantly influenced due to different crop establishment methods. Significantly lowest weed dry weight (29.4 g/m²) was recorded with CT-ZT+R method. Among weed control methods, integrated weed management approach recorded significantly lowest total weed density (24.2/m^2) over recommended herbicide (60.2/m^2) and unweeded control (172/m^2).

Grain yield and economics did not differ significantly due to tillage methods. But, IWM recorded significantly higher grain yield of 4.85 t/ha over recommended herbicide (4.64 t/ha) and weedy check (3.97 t/ha). Similar trend was also followed in respect to net returns.

Zero tillage under residue retention condition recorded highest dehydrogenase activity on 10, 20, 30, 40, 50, 60, 70, 80 and 90 DAS (5.53, 8, 27, 8.73, 3.95, 4.94, 5.53, 18.21, 4.58 and 6.30 µg TPF formed /g soil /d). Similar trend was also noticed with phosphatase and urease activity.

Pearlmillet–chickpea cropping system (Bikaner)

Adoption of conventional tillage for pearlmillet sowing under CT-CT or CT-ZT methods of crop establishment recorded reduced density and dry weight of weeds. However, zero tilled plots (ZT) gave significantly higher density and dry weight of grassy as well as broad leaved weeds over conventional tillage. But, ZT (Pearl millet) recorded plant height, yield attributes and seed yield of pearlmillet statistically at par with conventional tillage (CT). Amongst weed control, integrated weed management (atrazine +hand hoeing) resulted in significant reduction in the density and dry weight of mixed weed flora compared with weedy check, gave significantly higher plant height, yield attributes and seed yield of pearl millet.

Pearlmillet–mustard cropping system (Anand)

Dominant weed flora in perlmillet were *Eragrostis major, Eleusine indica, Digitaria sanguinalis, Cynodon dactylon* and *Echinochloa colona* among grasses; *Euphorbia hirta, Spergula arvensis, Mollugo nudicaulis, Boerhavia diffusa, Amaranthus spinosus, Tridex procumbens* and *Phyllanthus niruri* among broad-leaved weeds; and *Cyperus rotundus* and *Cyperus iria* among sedges. Whereas, dominant weed species in mustard were *Cynodon dactylon* and *Eleusine indica* among grassy weeds; *Chenopodium album*, *Chenopodium murale*, *Amaranthus viridis*, *Oldenlandia umbellata*, *Portulaca quadrifida* and *Digera arvensis* among broad-leaved weeds; and *Cyperus rotundus* among sedges

Neither different crop establishment nor weed control methods showed significant difference on total weed density, weed dry matter accumulation at 60 DAS, yield attributed and grain yield of pearlmillet as well as mustard. However, adoption of conventional tillage for sowing recorded reduced weed growth and higher yield of pearlmillet and mustard. Among weed management practices, higher grain and straw yields were recorded with integrated approach using pre-emergence application of atrazine @ 0.50 kg/ha in maize and pendimethalin @ 0.5 kg/ha in mustard *fb* one inter culture operation at 30 DAS.

Soybean-chickpea cropping system (Parbhani)

Dominant weed species were *Acalypha indica, Digera arvensis, Euphorbia geniculata and Parthenium hysterophorus* in soybean crop. Different crop establishment techniques did not influence the weed growth at all the stages of crop growth, seed yield and net return in soybean. Amongst weed control measures, adopting integrated method of weed control being statistically at par with recommended herbicide recorded significantly reduced weed growth and higher seed yield, net return and B: C ratio in soybean.

WS 3.7: Long-term herbicide trial in different cropping systems

WS 3.7.1. Rice-wheat

PAU, Ludhiana

Rice-wheat is the dominant cropping system almost in all the areas of Punjab state. Weeds are a major problem in both these cereal crops. A number of herbicides are recommended for the control of weeds in both the crops. However, in general, the farmers adopt only one or two herbicides due to higher efficacy, lower cost or easy availability of the product. This happened in wheat, the continuous use of isoproturon resulted in development of resistance in *P. minor* against this herbicide. Alternate herbicides were recommended for the control of *P. minor* in wheat and there are reports of reduced efficacy of these alternate herbicides. Moreover, with the use of grassy herbicides, broad leaf weeds are increasing in both rice and wheat crops. Thus, a long term field experiment to study the effect of continuous and rotational use of herbicides on shifts in weed flora and productivity of rice-wheat system was studied at different centres. Salient findings are presented below:

Wheat (*Rabi* 2012-13):

Weed flora in experimental field included *Phalaris minor, Avena ludoviciana* and *Poa annua* among grasses and *Rumex dentatus, Medicago denticulata, Anagallis arvensis, Chenopodium album, Coronopus didymus*, *Malva parviflora, Fumaria parviflora* and other among broadleaf weeds. All the herbicides effectively controlled *P. minor* as compared to unweeded control and significantly reduced its dry matter as compared to weedy check. Pendimethalin was poor against *Medicago* and *Avena*; 2,4-D against *Medicago* and *Rumex;* sulfosulfuron and metsulfuron against *Rumex*. *Avena ludoviciana* infestation continued in pendimethalin and *Poa annua* in clodinafop plots since last year. Poor control of *Avena* increased dry matter of grasses under pendimethalin alone and poor control of *Rumex* increased broadleaf weeds dry matter under sulfosulfruon alone treatments. The continuous/ rotational use of pre- and post-emergence herbicides or grass and broadleaf killers reduced the population and dry matter, both grassy and broadleaf weeds, and recorded significantly higher wheat grain yield and net returns and B:C ratio as compared to the weed control treatments and unweeded control (Table 3.7.1.1). The results indicated that sequential application of pre- and post-emergence herbicides or grass and broadleaf killers is desirable for getting sustained weed control and higher prodcutivity and profitability from wheat. The continuous use of same herbicides results in rapid weed flroa shifts over the year which reduces the crops productivity.

Rice (*kharif* 2013): *Echiochloa crus-galli, I. rugosum, C. axillaries, C. iria,* were the major weeds in the rice field. There was heavy weed pressure in the experimental field. *Ammania baccifera, Alternanthera and Cyperus compressus* has started appearing in traces in the experimental field. All the three herbicides butachlor, pretilachlor and anilophos provided satisfactory control of grass weeds and recorded significanlt lower grasses dry matter as compared to weedy check. Anilophos alone was relatively poor on broadleaves and sedges weeds and the dry matter of these weeds was at par to weedy check. The follow up application of metsulfuron provided effective control of broadleaves and sedges. Sequential application of butachlor and metsulfuron and rotational herbicide treatments recorded the highest rice grain yield, net returns and B:C ratio (Table 3.7.1.2).

Table 3.7.1.1: Long term effect of continuous/rotational use of herbicides on weed growth and yield of wheat during *rabi* 2012-13 at Ludhiana

Treatment (dose kg/ha)	Weed dry matter at 60 DAS (g/m²)		Grain yield of wheat (t/ha)	Net returns (x10³ ₹/ha)	B:C ratio
	Grasses	BLW			
Pendimethalin 0.75 (C)	4.0 (23)	5.1 (27)	3.43	12.01	1.43
Pendimethalin 0.75 *fb* 2,4-D 0.5 (C)	1.4 (1)	2.1 (4)	5.34	33.66	2.16
Clodinafop 0.06 *fb* metsulfuron 0.005 (C)	1.0 (0)	2.2 (4)	5.78	38.99	2.36
Clodinafop 0.06 *fb* 2,4-D 0.5 (C)	2.3 (5)	3.5 (12)	5.54	36.52	2.29
Sulfosulfuron 0.025 (C)	1.9 (4)	4.4 (20)	4.30	22.61	1.82
Sulfosulfuron 0.025 *fb* 2,4-D 0.5(C)	1.8 (3)	2.6 (6.5)	5.66	37.78	2.33
Triflu/Clodi/Sulfo* 0.025 f.b. 2,4-D 0.5 (R)	1.1 (0)	2.8 (7)	5.38	22.61	1.82
Weedy check	8.5 (78)	6.9 (47)	2.02	-1.683	0.93
SEm±	0.9	0.4	0.291		
LSD (P= 0.05)	2.5	1.3	0.855		

Parentheses are means of original values. Data subjected to square root (x + 1) transformation.

Table 3.7.1.2: Long-term effect of continuous (C) / rotational (R) use of herbicides on weed growth and yield of rice at Ludhiana during *kharif* 2013

Treatment (kg/ha)	Weed dry matter (g/m^2)		Grain yield (t/ha)	Net returns ($x10^3$ ₹/ha)	B:C ratio
	Grasses + Sedges	BLW			
Butachlor 1.5 (C)	19.1 (372)	2.64 (6)	5.52	31.10	2.03
Pretilachlor 0.75 (C)	15.4 (240)	1.38 (1)	6.25	39.09	2.29
Anilofos 0.4 (C)	14.8 (223)	6.90 (49)	5.93	35.92	2.20
Anilophos / pretilachlor/butachlor* (R)	12.6 (160)	4.91 (32)	6.66	44.02	2.47
Butachlor 1.5 *fb* metsulfuron 0.015(C)	13.8 (202)	1.33 (1)	6.87	44.87	2.43
Pretilachlor 0.75 *fb* metsulfuron 0.015(C)	15.0 (236)	1.22 (0)	5.41	28.58	1.91
Anilofos 0.4 *fb* metsulfuron 0.015 (C)	10.8 (117)	2.03 (4)	6.04	35.81	2.15
Weedy check	28.8 (902)	1.26 (1)	0.25	-26.75	0.09
SEm±	1.44	0.81	0.44		
LSD (P = 0.05)	4.39	2.46	1.34		

Data subjected to square root transformations, in parentheses are original values

GBPUAT, Pantnagar

Long-term effect of weed management practices in rice–wheat cropping system

Among the different weed species the *P. minor* population was more than 50% over the non-grassy weeds; however among the BLWs the highest population was *M. indica* (17.1%), followed by *M. denticulata* (16.4%) and *P. plebeium* (1.4%). The highest reduction in density of weeds was observed with the application of isoproturon 1.0 +2, 4-D at 0.5 kg/ha at 30 DAS, although it was found at par with application of clodinafop 0.06 kg/ /ha (POE) 30 DAS *fb* 2,4–D 0.5 kg/ha. Except clodinafop 0.06Kg/ha 30 DAS *fb* 2, 4–D at 0.05 kg/ha and sulfosulfuron 0.025 kg/ha all other treatments provided complete reduction of *M. indica* over the weedy check. Among the herbicidal treatments, highest grain yield of 5075 kg/ha was recorded with application of sulfosulfuron applied at 0.025 g/ha followed by isoproturon 1.0 kg/ha (30 DAS) along with 2, 4-D at 0.5 kg/ha and clodinafop 0.06 kg/ /ha 30 DAS *fb* 2,4–D 0.5 kg/ha and they were significantly higher over weedy check (Table 3.7.1.3). Within herbicidal treatments, the lowest yield was obtained by farmer's practice application of isoproturon 1.0 kg/ha at 30 DAS and reduction in weedy plot was obtained 14.2 and 25.6% over the farmer's practice and sulfosulfuron treated plots, respectively.

During *kharif* season, the density of grassy weeds was more than broad leaved weeds and sedges. Among the grasses and broad-leaf weed population of *P. disticum* and *A. baccifera* were heavily

Table 3.7.1.3: Effect of treatments on weed growth and grain yield of wheat at Pantnagar

Treatment	Total weed density (no./ m^2)	Total weed dry weight (no./ m^2)	Grain yield (t/ha)
Farmer's practice (isoproturon 1.0 kg/ha 30 DAS) (POE))	37.3	36.5	4.40
Isoproturon 1.0 kg/ha (30 DAS)+2, 4-D at 0.5 kg/ha	17.3	22.3	4.72
Isoproturon 1.0 kg/ha (30 DAS) +2, 4-D at 0.5 kg/ha (with green manuring in *kharif*)	36.0	17.2	4.90
Clodinafop 60 g/ha (POE) 30 DAS *fb* 2, 4–D at 0.5 kg/ha (7 days after clodinafop spray)	32.0	2.8	4.77
Clodinafop 60 g//ha (POE) 30 DAS *fb* 2,4–D 0.5 kg/ha (7 days after clodinafop spray)	20.0	8.3	4.90
Isoproturon 1.0 kg/ha (30 DAS) + HW (45 DAS)	25.3	14.5	4.77
Weedy	170.7	137.3	3.77
Sulfosulfuron 25 g/ha	52.0	6.8	5.07
SEm±	5.34	6.78	0.081
LSD (P=0.05)	16.5	20.5	0.247

infested having 35.7 and 29.2 % density respectively. The weed density and dry weight of all species significantly reduced by the application of herbicide either applied as pre or post- emergence at 60 DAS. All the treatments showed its superiority by recording least density of *E. colona* and *E. crus-galli* over the weedy check. Lower density of *P. disticum* was recorded under butachlor 1.5 kg/ha (PE) *fb* 2,4-D (0.5 kg/ha) 20 DAT + OM (*sesbania*) which was at par with Farmer's practice (butachlor 1.5 kg/ha at 3-5 DAT) (PE). All the treatments have depicted complete reduction of *A. baccifera* and *C. difformis* over weedy check and bispyribac sodium 25 g/ha. The minimum dry weight of weeds was obtained with application of butachlor 1.5 kg/ha (PE) *fb* 2,4-D 0.05 kg/ha (POE) + GM, however no significant variation was found among the different herbicidal treatments.

The highest grain and straw yield were obtained under application of bispyribac-Na 0.025 kg/ha this treatment was at par with butachlor 1.5 kg/ha (PE) *fb* 2,4-D (0.5 kg/ha) 20 DAT + *Sesbania* (Table 3.7.1.4). The reduction in grain and straw yield in weedy plot were 36 and 34% as compared to bispyribac-sodium 0.025 kg/ha.

Table 3.7.1.4: Effect of treatments on total weed density, dry weight of weeds and yield of rice

Treatment	Total weed density (no./m^2)	Total weed dry weight (g/m^2)	Grain yield (t/ha)
Farmer's practice (butachlor 1.5 kg/ha at 3-5 DAT) (PE)	1.2 (13.3)	4.2 (88.0)	5.00
Butachlor 1.5 kg/ha (PE) *fb* 2,4-D (0.5 kg/ha) at 20 DAT	0.8 (10.7)	3.9 (67.9)	5.70
Butachlor 1.5 kg/ha (PE) *fb* 2,4-D (0.5 kg/ha) 20 DAT + OM (Dhancha)	0.8 (10.7)	2.9 (18.4)	5.96
Treatment–2 rotation with pretilachlor 0.7 kg/ha (PE)	0.9 (13.3)	3.1 (33.6)	5.36
Treatment-4 and dhaincha	0.8 (10.7)	2.3 (23.6)	5.40
Butachlor 1.5 kg/ha 3-5 DAT + HW at 20 DAT	1.2 (13.3)	3.0 (26.1)	5.26
Weedy	4.2 (205.3)	4.9 (167.6)	4.08
Bispyribac-sodium 25 g/ha	2.4 (56.0)	3.8 (50.7)	6.40
SEm ±	0.40	0.57	0.296
LSD (P=0.05)	1.2	NS	0.900

CSKHPKV, Palampur

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

Application of herbicides to control weeds is becoming popular due to scarcity and high cost of labours. Most of the herbicides are selective and specific to the crop and are persistent in the soil for a few months to a few years depending upon the chemical and concentration used. The residual effect of herbicide applied to one crop may be toxic to the succeeding crop. With the advent of multiple cropping, the use of herbicides has to be carefully regulated. In Maize-wheat copping system, atrazine and pendimethalin herbicides are using for weed management and information on long term effect of herbicides on weed flora and soil in this system is lacing therefore, this experiment is conducted from 2009.

Wheat

Major weeds of the experimental field were: *Phalaris minor, Avena ludoviciana, Lolium temulentum* and *Poa annua* among the grass weeds, *Vicia sativa* and *Anagallis arvensis,* among the broad leaved weeds. Among different weed species, the count and dry matter of *Phalaris minor Avena ludoviciana,* and *Poa annua* was significantly influenced by different treatments at 90 DAS. The weed control treatments except combination of continuous use of butachlor 1.5 kg/ha *fb* 2, 4-DEE with 75% N through fertilizer and 25% N through *Lantana* in rice and continuous use of isoproturon + 2, 4–D in wheat and butachlor 1.5 kg/ha *fb* 2, 4-DEE with 100% N through fertilizer in rice and rotational use of herbicides in wheat behaving statistically similar resulted in significantly lower count of *Phalaris minor*. Irrespective of continuous or rotational use of herbicides with 75% N through fertilizer and 25% N through *Lantana* or 100% N through fertilizer in rice and continuous use of herbicide in wheat behaving statistically similar resulted in significantly lower count and dry weight of *Poa annua,* indicating that use of clodinafop for the control of weeds increased its population and dry weight.

Different treatments did not influence all the yield attributes of wheat significantly. All the weed control treatments except farmers' practice and continuous use of herbicide in combination with100% N through fertilizer in rice and continuous or rotational use of recommended herbicides in wheat improved the yield attributes in wheat. Irrespective of continuous or rotational use of herbicides in rice or wheat, use of 75% N through fertilizer and 25% N through *Lantana* in rice resulted in significantly higher grain yield of wheat.

Beneficial soil microflora population and other important soil activity in long-term effect of continuous use of herbicides revealed that the total beneficial microorganisms i.e. *Azotobacter* and phosphate solublising microorganism population was not affected significantly by various treatments at the time of harvesing stage of wheat. However, the population of *Azotobacter* was numerically less over farmer practice in all the treatments. The population of total phosphate solublising microorganisms was also not influenced significantly by various treatments. The dehydrogenase activity of soil was not affected significantly by different treatments. Microbial biomass Carbon of the soil showed numerically highest value (972.45 µg/g soil) was recorded in farmer's practice, followed by isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha) (881.28 µg/g soil).

Rice

Major weeds of the experimental field were: *Echinochloa colona, Ammania baccifera* and *Cyperus iria* with minor population of *Erioclon spp., and* others. Among different weed species, the count and dry matter of *Echinochloa colona* was significantly influenced by different treatments at 60 DAS (Table 3.7.8). The species wise weed count and dry weight at 60 DAS in rice revealed that farmers' practice being statistically at par with combination of continuous use of butachlor 1.5 kg/ha *fb*. 2, 4-DEE with100% N through fertilizer in rice and rotational use of herbicide in wheat, combinations of continuous use of butachlor 1.5 kg/ha *fb*. 2, 4-DEE with 75% N through fertilizer and 25% N through *Lantana* in rice and rotational use of herbicide in wheat and rotational use of cyhalofop butyl/butachlor in rice with 100% N through fertilizer in rice and rotational use of herbicides in wheat resulted in significantly lower population and dry weight of *Echinochloa colona*. The population of other weed species was not influenced significantly by different treatments.

Total weed count and total weed dry matter were influenced significantly by different treatments at both the stages of observation. Farmers' practice resulted in significantly lowest count and dry weight of all the weeds as compared to other weed control treatments at 60 DAS. All the weed control treatments, irrespective of sources of nitrogen application and continuous or rotational use of herbicide in both the crops. Rotational use of herbicide with 75% N through fertilizer + 25% N through *Lantana* in rice and continuous or rotational use of isoproturon + 2, 4 – D in wheat and combination of continuous use of butachlor 1.5 kg/ha *fb*. 2, 4-DEE with 100%N through fertilizer in rice and rotational use of herbicides in wheat behaving statistically similar resulted in significantly lower total weed dry matter at harvest as compared to other treatments.Different treatments significantly improved the plant height and resulted in taller plants of the rice. Irrespective of continuous or rotational use of herbicides in rice and wheat, use of 75% N through fertilizer + 25% N through *Lantana* in rice resulted in significantly higher grain yield of rice over remaining treatment combinations.

Population of total beneficial microorganisms *viz*. *Azotobacter* and phosphate solublising microorganism at the time of harvesting of rice was not effected significantly in various treatments. Similarly, the dehydrogenase activity was not affected significantly by different treatments. Microbial phosphatases activitiy showed that the acid phosphatase enzyme not affected significantly in various treatments.

AAU, Jorhat

Long-term trial on weed management in rice-wheat cropping system

Wheat (14[th] crop)

Weed species, *viz*. *Polygonum* and *Stellaria* were the highest populated weeds in the field during *rabi* season. Broadleaved weeds *Polygonum plebeium, Ririppa dubia* and *Stellaria media*, along with grass *Cynodon dactylon* and *Eleusine indica* emerged in the field within 7-14 days after emergence of wheat. Weed control treatment imposed on the preceding crop (rice) significantly affected the weed density and weed dry weight in wheat. The lowest weed density and dry weight were recorded with pretilachlor 750 g/ha applied to preceding rice crop. However the effect was not observed at harvest of the succeeding wheat crop. Among different weed management treatment imposed on wheat crop, isoproturon 0.75 kg/ha + surfactant resulted lowest weed density and dry weight at both the growth stages which was closely followed by isoproturon 0.75 kg/ha + 1% urea.

Various weed management treatment adopted in preceding rice crop could bring about significant effect on the microbiological population in soil. The *Azotobacter* and PSB population were relatively higher in soil under weedy check as well as mechanical weeding method. Application of herbicides i.e. butachlor 1.5 kg/ha or pretilachlor 0.75 kg/ha resulted relatively lower count of all the three soil microbial population. Similarly, in wheat crop also, the weedy check treatment resulted relatively higher microbiological population followed by mechanical weeding and herbicide application resulted relatively lower microbiological population (Table 3.7.1.5).

Rice (15[th] crop)

In 2013, the narrow-leaved were more active in the rice crop. Amongst these narrow leaf weeds, *Cyperus iria* and *Scirpus* spp. emerged early and prevailed in the field atleast the entire critical period of crop weed competition, these were however, controlled effectively by the herbicides tested. Among the grasses the most common species were *Cynodon dactylon, Eragrostis unioloides, Echinochloa crusgalli, Leersia hexandra* and *Paspalum distichum*. Broadleaved weeds like *Ageratum houstonianum, Ludwigia linifolia* and *Cuphea balsamona* also appeared early in the field. *Commelina diffusa, Eclipta prostrata* and *Marsilea minuta* emerged about a month later. Application of either of butachlor 1000g/ha or pretilachlor 750 g/ha significantly reduced weed density and dry weight at all crop growth stages as compared to weedy check and mechanical weeding. Treatments applied to wheat did not have any residual effect on weeds in transplanted rice crop. Grain yield of rice was also significantly improved due to butachlor or pretilachlor application (Table 3.7.1.5). This could be attributed to effective control of weeds under these treatments. Weed management treatments in wheat failed to bring about any significant effect on growth, yield attributes and grain yield of rice.

Table 3.7.1.5: Effect of long-term weed management practices on weed growth and yield of wheat-rice cropping system at Jorhat

Treatment	Wheat			Rice		
	Weed density 30 DAS (no./m²)	Weed dry weight at 30 DAS (g/m²)	Grain yield (t/ha)	Weed density at 60 DAT (no./m²)	Weed dry weight 60 at DAT (g/m²)	Grain yield (t/ha)
Treatments to rice						
Weedy	44.6	37.3	1.11	76.2	42.0	2.58
Mechanical weeding	30.3	25.3	1.17	39.1	36.3	2.99
Butachlor 1000 g/ha	24.5	24.7	1.16	34.1	26.2	3.47
Pretilachlor 750 g/ha	22.5	20.6	1.17	33.5	27.4	3.45
LSD (P=0.05)	4.2	3.0	NS	4.4	4.2	2.7
Treatments to wheat						
Weedy	40.5	33.8	1.02	46.3	32.5	3.14
Mechanical	35.1	32.1	1.14	48.5	32.1	3.17
Isoproturon 1 kg/ha	27.5	26.0	1.16	43.0	33.3	3.14
Isoproturon 0.75 kg/ha + 1% urea	25.4	24.6	1.22	44.0	31.5	3.04
Isoproturon 0.75 kg/ha + surfactant	24.0	18.2	1.24	47.3	35.5	NS
LSD (P=0.05)	4.73	3.37	0.129	NS	NS	1.14

NDUAT, Faizabad

Long-term herbicide trial in rice-wheat cropping system

Phalaris minor among grasses and *Anagallis arvensis, Chenopodium album, Melilotus spp. Coronopus didymus* and *Medicago denticulata* in wheat field. Some other weeds, *viz. Vicia sativa, Lathyrus aphaca* and *Rumex acetosella* were sparsely present in the wheat field. Tank-mix application of isoproturon @ 1.0 kg + 2,4-D Na salt @ 0.5 kg/ha being at par with hand weeding 20 & 40 DAS showed effective control of weeds as compared to weedy treatment. The effect of *kharif* season treatments have been found to be helpful to reduce the weed density in wheat crop. During *rabi* season, weed control treatments interacted with *kharif* season treatments when mechanical weeding twice done in plots during *kharif* season where isoproturon @ 1.0 kg + 2,4-D Na salt @ 0.5 kg/ha provided the lowest weed density as compared to rest of the weed control treatments. Application of isoproturon @ 1.0 kg + 2, 4-D Na salt @ 0.5 kg/ha (tank-mix) being at par to HW 20 & 40 DAS provided significantly higher grain yield than weedy treatment. The treatments applied during *kharif* season in rice had their significant effect on grain yield in rice-wheat cropping system. Hand weeding being at par to butachlor @ 1.5 kg/ha encouraged the grain yield of wheat during *rabi* season. A major shift in weed flora was not observed. No resistant biotype of *P. minor* against isoproturon 1000 g/ha was recorded in the experiment.

WS 3.7.2 Long-term herbicide trial in transplanted rice under rice-wheat cropping system

Among grassy weeds, *Ecinochloa colona, E. crus-galli* and *Paspalum sp.* existed predominantly while *Fimbristylis dichotoma* and *C. iria* of sedges group existed with the highest population. BLWs included *Ammannia baccifera, Eclipta alba, Lindernia spp. Caesulia axillaris* and *Phyllanthus niruri* were also recorded. The effect of *kharif* season treatments on weed density was significant only when application of butachlor @ 1.5 kg/ha provided promising effects to reduce the weed density as compared to weedy and HW 20 & 40 DAS. Pre-emergence application of butachlor @ 1.5 kg/ha being at par to HW 20 and 40 DAS provided significantly higher grain yield than weedy treatment. No considerable variation in grain yield due to *rabi* season treatments and interaction of both rabi and *kharif* seasons were observed. There was no certain trend in change of weed shift due to different treatments being used for the last several years. However, a few new weeds, *viz., C. axillaris, Rumex spp* and *Lindernia spp.* were recorded in the weedy plots.

Weed control treatments applied during *rabi* and *kharif* season did not show any significant effect on bulk density, pH, EC and organic C in the soil at initial and at harvest stage of the wheat and rice crop. However on microbial properties i.e. free living N_2 fixing bacteria (FLNB), Phosphate solubilizing bacteria (PSB), Soil Respiration (SR), Per cent Root Colonization (PRC), alkaline-P, acid-P and Dehydrogenase Activity (DHA) showed significant effect at initial and at harvest stage during *rabi* and *kharif* season 2013. At harvest, maximum FLNB (17.5 and 20.5 cfu × 10^4/g), PSB (17.0 and 17.3 cfu × 10^4/g), SBC (142.6 and 137.5), SR (0.38 and 0.45 mg CO_2/ 100 soil/d), acid-P (107.0 and 105.5 µgp-NP/h/g), alkaline-P (187.6 and 194.4 µp-NP/h/g) and DHA (0.40 and 0.42 µg TPF/h/g) were recorded in two hand weeding treatment (K_1 and R_1) during *kharif* and *rabi* season 2013 respectively. This was mainly due mechanical weeding, sunlight and aeration effect. Hand weeding also allowed to facilitate the growth of microorganisms.

CCSHAU, Hisar

Studies on long-term effect of continuous or rotational use of herbicides with or without green manuring in rice-wheat sequence (permanent trial)

Wheat

Clodinafop at 60 g/ha as a continuously used herbicide provided effective control of *P. minor* and was at par with weed free check (Table 3.7.2.1). Reduction in density and dry weight of weeds was observed under both green manure and without green-manure situation under herbicide treated plots as compared to weedy check. Density and dry weight of *P. minor* was more under green manured plots than non-green manured plots. Broadleaf weeds were less under green manured plots than non-green manured plots, however, the differences in individual weed species were not always significant. Herbicide treated plots significantly increased the effective tillers and grain yield of wheat compared to weedy check under both with and without green manure condition. The grain yields under different treatments were also more in green manured plots than non-green manured plots. The continuous or rotational use of clodinafop provided comparable yields with weed free plots under both the situations of green manuring. More net returns and higher B:C ratio was realized under herbicide treated plots as compared to weed free and weedy checks, and the net returns and B:C ratio increased due to green manuring. There was no significant effect of green manuring and other treatments on bulk density of soil at 0-5 cm and 5-10 cm depth observed after harvest of the crop.

Table 3.7.2.1: Effect of continuous or rotational use of herbicides on weed growth, yield and economics of wheat during *rabi* 2012-13 at Hisar

Treatment	Dry weight of weeds (g/m^2)		Grain yield (t/ha)	Net returns (x10^3 ₹/ha)		B:C ratio		Bulk density of soil (after crop harvest)	
	Grassy	BLW		Over VC	Over TC	Over VC	Over TC	0-5 cm	5-10 cm
With green manuring									
Fix herbicide	1.8	5.3	5.43	63.72	19.87	3.23	1.27	1.28	1.47
Rotational herbicide	2.2	9.1	5.44	63.13	19.23	3.17	1.26	1.35	1.48
Weed free	0.0	0.0	5.59	52.09	6.79	2.21	1.08	1.40	1.39
Weedy check	41.6	1.1	3.69	36.32	-7.35	2.36	0.90	1.52	1.58
Without green manuring									
Fix herbicide	1.6	4.4	5.13	58.59	14.74	3.05	1.20	1.43	1.55
Rotational herbicide	1.6	4.9	5.13	57.63	13.72	2.98	1.19	1.49	1.54
Weed free	0.0	0.0	5.49	49.68	4.38	2.16	1.05	1.46	1.43
Weedy check	25.6	1.0	3.20	28.70	-14.98	2.07	0.79	1.53	1.50
SEm±	0.9	0.7	0.10					0.10	0.08
LSD(P= 0.05)	2.9	2.1	0.32					NS	NS

Rice

Continuous use of butachlor or rotational use of anilofos provided almost complete control of all type of weeds under both the situations of green manuring (Table 3.7.2.2). Under weedy checks, density and dry weight of *Echinochloa crus-galli* was more under green manuring. Effective tillers and grain yield of rice under different treatments were increased significantly due to green manuring. Similarly higher net returns and B:C ratio were realized under green manuring than non-green manuring. Also, net returns and B:C ratio were more under herbicide treated plots than weed free and weedy checks. Bulk density of the soil after harvest of rice crop was not affected due to different treatments.

Table 3.7.2.2: Effect of continuous and rotational use of herbicides on weed growth, yield and economics of rice during *kharif* 2013 at Hisar

Treatment	Dry weight of weeds (g/m^2)			Grain yield (t/ha)	Net returns (x10^3 ₹/ha)		B:C ratio		Bulk density of soil after crop harvest	
	Grass weeds	Sedges	BLW		Over VC	Over TC	Over VC	Over TC	0-5 cm	5-10 cm
With green manuring										
Fix herbicide	0.0	0.1	0.5	6.70	53.28	13.16	2.36	1.17	1.47	1.56
Rotational herbicide	0.0	0.1	0.5	6.64	52.46	12.34	2.34	1.16	1.50	1.61
Weed free	0.0	0.0	0.0	6.62	42.53	1.08	1.85	1.01	1.44	1.68
Weedy check	321.5	0.4	0.6	4.87	29.36	-10.64	1.75	0.86	1.44	1.62
Without green manuring										
Fix herbicide	0.0	0.0	0.0	5.67	39.32	-0.78	1.99	0.99	1.45	1.63
Rotational herbicide	0.0	0.0	1.0	5.64	39.02	-1.09	1.99	0.99	1.44	1.64
Weed free	0.0	0.0	0.0	5.59	28.59	-12.85	1.56	0.85	1.48	1.64
Weedy check	251.0	0.3	0.4	4.03	18.12	-21.89	1.45	0.71	1.48	1.58
SEm ±	28.9	0.2	0.2	0.15	-	-	-	-	0.07	0.05
LSD (P=0.05)	87.8	NS	NS	0.45	-	-	-	-	NS	NS

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

WS 3.7.2. Rice–rice cropping system

UAS, Bengaluru

Major weed flora were: *Cyperus difformis, Fimbristylis miliacea, Scirpus sp.* (sedges), *Paspalum dilatatum* and *Echinochloa crussgalli* (grasses), *Ludwigia parviflora, Spilanthes acmella, Eclipta alba, Dopatrium junceum, Glinus Marselia quadrifoliata, Rotala verticillaris* (among broad leaf weeds). At 30, 60 DAS and harvest broad leaf weeds dominated followed by sedges and grasses. Among different weed species *Fimbristylis miliacea, Scirpus* sp. *Spilanthes acmella, Eclipta alba* and *Dopatrium junceum* were dominant.

Hand weeding recorded significantly lower weed density and dry weight compared to herbicide application treatments. Among herbicide treatments, application of butachlor + 2,4-D EE in both the seasons or *fb* pretilachlor during summer showed slightly lower density of sedges and broad leaf weeds at 30, 60 DAP and harvest than the use of butachlor + 2,4-D EE in both the seasons due to effective control of sedges and broad leaf weeds with pretilachlor compared to butachlor herbicide. Weed management practices significantly influence the paddy grain, straw yield and number of panicles/m^2 during 2013 summer. Imposing two hand weedings at 20 and 45 DAP recorded significantly higher paddy grain yield (6.30 t/ha), straw yield (8.11 t/ha) and panicles/m^2 (423) compared to application of butachlor + 2,4-D EE during both summer and *kharif*. Application of butachlor + 2,4-D EE during both *kharif fb* pretilachlor 0.75 kg/ha during summer resulted in on par grain, straw yield and panicles/m^2 compared to two hand weedings due to effective control of sedges and broad leaf weeds with the pretilachlor and grasses with the butachlor herbicide.

Soil physico-chemical properties

The changes in pH, EC, bulk density, organic carbon, contents of P_2O_5 and K_2O were not observed due to herbicides or weed management practices when compared to initial values over a period of 1999 to 2013.

Soil microflora

The use of herbicides over 28 seasons did not lower the microbial counts as compared to hand weeding. The microbial counts were slightly higher in treatments receiving FYM than mere use of fertilizers only. Herbicides did not restrict the plant growth promoting bacteria, P solubilizer and cellulose decomposing fungi as compared to hand weeding and initial values recorded in *kharif* 2006. The herbicides' application did not affect the microbial activity, nitrogen fixers, P- solubilisers, urease activity and dehydrogenase activities in lowland rice–rice system compared to summer 2012.

Kharif Transplanted rice (2013)

Major weed flora observed in the experimental plots was *Cyperus difformis, Fimbristylis miliacea, Scirpus* sp. (sedges), *Panicum dilatatum* and *Echinochloa colona* (grasses), *Ludwigia parviflora, Dopatrium junceum, Spillanthus acmella, Marselia quadrifoliata. Eclipta alba* and Glinus *oppositilium* (among broad leaf weeds). *Fimbristylis miliacea, Scirpus* sp. *Spillanthus acmella* and *Dopatrium junceum* were the dominat weed species at 30, 60 DAP and at harvest.

Rice grain yield recorded in hand weeding was significantly higher compared to herbicide applied treatments. Among herbicide applied plots butachlor + 2, 4-D EE during both *kharif fb* pretilachlor 0.75 kg ai/ha during summer recorded numerically higher grain yield compared to application of butachlor + 2, 4-D EE during both summer and *kharif* indicating the efficacy of the herbicides in effectively controlling sedges and broad-leaved weeds (Fig. 3.7.2.1). The sources of fertility levels did not significantly influenced the grain yield of paddy, however continuous application of FYM + fertilizer treatments for the past 29 seasons resulted in higher yield compared to application of only inorganic source of nutrients. The interaction effect was not significant.

Mean data of 29 seasons indicate application of pretilachlor during summer *fb* butachlor + 2,4-D EE during *kharif* resulted in 4.5 % higher rice grain yield than application of butachlor + 2,4-D EE both during

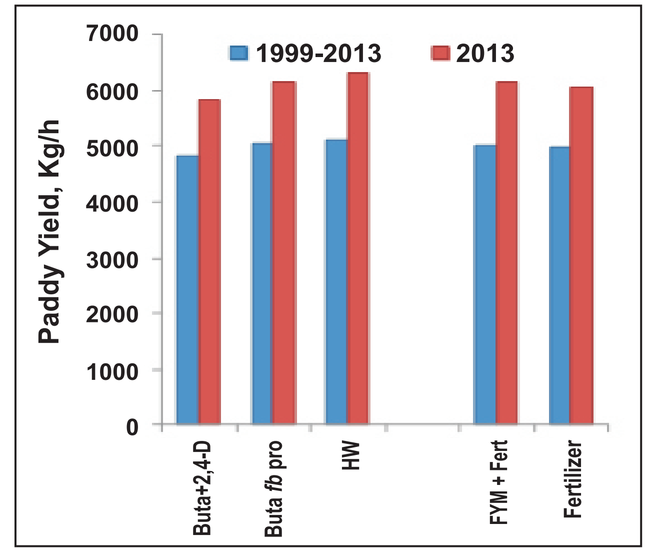


Fig.3.7.2.1: Effect of weed control treatments and sources of fertility on grain yield (kg/ha) during 2013 summer in comparison with average yield of 1999 to 2013 summer in transplanted rice at Kathalagere

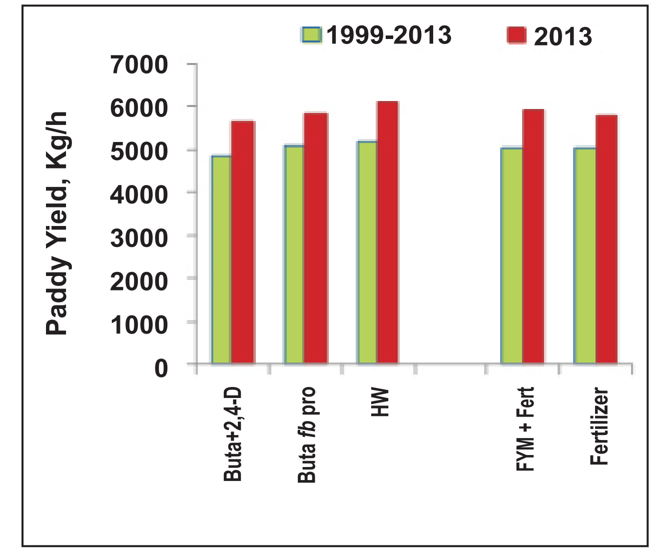


Fig. 3.7.2.2: Effect of weed control treatments and sources of fertility on grain yield in transplanted rice during 1999 to *kharif* 2013 at Kathalagere, UAS, Bengaluru

kharif and summer. Use of herbicides was cheaper than manual weeding and treatment involving application of pretilachlor during summer *fb* butachlor + 2,4-D EE during *kharif* resulted in a saving in weeding cost of Rs. 9600 compared to manual weeding without much sacrifice in paddy grain yield (Fig. 3.7.2.2).

AAU, Jorhat

Long-term herbicidal trial in rice-rice cropping sequence

Autumn rice:

Because of continuous cultivation and herbicide application for a prolonged period, the experiment has experienced a great reduction in species diversity of weed flora. Submerged seedlings of *Monochoria vaginalis* and *Sagittaria guayanensis* with linear fronds and some seedlings of *Scirpus* were the early appeared weed in the field. These species, along with *Cyperus iria* and *Eleocharis acutangula* were the other common species prevailing in the autumn season.

All the weed management treatments caused significant reduction in weed density and dry weight as compared to farmers' practice. Weed density and dry weight at different crop growth stages under the treatments butachlor + 2,4-D (75% NPK through chemical fertilizer, 25% through organic source), Butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) and butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) were similar. The grain and straw yield were also significantly affected by the treatments. All the treatments recorded higher yields over farmers' practice. The highest yields were obtained with butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source) and butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer).

Winter rice

In *kharif* rice, *Monochoria vaginalis, Ceratophyllum-Utricularia* complex and *Sphenoclea zeylanica* were the common broadleaved species. *Sagittaria guayanensis,* which prevailed in the field during autumn rice period, disappeared in the *kharif* season. *Leersia hexandra and Oryza rufipogon amongst the grasses, and Eocharis acutangula and Scirpus spp.* All the chemical weed management treatments resulted significantly lower values as compared to farmers' practice. However in general, application of butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) resulted relatively lower weed density and dry weight at all crop growth stages. Highest values of yield attributes were achieved with butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source). It was closely followed by butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer). Grain and straw yields obtained in these two treatments were also highest (Table 3.7.2.3). However, treatment with butachlor + 2,4-D (75% NPK through chemical fertilizer, 25% through organic source) was at par with the above treatments.

Table 3.7.2.3: Effect of long-term application of herbicides in autumn rice–winter rice cropping system at Jorhat

Treatment	Autumn rice			Winter rice		
	Weed density at 60 DAT (no./m²)	Weed dry weight at 60 DAT (g/m²)	Grain yield (t/ha)	Weed density at 60 DAT (no./m²)	Weed dry weight at 60 DAT (g/m²)	Grain yield (t/ha)
Farmers' practice (one HW)	56.3	36.1	2.21	51.2	33.7	3.62
Butachlor + 2,4-D (100% NPK through chemical fertilizer)	38.3	26.1	2.67	37.8	21.1	4.04
Butachlor + 2,4-D (75% NPK through chemical fertilizer, 25% through organic source)	26.2	24.7	2.62	28.5	23.2	4.26
Butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer)	25.0	24.1	2.85	22.5	20.7	4.56
Butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source)	26.3	23.3	2.83	25.0	21.1	4.60
LSD (P=0.05)	6.3	3.7	0.45	6.3	2.6	0.43
CV (%)	15.1	11.4	1.40	15.7	8.9	0.83

TNAU, Coimbatore

Permanent herbicide trial in transplanted lowland rice-rice cropping system

Common weed flora consisted of grasses, *viz. Echinochloa crus-galli* and *Panicum repens;* sedges *viz., Cyperus difformis* and broad leaved weeds (BLW) *viz., Marsilea quadrifolia, Ammania baccifera, Ludwigia parviflora* and *Eclipta alba*. Among the broad leaved weeds *Marsilea quadrifolia, Ammania baccifera, Cyperus difformis* under sedges and *Echinochloa crusgalli* under grasses were the dominant species. Grass weed density was increased in all the treatments when compared to I crop. However, *Echinochloa colona* and *Leptochloa chinensis* which were present in I crop were completely absent in XXVI and XXVII crop. The total sedge density was decreased in chemical treatment plots when compared to hand weeding plots. Broad leaved weed density was higher in hand weeding treatments (60 DAT) when compared to chemical treatments in XXVII crop.

During 60 DAT, lower weed density was observed in the plots which received herbicides when compared to hand weeding plots. Treatments which received 100% inorganic nitrogen recorded higher weed density than integration of nutrients. In both seasons *rabi* (2012-13) and *kharif* (2013), rotational application of herbicides, butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) with integration of nutrients (W_3N_2) recorded significantly lesser weed dry weight at 60 DAT. Among different treatments, weed control by chemical methods with integration of nutrients recorded maximum grain yield in transplanted lowland rice-rice cropping system. In both the seasons, higher grain yield was obtained with butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) with integration of nutrients (W_3N_2) which was on par with butachlor + 2,4-DEE with integration of nutrients (W_2N_2) (Table 3.7.2.4).

During *rabi* (2012-13), higher cost of cultivation (₹ 27,041) was obtained by hand weeding twice, with 100% inorganic nitrogen and with integration of nutrients . The lower cost of cultivation of ₹ 18,997 was obtained by butachlor + 2,4-DEE with and without integration of nutrients. The gross return was higher with herbicide rotation, butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) along with integration of nutrients (₹ 68,313). In *kharif* (2013), higher net returns of ₹ 47,879 were recorded with butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) with integration of nutrients. Higher benefit cost ratio (3.49) was recorded with butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) with 100% inorganic nitrogen. Benefit : cost ratio (2.27) was lower with hand weeding twice with integration of nutrients (Table 3.7.2.5).

Soil chemical and biological properties

Higher bacterial, fungal and actinomycetes population was registered under butachlor + 2,4-DEE (*kharif*) and pretilachlor + 2,4-DEE (*rabi*) along with integration of nutrients and it was on par with butachlor + 2,4-DEE with integration of nutrients. Application of 100% N as inorganic recorded less microbial population when compared to integration of nutrients.

Table 3.7.2.4: Total weed density and dry weight (60 DAT) as influenced by long-term herbicide and sources of N in rice-rice cropping system (*rabi*, 2012-13 & *kharif*, 2013)

Treatment	Sources of N		Total weed density (no./m²)			Total weed dry weight (g/m²)		
	Inorganic	Organic	1st crop	26th crop	27th crop	1st crop	26th crop	27th crop
W_1N_1 - Hand weeding twice	100%	-	41.7	62.7	40.5	18.4	76.4	35.9
W_1N_2 - Hand weeding twice	75%	25%	35.1	56.5	25.8	13.9	58.6	25.6
W_2N_1 - Butachlor 0.75 + 2,4 -DEE 0.4 kg/ha	100%	-	32.8	42.8	24.5	20.9	45.9	18.3
W_2N_2 - Butachlor 0.75 + 2,4 -DEE 0.4 kg/ha	75%	25%	27.5	31.5	17.5	16.3	34.8	14.0
W_3N_1 - Butachlor 0.75 + 2,4 -DEE 0.4 kg/ha - Pretilachlor 0.75+ 2,4 -DEE 0.4 kg/ha	100%	-	31.5	39.3	21.8	21.0	40.7	19.5
W_3N_2 - Butachlor 0.75 + 2,4-DEE 0.4 kg/ha - Pretilachlor 0.75+ 2,4 -DEE 0.4 kg/ha	75%	25%	26.4	27.3	15.3	15.8	26.5	12.8
SEd			3.7	4.2	3.5	1.5	2.9	2.9
LSD (P=0.05)			7.9	8.8	1.7	3.4	6.5	1.4

Table 3.7.2.5: Grain yield and economics of rice as influenced by long-term herbicide and sources of N in rice-rice cropping system

Treatment	Sources of N		Grain yield (t/ha)		*Rabi* 2012-13		*Kharif* 2013	
	Inorganic	Organic	*Rabi* (2012-13)	*Kharif* (2013)	Net returns (x10³ ₹/ha)	B:C ratio	Net returns (x10³ ₹/ha)	B:C ratio
W_1N_1 - Hand weeding twice	100 %	-	5.35	4.82	33.69	2.25	32.24	2.34
W_1N_2 - Hand weeding twice	75 %	25 %	5.54	5.35	36.28	2.34	34.78	2.27
W_2N_1 - Butachlor 0.75 + 2,4-DEE 0.4 kg/ha	100 %	-	5.66	5.57	45.75	3.41	46.15	3.46
W_2N_2 - Butachlor 0.75 + 2,4-DEE 0.4 kg/ha	75 %	25 %	5.82	5.80	47.57	3.50	45.83	3.07
W_3N_1 - Butachlor 0.75 + 2,4-DEE 0.4 kg/ha -pretilachlor 0.75 + 2,4-DEE 0.4 kg/ha	100 %	-	5.78	5.60	46.90	3.44	46.76	3.49
W_3N_2 - Butachlor 0.75 + 2,4-DEE 0.4 kg/ha -pretilachlor 0.75 + 2,4-DEE 0.4 kg/ha	75 %	25 %	5.98	5.99	49.11	3.56	47.87	3.17
SEd			0.15	0.17	-	-	-	-
LSD (P=0.05)			0.32	0.35	-	-	-	-

WS 3.7.3 Rice-groundnut cropping system

Long-term herbicidal trial in rice-groundnut system

OUAT, Bhubaneswar

The composition of weed flora in *rabi* groundnut (2012-13) was dominated with grasses (51.7%) followed by broad leaf (34.9%) and sedges (13.4%) at initial stages (25 DAS). Use of butachlor + 2, 4-DEE rotated with pretilachlor without OM in rice along with application of alachlor in groundnut recorded significantly the lowest weed density (62.5/m^2) in groundnut during initial stages of crop growth (25 DAS). There was a shift of *Celosia argentea* from alachlor treatment to hand weeding and butachlor treated plots was observed in *rabi* groundnut. Addition of organic matter to rice though increased the weed population marginally (18.9%), was effective in increasing pod yield of groundnut by 8.3%. Although hand weeding and earthing-up in groundnut produced the highest yield (2.12 t/ha), application of alachlor 1.0 kg/ha to groundnut was found to be superior in terms of yield (2.04 t/ha) and weed control.

In *kharif* rice (2013), during the initial stages of crop growth (25 DAS), use of herbicides reduced the weed density by 71.5 % over hand weeding and the treatment of butachlor 0.75 kg/ha + 2,4-DEE 0.4 kg/ha without OM recorded the lowest weed density of 44.0/m^2 (Table 3.7.3.1)The increase in weed biomass due to organic matter is in tune of 11.4% at 25 DAS, 10 % at 60 DAS and by 7% at harvest. Incorporation of OM over the years increased the grain yield in the tune of 3.2 % over the treatments without OM and the grain yield of herbicidal treatments was at par. Practice of two hand weeding along with OM to rice and hand weeding with earthing-up in groundnut produced the highest REY of 11.77 t/ha. But application of butachlor + 2,4D EE without OM to rice and alachlor to groundnut recorded the highest B:C ratio of 1.81.

Table 3.7.3.1: Effect of weed control measures on weed growth and yield of direct-sown rice during *kharif* season (2013) at Bhubaneswar

Treatment	Weed density 60DAS (no./m²)	Weed biomass 60 DAS (g/m²)	Grain yield (t/ha)	Straw yield (t/ha)
HW (2) – OM	25.7	18.4	3.57	5.07
HW (2) + OM	29.4	20.9	3.69	5.42
Butachlor 0.75 kg/ha + 2, 4-DEE 0.4 kg/ha - OM	54.4	31.2	3.47	5.00
Butachlor 0.75 kg/ha + 2, 4-DEE 0.4 kg/ha + OM	60.6	34.9	3.58	5.33
Butachlor 0.75 kg/ha + 2, 4-DEE 0.5 kg/ha rotated with pretilachlor 0.75 kg/ha - OM	59.0	34.1	3.43	4.95
Butachlor 0.75 kg/ha + 2, 4-DEE 0.5 kg/ha rotated with pretilachlor 0.75 kg/ha + OM	66.9	37.0	3.51	5.26
SEm±	1.67	0.73	0.05	0.11
LSD (P=0.05)	5.05	2.22	0.16	0.34

WS 3.7.4. Rice-chickpea cropping system

Long-term herbicide trial in rice-chickpea cropping system

IGKV, Raipur

Echinochloa colona, Ischaemum rugosum among grasses, *Alternanthera triandra, Cynotis axillaries* among broad leaf weeds and *Cyperus iria* among sedges were the predominant weed species observed during all the four years of experimentation. The lowest population of weeds was recorded under the treatment of hand weeding twice, followed by pyrazosulfuron 25 g/ha *fb* hand weeding at 25 DAS but at later stages it was lowest under oxadiargyl @ 80 g/ ha *fb* bispyribac 25 g/ha, next to hand weeding twice, in order. Dry matter of weeds was significantly lower in treatment of hand weeding twice than rest of the treatments. This was followed by oxadiargyl @ 80 g/ ha *fb* bispyribac 25 g/ha and pyrazosulfuron 25 g/ha *fb* hand weeding at 25 DAS, in order. Weed control efficiency also followed similar trend as that of weed dry matter at harvest (Table 3.7.4.1). Significantly higher seed yield was recorded from the treatment of two hand weedings and this was at par with pre emergence application of oxadiargyl 80 g /ha *fb* post-emergence bispyribac 25 g/ha and both were significantly superior over weedy check. Seed

yield was significantly lowest under unweeded control as compared to rest of the weed management treatments. Reduction in seed yield was maximum under unweeded control and minimum under hand weeding twice.

Table 3.7.4.1: Effect of various treatments on weed growth and yield of rice in a long-term herbicide trial during 2013 at Raipur

Treatment	Weed dry weight at 60 DAS (g/m²)	Weed dry weight at harvest (g/m²)	Grain yield (t/ha)	WCE at harvest (%)	Weed index
Oxadiargyl 80 g/ha *fb* bispyribac 25 g/ha	4.69 (21.7)	7.16 (51.2)	4.82	61.0	3.0
Fenoxaprop 60 g/ha + CME + MSM 4 g/ha	6.15 (37.5)	8.05 (64.7)	4.07	51.0	18.0
Pyrazosulfuron 25 g/ha	5.27 (27.5)	7.76 (60.1)	4.45	54.0	11.0
Hand weeding twice	4.25 (17.7)	6.78 (46.0)	5.02	87.40	-
Unweeded control	9.74 (94.6)	11.57 (133.4)	0.46	-	90.0
SEm±	0.07	0.31	0.071	-	-
LSD (P=0.05)	0.22	0.98	0.22	-	-

Figures in the parentheses are original values; data were transformed through $\sqrt{x + 0.5}$

Medicago denticulata, Chenopodium album, Melilotus indica were the predominant weeds in the experimental field of chickpea. Treatments applied to direct seeded rice during *kharif* had no significant effect on dry matter of weeds during subsequent rabi. Similarly, tillage practices also had no significant effect on dry matter production of weeds at any stage. Dry matter was marginally lower under zero tillage than conventional tillage at all the crop growth stages. Among weed control practices, pre-emergence application of pendimethalin @ 1.0 kg /ha produced significantly lowest weed dry matter as compared to weedy check but was at par with farmers' practice at 60 DAS and at harvest (Table 3.7.4.2). Effect of treatments applied to direct seeded rice during *kharif* on seed yield of chickpea during *rabi* was not found significant. However, seed yield of chickpea was slightly higher where oxadiargyl @ 80 g/ha *fb* bispyribac @ 25 g/ha was applied and this was narrowly followed by hand weeding twice. Tillage practices had no significant effect on seed yield of chickpea, though; the seed yield was slightly higher under conventional tillage than zero tillage. The effect of weed control methods was found significant on seed yield of chickpea. Among weed control methods,

Table 3.7.4.2: Effect of long-term application of herbicides on weed growth and yield of chickpea in direct seeded rice-chickpea cropping system at Raipur

Treatment	Dry weight of weeds at 60 DAS (g/m²)	Seed yield (t/ha) 2011-12	Seed yield (t/ha) 2012-13	Weed index (2012-13)
Weed control in rice				
Oxadiargyl @ 80g / ha *fb* Bispyribac @ 25 g/ ha	15.67	1.22	1.24	-
Fenoxaprop + (Chlorimuron + Metsulfuron) @ 60 + 4 g/ha	17.61	1.15	1.16	5.00
Pyrazosulfuron @ 20 g/ha *fb* hand weeding	16.52	1.14	1.12	9.00
Hand weeding twice	10.86	1.20	1.18	4.00
Unweeded	20.74	1.02	1.04	20.00
LSD (P=0.05)	NS	NS	NS	-
Tillage in chickpea				
Conventional tillage	17.97	1.20	1.22	-
Zero tillage	16.79	1.10	1.11	-
LSD (P=0.05)	NS	NS	NS	-
Weed control in chickpea				
Farmer's practice	14.36	1.22	1.39	6.00
Pendimethalin @ 1.0 kg/ ha	11.51	1.47	1.48	-
Control	23.29	0.61	0.62	58.00
LSD (P= 0.05)	2.95	0.13	0.12	-

pre-emergence application of pendimethalin @ 1.0 kg/ha produced significantly higher seed yield as compared to weedy check but was at par with farmers' practice, respectively.

WS 3.7.5. Rice-mustard cropping system

VB, Sriniketan

Long-term herbicide trial in rice-mustard cropping system

In the initial year (*kharif* 1999), *Hydrolea zeylanica, Fimbristylis miliacea* were pre-dominant, whereas in final year (*kharif* 2013), *Cynodon dactylon, Lindernia ciliata* and *Fimbristylis miliacea,* appeared as pre-dominant in rice. In mustard, *Digitaria sanguinalis* was dominant in initial year (*rabi* 1999-2000) whereas in final year (*Rabi* 2012-2013), *Cynodon dactylon, Echinochloa colona, Ageratum conyzoides, Gnaphalium purpureum* and *Polygonum plebeium* were predominant weed species along with *Digitaria sanguinalis.* Repeated and rotational application of pretilachlor / butachlor resulted in disappearance of *Hydrolea zeylanica*, increasing the density of *Fimbristylis miliacea, Lindernia ciliate* and Cynodon *dactylon.* Repeated use of pendimethalin resulted in the decrease of *Digitaria sanguinalis as compared to* isoproturon (rotational), new appearance of *Polygonum plebeuim* and *Solanum nigram* as well as increase in density of *Cynodon dactylon* in mustard.

Mustard (*Rabi* 2012-13)

Almost all the weed species, viz. *Digitaria sanguinalis, Echinochloa colona, Anagallis arvensis, Croton bonplandianum, Polygonum plebeium, Spergula arvensis, Solanum nigram, Spilanthes acmella, Physalis minima, Chenopodium album, Gnaphalium purpureum* and *Ageratum conyzoides* were successfully controlled by repeated and rotational application of pendimethalin and isoproturon/pendimethalin as compared to farmers practice. Both repeated and rotational application of pendimethalin and isoproturon/pendimethalin controlled the mixed weed flora very effectively. It was also noted that repeated and rotational application of pendimethalin and isoproturn/pendimethalin in addition with fertilizer was found more effective in controlling total weed population as compared to addition of FYM. In case of seed yield of mustard, rotational application of isoproturon/pendimethalin + FYM produced more seed yield as compared to fertilizer application. It was also to be noted that rotational application of isoproturon/pendimethalin in addition to FYM gave more seed yield in the plot where rotational application of pretilachlor/butachlor + O.M. were exercised in previous *kharif* rice. The highest net returns and wider B:C ratio were recorded under rotational application of isoproturon / pendimethalin + FYM (where rotational application of pretilachlor / butachlor + *fb* 2, 4-D + OM was applied in previous *kharif* season) and it was closely followed by rotational application of isoproturon / pendimethalin + fertilizer (where rotational application of pretilachlor / butachlor + *fb* 2, 4-D + OM fertilizer was applied in previous *kharif* season).

Rice (*Kharif* – 2013)

Repeated and rotational application of butachlor and pretilachlor/butachlor did not significantly control *Cynodon dactylon, Alternanthera sessilis, Commelina diffusa, Spilanthes acmella, Cyperus compressus* and *Fimbrystilis dichotoma* as compared to farmers' practice. But, *Digitaria sanguinalis, Panicum repens, Ageratum conyzoides, Lindernia ciliate, Lindernia crustacean, Ludwigia parviflora, Mullogo stricta, Oldenlandia corymbosa, Phyllanthes fraternus, Phyllatnus simplex, Cyperus iria* and *Fimbristylis miliacea* were controlled significantly by repeated and rotational application of pretilachlor/butachlor. The total number of weeds/m^2 differed significantly among the treatments but there were no significant differences in case of dry matter of weeds. Lowest number of total weed population was noticed in rotational application of pretilachlor/butachlor *fb.* 2,4-D + fertilizer and this was closely followed by rotational application of pretilachlor/butachlor *fb.* 2,4-D + OM. In case of grain yield of rice, rotational application of pretilachlor / butachlor + OM produced more grain yield as compared to fertilizer application. The highest net returns and B:C ratio were obtained in rotational use of pretilachlor / butachlor *fb* 2,4-D + OM. Farmers' method of weed control recorded more net returns and B:C ratio were lower as because of high cost of cultivation.

WS 3.7.6. Maize-chickpea cropping system

VNMKV, Parbhani

Long-term herbicide trial in maize-chickpea cropping system

The dominant weed species were: *Acalypha indica, Digera arvensis, Euphorbia geniculata, Parthenium hysterophorus, Ipomoea maxima and Cynodon dactylon.* In maize, weed density was significantly influenced due to various weed control treatments. Significantly lower weed density was observed in atrazine @ 0.75 kg/ha PE *fb.*2,4 - D @ 0.5 kg/ha and highest in weedy check. Dry weed weight at 60 DAS was significantly influenced due to various weed control treatments. Significantly lower dry weed weight at 60 DAS was observed in mechanical weeding and highest in weedy check. In chickpea, weed density was significantly influenced due to various weed control treatments.It was significantly highest in weedy check as compared to all other treatments. Dry weed weight at 60 DAS was significantly influenced due to various weed control treatments. It was significantly highest in weedy check as compared to all other treatments. Maize equivalent yield during both the seasons was significantly highest in mechanical weeding as compared to all other treatments (Table 3.7.6.1). It was lowest in weedy check. Net monetary returns were significantly highest in atrazine @ 0.75 kg/ha PE *fb.*2,4-D @ 0.5 kg/ha as compared to all other treatments. It was lowest in weedy check during *kharif* maize, whereas in rabi chickpea, Net monetary returns were significantly highest in mechanical weeding. B:C ratio was significantly highest in atrazine @ 0.75 kg/ha PE *fb.*2,4-D @ 0.5 kg/ha as compared to all other treatments. It was lowest in weedy check during *kharif* maize, whereas in *rabi* chickpea, net monetary returns were significantly highest in mechanical weeding.

Table : 3.7.6.1: Effect of weed management practices on weed growth and yield performance of maize–chickpea sequence

Treatment	Total weed density at 60 DAS (no./m^2)	Total weed dry weight at 60 DAS (g/m^2)	Maize equivalent yield (t/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
Treatments to maize					
Weedy check	17.6(64.0)	44.3	2.52	7.03	1.33
Mechanical weeding (2)	13.2(36.2)	28.2	3.61	11.22	1.38
Atrazine @ 0.75 kg/ha PE	13.8(39.5)	30.5	3.22	13.34	1.59
Atrazine @ 1.50 kg/ha PE	12.9(35.5)	31.5	3.23	12.80	1.55
Atrazine @ 0.75 kg/ha PE *fb.*2, 4-D @ 0.5 kg/ha	12.3(30.3)	30.1	3.39	14.35	1.62
SEm+			0.034	0.37	0.016
LSD (P=0.05)	1.7	5.6	0.099	1.08	0.046
Treatments to chickpea					
Weedy check	16.9(46.6)	42.8	2.47	3.79	1.16
Mechanical weeding (2)	13.1(30.0)	26.1	3.59	16.14	1.69
Pendimethalin @ 1.0 kg/ha PE	12.7(26.2)	33.2	3.35	13.48	1.57
Pendimethalin @ 0.75 kg/ha PE *fb* mechanical weeding	13.0(27.5)	30.2	3.36	13.58	1.57
SEm±			0.06	0.67	0.02
LSD (P=0.05)	1.5	12.6	0.17	1.95	0.08

Weed data transformed using square root transformation. Original values given in parentheses

UAS, Dharwad

Long-term effect of herbicides on weed seed bank and soil microflora in maize-chickpea cropping system

During *rabi* 2012, the main plots differed significantly with higher chickpea yield in mechanical weeding, followed by atrazine 0.75 kg/ha *fb* 2, 4-D 0.5 kg/ha. Among weed control treatments (Sub plots), mechanical weeding and pendimethalin 0.75 kg/ha + 1HW were on par with each other, but significantly superior over weedy check (Table 3.7.6.2). Among main plot treatments imposed on maize during *kharif* (2013), mechanical weeding and pre-emergence application of atrazine @ 0.75 kg/ha *fb* 2,4-D @ 0.5 kg/ha recorded significantly higher grain yield than other main plot treatments, but they themselves were on par with each other. The total weed density and total weed dry weight were significantly lower in these two treatments. Among subplot treatments, mechanical weeding and pre-emergence application of pendimethalin 0.75 kg/ha *fb* 1 HW gave significantly higher maize grain yields with significantly lower weed density and weed dry weight (Table 3.7.6.3)

Microbiological studies

In *rabi* 2012, highest dehydrogenase activity was recorded with mechanical weeding was observed on 30, 60 and 90 DAS (34.5, 9.4 and 11.9 μg TPF formed/g soil/d) and lowest was recorded with pendimethalin @ 1.0 kg/ha. However, on 60 and 90 DAS higest phosphates activity was recorded with X10^4 CFU/g soil (3.15 and 3.59 μg pnp released/g soil/h). Highest number nodules, nodules dry weight mycorrhizal root colonization was observed with mechanical weeding (30.1, 0.13 and 67.6%). Highest population of N$_2$ fixers and P- solubilizers were enumerated with mechanical weeding (56.25 and 31.75 x 10^4 CFU/g soil). In *kharif* 2013, the soil enzyme activities viz., dehydrogenase, phosphates and urease was highest with mechanical weeding at 30 DAS (4.66 μg TPF formed/g soil/d, 1.89 μg pnp released/g soil/h and 0.22 μgNH$^+$ N/g soil/day). Among the herbicidal molecules, application of atrazine @ 0.75 kg/ha + 2, 4-D @ 0.5 kg/ha at 30 DAS recorded highest population of N$_2$ - fixers (54.50 x 10^4 CFU/g soil), while application of atrazine @ 1.00 kg/ha recorded the lowest population of N$_2$ - fixers (43.75 x 10^4 CFU/g soil).

Table 3.7.6.2: Effect of herbicide and weed control methods on grain yield and economics in chickpea at Dharwad

Treatment	Total weed density (no./m²)	Total weed dry weight (g/m²)	Grain yield (t/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
Treatments to maize					
Weedy check	3.64 (13.0)	3.52 (15.0)	0.82	11.99	1.9
Mechanical weeding	2.55 (6.0)	2.64 (8.0)	0.97	16.59	2.3
Pre-em application of atrazine @ 0.75 kg/ha	2.96 (8.0)	3.12(11.0)	0.89	14.04	2.1
Pre-em application of atrazine @ 1.00 kg/ha	2.81 (7.0)	2.98 (10.0)	0.89	14.31	2.1
Pre-em application of atrazine @ 0.75 kg/ha *fb* post-em 2, 4-D @ 0.5 kg/ha at 30 DAS	2.32 (5.0)	2.42 (6.0)	0.98	16.96	2.3
LSD (P=0.05)	0.4	0.3	0.11	3.33	NS
Treatments to chickpea					
Weedy check	4.56 (20.4)	5.50 (29.9)	0.76	12.47	2.2
Mechanical weeding at 30 and 60 DAS	2.10 (3.5)	1.83 (2.5)	1.00	16.65	2.2
Pre-em application of pendimethalin @ 1.00 kg/ha	2.57 (5.8)	2.50 (5.4)	0.91	14.88	2.2
Pre-em application of pendimethalin @ 0.75 kg/ha + 1HW at 30 DAS	2.21 (1.6)	1.91 (1.1)	0.97	15.11	2.1
LSD (P=0.05)	0.2	0.2	0.04	1.16	0.1

Figures in parenthesis are the original values

Table 3.7.6.3: Effect of herbicides and weed control methods on yield attributes and grain yield in maize at Dharwad

Treatment	Total weed density (no./m²) at 60 DAS	Total weed dry weight (g/m²) at 60 DAS	Grain yield (t/ha)	Net returns (x10³ ₹/ha)	B:C ratio
Treatments to maize					
Weedy check	11.4 (129.1)	9.8 (95.5)	3.78	21.03	2.05
Mechanical weeding	5.2 (26.3)	3.4 (10.5)	5.16	43.67	2.81
Pre-em application of atrazine @ 0.75 kg/ha	7.1 (50.3)	3.7 (12.7)	4.83	41.96	2.95
Pre-em application of atrazine @ 1.00 kg/ha	6.7 (44.7)	3.5 (11.2)	4.98	43.86	2.99
Pre-em application of atrazine @ 0.75 kg/ha *fb* post-em 2, 4-D @ 0.5 kg/ha at 30 DAS	4.5 (19.9)	2.5 (5.4)	5.27	46.82	3.1
LSD (P=0.05)	1.2	0.9	0.16	1.35	0.07
Treatments to chickpea					
Weedy check	7.6 (63.7)	4.9 (30.7)	4.66	37.64	2.70
Mechanical weeding 30 DAS and 60 DAS	7.1 (55.0)	4.5 (26.2)	4.87	40.54	2.83
Pre-em application of Pendimethalin @ 1.0 kg/ha	7.1 (55.1)	4.5 (36.4)	4.76	39.06	2.76
Pre-em application of pendimethalin @ 0.75 kg/ha + 1HW at 30 DAS	6.2 (42.4)	4.3 (24.9)	4.92	40.63	2.83
LSD (P=0.05)	0.2	0.2	0.05	1.01	0.05

Figures in parenthesis are the original values

WS 3.7.7. Maize-wheat cropping system

AAU, Anand

Long-term herbicidal trial in maize-wheat cropping system

The long-term trial on effect of recommended herbicides in maize and wheat cropping system was initiated during 2008-09. The experimental field of maize was infested with *Dactyloctenium aegyptium*, *Eragrostis major*, *Phyllanthus niruri*, *Commelina benghalensis*, *Cyperus rotundus*, *Mulugo nudicuulis*, *Oldenlandia umbellata, Digera arvensis*. *Chenopodium album*, *Cyperus rotundus*, *Eragrostis major* and *Melilotus indica* were observed in wheat.

In maize, weed biomass recorded at 60 DAS and at harvest were found significant due to different weed management practices. Significantly the lowest dry weed weight was recorded in IC + HW carried out at 20 and 40 DAS. Significantly the highest grain yield was recorded in pendimethalin 0.25 kg/ha + atrazine 0.50 kg/ha (tank-mix) applied as PE. Pendimethalin 0.25 kg/ha + atrazine 0.50 kg/ha (tank mix) applied as PE recorded significantly higher straw yield.

In wheat, effect of weed management practices carried out in maize showed significant effect on weed counts as well as weed dry biomass recorded at 30 and 60 DAS and at harvest. Significantly the lower dicot weed dry biomass was recorded in pre-emergence of atrazine @ 1.0 kg/ha. Weed management practices carried out in wheat showed significant effect on weed counts and weed dry biomass recorded at 30 and 60 DAS and at harvest. Weed management practices imposed during the crop period in wheat showed significant effect on grain yield of wheat. Grain yield of wheat recorded in hand weeding carried out at 30 DAS was significantly at par with pre emergence application of pendimethalin @ 500 g/ha. Straw yield was not significantly influenced by the treatments imposed in maize as well as weed management practices carried out in wheat during the crop period.

WS 3.7.8. Groundnut–wheat cropping system

Long-term trial in different cropping systems (groundnut–wheat sequence)

UAS, Dharwad

During *rabi* 2012, the total weed density and total dry weight were significantly lower with metsulfuron methyl compared to other treatments. Wheat yields and net returns were significantly superior with metsulfuron-methyl compared to 2, 4-D, trisulfuron, isoproturon, isoproturon + 2, 4 - D, and metribuzin. In groundnut (*kharif*-2013), weed density and weed dry weight at 60 DAS, all the herbicides treatments along with HW and intercultivations (IC), weed free and farmers' practice were significantly superior over weedy check. All the herbicide treatments, weed free and farmers practice were on par with each other and were significantly superior over weedy check with respect to yield. Alachlor 1.5 kg/ha PE, butachlor 1.5 kg/ha PE, pendimethalin 1.0 kg/ha PE, pretilachlor 1.5 kg/ha PE, oxyfluorfen 0.25 kg/ha PE, Imazethapyr along with two intercultivations (IC) and one HW produced pod yields similar to farmers' practice (two IC + two HW), and weed free. Net returns followed the same trend as that of pod yield. But B:C ratio was significantly lower with farmer's practice (3.01) compared to butachlor.

Microbiological studies

During *rabi* 2012, highest population of N_2 fixers were recorded in the weedy check (92.00 X10 ^{4} CFU / g of soil), while lowest population was recorded with pendimethalin @ 1.00 kg/ha (53.33) and oxyfluorfen 0.25 kg/ha (55.67 X10 ^{4} CFU / g of soil). Among the herbicide molecules highest number of N_2 fixers were enumerated with butachor 1.5kg/ha. Simillar observations were also recorded with MPS flora at 30 DAS. AM colonization was significantly reduced in the treatment pendimethalin @ 1.00(48.60), while butachor 1.5 kg/ha recorded the highest AM root colonization(92.00 per cent) over other molecules. Application of oxyfluorfen 0.25 kg/ha and pendimethalin 1.0kg/ha significantly reduced the soil enzyme activity at all the intervals. In *kharif* 2013, application of alachlor 1.5 kg/ha recorded highest N_2 fixers, P-solubilizers and per cent root colonization (38.67, 23.33 X10 ^{4} CFU / g of soil and 98.00 per cent). The lowest microbial parameters were observed in the treatment pendimethalin 1.0 kg/ha followed with oxyfluorfen 0.25 kg/ha. The higest dehydrogenase, phosphatse and urease activity was measured with the treatment received butachor 1.5 kg/ha (7.94 µg TPF formed/g soil/d, 1.98 µg pnp released/g soil/h and 0.16 µgNH^+ N g/soil/day).

WS 3.7.9. Groundnut- transplanted finger millet cropping system

Long-term herbicide trial in groundnut-transplanted finger millet cropping system

UAS, Bengaluru

A. Groundnut - Summer 2013 (14th crop in the system)

Cyperus rotundus (sedge), *Digitaria marginata, Echinochloa colona, Cynodon dactylon, Chloris barbeta, Eleusine indica and Dactyloctenium aegyptium* (grasses), *Commelina benghalensis, Euphorbia geniculata, Ageratum conyzoides, Borreria articularis, Amaranthus viridis* and *Acanthospermum hispidum* among broadleaved weeds were the dominant weed flora.

Hand weeding at 20 and 40 DAS resulted in significantly lower weed density (sedge, grasses and broad leaved weeds) compared to herbicide application (pendimethalin and alachlor) at 30, 60 DAS and harvest except in case of broad leaf weed at 30 DAS and harvest, total weeds at harvest. Among herbicides, application of pendimethalin resulted in lower weed density and dry weight compared to alachlor application. Sources of nutrients and also interaction of weed management practices with nutrient sources did not significantly influence the weed density and dry weight at 30, 60 DAS and at harvest.

After 14th crop of groundnut, in alachlor applied plots, more grasses (*Digitaria marginata*) and broad-leaf weed (*Spilanthus acmella, Ageratum conyzoides*) density were noticed whereas in pendimethalin applied plots owing to suppression of grasses, more density of sedge (*Cyperus rotundus*) and broad leaf weeds (*Spilanthus acmella, Ageratum conyzoides* and *Commelina benghalensis*) were noticed during 2013 summer compared to 2000 summer. Substantial reduction in the density of sedges and grasses was noticed in hand weeded plots due to uprooting of *Cyperus rotundus* tubers and *Cynodon dactylon* roots. Weed management practices significantly influence the pod yield of groundnut. Hand weeding at 20 and 40 DAS recorded significantly higher pod yield compared to application of herbicides as a result of significant reduction in the weed density and weed dry weight. Among two herbicides, pendimethalin recorded significantly higher pod yield compared to alachlor application due to effective control of sedges and grasses during early stages of crop growth. Between sources of fertility, the pod yield did not differ significantly. However, use of FYM + fertilizer gave marginally higher yield under all weed management practices than fertilizer application alone, indicating the positive effect of organic manure.

Mean data of 14 years, indicated that the pod yield was significantly higher in plot treated with pendimethalin as compared to alachlor, but comparable with hand weeded plots. Grasses offered severe competition to groundnut crop and resulted in significant reduction in the pod yield. Sources of fertility had no significant influence on the pod yield of groundnut however combined application of FYM + inorganic fertilizers over the past fourteen years had positive influence on the soil properties and resulted in higher pod yield as compared to plot applied with fertilizer alone (Fig 3.7.9.1).

It was concluded that pre-emergence application of pendimethalin at 1.0 kg/ha in groundnut is more profitable and productive (15% higher yield) than application of alachlor at 1.0 kg/ha and gave similar yield as that of two hand weedings.

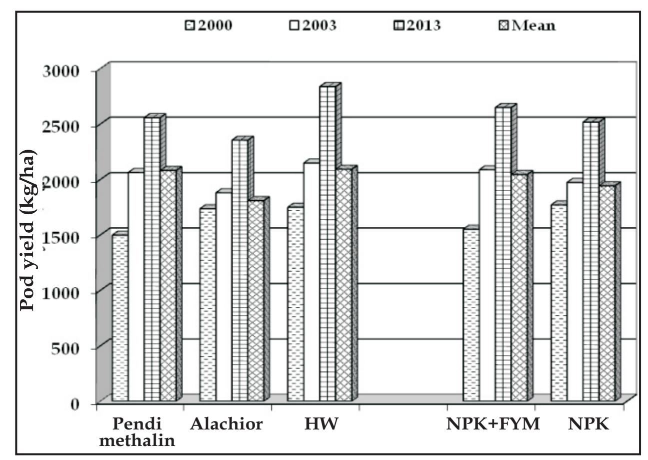


Fig. 3.7.9.1: Effect of treatments on pod yield in groundnut during summer at Hebbal, UAS, Bengaluru

B. Transplanted fingermillet (16th crop of the system, *Kharif* 2013)

Weed flora were: *Cyperus rotundus* (a sedge), *Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium, Echinochloa colona* (among grasses), *Commelina benghalensis, Lagascea mollis, Ageratum conyzoides, Spilanthus acmella, Amaranthus viridis* and *Euphorbia hirta* (among grasses). The density of sedge was higher followed by broad leaf weeds and grasses during 30 and 60 DAP, whereas broad leaf weeds took slightly upper hand towards harvesting stage of fingermillet. Weed management practices significantly influenced the weed density and dry weight at all stages except in case of sedge and broad leaf weed density, broad leaf and total weed dry weight at harvest stage of the fingermillet. Hand weeding at 20 and 40 DAP resulted in significantly lower weed density and dry weight compared to application of herbicides. Among herbicide applied plots, application of butachlor as pre-emergence herbicide at 1.0 kg ai/ha resulted in lower grass density whereas post-emergence application of 2,4 – D Na salt at 0.75 kg ai/ha resulted in lower sedge and broad leaf density but higher grass density which compete with finger millet during the early stages of crop growth.

During *kharif* 1999 among weed management practices the population of grasses, sedge and broad leaf weeds was almost similar between three weed management practices. After fifteen years of study it is evident that continuous application of butachlor has brought down the grass density substantially from 72.8/m^2 in 1999 to 27.4 /m^2 in 2013. Similarly application of 2,4 D Na salt has reduced the broad leaf weed density from 36.4/m^2 in 1999 to 16.9/m^2 in 2013. Continuous removal of weeds by manual weeding has reduced the weed density of all the three categories very effectively from a total weed count of 130.4/m^2 in 1999 to 15.0/m^2 in 2013.

Weed management practices significantly influenced the grain yield of fingermillet. Two hand weedings at 20 and 45 DAP resulted in significantly higher grain yield of finger millet compared to application of post-emergence herbicide 2,4 – D Na salt at 0.75 kg/ha but it was at par with application of butachlor at 0.75 kg/ha. Significantly lower weed density and dry weight recorded in two hand weeding treatment resulted in higher grain yield of fingermillet. The grain yield of finger millet did not differ much due to sources of fertility. The interaction effect was also not significant. Over 15 years (1999 to 2013), the grain yield obtained in finger millet applied with fertilizer only gave yield similar to finger millet receiving 75% fertilizer and FYM. Among weed control treatments, grain yield obtained in hand weeding was similar to the plot treated with butachlor and these were considerably superior to the plot treated with 2,4-D Na salt.

Soil physico-chemical properties

Continuous use of herbicides - alachlor or pendimethalin in groundnut and 2,4-D Na salt or butachlor in finger millet did not affect the soil physico-chemical properties namely pH, EC, bulk density, organic carbon, contents of P and K when compared to initial values over a period of fifteen years from 1999 to 2013. Compared to initial values, the values of these properties were slightly higher in the treatments, indicating no adverse effect of herbicides' applied continuously. Further, application of FYM increased the organic carbon slightly over mere fertilizer application. The continuous application of fertilizers increased the P and K contents in the soil as compared to initial values. Phosphorus build-up was slightly more in fertilizer applied plot than FYM applied plots.

Soil microflora

The use of pendimethalin or alachlor during summer to groundnut did not lower the microbial counts as compared to unsprayed treatments - hand weeding. Continuous use of herbicides had no influence on microbial growth as observed earlier or on beneficial microflora like plant growth promoting bacteria - pseudomonas, P solubilizer, N_2-fixing bacteria and cellulose decomposing fungi in groundnut–fingermillet over a period of fifteen years from 1999 to 2013 on red sandy loam soil under irrigated conditions.

Among weed management practices, over 15 years, use of herbicide butachlor 0.75 kg/ha – 3 DAP was relatively better in controlling grasses and gave yield higher than the plot treated with 2,4-D Na salt 0.75 kg ai/ha (15 DAP) and was similar to hand weeding. Butachlor was effective in suppressing the grasses which were the competitors with finger millet for critical growth resources during the critical period of crop weed competition of finger millet. Although 2,4 –D Na salt was effective against broad-leaf weeds and sedge, grasses emerged in large density and suppressed the growth of fingermillet. Regarding the cost spent on weed management, the use of herbicides was cheaper (Rs. 850 in butachlor to Rs. 1100/ha in 2,4-D Na salt in finger millet and Rs. 1100/ha in alachlor to 1965/ha in pendimethalin in groundnut) than hand weeding (Rs 7200/ha in finger millet and Rs. 6750/ha in groundnut). Continuous use of herbicides either in finger millet or groundnut had no adverse effect on soil physico-chemical properties and soil microbial activity at the time of harvest of crops as compared to unsprayed hand weeding as well as initial value at the time of start of experimentation in 1999. In addition, continuous use of herbicides had no adverse effect on beneficial microflora like plant growth promoting bacteria - pseudomonas, P solubilizer, N_2 fixing bacteria and cellulose decomposing fungi as compared to hand weeded plots in groundnut – finger millet over a period of fourteen years from 1999 to 2012 on red sandy loam soil under irrigated conditions.

WS: 3.7.10. Pearlmillet-wheat cropping system

RVSKVV, Gwalior

Long-term herbicide trial in wheat under pearl millet-wheat cropping system

The dominant weeds associated with wheat were *Cyperus rotundus, Phalaris minor, Chenopodium album, Medicago hispida, Fumaria parviflora* and *Convolvulus arvensis*. Weed population and dry weight of weeds were significantly influenced by different weed management practices except *Cyperus rotundus* at 30 and 60 DAS stages. Isoproturon 0.75 kg/ha as POE and its combination with 2,4-D 0.5 kg/ha markedly reduced the weed population and dry weight of weeds as compared to weedy check. Alone application of isoproturon 0.75 kg/ha and combined with 2, 4-D @ 0.5 kg/ha or one hand weeding at 30 DAS markedly reduced the population of *Phalaris minor, Convolvulus arvensis, Chenopodium album, Medicago hispida* and *Fumaria parviflora*. But those herbicides failed to control *Cyperus rotundus*.

All the weed control measures resulted in significantly higher grain and straw yield than weedy check (Table 3.7.10.1). Two hand weeding were significantly superior over alone application of isoproturon 0.75 kg/ha but statiscally at par with isoproturon 0.75 kg/ha +1 hand weeding and isoproturon 0.75 kg/ha + 2,4-D @ 0.50 kg/ha in respect to grain yield of wheat. Interection were not found significant in relation to yield attributes charecterstics. Five years pooled data indicate that the maximum net return of Rs. 49816/ha realized with the application of Isoproturon @ 0.75 + one hand weeding followed by Isoproturon @ 0.75 + 2,4-D @ 0.5 kg/ha. However weed free situation has maintained their higher productivity and having net return. While weedy check gave lowest net returns.

Under long term herbicidal trial on pearl millet-wheat cropping system, it was noted that hand weeding twice at 30 and 60 DAS (weed free) treatment gave maximum grain yield 4.58 t/ha but net return obtained with Isoproturon + one hand weeding treatment at 60 DAS (Rs. 49816/ha) as compared to other treatments. Consequently application of isoproturon @ 0.75 kg/ha + 2,4-D @ 0.5 kg/ha was also more effective weed management practices for control of mixed weed flora in wheat crop.

Table 3.7.10.1: Effect of different weed control measures on yield and economics of wheat (mean of 2008-09 to 2012-13)

Treatment	Yield (t/ha)		WCE (%)	Net returns ($x10^3$ ₹/ha)	B:C ratio
	Grain	Straw			
Isoproturon @ 0.75 kg/ha	3.60	5.46	21.4	42.63	2.76
Isoproturon @ 0.75 + 2,4-D @ 0.5 kg/ha	4.06	5.71	11.3	48.82	2.93
Isoproturon @ 0.75 + 1 HW	4.26	6.05	7.0	49.81	2.78
Weed free (2 HWs)	4.58	5.34	-	48.48	2.53
Weedy check	2.48	4.33	45.8	19.10	1.67

Long-term herbicide trial in pearlmillet under pearlmillet-wheat cropping system

Major weeds were: *Echinochloa crus-galli, Cyperus rotundus, Commelina benghalensis, Digera arvensis, Phyllanthus niruri, Celosia argentea, Eragrostis tenella and Dectyloctenium agyptium. Celosia argentea, Phyllanthus niruri* and *Dectylectenium agypticum* were not recorded in year 2013. Hand weeding twice proved significantly to be more effective in reducing weed density and dry weight of weeds followed by pre emergence application of atrazine at 0.5 kg/ha + one hand weeding at 30 DAS. Similar trend was also noted in weed biomass at harvest stage. On the basis of pooled data, all the weed control treatments gave significantly higher grain and stover yields over weedy check. Maximum grain yield of pearlmillet was recorded with two hand weedings which was 47.0% higher over weedy check (Table 3.7.10.2). It was closely followed by pre-emergence application of atrazine 0.5 kg/ha with one hand weeding at 30 DAS and atrazine 0.5 kg/ha with FYM 10 t/ha. It may be due to superiority in yield attributes of reduced crop weed components and increased nutrient availability to the crop. The weed free treatment gave maximum net return. Thus the use of atrazin at 0.5 kg/ha or combined with one hand weeding at 30 DAS could be one of the viable option to control the weed in pearlmillet under pearlmillet-wheat cropping system. It was concluded that 2 hand weeding at 30 & 45 DAS or by pre emergence application of atrazin at 0.5 kg/ha + one hand weeding at 30 DAS followed by atrazin @ 0.5 kg/ha + FYM 10 t/ha provides effective and profitable control of broad spectrum weeds in pearlmillet under pearlmillet-wheat cropping system.

Table 3.7.10.2: Yield and economics of pearlmillet as affected by different treatments under pearlmillet – wheat cropping system (pooled data of five years, 2008 to 2013)

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Cost of cultivation ($x10^3$ ₹/ha)	Net returns ($x10^3$ ₹/ha)	B:C ratio
Atrazine @ 0.5 kg/ha PE	2.70	8.54	12.75	10.26	1.80
Atrazine @ 0.5 kg/ha PE + FYM 10 t/ha	2.85	9.09	13.28	11.01	1.83
Atrazine @ 0.5 kg/ha PE + 1 HW 30DAS	2.97	9.51	14.75	10.56	1.72
Two hand weeding at 30 & 45 DAS	3.17	9.15	15.50	11.52	1.74
Weedy check	1.68	6.57	11.50	2.80	1.24
SEm ±	0.115	0.391	-	-	-
LSD (P=0.05)	0.355	1.198	-	-	-

Weed seed bank

In all, five weed species, viz. *Phalaris minor* (grass), three broad-leaved viz. *Chenopodium album, Anagallis arvensis* and *Spergula arvensis* and one sedge - *Cyperus rotundus* were recorded to emerge in post harvest soil of pearlmillet. *Phalaris minor* and

Chenopodium album were the major weeds in the soil weed seed bank. Highest number of total and broad leaved weeds were observed in weedy check plots followed by atrazine 0.5 kg/ha while lowest total and broad leaved weeds were recorded in two hand weeding treatment soil. Highest number of *Phalaris minor* were found in weedy check followed by atrazine 0.5 kg/ha + FYM 10 ton/ha and lowest number were found in two hand weeding. Similarly highest number of sedge weed *Cyperus rotundus* were found in weedy check followed by atrazine 0.5kg/ha PE+1 HW and lowest were found in atrazine 0.5 kg/ha.

WS 3.7.11 Clusterbean-wheat cropping system

SKRAU, Bikaner

A trial was conducted on long term effect of herbicides in cluster bean-wheat cropping system during *kharif*, 2013. The major weeds found infesting in cluster bean were: *Chorchorus tridense, Digera arvensis, Gisekia poiedious* and *Mullugo cerviana.* In wheat crop major weeds found infesting were, *Rumex dentatus, Chenopodiam album, Chenopodiam murale,* and *Melilotus indica*. In clusterbean, imazethapyr 40 g/ha at 20 DAS + one hand weeding at 40 DAS recorded significantly lower weed density and dry matter of weeds than weedy check and Imazethapyr 40 g/ha alone but statistically at par with two weeding at 20 and 40 DAS and eventually increased the yield attributes and seed yield of Cluster bean compared to weedy check and imazethapyr 40 g/ha alone but statistically at par with two mechanical weeding. There was no residual effect of metsulfuron methyl 4 g/ha applied in Wheat on succeeding clusterbean. In wheat, post-emergence application of metsulfuron methyl at 4 g/ha + One hand weeding significantly decreased the density and dry weight of weeds and consequently increased grain and straw yield of wheat. There was no residual effect of imazethapyr on succeeding wheat.

Microbiological studies

In clusterbean, the highest total bacterial count was recorded in hand weeding at 20 and 40 DAS plots and the lowest total count was found in iazethapyr 40 g/ha. At harvest, the total bacterial count in two hand weedings and imazethapyr+ one hand weeding treatment were at par to each other. Total fungal count was maximum in weedy check plots but at harvesting the highest number was recorded in the treatment imazethapyr 40 g/ha at 20DAS + one manual weeding. In wheat, the highest total bacterial count was recorded in the treatment mechanical weeding at 25 and 50 DAS and the lowest total count was observed in the treatment metsulfuron methyl 4 g/ha treated plots. At harvest, the total bacterial count in two hand weedings and weedy check treatments were at par to each other. Total fungal count at harvesting was at par in the treatments metsulfuron-methyl and metsulfuron-methyl + manual weeding.

WS 3.7.12. Pearlmillet-chickpea cropping system

SKRAU, Bikaner

The major weeds found infesting chickpea were: *Chenopodium album, Melilotus indica, Rumex dentatus* and *Asphodelus tenuifolius*. The results revealed that in *rabi* season, pedimethalin at 1.0 kg/ha *fb* one MW reduced the weed density and dry weight effectively and recorded significantly higher seed and straw yield of chickpea. It was also indicated that atrazine at 0.75 kg/ha applied in pearlmillet had no residual effect on succeeding chick pea but controlled weeds significantly. The highest total bacterial count in the treatment including hand weeding at 20 and 40 DAS in all three observations taken and the least total count was found with pendimethalin 1.0 kg/ha. Total fungal count initially was maximum in weedy check plots but at harvesting total fungal count was recorded at par in three treatments except in pendimethalin alone showing very minute effect of the herbicide on fungal population.

WS 4: Management of problematic / invasive / parasitic / aquatic weeds

WS 4.1a: Management of *Orobanche* in mustard and solanaceous crops

Orobanche infestation in mustard is increasing in Rajasthan, Haryana and M.P. lowering its productivity considerably. It is also infesting the solanaceous crops like tomato, brinjal etc.Its management strategy is not well developed hence a study was conducted.

WS 4.1a (i). Crop: mustard

Cooperating Centre: CCSHAU, SKRAU and RVSKVV

Experiment conducted by CCSHAU, Hisar in the farmer's field to study bio-efficacy of neem cake, pendimethalin and post emergence application of glyphosate at very low concentrations has indicated that pendimethalin along with neem cake and *Trichoderma viride* were not having any effect on *Orobanche*. The other treatment glyphosate @ 25 g/ha on 55 DAS alone or with 1% with $(NH_4)_2So_4$ provided about 80-95% control of *Orobanche*, up to 120 DAS. It was observed that glyphosate @ 50 g/ha on 40 DAS provided 80% control of *Orobanche* but caused phytotoxicity symptoms in plants, as chlorosis and necrosis and resulted in poor yield of the crop. It was observed that, overall *Orobanche* caused an yield loss of 29.4 % in mustard. Contrary to this SKRAU, Bikaner has reported that there is no phytotoxicity caused by glyphosate in mustard at the above doses and gave a control of about 72-82 reduction in *Orobanche* population. Further it was reported that PE application of imazethapyr @20 and 30 g/ha at 25 DAS also reduced the *Orobanche* population significantly but had phytotoxic effect on mustard.

Mustard field infested with *Orobanche*

Similarly RVSKVV, Gwalior has concluded that least population of Orobanche was recorded on application of glyphosate @ 50 g/ha after emergence of Orobanche at all the crop growth stages followed by pendimethalin @ 1.0 kg/ha as PE, neem cake at 200 kg/ha in furrow and pendimethalin @ 0.5 kg/ha as PE fb one hoeing at 40 DAS and glyphosate @ 25 g/ha with 2% solution NH_4SO_4 at 40 DAS (Table 4.1a.1).

Table 4.1a.1. Effect of herbicides and organic amendments on incidence of Orobanche in mustard at Gwalior

Treatment	*Orobanche* (No./m²)					
	2011-12		2012-13			
	60 DAS	90 DAS	60 DAS	75 DAS	90 DAS	105 DAS
Pendimethalin @ 1.0 kg/ha PE	1.52	1.27	1.49	3.75	4.46	4.66
Glyphosate 50g/ha alone after emergence of *Orobanche*	1.38	1.52	1.00	3.08	3.96	4.21
Trifluralin @ 1.5 kg/ha PPI	1.27	1.38	-	-	-	-
Glyphosate 25 g/ha alone with 2% solution NH_4SO_4 at 40 DAS	1.24	1.38	1.51	3.77	4.23	4.86
Neem cake at 200 kg/ha in furrow and pendimethalin at 0.5 kg/ha (PE) *fb* 1 hoeing at 40 DAS	1.27	1.27	1.00	3.91	4.36	4.67
Neem cake at 200 kg/ha in furrow *fb* imazethapyr 30 g/ha at 20 DAS	1.52	1.41	1.24	3.99	4.46	4.86
Trifluralin @ 1.5 kg/ha + Neem oil 1% PPI	1.13	1.13	-	-	-	-
Soybean oil 2 drops / shoot after emergence of *Orobanche*	1.71	1.79	1.33	4.26	4.66	4.90
Application of 25% extra dose of phosphorus & phosphorus solubilizing bacteria	1.62	1.48	1.38	4.28	4.97	5.18
Trichoderma viride 2.5 kg/ha as basal application	1.52	1.60	-	-	-	-
Farmer's practice 1 hoeing at 40 DAS	1.41	1.38	1.47	4.37	4.94	5.29
Weedy check	1.80	1.98	1.66	4.41	5.13	5.32
SEm (±)	0.14	0.12	0.21	0.17	0.29	0.06
LSD (P=0.05)	0.43	0.35	0.63	0.51	0.96	0.19
Transformation	$\sqrt{x + 0.5}$	$\sqrt{x + 0.5}$	$\sqrt{x + 0.5}$	Log x	Log x	Log x

WS 4.1.a. (ii) Crops: tomato and brinjal

Cooperative centre : UAS(B), OUAT, ANGRAU and RVSKVV

None of the centres have conducted this study

WS 4.1.a. (iii) Crop: Tobacco

Cooperating Centre: TNAU and NDUAT

Based on the experiments conducted in farmer's field, TNAU has reported that plant hole application of neem cake at 200 kg/ha on 30 DAT or DCA of imazethapyr at 30 g/ha on 55 DAT reduced *Orobanche* shoot density with better weed control and higher tobacco leaf yield. Experiments conducted in farmers field by NDUAT indicated that among the above treatments, neem cake @ 200kg/ha could delay emergence of *Orobanche* up to 45 DAP after which there was no effect. However other treatments, *viz.,* DCA of imazethapyr at 30 g/ha applied at 55 DAP and the farmer's practice of applying urea @ 20 g/plant on the beheaded *Orobanche* shoots at 80 DAP (ITK) recorded substantially declined number and dry weight of shoots of *Orobanche* at 90 DAP of tobacco. The ITK practice was found to be more effective (83.7%) and increased the yield (85%) than the other treatments, giving a net profit of ₹ 2,86,800.00 per ha with BCR of Rs 3.00 (Table 4.1.a.2)

Table 4.1.a.2. Economics of various treatments of *Orobanche* management in tobacco at Faizabad

Treatments	Common Cost of cultivation ($x10^3$ ₹/ha)	Addl. cost ($x10^3$ ₹/ha)	Total cost of cultivation ($x10^3$ ₹/ha)	Gross return ($x10^3$ ₹/ha)	Net return ($x 10^3$ ₹/ha)	B:C
DCA imazethapyr 30g/ha on 55 DAP	72.4	6.00	78.40	357.60	279.20	3.56
Neem cake 200 kg/ha (ppi)	72.4	4.00	76.40	301.76	225.36	2.95
Farmers practice (ITK)	72.4	9.60	82.00	368.80	286.80	3.50
Weedy check	72.4	-	72.40	199.31	126.91	1.75

No. of plants /ha: 10000, Sale rate of dry tobacco ₹ 160/ kg;

WS 4.1.b: Management of *Striga* in sugarcane

Cooperating Centre: TNAU, ANGRAU and UAS (D)

Field experiments conducted in the farmer's field by TNAU, indicated that the above treatment recorded lesser density of *Striga* followed by PE atrazine 1.0 kg/ha followed by hand weeding on 60 DAP and earthing up on 90 DAP. However, this treatment was not effective as reported by UAS(D) centre and hence they evaluated this treatment with other herbicide combinations viz., atrazine 1.25 kg/ha + 2,4-D Na salt 2 kg/ha, metribuzin 1 kg/ha + 2,4-D Na Salt 2 kg/ha, diuron 1 kg/ha + 2,4-D Na Salt 2 kg/ha, oxyfluorfen 0.25 kg/ha + 2,4-D Na Salt 2 kg/ha, which were applied after 110 DAP and 150 DAP (repeat spray) and followed by mulching. The experiment is under progress.

WS 4.1c: Management of *Cuscuta*

4.1. c. (i). Crops: Niger

Cooperating Centre: OUAT and BAU

Results from the experiments on *Cuscuta* management by OUAT indicated that when niger was grown in stale seedbed *fb* pendimethalin 1.0 kg/ha – PE, *Cuscuta* germination was less but appeared early i.e., 12 DAS, recorded the lowest density of 3.2 / m^2 and gave the highest grain yield of 792.5 kg/ha when compared to pendimethalin alone @ 1.0 kg/ha –PE or imazethapyr @75 g/ha as PPI. However, the treatment of pendimethalin 1.0 kg/ha PE produced the highest B:C ratio (1.85) followed by (1.81) in the treatment of imazethapyr 75 g/ha as PPI (Table 4.1c.1).

***Cuscuta* infested niger plant**

Table 4.1c.1: Effect of weed management on germination, density of *Cuscuta* and yield of niger

Treatments	Germination of *Cuscuta*		Density of *Cuscuta* (m^2)		Yield of niger (kg/ ha)	B:C ratio
	(DAS)	No/m^2	30 DAS	60 DAS		
Pendimethalin 1.0 kg/ha –pre-em	18.0	2.4	4.3	13.1	710	1.85
Stale seedbed *fb* pendimethalin 1.0kg/ha–pre-em	12.0	2.0	3.2	12.4	792	1.71
Imazethapyr 75 g/ha as PPI	14.0	2.8	4.8	12.8	702	1.81

4.1. c. (ii).Crop: Lucerne

Cooperating Centre: SKRAU, ANGRAU and AAU(A)

- An instruction was sent to AAU (A) from HQ, to conduct studies on *Orobanche* in tobacco this year, but it was not done
- SKRAU and ANGRAU have not conducted the studies

Experiments conducted at farmer's field by AAU, Anand indicated that pendimethalin and imazethapyr caused severe phytotoxicity and yield reduction in lucerne.

WS 4.1.c. (iii) Onion- UAS (D) and UAS (B)

UAS (D) and UAS (B) have not conducted the study

WS 4.1.d: Management of *Loranthus*

Cooperating Centre: KAU, UAS (B) and ANGRAU

ANGRAU has reported that there is no incidence of *Loranthus* in the area surveyed by them. In the survey conducted by UAS(B) it was observed that about 15% Sapota trees were infested with *Dendrophthoe falcata* in Chikkaballapura District of Karnatka. Thus to manage the infection, the following four treatments were applied on *Dendrophthoe* shoots in Sapota trees (15 years old plantation).

Based on the observations this year, it was concluded that padding of cotton with the paste made of 4 g copper sulphate + 0.5 g 2,4-D sodium salt 80 WP on the wounds of *Dendrophthe* shoots caused 100% defoliation after 2 months, without regeneration up to 6 months. Based on their studies on relative competitiveness of the parasites *Helicanthus elastica, Dendrophthoe falcata* and *Macrosolen capitellatum* on the host trees Mango, Sapota and Jack fruit, KAU centre has inferred that *D. falcata* has a higher competitive rate when compared to the other two species studied.

WS 4.2 Biological weed management

WS 4.2a: Biological control of *Parthenium* by *Zygogramma bicolorata*

Biological control is one of the methods to suppress Parthenium mainly in the waste land to reduce its seed bank in the soil. In this context, the bioagents are being released by all the AICRP-WC centers to see its establishment and subsequent effect on weed suppression.

Mexican beetle *Zygogramma bicolorata* either supplied by Directorate of Weed Science Research, Jabalpur or collected locally from already established sites were released in new *Parthenium* infested sites near community land, road sides or waste lands by all most all the centers. Observations were taken on the population buildup of Mexican beetle along with its establishment and control of *Parthenium* at the released sites.

Mexican beetles were recovered from the released sites at Anand (Gujrat) and about 14% *Parthenium* plants were found completely killed. All stages of bioagent were collected from the sites. However, in Jorhat, no stage was recovered at the released site. At Ranchi, beetles were recovered for the first time feeding on the *Parthenium* on the road side rout of Ranchi–Gumla, Ranchi– Daltonganj, Ranchi-Lohardaga and Ranchi –Tatanagar road.

In Haryana, *Zygogramma bicolorata* beetles collected from established sites in Pinjore area of Panchkula district and were released at 3 selected sites

which were heavily infested with *Parthenium* (Hisar, Kaithal and Naraingarh) during first week of July 2013. Visual observations revealed that *Zygogramma* beetles behaved differentially at different places of release due to difference in rainfall, R.H. and temperature at these sites. The observations taken at monthly interval revealed that progressive multiplication of beetles along with increase in damage up to 75 % at Narain Garh only. Beetle population was more during September. At Narain Garh 45% defoliation took place within one month of release. Highest damage was observed in month of September. Beetles did not multiply at Hisar but at Kaithal only 25% defoliation of mature leaves was observed with little multiplication due to poor rains in the region. At Hisar and Kaithal, only few beetles appeared in nature this year in October month only.

At Palampur, three new upland large sites infested with fresh growth of *Parthenium* were selected near village, Chabutra (Hamirpur) along road side. Each site was having on an average 24/m^2 plants. The activity of beetles increased from July beginning to September. Maximum population of larvae was seen during July and August.The beetle population per *Parthenium* plant was more during August end and September month, which caused a damage of 25% to71%. However, by the end of September and 1st fortnight of October the beetles might have completed the complete defoliation of the *Parthenium*.

In Pantnagar and nearby areas, *Z. bicolorata* significantly reduced the flower and seed production of the *Parthenium* at by the end of June to September. The population of grub and eggs and adult of *Zygogramma* were highest in the month of August and September compared to rest of the months. The extent of damage varied from 6-28% in the first site and 7-35% in the second site. The highest damage in both the sites was observed during the month of August which varied between 28-35 %. By this year beetle population was rarely found and they died of high temperature (Table 4.2a.1).

Table 4.2a.1: Egg, larvae and adult population of Mexican beetles per plant and per cent damage to *P. hysterophorus* at two sites during *kharif*, 2013

Months	Site1 (Behind campus school, Pantnagar)				Site-2 (Near store of weed control CRC, Pantnagar)			
	Egg	Larvae	Adult	Damage%	Egg	Larvae	Adult	Damage%
May	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0
July	0	0	0	0	2	10	2	7
August	10	20	13	28	8	21	17	35
September	6	14	7	15	6	18	12	25
October	0	0	0	0	1	0	1	1
November	0	0	0	0	0	0	0	0

At Ludhiana (Punjab), there was good establishment of beetles in 2013 than previous year (2012) which was relatively drier. IGKV centre at Raipur released 136 number of adult of Z. *bicolorata* in August, 2013 at vegetative phase of *Parthenium* plant but establishment of beetle failed might be due to heaviear and continuous rains. At Parbhani, the average *Parthenium* was recorded 8/m². The eggs, larve and adult population after one month of release was recorded 3.4, 3.9 and 4.9/plant, respectively. About 76% *Parthenium* plants were completely defoliated after one month of release of beetles. Good establishment and subsequent defoliation of *Parthenium* was observed at Kanpur.

At Kanpur, Mexican beetle defoliated *Parthenium* in large area up to 75%.The experiment was conducted by NDUAT, Faizabad in the university campus at the sites severely infested with *Parthenium* (48.4-66.5/m^2. The population of adult beetles increased in the range of 10.9 to 22.4/plant in the month of October, 2013 and was higher over September, 2013 population. However, population of adult beetles declined to a considerable extent in the month of November, 2013.At one site foliage was lost up to 100%, while at the remaining two sites 50-75% foliage loss was recorded in the month of November, 2013 (Table-4.2a.2).

Table 4.2a.2: Population of *Partheniu*m plants (no./m^2) and population build up of beetle (no./plant) (2013)

Site	Population of parthenium plants (no. m²)	Date of release of 600 no. of adult beetles	Population buildup of beetle (no/plant)			
			September, 2013	October, 2013	November, 2013	Rating
Site -1	66.5	01.08.13	12.2	22.6	13.8	4
Site -2	58.6	04.08.13	9.8	20.6	9.3	3
Site -3 Station	48.4	05.08.13	11.4	18.9	10.8	3

In Odisha, beetles (500) were released (June-July) at two sites i.e Adaptive Research Station, Sakhigopal premises and at Central farm, OUAT, Bhubaneswar. At Sakhigopal the beetles completely defoliate the site where *Parthenium* was heavily infested. At Bhubaneswar, the beetle could not multiply due to high temperature and cyclonic damage. At Samastipur (Bihar), beetles were released at three *Parthenium* infested sites namely Agribusiness management campus, Pusa, Morsand High School, Samastipur and KVK, Birauli, Samastipur. Beetles increased their population and caused appreciable damage ranging from 13 to 76, 9.0 to 78% and 5 to 43% with an average of 37.25, 40.50 and 19.5%, at site I, II and III, respectively (Table 4.2a.3).

Table 4.2a.3: *Parthenium* density and Mexican beetles at three selected sites in north Bihar

Particulars	Site I (Agribusiness management campus, pusa)	Site II (Morsand High School, Samastipur)	Site III (KVK, Birauli, Samastipur)
Plant population/ m^2 area	09-14	08-16	07-13
Plant height (mr)	0.55-0.89	0.51-0.83	0.45-0.81
Fresh biomass of plant (kg/m^2)	0.63-0.89	0.67-0.88	0.65-0.93
Adult population per plant (average)	6.5	6	5.13
Grubs (larvae) (AV)/plant	5.75	6.38	2.38
Eggs (AV)/plant	10.63	7.88	4.38
Percent damage (%)	37.25	40.5	19.5

At Gwalior, density of *Parthenium* at Ist (Mela ground), IInd (Surya mandir) and IIIrd (College ground) sites were 76, 84 and 180 plant/m^2, respectively. The highest population of adults 4.5 adults /plant were observed at site I followed by 3.8 adults/ plant at site II and lowest 2.3 adults /plant at site III at 15 days after release of beetles. The highest damage on the plants was seen 60 days after release of beetles at all the sites, highest at site I (mela ground) and lowest at site III (College ground) (Table4.2a.4).

Table 4.2a.4 : No. of beetle, grubs and eggs (Average numbers/plant) on parthenium Plants

Particulars	Days after release of beetles			
	15	30	60	90
Adults	3.5	2.3	1.3	1.1
Grubs	0.6	0.4	0.8	0.1
Eggs	0.4	0.5	0.5	0.3
Damage on plants (05scale)	1 (17%)	2 (40%)	2 (46%)	1(7%)

0- No attack, 1- Negligible, 2- 25%, 3-50 %, 4- 75%, 5- Complete defoliation

At Bikaner, *Z. bicolorata* was released at three *Parthenium* infested sites The population builup was poor but 15-20% defoliation was noticed. At Coimbatore, locations with heavy infestation of *Parthenium* were selected at Vadavalli, Thondamuthur and Mathampalayam blocks and beetles were released. After a month of release, there were 3.8 - 5.8 eggs/plant with 3.2 - 6.3 grubs and 3.2 - 5.4 adults/plant in the three sites. *Parthenium* damage was in the range of 25 - 55% during first month of observation with an average damage of 45%. Enhanced parthenium damage was observed at 3rd month of observation with a damage range of 60 - 65% with an average damage based on the biomass reduction in comparison with parthenium from beetle free areas.

In Kerala, the *Zygogramma* beetles received from DWSR Jabalpur, were released in parthenium infested areas in Kozhinjampara (Chittoor thaluk) on 31/07/2013. During survey, beetles were recovered from many places indicating its potential in this area too.

At Sriniketan, beetles were released at four sites. Highest number of egg, grub and adult was recorded in September where about 50% damage of *Parthenium* was noticed. From October onwards their number started to decrease. After November no egg, grub or adult was observed. Thus from the critical observations taken during last 6-7 years it appeared that the beetles released in the month of May-June after first flush of rain got established successfully with considerable damage on *Parthenium*. The *Parthenium* plants just start to emerge and remain in vegetative stage in these months. But when beetles were released late on matured *Parthenium* their chance of establishment was less.

Net work trial conducted throughout country revealed the potential of Mexcain beetle to suppress *Parthenium* in almost all the places except, Bikaner, Jorhat, Anand and Bhubaneswar. Therefore, in these areas, more concentrated efforts are required.

WS-4.2b: Biological control of *Parthenium* by competitive replacement through *Cassia tora*

In a country-wide survey, it was established that *Cassia tora* is an effective botanical which can be used to replace *Parthenium*. Therefore, a network trial was conducted in non-cropped area during *kharif* season of 2013 to establish the potential of *C. tora* to suppress *Parthenium* in wasteland, community land and on the road sides. The *Cassia tora* seeds were collected from the sites of establishment and were broadcasted in the month of February to May in the pre-marked *Parthenium* infested sites. Observations were taken on the plant density of *C. tora* and *Parthenium* at the experimental sites.

The trial was conducted almost by all the centers except a few like Bikaner, Parbhani, UAS (D). At Anand (Gujrat), seeds of cassia @ 15 kg/ha controlled 55% of *Parthenium* (Table-4.2b.1)

Table 4.2b.1: Effect of Cassia tora on plant stand of *Parthenium hysterophorus* at maturity stage

Treatments	*Cassia tora* (no./m^2)	*Parthenium hysterophorus* (no./m^2)	*Parthenium hysterophorus* Control (%)
Cassia tora 10.0 kg/ha	36	95	31
Cassia tora 12.5 kg/ha	42	78	43
Cassia tora 15 .0kg/ha	57	62	55
Control (*P. hysterophorus*) Only	0	137	-

At Jorhat, about 60% germination of *C. tora* seeds was recorded in the experimental area. Maximum plant density of *Parthenium* was recorded during April which reduced to nearly 50% in the month of August, 55.7% in October and 96% in November last. In the month of June the population stand of *C. tora* was of 60.4 ± 7.8, which reduced to the extent of 59.5% and 63.02%, in the months of October and December, respectively. At the time of *Cassia tora* germination, *Parthenium* plant started withering and drying in majority of locations. But, in the localities where there was new emergence of *Parthenium*, emergence of *Cassia tora* was considerably reduced. Only the established stand of *C. tora* could resist *Parthenium* aggression (Table-4.2b.2).

Table 4.2b.2: Plant density (No./m-2) of *Parthenium* and *Cassia tora* at different interval in Jorhat

Month	Spe-cies	Near Rly. station	Rajabari near TRA	Rawriah to airport	Mean	SD	% mortality
(April)	P.h.*	25	22	26	24	3.2	0.0
Jun	P.h.	24	21	24	23	3.0	1.9
	C.t.*	1	0	2	1	-	0.0
Aug	P.h.	10	15	11	12	3.6	49.6
	C.t.	61	53	67	60	7.8	0.00
Oct	P.h.	11	10	11	11	1.4	55.7
	C.t.	26	25	23	25	5.2	59.5
Nov- Dec	P.h.	1	0	2	1.0	-	95.8
	C.t.	22	23	21	22	3.6	63.0

* P.h. = *Parthenium hysterophorus*; C.t.= *Cassia tora*

At Ranchi, seeds of *C. tora* broadcasted during February and March at different localities did not germinate after pre-monsoon rains but *Parthenium* germinated. When the seeds of *C. tora* were broadcasted after monsoon rains, they germinated fast and quickly formed the canopy and suppressed the germination and growth of parthenium.

At Hisar, seeds of *Cassia tora* and *Cassia occidentalis* were collected during November-December, 2012 and broadcasted at 10, 15 and 20 kg/ha seed rate on these sites upon receipt of rainfall. Although both *C. tora* and *C. occidentalis* established in the first year at both th sites, but at Kalka, in foot hills of Shivalik hills with average rainfall of 1150 mm, *C. tora* was more successful with 90 % control of *Parthenium* by using *seed rate of* 20 kg/ha where as in Karnal and Narwana, *C.occidentalis* with seed rate of 20 kg/ha provided 80-72% replacement of *Parthenium* as against 40-69% by *C. tora* at same seed rate. At Kanpur, *C. tora* suppreseed Parthenium by 60-70% At Palampur, the effect of *C. tora* in suppression of *Parthenium* at three sites was well observed (Table-4.2b.3)

Cassia tora replacing Parthenium

Table 4.2b.3: Effect of Cassia tora population on Parthenium

S. No.	Site 1		Site 2		Site 3	
	Cassia	*Parthenium*	Cassia	*Parthenium*	Cassia	*Parthenium*
1	-	21	-	29	-	26
2	30	5	38	1	34	3
3	28	4	41	2	31	5
4	26	5	35	2	27	3

In Pantnagar, The density of *P. hysterophorus* ranged between 3-7 and 4-5/m^2 with *C. tora* and 43-99 and 65-89/m^2 in the absence of *C. tora* after broadcasting of *C. tora* seeds @ 60 kg/ha. The average reduction in density of *P.hysterophorus* due to *C. tora* was observed 93.1 and 95.9% respectively at both the sites selected for the study. Similar trend was also observed at Ludhiana. At Raipur, poor germination of *C. tora* was recorded at the experimental site while in natural conditions at other places, there was good suppression of *Parthenium*.

Experiment conducted at Faizabad by NDUAT revealed good suppression of *Parthenium* due to *C. tora* germination in the severely *Parthenium* infested sites (Table-4.2b.4).

Table4.2b.4: Population (no. m-2) of *Parthenium, Cassia tora* and other weed species at different demonstration site (2013)

Site	July, 13			September, 13			October, 13		
	Parthe-nium	*Cassia tora*	Others	*Parthenium*	*Cassia tora*	Others	*Parthenium*	*Cassia tora*	Other
1	52.0	48.0	12.5	52.0	52.0	11.5	18.0	45.0	6.0
2	55.0	42.0	15.0	58.7	54.0	8.5	15.0	48.0	4.0
3	48.0	35.0	20.2	62.5	50.0	8.0	10.0	55.0	3.0
Mean	51.7	41.7	15.9	57.7	52.0	9.3	14.3	49.3	4.3

Note: Other weed species include *Cynodon, Cyperus, Dactyloctenium* etc.

At Bhubaneswar, *Cassia* replaced about 85 % of *Parthenium* at the treated sites. At Muzaffarpur, good germination of *C. tora* was observed at three sites, which suppressed *Parthenium* effectively in subsequent months. Similar observations were observed at Gwalior, and Sriniketan. At Coimbatore, *C. tora* did not germinated well due to scanty rainfall.

WS 4.2c : Biological control of water hyacinth (*Eichhornia crassipes*)

A network trail was proposed for those centers which may found a perennial water body infested with the water hyacinth. Initial culture of *Neochetina* was sent from DWSR on receiving of request from the concerned center.

At Hyderabad and surrounding area, under the aegis of ANGRAU, two perennial tanks viz., Mylardevpally and Pragathinagar tank were selected. Initial observations reveled that, water hyacinth infestation was very severe in Mylardevapally tank and the entire tank was completely covered by the weed. In case of the Pragathinagar tank, the water body was partially infested with the weed (approx30 % of the surface area). Initially, water hyacinth samples were collected and observed for infestation of the *Neothichetina* weevils. In Pragathinagar tank, very low infestation was noticed initially (0.8 weevils/water hyacinth clump based on 10 plants data). In Mylardevpally tank, no infestation of weevil could be observed.

About 600 weevils in Mylardevpally and 300 weevils in Pragatinagar tank were released at different spots during third week of September, 2013. Observations were taken after three months after release of the weevil i.e on 20th December 2013. Number of weevils/water hyacinth plant (based 10 plant data) was observed 2.8 weevils/plant and number of scars/leaf (based 10 leaf count) were 45-126 (average 66.4) Significant portion of water hyacinth present in the tank (>80% surface area) exhibited more than 50% dried leaves (3 on the scale of 0-4) (dieback) and plants were in withering stage. The population buildup was found increased by December after augmentation of bioagent in the tank. The dieback symptoms were also increased by December

Before

After 3 months

Mylardevpally tank view of the tank on 19-09-2013 at the time of release of weevils

which indicated the corresponding population increase of the bioagetn in the pond. In Pragathinagar tank, initial survey did not reveal the presence of bioagent but after inoculation of *Neochetina* sp. in September, population was found (0.7 weevils/plant) which indicated the process of establishment of the bioagent in the water body.

At Thrissur and adjoining area, it was difficult to get isolated ponds to conduct studies on the efficacy of the bioagent because of natural infestation. Therefore, study was conducted in concrete tanks of 1m^3 capacity. Ten *Eichhornia* plants free from bioagents were grown in the tanks filled with water and 10 weevils were introduced into three tanks. One tank with *Eichhornia* alone (without releasing weevil) was maintained as the control. Observations on the total number of leaves and leaves damaged by feeding of the weevil were recorded at weekly intervals upto 10 months after introduction of the bioagents. About 40% of the leaves were fully damaged by the weevil. In the control, more number of plants were observed. Higher plant density would have resulted in more decaying of the leaves. The study indicated that the beetle is not effective in controlling water hyacinth under Kerala conditions.

Two locations were selected by CCSHAU, Hisar to demonstrate the efficacy of *Neochetina bruchi weevils. The* weevils could multiply up to November and caused only scars on water hyacinth leaves at both the locations. Complete defoliation was not observed.

Two ponds were selected by NDUAT, Faizabad, one large size pond of about 20 acres of water area on Milkipur village and another pond of about 15 acres of water area in Ram Nagar village). The 500 adult beetles were released at each site distributing evenly on the entire area (200 m^2). Population buildup of the bioagent was recorded from the same pond by taking samples from 10 places at quarterly basis (90 days after the release). Data on population buildup of *Neochetina* weevils at 90 days after release, per cent leaf damage at 30, 60 and 90 days after release of weevil and dry weight loss per cent (per plant) over the control were recorded which (Table-4.2c.1).

Table 4.2c.1 : Density of water hyacinth (plant/m^2), and population build up of *Neochetina* at 90 days after release

Sites	Density of hyacinth plants (no./m^2)	Date of release of 500 adult weevils	Population buildup (no./m^2) at 90 days stage			
			Eggs	Grubs	Pupa	Adults
Milkipur	9.8	01.08.13	43.3	72.2	10.2	24.0
Ram Nagar	12.2	03.08.13	48.7	78.5	13.4	29.0
Control	13.4		8.6	6.6	3.2	4.0

The eggs, grubs, pupa and adult (per m^2) were recorded in higher numbers with respect to control treatment at both the sites. However, at Ram Nagar site, slightly higher number were recorded over Milkipur site. There was a gradual increase in the leaf damage due to weevils at both the sites and recorded more than 50% leaf damaged by weevils which were substantially higher over control (no release of weevils) treatments (Table 4.2c.2).

Table 4.2c.2: Per cent leaf damage due to Neochetina weevil population

Site	Per cent leaf damage (m^{-2}) (days after release)		
	30	60	90
Milkipur	16.2	31.9	53.6
Ram Nagar	19.5	36.6	57.3
Control	6.2	4.2	4.2

One pond was selected by OUAT at Delang of Puri district. *Neochetina* spp. (200 nos) were released in October 2013 but so far no control, multiplication of bioagent has been observed.

Ponds have also been selected by the centers located at Jorhat, Sriniketan and Samastipur where bioagent will be released in next season after receiving the initial culture from DWSR.

WS 5: Herbicide residues and environmental quality

WS 5.1: Herbicide residues in long-term herbicide trial

Use of herbicides is expected to increase in coming days due to scarcity of labourers. Continuous and repeated use of herbicides may cause residues build-up in soil and pose risk of contamination of water and surrounding environment. Thus, analysis of herbicide residues in long-term experiments was conducted to assess residues in soil, and crop plants at harvest in rice-wheat, pearl millet-groundnut, groundnut-finger millet, maize-pea, sorghum-wheat, rice-rice and rice-groundnut cropping systems in different agro-climatic zones.

(i) Rice-wheat cropping system

In a long term herbicide trial of rice-wheat cropping system at Hisar, butachlor remained as permanent herbicide treatment, whereas pretilachlor and anilofos were applied as rotational herbicides right from the year of start of experiment under rice-wheat cropping system. After harvest of wheat and before transplanting rice crop, *Sesbania* crop was grown for incorporation as green manuring. At harvest, soil, grains and straw samples were analyzed by GCMS/MS Triple Quadrupole. It was observed that under green manuring, the residues of pretilachlor, butachlor and anilofos were dissipated faster than under non-green manuring conditions. Residues were found to dissipate nearly 100% after 30 days under non-green manuring, whereas residues reached to below detection level after 15 days under green manuring. The half life of pretilachlor, butachlor and anilofos was found to be 8.9, 12.5, 9.4 days, and 7.4, 4.8 and 4.9 days, respectively under non-green manuring and under green manuring, respectively. Herbicide residues were found below detection limit (1 ppb) in soil, paddy grains and straw at harvest.

Similarly, a long-term trial was started since 1999-2000 at Palampur to study the weed dynamics in rice-wheat cropping system. Soil, grain and straw samples from the experimental plots treated with isoproturon and butachlor were collected to determine residues. Initial deposits of butachlor residues in soil immediately after application of butachlor in four treatments (butachlor 1.5 kg/ha *fb* 2,4-DEE 1.0 kg/ha (100% N through fertilizer source) - isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha , butachlor 1.5 kg/ha *fb* 2,4-DEE 1.0 kg/ha (100% N through fertilizer source) - clodinafop 75 g/ha *fb* 2,4-D 0.75

kg/ha, butachlor 1.5 kg/ha *fb* 2,4-DEE 1.0 kg/ha (75% N through fertilizer source and 25% N through Lantana - isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha, butachlor 1.5 kg/ha *fb* 2,4-DEE 1.0 kg/ha (75% N through fertilizer source and 25% N through Lantana - clodinafop 75 g/ha *fb* 2,4-D 0.75 kg/ha) were found 0.46, 0.38, 0.26 and 0.25 µg/g, respectively. At 60 days of herbicide application, the residues were below detectable level in all the four treatments of butachlor application.

At Pantnagar, isoproturon residues were found below the detection limit (0.005g/g) in soil, and wheat plants at harvest. Similarly residues of butachlor were not detected at harvest in soil, rice grain and rice straw. In another long-term study on effect of herbicides on weed seeds in rice-wheat cropping system under different tillage conditions was assessed at Pantnagar where isoproturon (1.0 kg/ha) in wheat and anilofos and pendimethalin (0.4 and1.0 kg/ha) in rice, respectively, were applied and were changed in 2012-13 to clodinafop-propargyl + metsulfuron-methyl at 60 g/ha in wheat and bispyribac- sodium at 20 g/ha in rice. Residues of applied herbicides were found below the detection limit (0.01 g/g) in soil grain and straw of wheat or rice collected at harvest. At Faizabad, soil samples were from a long-term field trial to find out butachlor and pretilachlor residue under long term rice-wheat cropping system and rice-wheat – summer green gram cropping systems. The biometric observations demonstrated that butachlor and pretilachlor did not leave toxic level of residue in soil of rice field. Similarly, herbicides residue in the post harvested soil of rice in rice-wheat – summer green gram cropping system in Kharif 2013 were determined at Faizabad.

At Ludhiana, continuous use of butachlor (1.5 kg/ha), pretilachlor (0.75kg/ha) and anilophos (0.375 kg/ha) to rice crop and pendimethalin (0.75 kg/ha) and clodinafop (0.06 kg/ha) to wheat for years in the rice-wheat cropping sequence was studied for herbicide persistence in soil, rice and wheat plants. Pretilachlor and butachlor residue was detected in soil up to 60 and 45 days, respectively. However, pretilachlor, butachlor and anilofos residue in rice grain and straw at harvest were found below the detectable limit. Pendimethalin residue in soil was monitored at 0 to 90 days and at harvest while wheat grain and straw samples were taken at harvest. Pendimethalin residue were not detected at 90 days in field soil samples and found below detectable limit (0.003 ug/g) in wheat grains and straw samples. Clodinafop-propargyl rapidly degrades in soil and residues were not detected after 10 days of application. At harvest residues were found below detectable limit (0.006 µg/g) in soil, grains and straw. It was found that continuous use of butachlor, pretilachlor and anilophos to rice crop and pendimethalin and clodinafop-propargyl to wheat for years in the rice-wheat cropping sequence did not leave residues in soil, grain and straw.

(ii) Maize-pea cropping system

Post harvest soil and maize samples were collected where atrazine was applied (1.0 kg/ha+ 1 HW, atrazine 1.5 kg/ha and atrazine 1.0 kg/ha *fb* 2, 4-D 0.50 kg/ ha) for the weed control in a long term experiment of weed management in maize-peas cropping system at Palampur and residues were determined after the harvest of maize crop. The atrazine residues in soil in all three different treatments were found to be below detectable levels. Similarly, post harvest soil samples and crop produce from pendimethalin applied plots of chickpea, peas and mustard crops from long term experiment of weed management in maize based cropping system were collected during Rabi after the harvest at Palampur and determined for residues. Residues of pendimethalin in soil were found below the detectable level in all the different treatments. However 0.095 µg/g were detected in mustard at the time of harvest of crop.

(iii) Sorghum-wheat cropping system

At Parbhani long-term experiment on sorghum-wheat sequence was conducted with two doses of atrazine (0.75 and 0.50 kg /ha) in each crop since last 10 years. Oxyfluorfen at application rates of 0.125 and 0.100 kg/ha was applied in wheat. Atrazine residues were found below the permissible limit (0.10 µg/g) in sorghum grains in both the treatments, where as in the soil the residue level of atrazine was found 0.020 and 0.017 µg/g at 30 and 60 DAS, which was reduced to 0.011 µg/g at harvest after sowing where atrazine was applied at 0.75 kg/ha. In plots where atrazine was applied at 0.50 kg/ha the residue level was found 0.012 and 0.009 µg/g at 30 and 60 DAS, which was dissipated to 0.007 µg/g at harvest. Oxyfluorfen residues were also found under the permissible limit (0.05 µg/g) in grains in both the

treatments, where as in the soil, oxyfluorfen residues were found 0.009 and 0.006 µg/g at 30 and 60 DAS, respectively where oxyfluorfen was applied at 0.125 kg/ha, and dissipated to 0.004 µg/g at harvest. The residues of atrazine in sorghum and oxyfluorfen in wheat were found below the permissible limit. i.e. 0.10 µg/g in sorghum and 0.05 µg/g in wheat respectively.

(iv) Rice-rice cropping system

Weed infestation under rainfed-transplanted situation strongly influences crop yield owing to alternate wetting drying cycles. Accordingly, the residue status of butachlor and pretilachlor in soil as well as grain and straw of rice were assessed in a long term experiment of rice-rice system. Surface soil samples were collected at 15 days interval from the date of application of herbicides and analysed for butachlor residue at Jorhat. Irrespective of herbicides, highest concentration was observed on the day of application, and was below detectable level (0.0µg/g) at 45 days after application in winter rice representing 24[th] crop (Table 5.1.1).

Table 5.1.1: Butachlor residue in surface soil at different days after application

Treatment	Butachlor residue (µg/g) at days after application				Butachlor residue (µg/g) at harvest	
	0	15	30	45	Grain	Straw
Farmers' practice (one HW)	BDL	ND	ND	ND	BDL	BDL
Butachlor + 2,4-D (100% NPK through chemical fertilizer)	0.23	0.038	BDL	ND	BDL	BDL
Butachlor + 2,4-D (75% NPK through chemical fertilizer, 25% through organic source)	0.20	0.032	0.012	BDL	BDL	BDL
Butachlor + 2,4 -D rotated with pretilachlor (100% NPK through chemical fertilizer)	BDL	ND	ND	ND	BDL	BDL
Butachlor + 2,4 -D rotated with pretilachlor (75 % NPK through chemical fertilizer, 25% through organic source)	BDL	ND	ND	ND	BDL	BDL

ND = Not determined

At Hyderabad, in no-till maize soils, atrazine residues in soil were detected up to 60 days after application at recommended level of application either in combination with the paraquat or sole application. In post-emergence application, butachlor residues were detected up to 45 days in *rabi* afterward residues were found below detection limit in soil and plants. In *kharif*, initially after 2.0 hours, residues of butachlor and pretilachlor were found 0.412 and 0.368 mg/kg, respectively. Residue dissipated to 0.226 and 0.032 mg/kg in the soil collected at 15 and 30 days after application of butachlor. The residues were found BDL by 45 days after herbicide application. Whereas cyhalofop residues dissipated in the soil to 64.13 % and at 45, 60 days and harvest, cyhalofop residues did not found in soil. Residues of butachlor and cyhalofop could not be detected in the rice grains or straw samples. In soils, where organic manure was applied, both the herbicides were detected up to 30 days after application. In rice grain and straw, collected after harvest of the crop, the herbicide residue was below detectable level. In a transplanted rice – rice system at Kathalagere, bagluru the residue of butachlor were below the detectable level of 0.01 ppm, in soil, grain and straw samples (113 days after herbicide application) at the time of harvest.

In the autumn rice (25[th] crop) butachlor residues in soil ranged from 0.18 to 0.24 µg/g on the day of application. Residue was below detectable level at 45 days after spray and the lowest concentration of 0.022 µg/g soil was recorded on 30 days after application due to application of butachlor in both the crops with partial substitution of N-fertilizer by organic manure. There was build up in nutrient status over initial level.

The soil, plant and grain samples collected during *rabi*, 2012 and *kharif*, 2013 were analyzed for butachlor, 2, 4-D and pretilachlor residue at Coimbatore. A progressive decline in butachlor residue content in soil was observed with advancement of crop growth. More than 90 per cent of the applied butachlor degraded from the soil within 30 days of application in both the seasons. The pattern of butachlor and 2, 4-D degradation is similar in both the seasons and 80% of the applied 2,4-D herbicide degraded from the soil within 7 days of their application. The continuous application of either butachlor + 2,4-D or butachlor/ pretilachlor + 2,4-D herbicide mixtures did not show build up of butachlor residue in the post harvest soil of twentieth and twenty-first crops. The grain and straw samples were found to have below detectable level of all the applied herbicides. Pretilachlor residue, were degraded to nearly 80% within 30 days and found below detectable level at harvest. Butachlor and pretilachlor degradation rate is higher under 75% inorganic N source + 25% organic source treatment (Fig. 5.1.1). In the grain and straw of 26^{th} crop pretilachlor residue were not detected under the treatment of alternate application of butachlor/pretilachlor. Continuous application of butachlor + 2, 4-DEE herbicide mixtures in every season or rotational application of butachlor + 2,4-DEE during *kharif* and pretilachlor + 2,4-DEE during *rabi* did not show build up of these herbicides in the post harvest soil or grain and straw of the 24^{th} and 25^{th} crops.

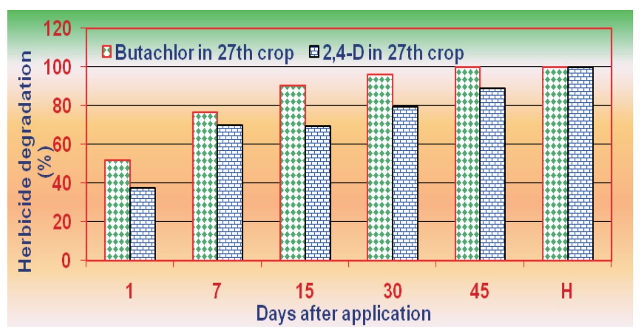


Fig 5.1.1: Degradation of butachlor and 2, 4-D herbicides in rice soil under long term herbicide trial during rabi 2012 (27^{th} crop)

(v) Rice-groundnut cropping system

A study was conducted to determine long term effects of weed management practices on soil microbial attributes, soil properties, nutrient status and herbicide residues in long term herbicidal trial on rice-groundnut system. There were combination of 6 weed control measures in rice and 2 weed control measures in groundnut. If was found that addition of organic matter decreased the persistence of both the herbicides. Residues were not detected after 60 days of herbicide application (Fig 5.1.2 and 5.1.3).

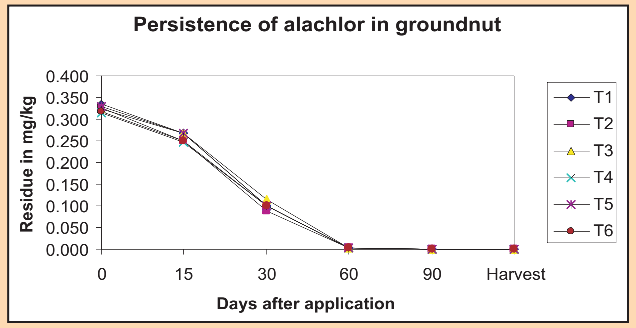


Fig 5.1.2: Persistence of alachlor in groundnut

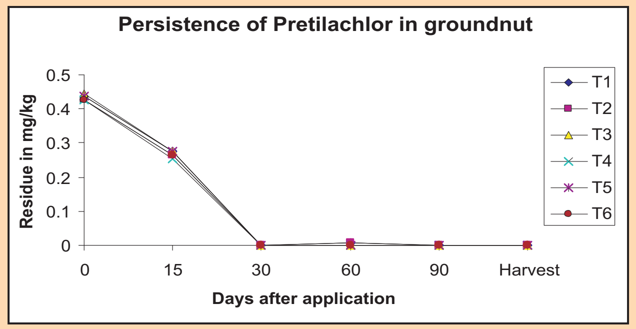


Fig5.1.3: Persistence of pretilachlor in groundnut

The dissipation pattern of both the herbicides in all the treatments was found almost equal. After 30 and 60 days, pretilachlor and alachlor were not detected in soil. Addition of organic matter decreased the residue rapidly.

(vi) Pearlmillet wheat cropping system

Persistence of herbicides applied to wheat in long term herbicide trial under pearl millet- wheat cropping system was evaluated at Gwalior. The experiment consisting of three chemical weed control measures viz. pre-emergence atrazine 0.5 kg/ha, atrazine 0.5 kg/ha+FYM 10 t/ha, atrazine 0.5kg/ha+ one hand weeding at 25 DAS, along with hand weeding and weedy check control in pearl millet (*kharif*) in main plots and isoproturon 0.75 kg/ha POE, isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha POE, isoproturon 0.75 kg/ha+ 1 hand weeding at 30 DAS, 2 hand weeding (30 and 60 DAS) and weedy check in wheat crop (*rabi*) as sub plot treatments replicated thrice. Cucumber was used as indicator plant to determine the persistence of these herbicides in soil collected at 0 to 60 days and at harvest after application of herbicide. A significant reduction in plant height of cucumber plants was recorded up to 45 days in all the three treatments of herbicide while fresh weight and dry weight of test plant were reduced significantly up to 30 days only. Atrazine applied to pearl millet at 0.5 kg/ha either alone or along with 10 q/ha FYM to pearl millet persisted in soil for 45 days.

(vii) Pearlmillet-groundnut and groundnut-finger millet cropping systems

Persistence of herbicides applied to finger millets and groundnut under pearlmillet-groundnut and groundnut- finger millet cropping systems was evaluated at Hebbal, Bengaluru. At the time of crop harvest, the residue of butachlor and pendimethalin were below the detectable level of 0.01 ppm in soil, and plants both at recommended and double the recommended level of application.

WS-5.2: Studies on herbicide persistence in water

Cooperating Centres: PAU, UAS (B), RVSKVV, GBPUAT, CSKHPKV, AAU(J), VNMKV, AAU(A), TNAU, NDUAT, CSAUAT, KAU, OUAT, ANGRAU and CCSHAU

Indiscriminate use of herbicide in rice field has a chance of escaping into the adjacent water bodies and it may lead to health and other hazards to human, animal and plants. Therefore experiments were undertaken to study the persistence of herbicide in water under field condition and their effect on aquatics'.

Paraquat residues in water were decreased as the stage of sampling advanced in X and 2X application levels at Anand. Paraquat residues were lower at all the intervals in water under the application of paraquat applied at 0.50 kg/ha as compared to 1.00 kg/ha. Paraquat residues were detected up to the fifteen days from the application of herbicide. pH and EC (dS/m) of water at various intervals were influenced by application of paraquat in water bodies. At Jorhat water samples were collected during January/February 2013 from water bodies at different locations adjacent to fields where herbicides were applied in *Boro* rice crop. Butachlor or pretilachlor residues were found below detectable level (0.01 µg/g). Water samples were collected during August and September 2013 from water bodies at different locations adjacent to fields where herbicides are applied in winter rice crop in kharif 2013. Persistence of paraquat in water was determined at Jorhat using 5 RCC water tanks (1mx1mx1m). Water hyacinth was grown in three tanks out of five tanks and paraquat was applied at 0.50 and 1.00kg/ha on water hyacinth. pH and EC (dS/m) of water at various intervals were influenced by application of paraquat in water on water hyacinth. Paraquat residues in water were detected up to 15 days.

Residues of atrazine were evaluated in groundwater in maize growing area in Mahabubnagar District of Andhra Pradesh. The pH and EC of the water samples did not vary significantly during different sampling stages and residues were not detected in water samples. However, in Hisar, the water samples from the tube-wells from farmers' fields were taken after 45 days of application of herbicide and analysed GCMS/MS Triple Quadrupole. It was observed that 5 out of 21 sites were having pretilachlor residues ranging between 0.21–1.30 µg/ml.

Butachlor residues were not detected in water samples at two sites collected near the agricultural field at Palampur, after one month of herbicide spray. Under laboratory conditions the concentration of 2, 4-D and pH was estimated periodically at five days interval by spectrophotometer and pH meter, respectively. More than 95 % of the applied herbicide degraded from the aquatic system within 20 days. Dissipation of 2,4-D in water was rapid and followed similar trend at both concentrations. Half life of 2,4-D was found less than 10 days.

Herbicide persistence in water under field conditions and their effect on aquatics were conducted at Pantnagar. Water samples were collected near the agricultural field, within one week of herbicide spray and after one month to see persistence in water and change in water quality. Samples of water were drawn from water bodies at 0-5, 15-20 and 30-35 days after application of herbicides in nearby fields. Isoproturon, 2,4-D, clodinafop, sulfosulfuron, pretilachlor, butachlor, anilophos, atrazine, metribuzin and pendimethalin collected from different places and location were below detectable limits. The study under laboratory condition showed presence of isoproturon, atrazine, pendimethalin residues even after 60 days of application. The water samples were collected one week of herbicide spray in the month of June 2013 and again after one month of herbicide spray in the month of July 2013 to see the persistence in water at Parbhani, atrazine residues were found 0.07 and 0.02 ppm after one week and one month of its application in nearby dug well water below the permissible limit (2 µg/g) in agricultural field at Parbhani. At Bhubaneswar, residues were found below detection limit (0.01 mg/kg) in water samples.

Ground water samples were collected from tube-wells where farmers had applied pretilachlor and butachlor in rice and cladinofop-propagyl and pendimethalin in wheat in rice-wheat cropping system during the year 2012-13 in Ludhiana to determine the extent of herbicides contamination in the ground water samples. In tubewell water, residues of pretilachlor, butachlor, cladinafop-propargyl and pendimethalin were not detected. At Coimbatore, water samples were collected from the cropped field bore well, pond (tail end of the area where the drained water from the rice ecosystems were collected and stored) during 3, 7 and 30 days after herbicide applications. Water samples collected did not show residues of pretilachlor, butachlor, cladinofop-propagyl and pendimethalin even on 3rd after application. Under submerged ecosystem, residues of herbicides were found below detectable limit on 3rd day after application irrespective of source of water except for pretilachlor, 2,4-DEE, 2,4-D acid and bispyribac sodium in field water. Under laboratory conditions, the initial concentration of 2,4-DEE in water varied from 0.202 to 0.247 mg/kg across different doses with highest value in the highest dose of 1.8 kg a.i./ha treatment . More than 90% of the applied 2, 4-DEE disappeared from the soil on 7th day irrespective of the dose of application. At doses of 0.90 and 1.80 kg a.i./ha, it persisted up to 15 days and becomes BDL on 30th day after application. The initial concentration of pyrazosulfuron ethyl in water varied from 0.982 to 0.0.416 mg/kg across different doses with highest value in the highest dose of 300 g a.i./ha treatment. Half life values of pyrazosulfuron ethyl residueranged from 2.38 - 2.41 days at Coimbatore.

Pyrazosulfuron ethyl persistence was evaluated in water in transplanted rice at 25 and 50g/ha, within 3 days of transplantation of rice plants at Kathalagere Bengaluru. It was found that water quality was not affected by pyrozosulfuron ethyl. Pyrazosulfuron ethyl residues were detected up to 30 days in water and later on residues were found below detectable level in underground water in rice cultivated field. In the soil, pyrazosulfuron ethyl degraded fast at both 25 and 50g ai/ha. The persistence pattern indicated that residue of pyrazosulfuron ethyl was not observed after 45 days at 25g ai/ha and also at 50g ai/ha (Table 5.2.1).

Table 5.2.1: Persistence of pyrazosulfuron ethyl in underground water (ppm) under transplanted rice at Kathalagere during *kharif* 2013

Days after treatment	Pyrazosulfuron-ethyl application (g/ha)	
	25	50
0 day	0	0
15th day	0.0070	0.0164
30th day	0.0038	0.0031
45th day	BDL	BDL
Harvest	BDL	BDL

WS 5.3: Characterization of leaching behaviour of herbicide in soil

Cooperating Centres: PAU, UAS (B), RVSKVV, GBPUAT, CSKHPKV, AAU(J), VNMKV, AAU(A), TNAU, NDUAT, CSAUAT, KAU, OUAT, ANGRAU and CCSHAU

A considerable part of applied herbicide finds its way to the soil. The fate of which is influenced by its subsequent adsorption, degradation and leaching through the soil profile. In high rainfall areas with shallow water table, leaching is an important process contributing to the contamination of ground water by herbicide residues. Therefore, investigations were carried out to study leaching herbicides in soil profile.

Results of the leaching studies conducted at Hyderabad indicated that pretilachlor applied to surface of the soil at 500 g/ha leached up to 10-15 cm in recommended and double the recommended doses in red soils. When the pretilachlor was applied at double the recommended dose, the herbicide detected in the top 0-5 cm layer was 50.6 % (0.365 mg/kg) of the total herbicide detected in the soil column. In black soils, pretilachlor leached up to 10 cm depth. In double the recommended dose, pretilachlor leached up to 15 cm depth. At both the doses of herbicide application, the residues could not be detected beyond 15 cm depth, which indicated

limited leaching potential of pretilachlor. Similarly, metribuzin was detected up to 15-20 cm in X dose and up to 20-25 cm layer in 2X dose in red soils, and depth wise distribution of the detected amount of herbicide amount indicated that most of the applied herbicide could be detected in the top 15 cm layer of the soil.

Residues of pretilachlor (1.0 kg/ha) were not detected up to 30 cm depths from the clay loam samples collected at farmer's field village Dabra near Hisar. However under laboratory conditions the residues were found up to the soil depth of 35-40 cm and BDL in soil depth 35-40 cm in sandy loam soil at 40µg dose. In clay loam soil, retention of pretilachlor was greater and no residue was detected after 25 cm depth. In leachates collected from 40µg treatment, pretilachlor residues were not found. But, at 145µg dose, residues up to 40 cm depth were detected in case of clay loam soil. The leachates collected from higher dose treatment were found to contain 110.5 and 30.6 µg residues. The amount of residues in leachates collected from sandy loam soil was higher than the leachates collected from clay loam. This show high absorption of pretilachlor in clay loam soil. Leaching behaviours of metribuzin and cyhalofop-butyl was characterized in silty clay loam (sand 28, silt 42 and clay 30) at Palampur. Soil from a depth of 0-15 cm was collected from CSKHPKV, Palampur. The depth wise mean concentrations of metribuzin followed the decreasing pattern. Metribuzin applied at 1000 g/ha resulted into 0.0037 µg/g in the leachates collected on 7 days after herbicide application.

Cyhalofop butyl could not be detected both in the soil and leachates when herbicide was applied at 75 g/ha and 150 g/ha. Leaching behaviour of anilofos in sandy loam soil was determined at Faizabad. It was found that anilofos persisted up to 45 and 60 days in sandy loam soil and leached up to 15 and 30 cm soil depth at 0.4 and 0.8 kg/ha application rates. It was observed that most of pretilachlor residue remained up to 20 cm depth indicating low mobility of pretilachlor in soil column in loamy sand (sand 82.8%, silt 8.6% and clay 7.4%) of Ludhiana. However, at higher dose it leached down to 30 cm soil also (Fig 5.3.1). The results also indicated the mobility of herbicide in soil at higher dose was comparatively higher than that at lower dose.

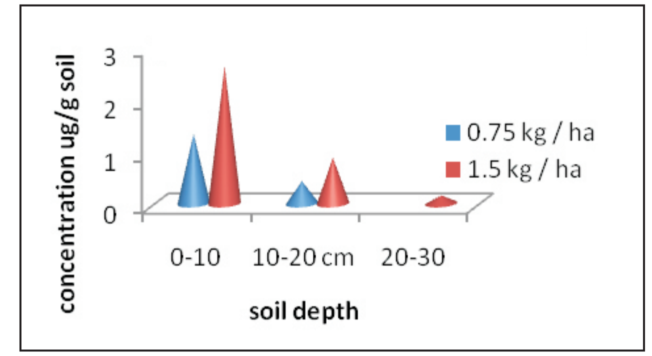


Fig 5.3.1: Distribution of pretilachlor at different depth of soil column

Leaching behaviour of metribuzin and butachlor was characterized in soil under two irrigation levels at Gwalior. The leaching of metribuzin was affected by concentration of herbicide as well as irrigation levels as depicted by growth of black gram plant at different depth. Plant height, fresh weight and dry weight of black gram were reduced up to 25-30 cm and 35-40 cm depth at recommended (0.5 kg/ha) and double the recommended (1.0 kg/ha) doses at 2.5 cm irrigation level. At 7.5 cm irrigation, the plant growth of black gram was reduced up to 35-40 cm at 0.5 kg/ha and 40-45 cm at 1.0 kg/ha metribuzin. Metribuzin and butachlor leaches in soil up to 25-30 and 20-25 cm at 0.5 kg/ha and 35-40 and 25-30 cm at 1.0 kg/ha at 2.5 cm irrigation/day up to 7 days. At 7.5 cm irrigation the herbicide leaches up to 35-40 and 25-30 cm at 0.5 kg/ha and 40-45 and 30-35 cm at 1.0 kg/ha, respectively. However, leaching of pyrazosulfuron ethyl was observed up to 50 cm in sandy loam from Hebbal soil but its movement was only up to 40 cm in loamy sand soil at Kathalagere. Whereas, double the dosage had moved the herbicide more up to 55 cm deeper layer of the soil.

Leaching behaviour of pyrazosulfuron ethyl and bispyribac sodium in different soil types was determined at Coimbatore. The pyrazosulfuron ethyl residue decreased with increase in soil depth and residue was detected up to 30 and 45 cm depth under 150 and 300 g/ha respectively, irrespective of soil types. After 15 days, only 0.48 - 9.09 and 1.83 - 10.33 per cent of the applied quantity of pyrazosulfuron ethyl remained in the soil (Fig 5.3.3) across different depths respectively in sandy clay and organic soils and the per cent retention is more in double the recommended dose (2x) applied column. Unlike pyrazosulfuron, the residue of bispyribac decreased with depth and was maximum at 15-30 cm depth in sandy clay and 0-5 cm in organic soil respectively under both the levels of application. Retention of the applied bispyribac sodium is high in sandy clay soil than in organic soil irrespective of dose of application (Fig 5.3.4). Residues of pyrazosulfuron ethyl were not detected in the leachates collected from the experiment on 5 days and at the end of experiment.

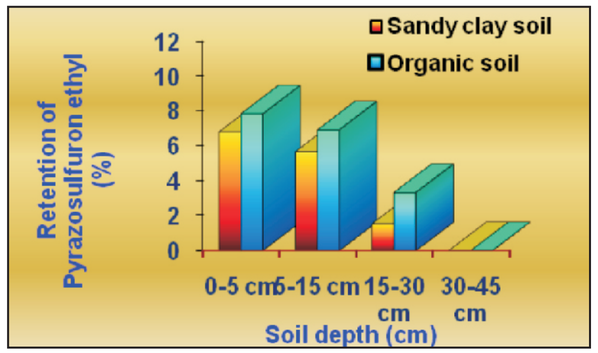


Fig 5.3.3: Retention of pyrazosulfuron-ethyl at different depths after 15 days

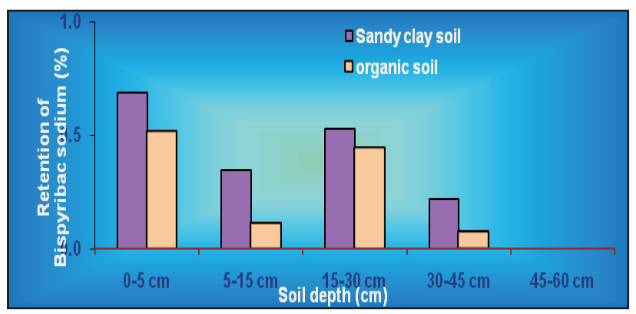


Fig 5.3.4: Retention of bispyribac-sodium at different depths after 15 days

While more than 10% of the applied pyrazosulfuron ethyl present across different depths, only 1-2% of the applied bispyribac sodium was retained and showed that the bispyribac is dissipated faster from the soil than pyrazosulfuron. While the pyrazosulfuron was detected only to 30 cm depth, bispyribac was detected up to 45 cm depth and confirmed that the later is more mobile in soil than former one. The difference is attributed to the inherent soil properties like clay and organic matter content.

WS 5.4 Testing of herbicide residue at farmer's field

The consumption of herbicide in field crops, especially transplanted rice crop, has increased considerably during last few years owing to their cost effectiveness and efficiency in weed management. However, long-term use of herbicide and indiscriminate use of the chemical may cause persistence of the residue in soil, food and groundwater for longer time. Therefore, studies were undertaken to evaluate herbicide residues from farmer field.

At Jorhat, surface (0-15 cm) soil samples were collected in the month of June/July 2013 from farmers' field growing *boro* rice with pretilachlor application and analysed for the herbicide residue. The pretilachlor residue in soil after harvest of *boro* rice was found below detectable level. Residues of metribuzin in soil and tomato fruit samples collected from farmers fields were evaluated for herbicide residues at Hyderabad. Among the four soil samples collected at harvest of the tomato fruits, residues of metribuzin were below BDL in four samples (<0.015 mg/kg). In two samples the residues detected were just above the BDL i.e. 0.051 and 0.032 mg/kg. All the four tomato samples collected from the farmers fields did not contain metribuzin residues above BDL (0.015 mg/kg). However at Hisar, soil, wheat grain and straw samples were collected from farmers' field at harvest from different rice-wheat growing regions of Haryana. The samples were taken from the sites where farmers were continuously using the pretilachlor from many years. At harvest four samples were found to contain sulfosulfuron with in rage 0.011-0.028 µg/g. Five soil samples was having either sulfosulfuron or meso+iodosulfuron. No other herbicides residues were detected in wheat grain and straw in the framers field.

In *kharif*, it was observed that 6 out of 21 sites were having pretilachlor residues ranging between 0.21-1.30 µg/ml in soil. Pretilachlor residues were detected from grain and straw from farmers fields.

Soil and rice grain samples were collected at harvest from the butachlor treated fields of nine farmers of Kangra district, Palampur and were analysed for butachlor residues. Butachlor residues were found below detectable limits in soil and rice grain samples. Samples of isoproturon (1kg/ha), clodinafop-propargyl (0.06 kg/ha), sulfosulfuron (0.025 kg/ha), and 2, 4-D (0.50 kg/ha) treated field of

farmers were collected at harvest of the crop and clay loam soil was analysed for its residue components at Pantnagar. Residues were found below detectable limits in all components at the time of harvest of wheat. Samples of butachlor 1.5 kg/ha, pretilachlor 0.75 kg/ha, and anilofos 0.75 kg/ha treated field of farmer were collected at harvest of the rice crop and soil was analysed for its residue components. The analysis revealed that no residues of butachlor were detectable in the farmer field at the time of harvest in soil, rice grain and straw. Similarly in sugarcane crop and soil samples collected from atrazine 2.0 kg/ha and 2, 4-D 0.50 kg/ha treated field of farmer residues were not detected. The soil samples and grains of sorghum were collected from ten farmers field from Parbhani, Nanded and Beed districts at harvest of sorghum where atrazine was used for weed control. 0.004, 0.002 and 0.02 µg/g residues of atrazine were found in plant, grain and soil respectively.

Soil samples from the farmers fields of Nilgris district was collected from four different locations during *Rabi* 2012-13 cropped with potato and treated with 2,4-DEE and paraquat and from the groundnut and onion grown fields during *kharif* 2013 from Bhavanisagar area of Coimbatore district that received imazethapyr and oxyfluorfen. Applied herbicides were not detected in the different plant matrices and soil at harvest. This showed that they have been degraded from the soil before the harvest of the crop.

WS 5.5: Studies on secondary metabolites of herbicides

Owing to the rapid degradation of the esters of 2,4-D in water, the primary breakdown product is 2,4-D acid, which is more persistent in water and soil. Further 2,4-D acid converted to 2,4-D anion due to hydrolysis /2,4-Dcihlorophenol by anaerobic aquatic metabolism or aerobic soil metabolism. In this view, the presence of 2,4-D acid and 2,4-DCP in the rice field which received 2,4-DEE at 2 levels were examined. 2,4-D acid was detected in soil up to 7 days after its application, 2,4-DCP was detected only on 1st to 5th day after its application.

WS 5.6: Adsorption and desorption behaviour of herbicides

Adsorption-desorption of pendimethalinm, metribuzin, pretilachlor, pyrazosulfuron, oryzylin, quizalofop- ethyl, bispyribac sodium and pyrazosulfuron ethyl were determined in different soil type using batch equilibrium method.

Cooperating Centres: AAU (J), AAU(A), ANGRAU, CSKHPKV, OUAT, UAS(B), GBPUAT, CCSHAU, KAU, TNAU, PAU

A laboratory experiment was conducted to study the behaviour of pendimethalin in clay loam type soil at Hisar. Adsorption of pendimethalin in clay loam type soil were quite strong and desorption were very difficult. A laboratory experiment was conducted to study the behaviour of pretilachlor and metribuzin in silty clay loam soil of Palampur. Pretilachlor at different concentrations was added to these soils and equilibrated. The total amount of pretilachlor adsorbed increased with increasing initial concentration from 2.5 to 25 g/ml of equilibrium solution (25 g to 250 µg/g soil). The amount of pretilachlor adsorbed varied from 20.8 to 155.5 µg/g. Total amount of metribuzin adsorbed increased with increasing initial concentration from 2.5 to 25 (g/ml) of equilibrium solution (25 µg to 250 µg/g soil). The amount of metribuzin adsorbed varied from 14.0 to 115.1µg/g. However, adsorption data did not show much difference at different concentrations.

Adsorption and desorption behaviour of oryzalin in silty clay loam and sandy loam soil was evaluated at Pantnagar. In silty clay loam soil the adsorption of oryzalin increased up to 95.766 µg/g soil at 10 µg/g initial concentration, while least adsorption 22.617 µg/g soil at 2.5 µg/g initial concentration. In sandy loam soil the adsorption increased up to 94.357 µg/g soil at 10 µg/g initial concentration, while least adsorption 21.700 µg/g soil at 2.5 µg/g initial concentration. In silty clay loam soil the desorption found up to 3.882 µg/g soil at 10 µg/g, while least desorption was 1.987 µg/g soil at 2.5 µg/g, while in sandy loam soil desorption was found up to 4.975 µg/g soil at 10 µg/g, while least desorption was 2.763 µg/g soil at 2.5 µg/g. Adsorption and desorption behaviour of quizalofop-ethyl was evaluated in soil at Bhubaneswar. Adsorption and desorption processes were found time dependant with quicker adsorption in soil. The rate of adsorption was rapid initially and the platue was reached within one hour of equilibration. But the process of desorption was slower and the maximum was reached at about 60 hours of equilibration. Only 35% of the amount adsorbed could be desorbed in 72 hours of equilibration.

Pretilachlor adsorption behaviour were evaluated in three soils, sandy loam, loam and clay loam of Punjab having different textures. Total amount of pretilachlor adsorbed increased with increase in initial concentration from 10 to100 μg/ml. It was observed that the adsorption and desorption of pretilachlor increased with the increase in temperature from 30^0C to 50^0C indicating endothermic nature of adsorption. It was observed that as the OM and clay content in soils increased the adsorption in soils also increased. Also the $\log K_{Fads}$ values increased for the soil as the temperature increased from 30^0C to 50^0C indicating that temperature strongly influences the adsorption. Values of 1/n for three soils ranged from 0.6171 to 0.7975 indicating a favourable adsorption in three soils.

Adsorption and desorption behaviour of bispyribac sodium and pyrazosulfuron ethyl in different soil types were conducted at Coimbatore. Increase in the concentration of pyrazosulfuron ethyl and bispyribac sodium increased the adsorption of pyrazosulfuron ethyl. The isotherm expressed an increasing trend in the adsorbed content C_s (mg/kg) with respect to increase in the equilibrium concentration of pyrazosulfuron ethyl and bispyribac sodium C_e (mg/L) in solution. The shape of the pyrazosulfuron-ethyl and bispyribac sodium adsorption isotherm in all the soils was S and 'C' type. The adsorption of pyrazosulfuron-ethyl in different soils from different agro-climatic zones of Karnataka were in the decreasing order of Kathalagere> Mandya> Mudigere> Mangalore which is also the order for organic carbon in these soils. Hence, higher adsorption of pyrazosulfuron-ethyl in Kathalagere soil was mainly due to higher organic carbon content than Mandya and Mangalore soils. Whereas, in Mudigere soil even though the organic carbon content is lower than Kathalagere soil, the adsorption of pyrazosulfuron-ethyl is low due to low pH.

WS 5.7 Persistence / dissipation and residue analysis studies of herbicides in other system

Residues of pretilachlor, bispyribac sodium, metsulfuron methyl and chlorimuron ethyl in the soil and rice grain were determined in conservation agriculture experiment at Hyderabad. The residues of pretilachlor and bispyribac sodium in rice grain and straw at harvest was found below detectable level (BDL). Atrazine residues were monitored in sweet corn samples and maize stover at X and 2X doses. No detectable residues of atrazine were present in the grain and stover collected at harvest at both doses of atrazine i.e. 1.0 and 2.0 kg/ha. Metsulfuron-methyl at 4 and 8 g/ha was evaluated in soil and wheat crop at Pantnagar. No detectable residue (<0.001 g/g) was found on 30^{th} day of application. No detectable residue (<0.005 g/g soil) of metsulfuron-methyl and chlorimuron-ethyl were observed in soil after 45 and 60 day of application. Persistence of pendimethalin was evaluated applied at recommended dose in zero and conventional tillage in transplanted (T) and direct seeded (DS) rice at Ludhiana. There was no residues of pendimethalin in grain, straw and soil at harvest in both tillage and residue management techniques.

Ws 6.0 Transfer of technology

WS 6.1: On-farm trials

Appropriate technologies are roots of agrarian development. However, any weed management technology cannot perform equally in every agro-climatic situation. On-farm trials (OFT) aim at testing a new technology or an idea in farmer's fields, under farmers conditions and management, by using farmer's own practice as control. It should help to develop innovations consistent with farmer's circumstances, compatible with the actual farming system and corresponding to farmer's goals and preferences. On-farm trial is not identical to a demonstration plot, which aims at showing farmers a technology of which researchers is sure that it works in the locality. Accordingly, OFTs are formulated by the AICRP-WC centres based on weed problems faced by the farmers and priority of the problems. Economically viable, practically feasible weed management technologies matching with farmers

needs are identified by AICRP-WC centres and OFT have been conducted on this aspect to solve the weed problem as given below:

At Hisar, OFTs conducted at 5 locations revealed that new herbicide tembotrione at 100 g/ha is very effective to control weeds (85.6%), viz. *Cyperus rotundus, Brachiaria, reptans, Commelina, Digitaria sanguanalis and Elusine indica* in maize crop. These weeds are not controlled by the existing farmers practice of atrazine application. Similarly, readymix combination of pretilachlor +bensulfuron was tested against complex weed flora in transplanted rice at 17 locations in various parts of Haryana and compared with existing herbicide pretilachlor. Results showed 94.2% control of complex weed flora with tested new herbicide against 84.7% with pretilachlor and also yield increase of 157 kg/ha. In another OFT bio-efficacy of ready mix combination of clodinafop +metribuzin was tested against complex weed flora in wheat at 16 locations and compared with earlier recommended herbicides i.e. mesosulfuron +iodosulfuron and sulfosulfuron + metsulfuron. On an average clodinafop + metribuzin had an edge over farmer's practice as it provided more than 87.6% control of *P. minor* as against 83.1% by use of mesosulfuron + iodosulfuron or sulfosulfuron + metsulfuron. New molecule showed good efficacy against grassy and broadleaf weeds but with toxicity to some of varieties, *viz.* 'PBW 550', 'HD 2967', 'HD 2891' and 'Barbat' under high moisture conditions and regeneration of *P. minor.*

At Parbhani, 15 OFTs were conducted during *kharif* season of 2013 using integrated weed management technologies for weed management in soybean, cotton and sorghum at various places of marathwada Region. On an average 18.5, 26.1 and 18% increase in soybean seed yield, seed cotton yield and sorghum grain yield, respectively, was observed due to adoption of integrated weed management practices over farmers practice.

At Ludhiana, On-farm trials using paddy straw mulch at 6 t/ha spread uniformly in the entire field after planting of autumn potato for weed control were conducted which gave higher yield 300 g/ha with BC ratio 4.74 than farmers practice (286 q/ha with BC ratio 4.72). Similarly fenoxaprop with safener @ 67.5 g/ha as PO showed good control of grassy weeds and higher grain yields (45 q/ha) over existing farmer practice (Bispyribac 25g/ha PO) in OFT conducted on weed management in direct seeded rice.

At Pantnagar, OFTs were conducted at five locations in the Distt. US Nagar and Nainital. In *Tarai* region of Uttarakhand, application of ready mix of clodinafop and metsulfuron methyl in wheat crop was found more effective against weeds at farmer's field as compared to alone application of clodinafop *fb* metsulfuron methyl. While in hilly areas application of sulfosufuron +metsulfuron methyl at 4.0 g/ha was found effective to control the weeds in wheat crop. Application of recommended herbicide (bispyribac-Na) at 20 g/ha was found more effective against weeds in rice compared to farmers practice and it recorded 2.94 and 11.7% grain yield in *tarai* and hilly areas, respectively. Alone application of imazethapyr at 100 g/ha gave highest WCE (68.6 %) and produced (37.1%) higher yield of soyabean over the farmers practice.

At Thrissur, OFTs conducted at two locations in the Distt Palakkad (Chithali) and Thrissur (Alappad). *Echinocloa colona, E. crusgalli, Sacciolepis interrupta* and *Leptochloa chinensis* were the major weeds in the wet seeded rice locality. Cyhalofop butyl was found very effective against all these weeds and resulted in high yields. In dry seeded rice condition at Chithali, Palakkad district, the field had severe infestation of *Echinochloa crus-galli, E. stagnina* and *Leptochloa chinensis.* Herbicide cyhalofop was found effective against all these weeds whereas, bispyribac was not effective against *Leptochloa chinensis* in both the conditions even though it was effective against all other weeds. Cyhalofop resulted in yield on par with hand weeding.

At Ranchi, on-farm trial using pyrazosulfuron @ 20 g/ha *fb* bisparibac- sodium @ 25 g/ha was conducted at five farmers fields for weed management in transplanted rice. The tested technology gave higher seed yield over farmers practice. The mean net returns were ₹ 47501 and ₹ 24030 and B:C ratio were 2.29 and 2.06 under chemical method and farmers practice of weed control, respectively.

At Anand, OFTs conducted at two locations showed that IC +HW carried out at 20 and 40 DAS was more effective for weed management in soybean as compared to post emergence application of quizalofop-ethyl.

At Palampur, OFTs using quizalofop +chlorimuron ethyl were conducted during *kharif* season at different location for weed management in soybean. The tested technology gave higher seed yield over farmer's practice.

At Bhubaneswar, 6 OFTs conducted on transplanted rice at Gopapur village of Keonjhar district. The results revealed that maximum yield of 4.21 t/ha was recorded in the plot applied with oxadiargyl 0.065 kg/ha followed by pyrazosulfuron-ethyl 0.02 kg/ha (4.02 t/ha). A net saving of ₹ 2150 - 2654/ha was obtained in the plots treated with herbicides.

At Gwalior, technology in wheat, two in cluster bean, two technologies in soybean and one in pearlmillet were evaluate twenty OFTs in wheat, seven in cluster bean, four in soybean, and five in pearlmillet were conducted at farmers field at various locations. Application of isoproturon @ 1.0 kg/ha as PO in wheat performed better in respect to control of weed flora, productivity (3.86 t/ha) and net return of ₹ 45623/ha, as compared to farmers practices (3.65 t/ha). Imazethapyr + imazamox @ 50 g/ha as PO was most effective to control weeds in clusterbean and gave maximum seed yield (1.23 t/ha) followed by quizalofop ethyl @ 50 g/ha.

At Bengaluru, OFTs using bensulfuron methyl 0.6% G at 60 g/ha + pretilachlor 6% G at 600 g/ha -3 DAP and pyrazosulfuron ethyl 10 WP at 25 g ai/ha – 3 DAS followed by one hand weeding at 30 DAP /ha were conducted in transplanted rice in southern dry zone which gave 8 and 7.0% higher yield over farmer's practice. Similarly, pretilachlor 50 EC at 750 g/ha as PE followed by bispyribac sodium 10 SC at 25 g ai/ha as PO gave 15.3 % higher yield than farmers practice of two hand weeding (20 and 40 DAP), besides saving weeding cost by ₹ 3500 to 5000/ha.

At Bikaner, 20 OFTs on application of metsulfuron at 4 g/ha to control broad leaved weeds in wheat and imazethapyr at 40 g/ha in cluster-bean were conducted. Imazethapyr at 40 g/ha in cluster bean controlled weeds effectively and increased the grain yield and had highest net return in the range of ₹ 20100 to 43912/ha with B:C ratio 2.12 to 3.44. Similarly in wheat metsulfuron at 4.0 g/ha at 30 to 35 DAS effectively controlled broad leaved weeds as compared to farmers practice in all locations and increased grain yield of wheat. The per cent increase in the grain yield was in the range of 34.0 to 36.4% and had highest net return ranging from ₹ 12761 to 41346/ha with B:C ratio 1.54 to 2.76 .

At Dharwad, 10 OFTs were conducted in groundnut, maize, sugarcane, rice, sunflower. The tested technologies like butachlor in groundnut, sunflower and rice, metribuzin in sugarcane, bispyribac sodium in rice, atrazine in maize gave higher yield and net returns compared to farmer's practice of weed management.

At Faizabad, OFTs were conducted in tobacco to control *Orobanche cernua*. Results revealed that application of 20g urea/plant after beheading of *Orobanche* shoots gave higher tobacco leaf yield (2.31 t/ha), net return (₹ 286800/ha) and BC ratio (3.56) followed by imazethapyr 30 g/ha at 55 DAP (net return ₹ 279200 and BC ratio 3.50). similarly application of clodinafop + metsulfuron methyl (60 g+4 g/ha) as PO or clodinafop 60 g/ha as PO *fb* one hand weeding at 45 DAS in wheat showed higher, grain yield and economic benefits, whereas in rice, application of pretilachlor 1000 g/ha as PE *fb* one hand weeding recorded higher grain yield (5410 kg/ha) with net profit of ₹ 46280/ha.

At Sriniketan, 9 OFTs were carried out using proven herbicides, bispyribac sodium and fenaxoprop in *kharif* rice, pendimethalin in ladies finger, pendimethalin and oxyflourfen in onion, pyrazosulfuron in boro-rice nursery and pendimethalin in radish under Birbhum and Burdwan districts of West Bengal. In all the cases farmers were satisfied with improved weed management technology as these technologies were more effective in managing weeds producing higher yield and economic return as compared to existing technologies.

OFT on early (post *kharif*) radish at VB, Srinikeatan

At Pusa, OFTs were conducted using the chemical weed management technologies for various crops in different farmers field. Pyrazosulfuron 20 g/ha in rice, metribuzin 500 g/ha in *kharif* maize, and pendimethalin @ 1 kg/ha in lentil were found superior in term of grain yield over farmers practices.

At Coimbatore, 5 OFTs were carried out in groundnut. Results revealed that pre-emergence application of oxyfluorfen 250 g/ha followed by imazethapyr 100 g/ha + quizalofop ethyl 60 g/ha PO at 15 DAS was superior to farmers practice in terms of broad spectrum weed control and seed yield and economic returns. Similarly 5 OFT were conducted for weed control in onion using oxyflourfen at 250 g/ha on 3 DAS followed by wheel hoe weeder on 45 DAS, showed higher onion yield (11-15.3 t/ha). Gross and net returns were also higher (₹140810-149340/ha and ₹ 110460-118990/ha).

WS 6.2 Front Line Demonstrations

Frontline demonstration is a long term educational activity conducted in a systematic manner in farmers field to show the worth of a new practice/ technology. In order to popularize and show the performance and profitability of proven weed management technologies among farming community with objective to make them aware and adopt these for enhanced crop productivity, following FLD has been conducted by AICRP-WC centres during the year 2013 through farmer participatory approach.

At Kanpur, 10 FLDs using herbicides for managing weeds in wheat were conducted at farmers fields in different locations. The grain yield of wheat increased from 7.6% to 21% due to herbicide application. The farmers showed keen interest for using herbicides to control weeds in wheat crop. Similarly, 14 FLDs conducted on rice at farmers field in different locations showed grain yield increase of 16.2% to 21.8% due to integrated weed management practices. Improved weed management practices showed an increase in seed yield by 29.9% in black gram (2 FLDs), 43.4% in maize (4 FLDs). The farmers showed keen interest for using herbicides to control weeds in rice, black gram and maize crop.

At Ranchi, 30 FLDs were conducted in transplanted rice in Lohardaga, Khunti and Ranchi area using pyrozosulfuron @ 0.02 kg/ha. The demonstration technology performed better than farmers practice (hand weeding) and recorded 20.8% higher grain (2.89 t/ha) with higher net return and B:C. ratio.

At Anand, two FLDs on weed management in soybean were conducted at farmers fields. The higher grain yield and B: C ratio (2.0) was recorded with improved weed management technology over farmers' practice.

At Raipur, FLDs were conducted on weed management in rice , maize and wheat in 26 tribal villages of Bastar, Kondagaon, Kanker, Dhamtari, Balod, Bilaspur, Balrampur, Korea, Sarguja and Mahasamund Districts. In transplanted rice 60, direct seeded rice 115, *rabi* maize 65 and 15 demonstrations in wheat were conducted during *kharif* and *rabi* seasons of reported year with the help of KVK's of respective district. The overall average benefit cost ratio of recommended weed management practices were recorded as 19.7, 10.5, 27.0, 52 and 252% in transplanted rice, direct seeded line shown rice, direct broadcast seeded beushened rice, maize and wheat respectively, and these values were higher than farmer's practices.

At Bhubaneswar, 10 FLDs were carried out in the village Pipli Jaganathpur and Singhberhampur on transplanted rice during *kharif* 2013. The yield increase of 21-42% was obtained with oxadiargyl (0.060 kg/ha) + one hand weeding at 45 DAT over farmers practice (two hand weeding).

At Gwalior, 30 FLDs on weed management in wheat (5), gram (1), pea (8), potato(7) during *rabi* and pearl millet (4) and soybean (5) during *kharif* were conducted in different locations. Results showed clodinafop at 60 g/ha gave higher yield (3.9 t/ha) in wheat, pendimethalin at 1.0 kg/ha gave significantly increased yield of 1.2 t/ha and 1.7 t/ha in gram and pea, respectively, whereas application of metribuzin at 250 g/ha gave higher net profit (₹ 62749 /ha) in potato over farmers practice (₹ 45683/ha). Similarly, during *kharif* FLDs were conducted in pearlmillet and soybean at farmers field. The improved weed management technology viz. atrazin @ 0.5 kg/ha PE and imazethapyr 100 g/ha PO gave higher grain yield 2.2 t/ha and 1.3 t/ha in pearl millet and soybean, respectively as compared to farmers practice.

Management of *Orobanche* in mustard crop

At Hisar, results of 84 FLDs conducted on 385.5 acres in different blocks of Bhiwani and Hisar district revealed that post-emergence application of glyphosate 25 g/ha at 25 DAS followed by its repeated application at 55 DAS provided effective control (66%) of *Orobanche aegyptiaca* in mustard with yield increase of 13.6 percent.

Use of glyphosate in mustard at Hisar

At Bengaluru, the result of FLDs conducted on transplanted rice in farmers field showed that pretilachlor 50 EC at 750 g/ha as PE followed by bispyribac sodium 10 SC at 25 g/ha PoE provided 15.3% more grain yield , and a saving of ₹ 3500-5000/ha as weeding cost compared to farmers practice of two hand weeding at 20 and 40 DAT.

At Jorhat, several FLDs were conducted on weed management in boro rice and winter rice in farmers fields at different locations of Assam using recommended herbicide pretilachlor at 750 g/ha as PE followed by paddy weeder at 35 DAT. The results revealed that higher average grain yield (4.3 t/ha) was recorded with 22% increase over farmers practice in all the locations.

At Parbhani, during *kharif* season 2013, 5 FLDs were conducted on weed management technology in soybean at various places in Marathwada region. The recommended weed management technology pendimethalin @ 2.5 l/ha PE + 1 HW and 1 hoeing at 6 week after sowing was compared with farmers practice. On an average, integrated weed management practices gave 2.3 t/ha soybean seed yield with 2.58 B: C ratio and ₹ 42056 as net monetary return.

At Ludhiana, 5 FLDs in wheat for the control of *P. minor* and broadleaf weeds were carried out at farmers field in different locations. The demonstrated technology, pendimethalin at 750 g/ha PE performed better than farmer's practice (hand weeding) and recorded higher net returns ₹ 40500/ ha with 2.59 B:C ratio. Similarly in direct seeded rice FLDs were conducted at famers field. The integrated weed management involving sequential application of pendimethalin at 750 g/ha PE and bispyribac sodium at 25 g/ha as PO resulted in higher net returns of Rs. 60220/ha with 3.41 B:C ratio compared to farmers practice.

At Bikaner, 20 FLDs using herbicides for managing weeds in groundnut (10) and wheat (10) were conducted at farmers field in different location. In groundnut results revealed that pendimethalin at 1.0 kg/ha gave broad spectrum weed control and increased mean net return with B: C ratio from 1.91 to 2.47. Similarly in wheat application of metsulfuron at 4 g/ha at 30 DAS effectively controlled broad leaved weeds in all locations and increased grain yield, mean net return and B: C ratio from 1.79 to 2.19.

At Dharwad, 10 FLDs were conducted in Dharwad, Bagalkot and Belgaum district on major crops like maize, sugarcane, soybean , sunflower, rice, and onion using improved weed management technologies for weed control. All the applied herbicides effectively controlled the weeds, with enhanced yield and reduced cost of cultivation.

At Hyderabad, FLDs were conducted in Nalgonda, Warangal, Ranga reddy and Mahaboobnagar districts for rice and cotton. In rice, FLDs were conducted at 10 farmer's fields in Nalgonda (1), Warangal (5), Khamman(2), Ranga Reddy (2) district. The integrated weed management

involving pre-emergence application of bensulfuron methyl + pretilachlor *fb* one hand weeding at 35-40 DAT resulted in higher B: C ratio (1.85-2.3) compared to farmers practice (1.55-2.1) of hand weeding twice at 25 and 50 DAT, indicating the superiority of the demonstrated technology. In cotton, FLDs were conducted at four farmer's fields in Srikakulam (2) and Renga reddy (2) district. The integrated weed management involving post emergence application of pyrithiobac sodium + propaquizafop *fb* inter cultivation resulted in higher B: C ratio (1.59-1.89) compared to farmers practice (1.35-1.51) in Srikakulam district. Whereas in Ranga reddy district, relatively higher B:C ratio was recorded (2.45) with herbicidal treatment as compared to farmer's practice (2.27).

At Faizabad, 10 FLDs were conducted during *rabi* 2012-13 covering wheat (4), gram (2) and potato (4) using 0.4 ha land for each FLD in Faizabad and adjoining districts. Compared to the farmer's practices, yield increase ranged from 13.6 to 18.4% (average 15.9%) in wheat, 18.9 to 19.5% (average 19.2%) in gram, and 16.9 to 23.5% (average 21.5%) in potato. Results further revealed that herbicidal weed control methods increased additional net return in the tune of ₹ 7779/- in wheat, ₹ 11360/ha (Gram) and ₹ 38250/ha in potato as compared to farmer's practices.

At Pusa, 10 farmers were selected from Muzaffarpur district for FLDs during *rabi* maize 2012-13 to demonstrate performance of metribuzin @ 500 g/ha. Total area for this demonstration was 10 ha. The results revealed that highest grain yield of *rabi* maize (4.3 t/ha) was recorded with the metribuzin which was 58.9% higher than weedy check, and 16.4% higher than farmers practice. Similarly FLDs were conducted in 10 farmers fields using carfentrozone @ 20 g/ha and sulfosulfuron @ 25 g/ha for managing weeds in wheat in Samastipur district. Compared to farmer's practice, wheat yield was 24.9 and 22.7% higher with carfentrazone (4.56 t/ha) and sulfosulfuron.

At Coimbatore, 10 FLDs were carried out in onion crop at Viraliyur Taluk. Due to adoption of improved weed management technology (oxyflourfen 250 g /ha PE on 3 DAS + weeding with twin wheel hoe at 40 DAS). On an average the onion yields increased by 15.9 to 43.1% higher over farmers practice (two hand weeding). The highest income also obtained in improved practice over farmers practice. 70% of the farmers were fully satisfied with the performance of improved weed management technology.

Table 6.1: Extension activities under taken by coordinating centres

Centre	Trainings imparted	Radio talks	TV programmes	Kisan melas	Handouts/ folders/pamphlets	Bulletins/ booklet	Training participated	Front Line Demonstrations	Parthenium Awareness Week
PAU, Ludhiana	04	01	01	-	01	01	01	10	✓
UAS, Bengaluru	01	-	-	-	-	-	-	05	✓
RVSKVV, Gwalior	-	-	-	-	-	-	-	07	✓
GBPUAT, Pantnagar	-	10	-	01	-	02	-	19	✓
CSKHPKV, Palampur	-	-	-	-	-	04	-	05	✓
AAU, Jorhat	08	01	-	-	-	-	02	140	✓
VNMKV, Parbhani	03	04	-	-	-	-	-	05	✓
AAU, Anand	15	-	01	01	-	-	04	02	✓
TNAU, Coimbatore	03		03	-	-	-	02	10	✓
NDUAT, Faizabad	04	06	01	-	-	-	-	20	✓
VB, Sriniketan	03		01	02	-	-	-	12	✓
BAU, Ranchi	-	-	-	-	-	-	-	30	✓
CSAUAT, Kanpur	-	-	-	-	-	-	-	30	✓
KAU, Thrissur	-	-	-	-	-	-	-	01	✓
OUAT, Bhubaneswar	01	01	02			01	01	12	✓
ANGRAU, Hyderabad	11	-	04	-	-	-	02	15	✓
CCSHAU, Hisar	07	01	02	03	-	04	-	84	✓
RAU, Pusa	05	-	02	02	-	02	-	20	✓
DBSKKV, Dapoli	-	-	-	-	-	-	-	-	✓
IGKVV, Raipur	01	5	10	-	-	-	-	386	✓
UAS, Dharwad	14	-	-	01	04	01	-	10	✓
SKRAU, Bikaner	-	-	-	-	-	-	01	20	✓

4. STATION TRIALS

Weed management in sole crops

Bio-efficacy and phytotoxicity of bispyribac sodium 10% SC (Oriental) on direct seeded rice

At Hyderabad, bispyribac sodium 10% SC at 20 g/ha or 200 ml/ha was economically effective and efficient in weed control and resulted in higher rice yields in direct seeded rice because of broad spectrum weed control and no phytotoxic effect.

Weed and nutrient management under upland direct-seeded rice intensification

At Jorhat, the lowest weed density up to 60 DAS was found in single seed (20 x 15 cm), 50% RDF + vermicompost 1000 kg/ha at sowing, pretilachlor 750 g/ha + grubber 20 and 40 DAS and single seed (20 x 15 cm), 50% recommended dose of fertilizer (RDF) + vermicompost 1000 kg/ha at sowing and 20 DAS, pretilachlor 750 g/ha + grubber 20 and 40 DAS. Lower weed dry weight up to 40 DAS was recorded with single seed (20 x 15 cm), unfertlized, pretilachlor 750 g/ha + grubber 30 DAS and single seed (20 x 15 cm), RDF, pretilachlor 750 g/ha + grubber 30 DAS. The treatment with single seed (20 x 15 cm), 50% RDF + vermicompost 1000 kg/ha at sowing and 20 DAS, pretilachlor 750 g/ha + grubber 20 and 40 DAS resulted highest grain and straw yields and a higher benefit: cost ratio.

Developing weed management strategy for direct (dry) seeded rice under different planting geometry

At Pantnagar, under different planting geometry in direct seeded rice, at spacing of 20 cm regular sowing proved most effective planting geometry in reducing the density and dry weight of weeds. The highest grain yield was recorded with application of bispyribac-Na @ 25 g/ha *fb* one hand weeding (45 DAS).

Bio-efficacy and phytotoxicity and residue studies of bispyribac sodium on transplanted rice

At Hyderabad, bispyribac sodium at 20 and 25 g/ha was effective in controlling without any phytotoxicity on rice and in realizing higher grain yield without any carryover effect on succeeding greengram crop. The residues of bispyribac sodium in grain and straw of rice was found to be Below Detectable Limit (BDL).

Studies on the bio–efficacy and phytotoxicity of bispyribac sodium in transplanted rice

At Pantnagar, in transplanted rice, spray of bispyribac-Na at 20 g/ha was found more effective as compared to its lower dose (15 g/ha) against weeds and also it has recorded highest grain yield (4128 kg/ha).

Effect of time of sowing and weed control methods in direct-seeded rice

At Dharwad, with respect to time of sowing, there was significant difference among the main plots (i.e. sowing before onset and sowing after onset of monsoon). Sowing before on set of monsoon was significantly superior (3696 kg/ha) over sowing after onset (3499 kg/ha). Among weed control treatments, bispyribac sodium recorded significantly higher grain (4790 kg/ha) and higher net returns (Rs 32353/ha) than other treatments, but was on par with butachlor (4828 kg/ha and Rs 31073/ha, respectively). The total weed density/m^2 and weed dry weight were significantly lower in these two treatments compared to other treatments.

Efficacy of carfentrazone-ethyl + sulfosulfuron (Premix) against complex weed flora in wheat

At Ludhiana, one post-emergence application of pre-mix of carfentrazone-ethyl + sulfosulfuron @ 100 g/ha recorded effective control of annual grasses and broadleafe weeds and produced significantly higher wheat grain yield than already recommended herbicides; the new pre-mix was safe to the crop.

Evaluation of pre-emergence herbicide PIH 485 85% WG against mixed weed flora in wheat

At Ludhiana, one pre-emergence application of new herbicide PIH 485 85%WG @ 102 and 127.5 g/ha significantly reduced population of *P. minor* and many broadleaf weeds as compared to recommended herbicides viz., sulfosulfuron, fenoxaprop, clodinafop and unweeded control. The new herbicide controlled all the flushes of *P. minor* upto three months after sowing. PIH 485 85% WG at 127.5 g a.i./ha recorded the highest wheat grain yield and was safe to the wheat crop.

Management of resistant *P. minor* in wheat with herbicides alone and in combination of different herbicides

At Hisar, increase in dose of clodinafop from 60 to 75 g/ha and sulfosulfuron from 25 to 30 g/ha slightly improved the control of *P. minor* but not significantly. Mesosulfuron+ iodosulfuron (14.4 g/ha) provided satisfactory control of *P. minor* along with the BLW. Pinoxaden 50-60 g/ha, clodinafop+ metribuzin 60+105 g/ha, trifluralin or pendimethalin 1000 g/ha (PRE) *fb* clodinafop 60 g/ha, pendimethalin 1000 g/ha *fb* sulfosulfuron 25 g/ha, provided effective control of *P. minor* with no phyto-toxicity on the crop.

Integrated weed management in soybean

At Gwalior, pre mix herbicide imazethapyr + pendimethalin 1000 g/ha as PE + one hand weeding at 30 DAS was most effective in controlling the weed growth and producing higher yield and economic return. The same treatment recorded the maximum net monetary return and B:C ratio.

At Akola, combination of imazethapyr @ 0.100 kg/ha PoE + quizalofop ethyl @ 0.075 kg/ha PoE 15 DAS (Tank mix) was found better in controlling weeds, weed control efficiency, weed index, grain yield and NMR but found at par with imazethapyr @ 0.100 kg/ha PoE *fb* quizalofop ethyl @ 0.075 kg/ha PoE 15 DAS, 1 Hoeing 15 DAS *fb* 1 Hand weeding and fluazifop-p-butyl @ 0.125 kg/ha PoE 15 DAS. While on the basis of economics same treatment of tank mix recorded highest B:C ratio.

Weed management in sunflower

At Dharwad, pre-emergence application of alachlor @ 1.5 kg/ha, pretilachlor @ 1.5 kg/ha, oxyfluorfen @ 0.15 kg/ha along with one intercultivation at 30 DAS have produced significantly higher grain yields which were on par with farmers practice (1917 kg/ha) and the check treatment i.e. butachlor (1958 kg/ha). These treatments were also superior with respect to higher net returns.

Weed management in sesame

At Sriniketan, post-emergence application of quizalofop-p-tefuryl @ 50 and 60 g/ha effectively controlled grassy weeds and imazethapyr + pendimethalin (tank mixture) 800 and 1000 g/ha as pre-emergence controlled broad leaved and sedge weed population. Post-emergence application of quizalofop-p-tefuryl and pre-emergence application of imazethapyr + pendimethalin (tank mix) produced higher seed yield of sesame.

Weed management in greengram

At Sriniketan, post-emergence application of quizalofop-p-tefuryl @ 50 and 60 g/ha effectively controlled grassy weeds and imazethapyr + pendimethalin (tank mixture) 800 and 1000 g/ha as pre-emergence controlled broad leaved and sedge weed population. Post-emergence application of quizalofop-p-tefuryl and pre-emergence application of imazethapyr + pendimethalin (tank mix) produced higher seed yield of green gram.

Screening of suitable post emergence herbicides in cluster bean

At Bikaner, application of imazethapyr+ imazamox (factory mix) 40 g/ha or imazethapyr alone @ 40 g/ha or pendimethalin @ 0.75 kg/ha as pre-emergence significantly reduced the density and dry weight of weeds and increased seed yield and net return.

Studies on bio-efficacy, phytotoxicity, carry over and residual effect of imazethapyr in groundnut

At Pantnagar, application of imazethapyr at 200 g/ha groundnut was found effective against both the grassy and broad leaved weeds as it recorded lowest weed dry matter accumulation. The highest kernel yield was also recorded with application of imazethapyr at 200 g/ha.

Weed management in potato

At Jorhat, application of metribuzin 750 g/ha as early post-emergence at 10 DAP resulted lowest weed density and dry weight up to 50 DAP followed by pretilachlor 750 g/ha as pre-emergence and oxadiargyl 90 g /ha pre-emergence.

Evaluation of herbicides for weed control in sugarbeet

At Ludhiana, pendimethalin @ 365 and 562 g, alachlor @ 937 and 1250 g, oxadiargyl @ 67 and 90 g and oxyfluorfen @ 58 and 87 g/ha as pre-emergence provided effective control of grasses and broadleafes weeds during early stages of crop growth; oxyfluorfen and pendimethalin were phytotoxic to sugarbeet seedlings at higher levels. All the herbicidal treatments except oxyfluorfen 87 g/ha, recorded statistically higher beet root yield than weedy check; herbicides did not influence sucrose content in beet roots

Weed management in chilli after winter rice

At Jorhat, results revealed that metribuzin @ 500 g/ha + garden hoe 30, 60 DAP and metribuzin @ 500 g/ha + garden hoe 30, 50, 80 DAP resulted lowest weed density and dry weight and higher pod yield.

Weed management in *Bt* cotton

At Anand, weed counts and weed dry weight (group wise) were recorded at 25 and 50 DAS, revealed that significantly the lowest monocot, dicot and total weeds/m^2 were recorded in IC+HW carried out at 15, 30 and 45 DAS treatment. Among weed management practices, significantly the lowest dicot weed density and dry matter were recorded in IC + HW carried out at 15, 30 and 45 DAS treatment. Seed cotton and stalk yield of Bt cotton were significantly higher in IC+HW carried out at 15, 30 and 45 DAS treatments which was at par with PE application of pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS and IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray) at 70 DAS respectively in all the three years and in pooled analysis. Germination was recorded at 10 DAS and plant heights as well as dry matter accumulation recorded at 30 DAS of succeeding crops viz, chickpea, wheat and mustard were not significantly affected due to residual effect of pendimethalin or quizalofop-ethyl or fenoxaprop-p-ethyl, glyphosate and paraquat during all three years as well as in pooled analysis.The Economics analysis of the weed management practices for the crop revealed that maximum net return was recorded in IC+HW carried out at 15, 30 and 45 DAS.

Weed management in cotton

At Dharwad, clomazone was tried at different doses (200 g to 600 g/ha PE) and was compared with diuron (recommended herbicide). Among different doses, clomazone at 300 g/ha was on par with clomazone at 400 g/ha in total weed density and total weed dry weight (11.3/m^2 and 7.1g/m^2 and 8.0/m^2 and 5.6 g/m^2, respectively). Clomazone either at 500 g/ha or at 600 g/ha caused phytotoxicity. The crop is to be harvested. Clomazone at 300 g/ha (916 kg/ha) and clomazone at 400 g/ha (958 kg/ha) were on par with diuron 1 kg/ha (995 kg/ha) in seed cotton yield of first picking.

At Akola, one hoeing at 20 DAS + glyphosate 41 SL @ 1.0 kg/ha 45 DAS proves better in controlling weeds, lesser weed dry matter accumulation, weed control efficiency, weed index, NMR and B:C ratio. While treatment combination of pyrithiobac sodium 10 EC @ 0.062 kg/ha PoE *fb* quizalofop ethyl 10EC @ 0.075 kg/ha PoE 20-25 DAS + hoeing at 45 DAS recorded higher seed cotton yield and GMR but found at par with said treatment. Glyphosate @ 1.0 kg/ha as directed spray at 45 DAS was found most effective in controlling weeds and increasing seed cotton yield.

Bio-efficacy of different herbicides in fenugreek

At Hisar, pre-emergence or pre-plant incorporation of imazethapyr at 80 g/ha either alone or in combination with one hoeing at 45 DAS provided 80-95% control of *C. album, C. murale, Coronopus didymus and Rumex dentatus* without any adverse effect on fenugreek. Residual effect of these herbicides applied in fenugreek studied on succeeding sorghum, bitter guord, okra, cowpea, cotton and bottle gourd revealed that post-emergence application treatments of imazethapyr +imazamox(RM) caused suppression in cotton and okra crops.

Weed management in Berseem (*Trifolium alexandrinum* L.)

At Gwalior, results revealed that weed free treatment recorded higher seed (681 kg/ha) and

fodder yield (48700 kg/ha) of berseem. Early post-emergence application of pendimethalin @ 500 g/ha or isoproturon @ 750 g/ha, butachlor @ 500 g/ha and one hand weeding at 25 DAS were also found effective for control of weeds and getting higher yield.

Weed management in cropping systems

Integrated weed and nutrient management through intercropping and fertilizer-herbicide-compost mixture

At Jorhat, pretilachlor 750 g/ha + incorporation of cowpea-*dhaincha* (20 DAS) + HW 40 DAS with 50% RDF- vermicompost (2 t/ha) mixture (20 and 40 DAS), pretilachlor 750 g/ha) HW 20 and 40 DAS resulted lower weed density. Pretilachlor 750 g/ha) HW 20 and 40 DAS followed by Pretilachlor 750 g/ha + incorporation of Cowpea-dhaincha (20 DAS) + HW 40 DAS with 50% RDF- vermicompost (2 t/ha) mixture (20 and 40 DAS) caused reduction in weed dry weight. The grain yield were significantly higher under pretilachlor 750 g /ha + incorporation of inter-row cowpea-*dhaincha* (20 DAS) + HW 40 DAS with 50% RD fertilizer applied as vermicompost (2 t /ha) mixture (20 and 40 DAS) followed by pretilachlor 750 g /ha + HW 20 and 40 DAS.

Weed management in brinjal under rice fallow sequence

At Jorhat, application of oxadiargyl @ 90 g/ha + garden hoeing at 30, 50, 80, 80 DAP and @ oxadiargyl 90 g/ha + garden hoeing at 30, 60 DAP recorded lowest weed density and dry weight up to 60 DAP. Highest fruit yield was observed under garden hoeing 20, 40, 60, 80 DAP, garden hoeing 25, 50, 75 DAP, oxadiargyl @ 90 g/ha + garden hoeing at 30, 50, 80, 80 DAP and oxadiargyl 90 g/ha + garden hoeing at 30, 60 DAP.

Integrated weed and nutrient management in transplanted summer rice through herbicide-compost-fertilizer mixture

At Jorhat, the lowest population of weeds and dry weight per unit area was observed through application of pretilachlor as vermicompost mixture with recommended dose of fertilizer both at 30 and 60 DAT. Highest grain yield was obtained due to application of 75% recommended dose fertilizer-vermicompost (2 t/ha) mixture with pretilachlor 750 g/ha mixed with the first split followed by HW 30 DAT. Maximum benefit: cost ratio was recorded with recommended practice for weed and nutrient management closely followed by 75% recommended dose fertilizer-vermicompost (2 t/ha) mixture with pretilachlor 750 g/ha mixed with the first split followed by HW 30 DAT.Except for available K, NH_4-N, NO_3-N and available phosphorous significantly increased due to 75% RD fertilizer-vermicompost (2 t/ha) mixture with pretilachlor 750 g/ha mixed with the first split followed by HW 30 DAT.

Management of *Cyperus rotundus*

At Bengaluru, 2,4-D sodium salt 0.5 kg/ha spray induce senescence 48h followed by glyphosate 0.97 kg/ha lowered the regeneration potential on par with 2,4-D sodium salt 2 kg/ha or glyphosate 1.3 kg/ha. Thus reduction of 2,4-D sodium salt by 75 % and glyphosate by 25% dosage is possible. Reduction in dosage of herbicide leads to reduced dried out deposit on weed foliage.

5. RECOMMENDATIONS FOR PACKAGE OF PRACTICES

PAU, Ludhiana

Carrot: One pre-emergence application of oxyfluorfen at 117 g/ha, applied by dissolving in 500 litres of water, for effective control of annual grasses and broadleaf weeds in carrot.

Soybean: One post-emergence application of imazethapyr at 75 g/ha, applied by dissolving in 375 litres of water, for effective control of mixed weed flora (grasses, broadleaves and sedges) in soybean.

Autumn sugarcane + garlic intercropping system: One pre-emergence application of either pendimethalin 750 g/ha and oxyfluorfen 234 g/ha, applied by dissolving in 500 litres of water, for effective control of annual weeds in autumn sugarcane + garlic intercropping system.

Wheat: One post emergence application of pre-mix metsulfuron + carfentrazone at 25 g/ha + 0.2% Non-Ionic Surfactant for effective control of all the broadleaf weeds including the hardy one viz. *Solanum nigrum, Rumex spinosus, Vicia sativa* and *Convolvulus arvensis.*

RVSKVV, Gwalior

Wheat: For controlling grassy and broad leaved weeds, higher yield and net return from wheat, application of pinoxaden 40 g/ha (25 DAS) followed by carfentrazon 25 g/ha as post emergence (one week after pinoxaden spray) or sulfosulfuron 25 g/ha (30 DAS) 2,4-D 0.5 kg/ha + isoproturon 1.0 kg/ha as PoE may be used.

Mustard: Fluchloralin 1.0 kg/ha as PPI or oxadiargyl 90 g/ha or isoproturon 0.75 kg/ha as PE application controlled the majority of weeds under blackgram-mustard cropping system.

Gram: Application of pendimethalin 1.0 kg/ha pre emergence controlled almost all weeds and in turn gave the higher yield.

Pea: Application of fluchloralin 1.0 kg/ha as PPI or isoproturon 0.75 kg/ha as PE + 1 HW or pendimethalin 1.0 kg/ha + 1 HW or metribuzin 250 g/ha as EPoE performed better for controlling the weeds as well as getting higher seed yield of pea.

Onion: For obtaining higher bulb yield of onion and net return, 3 hand weeding at 30, 45 & 60 DAT (weed free) or pre emergence application of oxyfluorfen 250 g/ha + 1 HW at 40 DAT or oxadiargyl at 900 g/ha with 1 hand weeding at 45 DAT may be practiced. No residual effect observed in succeeding cucumber, maize and greengram crops.

Coriander: For effective control of weeds, higher yield and economic returns from coriander (grain) two hand weeding (30 and 45 DAS) or pre emergence application of pendimethalin 1.0 kg/ha or isoproturon 0.75 kg/ha PE with one hand weeding at 30 DAS could be used.

Rice: Butachlor 1.5 kg/ha as PE or pretilachlor 1.0 kg/ha as PE or 2,4-D EE 0.75 kg/ha as PoE may be applied for good control of weeds and higher yield and monitory return.

Pearlmilet: Pre emergence application of atrazine 0.5 kg/ha controlled most of the weeds and gave higher yield and left no residue in soil. Conventional tillage operation is better than other tillage practices.

Groundnut: Application of imazethapyr 100 g/ha as post emergence + 1 HW at 30 days after sowing of oxyfluorfen 120 g/ha as PoE + 1 hand weeding at 30 DAS or 2 hand weeding are effective for controlling the weeds.

Soybean: Application of imazethapyr 100 g/ha PoE for controlling the broad leaved weeds and quizalofop ethyl 50 g/ha as PE for controlling grassy weeds as well as 2 hand weeding could be used in soybean. No herbicide residue was present in post harvest soil.

Sesame: Application of quizalofop ethyl 0.05 kg/ha as PE or trifluralin 0.75 kg/ha as PPI or pendimethalin 0.75 kg/ha alone or in combination with one hand weeding at 30 DAS may be used.

Blackgram: Alachlor 2.0 kg/ha as PE or imazethapyr 100 g/ha as PoE or imazethapyr + imazamox (pre mix) 50 g/ha as PoE pendimethalin + imazethapyr (pre mix) 1000 g/ha PE could be applied for controlling weeds in blackgram and obtaining higher yield.

CSKHPKV, Palampur

Soybean: Post-emergence application of quizalofop-ethyl 60 g/ha + chlorimuron ethyl 4 g/ha at 25-30 DAS at 2-3 leaf stage recommended to control the weeds in soybean.

VNMKV, Parbhani

Direct-seeded upland rice: Post-emergence application of fenoxaprop @ 60 g/ha + (Chlorimuron + metsulfuron) @20g/ha or azimsulfuron 20WP @ 35 g/ha.

AAU, Anand

Bt cotton: The farmers of Middle Gujarat zone-III (AES-II) growing Bt cotton are advised to carry out inter culturing and hand weeding at 15, 30 and 45 days after sowing (DAS) in timely availability of laborer, in paucity of laborer, post-emergence application (15-20 DAS) of quizalofop-ethyl @ 50-100 g/ha *fb* IC+HW at 30 DAS or per-emergence application of pendimethalin @ 900 g/ha *fb* IC+HW at 30 and 60 DAS or post-emergence application (15-20 DAS) fexoxaprop-ethyl @ 50-100 g/ha *fb* IC+HW at 30 DAS for efficient weed management in Bt cotton.

VB, Sriniketan

***Kharif* rice:** Post-emergence application of bispyribac-sodium at 25 g + ethoxysulfuron @ 18.75 g/ha in transplanted *kharif* rice.

Transplanted rice: Post-emergence application of bispyribac sodium + [metsulfuron methyl + chlorimuron ethyl] (Almix) (20 g + 4 g). or pre-emergence application of pretilachlor at 750 g/ha *fb.* metsulfuron methyl + chlorimuron ethyl] (Almix) at 4 g/ha at 25 DAT in transplanted rice.

Blackgram: Pre-emergence application of imazethapyr + pendimethalin (pre mix) at 800-1000 g/ha.

IGKV, Raipur

Wheat: Combination of sulfosulfuron + metribuzin @ 25 + 105 g/ha and clodinafop + metribuzin @ 60 + 105 g/ha or combination of pinoxaden + carfentrazone @ 50 + 20 g/ ha and pinoxaden + metsulfuron @ 50 + 4 g/ ha are the effective herbicides for the control of mixed weed flora in wheat.

SKRAU, Bikaner

Cluster bean: Application of imazethapyr at 40 g/ha at 3-4 leaf stage of cluster bean controlled broad leaved weeds effectively or application of imazethapyr+ imazamox at 40 g/ha at 3-4 leaf stage of cluster bean controlled broad-leaved weeds as well as grassy weeds and increased seed yield and net returns.

6. TRIBAL SUB PLAN PROGRAMME

AAU, Anand

In the year 2013-14, Dahod district was chosen to distribute weed management inputs *i.e.* ASPEE Bakpak Sprayer Plastic Pumps, Hand hoe *Dharti* Brand, Spray Nozzles XL-54 and Spray Nozzles FFP/95/900. Spray pumps and hand hoes were provided to fifty farmers. Herbicide spraying nozzles have also been provided to all farmers who participated in group meeting at village level. Distribution of inputs has been carried out in collaboration of KVK, Dahod and Tribal Women FarmerTraining Centre, Devgadh Baria (Dahod district).

In tribal area, programme on weed management were conducted in which folders, leaflets and booklets of weed management technologies distributed in each programme. On Farm Trials (OFT) were also conducted in Dahod district. Special lectures were delivered by the scientists of the project in farmer's day and meeting organized by KVK, Dahod and KVK, Devgadh Baria in tribal's areas.

AAU, Jorhat

Frontline demonstration on Weed management in boro rice were conducted at Dokmoka of Karbi Anglong, Nayekgaon of Kokrajhar, Nayekgaon, Salakati Kokrajhar, where 80 farmers participated. Inputs were distributed individually to the participating farmers well in time. A hands on training was organized in each location and the participating farmers were trained on " Weed management in *boro* rice" including demonstration on application technique of herbicide in transplanted rice. The highest grain yield of 56.3 q/ha was recorded in the field of Mr. Prafulla Daimary of Nagekgaon in Kokrajhar district while the same in other locations was 54.0 q/ha (Mr. Hemson Bey) at Tumpreng and 51.8 q/ha (Mr. Horsing Ronghang and Mr. Sarsing Terang) at Dokmoka of Karbi Anglong district. The average grain yield over all locations was found to be 43.0 q/ha which is about 22% higher than the maximum average yield of the locations. A field day was organized in each location. About 33 to 38 farmers attended and participated the field day in Karbi Anglong at Dokmoka and at Tumperng. Similarly, frontline demonstration on Weed management in winter rice were conducted at, Langsoliet under Lumbajong ADO circle in Karbi Anglong and Rajabari under Mainbang ADO circle in Dima Hasao districts where 63 farmers participated. Inputs were distributed individually to the participating farmers. A hands on training was also organized in each location and the participating farmers trained on Weed Management I winter rice including demonstration on application technique of herbicide in transplanted rice. Highest yield of 49.5 q/ha was observed in the field of Mr. Sonjoy Bey of Langsoliet, and 54.0 q/ha in the field of Mr. Sarba Thaosen at Mailbang. The average grain yield of 4258 kg/ha showed 21.6 to 41.9% increase over average maximum yield of the districts. A field day was organized in each location.

BAU, Ranchi

Two training programmes on Weed Control under Tribal Sub Plan of AICRP on Weed Control (ICAR) during 12-14 February, 2013 and 5-7, March, 2013 were conducted. Altogether 40 trainees and farmers in each training programe from tribal dominated districts of Ranchi, West Singhbhum, Lohardaga and Gumla districts and from different tribal districts of Jharkhand namely Lohardaga, Ranchi and East Singhbhumi districts, participated.

In these training programmes series of lectures on weed control in different crops were conducted. Farmers were trained to convert active ingredient into commercial formulation and were also practiced to prepare herbicide solution to spray in their fields. Farmers were distributed with a set of three implements namely, cono weeder, grubber and dutch hoe so that they can perform mechanical weed control in their crop for higher production.

Training and distribution of inputs to tribal farmers

CSKHPKV, Palampur

Five trainings programmes were conducted in different villages viz. Chausu, krupa, Kamru, Badseri, Urni, Rakham, Chitkul of the tribal district and more than five hundred farmers were made aware of the losses being caused by the weeds in commercial crops, field crops and as well as in grasslands/pastures. Weed control scientists delivered lectures on different aspects of weed management. Provided package of practices to the farmers for *rabi* and *kharif* in terms two bookets Weed management techniques and *aaloo mein kharpatvar niyantaran*. Farmers were also provided Knapsack sprayers and hand tools for weed management.

IGKV, Raipur

In Tribal sub plan programme front line demonstrations on weed management in different corps maize, wheat and rice were laid down in 26 tribal villages in districts of Bastar, Kondagaon, kanker, Dhamtari, Balod, Bilaspur, Balrampur, Korea, Sarguja and Mahasamund. A total of 318 farmers were the participants. Based on above demonstrations, it was concluded that an average increase of 19.75, 10.50, 27.0 and 52.0 % in benefit cost ratio was obtained due to recommended practice over farmers practice in transplanted rice, direct seeded line sown rice with low seed rate, direct broadcast seeded beushened rice and maize, respectively. The demonstrations were conducted by KVK's of respective district and AICRP-Weed Control, Raipur.

Training and distribution of inputs in TSP Programme at village Parsadih, Chhattisgarh

OUAT, Bhubaneswar

Tribal sub-plan programme was initiated in the tribal dominated areas for the over all development of their livelihood by supplying inputs like herbicides, weed control tools and implements and plant protection chemicals to the TSP farmers at village Poipani and Gopapur of Keonjhar districts. In different districts of Odisha like Keonjhar, Deogarh, Sundergarh and Mayurbhanja, this TSP programme is being carried out with the help of different NGOs and state govt. personnel. Agricultural Implements, plant protection chemicals and First aid box were supplied to different Farmers Club, NGO. The results of herbicide application in transplanted rice was observed wherein increase in yield from 1.75 t/ha to 4.2 t/ha, and saving on weeding (Rs/ha) over farmer practice from Rs. 1350 to Rs 2000/ha was recorded.

SKRAU, Bikaner

Under Tribal Sub plan three training programmes were organised at KVK, Dungarpur and

KVK, Banswara on weed management techniques in crops of southern Rajasthan for the Schedule Tribe farmers. In context power operated sprayers and herbicides were distributed among 90 Schedule Tribe farmers of Dungarpur and Banswara districts. Off campus trainings were organised by the scientists on weed management in wheat, mustard, clusterbean and groundnut.

TNAU, Coimbatore

Tribal sub plan programme was conducted in tribal areas *viz*., Karumanthurai, Denkanikottai, Karmandurai (Salem) and Perunkadu (Dharamapuri) where training on Integrated Weed Management was imparted and demonstrated application of herbicide on management of *Cyperus rotundus* in banana at Somayampalayam.

UAS, Bengaluru

Activities under Tribal Sub Plan (TSP) were carried out in Tribal areas like Naaganaapura, Khotanahally of Nanjanagudu Taluk; Netkalhundi, Sollepur and Vaddara Gudi of HD Kote Taluk; and Panjahalli colony and Pakshirajpura of Hunsur Taluk of Mysore District whereby 140 scheduled tribe families were benefited. These tribal peoples were provided different weeding tools like high tech Aspee sprayers, Cycle weeders, Iron kuntes/hoes for each of the cotton & finger millet crops and local hand weeding tools of Kale hari guddhalli. Distributed of brochures and cycle weeders, sprayer, iron hoes and other tools to the beneficiaries. Farmers were aware of weed control implements viz. Animal drawn kunte and request for Iron Kunte came from them.



A -Iron Hoe, B - Cycle weeder & C – Sprayer and local hand tools like, Kale hari and Kale guddali were distributed to the beneficiary in Mysore district

UAS, Dharwad

During 2012-13, sprayers and herbicides were supplied to farmers of Ganadhal village (Koppal District, erstwhile Raichur district.

DBSKKV, Dapoli

A farmers ralley regarding awareness on weed management in different crops was organized at Nandgaon (Tribal area) Taluk, Karjat, Raigad district on occasion of World Food Day. The awareness was created amongst the tribal farmers regarding management of weeds in different crops by the use of herbicide, hand hoes and weed hook. About 250 farmers participated in one –day weed management awareness programme. Tools like weeding hooks, toothed spades, knapsack Sprayer with plastic hood and herbicides were distributed.



TSP activities at Dapoli Centre

7. PUBLICATIONS

ANGRAU, Hyderabad

Sudarshana, C., Ram Prakash, T., Jayasree, G. and Reddy, A.P.K. 2013. Influence of pendimethalin and imazethpyr on nodulation and nitrogen-fixing ability of groundnut grown on Alfisols of Southern Telangana Zone. ***Journal of Bioresource and Stress Management*** **4**(2):309-313.

Sudarshana, C. and Ram Prakash, T. 2013. Phytotoxicity and persistence of imazethapyr and pendimethalin in groundnut. ***International Journal of Tropical Agriculture*** **31**(3-4): 203-205.

Suneel Kumar, M., Madhavi, M., Manohar Rao, A. and Reddy, K.C. 2013. Influence of IWM on growth and yield of tomato. ***Crop Research*** **45**(1-3): 215-217.

Suneel Kumar, M., Madhavi, M., Manohar Rao, A. and Reddy, K.C. 2013. Integrated weed management in tomato. ***Andhra Agricultural Journal*** **60**(2): 398-400.

GBPUAT, Pantnagar

Chandola, P., Dhyani, K., Bhandari, K., Guru, S.K. 2012. Effect of pre-emergence herbicides and hand weeding on the weed dry weight and grain yield of transplanted rice. ***Journal of Sustainable Environmental Research*** **1**(2): 121-123.

Singh, V.P., Guru, S.K., Kumar, A., Banga, Akshita and Tripathi, Neeta. 2012. Bio-efficacy of tembotrione against mixed weed complex in maize. ***Indian Journal of Weed Science*** **44**(1):1-5.

Singh, V.P., Singh, S.P., Kumar, A., Banga, Akshita and Tripathi, Neeta. 2012. Effect of monsoon and weed management on growth and yield of direct-seeded rice. ***Indian Journal of Weed Science*** **44**(3):147-150.

Guru, S.K., Pratap, T. and Singh, V.P. 2013. Parthenium weed awareness campaigns and people's initiative. ***International Parthenium News*** **7**: 4-7.

RVSKVV, Gwalior

Arora, Asha 2012. Leaching behavior of pendimethalin in sandy clay loam soil of northern Madhya Pradesh. ***Indian Journal of Weed Science*** **44**(1): 60-61.

Arora, Asha, and Tomar, S. S. 2012. Effect of soil solarization on weed seed bank in soil. ***Indian Journal of Weed Science*** **44**(2): 122-123.

Bhadauria, Nisha, Arora, Asha, and Yadav, K.S. 2012. Effect of weed management practices on seed yield and nutrient uptake in sesame. ***Indian Journal of Weed Science*** **44**(2): 129-131.

Bhadoria, Nisha, Yadav, K.S., Rajput, R.L. and Singh, V.V. 2012. Integrated weed management in sesamum. ***Indian Journal of Weed Science*** **44**(4): 244-246.

TNAU, Coimbatore

Babu, C., Siddeswaran, K., Chinnusamy, C. and Sathya, Priya, R. 2013. Influence of imazethapyr on weed control and yield of groundnut and its residual effect on succeeding sunflower and pearlmillet. ***Madras Agricultural Journal*** **100**(1-3): 123-126.

Janaki, P., Sathya, Priya, R. and Chinnusamy, C. 2013. Field dissipation of oxyfluorfen in onion and its dynamics in soil under Indian tropical conditions. ***Journal of Environmental Science and Health Part B: Pesticides, Food Contaminants,*** and ***Agricultural Wastes*** **48**(11): ***941-947. http://dx.doi.org/10.1080/03601234.2013.816599***

Janaki, P., Rathika, S., Chinnusamy C. and Prabhakaran, N.K. 2013. Field dissipation of metamitron in soil and sugarbeet crop. ***Bulletin of Environmental Contamination and Toxicology*** **90**:116–119. DOI 10.1007/s00128-012-0878-2.

Masilamani, P., Paramathma, M., Chinnusamy, C., Jude Sudhagar, R. and Annadurai, K. 2013. Effect of pre-emergence herbicides on weed control in Jatropha (*Jatropha curcas* L.). ***Nursery Journal of Non-Timber Forest Products*** **19**(3): 235-238.

Nalini, K., Muthukrishnan, P., Chinnusamy, C. and Janaki, P. 2013. Response of soil microflora in herbicide residue of winter irrigated cotton. ***Crop Research*** **45**(1, 2 & 3): 268-271.

Nithya, C., Chinnusamy, C. and Prabhakaran, N.K. 2013. Evaluation of weed control efficacy and seed cotton yield in glyphosate tolerant transgenic cotton. ***American Journal of Plant Sciences*** **4**(6): 1159-1163.

Nithya, C. and Chinnusamy, C. 2013. Evaluation of weed control efficacy and seed cotton yield in transgenic cotton. ***Indian Journal of Applied Research*** **3**: (6): 10.

Nithya, C. and Chinnusamy, C. 2012. Evaluation of weed control efficacy and yield of glyphosate resistant cotton hybrids in winter irrigated ecosystems of Tamil Nadu. ***Madras Agricultural Journal*** **99**(10-12): 778-781.

Nithya. C., Chinnusamy, C. and Ravisankar, D. 2013. Weed management in herbicide tolerant transgenic cotton (***Gossypium hisrsutum* L.**) - A review. ***International Journal of Agricultural Science and Research*** **3**(2): 257-264.

Sathya Priya, R., Chinnusamy, C., Manickasundaram, P. and Babu, C. 2013. A review on weed management in groundnut (***Arachis hypogaea* L.**). ***International Journal of Agricultural Science and Research*** **3**(1): 163-172.

Sathya Priya, R., Manickasundaram, P., Chinnusamy, C. and Babu, C. 2013. Influence of oxyfluorfen on weed control and yield of onion and its residual effect on succeeding sunflower and pearlmillet. ***Madras Agricultural Journal*** **99**(10-12): 782-785.

IGKV, Raipur

Dwivedi, Sanjay, K., Shrivastava, G.K., Singh, A.P. and Lakpale, R. 2012. Weed and crop productivity of maize + blackgram intercropping system in Chhattisgarh plains. ***Indian Journal of Weed Science*** **44**(1): 26-29.

Sharma, Kunti, Gaurav, and Singh, A.P. 2012. Weed management practices on growth and yield of winter season brinjal under Chhattisgarh plain conditions. ***Indian Journal of Weed Science*** **44**(1):18-20.

VNMKV, Parbhani

Deshmukh, M.S, Patil, V.D., Jadhav, A.S., Gadade, G.D. and Dhamak, A.L. 2013. Assesment of soil quality parameters and yield of rainfed Bt cotton as influenced by application of herbicides in vertisols. ***International Journal of Agricultural Sciences*** **3**(6): 553-557.

Jadhav, A.S, and Gadade, G.D. 2012. Evaluation of post-emergence herbicides in soybean. ***Indian Journal of Weed Science*** **44**(4): 259–260.

Jadhav, A.S. and Pawar, S.U. 2013. Time of sowing and influence of weed control methods on yield of direct-seeded rice. ***Journal of Agricultural Research and Technology*** **38**(8): 466-469.

.Jadhav, A.S. 2013. Sowing time – a tool for weed control in direct-seeded upland rice. ***Indian Journal of Weed science*** **45**(1): 16-18.

BAU, Ranchi

Upasani, R.R., Kumari, Priyanka, Thakur, R. and Singh, M.K. 2012. Effect of seed rate and weed control methods on productivity and profitability of wetland rice under medium land conditions. ***Indian Journal of Weed Science*** **44**(2): 98–100.

Upasani, R.R., Thakur, R., Barla, Sheela, Pal, S.K. and Singh, M.K. 2012. *Parthenium hysterophorus* – A potential threat to biodiversity. ***Journal of Research BAU*** **24**(2): 121-128.

PAU, Ludhiana

Bhullar, M.S., Singh, Shergill, Lovreet, Kaur, Rupinder, Walia, U.S. and Kaur, Tarundeep 2012. Bioefficacy of herbicides in relation to sowing methods in wheat. ***Indian Journal of Weed Science*** **44**(4): 207-210.

Brar, Harjeet Singh, Bhullar, M.S. and Sharma, Neerja. 2012. Dry-seeded rice productivity in relation to sowing time, variety and weed control. ***Indian Journal of Weed Science*** **44**(3): 195–197.

Kaur, Simerjeet, Singh, Surjit, Kaur, Tarundeep and Bhullar, M. S. 2012. Residues of bispyribac and azimsulfruon in direct-seeded rice (***Oryza sativa* L.). *Crop Improvement Special Issue***: 793-794.

UAS, Bengaluru

Basavaraj, Kumbar, Ramachandra Prasad, T.V. and Sanjay, M.T. 2013. Bioefficacy of new herbicide fluazifop-p-butyl for grass weed management in groundnut and carry over effect on succeeding fingermillet. ***Research on Crops*** **15**(1): 315.

Basavaraj Kumbar, Ramachandra Prasad, T.V., Sanjay, M.T, Shankarlingappa, B.C., Balakrishna, A.N. and Sudheendra Saunshi. 2013. Effect of weed management practices on pod yield of groundnut and soil microbial biomass, and residual effect of fluazifop-p-butyl on succeeding crop of finger millet. ***Bioinfolet*** **10**(4): 243-246.

Devendra, R., Asok, R.C., Jalendra Kumar, H.G., Manjunatha, S.B. and Ramachandra Prasad, T.V. 2012. Techniques to reduce pollution by enhancing cuticle loading and entry of herbicide. ***Indian Journal of Weed Science*** **44**(2):101-105.

Dhanraj, Manjunatha, S.B., Shweta, B. and Devendra, R. 2012. Relative effects of pre-treatment of ethephon, glyphosate and paraquat on glyphosate translocation and potency in control. ***Indian Journal of Weed Science*** **44**(4): 238-241.

Dinesh, M.S. and Dhanapal, G.N. 2013. Chemical control of Orobanche cernua in tomato fields in Karnataka. ***Bioinfolet*** **10**(1B): 187-190.

Dinesh, M.S., Dhanapal, G.N., Prabhudev Dhumgond, Vignesh, N.N., Madukumar, V. and Raghavendra. 2012. Efficiency and economics of broomrape (***Orobanche cernua* Loefl.**) control with herbicides in infested tomato (***Lycopersicon esculentum* Mill.**) field. ***Plant Archives*** **12**(2): 833-836.

Madhukumar, V., Kalyana Murthy, K.N., Sanjay, M.T., Prashanth, R. and Sunil, C.M. 2013. Growth and yield attributes of aerobic rice (***Oryza sativa* L.**) as influenced by application of pre- and post-emergence herbicides. ***Plant Archives*** **13**(2): 216.

Ramachandra Prasad, T.V., Rao, R.R., Sanjay, M.T. and Sharma, R.A. 2013. *Ambrosia psilostachia* DC (Asteraceae) - a new record but a potential threat to Indian flora. ***Current Science*** **104**(3): 294-296.

Shweta, B., Manjunatha, S.B., Devendra, R. and Channabasavegowda. 2012. Effect of density and dose of herbicides on entry, translocation and root exudates in water hyacinth. ***Indian Journal of Weed Science*** **44**(2): 77-80.

Sylvestre Habimana, Kalyana Murthy, K.N., Shankaralingappa, B.C., Sanjay, M.T. and Ramachandra, C. 2013. Effect of pre- and post-emergence herbicides on weed dynamics, growth and yield of soybean (***Glycine max* L.**). ***Advances in Applied Science Research*** **4**(4): 72-75.

Sylvestre Habimana, Kalyana Murthy, K.N., Shankaralingappa, B.C., Sanjay, M.T. and Ramachandra, C. 2013. Efficiency and economics of weed control with pre and post-emergent herbicides in soybean (***Glycine max* L.**). ***Asian Journal of Plant Science and Research*** **3**(4): 18-20.

Sylvestre Habimana, Kalyana Murthy, K.N., Shankaralingappa, B.C., Sanjay, M.T. and Ramachandra, C. 2013. Nutrient uptake and yield of soyabean (***Glycine Max* L.**) as influenced by pre- and post-emergence herbicides. European ***Journal of Experimental Biology*** **3**(5): 33-40.

CSKHPKV, Palampur

Katara, Pawan, Kumar, Suresh, Rana, S.S. and Chander, Navell. 2012. Combination of pinoxaden with other herbicides against complex weed flora in wheat. ***Indian Journal of Weed Science*** **44**(4): 225-230.

Kumar, Suresh, Angiras, N.N. and Rana, S.S. 2012. Chemical weed control in potato under mid hill conditions of Himachal Pradesh. ***Himachal Journal of Agricultural Research*** **38**(2): 87-92.

Kumar, Suresh, Rana, S.S., Chander, Navell and Angiras, N.N. 2012. Management of hardy weeds in maize under mid-hill conditions of Himachal Pradesh. ***Indian Journal of Weed Science*** **44**(1): 11-17.

Kumar, Suresh, Rana, S.S. and Angiras, N.N. 2013. Comparative efficacy of tank-mix and sequential application of herbicides against complex weed flora in wheat. ***Himachal Journal of Agricultural Research*** **39**(1): 34-42.

Kumar, Suresh, Rana, S.S., Ramesh and Chander, Navell. 2013. Herbicide combinations for broad-spectrum weed control in wheat. ***Indian Journal of Weed Science*** **45**(1): 29-33.

Kumar, Suresh, Kumar, Ashwani, Rana, S.S., Chander, Navell, and Angiras, N.N. 2012. Integrated weed management in mustard. ***Indian Journal of Weed Science*** **44**(3): 139-143.

Kumar, Suresh, Rana, S.S., Chander, Navell and Sharma, Neelam. 2013. Integrated weed management in garlic. ***Indian Journal of Weed Science*** **45**(2): 126-130.

Sharma, Neelam, Rana, Usha and Sharma, Swati. 2013. Consequences of 2,4-D on nitrate reductase activity and nitrogen content in wheat and its relationship to grain protein. IOSR–***Journal of Environmental Science, Toxicology and Food Technology*** **3**(2): 45-46.

Sharma, Neelam, Sharma, Swati, Kumar, Suresh and Joshi, Robin. 2013. Dissipation and harvest time residue studies of 2,4-D in soil and wheat crop. ***Indian Journal of Weed Science*** **45**(1): 68-70.

NDUAT, Faizabad

Kumar, R., Sharma, Jaidev, Singh, R.S., Singh, S.S. and Tripathi, S.K. 2013. Effect of tillage system and weed control practices on soil health and yield of wheat. ***Journal of Kalash Science*** **1**(2): 159-161.

Kumar, R., Sharma, Jaidev, Singh, R.S., Prakash, V. and Tripathi, S.K. 2013. Soil enzymes and beneficial micro-organism as influenced by weed management practices under rice wheat cropping system. ***New Agriculturist*** **24**(2): 185-187.

CCSHAU, Hisar

Dhanda, Sanjeev, Sangwan, Naresh and Punia, S.S. 2012. Evaluation of pinoxaden in combination with metsulfuron against complex weed flora in barely (***Hordeum vulgare*** **L.**). ***Haryana Journal of Agronomy*** **28**(1&2): 84-87.

Punia, S.S., Yadav, Dharam Bir, Hooda, V.S., Dhaka, Anil and Malik, Yash Pal. 2013. Evaluation of Columbus, a new brand of clodinafop-propargyl 15 WP against *P. minor* in wheat and its residual effect on succeeding sorghum crop. ***Haryana Journal of Agronomy*** **28**(1&2): 93-96.

Singh, Samunder, Punia, S.S, Singh, Attar and Brar, A.P.S. 2013. Weed control efficacy of trifluralin in cotton in N-W India. ***Haryana Journal of Agronomy*** **28**(1&2): 1-10.

SKRAU, Bikaner

Gochar, R. and Yadav, R.S. Kumawat, A., Kumar, R. and Prasad, M. 2013. Effect of cultivars and weed management on late sown groundnut (*Arachis hypogaea*) in North-Western Rajasthan. ***Annals of Agri Bio Research*** **18**(2): 128-131.

Kiroriwal, A., Yadav, R.S. and Kumawat, A. 2012. Weed management in pearlmillet-based intercropping system. ***Indian Journal of Weed Science*** **44**(3): 200-203.

Summary of publications

Centre	Research papers	Popular articles	Papers presented in seminars /symposia/conferences	Books	Book chapters	Lectures delivered during training	Students guided	
							M.Sc.	Ph.D.
PAU, Ludhiana	03	-	-	-	-	15	06	03
UAS, Bengaluru	12	01	24	-	01	-	07	-
RVSKVV, Gwalior	04	-	07	-	-	-	-	-
GBPUAT, Pantnagar	04	02	13	-	01	06	10	03
CSKHPKV, Palampur	09	-	01	-	-	42	01	-
AAU, Jorhat	-		03	02		01	03	03
VNMKV, Parbhani	04	04	-	-	-	-	01	-
AAU, Anand	-	07	01		01	06	-	-
TNAU, Coimbatore	11	-	03	01	02	02	07	03
NDUAT, Faizabad	02	05	07	-	-	-	08	06
VB, Sriniketan	-	-	07	-	01	11	02	07
BAU, Ranchi	02		-	02	-	-	-	-
CSAUAT, Kanpur	-	02	01	-	01	-	09	01
KAU, Thrissur	05	02	04	1	-	06	03	02
OUAT, Bhubaneswar	-	03	-	-	02	-	-	-
ANGRAU, Hyderabad	04	03	04	-	-	-	02	03
CCSHAU, Hisar	03	05	01	-	-	32	02	01
RAU, Pusa	-	02	-	02	-	-	-	-
DBSKKV, Dapoli	-	-	04	-	-	-	-	-
IGKVV, Raipur	02	01	03	-	-	14	02	-
UAS, Dharwad	-	-	01	-	-	-	01	06
SKRAU, Bikaner	02	-	-	-	-	-	01	01

8. AWARDS / RECOGNITIONS

GBPUAT, Pantnagar

A poster entitled "Assessment of crop yield and weed growth under the application of pre-emergence herbicides in rice" under the discipline agricultural sciences was presented on the occasion of 8th Uttarakhand State Science & Technology Congress 2013 held during 26-28th Dec 2013 by Dr. Pawanika Chandola. *The poster presenter was awarded "Young Scientist Award 2013" in her category*.

Dr. S.P. Singh was awarded for his outstanding contribution for the Parthenium Awareness Programme on August 22, 2013.

VNMKV, Parbhani

Dr. A.S.Jadhav received Bharat Jyoti Award - 13 from India International Friendship Society, New Delhi for his contribution in Research and Extension of Weed Management and use of weedicides.

UAS, Bengaluru

Dr. G. N. Dhanapal received the following awards:

(i) "Scientist of the year-2013" by National Environmental Science Academy, New Delhi in 2013. Place photo here

(ii) 1st prize for best poster presentation at National conference on " Farmers First for Conserving Soil and Water Resources in Southern Region" (FFCSWR) organized by IASWC, Dehradun, CSWCRTI, Bellary & Udhagamandalam and UAS, Bangalore in 2013.

(iii) "Best demonstration award" during National and International Agricultural Fair organized by UAS, Bangalore in 2013.

Dr. Devaraj, Vice Chairman, University Grants Commission, New Delhi presenting "Scientist of the year-2013" award to Dr. G.N. Dhanapal of the National Environmental Science Academy, New Delhi.

9. RECOMMENDATIONS OF AICRP-WC ANNUAL GROUP MEETING

Recommendations of Annual Group Meeting of All India Coordinated Research Project on Weed Control held at Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (Himachal Pradesh) during 26-27 April, 2013

General recommendations

Research

1. A quarantine weed, Ambrosia psylostachia noticed in Karnataka is a cause of concern. It was suggested to attend the problem immediately to restrict its further distribution followed by its eradication.
2. High-value crops like turmeric should not be overloaded with herbicides. A combination of chemical along with mechanical and cultural practices should be worked out for effective weed management.
3. Conservation tillage should become a part of farming and at least 30% of soil surface should be covered with crop residues. Weeds management in conservation agriculture needs utmost attention.
4. Indigenous weed management techniques are to be documented, validated and fine-tuned to suit local conditions.
5. Weeds are used as fodder or green manures, and such uses also need to be accounted for while calculating monetary returns.
6. Physiological studies on weeds in long-term experiments should be done in addition to weed density and seed bank.
7. Sponsored trial on "Evaluate weed control efficacy of glyphosate formulation (MON 76366) against weeds occurring in cotton and corn" should be conducted by the identified centres during 2013-14. Funds received from Monsonto will be released from the HQ.
8. Many Centres are not conducting the allocated experiments as per the approved network technical programme. It was decided that Centres should submit a detailed list of network trials to be conducted during 2013-14 along with modifications, if any, to Coordinating Unit within a month. If no information is received, it would imply that experiments listed in the Technical Programme for 2012-14 will be conducted by the respective centres.
9. A compilation of five major weeds at different states is underway. All PIs should submit the information including utilization aspects of the weed species in the proforma already supplied by Coordinating Unit by June 2013.
10. Coordinating Centres who have not submitted the comprehensive data on long-term trials on herbicides and tillage should submit the same within 3 months i.e. by July 2013.
11. Dr. Shobha Sondhia, Sr. Scientist, DWSR will compile the information on residue studies at the Coordinating Centres. She will provide common protocols/ methodology, and arrange to provide herbicide standards for conducting herbicide residue studies to the Coordinating Centres. It was also decided that laboratory facilities at DWSR can be utilized by the Centres in consultation with Dr. Shobha.
12. It was emphasized that chromatogram must be provided in all matrix under herbicide residue studies.
13. It is not possible to strengthen all centres for herbicide residue studies. Facilities available within the region at a nearby centre or at the DWSR HQ can be utilized.
14. It was noted that a common format for economic analysis of the experiments should be followed. Dr. Govindrajan, Economist at TNAU Centre will provide a common proforma for economic analysis.
15. All the Coordinating Centres will compile data on herbicides consumption in their respective states and provide the information to the Coordinating Unit by June end 2013.
16. Annual Report must be prepared as per the prescribed format and guidelines. PIs should take care of minute details such as font size, units, spacing, no. of pages, data analysis etc. There is no need to send the copy of the Annual Report by each centre directly to the ADG / DDG.
17. Nodal Officers identified for different regions / thematic areas should compile and synthesize the research findings, and present an overview of the centre's performance based on their assessment.
18. Quality of slides and presentation by some of the Centres was not good. PIs should check all the data carefully and present the major findings in a concise and scientific manner.
19. A presentation on the research work done at DWSR should also be made during the Annual Group Meeting. A copy of the Annual Report of the Directorate can be sent to all AICRP-WC centres.
20. There are large variations in the economic analyses, despite similar yields levels, due to different methodologies adopted for such analysis. A common protocol for economic analysis of the data will be developed and sent to all centres.
21. Protocols for on-station as well as on-farm trials / FLDs are not being followed by most centers. Some centers also do not conduct the allotted experiments as per approved technical programme. This is a serious issue, and the centers must do the committed experiments as per guidelines.
22. On-Farm Trials and FLDs should be conducted as per the prescribed guidelines and impact assessment of the technologies adopted should be done. Yields in most experiments, OFTs, FLDs are quite low – even lower than the state average. Trials should be well conducted so that the yields in the best treatment are up to potential level of the crop/variety.
23. Research work on weed management in horticultural and plantation crops, and also under rainfed conditions should be conducted.
24. Information for RFD i.e. technologies generated, impact, increase in productivity, trainings organized etc. should be submitted by the centres regularly for onward submission to the ICAR.
25. Weed Atlas prepared by the Directorate has to be revised as per the recent recommendation of RAC. Necessary information for this revision should be submitted by the Centres.
26. A compilation on important weed management technologies developed by each AICRP-WC centre will be made. One page note on each technology specifying the problem, technology developed, productivity and economic benefits, and precautions / constraints along with one small table and photograph should be submitted.

Administrative

1. Annual Group Meeting will be conducted for three days, and all scientists working in the project will be invited as in the case of all other AICRPs. As part of the Silver Jubilee year (2013-14) of DWSR, the next Annual Group Meeting will be held at DWSR, Jabalpur during last week of February or early March, 2014.
2. Most Centres complained about inadequate budget under contingency for conducting experiments in view of the enhanced wages of farm workers. It was informed that this aspect has been taken care of in the SFC submitted to the Council which is yet to be approved.
3. There will not be necessarily uniform allocation of funds to all centres. Best performing centres will be identified based on selected criteria. Such centers can be considered for additional grants based on their performance.
4. A provision of Rs. 1.5 lakhs will be made under XII plan for purchase of happy seeder to be used under conservation agriculture experiments at Coordinating Centres.
5. General recommendations of QRT and specific recommendations to each centre should be effectively implemented. Centres identified as 'Average' and 'Below average' need to do serious introspection and improve their performance considerably.
6. Performance of the centres will be judged based on the reports of the monitoring teams, implementation of approved technical programme, quality of data in the Annual Report, presentation made in the AGM, research publications, OFTS / FLDs conducted, timely submission of AUC, staff position, expenditure statement and other information sought by the HQ, budget utilization, extension activities, awards / recognitions etc.
7. Funds under TSP will be allotted to those states having tribal districts as per classification of the Planning Commission. These funds should be effectively utilized for On-Farm Research Trials / FLDs, training and capacity building, and for development of physical assets as per guidelines.
8. It was suggested to propose change in the name of AICRP from 'AICRP on Weed Control' to 'AICRP

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