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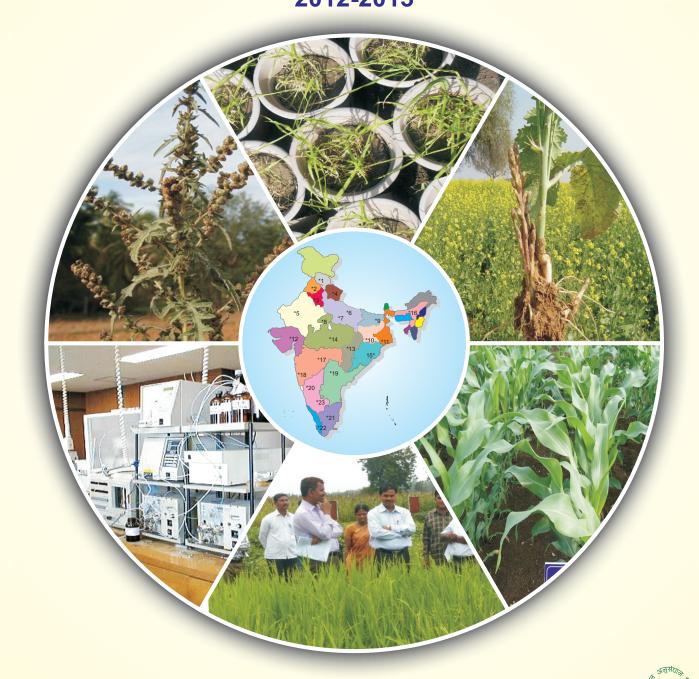
Annual Report 2012-2013

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अखिल भारतीय समन्वित खरपतवार नियंत्राण अनुसंधान परियोजना

All India Coordinated Research Project on Weed Control

वार्षिक प्रतिवेदन Annual Report 2012-2013





खरपतवार विज्ञान अनुसंधान निदेशालय Directorate of Weed Science Research

जबलाए (मध्य प्रतिषा) भारत

जबलपुर (मध्य प्रदेश) भारत Jabalpur (Madhya Pradesh) India



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FLOWER POWER

Bugged by parthenium?

UAS shows how to Staff Reporter

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उधमसिंह त

गाजर घास से अस्थमा और चर्म रोग का खतरा : डा. गुरु



गाजर घास जागरूकता

कासं)। स्त्रामी केशवानन्द विज्ञान कृषि महाविधालय न जाति कार्यक्रम में विद्यार्थियों, इकता सपाह में आखित याजर घास प्रकाश डाला। उन्होंने बताया कि जहां धास जागरूकता कार्यक्रम में विद्यार्थियों, इकता सपाह में आखित दिन भी गाजर घास का प्रकाप ज्यादा है उन

अत्यधिक घातक है गाजरघास खरपतवार मिटान के बाद

नियंत्रण भी समझा

रासायनिक विधि और



ਕੋਟ ਵਤੂਹੀ, 21 ਅਗਸਤ (ਮਨਕੀਅਤ)-ਸੰਤ ਬਿਸ਼ਨ ਸਿੰਘ ਯਾਦਗਾਰੀ ਸਰਕਾਰੀ ਸਮੇਂ ਖੁਦ ਬੀਮਾਰ ਕ ਲੱਡ ਹੈ। ਇਸ ਪਈ ਹੈ। ਲੇਡੀ ਡਾਕਟਰ ਦੀ ਅਸਾਮੀ ਵੀ ਖਾਲੀ ਹਨ। ਜੋੜ੍ਹਾਂ ਵਿਚ 2 ਡਾਕਟਰ ਹੀ ਕੰਮ ਚਲਾ ਡਾਕਟਰ ਮੰਗਵਾ ਕੇ ਕੰਮ ਚਲਾਇਆ ਜਾ ਰਿਹਾ ਹੈ। ਹਸਪਤਾਲ ਵਿਚ ਸਫਾਈਨਾਂ ਦੀ ਕੋਈ ਚੀਜ਼ ਹਹੀਂ ਹੈ। ਹਸਪਤਾਲ ਵਿਚ ਸਫਾਈਨਾਂ ਦੀ ਕੋਈ ਚੀਜ਼ ਹਹੀਂ ਹੈ। ਹਸਪਤਾਲ ਪਤਾਲ ਹੈ ਗਾਜਰ ਬੁਟੀ ਨਾਲ ਫਰਿਆ ਪਿਆ ਹੈ ਪਰਵੀ ਦੀ ਮੋਟਰ ਮਹਾਤ

खेतों में रोपें सब्जियां

2/3-13/47, 2012

10 प्रतिशत उपजाऊ भूमि पर फसल न होने के लिए गाजर घास जिम्मेदार

जागरूक करने के लिए बुद्धा पार्क, इंदिरा नगर में सोमवार सुबह गोष्ठी का आयोजन किया गया। कार्यक्रम की अध्यक्षता सेवानिवृत्त पुलिस अधिकारी भूषण सिंह ने की। गोष्ठी में मौजूद क्षेत्रीय लोगों को गाजर घास से होने वाले नुकसान की जानकारी देते हुये सीएसए में खरपतवार विभाग के कृषि वैज्ञानिक डा. आरए यादव ने बताया कि

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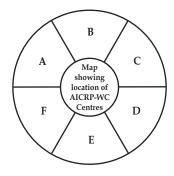
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Cover page photographs



- A. Ambrosia psilostachya a new record of weed from Tumkur District at Karnataka.
- B. Physiological study on *Phalaris Minor* plants.
- C. Orobanche infestation in mustard.
- D. Weed management in maize.
- E. Scientists interaction in Front Line Demonstration plots.
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Preface

All India Coordinated Research Project on Weed Control was initiated in 1978 to conduct location-specific research for developing appropriate weed management technologies, and to demonstrate these technologies through on-farm adaptive trials. Presently, there are 22 centres of this project in different state agricultural universities of the country engaged in developing and disseminating weed management technologies. Over the last 35 years, the project has led to development of improved weed management technologies in almost all crops and cropping systems, noncropped lands and aquatic bodies, which have been adopted on large areas in the country. Today, weed management is the most important issue for the farmers in view of the acute labour scarcity and high cost of production.



Further, new weed problems are emerging due to various factors such as high-input agriculture, climate change, herbicide resistant weeds, threat of invasive weeds, globalization etc. In view of these challenges, the weed management technologies need to be continuously refined and updated so as to ensure sustainable productivity and livelihood security.

Research and extension activities of the AICRP on Weed Control were reoriented and focused multi-disciplinary programmes were formulated during the Annual Review Meeting held on 17-18 April, 2012 at Kerala Agricultural University, Thrissur. Six major research programmes were undertaken from 2012-13: (i) Weed surveillance, (ii) Weed biology and physiology, (iii) Weed management in crops and cropping systems, (iv) Management of problematic, invasive, parasitic and aquatic weeds, (v) Herbicide residues and environmental quality, and (vi) Transfer of Technology. New experiments on integrated weed management involving low-dose, high-potency and non-residual herbicide molecules were formulated on direct-seeded rice, wheat and turmeric. A major research programme on weed management in conservation agriculture was launched in diversified cropping systems, which involved 11 centres for rice-based cropping systems, 2 centres for maize-based cropping systems; and 5 centres for pearl millet-based cropping systems. In view of the growing threat of Orobanche in mustard and solanaceous crops, a network trial was initiated at Hissar, Bikaner, Gwalior, Bhubaneswar, Bengaluru and Hyderabad centers. It was proposed to undertake regular monitoring and evaluation of the work done at different centres, and for this purpose, 5 Nodal Officers from the headquarters were identified. Detailed guidelines for undertaking and reporting of on-station as well as on-farm trials were prepared to improve quality and visibility of the information generated. Further, effective linkages were established with all ICAR institutes and agricultural universities for research and training in weed management.

During the period under report, Quinquennial Review Team reviewed the progress of work made by all the centres during the period from 2006-2012, graded the centres based on their performance, and made specific recommendations for further improvement. It was suggested that weed survey data collected over the years should be compiled and analyzed, five major weeds in each state should be identified and their biology and management studied in detail, technologies and their impact on socio-economic livelihoods should be worked, and quality publications in scientific journals should be brought out. Implementation of these recommendations is likely to go a long way in improving and strengthening the activities of this project.

Progress of the work done during the year 2012-13 was reviewed in the Annual Review Meeting held at the CSK Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur during 25-26 April, 2013. It was

realized that some centres are doing very well while others need to improve their performance. Better performing centres will be identified and recognized during the annual group meeting. Such centres can also be considered for additional grants and other incentives.

This report contains the significant findings on research and extension activities carried out by the centres during the period from April 2012 to March 2013. New weed species, viz. *Tithonia diversifolia* and *Ambrosia psilostachya* were reported from hilly zone and Turuvekere taluk in Karnataka respectively. At Pusa, weedy rice infestation in deep water rice caused yield loss of 20-45%. At Hissar, post-emergence application of glyphosate @ 25 g/ha at 30 days after sowing, followed by its use @ 50 g/ha at 55 days after sowing of mustard provided effective control of *Orobanche*. All the centres actively participated in imparting training to the farmers and transfer of technology related to weed management. *Parthenium* Awareness Week was organized from 16-22 August 2012, in which, a large number of rallies, exhibitions, seminars and other meetings were organized.

I compliment the efforts made by the Principal Investigators and all other scientists of different centres in generating voluminous data, and expect that these valuable information will soon find a place in high quality scientific journals. I also thank the Nodal Officers, Dr. V.P. Singh, Dr. Sushil Kumar, Dr. Anil Dixit, Dr. D.K. Pandey, Dr. P. K. Singh, Dr. Shobha Sondhia, Dr. C. Kannan, and Dr. Bhumesh Kumar for monitoring the work of different centres and compiling the report in a revised format. Commendable efforts were made by the In charge of the project, Dr. R.P. Dubey, and technical officers, Mr. O.N. Tiwari and Mr. Pankaj Shukla in smooth running of the project and printing this report.

It is regretted that printing of the report has been delayed during this year due to unforeseen circumstances, and it will be ensured that such delays are avoided in future. I welcome critical comments and suggestions for improving the work efficiency of the project, and on the quality of the report.

Date: 12/11/2013 (A.R. Sharma)

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, ADG (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; T.V.R.S. Ramchandra Prasad and R. Devendra, UAS, Bengaluru; R.A. Yadav, CSAUAT, Kanpur; S.S. Punia, CCSHAU, Hisar; C. Chinnusamy, TNAU, Coimbatore; S.S. Mishra and 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; R.B. Patel, AAU, Anand; A.S. Jadhav, MAU, 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. B.P. Singh, RBS College, Agra; Dr. Anil Kumar, SKUAST, Jammu, J&.K; Dr. Raghuvir Singh, SVBPUAT, Meerut; Dr. J.P. Deshmukh, DPDKV, Akola; and Dr. Balasubramanian, ACRI, Madurai for generating and contributing research results in the project.

I express my sincere thanks to In-charge, AICRP-WC, Dr. R.P. Dubey, Principal Scientist (Agronomy) and Nodal Officers, viz. Dr. V.P. Singh, Principal Scientist (Agronomy); Dr. Anil Dixit, 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, Mr. Sandeep Dhagat and Dr. M.S. Raghuwanshi for providing technical help in bringing out this report.

Date: 12/11/2013 Place: JABALPUR (A. R. Sharma)

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विशिष्ट सारांश

निदेशालय के अंतर्गत 22 समन्वित एवं 7 स्वेच्छिक केन्द्र जो कि देश के विभिन्न राज्यों में स्थित कृषि विश्वविद्यालयों के माध्यम से नेटवर्क अनुसंधान एवं विभिन्न फसलों, फसल प्रणाली और गैर—फसलीय क्षेत्रों हेतु विकसित विशेष प्रौद्यौगिकी पर अनुसंधान कार्य कर रहे हैं।

वर्ष 2012–13 के दौरान किये गये मुख्य अनुसंधान उपलब्धियां निम्नानुसार है:--

खरपतवार निगरानी

 नई खरपतवार प्रजाति जैसे टिथोनिया डाइवर्सी— फोलिया और मिकानिया मिकरान्था पहाड़ी क्षेत्रों में, आइपोमिया ट्राइलोबा गन्ने के खेत में चामराजनगर और मैसूर जिले में, एम्ब्रोशिया, तुरूवेकर तालुक में, आइपोमिया पेस्टीमिड्रिस चिकनी दूमट मिट्टी, कपास और गन्ने में हिरियूर और दावनगेरे क्षेत्रों में, आइपोमिया कारिका, आइपोमिया स्टाफाईलिना और आइपोमिया ओसिनिया दक्षिण कर्नाटक के अनेक क्षेत्रों में सडक के किनारे दर्ज किये गये।





Ambrosia psilostachya

Ipomoea triloba

- अल्टरनेंथ्रा ट्राईन्ड्रा उपरॉव धान में छत्तीसगढ में एक नई समस्या के रूप में उभर रहा है । यह रायपुर क्षेत्र में सड़क के किनारे और खेतों की मेढ़ों पर भी अपना विस्तार कर रहा है।
- मिकानिया मिकरेन्था, गाजरघास, जलकुभी और अल्टरनेथा फिलाक्जरोड्स मुख्य खरपतवार के रूप में उड़ीसा के पूर्वी और दक्षिण पूर्वी तटीय समतल जोन में दर्ज किये गये । मध्य सेन्ट्रल टेबल लैंड जोन में वर्षा आधारित उपरॉव स्थिति में सीलोसिया अर्जिटिया मूंगफली एवं दलहनी फसलों में पाये जाने की सूचना मिली। फेगमाईट्स कार्का चिलिका लगून झील के दसवे हिस्से तक फैलने के कारण नेवीगेशन और मछली पकड़ने हेतु गंभीर समस्या निर्मित कर रही है।
- कसकुटा चिनेसिस, का प्रकोप बरसीम में हरियाणा

- के अंबाला, यमुना नगर, करनाल, कैथल, टोहाना, कुरूक्षेत्र और कैथल क्षेत्र में पाया गया । औरोबंकी एजीप्टिका की उपस्थिति सरसौं में मेहम, मिर्चपुर, चौधरीवास और जगलन (हिसार), कढुरा (गौहाना), ओधन (सिरसा) और भट्टो (फतेहबाद)। के रेतीले डूनल क्षेत्रों में दर्ज की गई।
- असम के डिब्रूगढ़ जिले में ग्रीष्म ऋतु में जलकुंभी के बाद आइपोमिया कार्निया सबसे प्रमुख खरपतवार दर्ज किये गये। चौड़ी पत्ती वाले खरपतवार मोनोकोरिया वेजीनेलिस व इसके बाद मोथा कुल वाले (sedges) जैसे इलियोकेरिस एक्युटांगुला और फिमब्रिसटाइलिस लिट्टोरेलिस वर्षा ऋतु में रोपाई वाली धान के प्रमुख खरपतवार पाये गये।
- पंजाब के विभिन्न क्षेत्रों में खरपतवार निगरानी द्वारा यह पाया गया कि फैलेरिस माइनर की प्रबलता गेहूं में बढती जा रही है। पोआ अनुआ गेहूं, बरसीम एवं जौ में, आइपोमिया बरसीम में और वीडी राईस रोपाई वाली धान में महत्वूपर्ण खरपतवार दर्ज किये गये है। डेक्टीलोक्टीनम एजीपिक्टम, लेपटोक्लोआ जाति और इराग्रोसटिस जाति के खरपतवपार उपरॉव धान में बढ़ रहे है और ये इकाइनोक्लोआ जाति को विस्थापित कर रहे है।
- केरल में त्रिशूर के मध्य भाग में, जंगली धान (ओराइजा स्पोनेन्टिनिआ) और चाईनीज स्प्रेंगलेटाप (लेटटोक्लोआ चिनेन्सिस) ज्यादातर धान के खेतों में देखा गया है और इसकी सघनता भयप्रद हो रही है। अल्टरनेथ्रा बेट्जीकियाना, एक्जोनोपस कमप्रेसस और हिपटिस केपीटाटा समस्याकारी खरपतवार के रूप में उभर रही है।

खरपतवारों का जीव एवं किया विज्ञान

- जोरहाट में, इकानोक्लोआ कोलोना के जर्मप्लाज्म में आकृति मूलक विषमता ई. ग्लेबरेसन्स की तुलना में काफी अधिक पायी गई है। श्रीनिकेतन में, इकाईनोक्लोवा कोलोना के ताजे बीजों में सर्वाधिक अंकुरण 61 % बोने के दस दिन बाद प्रारंभ हुआ और बीज की आयु में वृद्धि के साथ कम हुआ।
- जोरहाट में अभी तक ओराईजा रूफीपोगान जंगली धान की जाति एकत्र कर पहचान की गई है । पालमपुर में, उपरॉव धान में जंगली धान का ज्यादा ग्रसन पाया गया है जबिक रोपाई वाली धान में

इसका ग्रसन सबसे कम पाया गया है। पूसा (बिहार) मे जंगली धान ओराइजा रूफीपोगन और ओराइजा सपोनटेनिया दरभंगा और मधुवनी जिलो में गहरे जलमग्न क्षेत्रों में पाई गई है। जंगली धान के कारण धान में 20-45 प्रतिशत की उपज की हानि दर्ज की गई है।

तालिकाः धान और जंगली धान के प्रभेदक लक्षण पालमपुर में दर्ज किये गये

लक्षण	धान	जंगली धान
झंडा पत्ती	छोटी	लंबी
तना	समतल	गोलाकार
पत्तियां	गहरा हरा रंग	हल्का हरा रंग
स्पाइकलिट्स	शूकहीन, छोटी शूक	शुकमय और कोर्स ग्रेन्स
परिपक्वता और	देर से परिपक्व और	जल्द परिपक्वता और
बिखरता	कम बिखराव	जल्दी बिखराव

फेलेरिस माइनर (गेहूं का मामा) की प्रतिरोधकता क्लोडिनोफाप—प्रोपारजिल के प्रति कटिहाल, करनाल, जिन्छ, पानीपत और फतेहबाद का भाग, अंबला और कुरूक्षेत्र में देखी गयी है। मीजोसल्फयूरान + आइडोसल्फयूरान (रेडीमिक्स), सल्फोसल्फयूरान + मेट सल्फयूरान (रेडीमिक्स) 32 ग्रा./हे. और पिनाक्साडान 50 ग्रा./हे का प्रयोग करने पर फेलेरिस माइनर का 80–92 प्रतिशत तक नियंत्रण कर गेहूं के उपज में वृद्धि दर्ज की गई है।

फसलों एवं फसलीय चक में खरपतवार प्रबंधन

- उपरॉव धान में जिटल खरपतवारों के नियंत्रण हेतु अंकुरण के पूर्व पेन्डीमीथेलिन @ 1000 ग्रा. / हे तथा बिसपायरीबेकसोडियम @ 25 ग्रा. / हे + एक बार हाथ द्वारा निराई, बुवाई के 45 दिन बाद करने से खरपवतारों का घनत्व, जैव भार सबसे कम दर्ज कर उच्च उपज दर पंतनगर, भुवनेश्वर, हैदराबाद, बैंगलुरू, रांची, पामपुर और रायपुर केन्द्रों में प्राप्त की गई। जबिक पेन्डीमीथेलिन @ 1.0 कि.ग्रा. / हे तथा हाथ द्वारा बुवाई के 25 दिन बाद निराई करने पर जोरहाट एवं दपोली केन्द्रों में ज्यादा प्रभावकारी पाया गया।
- हल्दी में अंकुरण के पूर्व पेन्डीमीथेलिन @ 1.0 ग्रा. /हे, मैदीब्यूजिन 0.7 कि.ग्रा./हे या एदाजिन @ 0.5 कि.ग्रा/हे के पश्चात् 10 टन/हे. की दर से पुआल का मल्च कर हाथ द्वारा, दो बार बोने के 45 एवं 75 दिन बाद, निराई करने पर कम खरपतवार घनत्व, हिसार, लुधियाना, पालमपुर और कोयम्बटूर केन्द्रों में दर्ज की गई। पूसा में, एदाजिन @ 0.7 कि. ग्रा./हे तथा फेनाक्साप्रोप @ 67 ग्रा./हे+ मेटसल्फयुरॉन 4 ग्रा./हे, जोरहाट में, मेदीब्यूजिन @ 700 ग्रा./हे+ गुड़ाई बहुत ही प्रभावकारी पाया गया।

तालिका : शाकनाशी का हल्दी की कंद की उपज (टन/हे.) पर प्रभाव

उपचार	लुधियाना	पालमपुर	पूसा	जोरहाट
मैट्रीब्यूजिन @ 0.7 कि.ग्रा. / हे. तथा दो बार गुड़ाई	10.8	5.4	41.6	13.1
मैट्टीब्यूजिन @ 0.7 कि.ग्रा. / हे तथा फेनाक्साप्रोप तथा	8.2	2.8	48.3	10.1
फेनाक्साप्रोप @ 6.7 ग्रा. / हे.+मेटसल्फयूरान 4 ग्रा. / हे.				
मैट्रीब्यूजिन @ 0.7 कि.ग्रा. / हे. तथा पुआल का मल्य 10	18.2	13.7	45.1	11.6
टन / है. तथा एक बार हाथ से निराई				
पेन्डीमीथेलिन @1.0 कि.ग्रा. / हे. तथा दो बार गुड़ाई	12.0	6.3	42.8	12.8
पेन्डीमीथेलिन @ 1.0 कि.ग्रा. / हे. तथा फेनाक्साप्रोप @ 67	0.9	2.8	49.5	11.1
ग्रा. / हे.+मेटसल्फयूरान @ 4 ग्रा. / हे.				
पेन्डीमीथेलिन @ 1.0 कि.ग्रा. / हे. तथा पुआल का मल्च @	16.8	13.4	45.8	12.8
10 टन / हे. तथा एक बार हाथ से निराई				
एट्राजिन @ 0.75 कि.ग्रा. / हे. तथा फेनाक्साप्रोप @ 67 ग्रा.	9.8	2.3	50.6	10.5
/ हे. + मेटसल्फयूरान @ 4 ग्रा. / हे.				
एट्राजिन @ 0.75 कि.ग्रा./हे. तथा पुआल का मल्य @ 10	16.7	12.0	46.1	12.6
टन / हे. तथा एक बार हाथ से निराई				
2 बार हाथ से निराई	17.1	7.0	52.5	12.6
खरपतवार युक्त	4.2	2.9	29.3	3.6
एल. एस. डी. (पी = 0.05)	4.7	2.4	3.9	2.4

 मूंग में इमेजेथापायर 50-70 ग्रा, इमेजेथापायर + इमाजामॉक्स (रेडीमिक्स) 60-80 ग्रा, इमाजथापाइरस + पेन्डीमीथेलिन 800-1000 ग्रा. /हे. का छिड़काव करने से इकाइनोक्लोवा कोलोना खरपतवार पर प्रभावकारी नियंत्रण पाया गया । पेन्डीमीथेलिन का प्रयोग 1000 ग्रा./हे. अंकुरण के पूर्व करने पर डी. एजी टिकम के नियंत्रण पर प्रभावकारी असर हिसार और लुधियाना में पाया गया लेकिन यह प्रयोग करने के 20 दिन बाद अपनी प्रभावकारिता खो देता है।

फसलीय चकों में लंबी अवधि की जुताई का प्रभाव

- रांची, कानपुर एवं फैजाबाद केन्द्रों पर धान—गेहूं फसल चक अंतर्गत अभिसामयिक जुताई द्वारा धान, एवं गेहूं में प्रभावकारी रूप से खरपतवारों का शुष्क पदार्थ कम पाया गया जो कि शून्य—अभिसामयिक एवं शून्य— शून्य जुताई की तुलना में कम दर्ज की गई।
- धान—धान फसलीय चक्र में, भुवनेश्वर एवं त्रिशूर में अभिसामयिक भूपरिष्करण द्वारा 29.4 प्रतिशत तक खरपतवारों की सघनता में कमी प्राप्त हुई है। जबिक शून्य भूपरिष्करण वाले प्लाटों में सामान्य खरपतवारों से इलियोकेरिस का शिफ्ट भी पाया गया है। अनाज एवं भूसा की उपज अभिसामयिक भूपरिष्करण / अभिसामयिक—शून्य भूपरिष्करण में अधिक प्राप्त हुई, जबिक निरंतर शून्य भूपरिष्करण से निम्नतम अनाज एवं भूसे की उपज प्राप्त हुई।
- मक्का-सूर्यमुखी फसल चक्र में कोयम्बटूर एवं बैंगालुरू में, अभिसामयिक—अभिसामयिक भूपरिष्करण और एट्राजिन 0.5 कि.ग्रा./हे.+हाथ द्वारा बोने के 45 दिन बाद निराई करने पर खरपतवारों की कम सघनता, शुष्क भार व उच्च्तर उपज प्राप्त हुई। बुवाई के 60 दिन बाद निराई करने पर खरपतवारों की सघनता 30 दिन पर निराई की तुलना में बढ़ जाती है। सूर्यमुखी की अधिकतम उपज शून्य भूपरिष्करण की तुलना में निरंतर अभिसामयिक भूपरिष्करण में दर्ज की गई।

संरक्षण कृषि प्रणालियों में खरपतवार प्रबंधन

धान—गेहूं फसलीय चक्र में, उपरॉव धान (शून्य भूपरिष्करण) गेहूं (शून्य भूपरिष्करण)— लोबिया (शून्य भूपरिष्करण) लोबिया (शून्य भूपरिष्करण) लोबिया (शून्य भूपरिष्करण) तदुपरांत रोपण धान (अभिसामयिक भूपरिष्करण) पंतनगर केन्द्र में 60 दिन पर खरपतवारों की सघनता न्यूनतम प्राप्त हुई। पूसा और बैंगालुरू केन्द्र में अभिसामयिक भूपरिष्करण से खरपतवारों की सघनता और उनका शुष्क भार थोड़ा कम शून्य भूपरिष्करण की तुलना में प्राप्त हुआ। न्यूनतम खरपतवारों की संख्या बुवाई के 60 दिन बाद (11.2/मी)। और शुष्क भार (22.8 ग्रा./मी. (अभिसामयिक भूपरिष्करण) (रोपण धान) — शून्य भूपरिष्करण—शून्य भूपरिष्करण से प्राप्त हुआ जो कि

सांख्यकीय तौर पर अभिसामयिक भूपरिष्करण (रोपण धान)— अभिसामयिक भूपरिष्करण के समकक्ष था किन्तु यह अन्य उपचार की तुलना में अधिक प्रभावकारी पाया गया।

- अभिसामयिक भूपरिष्करण अपनाने से रोपित धान (4.41 टन/हे.) या सीधी बुवाई वाली धान (4.18 टन/हे. में प्रभावकारी उच्चतम उपज शून्य भूपरिष्करण में सीधी बुवाई धान (3.34 ट./हे.) की तुलना में बैंगालुरू में दर्ज की गई । इसी प्रकार पूसा में उच्चतम धान की उपज (4.21 ट./हे.) (अभिसामयिक भूपरिष्करण (रोपाई वाली धान)–। (अभिसामयिक भूपरिष्करण में दर्ज की गई जो कि सांख्यकीय तौर पर अभिसामयिक। रोपाई वाली धान) –शून्य भूपरिष्करण –शून्य भूपरिष्करण के समान थी। तथापित सीधी बुवाई वाली धान में रोपित धान की तुलना में पंतनगर में अधिक उपज दर्ज की गई।
- धान—गेहूं फसलीय चक्र में, कोयम्बटूर में खरपतवारों का न्यूनतम शुष्क भार अभिसामयिक भूपरिष्करण (रोपित धान)— अभिसामयिक भूपरिष्करण (सीधी बुवाई वाली धान) अभिसामयिक —शून्य भूपरिष्करण में दर्ज की गई। एकीकृत खरपतवार प्रबंधन से खरपतवारों का न्यूनतम शुष्क भार दर्ज किया गया जो कि रसायनिक विधि से खरपतवार नियंत्रण के काफी समान था। धान की उच्चतम उपज अभिसामयिक भूपरिष्करण—अभिसामयिक भूपरिष्करण प्रणाली में (5.60 ट. / हे.) और रोपाई वाली धान—अभिसामयिक भूपरिष्करण (5.28 ट. / हे.) दर्ज की गई।
- धान—मक्का फसलीय चक्र में, हैदराबाद में, खरपतवारों का शुष्क भार अंकुरण के तुरंत बाद बिसबायरीबेक— सोडियम का 20 ग्रा./हे. की दर से तदन्तर यांत्रिक विधि और अंकुरण के पूर्व प्रेतीलाक्लोर 5 ग्रा./हे. तदन्तर अंकुरण के बाद साइलो फॉप—पी—ब्यूटाईल+अलिमक्स (मेटसलफयूरान—मिथाइल+क्लोरीम्यूरॉन—इथाईल) रोपाई के 25 दिन बाद (20.7 ग्रा/मी²) दर्ज किया गरा।

विभिन्न फसलीय चकों में लंबी अवधि वाले शाक-नाशियों का प्रभाव

 धान—धान फसलीय चक्र में, जोरहाट में, धान की उच्च्तम उपज शरद ऋतु और शीत ऋतु के अनुक्रम में बूटाक्लोर+2,4—डी के रोटेशन के साथ (100 प्रतिशत रासायनिक उर्वरक, इसके तुरंत बाद बूटाक्लोर+ 2,4—डी के रोटेशन के साथ प्रीतिलाक्लोर (75 प्रतिशत न.फा.पो. के रासायनिक उर्वरक द्वारा, 25 प्रतिशत कार्बनिक स्त्रोत द्वारा) दर्ज की गई। ब्यूटाक्लोर के बाद प्रीतिलाक्लोर का रोटेशन मोनोकेरिया वेजीनेलिस और सजीटेरिया ग्वेनेनिसस, इलोकेरिस डुलिसस और साइप्रस इरिया खरपतवारों की संख्या कम करने के लिए बहुत ही प्रभावकारी पाया गया है।

- कोयम्बटूर में, निचली भूमि में रोपित धान—धान फसल प्रणाली में, खरपतवाारों की सघनता और शुष्क भारी न्यूनतम शाकनाशियों के रोटेशन से (बूटाक्लोर वर्षा ऋतु में और प्रेटिलाक्लोर शीत ऋतु में) पोषक तत्वों के एकीकृत प्रयोगसे प्राप्त किया गया। खरपतवार शिफ्ट चौड़ी पत्ती वाले खरपतवार (मार्सीलिया क्वार्डीफोलिया) से घास कुल (इकाइनोक्लोवा कसगाली) और सेजिज (साइप्रस डिफोरिमस) में भी देखा गया।
- धान—धान फसलीय चक्र में, बैंगालुरू में, बूटाक्लोर 0.75 कि.ग्रा. + 2,4—डी ई ई 0.4 कि.ग्रा. / हे. का रोपण के 3 दिन बाद अनुक्रमिक प्रयोग वर्षा ऋतु में करने पर धान की उपज हाथ द्वारा निराई करने के समान दर्ज की गई । शाकनाशी रसायन का लगातार उपयोग करने पर मृदा भीत रसायनिक गुण सूक्ष्मजीवी वृद्धि या लाभकारी सूक्ष्म जीव का बदलाव धान—धान फसल चक्र में 14 फसलीय चक्र तक नहीं पाया गया।
- धान—गेहूं फसल चक्र में, हिसार में क्लोडिनाफॉप 60 ग्रा. / हे. का निरंतर उपयोग पर गेहूं में फेलिरेस माइनर का प्रभावकारी नियंत्रण पाया गया है। क्लोडिनाफॉप का निरंतर या रोटेशनल उपयोग करने पर खरपतवार मुक्त प्लाट के तुलनीय उपज प्राप्त होती है। धान में, क्लोडिनाफाप का निरंतर निष्पादन गेहूं में और बूटाक्लोर का धान में उपयोग करने पर खरपतवारों में प्रभावकारी नियंत्रण पाया गया है। शाकनाशी का निरंतर या रोटेशनल उपयोग करने पर इकानोक्लोवा क्रसगाली की प्रतिरोधकता क्षमता के विकास का कोई भी संकेत नहीं पाया
- पालमपुर में, रोपित धान—गेहूं फसल चक्र में,
 शाकनाशियों का निरपेक्ष निरंतर या रोटेशनल उपयोग धान एवं गेहूं में करने पर, 75 नाइद्रोजन

- उर्वरक द्वारा + 25 नाइद्योजन लेनटाना द्वारा धान में उपयोग करने पर प्रभावकारी धान और गेहूं की उपज प्राप्त हुई ।
- लुधियाना में, दाइफलूरालिन (1.2 कि.ग्रा./हे.) और 2,4—डी (0.5 कि.ग्रा./हे.) का अनुक्रमिक प्रयोग करने पर गेहूं में उच्चतम उपज, शुद्ध प्रतिफल और लागत—लाभ अनुपात दर्ज किया गया। यह सल्फोसलफयूरान और 2,4—डी और रोटेशनल शाकनाशी के अनुक्रमिक प्रयोग के समतुल्य पाया गया। धान में, बूटाक्लोर (1.5 कि.ग्रा./हे.) और मेटसल्फयूरान (0.015 कि.ग्रा./हे.)के अनुक्रमिक उपयोग करने पर उच्चतम उपज एव लागत—लाभ अनुपात दर्ज किया गया। यह एनिलोफॉस और मेटसल्फयूरान के अनुक्रमिक उपयोग के समतुल्य दर्ज की गई।
- श्रीनिकेतन में. धान—सरसौं फसल चक्र में, प्रीतलाक्लोर / बूटाक्लोर का पुनरावृत्त और रोटेशनल उपयोग करने पर हाइड्रोलिया जेलिनिका खरपतवार लोप हो गये, और फिमब्रिसटायलिस मिलिएसिया की सघनता में कमी और साइनोडान डेक्टीलान और डिजिटेरिया संग्युलेनिस की सघनता में बढोतरी 10 वर्ष तक प्रयोग करने में दर्ज की गई।

समस्याग्र स्त / आक्रामक / परजीवी / जलीय खरपतवारों का प्रबंधन

- हिसार में, ग्लाइफोसेट 25 ग्रा./हे. अंकुरण के 30 दिन पश्चात् तदन्तर 50 ग्रा./हे. बुवाई के 55 दिन तक उपयोग करने पर सरसों में भुंईफोड़ पर प्रभावकारी (79 प्रतिशत)नियंत्रण पाया गया है। ग्वालियर में, सरसों में, द्राइफलूरालिन 1.5 कि.ग्रा./हे + नीम का तेल 1 प्रतिशत पी पी आई तदन्तर ग्लायफोसेट 25 ग्रा./हे. 2 प्रतिशत अमोनियम सल्फेट का बुवाई के 40 दिन बाद प्रयोग करने पर भुंईफोड़ की शाखाओं की संख्या में कमी दर्ज की गई।
- भुवनेश्वर में, स्टेल सीड बेड तदन्तर पेन्डीमीथेलिन 1.0 कि. ग्रा./हे. का अंकुरण के पूर्व रामतिल में उपयोग करने पर बुवाई के 30 और 60 दिन बाद अमरबेल की सघनता में न्यूनतम दर्ज की गई । बुवाई के पूर्व जुताई करने के बाद पेन्डीमीथेलिन 1.0 कि. ग्रा./हे. रेत के साथ मिलाकार फील्ड बीज के अंकुरण के पूर्व प्रयोग करने पर ढपोली में अमरबेल का ग्रसन कम पाया गया और फील्ड बीन की सार्थक उच्च उपज प्राप्त की गई ।

बेंगालुरू में, चीकू के पेड़ पर डेनड्रोप्थी पाया गया। डेनड्रोप्थी की टहनी को थोड़ा काटकर उसमें रूई की गद्दी में 4 ग्रा. कापर सल्फेट + 0.5 ग्रा. 2,4—डी साल्ट लगाकर 2 माह बाद 100 प्रतिशत निष्पत्रण पाया गया और 6 माह तक पुनर्जनन नहीं पाया गया । इसकी छोटी टहनी भी 2 माह बाद सूख गई ।



Ethrel application for controlling Loranthus

त्रिशूर में टेक्जीलस कुनेटस (लोरेन्थस) का सेव,
 आडू, प्लम और अनार में ग्रसन पाया गया । इथ्रेल
 25 मि.ली. / ली. और 2,4—डी (1 ग्रा. / 20 मि.ली. की पेडिंग करने पर लोरेन्थस में प्रभावकारी नियंत्रण पाया गया ।

खरपतवारों का जैविकीय प्रबंधन

- जाइगोग्रामा बाइकोलोराटा को विभिन्न स्थानों पर छोड़ने से अलग—अलग प्रभाव देखा गया । यह आनंद, जोरहाट, रांची, त्रिशूर, श्रीनिकेतन, ढपोली और हिसार में छोड़ने के बावजूद स्थापित नहीं हो पाया । यद्यपि यह कानपुर, पालमपुर, पंतनगर, परभनी, फैजाबाद, लुधियाना और ग्वालियर केन्द्रों में 10-70 प्रतिशत तक स्थापित होना पाया गया।
- केशिया तोरा के बीजों का छिड़काव अप्रैल-मई माह में वर्षा के पूर्व गाजरघास से ग्रसित साईट पर करने से सितंबर-अक्टूबर माह में गाजरघास को सफलतापूर्वक प्रतिस्थापित किया गया।
- नियोकेटिना जाति वीविल्स गुणित होकर जलकुंभी को उत्कृष्ट तरीके से नियंत्रित करते है । जलकुंभी से रिक्त स्थान पर एलीगेटर वीड आ जाते है । संवर्धन द्वारा भी वीविल्स की जनसंख्या बढ़ाने से जलकुंभी को नियंत्रित किया जा सकता है ।



Sequence of control of water hyacinth by *Neochetina* spp.

शाकनाशी अवशेष और पर्यावरण की गुणवत्ता

- बाजरा—मूंगफली और मूंगफली—रागी फसल चक में, बैंगालुरू एवं आनंद में पेण्डीमीथेलिन के अवशेष मृदा और मूंगफली के दालनों में पता लगाने योग्य स्तर (0.01 मि.ग्रा. / कि.ग्रा.) से भी कम पाये गये। रागी में, बूटाक्लोर का अवशेष पता लगाने योग्य स्तर (0.01 / पी.पी.एम)से भी कम मृदा, दानों और भूसा में पाया गया। रागी में पेन्डीमीथेलिन का प्रयोग करने पर मृदा में अवशेष 30 दिन तक पाया गया जबिक दानों एवं भूसे में यह पता लगाने योग्य स्तर से कम पाया गया।
- मक्का-मटर फसल चक्र में, पालमपुर में पेन्डीमीथेलिन-शाकनाशी के अवशेष फसल की कटाई के बाद मृदा में, दानों में और पुआल में पता लगाने योग्य स्तर से कम (0.001µग्रा./ग्रा.) पाया गया। चना, मटर और सरसों के खेत से मृदा का परीक्षण करने पर पेन्डीमीथेलिन शाकनाशी के अवशेष अपेक्षित स्तर से कम दर्ज किये गये।
- बैंगालुरू में, धान में, खेतों से सटे तालाब के पानी में जहां बूटाक्लोर और प्रेटिलाक्लोर शाकनाशी का प्रयोग किया गया, वहां शाकनाशी के अवशेष पता लगाने योग्य स्तर से भी कम पाये गये। पायराजुसल्फूरान—इथाईल 50 ग्रा. / हे. और 25 ग्रा. / हे. शाकनाशी के अवशेष इसके प्रयोग के चार सप्ताह तक भूमिगत पानी में (0.0052 और 0.0061 µ ग्रा. / ग्रा.) पाया गया। यद्यपि 45 दिन पर इसके अवशेष दोनों निर्धारित मात्रा में भूमिगत पानी में पता लगाने योग्य स्तर के नीचे पाये गये।
- कारफेन्ट्राजोन—इथाईल का उपयोग गेहूं में करने से 30 दिन तक गेहूं के पत्तों में अवशेष देखा गया ओर इसका मेटाबोलाईट क्लोरोप्रोपाइनिक अम्ल 7 दिन तक पाया गया। बाद में दोनों यौगिक अपेक्षित स्तर से कम कोयम्बटूर में दर्ज किये गये।

तकनीकी स्थानान्तरण

- वर्ष 2012 के दौरान अखिल भारतीय समन्वित खरपतवार अनुसंधान परियोजना के केन्द्रों में 369 फंट लाईन डिमान्शट्रेशन खरपतवार प्रबंधन तकनीकों के प्रदर्शन हेतु किये गये, 29 रेडियो द्वारा प्रसारण और 21 दूरदर्शन व्दारा वार्तालाप के माध्यम से किया गया । इसके अलावा 51 प्रशिक्षण कार्यक्रम भी किये गये । 28 हेन्ड आउट, फोल्डर, पम्पलेट, बुलेटिन्स / बुक लेट विभिन्न भाषाओं में प्रकाशित कर किसानों को बांटे गये ।
- कर्नाटक मण्डया में, रोपित धान में 9 फंटलाईन प्रदर्शन किये गये। बिसपायरीबेक—सोडियम @ 20 ग्रा./हे. रोपण के 20 दिन बाद प्रयोग करने पर 18 प्रतिशत ज्यादा धान की उपज प्रप्त की गई एवं निंदाई की रू. 3900/हे. बचत की गई और वीडी चेक की तुलना में रू. 6900/हे. आमदनी की बढोत्तरी दर्ज की गई।
- कोयम्बटूर के विराईलीपुर तालुक में प्याज के 10 फ्रंटलाईन प्रदर्शन किये गये। आक्सीफलोरफेन @ 250 ग्रा. / हे. अंकुरण के पूर्व (बुवाई के 3 दिन बाद) + टि्वन व्हील-हो द्वारा बुवाई के 40 दिन बाद निंराई करने पर कृषकों द्वारा अपनाई गई तकनीक की तुलना में प्याज की उपज में 15.9-43.1% बढोत्ररी दर्ज की गई।
- रांची में, रोपित धान में 20 फंटलाईन प्रदर्शन किये गये । पायराजुमलफयूरान @ 0.02 कि.ग्रा. / हे. का उपयोग करने से 33.2 प्रतिशत धान में उच्च्तम उपज (3.45 ट. / हे.)दर्ज की गई और 39.7 प्रतिशत उच्च शुद्ध लाभ (रू. 28,061 / हे..) कृषक द्वारा अपनाये गये खरपतवार नियंत्रण विधि की तुलना में दर्ज किया गया ।

Executive Summary

Directorate has 22 coordinating and 7 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 systems and non-crop situations.

Salient research achievements made during 2012-13 are presented below:

Weed surveillance

New weeds species, viz. *Tithonia diversifolia* and *Mikania micrantha* in hilly zone; *Ipomoea triloba* in sugarcane fields in Chamarajanagar and Mysore districts; *Ambrosia psilostachya* in Turuvekere taluk; *Ipomoea pes-tigridis* in clayloam soils in cotton and sugarcane fields in Hiriyur and Davanagere areas; *Ipomoea cairica, Ipomoea staphylina* and *Ipomoea occinea* in many areas on road side were noticed in Southern Karnataka.





Ambrosia psilostachya

Ipomoea triloba

- Alternanthera triandra has emerged as a new problem in direct-seeded rice in Chhattisgarh. This is also invading road sides and field bunds in areas around Raipur.
- Mikania micrantha, Parthenium hysterophorus, Eichhornia crassipes and Alternanthera philoxeroides were prominent weeds observed in East and South Eastern Coastal Plain Zone of Odisha. In Mid- Central Table Land Zone, Celosia argentea was reported in groundnut and pulses under rainfed upland situation. Phragmites karka, covering one-tenth area of the Chilika Lagoon lake, posed a serious problem in navigation and fishing.
- स Cuscuta chinensis was observed in berseem in Ambala, Yamuna Nagar, Karnal, Kaithal,

- Tohana, Kurukshetra and Kaithal areas of Haryana. Infestation of *Orobanche aegyptiaca* was also observed in mustard in sand dunal areas of Meham, Mirchpur, Choudhriwas and Juglan (Hisar), Kathura (Gohana), Odhan (Sirsa) and Bhatto (Fatehbad).
- In Dibrugarh district of Assam, Eichhornia crassipes was found to be the most dominant weed in the summer season, followed by Ipomoea carnea. Among broadleaved species, Monochoria vaginalis was the most dominant weed, followed by sedges, viz. Eleocharis acutangula and Fimbristylis littoralis in the transplanted rainy season rice.
- Weed surveillance in different parts of Punjab indicated that intensity of *Phalaris minor* was on the increase in wheat. *Poa annua* was likely to become important weed in wheat, berseem and oats; *Ipomoea* in berseem; and weedy rice in transplanted rice. *Dactyloctenum aegyptiacum, Leptochloa* sp. and *Eragrostis* sp. were on the increase in direct-seeded rice, replacing *Echinochloa* sp.
- In the central part of Kerala in Thrissur, incidence of weedy rice (*Oryza spontanea*) and Chinese sprangletop (*Leptochloa chinensis*) was seen in most rice fields in alarming densities. In upland crops, *Alternanthera betzickiana*, *Axonopus compressus* and *Hyptis capitata* are emerging as problem weeds.

Weed biology and physiology

- At Jorhat, morphological dissimilarity amongst *Echinochloa colona* germplasm was considerably higher than that of *E. glabrescens*. At Sriniketan, the highest emergence (61%) was recorded in fresh seeds of *E. colona* which started within 10 DAS and decreased with increase in age of seeds.
- Weedy rice species so far collected and identified in Assam was *Oryza rufipogon*. At Palampur, infestation was highest in direct-seeded rice, followed by direct-seeded puddled rice and least in transplanted rice

(Table -). At Pusa, weedy rice found in deep water areas in Darbhanga and Madhubani districts were *Oryza rufipogan* and *Oryza spontanea*. The yield loss due to weedy rice varied from 20-45%.

Table: Distinguishing characters of rice an weedy rice observed at Palampur

Character	Rice	Weedy rice		
Flag leaf	Small	Long		
Stem	Flattened	Round		
Leaves	Dark green colour	Light green colour		
Spikelets	Awnless, small awned	Awned and course grains		
Maturity and shattering	Late maturing and less shattering	Early maturing and early shattering		

Phalaris minor showed resistance against clodinafop-propargyl in Kaithal, Karnal, Jind, Panipat and parts of Fatehbad, Ambala and Kurukshetra districts of Haryana. Mesosulfuron + iodosulfuron (RM), sulfosulfuron + metsulfuron (RM) at 32 g/ha and pinoxaden at 50 g/ha performed well with 80-92% control of P. minor and resulting in the highest yield of wheat.

Weed management in crops and cropping systems

- For control of complex weed flora in direct-dry seeded rice, application of pendimethalin @ 1000 g/ha PE followed by bispyribac-Na @ 25 g/ha + one hand weeding at 45 DAS resulted in the lowest weed density, weed biomass and higher grain yield at Pantnagar, Bhubaneswar, Hyderabad, Bengaluru, Ranchi, Palampur and Raipur; whereas application of pendimethalin @ 1.0 kg/ha fb manual weeding at 25 DAS was found most effective at Jorhat and Dapoli.
- In turmeric, pre-emergence application of pendimethalin @ 1.0 kg/ha, metribuzin @ 0.7 kg or atrazine @ 0.75 kg/ha fb straw mulching @ 10 t/ha + 2 hand weedings on 45 and 75 DAP recorded less weed density, dry weight and highest rhizome yield at Hisar, Ludhiana, Palampur and Coimbatore. At Pusa, atrazine @ 0.75 kg/ha fb fenoxaprop @ 67 g/ha+ metsulfuron @ 4 g/ha and at Jorhat metribuzin @ 700 g/ha + hoeing were found most effective (Table).

Table: Effect of herbicides on rhizome yield (t/ha) of turmeric

Treatment	Ludhiana	Palampur	Pusa	Jorhat
Metribuzin @ 0.7 kg/ha fb two hoeings	10.8	5.4	41.6	13.1
Metribuzin @ 0.7 kg/ha fb fenoxaprop @ 67 g/ha+ metsulfuron @ 4g/ha	8.2	2.8	48.3	10.1
Metribuzin @ 0.7 kg/ha fb straw mulch @ 10 t/ha fb one HW	18.2	13.7	45.1	11.6
Pendimethalin @ 1.0 kg/ha fb two hoeings	12.0	6.3	42.8	12.8
Pendimethalin @ 1.0 kg/ha fb fenoxaprop at @ 67 g/ha+ metsulfuron @ 4g/ha	0.9	2.8	49.5	11.1
Pendimethalin @ 1.0 kg/ha fb straw mulch @ 10 t/ha fb one HW	16.8	13.4	45.8	12.8
Atrazine @ 0.75 kg/ha fb fenoxaprop at @ 67 g/ha+ metsulfuron @ 4 g/ha	9.8	2.3	50.6	10.5
Atrazine @ 0.75 kg/ha fb straw mulch @ 10 t/ha fb one HW	16.7	12.0	46.1	12.6
2 hand weedings	17.1	7.0	52.5	12.6
Weedy check	4.2	2.9	29.3	3.6
LSD (P=0.05)	4.7	2.4	3.9	2.4

स Imazethapyr @ 50-70 g, imazethapyr + imazamox (*RM*) @ 60-80 g, imazethapyr +

pendimethalin @ 800-1000 g/ha provided effective control of *E. colona* in greengram.

Pendimethalin @ 1000 g/ha as pre-emergence was effective against *D. aegyptium* and lost its efficacy 20 days after its use at Hisar and Ludhiana.

Long-term trial on tillage in different cropping systems

- In rice-wheat cropping system at Ranchi, Kanpur and Faizabad, conventional tillage in rice and wheat recorded significantly reduced weed dry matter accumulation as compared to zero-conventional and zero-zero tillage.
- In rice-rice cropping system at Bhubaneswar and Thrissur, the practice of conventional tillage reduced weed densities to the tune of 29-44%. However in zero tillage plots, there was a shift from common weeds to *Eleocharis*. Grain and straw yields were higher with conventional tillage/ conventional-zero tillage and lowest with continuous zero tillage.
- In maize-sunflower cropping system at Coimbatore and Bengaluru, lower density and dry weight of weeds with higher yield were recorded in CT-CT and atrazine @ 0.5 kg/ha+hand weeding on 45 DAS. At 60 DAS, density of all weeds showed an increasing trend as compared to 30 DAS. The yield of sunflower was higher in continuous conventional tillage than zero tillage.

Weed management in conservation agriculture systems

- In rice-wheat cropping system, the lowest weed density at 60 days stage was obtained with DSR (ZT)-wheat (ZT)-cowpea (ZT), followed by TPR (CT)-wheat (CT) at Pantnagar. At Pusa and Bengaluru, conventional tillage had slightly lower weed density and dry weight as compared to zero tillage at all stages. The lowest weed count (11.2 /m²) and dry weight (22.8 g/m²) were recorded at 60 DAS under CT (transplanted)-ZT-ZT, being statistically at par with CT (transplanted)-CT but significantly superior to rest of the treatments.
- ਜ Adopting conventional tillage for transplanted rice (4.41 t/ha) or direct-seeded rice

- (4.18 t/ha) gave significantly higher yields than zero tillage with direct-seeded rice (3.34 t/ha) at Bengaluru. Similarly at Pusa, the highest grain yield of rice (4.21 t/ha) was recorded under CT (transplanted)–CT, which was statistically at par with CT (transplanted) ZT-ZT. However, DSR gave more grain yield as compared to transplanted systems at Pantnagar.
- In rice-rice cropping system at Coimbatore, lower weed dry weight was observed in conventional tillage (TPR) conventional tillage system and conventional tillage (DSR)-CT-ZT. Integrated weed management recorded lower weed dry weight, which was closely followed by chemical method of weed control. Higher grain yield was observed in conventional tillage-conventional tillage system (5.60 t/ha) and transplanted conventional tillage system (5.28 t/ha).
- In rice-maize cropping system at Hyderabad, the lowest weed dry matter was recorded with early post-emergence application of bispyribac-Na @ 20 g/ha fb mechanical weeding and pre-emergence application of pretilachlor @ 0.5 kg/ha fb post-emergence application of cyhalofop-p-butyl + almix (metsulfuron-methyl + chlorimuron-ethyl) at 25 DAT (20.7 g/m²).

Long-term herbicide trial in different cropping systems

- In rice-rice cropping system at Jorhat, the highest grain yield in both autumn and winter rice crops in sequence was obtained with butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer), closely followed by butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source). Rotation of butachlor with pretilachlor was very effective in reducing the population of *Monochoria vaginalis* and *Sagittaria guayanensis*, *Eleocharis dulcis* and *Cyperus iria*.
- At Coimbatore in lowland transplanted ricerice cropping system, the effect on weed density and dry weight was minimum under rotational use of herbicides (butachlor in rainy and pretilachlor in winter) with

- integration of nutrients. Weed shift from broadleaved weed (*Marsilea quadrifolia*) to grasses (*Echinochloa crusgalli*) and sedges (*Cyperus difformis*) was also observed.
- At Bengaluru in rice-rice cropping system, sequential application of butachlor @ 0.75 kg + 2,4-D EE @ 0.4 kg/ha at 3 DAT during rainy season *fb* application of pretilachlor @ 0.75 kg/ha as pre-emergence in summer resulted in grain yield similar to hand weeding. The use of herbicides continuously did not alter the soil physico-chemical properties nor affected the microbial growth or beneficial micro-organisms in rice-rice system over a period of 14 cropping cycles.
- In rice-wheat system at Hisar, continuous use of clodinafop @ 60 g/ha provided effective control of *P. minor* in wheat. The continuous or rotational use of clodinafop provided comparable yields with weed-free plots. In rice, the performance of continuously used clodinafop in wheat and butachlor in rice provided effective control of weeds. There was no sign of development of resistance in *Echinochloa crusgalli* against continuously-used or rotationally-applied herbicides.
- At Palampur in transplanted rice-wheat cropping system, 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 and wheat.
- At Ludhiana, sequential application of trifluralin (1.2 kg/ha) and 2,4-D (0.5 kg/ha) recorded the highest wheat grain yield, net returns and B:C ratio. It was at par with sequential application of sulfosulfuron and 2,4-D, and rotational herbicides. In rice, sequential application of butachlor (1.5 kg/ha) and metsulfuron (0.015 kg/ha) recorded the highest rice grain yield and B:C ratio. It was at par with sequential application of anilophos and metsulfuron.
- In rice-mustard cropping system at Sriniketan, repeated and rotational application of pretilachlor / butachlor

resulted in disappearance of *Hydrolea* zeylanica, decrease in the density of *Fimbristylis miliacea* and increase in the density of *Cynodon dactylon* and *Digitaria* sanguinalis after 10 years of application.

Management of problematic/invasive/ parasitic/aquatic weeds

- At Hisar, post-emergence application of glyphosate @ 25 g/ha at 30 DAS followed by its use @ 50 g/ha at 55 DAS provided effective control (79%) of *Orobanche* in mustard. At Gwalior, number of *Orobanche* shoots was the lowest when mustard was applied with trifluralin @ 1.5 kg/ha + neem oil 1% PPI, followed by glyphosate @ 25 g/ha with 2% ammonium sulphate at 40 DAS.
- At Bhubaneswar, stale seedbed *fb* preemergence application of pendimethalin @ 1.0 kg/ha recorded the lowest *Cuscuta* density at 30 and 60 DAS and highest yield of niger. Ploughing before sowing and application of pendimethalin @ 1.0 kg/ha as pre-emergence sand-mix resulted in significantly higher yield of field bean and lower infestation of *Cuscuta* at Dapoli.
- At Bengaluru, *Dendrophthoe* was observed on sapota trees. Padding of cotton with the paste of 4 g copper sulphate + 0.5 g 2,4-D Na salt on the cuts of *Dendrophthoe* shoots caused 100% defoliation after 2 months without regeneration up to 6 months. The younger shoots showed drying after 2 months.
- At Thrissur, *Taxillus cuneatus* (*Loranthus*) was observed on apple, peach, plum and pomegranate. Ethrel application @ 25 ml/l and padding with 2,4-D (1 g/20 ml) was found effective for controlling *Loranthus*.



Ethrel application for controlling Loranthus

Biological weed management

- Zygogramma bicolorata behaved differently at different places of its release. There was no establishment of the beetle at the released sites at Anand, Jorhat, Ranchi, Thrissur, Sriniketan, Dapoli and Hisar. However, the beetles established well at Kanpur, Palampur, Pantnagar, Parbhani, Faizabad, Ludhiana and Gwalior centres, with its effect varying from 10-70%.
- Broadcasting of seeds of *Cassia tora* during April-May well before the onset of monsoon on infested sites of *Parthenium* successfully replaced *Parthenium* by September-October.
- Neochetina spp. weevils multiplied and caused excellent control of water hyacinth. Alligator weed replaced the niche vacated by water hyacinth. Augmentation also helped in population build-up of weevil, which controlled most of the water hyacinth.







Sequence of control of water hyacinth by *Neochetina* spp.

Herbicide residues and environmental quality

- In pearlmillet-groundnut and groundnut-fingermillet cropping systems at Bengaluru and Anand respectively, the residues of pendimethalin were below detectable level (0.01 mg/kg) in both soil and kernels of groundnut. In fingermillet, the residues of butachlor were found below detectable level (0.01 ppm) in soil, grain and straw. Atrazine residues were detected up to 30 days in soil after its application in pearlmillet, while the residues were below detection limit in grain and straw of pearlmillet.
- 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.
- Residues of butachlor and pretilachlor were found below detectable level in pond adjacent to fields where herbicides were applied in rice at Bengaluru. The residues of pyrazosulfuron-ethyl were seen up to 4th week after application in underground water (0.0052 and 0.0061 µg/g at 25 g and 50 g/ha dose, respectively). However after 45 days, it was below detectable limits in underground water at both the doses.
- Tarfentrazone-ethyl was detected in wheat foliage up to 30 days after application, and its metabolite chloropropionic acid was detected up to 7 days. Thereafter, both the compounds were found below detectable limits at Coimbatore.

Transfer of technology

- During 2012, AICRP-WC centres conducted 369 frontline demonstrations on location-specific weed management technologies, and broadcast 29 radio and 21 TV talk-shows. In addition to this, 51 training programmes were conducted, 28 handouts, folders, pamphlets, bulletins/ booklet in various languages were published and distributed to the farmers and other end-users.
- In 9 frontline demonstrations in transplanted rice at Mandya, Karnataka, use of bispyribacsodium @ 20 g/ha at 20 DAP resulted in 18% more rice grain yield, saved weeding cost by ₹ 3900/ha and increased income by ₹ 6900/ha over weedy check.
- In onion, 10 FLDs at Viraliyur Taluk of Coimbatore revealed that application of preemergence oxyfluorfen @ 250 g/ha (3 DAS) + twin wheel-hoe weeding (40 DAS) increased yield by 15.9-43.1% over farmers' practice.
- In 20 frontline demonstrations on transplanted rice at Ranchi, pyrazosulfuron @ 0.02 kg/ha recorded 33.2% higher grain yield (3.45 t/ha) and 39.7% higher net returns (₹ 28,061/ha) compared with farmer's practice.

1.0 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 `Rs. 42.97 lakhs for five years. The tenure of the project was, however, extended for one more year till March, 1984 with the savings. Further work was continued at these centres with the AP Cess fund of ICAR till the implementation of VII Plan in April, 1986.

The activities of the project were extended covering 7 more cooperating centres, 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 Rs 58.10 lakhs for five years. The work at these centres was effectively implemented from 1982-83 to 1986-87.

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

In the VIII Plan, 4 new centres, 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 Rs. 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 Rs 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

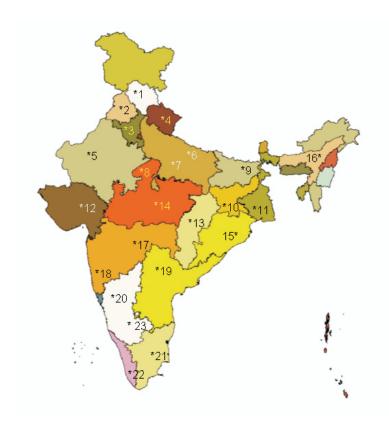
- To conduct location-specific research for developing appropriate weed management technologies
- To demonstrate the weed management technologies through on-farm adaptive trials.

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 enhance herbicide-use efficiency through adjuvants
- 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 adoptive research
- To work out soil herbicide interaction with reference to hazards due to pollution
- To test available tools/ implements for weed management under various agroecosystems; and
- To transfer weed management technologies on farmers' fields through OFT, and FLD, their impact assessment and training



AICRP-WC Coordinating Centres

- 1 CSKHPKV, Palampur
- 2 PAU, Ludhiana
- 3 CCSHAU, Hisar
- 4 GBPUAT, Pantnagar
- 5 RAU, 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 MAU, Parbhani
- 18 DBSKKV, Dapoli
- 19 ANGRAU, Hyderabad
- 20 UAS, Dharwad
- 21 TNAU, Coimbatore
- 22 KAU, Thrissur
- 23 UAS, Bengaluru

Volunteer Centres: (i) RBS College, Agra; (ii) SKUAST, Jammu; (iii) SVBPUAT, Meerut; (iv) DPDKV, Akola; (v) ACRI, Madurai; (vi) SKUAST, Kashmir; (vii) PAJANCOA & RI, Puducherry.

2.0 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 interdisciplinary mode. Besides 22 main centres, 7 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2012-13 are given below:

Staff position at different coordinating centres during 2012-13

Centre	Scientific		Technical (Including Driver)		Administrative		Supporting	
	Sanctio-	Filled	Sanctio-	Filled	Sanctio-	Filled	Sanctio-	Filled
	ned		ned		ned		ned	
PAU, Ludhiana	4	4	3	3	1	1	2	2
UAS, Bengaluru	4	4	3	2	1	-	2	2
JNKVV, Gwalior	4	4	2	2	1	1	2	2
GBPUAT, Pantnagar	4	4	3	2	1	1	2	2
CSKHPKV, Palampur	4	4	3	3	1	1	2	2
AAU, Jorhat	4	4	3	3	1	1	2	1
MAU, Parbhani	4	3	3	2	1	1	2	1
AAU, Anand	4	4	3	3	1	-	2	2
TNAU, Coimbatore	4	4	3	3	1	1	2	2
NDUAT, Faizabad	4	3	2	2	1	-	2	2
V.B.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	2
KAU, Thrissur	3	3	2	2	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
RAU, Bikaner	2	2	1	1	1	-	1	1
Total	72	67	46	40	22	16	32	28

Funds released to different coordinating centres during the financial year 2012-13

(₹ in lakhs)

	,						(\ III lakiis)
Sl.	Centre name	Pay &	TA	Recurring	IT	TSP	Total (ICAR
No.		Allowances		Contingency			share)
1	PAU, Ludhiana	42.92	0.60	3.08	1.70	0.00	48.30
2	UAS, Bengaluru	61.62	0.60	2.40	1.70	1.72	68.04
3	RVSKVV, Gwalior	52.09	0.60	2.98	1.70	2.63	60.00
4	GBPUAT, Pantnagar	42.83	0.60	3.22	1.70	1.72	50.07
5	CSKHPKV, Palampur	52.40	0.60	2.90	1.70	2.24	59.84
6	AAU, Jorhat	90.06	0.60	2.40	1.70	5.24	100.00
7	MAU, Parbhani	43.83	0.60	2.40	1.70	2.24	50.77
8	AAU, Anand	55.55	0.60	2.40	1.70	3.24	63.49
9	TNAU, Coimbatore	45.70	0.60	2.80	1.70	1.72	52.52
10	NDUAT, Faizabad	52.19	0.60	2.98	1.70	1.72	59.19
11	V.B.Sriniketan	26.58	0.60	2.40	2.27	0.00	31.85
12	BAU, Ranchi	31.40	0.45	2.18	1.70	5.12	40.85
13	CSAUAT,Kanpur	30.70	0.45	2.58	1.70	0.00	35.43
14	KAU, Thrissur	49.53	0.45	1.80	1.70	0.00	53.48
15	OUAT, Bhubaneshwar	39.20	0.45	1.80	1.70	6.12	49.27
16	ANGRAU, Hyderabad	30.30	0.45	2.48	1.70	2.24	37.17
17	CCSHAU, Hisar	32.01	0.45	2.60	1.70	0.00	36.76
18	RAU, Pusa	22.21	0.45	1.80	1.70	1.72	27.88
19	DrBSKKV, Dapoli	16.60	0.30	1.58	1.70	2.24	22.42
20	IGKVV, Raipur	23.54	0.30	1.58	1.70	6.12	33.24
21	UAS, Dharwad	27.27	0.30	1.58	1.70	1.75	32.60
22	SKRAU, Bikaner	16.44	0.30	1.58	1.70	2.22	22.24
	Total	884.97	10.95	51.52	37.97	50.00	1035.41
23	PC Unit, Jabalpur	0.00	2.57	1.60	0.00	0.00	4.17
	Total ICAR share	884.97	13.52	53.12	37.97	50.00	1039.58

3.0 RESEARCH ACHIEVEMENTS

WS1: Weed surveillance

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

1.1. Agra centre

1.1.1. Weeds of winter season crops

The centre reported common weeds from Agra region. These were grassy species *Phalaris minor, Avena fatua, Avena ludoviciana, Cynodon dactylon* and *Asphodelus tenuifolius* and broadleaved species *Chenopodium murale, Anagalis arvensis, Chenopodium album, Convolvulus arvensis, Portulaca oleracea, Melilotus indica* and *Lathyrus aphaca*.

1.2. Akola centre

1.2.1. Weeds of rainy season crops

Major weed flora during kharif season in soybean crop were monocots Commelina benghalensis, Dinebra arabica, Poa annua, Echinochloa crus-galli, Eragrostis major, Cynodon dactylon, Cyperus rotundus and dicots Lagascea mollis, Euphorbia hirta, Digera arvensis, Tridex procumbense, Parthenium hysterophorus, Celosia argentea, Euphorbia geniculata, Alysicarpus rugosus, Alternanathera triandra, Xanthium strumarium, Portulaca oleracae, Phyllanthus niruri and Amaranthis viridis.

1.3. Anand centre

1.3.1. Weeds of rainy season crops

Weed species in North Saurashtra Zone, viz. Jamnagar, Porbandar and Rajkot districts were surveyed. Major crops grown in the areas were: cotton, groundnut, pearlmillet and sorghum. Major narrow-leaf weeds were: Cyperus rotundus, Eragrostis major, Echinochloa crus-galli, Commelina forskalaei and Dactyloctenium aegyptium. Major broad leaved weeds appeared were Digera arvensis, Phyllanthus niruri, Trianthema monogyna, Euphorbia hirta and Oldenlandia umbellate. Among other weeds infesting the crops were: Parthenium hysterophorus, Cuscuta spp., Cassia sericea, Prosopis

julifera, Saccharum spontanium and Aristida redacta. Gujarat had eight agro-climatic zones viz., I. South Gujarat (heavy rainfall area), II. South Gujarat, III. Middle Gujarat, IV. North Gujarat, V. North West zone, VI. North Saurastra, VII. South Saurastra and VIII. Bhal and coastal area. Survey work was carried out during *kharif* in Agroclimatic Zone VI.

1.4. Bengaluru centre

1.4.1. New weeds/spread of weeds

New weeds were noticed in different parts of southern Karnataka and it was feared that these might spread in due course of time to other areas and might pose problem in crops.

Tithonia diversifolia (Hemsl.) A. Gray (Giant Mexican sunflower, Asteraceae): Weed attained flowering during November – December months. The weed was noticed on roadsides in Ponnampet – Virajpet valley areas of Kodagu District (851-909 m elevation, 12° 2″ N, 75° 8″ to 75° 9″ E) during *kharif* 2012.

Mikania micrantha Kunth (Mile-a-Minute or Bittervine, Asteraceae): The weed is spread to many areas along roadsides and valleys in Ponnampet area of Kodagu district in hilly zone (851-909 m elevation, 12° 2″ N, 75° 8″ to 75° 9″ E) during *kharif* 2012. The weed has occurred in the area for the past two years



Mikania micrantha

Ipomoea triloba L. (Little bell, Convolvulaceae): The weed was moderate to severe in Nanjangud taluk (657 m, 12° 12″ N, 76° 68″ E), T. Narasipura

taluks (638 m, 12° 21″ N, 76° 906″ E) of Mysore District and Kollegal taluk (558m, 12° 1628″ N, 76° 9777″ E) of Chamarajanagar District. The weed emerges after final earthing up around 120 days after planting and final split of fertilizer application.



Ipomoea triloba

Ambrosia psilostachya DC (Western/ Cuman/ Perennial Ragweed, Asteraceae): The weed was noticed in villages of Tumkur district throughout the year. The species replaced other species and made crop raising difficult.



Ambrosia psilostachya

Ipomoea pes-tigridis L. (Tiger Foot Morning Glory, Convolvulaceae): A weed seen in black soils in Hiriyur (630 m, 13° 95' N, 76° 02' E), around cotton fields and Kathalagere in sugarcane fields (660m, 14° 17' 45" N, 75° 50' 17" E), during July to December months of 2012.

Ipomoea cairica (L.) Sweet (Synonym *Ipomoea palmate* Forssk.) (Mile-a-minute vine, railway creeper, railroad creeper, Convolvulaceae): The weed is seen on road sides, plantations in many places, Bengaluru Rural (915m, 13° 06' N, 77° 59' 05" E), Chitradurga (732m, 14° 23' N, 76° 04' E), Davanagere (602.5m, 14° 46' 66" N, 75° 92' 42" E) districts in Southern Karnataka.

Ipomoea staphylina Roem. & Schult. (Synonym *Ipomoea sumatrana* (Miquel) van Ooststroom, Blumea, Convolvulaceae): The weed was seen around Bengaluru Rural (915m, 13° 06' N, 77° 59' 05" E), Mysore (920 m, 12° 28' N, 77° 34' E), Mandya (920 m, 12° 28' N, 77° 34' E), Shimoga (920 m, 12° 28' N, 77° 34' E), Ponnampet (920 m, 12° 28' N, 77° 34' E), and Kodagu Districts (915m, 13° 06' N, 77° 59' 05" E) of Southern Karnataka.

Ipomoea occinea L. var. hederifolia (L.) House (Red morning glory, tedstar, Mexican morning glory, Convolvulaceae): The weed was seen growing along road sides during August to December in areas around Bengaluru Rural (915m, 13° 06' N, 77° 59' 05" E), Mysore (920 m, 12° 28' N, 77° 34' E), Mandya (920 m, 12° 28' N, 77° 34' E), Shimoga (920 m, 12° 28' N, 77° 34' E) and Kodagu (915m, 12° 42' 08" N, 75° 73' 97"E) Districts of Southern Karnataka.

1.5. Bhubaneswar centre

1.5.1. Weeds of rainy season crops

Transplanted rice was dominated with grasses like *Panicum repens*, *Echinochloa crus-galli* and *Paspalum scorbiculatum*, and broadleaved weeds like *Ludwigia parviflora*, *Alternanthera sessilis*, and *Ammania bacifera*. Sedges like *Cyperus iria* and *Fimbristylis miliaceae* were also present.

1.5.2. Weeds of winter-season crops

Weed flora were surveyed in pulses. The weeds were dominated with grasses like *Cynodon dactylon*, *Echinochloa colona*, *Digitaria ciliaris* and *broad-leaved* weeds like *Ageratum conyzoides*, *Amaranthus viridis*, *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*.

1.5.3. Weeds of non-cropped lands

Dominant weeds in non-cropped areas were Cynodon dactylon, Eleusine indica, Digitaria ciliaris, Ageratum conyzoides, Amaranthus viridis, Achyranthus aspera, Spaeranthus indicus and Cyperus rotundus.

1.5.4. Shifts in weed flora

The centre reported spread of weeds to different zones in the surveyed areas.

East and Southestern Coastal Plain Zone: Mikania micrantha, Parthenium hysterophorus, Eichhornia crassipes and Alternanthera philoxeroides were prominent weeds. The Mikania micrantha was spreading alarmingly in the interior areas of Puri, Jagatsinghpur, Kendrapara and Khurda districts in the orchards of mango, banana, coconut and papaya, fences and roadside plantations. The Parthenium hysterophorus was predominant in the embankments of all the major canals of coastal command area such as Puri main canal, Taladanda canal, Sakshigopal main canal and Birupa canal. The Eichhornia crassipes was a menace in almost all low lying waterlogged areas, ponds, canals and their sub-distributaries under coastal command areas. Similarly, Alternanthera philoxeroides, commonly known as alligator weed, was observed in low land paddy areas and lowlying swampy areas along the roadsides of coastal districts (Jagatsinghpur, Kendrapara, Puri, Khurda and Jajpur).

Mid Central Table Land Zone: In this zone, *Celosia argentea* invaded groundnut and pulses under rainfed upland situation of Dhenkanal and Anugul districts.

Chilika Lagoon: A submerged and emergent weed *Phragmites karka* covering one-tenth area of the lake posed a serious problem in navigation and fishing. The weed kept confined to a particular area of the lake and now spreading towards the bank of the lake posing serious problem.

1.6. Coimbatore centre

1.6.1. Crop weeds

The centre reported *Parthenium hysterophorus* as a predominant broad leaf weed in

cropped areas. Earlier during 2008 *Tridax* procumbens was the dominant weed in the area. Incidence of Cyperus rotundus had declined. The Cynodon dactylon, which was dominant among grasses during 2008, had been replaced by Dactyloctenium aegyptium. In non-cropped areas dominant broad-leaved weed of 2008, Gomphrena decumbens, was replaced by Parthenium hysterophorus during 2012. As in cropped situation, the incidence of Cyperus rotundus had also come down during 2012 when compared to the infestation in 2008. During 2012, Dactyloctenium aegyptium replaced the Cynodon dactylon that was predominant grass weed during the year 2008.

1.6.2. Weeds in non-cropped sitiations

The centre reported weeds of garbage areas. There was high intensity of *Parthenium hysterophorus* in 2012 than 2008 among broad leaved weeds. The invasion of *Cyperus rotundus* was observed during 2012 in areas where it did not exixt in 2008. Predominant weed *Cynodon dactylon* among grasses found during 2008 was replaced by dominant grass weed *Dactyloctenium aegyptium* during 2012.

1.6.3. Shifts in weed flora

The centre reported replacement of preexisting weed *Gomphrena decumbens* by *Parthenium hysterophorus* in non-crop situations in the past four years. Incidence of *Cyperus rotundus* infestation had also come down during 2012. Further, during 2012, *Dactyloctenium aegyptium* has replaced the *Cynodon dactylon*, which was predominant grass weed during the year 2008.

1.7. Faizabad centre

1.7.1. Weeds of rainy season crops

Survey was undertaken in the eastern districts of Uttar Pradesh, viz. Gorakhpur, Kushinagar and Deoria. Prominent weeds in rice were *Echinochloa* species, the most dominant weeds with a density of 24-106 plant/m² and IVI ranging from 130-139. In the lowlying areas of rice, weedy rice species, viz. *Oryza nivera, Oryza sativa f. spontanea* and *Oryza rufipogon* were recorded, and the intensity was found to increase with time. Sugarcane fields in Deoria district were

infested with gassy weeds, viz. Dactyloctenium aegyptium, Cynodon dactylon and Sorghum halepense recording IVI values of 67.0, 47.0 and 36.0; while the broadleaved species were viz. Corchorus spp., Ageratum conyzoides and Eclipta alba recording IVI values of 52.2, 43.4 and 41.4, respectively. Cyperus rotundus and Scirpus spp were also predominant with IVI values of 143.8 and 56.1, respectively.

1.7.2. Weeds of winter-season crops

Phalaris minor was found as a major weed of wheat in all the 3 districts surveyed viz. Gorakhpur, Kushinagar and Deoria. Anagallis arvensis and Chenopodium album were predominant broad leaved weeds in wheat. However, Poa annua and Polypogon monospensis also occurred in all the three eastern districts Gorakhpur, Kushinagar and Deoria in the U.P. Phalaris minor had high IVI values ranging from 109.5-135.2%. The Anagalis arvensis and Chenopodium album had IVI values ranging from 58.5-62.3% and 43.3-57.6%, respectively. Major grassy dominating weeds in lentil in Gorakhpur and Kushinagar districts were Phalaris minor and Avena ludoviciana with IVI values ranging from 111.3- 111.6%. Among the broad leaved weeds, Chenopodium album was dominant species with IVI value from 67-67.2% in Gorakhpur and Kushinagar districts. Newer weeds Poa annua and Polypogon monosplensis in grassy and Rumex spp. and Medicago denticulata in broad leaved categories had started infesting wheat in the last 3-4 years. Wild oat (Avena fatua) used to infest wheat fields 4-5 years ago was not found in this crop fields any more. Solanum nigrum, Medicago denticulata and Rumex spp. were apparent in wheat. The Pluchea lanceolata and Alhagi camelorum had completely disappeared from the Rabi season.

1.8. Gwalior centre

1.8.1. Weeds of rainy season crops

Weeds in the prominent cropping systems were surveyed.

Soybean-chickpea and rice-wheat: In soybean fields, prominent weeds (with relative density in prentheses) were *Echinochloa crus-galli* (25.5), *Cyperus rotundus* (14.1), *Commelina*

benghalensis (11.1) and Setaria glauca (11.4). In rice, prominent weeds in Shivpuri district with higher IVI values were wild rice (73.7), Echinochloa crusgalli (58.5) and Cyperus rotundus (43.3). In jowar, there were nine weeds infesting the fields. Among them, Cynodon dactylon (23.2), Digera arvensis (21.3%), Trianthema monogayana (18.0), Eragrostis spp. (10.5) and Echinochloa crus-galli (9.1) having higher relative density (in parentheses). Groundnut fields were infested with twelve species. The Cyperus rotundus recorded highest relative density (29.2) followed by Setaria glauca (13.5), Cynodon dactylon (10.9), Digera arvensis (10.4) and Cucumis trigonus (6.9). Based on IVI value; Cyperus rotundus (48.7), Setaria glauca (25.2) and Echinochloa crus-galli (23.0) were dominant weeds. In maize fields, there were nine weeds associated with the crop. Most prominent were Eragrostis spp., Portulaca quadrifida, Echinochloa crus-galli, Digera arvensis and Commelina benghalensis (with relative densities 40, 18, 10, 9 and 6, respectively).

Weed flora survey in Kharif was undertaken in soybean, paddy, sugarcane, maize and sesamum crops in Datia district. In soybean, ten weeds were prominent in the fields, out of which Eragrostis spp. (20.8), Ziziphus rotundifolia (17.7), Cyperus rotundus (16.4) and Digera arvensis (15.8) were major species with respect to relative density (figures in parentheses). Rice had five major weeds. Relative density wise the major weeds were Cyperus rotundus (37.5), Echinochloa crus-galli (36.2), Wild rice (12.5) and Commelina nudiflora (10.0). In sugarcane, 13 weeds were prominent. From amongst dominant weeds were Cyperus rotundus (relative density 25.2), Cynodon dactylon (14.3), Echinochloa crus-galli (11.1) and Digera arvensis (9.9). In clusterbean in Datia district, seven weed species were prominent. From amongst three major weeds were Cucumis trigonus (39.7), Cyperus rotundus (37.7) and Setaria glauca (33.1) which were dominant in respect to IVI value. Sesame fields had 9 weeds. Among them, Eragrostis spp. (20.6), Digera arvensis (17.1) and Cynodon dactylon (16.5) were major weeds having higher relative density. Maize crop fields had 9 weeds. The dominant weeds were Commelina benghalensis (21.0), Digera arvensis

(16.4), Echinochloa crus-galli (15.9) and Trianthema monogayana (12.8) considering relative density.

1.8.2. Weeds of winter season crops

The prominent cropping systems of the area were paddy-wheat, pearlmillet-wheat/mustard, soybean-wheat/ gram/mustard, urid-mustard, arhar-wheat and fallow-mustard. Weed survey in *rabi* mustard, one of the most important crops of Northern M.P., in Gird zone undertaken with special reference to broomrape (*Orobanche aegyptiaca*) and pyaji (*Asphodelus tenuifolius*) showed that there was an increase in the infestation under rain-fed or marginal land. These weeds were prominent in Gwalior, Morena and Bhind.

1.9. Hisar centre

1.9.1. Weeds of rainy season crops

Weed surveillance studies were conducted in *kharif* crops appearance of no weeds in the area in any crop. Wild rice (Oryza rufipogon) was not observed in any of the rice growing districts. Sporadic infestation of parasitic weed Cuscuta chinensis was observed in barseem crop in Ambala, Yamuna Nagar, Karnal, Tohana, Kurukshetra and Kaithal areas of the state. Coronopus didymus had become a major weed in barseem crop. Infestation of parasitic weed Orobanche aegyptiaca was also observed in mustard even in sand dunal areas of Meham, Mirchpur, Choudhriwas and Juglan (Hisar), Kathura (Gohana), Odhan (Sirsa) and Bhatto (Fatehbad) areas. In Pinjore area of Panchkula district, due to continuous use of Atrazine in maize crop, weed flora has been shifted towards Eleusine indica, Bracharia spp. and Commelina benghalensis.

1.9.2. Weeds of winter season crops

Studies were undertaken in 146 fields in Sirsa, Rewari, Mahender Garh, Sonepat, Rohtak, Faridabad and Palwal districts of the state during January - March, 2012. This region was characterized by low irrigation facilities and fertile alluvial soils. Crop was mainly grown after cotton, pearl millet and rice. Soils were sandy loam to loamy sand in texture using both tube well and canal water supply. In Mahender Garh

district, majority of soils were loamy sand in texture with sprinkler irrigation facility. In Sonepat and Rohtak districts, Phalaris minor was the most dominant weed with IVI values of 80.7 and 89.7%, respectively whereas in Rewari and Mahender Garh, Avena ludoviciana among grassy weeds and Chenopodium album and Chenopodium murale among broadleaf weeds dominated the weed flora. Broadleaf weed Convolvulus arvensis mainly found in wheat fields grown after pearl millet and cotton was present in all districts. In Rohtak and Sonepat, Rumex dentatus was present whereas in Rewari and Mahender Garh, Rumex spinosus was prominent with IVI values of 16.2 and 7.6%, respectively. In Sirsa, Faridabad and Palwal, Phalaris minor had low relative density (52%) and in addition to this Avena ludoviciana and broad leaved weeds were also present. Broadleaf weed Pluchea lanceolata was present only in Rewari district. Asphodelus tenuifolius and broadleaf weeds were also found in Sirsa, Rewari and Mahender Garh. Lower density of Carthamus oxycanytha was found in Rewari, Sirsa and Palwal only. Phalaris minor was present in Rohtak, Sonepat, Sirsa and Palwal districts. Malva parviflora, a robust dicotyledonous weed, was found only in Rohtak, Sonepat and Faridabad districts.

1.10. Hyderabad centre

1.10.1. Weeds of rainy season crops

Weeds in Anantapur district in groundnut and paddy were surveyed. In paddy, dominant weeds were *Cyperus difformis*, *Cyperus iria*, *Scirpus supinus* among sedges, *Panicum maximum*, *Echinochloa colona and Echinochloa crus-galli* among grasses, and *Eclipta alba*, *Alternanthera philoxeroides* and *Marsilea quadrifolia* among *broad leaved* species.

1.10.2. Weeds of winter season crops

Dominant weeds in groundnut were Cyperus rotundus and Cyperus kylinga among sedges and Cynodon dactylon, Eleusine indica, Dactyloctenium aegyptium and Dinebra arabica among grasses. Prominent broadleaf weeds were Celosia argentea, Digera arvensis, Parthenium hysterophorus, Amaranthus viridis, Legascea mollis and Allamania nudiflora.

1.11. Jammu centre

1.11.1. Weeds of rainy season crops

During kharif in maize dominant weeds were Poa annua, Cyperus iria, Eichnochloa crus-galli, Setaria glauca, Amaranthus viridis and Cynodon dactylon. The weed flora infesting wheat crop were Avena fatua, Chenopodium album, Vicia sativa, Fumaria parviflora, Phalaris minor, Medicago denticulata and Anagallis arvensis. Predominant weeds in rice were Eichnochloa crus-galli, Eichnochloa colona, Cyperus iria, Cyperus difformis and Cynodon dactylon.

1.12. Jorhat centre

1.12.1. Weeds of rainy season crops

Weeds were surveyed in different agroclimatic zones viz. Upper Brahmaputra Valley zone, Assam, Nagaland and Arunanchal Pradesh. The zones covered districts Dibrugarh, Golaghat, Kohima, Dimapur, W. Kameng and Tawang. The crop and situations under which the studies were undertaken were transplanted *kharif* rice, aquatic situation, roadside situation and *Parthenium* infested areas. The study in different areas covered summer or June to October.

Transplanted *kharif* rice was surveyed at 21 spots at flowering stage of the crop. Narrow leaf sedges dominated the weed flora of transplanted *kharif* rice fields in Dibrugarh district. The broadleaf weed *Monochoria vaginalis* was the most dominant weed followed by sedges namely, *Eleocharis acutangula* and *Fimbristylis littoralis*.

1.12.2. Weeds of non-cropped lands

Weeds along roadsides: Road-side situations in Dibrugarh had weed flora consisting of 3 ferns, 4 monocots and 22 dicot species. Species like Axonopus compressus, Chrysopogon aciculatus, Cynodon dactylon and Eleusine indica were common throughout the district. Some creeping broadleaf species like Alternanthera sessilis, Desmodium triflorum, Mecardonia procumbens, etc. were common along the roadsides. Chromolaena odorata followed by Colocasia antiquerum and Diplazium esculentum were the most dominant species along roadsides in this district. The

problematic thorny climbing shrub *Mimosa diplotricha* also appeared as one of the dominant weeds in Dibrugarh and Duliajan areas. *Parthenium hysterophorus* occurred in Dibrugarh to Tinsukia route and *Crotalaria pallida* and *Cassia tora* had infested the road sides from Namrup to Dimou via Moran. *Mikania micrantha* and *Thunbergia alata* were common vine weeds that climbed over the bushes and trees of the roadside in Dibrugarh district.

Weeds in Parthenium infested areas: Parthenium infested areas in Assam, Nagaland and Arunanchal Pradesh were investigated for extent of its spread and status of other species occurring with it. In Assam, Dibrugarh district had Parthenium infested areas restricted to the railway tracts and Trunk Roads (along the Dibrugarh-Tinsukia route) only. Species associated with Parthenium were Amaranthus spinosus, Chrysopogon aciculatus, Croton bonplandianum and Colocasia antiquerum, etc. Parthenium prevailed along the roadsides from Borhola (Kakodonga RF) to Furkating, through Ghilamari about 5 years ago, but the areas were from it in 2012. It was learnt that the local inhabitants cleared the weed from the infested areas. Furkating railway station and the railway tracts from Furkating to Jorhat through Barpathar and Horupathar and the roadsides and crop fields along the National Highway 39 and 37 were heavily infested with Parthenium. The Hatikhuli area along the National Highway 37 passing through the Kaziranga National Park had infestation of the weed threatening the park.

Survey for *Parthenium* in Nagaland was done during June-July, 2012 with the help of the Forest Department of Nagaland. In Kohima and Dimapur districts, *Parthenium* infestation was recorded along the western slopes of Dimapur district, and from the border of Kohima district to Assam border. The infestation was restricted to roadsides only. However, no infestation was recorded in Kohima district except its northwestern slope bordering Dimapur district.

In Arunanchal Pradesh, West Kameng and Tawang districts were surveyed for

Parthenium during October, 2012. The weed infestation was recorded from Bhalukpung. The Tawang district was apparently free from Parthenium infestation.

The centre also surveyed weeds in roadside situations in different agroclimatic zones viz. Upper Brahmaputra Valley zone, Assam, Assam, Nagaland and Arunanchal Pradesh. The zones covered districts Dibrugarh, Golaghat, Kohima, Dimapur, W. Kameng and Tawang covering summer or June to October. Prominent weeds in Dibrugarh had weed flora consisting of 3 ferns, 4 monocots and 22 dicot species. Species like Axonopus compressus, Chrysopogon aciculatus, Cynodon dactylon and Eleusine indica were common throughout the district. Some creeping broadleaf species like Alternanthera sessilis, Desmodium triflorum, Mecardonia procumbens, etc. were common along the roadsides. Chromolaena odorata followed by Colocasia antiquerum, Diplazium esculentum were the most dominant species along roadsides in this district. The problematic thorny climbing shrub Mimosa diplotricha also appeared as one of the dominant weeds in Dibrugarh and Duliajan areas. Parthenium hysterophorus occurred in Dibrugarh to Tinsukia route and Crotalaria pallida and Cassia tora infested along the road side from Namrup to Dimou via Moran. Mikania micrantha and Thunbergia alata were common vine weeds that climbed over the bushes and trees of the roadside situations in Dibrugarh district.

1.12.3. Aquatic weeds

Weeds were surveyed under aquatic situations in different agroclimatic zones viz. Upper Brahmaputra Valley zone, Assam, Nagaland and Arunanchal Pradesh. The zones covered districts Dibrugarh, Golaghat, Kohima, Dimapur, W. Kameng and Tawang. The study in different areas covered summer or June to October. Aquatic situations had a spectrum of narrow- and broad-leaf weed species. The narrow leaf weeds comprised of a sedge (*Scirpus grossus*) and five grasses, whereas, broad-leaf weedy species possessed one aquatic fern (*Christella crinipes*) and nine species, each of dicot- and monocot-hydrophytes. Altogether 25 weeds were

recorded in the study. Among them *Eichhornia* crassipes was the most dominant in the summer season. This was followed by *Ipomoea carnea*. Both the species have been gradually expanding their area of infestation. In some ponds and swamp areas, which were rich in organic matter, *Lemna minor* was highly populated species. However, the drains of mostly western parts of the district were dominated by the Zingiberaceous weed *Alpinia alughus*.

1.13. Kanpur centre

1.13.1. Weeds of rainy season crops

Weeds were reported from the central plain zone and in Bundelkhand of the University jurisdiction areas. In non-cropped areas, the major weeds were *Parthenium hysterophorus* with the IVI value of 58.4 and *Leucas aspera* with IVI 49.0. In groundnut crop, the major weeds were *Dactyloctenium aegyptium* and *Corchorus olitorious* with IVI value of 48.6.

In Jalaun district, sugarcane had *Eleusine indica* with IVI value of 70.0, *Achyranthus aspera* and *Parthenium hysterophorus* with the same IVI value *i.e.* 50.0 as major weeds. In non-cropped areas, major weeds were *Xanthium strumarium* and *Parthenium hysterophorus* both having IVI value of 65.0. In sorghum crop, major weeds were *Achyranthus aspera* with IVI value of 59.0 and *Leucas aspera* with IVI value of 42.9. In pigeon pea, major weeds were *Dactyloctenium aegyptium, Parthenium hysterophorus* and *Eclipta alba*, all with IVI value of 42.2.

In Ramabinagar, in pigeon pea + pearl millet mixed cropping, the major weeds were Parthenium hysterophorus, Ocimum annum and Ageratum conyzoides with IVI value of 38.2. In sorghum, major weeds were Parthenium hysterophorus with IVI value of 39.0 and Dactyloctenium aegyptium with IVI value of 38.2. In paddy, the major weeds were Heteropogon contourtus with IVI value of 83.3 and Celosia argentea and Parthenium hysterophorus with IVI value of 58.3. In pearl millets, major weeds were Dactyloctenium aegyptium with IVI value of 48.0, Eclipta alba and Achyranthus aspera with IVI value of 41.3.

1.13.2. Weeds of winter season crops

Weeds were surveyed in the central plain zone and in Bundelkhand of the University jurisdiction area. In Mahoba districts, pigeon pea had *Dactyloctenium aegyptium* with IVI of 78.6 and *Achyrathus aspera* with IVI of 67.9 as major weeds.

1.14. Ludhiana centre

1.14.1. Weeds of rainy season crops

Punjab surveyed weeds in *kharif* season in rice fields of Ludhiana, Kapurthala and Jalandhar districts.

Weed flora studies in rice in Ludhiana district at 33 locations revealed 7 major weeds infested this crop, of which 6 were grasses and one sedge. Among grasses, *Oryza* spp. were dominant having IVI value of 93.8 followed by *Echinochloa crus-galli* with IVI value of 40.8. *Fimbristylis tenera* recorded the density, RD, RF and IVI values of 0.1, 4.0, 4.2 and 8.2, respectively.

In Jalandhar district at 37 locations, 5 major weeds, all grasses infested rice crop. Weedy rice was the predominant species observed in transplanted rice with IVI value of 100 and R.D. and R.D. value of 50 each. Next in predominance was *Echinochloa crus-galli*, with IVI value of 46.2.

In Kapurthala district at 57 locations, total 5 major weeds (all grasses) infested this crop. *Echinochloa crus-galli* was major weed infesting rice crop (with IVI value of 77.6) and weedy rice was next to it (with IVI value of 69.4).

The weedy rice had started infesting transplanted rice. *Dactyloctenum aegyptium, Leptochloa* sp. *and Eragrostis* sp. intensity was on the increase in direct seeded rice, replacing *Echinochloa* sp. as major weeds.

1.14.2. Weeds of winter season crops

Weed survey and surveillance were undertaken in field areas of Ludhiana, Kapurthala and Jalandhar districts. Weed flora of wheat was diverse in different localities with predomination of *Phalaris minor*. In Ludhiana district, total 10 major weed species were found in this crop, of which 3 were grasses and 7 broadleaf species. *Phalaris minor* intensity was 6.6 plants/m² and IVI was 75.9. *Avena ludoviciana* and *Poa annua*

were also recorded in these areas with IVI values of 1.3 and 25.2, respectively. Among broadleaf weeds, Medicago denticulata recorded the highest RF followed immediately by Coronopus didymus which recorded the highest IVI. Rumex dentatus and Chenopodium album were also prevalent in the farmers' fields. In Kapurthala district, total 8 major weeds infested this crop, of which 3 were grasses and 5 broadleaf species. Phalaris minor was the dominant weed with IVI value of 94.4 followed by Poa annua. Among broadleaf species, Chenopodium album was the major weed having the highest IVI values and was followed by Rumex dentatus. It was closely followed by Malva parviflora and Anagallis arvensis. Medicago denticulata also recorded its presence. In berseem (Egyptian clover), in Ludhiana district, 5 major weeds were recorded. Of these, 1 was grass, 3 broad leaved and 1 parasitic weed. Coronopus didymus with IVI value of 59.9 was dominant species. The grass Poa annua was next in order having IVI value of 49.0 followed by broadleaf weed Cichorium intybus. Cuscuta sp infested berseem crop.

The intensity of *Phalaris minor* increased every passing year as the efficacy of two major herbicides (clodinafop and sulfosulfuron) decreased and farmers had started using higher doses and or mixtures of these and other herbicides. The intensity of *Poa annua* was on the increase in wheat, as clodinafop and sulfosulfuron, did not control this weed, and was likely to become second important grass weed in wheat. Intensity of *Poa annua* was also on the increase in winter season forages including berseem and oats. *Ipomoea* sp. had started infesting berseem crop, though the infestation was in traces, and might become a problem weed in future.

1.15. Meerut centre

1.15.1. Weeds of winter season crops

The centre reported major weeds from the area of their jurisdiction. These were *Phalaris minor, Anagallis arvensis, Chenopodium album, Rumex maritimus, Polygonum plebejum, Poa annua, Fumaria parviflora* and *Coronopus didymus*.

1.15.2. Weeds of rainy season crops

The major weeds in *kharif* were *Echinochloa colona*, *Echinochloa crus-galli*, *Commelina benghalensis*, *Eclipla alba*, *Phylanthus niruri* and *Cyperus* spp.

1.16. Parbhani centre

1.16.1. Weeds of rainy season crops

Weeds were surveyed in cropped as well as non-cropped areas during the *kharif* in Parbhani, Nanded and Hingoli.

In Parbhani district, prominent weeds in sorghum (with IVI in parentheses) were *Cyperus rotundus* (15.2) and *Cynodon dactylon* (18.1), and broad leaved weeds were *Digera arvensis* (10.4), *Commelina benghalensis* (30.2), *Euphorbia geniculata* (22.9) and *Parthenium hysterophorus* (24.5). Soybean had prominent grassy weeds *Cynodon dactylon* (22.6), *Cyperus rotundus* (16.2) and *Bracheria eruciformis* (10.1) and broad leaved weeds *Euphorbia geniculata* (20.5), *Parthenium hysterophorus* (24.2), *Commelina benghalensis* (30.4), *Ipomoea maxima* (18.8) and *Digera arvensis* (12.4).

In Nanded district, prominent weeds in soybean were grassy species (with IVI in parentheses) Cynodon dactylon (26.9) and Cyperus rotundus (12.1), and broad leaved species Parthenium hysterophorus (23.4), Commelina benghalensis (28.1), Euphorbia geniculata (40.1) and Convolvulus arvensis (20.5). Prominent weeds in cotton were grassy species (with IVI in parentheses) Cynodon dactylon (16.1) and Cyperus rotundus (35.7), and broad leaved species Euphorbia geniculata (34.5), Alternanthera sessilis (30.4), Digera arvensis (12.4) and Parthenium hysterophorus (41.3). Rice had prominent grassy weeds (with IVI in parentheses) Cynodon dactylon (22.2), Cyperus rotundus (12.2), Brachiaria erusiformis (20.2), and broad leaved weeds Parthenium hysterophorus (20.2), Commelina benghalensis (17.2), Amaranthus polygamus (14.3) and Euphorbia geniculata (29.3).

In Hingoli district, prominent weeds in soybean were grassy species (with IVI in parentheses) *Cynodon dactylon* (28.1) and *Brachiaria erusiformis* (15.1), and broad leaved

species Parthenium hysterophorus (38.2), Celosia argentea (28.8), Euphorbia geniculata (28.4) and Digera arvensis (16.1). In turmeric, grassy weeds (with IVI in parentheses) were Cynodon dactylon (40.5), Cyperus rotundus (27.3) and Brachiaria erusiformis (32.7), and broad leaved species were Parthenium hysterophorus (22.1), Amaranthus polygamous (10.6), Celosia argentia (30.5), Commelina benghalensis (25.6) and Euphorbia geniculata (21.4). In sorghum, prominent grassy weed (with IVI in parentheses) infested the crop was Cynodon dactylon (33.3) and the prominent broad leaved species appeared were Celosia argentia (40.2), Commelina communis (12.2) and Parthenium hysterophorus (25.8).

1.16.2. Weeds of winter season crops

The centre surveyed weeds in *rabi* season in Beed, Osmanabad and Latur Districts of Maharashtra state. The weeds infested different crops were as under.

In Beed district, in wheat, prominent grasses (with IVI in parentheses) infested the crop were Cynodon dactylon (13.3) and Cyperus rotundus (14.0), and broad leaved species were Euphorbia geniculata (40.6), Parthenium hysterophorus (36.8), Chenopodium album (42.4), Convolvulus arvensis (26.8), Portulaca oleracea (15.6) and Solanum nigrum (23.8). In gram, prominent grasses (with IVI in parentheses) infested were Cynodon dactylon (31.0), Cyperus rotundus (25.5), and broad leaved species were Chenopodium album (34.4), Convolvulus arvensis (23.3), Parthenium hysterophorus (42.6), Saccharum spontaneum (21.2), Solanum nigrum (13.1) and Euphorbia geniculata (14.5).

In Osmanabad district, wheat had prominent grassy weeds (with IVI in parentheses) Cynodon dactylon (14.8) and Cyperus rotundus (16.9), and broad leaved species Chenopodium album (33.1), Convolvulus arvensis (14.2), Argemone mexicana (29.1), Parthenium hysterophorus (46.1), Portulaca oleracea (18.9) and Euphorbia geniculata (25.9). In gram, prominent grassy weeds (with IVI in parentheses) were Cynodon dactylon (31.1) and Cyperus rotundus (16.2), and broad leaved weeds were Chenopodium

album (30.8), Convolvulus arvensis (15.1), Argemone mexicana (14.1), Parthenium hysterophorus (28.1), Portulaca oleracea (29.2) and Euphorbia geniculata (16.1).

In Latur district, wheat had grassy weeds (with IVI in parentheses) *Cyperus rotundus* (20.1) and *Cynodon dactylon* (27.1), and broad leaved weeds *Parthenium hysterophorus* (36.1), *Chenopodium album* (18.2), *Portulaca oleracea* (32.2) and *Digera arvensis* (12.1). Gram was infested by prominent grassy weeds (with IVI in parentheses) *Cynodon dactylon* (27.1), *Cyperus rotundus* (18.1) and broad leaved weeds *Chenopodium album* (20.1), *Parthenium hysterophorus* (22.1), *Portulaca oleracea* (23.1), *Euphorbia geniculata* (15.3) and *Euphorbia hirta* (16.7).

1.16.3. Weeds of non-cropped lands

The centre surveyed weeds in noncropped areas during the kharif in Parbhani, Nanded and Hingoli. In Parbhani district, prominent weeds of non-cropped lands (with IVI in parentheses) were Parthenium hysterophorus (36.2), Alternanthera sessilis (27.1), Tridex procumbens (12.3), Achyranthus aspera (14.9), Xanthium strumarium (16.2) and Cassia tora (31.4). In Nanded district, prominent weeds (with IVI in parentheses) were Parthenium hysterophorus (46.3), Xanthium strumarium (26.4), Achyranthes aspera (34.2), Cassia tora (49.2) and Alternanthera sessilis (44.2). In Hingoli district, weeds occurred (with IVI in parentheses) in non-cropped areas were Parthenium hysterophorus (40.3), Cassia tora (42.8), Alternanthera sessilis (34.1), Achyranthes aspera (13.6) and Tridex procumbens (6.8).

1.17. Pusa centre

1.17.1. Weeds of rainy season crops

The centre surveyed direct seeded upland rice, transplanted rice and sugarcane during *kharif* in Chhapra, Gopalganj and Siwan districts of Bihar.

Weeds of direct seeded upland rice comprised seventeen weed species. They were Cynodon dactylon, Echinocloa colona, Echinocloa glabrescens, Dactyloctenium aegyptium, Setaria glauca, Cyperus rotundus, Cyperus difformis, Amaranthus spinosus, Amaranthus viridis, Caesulia

axillaris, Celosia argentea, Cleome viscosa, Digera muricata, Euphorbia prostrate, Leucas aspera, Lippia nodiflora and Phyllanthus niruri.

Transplanated rice had nineteen weeds, out of which five were grasses, four sedges and ten broad leaved weeds. The dominant weeds were Echinochloa colona, Dactyloctenium aegyptium, Cynodon dactylon, Eleusine indica, Setaria glauca, Cyperus difformis, Cyperus distans, Cyperus iria, Cyperus rotundus, Amaranthus spinosus, Amaranthus viridis, Caesulia axillaris, Celosia argentea, Cleome viscosa, Digera muricata, Euphorbia prostrata, Leucas aspera, Lippia nodiflora and Phyllanthus niruri.

In sugarcane, there were eleven weed speices, out of which two species were grasses, one sedge and eight broad leaved weeds. These species were *Cyperus iria*, *Cyperus rotundus*, *Cynodon dactylon*, *Solanum nigrum*, *Physalis minima*, *Abutilon indicum*, *Euphorbia hirta*, *Croton bonplandianum*, *Launea pinnatifida*, *Melilotus indica* and *Melilotus alba*.

1.17.2. Weeds of winter season crops

The survey was undertaken on wheat, rabi maize and lentil in Sheohar and Muzaffarpur districts of Bihar. Predominant weeds in wheat were three grasses, one sedge and twelve broad leaved species. These were Avena fatua, Cynodon dactylon, Phalaris minor, Cyperus rotundus, Anagallis arvensis, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Eclipta alba, Fumaria purviflora, Lathyrus aphaca, Launia pinnatifida, Melilotus alba, Physalis minima, Rumex dentatus and Vicia hirsute. In rabi maize, fifteen prominent weeds occurred were Avena fatua, Digitaria sanguinalis, Setaria faberii, Cyperus rotundus, Cyperus articulatus, Anagallis arvensis, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Launea pinnatifida, Melilotus alba, Melilotus indica, Rumex dentatus, Solanum nigrum and Vicia hirsuta. In lentil, twelve weeds infested the fields. They comprised one grass, one sedge and ten broad leaved species. They were Cynodon dactylon, Cyperus rotundus, Anagallis arvensis, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Eclipta alba, Launea pinnatifida, Melilotus alba, Rumex dentatus, Solanum nigrum and Vicia hirsuta.

1.18. Thrissur centre

1.18.1. Weeds of rainy season crops

The centre surveyed weeds in district Thrissur in the central part of Kerala. The district included Kole lands, famous for rice cultivation below and near sea level. Prominent weeds (with IVI in parentheses) in rubber were Cyrtococcum trigonum (29.3), Cyathula prostrate (21.4), Axonopus compressus (19.8), Ischaemum indicum (6.8), Clerodendrum infortunatum (6.6), Elephantopus scaber (5.8), Cyrtococcum oxyphyllum (4.6), Chromolaena odorata (4.5), Spermacoce latifolia (4.5) and Macaranga peltata (3.0). In banana, prominent weeds appeared (with IVI in parentheses) were Alternanthera bettzickiana (11.6), Cynodon dactylon (10.5), Eleutheranthera ruderalis (9.2), Axonopus compressus (9.1), Ageratum conyzoides (8.9), Cyperus rotundus (8.4), Synedrella nodiflora (8.0), Desmodium triflorum (6.5), Kyllinga monocephala (6.1) and Spermacoce latifolia (5.4). In coconut, weeds recorded (with IVI in parentheses) were Ischaemum indicum (14.3), Ischaemum rugosum (11.8), Pouzolzia zeylanica (11.0), Hyptis suaveolens (9.2), Biophytum reinwardtii (6.8), Desmodium triflorum (5.4), Brachiaria miliiformis (5.0), Axonopus compressus (4.9), Borreria hispida (4.8) and Mimosa pudica (4.4).

During summer season, weeds in noncrop areas (with IVI in parentheses) were Cynodon dactylon (12.8), Tridax procumbens (11.9), Blumea mollis (9.5), Boerhaavia diffusa (9.2), Mimosa pudica (8.3), Sida acuta (7.4) and Mikania micrantha (7.4) and Merremia vitifolia (7.1), Chromolaena odorata (6.8) and Aerva lanata (6.0). In coconut, the weeds infested (with IVI in parentheses) were Cynodon dactylon (27.7), Blumea mollis (15.2), Digitaria ciliaris (17.6), Cleome viscosa (10.5), Scoparia dulcis (11.7), Brachiaria milliformis (11.2), Mimosa pudica (10.5), Centrosema pubescens (9.7), Borreria hispida (9.2) and Ischaemum rugosum (7.8). In banana, the weeds appeared (with IVI in parentheses) were Cynodon dactylon (4.0), Scoparia dulcis (10.8), Cleome viscose (10.3), Ischaemum rugosum (10.8), Borreria hispida (13.5), Phyllanthus amarus (11.1), Axonopus compressus (7.7), Mikania micrantha (6.5), Vernonia cineria (5.5) and Mimosa pudica (4.84). In rice, prominent weeds (with IVI in parentheses)

were Echinochloa crus-galli (35.6), weedy rice (31.5), Echinochloa stagnina (25.7), Leptochloa chinensis (13.1), Fimbristylis miliacea (10.2), Monochoria vaginalis (10.2), Lindernia hyssopioides (9.4), Cyperus iria (9.1), Ludwigia parviflora (8.5) and Limnocharis flava (7.6). In rubber, prominent weeds (with IVI in parentheses) were Cyrtococcum trigonum (54.7), Axonopus compressus (54.7), Cyathula prostrata (28.6), Clerodendrum infortunatum (20.0), Oplismenus compositus (16.4), Chromolaena odorata (11.3), Macaranga peltata (5.2), Ischaemum indicum (8.1), Tabernaemontana alternifolia (5.5) and Cyrtococcum oxyphyllum (4.8).

1.18.2. Weeds of winter season crops

The centre surveyed weeds in district Thrissur in the central part of Kerala. Weeds (with IVI in parentheses) appeared in rice were Echinochloa stagnina (11.3), weedy rice (10.5), Echinochloa crus-galii (10.2), Fimbristylis miliacea (9.8), Leptochloa chinensis (6.8), Monochoria vaginalis (6.3), Ludwigia parviflora (5.8), Lindernia hyssopioides (5.4), Cyperus iria (5.3) and Cyperus difformis (4.8). In coconut, prominent weeds (with IVI in parentheses) infested the fields were Ischaemum indicum (22.0), Ischaemum rugosum (17.5), Pouzolzia zeylanica (17.1), Desmodium triflorum (11.3), Axonopus compressus (15.5), Synedrella nodiflora (11.2), Hyptis suaveolens (9.5), Borreria hispida (9.4), Mimosa pudica (8.5) and Brachiaria milliformis (8.5). Banana fields were infested with (IVI in parentheses) Axonopus compressus (16.2), Scoparia dulcis (15.2), Cleome burmanni (13.2), Cynodon dactylon (8.8), Ischaemum rugosum (8.6), Mikania micrantha (7.9), Ageratum conyzoides (7.5), Eleutheranthera ruderalis (7.2), Borreria hispida (6.5) and Mimosa pudica (6.2). Weeds (with IVI in parentheses) Cyrtococcum trigonum (35.3), Axonopus compressus (21.3), Cyathula prostrata (14.7), Ischaemum indicum (13.6), Clerodendrum infortunatum (11.1), Chromolaena odorata (10.5), Oplismenus compositus (8.9), Spermacoce latifolia (7.2), Macaranga peltata (6.2) and Tabernaemontana alternifolia (5.5) infested rubber fields.

1.18.3. Weeds of non-cropped lands

Prominent weed in non-cropped areas (with IVI in parentheses) were *Alternanthera*

bettzickiana (13.8), Hyptis suaveolens (9.9), Synedrella nodiflora (8.8), Brachiaria milliformis (6.2), Axonopus compressus (6.2), Cynodon dactylon (5.8), Ischaemum indicum (5.6), Sida acuta (5.2), Borreria hispida (5.1) and Desmodium triflorum (4.4). Prominent weeds (with IVI in parentheses) during rabi season were Alternanthera bettzickiana (11.3), Brachiaria milliformis (10.4), Synedrella nodiflora (10.4), Ischaemum indicum (9.2), Hyptis suaveolens (8.0), Axonopus compressus (7.9), Sida acuta (7.5), Mikania micrantha (5.6), Merremia vitifolia (4.7) and Mimosa pudica (4.6). During kharif season, they were Alternanthera bettzickiana (13.8), Hyptis suaveolens (9.9), Synedrella nodiflora (8.8), Brachiaria miliiformis (6.2), Axonopus compressus (6.2), Cynodon dactylon (5.8), Ischaemum indicum (5.6), Sida acuta (5.2), Borreria hispida (5.1) and Desmodium triflorum (4.4).

1.18.4. Shifts in weed flora

Greater prominence of Alternanthera bettzickiana and Hyptis suaveolens was noticed in the non cropped areas previously occupied by Sida acuta, Chromolaena odorata and Cassia tora etc. Hyptis capitata was observed in more locations. The reduction in the population of shrub like weeds Chromolaena odorata, Triumfetta rhomboidea, Mimosa invisa, Urena lobata, Cassia spp. was mainly attributed to manual sickle weeding adopted along the roadsides under MNREGA programmes. Changes were not obvious in weeds in rubber, coconut, arecanut and banana like crops. Echinochloa crus-galli was prominent weed in rice. However, population of weedy rice was increased in most of the areas. Echinochloa stagnina and Leptochloa chinensis increased in many places.

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and UAS, Dharwad did not report information on weed surveillance.

WS 2: Weed biology and physiology WS 2.1. Biology of important weeds WS 2.1a Biology of *Echinochloa* species Jorhat centre

Germplasm belonging to *Echinochloa* was collected from different places and detailed morphology was studied in order to develop taxonomic criteria for easy identification of species

and varieties. Altogether, 84 Echinochloa specimens (Herbaria) were collected from different states of India (Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, West Bengal, Kerala, Madhya Pradesh, Karnataka and Punjab). Following observations were recorded:

- As many as 15 taxa of species and infraspecific ranks under 11 species have so far been identified. Out of all these taxa, *E.* stagnina (Retz.) Beauv. was the only perennial species found in this region.
- Echinochloa colona (L.) Link was the common facultative weed and appeared in deep water paddy field at before-flood condition, upland paddy fields as well as other upland crop and non-cropland situations of both plains and hills.
- The Eurasian species *E. crus-galli* subsp. *crus-galli* var. *crus-galli* was recorded as the most common rice associated obligate weed in the entire Brahmaputra valley, whereas its variety *practicola* Ohwi along with *E. crus-galli* subsp. *hispidula* (Retz.) Honda variety *hispidula* and *austro-japonica* Ohwi were of Asiatic origin but comparatively less frequent.
- Among the other common species, *E. oryzoides* (Ard.) Fritsch, *E. muricata* (Beauv.) Fern. and *E. inundata* Mitchel & Vickery of Asiatic, North American and Australian origin, respectively. Asiatic species *E. frumentacea* Link and South American species *E. crus-pavonis* (H.B.K.) Schult were found occasionally during the study. Two African species viz. *E. subverticellata* Pilger and *E. ugandensis* Snowd. & Hubb. have been recorded as newly introduced species in India.

Genetic Relationship:

The similarity index values ranged from 1.22 to 10.11 indicating the presence of high morphological diversity amongst the germplasm. The tested materials were classified into 2 clusters in similarity coefficient of 5.6 representing the species *E. colona* and *E. glabrescens,* respectively. The morphological dissimilarity amongst the *E.*

colona germplasm was considerably higher than that of *E. glabrescens. E. colona* germplasm of Assam plains (Dudhnoi) and Kerala (Thrissur) showed much similarity, however, the germplasm of Assam hills (Diphu) and Gwalior were quite distinct from the germplasm of Punjab, Kerala and Assam plains. On the other hand, *E. glabrescens* possess distinct morphotypes in the South India. The Bangalore and Kerala germplasm have shown similarity index value of 3.26. One type of Kerala germplasm (Kerala-5), however, is much similar with *E. glabrescens* of Punjab and Assam plains.

Hyderabad centre

Some distinguishing features of *E. colona* and *E. crus-galli* were recorded as below :

Attributes	Echinochloa colona	Echinochloa crus-galli
Days to emeregence	11	22
Plant height	57	68
No. of leaves	35-38	29
No. of productive tillers	7-10	6
Panicle emergence (DAS)	37	42
Panicle length (cm)	17	2
Root length (cm)	17	17.5
No. of grains/panicle	178	516

Ranchi centre

Some of the morphological characteristics *Echinochloa* sps. were as follows:

Plant characters	Magnitude
Emergence (DAS)	6-8
Plant height at maturity (cm)	65-78
Heading (DAS)	38-45
Number of leaves per plant	4-6
Total tillers per plant	3-5
Effective tillers per plant	1-2
Maturity (DAS)	80-85

Bhubneshwar centre

Morphological characters of two *Echinochloa* species were as follows:

Morphological characters	Echinochloa colona	Echinochloa crus-galli
Germination (%)	65	60
Emergence (DAS)	3-4	3-4
Dry weight at 25 DAE (g/plant)	0.25	0.30
Flowering (days)	33	35
No. of grains/plant	550	600
No. of grains/m ²	5200	5050
1000 grains weight (g)	0.027	0.033

Pusa centre

Seeds of *Echinochloa* species were collected from different places and they are sown in pots on 5th July, 2012. After germination three plants were maintained in each pot and observations were recorded as given below.

Plant characters	Contents
Germination (DAS)	5-9
Plant height (cm)	60-82
Flowering (DAS)	35-48
Number of leaves/plant	3-71
Total number of tillers/plant	3-6
Effective tillers/plant	1-3
Maturity (DAS)	75-90

Coimbatore centre

Seeds were collected from the *E. colona* and *E. crus-galli* infested area, soaked in water overnight and sown in pots containing soil medium @ 10 seeds per pot. Germination % of *E. colona* and *E. crus-galli* were up to 91 and 93 %. *E. colona* and *E. crus-galli* recorded a height of 143.5 and 157.2 cm, respectively, at 45 DAS. *E. crusgalli* having quick multiplication rate in shorter period (eg. 8-9 weeks) and able to record more dry matter production and grain yield.

Bengaluru centre

Seeds of *E. glabrascence* were sown on August 15, 2012 but did not germinate, hence, new seeds were collected in October 2012 from Khathalagere and Ponnampet area.

Shriniketan centre

Seeds of *E. glabrescens* (25 nos.) of different ages (storage period) were sown in earthen pots (25 cm dia.) filled with garden soil in July, 2012. In

a separate set, effect of different sowing depths (0, 2.5, 5, 10 cm) was also studied. Results obtained during study are given below in table 2.1a.1 and 2.1a.2.

Table 2.1a.1: Effect of age of seeds *E. glabrescens* on emergence, height and tillering.

Treatments (age of seeds)	Emergence at 35 DAS		Height (cr	n)	Tillers/hill at 90 DAS			
(g)	(%)	30 DAS	60 DAS	90 DAS	No. of tillers	Effective tillers		
3 years	6.8	8.3	43.0	61.0	7.0	5.7		
2 years	9.2	9.7	61.7	77.7	10.3	7.3		
1 year	20.0	21.3	81.7	90.3	36.3	30.3		
2 months	61.2	32.3	86.3	92.3	8.3	7.0		
S.Em ±	-	2.1	3.2	3.5	2.3	2.1		
LSD (P=0.05)	-	7.0	10.3	11.3	7.4	6.8		

Table 2.1a.2: Effect of depth of sowing on emergence, height and tillering.

Depth of	Emergenceat		Height (cm	1)	Tillers/hill at 90 DAS		
sowing (cm)	35 DAS (%)	30 DAS	60 DAS	90 DAS	No. of tillers	Effective tillers	
0.0 (surface)	12.0	36.3	75.7	90.3	12.3	10.3	
2.5	56.0	45.3	82.0	92.0	15.7	14.7	
5.0	26.8	37.3	90.3	94.0	11.0	9.7	
10.0	4.0	27.7	55.3	69.7	9.0	6.7	
S.Em ±	-	2.2	5.4	3.3	0.9	1.0	
LSD (P=0.05)	-	7.2	17.7	10.8	3.0	3.2	

WS 2.1b. Biology of weedy rice Jorhat centre

A review of the survey works conducted,



so far, in Assam revealed the presence of only one *Oryza* species having weedy nature. After the critical taxonomic study of the specimens collected from different parts of the state have been identified as *Oryza rufipogon* Griff. A highly frequent species in upper Brahmaputra Valley zone and North Bank Plain zone where it is a common weed in rice fields, especially of deep-

water paddy and also common in swampy areas

near tea gardens and forests as well as in beels. This species morphologically a tufted and scrambling herb, nearly 1.0 m high. tillers develop from lower and middle nodes; nodes swollen, about 1 cm long, ligule is membranous, 0.3 to 3.5 cm long, spikelets are 6.5 to 8 mm long, awns usually 3 to 5 cm long. Grains are collected and consumed preparing porridge, more.

Ranchi centre

Information pertaining to infestation of weedy rice in rice field in different parts of Jharkhand was obtained during weed survey programme in *kharif*, 2012. Farmers are of the opinion that it is difficult to control owing to mimicry with rice plants. Tillage after rice crop provides suitable soil environment to the weedy rice to re-appear in the next season. The occurrence of weedy rice in upland ecosystem with dry seeding of rice is rare. In wet land

ecosystem, occurrence of weedy rice in transplanted condition is lower as compared to direct seeded. In addition, weedy rice infestations have also been observed in low lying ditches having ponded water adjoining to rice fields.

Table-2.1b.1: Present status of weedy rice infestation in different parts of Jharkhand

District	Locations	Infestation	Local name
Ranchi	Pithoria and Ratu	10-15%	Pasra
	Mandar	20-30%	
	Tamar	75-90%	
Khunti	Sindari	25-30%	Pasra
	Sosohatu	10-15%	
	Chainpur	60-80%	
Saraikela/East	Urmal	15-20%	Jhara
Singhbhumi	Chandil	10-15%	
	Rangamati	8-10%	

Palampur centre

Survey on weedy rice was conducted in District Kangra and Bilaspur 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 followed by direct seeded *puddled* rice and least in transplanted rice. The infestation ranged between 15-55 % in direct seeded rice in different districts.

Faizabad centre

Three species of weedy rice viz. O. nivara, O. sativa f. spontanea and O. rufipogon were found during the survey in rice fields in Sultanpur, Jaunpur and Faizabad districts of eastern UP. Among the three species of weedy rice, O. sativa f. spontanea was the most dominant species in all the districts with a density of 28.4-36.3 plants/m² with a relative density of 45.8-59.6% and IVI values ranging from 94.7-112.8%. In all the

districts, the second important species was *O. rufipogon*, while density of *O. nivara* was lowest. The *O. nivara* and *O. rufipogon* species of weedy rice were also found in low lying non-crop land also. Farmers explained the severity of this weed species and told that *O. rufipogon* and *O. spontanea* are being observed in the crop fields only from last 5-6 years. Weedy rice samples were collected from the five rice growing eastern UP districts i.e. Sultanpur, Jaunpur, Faizabad, Kushinagar and Gorakhpur for further experimentations.

Pusa centre

Information regarding infestation of weedy rice in different parts of Bihar was collected during weed survey programme 2012. Type of weedy rice found in deep water rice areas in Darbhanga and Madhubani districts were *O. rufipogan* and *O. spontanea* and locally known as 'Jharang' or 'Lalsar'. Some of the charecters of weedy rice are summarized in table 2.1b.2.

Table 2.1b.2: Morphological characters of weedy rice and yield reduction of rice

Biotype	Effective	No. of grains/	No. of grains/ Length of panicle		Reduction in
	tillers/m ²	panicle	(cm)	Awnless	rice yield (%)
1	12	50	17	Awned	25
2	9	45	13	Awned	45
3	7	60	15	Awned	35
4	8	35	11	Awned	40
5	5	30	10	Awned	20

Srinikatan centre

Emergence and growth parameters of four weedy rice species (*O. rufipogon, O. barthii, O. nivara* and *O. minuta*) under different depths of sowing were studied. Highest emergence was recorded in *O. minuta* and lowest in *O. barthii*. Maximum height (at 90 DAS) was recorded in *O. nivara* and minimum in *O. rufipogon,* while height of *O. barthii* and *O. minuta* was at par of *O. nivara*. Maximum number of tillers/hill (at 90 DAS) was recorded in *O. barthii* and minimum in *O. nivara* and they were significantly different. *O. rufipogon* and *O. barthii* as well as *O. nivara* and *O. minuta* were at par in respect to number of tillers/hill. Number of effective tillers/hill was recorded

maximum in *O. barthii* and this was at par with *O. rufipogon* and *O. minuta*, while, minimum was in *O. nivara*. Considering the sowing depth, maximum emergence, height (at 90 DAS), number of tillers/hill and effective tillers/hill was recorded in 0.0 cm (surface sowing) and minimum in 10.0 cm sowing depth. From the data it is quite clear that sowing depth adversely affect the emergence and other growth parameters studied.

WS 2.1c: Studies on herbicide resistance in weeds Hisar centre

In on-farm trials at village Kheri Raiwali in Kaithal district, the efficacy of different herbicides against *P. minor* was studied during 2011-12 (Table 2.1c.1):

Table 2.1c.1: Efficacy of different herbicides in wheat

Treatment	Dose (g/ha)	Weed control at 75 DAS (%)		Phytotoxi	Grain yield	
		Grassy	BLW	15 DAT	45 DAT	(t/ha)
Pinoxaden	50	80	0	0	0	4.40
Clodinafop	60	30	0	0	0	3.96
Fenoxaprop	120	28	0	0	0	3.80
Sulfosulfuron	25	60	80	0	0	4.50
Mesosulfuron+ iodosulfuron (RM)	15	90	90	5	0	5.00
Fenoxaprop+ metribuzin (RM)	100+175	70	90	15	10	4.60
UPH110 (product dose)	500	75	90	0	0	4.96
Sulfosulfuron+ metsulfuron (R.M.)	32	92	90	0	0	5.20
LSD (P=0.05)		-	-	-	-	0.118

Isoproturon resistant *P.minor* has started showing signs of developing cross resistance against alternate herbicides like fenoxaprop, clodinafop, sulfosulfuron etc. at farmers' fields in rice-wheat cropping system in Haryana. Hence, an experiment was conducted to evaluate the efficacy of herbicides in combinations for management of the resistance in *P. minor* at farmers' field. Results indicated that combination of herbicides improved the control of broadleaf weeds in addition to the grasses, hence; provide an effective management strategy against resistant *P. minor* in wheat.

Inheritance of resistance against alternate herbicides in various biotypes of *P. minor*

Pot-culture studies with 10 biotypes

collected from farmers' fields (Kheri Raiwali, Pai, Naina, Rar, Ban Mandori, Lalodha, Khudda, Chanarthal, Salarpur and Rukanpur) indicated that clodinafop at X dose did not provide effective control of six biotypes with 10-20% control of three biotypes (Salarpur, Rukanpur, Chanarthal) and 45-60% control of other three biotypes (Kheri Raiwali, Rar, Pai). Similar was the case with fenoxaprop with 0-30% control of five biotypes (Salarpur, Rukanpur, Kheri Raiwali, Rar, Pai) and 70% control of one biotype (Chanarthal). Sulfosulfuron performed better against these biotypes with ≥90% control of six biotypes (Ban Mandori, Lalodha, Salarpur, rukanpur, Khudda, Naina) and 30-80% control of four biotypes (Kheri Raiwali, Rar, Pai, Chanarthal). New herbicide pinoxaden provided ≥90% control of all the biotypes. All of the herbicides were effective against the check biotypes (RRS, Uchani and CCS HAU, Hisar) under pot culture. Four biotypes (Ban Mandori, Lalodha, Khudda, Naina) were controlled effectively (≥90%) by all the herbicides at X dose. These biotypes were controlled by one or the other herbicide indicating the possibilities of management strategies.

Palampur centre

Survey on *P. minor* was conducted in District Kangra in wheat growing areas to assess the extent of resistance to isoproturon. In the mid hill conditions of district, resistance to isoproturon was not noticed on *P. minor*. However the farmers of areas adjoining to Punjab are now realizing that *P. minor* is not being controlled with the application of isoproutron. Realizing the seriousness of the problem, the state government has procured clodinafop for the control of weeds in the state during this *Rabi* season.

Pantnagar centre

Resistance of *P. minor* to isoproturon was tested in a pot experiment during 2011-2012. Seeds of P. minor collected from farmers' fields of different areas of Udham Singh Nagar and Nainital districts of Uttarakhand and adjoining areas of Uttar Pradesh. Specific locations from where seeds were collected are Dibdiba-1 (S1), Dibdiba-2 (S2), Dibdiba-3 (S3), Kaushalganj (S4), Jaffrabad (S5), Jhagadpuri (S6), Gadarpur-Bajpur area (S7), Gadarpur (S8), Kaladungi (S9), Namuna circle (S10), Namuna-Bhattpuri (S11), Hussainganj (S12), Lamachaur (S13) and Kusumkheda (S14). Under the first date of sowing (D1, November 16), at the recommended dose of isoproturon (1kg/ha), mortality of *P. minor* plants ranged between 8.4-12.5 % for the sources S-13 and S-4 to 50- 52.1 % for the sources S-6 and S-9. At double dose (2 kg/ha), mortality per cent was higher for the plants from all locations as compared to the recommended dose. It ranged between 43.8-45.8 % for the sources S-13 and S-4 to

87.5-89.5 % for the sources S-6 and S-9. Under the second date of sowing (D2, December 07), the mortality of *P. minor* plants ranged between 12.45-18.40 % (for the sources S-13 and S-14) to 52.3-56.8% (for the sources S-6 and S-9) at the recommended dose of isoproturon. With double dose, mortality per cent was increased as in first date of sowing. It ranged between 76.3-76.9 % up to 100 % for most of the sources.

Efficacy of sulfosulfuron and clodinafop: The per cent mortality of P. minor plants due to sulfosulfuron treatment ranged between 9.3 to 67 % for the different sources under the first date of sowing. Under the second date, its efficacy was still lower where the mortality per cent varied between 12.5 to 56%. It was found that sulfosulfuron was less effective than double dose of isoproturon under delayed sowing. Under the first date of sowing (Nov.16), the regeneration (%) of P. minor plants ranged between 30-35 % for the sources (S-9 and S-11) to 80-90 % for the sources S-1 and S-5. Under the second date of sowing (Dec.07) the regeneration % of *P. minor* plants ranged between 15-20 % for the sources S-3 and S-2 to 80-85% for the sources S-1 and S-5. At the recommended dose of clodinafop, all the P. minor plants from all the sources were killed 20 days after the herbicide application.

Effect of herbicides on chlorophyll 'a' fluorescence: Chlorophyll 'a' fluorescence (Fv/Fm) value of *P. minor* plants from different source swere estimated at 5 and 15 days after herbicide application. The mean data of all 14 locations is presented in Fig. 2.1c.1. At normal dose of isoproturon, the chlorophyll 'a' fluorescence values were significantly reduced at 5 days after spray under both the sowing dates while at double dose, it was significantly reduced at both the dates of observation. Sulfosulfuron and clodinafop recorded almost similar values at 5 days after spray which was reduced further at 15 days after spray. The trend was similar under both the dates of sowing.

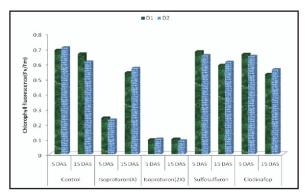


Fig. 2.1c.1: Chlorophyll 'a' fluorescence (Fv/Fm) of *P. minor* leaves treated with herbicide isoproturon (X and 2X doses), sulfosulfuron and clodinafop (at X doses) at 5 and 15 days after spraying of herbicides. (Nov 16, D1 and Dec 07, D2). (Data: Mean of 14 locations)

Ludhiana centre

To monitor the response of P. minor to different herbicides, seeds of ten plants from populations escaped after application of different herbicides at farmers' field were collected during Rabi 2010-11 and these seeds were sown in rows during Rabi 2011-12. Different herbicides were sprayed at their recommended doses at 35 DAS and observations were recorded in terms of dry weight and population at 20 and 40 days after spray (DAT). The dry matter of *P.minor* at 20 DAT was the lowest in clodinafop treatment which was at par with pinoxaden, sulfosulfuron and mesosulfuron + iodosulfuron but significantly lower than fenoxaprop-p-ethyl, isoproturon and control. At 40 DAT, dry matter accumulation was the lowest in pinoxaden treatment which was at par with clodinafop and mesosulfuron + iodosulfuron but significantly lower than sulfosulfuron, fenoxaprop-p-ethyl, isoproturon and control. Pinoxaden, sulfosulfuron, mesosulfuron + iodosulfuron and clodinafop recorded only 47 to 58% control of P minor biotypes indicating that the development of cross resistance in P minor to existing herbicides and that the new herbicides like pinoxaden may meet the same future. The control with fenoxaprop was only 25% while isoproturon fail to exhibit any effect on the *P. minor* biotypes.

Studies on cross/multiple resistance in *P. minor***:** Seeds of *P. minor*, collected from the plants

escaped after the application of different herbicides and were sown in rows during last week of November 2011. Different herbicides were sprayed at 35 DAS at 0.5x, x and 2x doses along with untreated control. Observations on dry matter of 5 plants from each replication were taken at 40 DAT and the GR_{50} values were worked out using data on dry matter accumulation. In case of sulfosulfuron the dry matter accumulation at 40 DAT, the GR_{50} dose for sulfosulfuron, pinoxaden and mesosulfuron + iodosulfuron was 8.6, 98.7 and 5 g/ha, respectively which was significantly lower than the recommended doses of these herbicides indicating that these three herbicides are still very effective against P. minor.

WS 2.1d Biology of Orobanche

Coimbatore centre

Orobanche is an annual parasitic weed propagated through seeds. Broom rape seeds are germinated with the stimulant released from the host. To study the biological characteristics of the Orobanche, a pot culture experiment was conducted with soil samples collected from four locations of Farmers' holdings, replicated five times. The soil samples were collected from where Orobanche infestation was very high. Five seedlings of tobacco were planted in each pot to stimulate the germination of Orobanche seeds. Results showed that Orobanche cernua seeds germinated on an average of 50.5 days after tobacco transplanting. The fresh and dry shoot weights at 15 days after emergence were in the range of 37.4 to 41.1 and 3.65 to 4.25 g/shoot, respectively. The shoot production (no. of tillers) varied from 5 to 15 with an average of 10.5 per plant. In general, flower initiation was recorded on 10 to 13 days after emergence of Orobanche shoot. The capsule number per shoot varied from 45 to 51, while, capsule weight was observed to be in the range of 0.086 to 0.125 g. The number of seeds per capsule varied from 3,670 to 4,250 with an average of 4,020 seeds per capsule.

Bengaluru centre

During December 2012, seeds were collected from *Orobanche* shoots present on *Parthenium* plants in Jilakarapally and on tomato

plant in Hosakote, Bagepally taluk. Seeds are processed in the laboratory and biological studies will be attempted during summer 2013.

WS 2.1e. Biology of Striga

Coimbatore centre

For biological characterization of *Striga asiatica*, pot culture experiment was conducted by collecting soil samples from ten locations in North Western Zone of Tamil Nadu where *Striga* infestation was severe. Cane setts were planted to stimulate the germination of *Striga*. Seeds took on an average 46 days for emergence after cane planting and recorded a maximum of 3.526 g and minimum of 2.284 g/plant fresh weight at vegetative growth stage (30 days after emergence). Capsule production capacity was very high with an average of 326.5 capsules/plant and weight of 0.319 g/capsule. Each capsule contained thousands of seeds.

Dharwad centre

The weed biology is being studied on farmers field in sugarcane crop. Out of 20 fields studied, *Striga* emergence was noticed after 100 days after planting (DAP) in three farmers fields, about 110 DAP in eight fields, and about 120 DAP in nine fields. Further studies are in progress as it is implemented in cane planted during November-December 2012.

WS 2.1i. Biology of Cyperus rotundus

Coimbatore centre

An experiment was conducted in pots containing soil medium with the objective to quantify the biological characteristics of *Cyperus rotundus* and to study the regeneration potential in vertisols under irrigated upland condition. From the study, it can be concluded that *C. rotundus* having quick multiplication rate in shorter period (9 weeks) and 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.

Bengaluru centre

Tubers were planted in pots for periodic observations at different growth stages. 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". Plant biomass increased with time, but as 100 DAS coincide with November month, growth suppressed thus biomass production was at par with other growth stages except 75 DAS which showed maximum biomass. Tubers data showed that though biomass reduced the percent biomass of tubers increased compared to other plant parts. Percent tuber biomass reduced from 67% to 28% till 75 DAS and increased to 38% at 125DAS growth stage. In-spite of no growth between 75 to 100 DAS, number of tubers remained same and production of tertiary tubers reduced or stopped whereas number of secondary tuber increased. Thus tuber biomass contributed more to total biomass. Percent shoot biomass remained constant throughout growth stages around 30%. Inflorescence biomass percent was only 5%. Shoot weight was more in planted tubers later on shifted to primary and other tuber types. Higher shoot weight was observed in primary followed by secondary and tertiary tubers irrespective of growth satge.

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

Anand centre

Post emergence application of glyphosate @ 0.75 to 1.50 kg/ha alone as well as with jaggery (2%) reflected their effect in terms of toxicity on *C. rotundus*. There was consistent increase in the efficacy of each concentrations with corresponding increase in doses against the *C. rotundus*. All the concentrations of glyphosate alone and with jaggery showed 42 to 100 % control of *C. rotundus* but higher dose (1.5 kg/ha) was more effective.

Ranchi centre

Experiment was conducted in 2 x 2 m plots and herbicide treatments were applied twice at 48 h senescence period as per decided protocol. Glyphosate 1.5 kg/ha was found to be most effective followed by glyphosate 1.0 kg/ha..Ten bulbs were up rooted and planted in pots one

month after application of herbicides for observing their viability. Bulbs which were treated with 1.5 and 1.0 kg/ha glyphosate showed no germination, however tubers receiving lower levels of glyphosate as well as jaggery mixed glyphosate did not influence mortality of *C. rotundus* tubers.

Pantnagar centre

The trial on the effect of glyphosate on the propagation potential of C. rotundus was continued for the fourth year during the rainy season, 2012. Nine treatments consisting of different doses of glyphosate (0.5, 0.75, 1.0 and 1.5 kg/ha) with or without jaggery (2%) were applied to the plots where uniform population of C. rotundus was maintained. All the treatments were repeated after 48 h as per the revised protocol. Mortality of C. rotundus was estimated at 30 days after glyphosate treatment. It ranged between 4.3% to 30.2% at different doses. Maximum mortality was observed at 1.5 kg glyphosate application. Addition of jaggery improved the efficacy of glyphosate only at 0.5 kg /ha but not at higher doses. In rest of the treatments other than control and 0.5% glyphosate, significantly lower number of tubers was recorded. With higher doses of glyphosate, the biomass was significantly reduced; however, jaggery did not have any significant effect on the efficacy of the herbicide. The tubers remained viable in all the treatments. It indicates that glyphosate is not able to reduce the viability of Cyperus tubers.

Ludhiana centre

To test the efficacy of glyphosate with 2% jaggery against *C. rotundus* and its propagation potential, a field which had natural high population of *C. rotundus* was prepared during second week of July and *Cyperus* was allowed to emerge. Glyphosate treatments as per revised protocol were applied during first week of August and the second split application was applied 4 days after first application. The initial population of *Cyperus* was recorded and again at 20 DAS for living shoots and the tuber population was taken by digging up to 30 cm

depth using a quadrate of 30 cm x 30 cm at the same spot from where shoot population was taken at the end of season. Results revealed that all glyphosate treatments significantly reduced Cyperus shoot populations due to shoot mortality. Glyphosate @ 1.5 kg/ha was most effective in controlling C. rotundus. The addition of 2% jaggery had no added advantage on shoot mortality over glyphosate alone. Glyphosate @ 1.5 kg/ha alone and with 2% jaggery and glyphosate @ 1.0 kg/ha significantly reduced tuber number. However, no significant difference was observed in other treatments. Tuber weight at 20 DAS was minimum in glyphosate @ 1.5 kg/ha treatment and was at par with glyphosate @ 1.0 and 0.75 kg/ha, glyphosate @ 1.5 kg/ha + 2% jaggery and glyphosate @ 0.5 kg/ha + 2% jaggery treatments. No significant difference was observed in tuber weight due to other treatments. Moreover, the addition of jaggery had no added advantage over glyphosate alone in reducing tuber number and tuber weight.

Coimbatore centre

An attempt has been made to evaluate the performance of glyphosate treatment on propagation potential of *C. rotundus* and to study the propagation potential of shoot growth, sprout formation and tuber formation and assess the mortality of shoots after the herbicide spray. Results obtained during study are summarized in table 2.2.1.

Bengaluru centre

Plots of 2 X 2 m² area infested with *C. rotundus*, were sprayed with different concentrations of glyphosate viz. 0.5, 0.75, 1.0 and 1.5 kg/ha with or without jaggery (2%) or biosurfactant - 0.25% (12.5 g of dry fruit of Soap nut *Sapindus laurifolia* in 100 ml, boil it for 10 min cold extract was squeezed, filtered and diluted to 20ml per litre of glyphosate varied concentration). These treatments along with control were sprayed on 1st and 3rd Aug. 2012. On 4th Oct. 2012 observations were recorded viz. no. of tubers (size wise–large, medium and small), shoot, root, tuber weight, stolon weight, total biomass. Lowest values of all these parameters

	Weed o	lensity (N	Jo./m²)	Dry weight (g/m²)			
Treatment	Before	15	30	Before	15	30	
	spray	DAT	DAT	spray	DAT	DAT	
Glyphosate 1.5 kg/ha	208.2	98.8	24.6	90.1	31.6	2.4	
Glyphosate 1.0 kg/ha	188.5	102.4	38.4	89.4	34.4	3.8	
Glyphosate 0.5 kg/ha	215.6	132.8	40.4	84.2	51.6	5.1	
Glyphosate 0.75 kg/ha	230.4	124.5	43.4	88.6	49.5	4.2	
Glyphosate 1.5 kg ha-1 + jaggery (2%)	217.4	75.6	17.3	90.8	26.3	1.2	
Glyphosate 1.0 kg/ha + jaggery (2%)	205.4	87.4	23.4	98.6	30.1	2.8	
Glyphosate 0.5 kg/ha + jaggery (2%)	242.1	105.3	31.1	87.4	37.8	3.9	
Glyphosate 0.75 kg/ha + jaggery (2%)	248.4	98.0	28.4	92.6	32.3	3.4	
Control	254.8	286.5	298.6	93.6	128.4	144.7	

Table-2.2.1: Effect of different doses of glyphosate with or without jaggery on propagation potential of *C. rotundus* at Coimbatore

were recorded under treatment with glyphosate 1.5 kg/ha with bio-surfactant (0.25%) compared to all other treatments, however, effectiveness of surfactant was not found at 1.5 kg/ha glyphosate. Large size tuber number and weight showed significant reduction with glyphosate 1.5 kg/ha with bio-surfactant as compared to that with glyphosate alone, suggesting that addition of bio-surfactant increased glyphosate translocation to the non-dormant actively growing tubers (large tubers) and not to the less active (medium) or dormant (small) tubers.

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

Anand centre

Pearl millet-wheat cropping system

During the course of seed bank studies, the predominant weed species of grasses were *E. major*, *E. indica*, *D. sanguinalis*, *C. benghalensis*, *D. aegyptium* and *C. barbata*. The major species of weeds as dicot were *E. hirta*, *B. diffusa*, *M. nudicaulis*, *D. arvensis*, *O. umbellata*, *P. niruri*, *T. monogyna*, *T. procumbens* and *A. spinosus*. *C. rotundus* and *C. iria* were recorded as sedges.

Maize-wheat cropping system

Predominant weed species of grasses were E. major, D. sanguinalis, E. indica, D. aegyptium, C. benghalensis and E. crus-galli. The major species of weeds as dicot were Phyllanthus niruri, M. nudicaulis D. arvensis, O. umbellata, A. spinosus, E.

hirta, B. diffusa, T. monogyna and A. viridis. C. rotundus, Cyperus deformis and C. iria were recorded as sedges.

Maize-chickpea cropping system

Predominant weed species of grasses were Eragrostis major, Eleusine indica, C. benghalensis, D. sanguinalis, E. crus-galli and D. aegyptium. The major species of weeds as dicot were D. arvensis, P. niruri, O. umbellata, M. nudicaulis, E. hirta, B. diffusa, A. spinosus, T. monogyna and A.viridis. C. rotundus, C. iria and C. deformis were recorded as sedges.

Hyderabad centre

The soils from two sites of 25 x 25 cm area from each plots were collected and put in a plastic trays from long term experiments namely WS 3.5: Long-term trial on tillage in different cropping systems (Rice-Wheat) and WS 3.7: Long-term herbicide trial in different cropping systems were collected before sowing/ transplanting of rice respectively. From the results, following points emerged.

- Tonventional method recorded lower weed seed bank of grassy (12.5%) and broad leaved (63.63%) weeds compared to Z–Z tillage methods.
- Recommended herbicide recorded 50.62, 80.00% and 78.37 and 86.49% reduction in weed seed bank of grassy and broad leaved weeds

respectively compared to hand weeding and weedy check.

Long term use of herbicides i.e. butachlor 1.5kg PE + Almix 4g/ha PoE in rice and Isoproturon 1.0 kg PoE+ 2,4-D 0.5 kg/ha PoE in wheat recorded reduced weed seed bank of grassy and broad leaved weeds by 69.83 and 85.71% respectively compared to hand weeding while 77.04 and 93.75%,respectively, compared weedy check.

Dapoli centre

Rice-lablab bean cropping system

In pooled results, density of monocot weeds at 60 and 90 DAS did not differ significantly due to different tillage systems. However, weed density of BLWs at 60 DAS was significantly less in CC tillage systems while being at par with ZC and CZ tillage systems. Similar trend was observed in density of BLWs at 90 DAS where only CC and ZC tillage systems were statistically similar.

Significantly less weed density of BLWs at 90 DAS in ZC, CZ and CC tillage systems in comparison to ZZ tillage systems and which were at par with each other in pooled results. The weed density of BLWs at 60 DAS during individual years significantly less due to hand weeding twice over other measures..

Shallower soil layer of 0-5 cm depth recorded emergence of more number of monocots as compared BLWs than 5-10 and 10-15 cm soil layers. Z-C tillage system recorded higher weed emergence of monocots than BLWs followed by C-Z tillage system from 0-5 cm, 5-10 cm and 10-15 cm soil layers.

Of the two major weeds of *rabi* field bean, *L. aspera* was having higher seed rain than *C. argentea*. Seed rain of *L. aspera* was highest in case of Z-Z tillage system (28993/m²) which was reduced by 23.45% (22193/m²) in case C-C tillage system followed by ZC and C-C tillage system. However, in case of *C. argentea* seed production potential was highest in case Z-Z tillage system (10592/m²) compared to other tillage systems. Weed control measures *viz.* hand weeding twice at 20 and 40 DAS and use of oxadiargyl reduced

seed rain of *L. aspera* by 87.33% and 52.01% respectively. Such reduction in case of *C. argentea* was of in tune of 96.16% and 68.50%, respectively.

Effect of tillage system on soil microflora: Results are summarized as below:

- Estimated microbial population namely bacteria, fungi, free living nitrogen fixers and phosphate solubilisers did not influenced by tillage systems at any of the three stages *viz.*, 30, 50 DAS and at harvesting stage of crop growth during both *kharif* and *rabi* season. In the C-C tillage system, estimated microbial population found to be slightly higher as compared to rest of the tillage system.
- Microbial population namely bacteria, fungi, free living nitrogen fixers and phosphate solubilisers were significantly higher in hand weeding (at 20 & 40 DAS) as compared to other weed control treatment viz. application of oxadiargyl@0.12 kg/ha during both the season.
- Benificial microflora such as phosphate solubilisers (during *kharif*) and free-living nitrogen fixers (during *rabi*) were significantly higher in weedy check as compared to the oxidiargyl treatment at 30 and 50 DAS, respectively.
- Hereficial microflora like free living nitrogen fixers and phosphate solubilisers in weedy check
- Treatment were at par with oxadiargyl treatment at harvesting stage of crops in both seasons.

Pantnagar centre

Seed longevity of weeds associated with major cropping system

Weed seed longevity was assessed in rice-wheat and soybean-wheat cropping systems during the rainy season, 2012. Rice cultivar "Sarjoo 52" was transplanted on July 17th, 2012 while soybean cultivar "PS 1347" was sown with a row to row spacing of 50 cm on July 14th, 2012. Data on weed flora was recorded in rice and soybean crops. In rice, maximum population was of *C. rotundus* (846.7/m²) followed by *Eleusine*, while among the BLWs, *Eclipta alba* and *Ammania*

baccifera were the major species that appeared during early stages. Small numbers of Celosia argentia, Cleome viscosa and Parthenium were also present. At later stages, only Cyperus and Lindernia were present. In soybean, Eleusine was the only grassy weed (62.7/m²) while among the BLWs, Trianthema monogyna was the major species (105.3/m²) followed by Cleome viscosa (46.7/m²). Parthenium and Celosia were also observed in small numbers. Again, the maximum population was of C. rotundus (1064.0/m²).

Periodicity of weed emergence in long term trial: Flora of grasses and broad leaf weeds were recorded in different treatments at 30, 60 DAS/DAT and at harvest. Most of the grasses, BLWs and the sedge *C. rotundus* were present in all the treatments at 30 DAS. *P. maximum, T. monogyana* and *C. rotundus* were absent in the treatments CT-CT at 30 DAS/DAT. *C. iria* and *C. difformis* appeared at later growth stages (60 DAS/DAT) in all the treatments, but were absent at harvest. The BLWs *A. baccifera* appeared at 60 DAS/DAT and continued upto harvest. *T. monogyana* was not observed at 60 DAS and harvest in any of the treatments.

Raipur centre

Rice-chickpea cropping system

Soil samples from a depth of 0-15 cm were collected treatment wise from 3 random spots after harvesting of chickpea in 2010-11. Soil samples weighing 500 g were put in small pots followed by a regular watering to facilitate early emergence of weeds. Species wise weed emergence was recorded at 30 DAS. M. denticulata was the most dominant weed emerged in each pot. Other species like C. album, C. iria and others were also recorded in small number. Among two tillage systems, M. denticulata was 39% higher in CT than ZT. It was also noticed that *M. denticulata* was slightly higher in plots under farmers' practice than plots weeded with pendimethalin @ 1.0 kg/ha as pre-emergence under both CT as well as ZT. Weed pressure was very high under weedy check plots than plots where weed control measures were adopted.

Thrissur centre

Effect of CO₂ fertigation on weeds

Two trenches of size $3 \times 0.9 \times 0.9$ m length x breadth x depth were dug and a structure of size $3.3 \times 1.2 \times 0.9$ m (length x breadth x depth) made of iron rods was constructed over these trenches. Taking into consideration the heavy rainfall in Kerala, a slanting roof was adopted instead of a dome shaped structure. Polyethylene sheets were used to cover the iron structure. The roof of the structure was designed in such a manner that it can be kept open during day time and closed at night. A set up of CO_2 fumigation is illustrated below in Fig. 2.3.1



Fig. 2.3.1: Experimental set up for CO₂ fumigation

Seeds of rice and C. iria, E. crus-galli, L. parviflora and L. chinensis were sown together in the ratio 3:1:1:1:1 by weight in crates of size 30cm x 45cm and placed in trenches. Five crates were kept in open air outside the chamber. Night respiration of the seedlings will enhance the CO₂ concentration in the chamber. In the morning, chamber was opened so as to enhance light infiltration for photosynthesis. The CO₂ concentration and the photosynthetic rate inside and outside the chamber were measured using IRGA. Results revealed that seeds germinated by the fourth day in the case of rice while weed seed germinated one day after that of rice. The weed seed germination was more outside the chamber than inside. Among the weed speices, C. iria was found to be more competitive outside than inside the trench where CO₂ enrichment was given. The other C4 grasses such as E. crusgalli and L. chinensis also had lower growth characters. However, inside the chamber the C_3 species were found to be more competitive than the C_4 species. The growth of *Ludwigia*, wild rice and rice was much better when CO_2 enrichment was given than in the open condition.

Faizabad centre

Rice-wheat system

Studies on weed seed dynamics in rice-wheat system was initiated in the year 2006 from the ongoing long term experiment on tillage in rice-wheat systems. The soil samples from the experimental plots were collected from 0-10 cm depth from all the treatments after harvest of both the crops during rainy and winter season in June 2012.

During the *rabi* season, substantially higher number of weed seeds were recorded in the CT-CT as compared to CT-ZT. It might be due to the fact that under zero tillage germination of the weeds especially *P. minor* was less than what grown under conventional tillage system. Like wise, weedy check in wheat treatment recorded higher seed bank population over hand weeding and recommended herbicides. However, weed control treatments applied in rice did not affect the population of weed seed bank in wheat.

During the *kharif* season, higher weed seed population was recorded with conventional rice-conventional wheat system with weedy check over rest of the treatments. It might be due to the fact that the weed seed population was buildup in weedy check treatment over the hand weeding and recommended herbicides. Weed control treatments applied in wheat did not have much impact, however, Weedy check in wheat recorded higher weed seed population.

Another experiment is being conducted since *kharif*, 1991 under rice-wheat cropping system with the objective to observe the weed shift due to continuous use of herbicide and mechanical weeding in rice-wheat cropping system. Results of the trial revealed that number of weed seeds/m² varied substantially due to weed control treatments executed during *rabi*

season. Maximum number of weed seeds recorded in R₀ (weedy check in wheat) along with all the weed control treatments executed during kharif (rice) (W₁ and W₂). While in R₁ (HW 20 and 40 DAT) and R_2 (IPU 1.0 kg/ha + 2,4-D 0.5 kg ha⁻¹), weed seed population declined to a greater extent in all the three kharif season treatments. Among the different weed, Phalaris minor and Polypogon monosplensis in grassy, Melilotus, C. album, A. arvensis and Rumex acetosella were recorded, but relatively density of P. minor and C. album was recorded higher in weedy check treatments (R₀) followed by R₁ and R₂ irrespective of *kharif* season weed control treatments. It might be due to the fact that in weedy treatment, there was a buildup of weed seed population especially of P. minor, however, few plants of Polypogon monosplensis were also recorded.

Regarding the weed seed population in rice, E. colona and Eleusine among the grassy, Lindernia and Eclipta alba among BLWs and Fimbristyllis spp. and Cyperus spp among sedges were the most dominating weed seed population. Population of all the group of weed seeds was found substantially higher in weedy check plot (K₀) followed by HW (20 and 40) DAT and Butachlor 1.5 kg/ha (PE) irrespective of rabi season treatments executed in the preceeding crop (wheat). Presence of weed was recorded in in treatments with HW (20 and 40 DAT) and butachlor 1.5 kg ha⁻¹ might be due to the fact that butachlor did not control the all BLWs and sedges as well as some of the grassy weeds very effectively. During the later flushes, few weeds came up in HW and butachlor treatments. As far as the effect of rabi season weed control treatments is concerned, no such effect was observed during kharif season.

Bikaner centre

Pearlmillet-chickpea system

After harvesting of pearl millet, samples were taken for weed seed bank study in chickpea crop from the field where treatments were applied to the crop. The soil was spread over the shallow plastic trays and watered frequently as per need for the germination of *rabi* weeds.

Maximum weed seeds were germinated in weedy check plot and minimum were recorded in preemergence atrazine at 0.75 kg/ha post emergence + 2,4-D PE at 0.5 kg/ha. In the next season soil samples were taken from chickpea field and spread over on shallow plastic trays for facilitating weed germination and observations were recorded. Maximum weed seeds germinated in weedy check treatment and that minimum weed seeds were germinated in pendimethalin 1.0 kg/ha PE fb a hand weeded plots. The study further indicated that density of Digera arvensis increased many fold followed by, Chorchorus olitorius but density of Amaranthus viridis, Euphorbia hirita and Trianthima monogyna decreased drastically when compared with the density of kharif 2008 weeds.

Cluster bean-wheat cropping system

After harvesting of cluster bean, samples were taken from the field where the treatments were applied to the crop for weed seed bank study in wheat crop season. Observations on weeds species-wise were recorded. Maximum weed seeds were germinated in weedy check plot while minimum was recorded in herbicide treatment + One hand weeding at 40 DAS. In the next season, soil samples were taken from wheat field and spread over on shallow plastic trays for facilitating weed germination and observations were recorded. Maximum weed seeds germinated in weedy check treatment and minimum were germinated in herbicide treatment + hand weeding applied plot. Weed seed bank study indicated that in cluster bean, Corchorus species became dominate with maximum population followed by Digera arvensis. One new species Digitera ciliaris is noticed in imazethapyr treated plots and weedy check in weed seed bank study.

Ludhiana centre

Rice-wheat system

Studies on soil weed seed dynamics in ricewheat system is being done since 2002. Soil samples from the experimental plots were taken in the month of Nov. 2011 and again in June 2012. An augur of 10 cm diameter and 15 cm height was used to draw the samples from 4 spots taken diagonally in each plot. The soil was washed through a mesh and reduced to a small mass which was placed in Petri dishes. The Petri dishes were kept under the laboratory conditions. The seedlings were counted and the seed number was worked out.

No significant differences were observed in weed seed bank of P. minor and P. annua in different treatments than control. Surprisingly, no seedling of *P. minor* was observed in clodinafop + 2,4-D treatment in this season as was the case with previous season. The weed seed bank of *P. minor* increased in trifluralin, trifluralin+2,4-D, sulfosulfuron and trif/clodina/sulfo treatments as compared to previous season. Clodinafop and sulfosulfuron + 2, 4-D treatments reduced seed bank of *P. minor* as compared to previous season. This year also, large numbers of seedlings of P. annua were observed in all treatments. The seed bank of P. annua increased in clodinafop and clodinafop+2,4-D treatments as compared to previous season. However, all other treatments lowered weed seed bank of P. annua than previous season. Amongst the broad leaf weeds, the R. dentatus had the highest weed seed bank. All weed control treatments had significantly lower weed seed bank of R. dentatus than control. The seed bank of R. dentatus decreased in all treatments as compared to previous season. During kharif 2012 in rice, E. crus-galli, I. rugosum, and L. chinensis were the major weeds. The seed bank of E. crus-galli, I. rugosum and L. chinensis had increased in all treatments as compared to previous season.

RVSKVV, Gwaliar

Pearlmillet-wheat system

Soil samples (0-15 cm depth) were collected after harvest of pearlmillet to find out the weed seed bank under various treatments. Soil samples were spread over shallow trays followed by watering to encourage the emergence of weeds. The species wise weed population was recorded 3-4 times after flushes of weed emergence. Six weed species namely *P. minor*, *C. album*, *Anagallis arvensis*, *Spergula arvensis* and *Fumaria pulviflora*

and C. rotundus were recorded to emerge in post harvest soil of pearlmillet. P. minor, C. album and C. rotundus were major weeds in the soil weed seed bank. Highest number of weeds were found in weedy check treatment while lowest were found in 2 HW treatment. Similarly, highest number of total broad leaved weeds and sedges were recorded in soil of weedy check plots followed by atrazine @ 0.5 kg/ha + FYM 10 t/ha, atrazine 0.5 kg/ha and atrazine 0.5 kg/ha + one hand weeding. P. minor was recorded highest in atrazine @ 0.5 kg/ha followed by weedy check, atrazine @ 0.5 kg/ha + FYM 10 t/ha and atrazine 0.5 kg/ha + 1 hand weeding. The lowest number of total weeds, as well as total broad leaves weed, grasses and sedges were observed in two hand weeding treatment.

Weed seed bank study was conducted in soil after harvesting of wheat during kharif season. A total 6 weed species viz. C. benghalensis, E. crusgalli, D. arvensis, P. niruri, T. monogyna and C. rotundus were recorded. E. crusgalli was the major weed followed by C. rotundus, D. arvensis and C. benghalensis. Highest number of grasses, broad leaves weeds and total weeds were recorded in soil treated with isoproturon @ 0.75 kg/ha + 1 HW while highest number of C. rotundus were found in isoproturon @ 0.75 kg/ha treatment. The lowest number of total weeds, broad leaved weeds and grasses were

found in isoproturon @ 0.75 kg/ha + 2,4-D 0.5 kg/ha treatment. Lowest number of *C. rotundus* were found in weedy check treatment. Similarly, highest number of total weeds, broad leaved weeds, grasses and sedges were found in atrazine @ 0.5 kg/ha followed by atrazine @ 0.5 kg/ha + FYM 10 t/ha and atrazine @ 0.5 kg/ha + 1 HW treated soil applied to pearl millet in previous *kharif* season.

Coimbatore centre

Maize-sunflower system

Experiment was conducted with main plot treatments consisted of four tillage methods viz., ZT-ZT, ZT-CT, CT-ZT and CT-CT for maizesunflower cropping system. Weed management methods adopted for both the crops were HW on 25 and 45 DAS, PE herbicides with HW on 45 DAS and weedy check. Soil samples taken from individual treatment plots at a depth of 0-15cm were spread on a shallow plastic trays and left undisturbed with exposure to sun and optimum soil moisture. Individual weed seed germination was recorded cumulatively up to 7 days. After 15 days, the germinated weed seedlings were uprooted and the soil was treated with GA3 to induce dormant weed seeds for germination and further seed germination was recorded for every kg of soil. Results of experiment are given in table 2.3.1.

Table 2.3.1: Effect of tillage and weed management practices on group wise weed density and relative weed density of weed seed bank before sowing of sunflower and maize

	Weed density (no/ pot) in weed seed bank						Relative weed density in weed seed bank (%)				seed	
Treatment	Before sowing of maize			Before sowing of sunflowe				Before sowing of maize		Before sowing of sunflower		
	Grass- es	BLW	Total	Grass- es	Sedges	BLW	Total	Grass- es	BLW	Grass- es	Sedges	BLW
ZT-ZT	1.7 (5.2)	1.3 (3.8)	2.2 (9.0)	2.1 (7.8)	1.8 (0.8)	2.3 (11.8)	3.0 (20.4)	57.8	42.2	38.2	14.7	57.8
ZT-CT	1.9 (6.8)	0.3 (1.3)	2.1 (8.1)	1.9 (6.8)	1.3 (0.5)	2.3 (9.5)	2.8 (16.8)	84.0	16.0	40.5	14.9	56.5
CT-ZT	1.5 (4.3)	1.4 (4.1)	2.1 (8.4)	1.1 (3.0)	1.5 (0.6)	1.0 (2.6)	1.8 (6.2)	51.1	48.8	48.4	41.9	41.9
CT-CT	1.0 (2.8)	0.3 (1.4)	1.4 (4.2)	1.3 (3.5)	1.5 (0.4)	0.4 (1.5)	1.7 (5.4)	66.7	33.3	64.8	44.4	27.8
LSD (P=0.05)	NS	NS	NS	0.3	NS	0.4	0.4	-	-	-	-	-
2 HW (25 & 45 DAS)	0.9 (2.4)	0.5 (1.7)	1.4 (4.1)	0.9 (2.4)	0.8 (0.3)	1.1 (3.1)	1.8 (5.8)	58.5	41.5	41.4	39.7	53.4
PE herbicide + HW (45 DAS	1.0 (2.6)	0.3 (1.3)	1.4 (3.9)	1.0 (2.7)	1.0 (0.7)	1.5 (4.5)	2.1 (7.9)	66.7	33.3	34.2	34.2	57.0
Weedy check	2.3 (9.6)	1.8 (5.9)	2.7 (15.5)	2.4 (10.7)	0.8 (0.3)	2.6 (12.8)	3.2 (23.8)	61.9	38.1	45.0	9.7	53.8
LSD (P=0.05)	0.35	0.38	0.38	0.29	NS	0.36	0.31	-	-	-	-	-

Figures in parentheses are original values

Long-term trial on weed management in ricebased conservation agriculture system

A field experiment was conducted to analysis weed seed study in cropping system as influenced by tillage and weed management methods under rice-rice cropping system condition. Main plot treatments consisted of 5 tillage methods for rice-rice cropping system. Three weed management methods were adopted for both the crops in the system. Results obtained are summarized in table 2.3.2.

Table-2.3.2: Effect of tillage and weed management practices on weed seed bank study (0-15cm) in rice based conservation agriculture system

Treatment		7th day			15 th day		21 th day			
Treatment	Grass	Sedge	BLW	Grass	Sedge	BLW	Grass	Sedge	BLW	
T (CT CT)	1.7	1.4	1.4	2.1	1.4	1.4	2.4	1.4	1.4	
T_1 (CT-CT)	(2.8)	(0.0)	(0.0)	(7.7)	(0.0)	(0.0)	(9.0)	(0.0)	(5.3)	
T. (CT 7T 7T)	1.7	1.4	1.4	1.8	1.4	1.4	2.3	1.4	1.5	
T_2 (CT-ZT-ZT)	(2. 7)	(0.0)	(0.0)	(4.0)	(0.0)	(0.0)	(8.6)	(0.0)	(3.7)	
T. (CT CT 7T)	2.1	1.4	1.4	2.6	1.4	1.4	2.7	1.4	1.7	
T ₃ (CT-CT-ZT)	(7.0)	(0.0)	(0.0)	(12.3)	(0.0)	(0.0)	(9.9)	(0.0)	(6.1)	
T (CT 7T 7T	2.1	1.4	1.4	2.6	1.4	1.4	2.7	1.4	1.7	
T ₄ (CT-ZT-ZT	(7.7)	(0.0)	(0.0)	(12.7)	(0.0)	(0.0)	(10.0)	(0.0)	(6.3)	
T (7T 7T+CD 7T)	2.6	1.41	1.4	3.2	1.4	1.4	3.2	1.4	1.8	
T_5 (ZT-ZT+CR -ZT)	(8.5)	(0.0)	(0.0)	(11.0)	(0.0)	(0.0)	(11.8)	(0.0)	(6.7)	
CD(P=0.5)	0.13	NS	NS	0.17	NS	NS	0.11	NS	0.05	
M. (Chamical)	1.8	1.4	1.4	2.1	1.4	1.4	2.7	1.4	1.5	
W ₁ (Chemical)	(2.9)	(0.0)	(0.0)	(5.0)	(0.0)	(0.0)	(6.6)	(0.0)	(5.6)	
W ₂ (IWM)	1.8	1.4	1.4	2.1	1.4	1.4	2.3	1.4	1.6	
VV 2 (1 VV IVI)	(2.6)	(0.0)	(0.0)	(4.9)	(0.0)	(0.0)	(6.3)	(0.0)	(6.0)	
W ₃ (Unweeded check)	2.2	1.4	1.4	2.8	1.4	1.4	3.1	1.4	1.8	
w ₃ (Offweeded check)	(6.7)	(0.0)	(0.0)	(13.2)	(0.0)	(0.0)	(10.7)	(0.0)	(6.5)	
LSD(P=0.5)	0.41	NS	NS	0.05	NS	NS	0.05	NS	0.03	
T at W	0.15	NS	NS	0.20	NS	NS	0.16	NS	0.08	
W at T	0.1	NS	NS	0.13	NS	NS	0.14	NS	0.07	

Figures in parentheses are the original values

Bengaluru centre

Weed seed longevity in major cropping systems

To understand the influence of cropping system of local importance on seed longevity of few predominant weed species from infested soil, experiment being carried out from past 5 years. Plots were near to water source and each plot. Care was taken not to allow the weed species to flower and shed seeds to the existing weed seed bank. Plots of size 2 x 2.2 m for finger millet – groundnut cropping system and 3 x 2.2 m² for maize sunflower cropping system were prepared. Seeds of finger millet and maize were sown during kharif 2008, after harvest of respective crops field was left fallow for 60 days and plots were prepared for sowing followed by groundnut and sunflower crops were sown during summer 2009. After harvest of summer crops, land was left fallow for 60 days and prepared for sowing of finer millet and maize during kharif. Irrigation and after care were carried out as per recommendation. After each weed counts, hand weeding was carried out so that only weed seedlings emerge from the seed bank occurs.

Seven predominant weed species viz. C. rotundus, Dactyloctenium aegyptium, Digiteria marginata, Chloris barbata, Borreria articularis, A. conyzoides and Spilanthus acmella were tracked. Increase in population of *C. rotundus*; decrease in *A. conyzoides* population while no change in *D. aegyptium* and *S.* acmella population was observed in maizesunflower cropping system compared to that in fingermillet- groundnut cropping system. Same trend followed amongst different weed species, as reflected by relative density, except D. aegyptium which showed significant reduction in both cropping systems compared to initial relative density. Both cropping system suppressed all weed species to the same extent but C. rotundus population drastically increased in maizesunflower cropping system compared to finger millet-groundnut cropping system. Polynomial 2rd degree equation can predict the population to certain extent between cropping system. Both cropping system failed to control C. rotundus especially maize-sunflower cropping system.

Sriniketan centre

Rice-mustard cropping system

To have an idea of the extent of weed seed deposition in the soil in different treatments in long term experiment of rice – mustard cropping system, experiment was conducted.. Results of the experiment are summarized below.

Three grasses namely, C. dactylon, D. sanguinalis, E. colona; five broad leaved weeds namely, A. arvensis, C. bonplandianum, G. purpureum, P. plebeuim, S. acmella and one sedge namely, C. iria were recorded. Among these, P. plebeuim and D. sanguinalis were the dominant species. Highest emergence of weeds was recorded in farmers practice in rabi followed by farmers' practice in kharif. Lowest emergence was recorded 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 found to be better (63% reduction of emergence in compare to farmers' practice) than rotational application of isoproturon/ pendimethalin followed by rotational application of pretilachlor/butachlor (16% reduction) in reducing total weed emergence. Herbicides either repeated or rotational when coupled with 100% fertilizer was found to be more effective than coupled with 70% fertilizer + 30% OM in reducing total weed emergence. Any herbicide treatment either repeated or rotational could not reduce the total grass population as compared to farmers practice, however, total broad leaved weed population was reduced to the tune of 46% in repeated application of pendimethalin followed by repeated application of butachlor and 28% in isoproturon/pendimethalin rotation followed by pretilachlor/butachlor rotation as compared to farmers' practice and 50% reduction of sedges was recorded in both repeated and rotational treatments.

Periodicity of weed emergence on weed seed bank

The emergence of seedlings was recorded in three flushes (up to 90 days) from each treatment in three different depths of soil (0-5, 5-10 & 10-15 cm)

in both the seasons. After second flash GA (100 ppm) was applied.

Rabi 2011-12: The experiment was started on 18th December, 2011-12. Emergence of *P. plebeium* was started three days after first watering. *Digitaria sanguinalis* and *S. acmella* appeared eight days after first watering. *Anagallis arvensis, G. purpureum* and *E. colona* appeared twelve days after first watering. *Croton bonplandianum, S. acmella* and *C. dactylon* appeared in second flush i.e., after 30 days. *Polygonum plebeium* appeared in three flushes but more in first flush while *C. bonplandianum* appeared only in two flushes. After application of GA, no other weed species appeared except *Polygonum* and *Croton*. Number of emergence was recorded higher in 0-5 cm followed by 5-10 cm and 10-15 cm soil depth.

Kharif 2012: The experiment was started on 9th July, 2012. Emergence of *F. miliacea, C. iria* and *L. ciliate* was started 4-5 days after first watering and emergence continued up to third flush. *Ludwigia parviflora, E. colonua* and *D. sanguinalis* appeared at 7-10 days after first watering and emergence continued up to 2nd flush. *Spilanthes acmella* appeared at 2nd flush only. In most cases, emergence was recorded higher in first flush followed by 2nd and 3rd flush and number was also higher in 0-5 cm depth than that of 5-10 cm and 10-15 cm.

Weed emergence pattern

In both *kharif* and *rabi* seasons, an area of 1 m x 1m in the experimental field was earmarked and periodic emergence of weed species was recorded at pre-sowing stage, after first irrigation (7 DAS), 25 days after herbicide application (28 DAS), 60 DAS and at harvest. Total emergence under each species in 4 stages of crop growth was calculated and weed survival percent to the total emergence at harvesting stage was computed.

Rabi 2011-12: In mustard, 15 weed species were recorded out of which *D. sanguinalis* was most dominant followed by *P. plebeium, C. dactylon, C. bonplandianum* and *G. purpureum*. Emergence of *Cynodon, Digitaria, Ageratum, Croton, Polygonum* and *Spilanthes* was recorded throughout the cropping period. Weed species restricted to only

rabi season namely, Anagallis, Chenopodium, Gnaphalium, Polygonum and Vicia were appeared after first irrigation and emergence continued up to 65 DAS.

In farmers practice, highest survival percent (87%) was recorded in *Cynodon*. Fifty to seventy five percent survival was recorded in 5 species namely, *Digitaria* (50%), *Echinochloa* (53%), *Croton* (75%), *Gnaphalium* (61%) and *Polygonum* (53%). Less than 50% survival was recorded in three species namely, *Spilanthes* (11%), *Anagallis* (20%) and *Vicia* (33%). As *Cynodon* is propagated vegetatively its number at harvest was recorded more than total number at previous four stages particularly in herbicidal treatments.

Under most of the species survival percent at harvest was recorded higher in isoproturon / pendimethalin rotation (isoproturon in *Rabi* 2011-12) than that of repeated application of pendimethalin. Most of the species which are restricted to *rabi* season only did not survive up to harvest of crop under the treatment repeated application of pendimethalin e.g., *Anagallis*, *Polygonum* and *Vicia* whereas in isoproturon/pendimethalin rotation 25-69% survival was recorded in those species.

Kharif 2012: Cynodon remained dominant from pre-sowing stage to harvesting of crop. In rice, 18 weed species were recorded. At pre-sowing stage, in addition to Cynodon, dominant species were Croton and Digitaria. At 30 DAS, dominant species were Ludwigia, Fimbristylis and Lindernia. At 60 DAS, dominant species were Fimbristylis, Ludwigia and Cyperus. Under farmers' practice, survival percent at harvest of crop was recorded high in

Cynodon (43%), Oldenlandia (37%), Ludwigia (36%); medium in Fimbristylis and Croton (25% in each) and low in Digitaria (17%). Survival percent at harvest of crop was recorded higher in grassy weeds [Cynodon (26 & 61%), Digitaria (17 & 33%)] under repeated application of butachlor than rotational application of pretilachlor / butachlor (27 & 32% and 14 & 25% in Cynodon and Digitaria respectively). Whereas, survival percent in broad leaved weeds (Croton and Ludwigia) was recorded more under rotational application of herbicide (27 & 33% and 23 & 50% in Croton and Ludwigia respectively) than that of repeated application (20 & 29% and 37 & 25% in Croton and Ludwigia respectively). In most of the cases irrespective of repeated or rotational application, herbicide coupled with organic matter showed higher percent of survival of weeds than that of coupled with fertilizer.

WS 3: Weed management in crops and cropping systems

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

Single herbicide applications are not very effective on complex weed flora; hence a study was conducted with herbicide combinations for control of complex weed flora in transplanted rice

Objectives:

- To study the bio-efficiency of combination of herbicides against complex weed flora, and their effect on growth and yield of transplanted rice.
- To study the phytotoxic effects on the crop, if any.

Trea	tment	Dose (g/ha)	Time (DAT)
T_1	Bispyribac-Na	25	25 DAT (3-4 leaf stage)
T_2	Pretilachlor/Butachlor	1000/1500	0-3
T ₃	Penoxsulam	22.5	8-12
T_4	Pyrazosulfuron	20	0-3
T_5	Bispyribac + ethoxysulfuron	25+18.75	25 DAT (3-4 leaf stage)
T ₆	Bispyribac + (chlorimuron + metsulfuron)	20+4	Do
T_7	Pretilachlor fb ethoxysulfuron	750/18.75	25 DAT (3-4 leaf stage)
T_8	Pretilachlor <i>fb</i> (chlorimuron + metsulfuron)	750/4	25 DAT (3-4 leaf stage)
T ₉	T ₄ fb manual weeding	20	0-3 fb 25
T_{10}	Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660 (10.0 kg/ha)	0-5
T ₁₁	Weed free (hand weeding at 25 and 45 DAS)	-	-
T_{12}	Weedy check	-	-

Spray volume: 500 L/ha

Design: RBD; Replications: 3

Observations:

i. Weed population and dry matter at 60 DAT

ii. Crop growth parameters

iii. Yield attributes and yield

iv. Phytotoxicity on crop

v. Economic analysis

Cooperating centres: CCSHAU, PAU, OUAT, ANGRAU, AAU (J), NDUAT, CSAUAT, IGKV, KAU, VB, GBPUAT, UAS (B), TNAU, RAU (P) and SVPUAT

At Hissar, combination of ethoxysulfuron 18.75 g/ha, chlorimuron+ metsulfuron (RM) 4 g/ha with bispyribac or pretilachlor and pretilachlor + bensulfuron (RM) provided effective control of complex weed flora in transplanted rice, while pyrazosulfuron at 20 g/ha was not effective against *Echinochloa crus-galli*.

At Ludhiana, sequential application of pyrazosulfuron 20 g/hapre-emergence and one hand weeding at 25 DAT provided effective control of *Echinochloa sp, Ischaemum, Cyperus, Eclipta* and *Sphenoclea* and recorded the highest rice grain yield, net returns and B:C ratio; it was at par with weed free check and tank mix application of bispyribac 25 g + ethoxysulfuron 18.75 g/ha at 25 DAT. Almix resulted in yellowing of foliage and growth suppression which recovered in three weeks period. The crop was infested by sheath blight which reduced the rice grain yield in all the treatments.

At Bhubaneswar, post emergence application of bispyribac + Almix recorded significantly higher yield of 5.54 t/ha which was at par with post emergence application of bispyribac + ethoxysulfuron (5.36 t/ha) where as weedy treatment recorded the lowest yield (2.25 t/ha). Weed free plots recorded rice yield of 5.09 t/ha. Highest net return of Rs.25513/ha and B:C ratio of 1.85 was obtained from post emergence application of bispyribac + Almix followed by bispyribac + ethoxysulfuron.

Table 3.1.1: Effect of herbicides on weed density (no/m²) at 60 DAS in transplanted rice at different coordinating centres

Treatment	Dose (g/ha)	Jorhat	Coimbatore	Bhubaneshwar	Bengaluru	Pusa
Bispyribac-Na	28	63	4.7 (20.6)	5.0 (24.7)	1.7 (40.1)	11.5
Pretilachlor / Butachlor	1000/1500		4.7 (20.6)	5.8 (32.7)	1.6 (47.5)	10.9
Penoxsulam	22.5	-	-	5.4 (28.5)	1.6 (40.3)	13.1
Pyrazosulfuron	20	31.3	2.5 (4.6)	5.3 (27.8)	1.6 (42.6)	11.9
Bispyribac + ethoxysulfuron	25+18.75	43.3	5.2 (25.3)	4.0 (15.2)	1.6 (41.6)	8.1
Bispyribac + (chlorimuron + metsulfuron)	20+4	47.0	3.4 (10.0)	3.8 (13.8)	1.6 (37.2)	9.5
Pretilachlor <i>fb</i> ethoxysulfuron	750/ 18.75	26.3	3.3 (9.3)	4.6 (20.5)	1.4 (26.4)	9.1
Pretilachlor <i>fb</i> (chlorimuron + metsulfuron)	750/4	16.7	2.7 (5.3)	4.2 (17.3)	1.5 (27.0)	9.3
Pyrazosulfuron <i>fb</i> manual weeding	20	21.3	4.5 (18.6)	4.9 (23.7)	1.3 (17.1)	7.0
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660 (10.0 kg/ha)	28.3	5.1 (23.9)	5.0 (24.7)	1.5 29.0	10.6
Weed free (hand weeding at 25 and 45 DAS)	-	27.3	1.4 (0.0)	2.0 (3.5)	1.4 (21.4)	5.1
Weedy check	-	63.0	6.3 (38.6)	10.0 (100.5)	1.9 (70.7)	22.3
LSD (P=0.05)		9.7		0.4	0.03	0.7

Table 3.1.2: Effect of herbicides on weed dry biomass at 60 DAS in transplanted rice

Treatment	Dose (g/ha)	Jorhat	Faizabad	Raipur	Hyderabad	Pantnagar	Coimbarore	Sriniketan	Kanpur	Bhubneshsar	Ludhiana	Hisar	Bengaluru	Pusa	Modipuram
Bispyribac-Na	25	29.6	4.0 (15.1)	12.7	5.5 (29.3)	3.9 (51.4)	6.3 (37.7)	3.5 (12.1)	4.5 (19.7)	4.7 (21.5)	1.0 (0.0)	3.6	1.8 (79.8)	22.7	40.6
Pretilachlor / butachlor	1000 / 1500	20.1	4.1 (15.7)	14.7	6.3 (39.5)	4.5 (95.4)	5.3 (26.2)	3.5 (11.8)	4.7 (21.7)	4.9 (23.7)	17.1 (300.0)	1.4	1.9 (100.0)	22.4	64.1
Penoxsulam	22.5		4.6 (19.9)	12.4		3.9 (49.6)		3.1 (9.4)	4.7 (21.0)	4.9 (23.8)	20.7 (444.0)	1.8	1.9 (85.5)	26.8	60.4
Pyrazosulfuron	20	21.5	4.3 (17.2)	13.3	6.7 (44.5)	4.6 (101.3)	11.2 (124.3)	3.7 (13.3)	4.9 (22.7)	4.9 (23.5)	26.4 (708.0)	89.2	1.8 (79.4)	22.8	61.6
Bispyribac + ethoxysulfuron	25 + 18.75	25.3	3.7 (12.6)	9.3	4.9 (23.2)	3.4 (29.7)	5.2 (25.1)	2.2 (4.6)	3.9 (15.0)	3.3 (10.5)	8.0 (64.0)	4.4	1.7 (57.4)	16.7	37.8
Bispyribac + (chlorimuron + metsulfuron)	20 + 4	27.6	2.4 (4.9)	7.5	4.8 (22.9)	3.4 (30.2)	8.9 (77.8)	1.4 (1.5)	3.7 (12.7)	2.6 (6.3)	6.9 (66.0)	0.9	1.7 (57.4)	22.0	35.2
Pretilachlor fb ethoxysulfuron	750 / 18.75	20.1	3.9 (14.6)	13.2	4.8 (22.5)	3.6 (34.9)	3.9 (13.4)	3.3 (10.2)	4.4 (18.5)	3.7 (12.9)	12.0 (152.0)	0.6	1.5 (34.0)	21.0	60.5
Pretilachlor fb (chlorimuron + metsulfuron)	750 / 4	12.6	3.2 (8.9)	12.7	4.7 (21.8)	3.3 (27.8)	3.3 (9.4)	2.6 (6.2)	3.8 (13.5)	2.9 (7.9)	16.5 (274.0)	0.3	1.5 (38.0)	20.1	55.6
Pyrazosulfuron fb manual weeding	20	18.0	3.5 (11.0)	10.9	4.5 (19.9)	3.5 (33.5)	5.1 (24.1)	2.4 (5.4)	3.4 (11.0)	4.2 (17.3)	7.5 (76.0)	17.2	1.4 (28.5)	14.8	29.6
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660 (10 kg/ha)	23.3	4.2 (16.2)	10.5	5.5 (30.2)	4.3 (75.9)	9.1 (81.5)	2.9 (7.9)	4.1 (15.6)	4.5 (19.5)	14.4 (226.0)	1.2	1.7 (54.6)	21.4	50.7
Hand weeding at 25 and 45 DAS	-	14.5	1.0 (0.0)	7.1	3.5 (11.5)	2.9 (18.2)	1.4 (0.00)	0.7 (0.0)	0.7 (0.0)	2.4 (5.2)	6.8 (64.0)	0.0	1.6 (46.0)	10.2	00
Weedy check	-	50.1	7.1 (49.6)	31.6	9.3 (85.8)	5.9 (160.0)	11.8 (137.2)	10.5 (109.3)	5.3 (26.7)	6.0 (35.7)	26.4 (702.0)	151.3	2.1 (156.9)	34.9	130.6
LSD (P=0.05)		5.6	0.2	5.6	0.4	0.2		0.4	0.3	0.3	6.4	17.1	0.0	1.7	6.2

Original values are given in parentheses

Table 3.1.3: Effect of herbicides on grain yield (t/ha) of transplanted rice at different coordinating centres

Treatment	Dose (g/ha)	Jorhat	Faizabad	Raipur	Hyderabad	Pantnagar	Coimbarore	Sriniketan	Kanpur	Bhubaneshwar	Ludhiana	Hisar	Bengaluru	Pusa	Modipuram
Bispyribac-Na	25	2.54	4.90	4.93	4.48	5.27	4.68	4.62	4.25	4.93	4.66	6.33	3.84	3.88	4.83
Pretilachlor / butachlor	1000 / 1500	3.00	4.79	4.67	4.27	4.50	4.35	4.38	4.00	4.56	2.77	6.36	3.49	3.93	3.96
Penoxsulam	22.5		4.70	4.95		5.25		4.38	4.18	4.84	3.00	6.29	3.76	3.43	4.55
Pyrazosulfuron	20	3.12	4.58	4.69	4.37	3.94	4.61	4.50	3.63	4.63	2.71	5.17	4.00	3.70	4.26
Bispyribac + ethoxysulfuron	25 + 18.75	2.79	4.99	5.12	5.16	5.70	4.87	5.02	4.67	5.36	4.73	6.49	4.59	4.33	5.15
Bispyribac + (chlorimuron + metsulfuron)	20 + 4	2.41	5.32	5.14	5.28	5.56	4.41	5.22	5.00	5.54	3.22	6.45	4.41	4.13	5.42
Pretilachlor fb ethoxysulfuron	750 / 18.75	3.02	4.93	4.87	5.47	5.50	5.08	4.57	4.33	5.12	4.44	6.43	5.29	4.34	4.26
Pretilachlor fb (chlorimuron + metsulfuron)	750 / 4	3.48	5.27	4.89	5.59	5.65	5.66	5.05	4.83	5.18	2.68	6.42	5.12	4.33	4.45
Pyrazosulfuroin fb manual weeding	20	3.28	5.20	5.12	5.83	5.22	4.70	4.96	5.17	5.00	5.88	6.21	5.33	4.34	5.36
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660 (10 kg/ha)	2.99	4.74	5.11	4.57	4.80	4.64	4.93	5.33	4.99	2.94	6.48	4.85	4.18	4.55
Hand weeding at 25 and 45 DAS	-	3.08	5.42	5.27	5.85	5.91	5.75	5.16	3.31	5.09	5.48	6.60	5.10	4.42	5.54
Weedy check	-	2.51	3.82	3.68	2.97	2.65	3.25	3.56	-	2.25	2.44	4.09	2.19	2.91	3.16
LSD (P=0.05)		0.670	0.467	0.490	0.675	0.417		0.459	0.510	0.243		0.515	0.795	0.450	0.460

Table 3.1.4: Effect of herbicide combinations on net returns (Rs) and B:C ratio in rice at different coordinating centres

		Faizab		Srinike	etan	Bhubane	shwar	Ludhia	ana
Treatment	Dose (g/ha)	Net returns (x10 ³ ₹/ha)	B:C	Net returns (x10³₹/ha)	B:C	Net returns (x10³₹/ha)	B:C	Net returns (x10³₹/ha)	B:C
Bispyribac-Na	25	29.7	1.5	29.5	1.14	19.41	1.6	23.5	0.8
Pretilachlor/ Butachlor	1000/1 500	29.4	1.5	28.4	1.18	16.45	1.5	3.3	0.1
Penoxsulam	22.5	27.1	1.4	27.5	1.1	18.2	1.6	5.7	0.2
Pyrazosulfuron	20	28.4	1.3	30.0	1.2	16.6	1.5	2.7	0.1
Bispyribac + ethoxysulfuron	25+ 18.75	30.0	1.5	33.7	1.2	23.7	1.7	23.7	0.8
Bispyribac + (chlorimuron + metsulfuron)	20+4	33.4	1.6	36.9	1.4	25.5	1.8	5.9	0.2
Pretilachlor <i>fb</i> ethoxysulfuron	750/ 18.75	29.4	1.5	29.7	1.1	22.0	1.7	21.7	0.8
Pretilachlor fb (chlorimuron + metsulfuron)	750/4	33.3	1.7	35.8	1.4	22.1	1.7	0.7	0.03
Pyrazosulfuron fb manual weeding	20	31.4	1.5	33.7	1.3	20.9	1.7	34.	1.1
Pretilachlor (6%) + bensulfuron (0.6%) 6.6%GR	660 (10.0 kg/ha)	28.8	1.5	34.4	1.4	20.5	1.7	4.6	0.2
Weed free (hand weeding at 25 and 45 DAS)	-	32.7	1.5	34.2	1.2	18.7	1.5	27.5	0.8
Weedy check		20.7	1.1	19.7	0.8	0.02	1.0	0.02	0.01

At Hyderabad, pyrazosulfuron @ 20 g/ha fb manual weeding or pretilachlor 750 g/ha (PE) fb ethoxysulfuron (POE) or pretilachlor fb Almix are better options for efficient weed control and higher grain yield in transplanted rice. If profit is given due importance application of either pyrazosulfuron or pretilachlor + Almix are best options.

At Jorhat, pretilachlor 1000 g/ha alone or followed by either ethoxysulfuron 18.75 g/ha or Almix 4 g/ha, pyrazosulfuron 20 g/ha alone or followed by manual weeding 30 DAT resulted lower weed density and dry weight at 25 and 60 DAT while at harvest, pretilachlor 1000 g/ha followed by Almix 4 g/ha maintained a lower weed density and dry weight as compared to

other treatments. The highest grain yield was achieved from pretilachlor 1000 g/ha followed by Almix 4 g/ha which was followed by pyrazosulfuron 20 g/ha followed by manual weeding 30 DAT. However, it was at par with pyrazosulfuron 20 g/ha, hand weeding 25 and 45 DAT, pretilachlor 1000 g/ha followed by ethoxysulfuron 18.75 g/ha and pretilachlor 1000 g/ha.

At Faizabad, complex weed flora of transplanted rice could be controlled effectively by using a combination of bispyribac-Na + Almix (25 +4 g/ha) followed by pretilachlor + Almix (1000+4 g/ha applied at 25 DAT fb pyrazosulfuron 20 g g/ha fb manual weeding at 25 DAT. The same treatment recorded higher

values of grain yield (5270 kg/ha) and economics (net profit Rs. 33470/ ha and BCR Rs. 1.68) followed by rest of the treatments. No phytotoxicity was recorded on the crop due to different herbicide molecule.

At Kanpur, weed population/ m^2 and dry weight was minimum with application of pyrazosulfuron (20 g/ha) + 1 manual weeding fb with the application of bispyribac (20 g/ha) + Almix (4 g/ha) and significantly maximum in weedy plot. The significantly higher yield (5.17/ha) was recorded with the application of pyrazosulfuron (20 g/ha) + 1 hand weeding followed by bispyribac (20 g/ha) + Almix (4 g/ha).

At Raipur, significantly lowest weed dry matter was obtained under bispyribac + ethoxysulfuron @ 25 + 18.75 g/ha at harvest but it was statistically at par with rest of the treatments except with weedy check, butachlor @ 1500 g/ha, pretilachlor fb ethoxysulfuron @ 750 + 18.75 g/ha and pretilachlor fb (chlorimuron + metsulfuron) @ 750 + 4 g/ha, in descending order. Significantly higher seed yield was recorded under hand weeding twice than weedy check. Herbicide combination 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%) 6.6% GR@ 660 g/ha were also found equally effective with hand weeding twice.

At Sriniketan, post-emergence application of bispyribac sodium (20g) + [metsulfuron methyl + chlorimuron ethyl] (Almix) (4g) was the most effective in controlling sedge and total weed population, reducing dry weight and registered the highest grain yield in transplanted rice. Grain yield in bispyribac + ethoxysulfuron, pretilachlor followed by Almix, pretilachlor followed by bensulfuron were at par with that of best treatment.

At Pantnagar, application of pretilachlor 750g fb chlorimuron-ethyl (CME) 10% + metsulfuron-methyl (MSM) 10% 4g/ ha at 25 days after transplanting of rice proved most effective in

reducing the density as well as dry matter of total weeds. Application of bispyribac-Na 25g + ethoxysulfuron 18.75g/ ha at 25 days after transplanting of rice gave highest rice yield.

At Bengaluru, among herbicide combinations, pretilachlor 750 g - 3 DAP fb ethoxysulfuron 18.75 g ai/ha - 25 DAP or chlorimuron ethyl + metsulfuron methyl 20 WP 4 g ai/ha - 25 DAP, pyrazosulfuron ethyl 20 g ai/ha - 3 DAP fb manual weeding (45 DAP) and pretilachlor + bensulfuron methyl 6.6% G 660 g ai/ha - 3 DAP were better in controlling weed complex, gave rice yields similar to that of hand weeding, besides being economical.

At Coimbatore, among the different weed control treatments pre- emergence application of pretilachlor fb POE (chlorimuron + metsulfuron) at 750/4 g a.i/ha recorded lesser total weed density, dry weight and higher grain and straw yield and it was comparable with pretilachlor fb ethoxysulfuron at 750/18.75 g/ha.

At Pusa, 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 (4.42 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, pretilachlor fb (chlorimuron + metsulfuron), bispyribac + ethoxysulfuron, pretilachlor (6%) + bensulfuron (0.6%) 6.6% GR and bispyribac + (chlorimuron + metsulfuron).

At Meerut, the major weeds of the experimental field were *Echinochloa colona*, *Echinochloa crus-galli*, *Commelina bengalines*, *Eclipla alba*, *Phylanthus niruri* and *Cyperus spp*. All the weed control treatments were found superior than weedy check. Among the weed control treatments the lowest weed density (25 m²) was recorded in treatment pyrazosulfuron fb manual weeding. Post- emergence application of bispyribace sodium + Almix @ 20 + 4 g a.i/ha gave significantly higher grain yield (5.42 t/ha).

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

The problem of infestation of diverse weed flora is comparatively higher in direct seeded rice than transplanted crop. No single herbicide could be effective for total weed management. Hence, an experiment was conducted with the following objectives.

- To study the bio-efficacy of combination of herbicides against weed complex; and their effect on growth and yield of direct-seeded rice
- To study the phytotoxic effects on the crop, if any.

Treatments:

Treat	ment	Dose (g/ha)	Time of application (DAS)
T ₁	Bispyribac-Na	25	20 DAS (3-4 leaf stage)
T ₂	Pendimethalin* fb bispyribac	1000 fb 25	0-2 fb 25
T ₃	Oxadiargyl fb bispyribac	100 / 25	0-2 fb. 25
T_4	Pyrazosulfuron fb bispyribac	20/25	0-3 fb. 25
T_5	Pendimethalin* fb bispyribac fb manual weeding	1000 fb 25	0-2 fb. 20DAS (3-4 leaf
			stage) fb 45d
T ₆	Pendimethalin* fb manual weeding	1000	0-2 fb. 25-30d
T ₇	Bispyribac + (chlorimuron + metsulfuron)	20+4	20 DAS
T ₈	Three mechanical weedings (cono / rotary weeder)	-	20,40,60 DAS
T ₉	Weed free (HW at 20, 40 and 60 DAS)	-	-
T ₁₀	Weedy check	-	-

^{*}Pendimethalin (Stomp Xtra 38.7% CS)

Spray volume: $500 \, \text{L/ha}$ for PRE and $375 \, \text{L/ha}$ for POST herbicides

Note: Pendimethalin in wet-seeded rice be applied as early post-emergence (10-15 DAT).

Design: RBD Replications: 3

Observations:

- i. Weed population (no./ m^2) and dry matter (g/m^2) at 60 DAS.
- ii. Weed control efficiency (%)
- iii. Crop growth parameters
- iv. Yield attributes and yield.
- v. Phytotoxicity on crop
- vi. Economic analysis

Cooperating centres:

TH Dry seeded: OUAT, ANGRAU, UAS (B), BAU, CSKHPKV, AAU (J), DBSKVV, IGKV and GBPUAT

स Wet seeded: NDUAT, CSAUAT , TNAU, KAU and RAU (P)

At Bhubaneswar, weed free treatment (HW at 20, 40 and 60 DAS) recorded significantly highest yield of 4.48 t/ha where as weedy check treatment recorded the lowest yield (1.85 t/ha). Application of pendimethalin fb bispyribac fb manual weeding recorded lowest weed index of 1.56 % followed by oxadiargyl fb bispyribac (3.35 %). The highest value of 58.71 % was obtained from weedy check treatment. Highest net return and B:C ratio of Rs.17900/ha and 1.68 were obtained respectively from application of pendimethalin fb bispyribac fb manual weeding followed by oxadiargyl fb bispyribac (Rs16600/ha and 1.62).

At Hyderabad, pre-emergence application of pendimethalin or oxadiargyl or pyrazosulfuron ethyl *fb* bispyribac sodium (PE) or pendimethalin *fb* bispyribac sodium *fb* manual weeding can be recommended for economic and

efficient weed control and higher grain yield in aerobic rice.

At Bengaluru, in direct seeded rice (upland rice), pendimethlain 38.7 CS 1000 g ai/ha – 2 DAS fb bispyribac sodium 10 SC 25 g ai/ha – 25 DAS or with hand weeding (45 DAS) or bispyribac sodium 10 SC 25 g ai/ha + chlorimuron ethyl + metsulfuron methyl 20 WP 4 g ai/ha – 20 DAS,

pyrazosulfuron ethyl 20 g ai/ha – 3 DAP fb bispyribac sodium 10 SC 25 g ai/ha were better in controlling weed complex up to 60 DAS and gave paddy yields (2138 to 2403 kg/ha) similar to that of hand weeding (2465 kg/ha) or passing conoweeder (20, 40 & 60 DAS) (2327 kg/ha), besides saving weeding cost by ₹3220 to 5400/ha (as against ₹6500/ha in hand weeding).

Table 3.2.1: Effect of herbicides on weed density (no./m²) at 60 DAS in direct-seeded rice at different coordinating centres

Treatment	Dose (g/ha)	Bhubaneswar	Bengaluru	Ranchi	Palampur	Jorhat	Dapoli	Raipur	Pantnagar
Bispyribac-Na	25	5.2	140.3	3.0	4.4	8.1	33.0	16.3	48.0
		(26.5)		(7.0)	(18.7)				
Pendimethalin* fb	1000 fb	4.8	79.7	3.5	3.5	7.1	54.6	12.9	60.0
bispyribac	25	(22.7)		(9.6)	(12.0)				
Oxadiargyl fb	100 / 25	3.9	121.3	5.1	3.9	7.2	27.3	16.4	29.3
bispyribac		(14.7)		(22.7)	(14.7)				
Pyrazosulfuron fb	20/25	5.1	113.7	2.5	3.8	7.3	33.0	12.3	40.0
bispyribac		(25.3)		(6.6)	(13.3)				
Pendimethalin* fb	1000 fb	3.3	64.2	1.6	4.3	5.5	31.0	13.3	13.3
bispyribac <i>fb</i> manual weeding	25	(10.3)		(4.0)	(18.7)				
Pendimethalin* fb	1000	4.9	86.0	1.7	3.4	6.6	9.6	11.9	14.7
manual weeding		(23.8)		(2.3)	(10.7)				
Bispyribac +	20+4	4.0	102.7	3.0	3.6	7.8	62.3	13.9	77.3
(chlorimuron + metsulfuron)		(25.0)		(10.0)	(12.0)				
Three mechanical	-	5.1	43.4	2.3	5.4	5.4	6.3	17.6	24.0
weedings (cono /		(25.5)		(5.0)	(28.0)				
rotary weeder)									
HW at	-	2.1	33.9	3.5	4.2	5.3	8.3	7.6	9.3
20, 40 and 60		(3.7)		(11.3)	(17.3)				
DAS									
Weedy check		10.0 (98.7)	160.6	11.1 (118.0)	7.4 (53.3)	9.2	70.0	43.3	57.3
LSD (P=0.05)		0.55	0.10	1.8	1.3	0.9			36.4

Table 3.2.2 : Effect of herbicides on weed dry biomass (g/m²) at 60 DAS in direct-seeded rice at different coordinating centres

Treatment	Dose (g/ha)	Hyderabad	Bhubaneswar	Bengaluru	Ranchi	Palampur	Jorhat	Dapoli	Raipur	Pantnagar
Bispyribac-Na	25	10.5	3.6	1.9	3.3	3.3	6.8	24.6	52.6	30.4
		(109.5)	(12.5)	(80.8)	(8.7)	(9.9)				
Pendimethalin* fb	1000 fb	9.3	3.0	1.6	3.8	2.5	5.9	20.0	15.0	3.3
bispyribac	25	(85.6)	(8.6)	(39.7)	(12.2)	(6.1)				
Oxadiargyl fb	100 /25	8.5	2.5	1.8	5.6	2.3	5.7	15.3	17.6	3.8
bispyribac		(71.8)	(5.8)	(65.9)	(28.5)	(5.1)				
Pyrazosulfuron fb	20/25	8.4	2.8	1.8	2.8	2.4	6.1	27.3	27.7	29.3
bispyribac		(69.7)	(7.2)	(62.1)	(8.4)	(5.1)				
Pendimethalin* fb	1000 fb	6.7	2.1	1.5	1.8	2.9	3.8	11.0	11.9	1.8
bispyribac fb	25	(45.2)	(3.8)	(34.1)	(5.2)	(7.7)				
manual weeding										
Pendimethalin* fb	1000	9.2	3.1	1.7	1.8	3.2	5.3	1.3	29.2	12.9
manual weeding		(84.6)	(9.5)	(49.7)	(2.6)	(9.6)				
Bispyribac +	20+4	9.5	3.2	1.80	3.2	2.5	6.6	13.6	43.5	58.7
(chlorimuron +		(89.5)	(9.8)	(62.0)	(12.0)	(5.3)				
metsulfuron)										
Three mechanical	-	5.6	3.3	1.3	2.4	4.6	3.9	5.6	51.2	83.3
weedings (cono /		(31.5)	(10.5)	(19.1)	(5.8)	(20.5)				
rotary weeder)										
HW at	-	3.6	1.5	1.2	3.8	3.5	4.0	2.3	12.8	6.2
20, 40 and 60 DAS		(12.5)	(1.9)	(15.4)	(13.1)	(11.3)				
Weedy check	-	13.1	4.6	2.0	12.3	5.1	7.2	35.3	138.2	126.2
		(170.2)	(20.8)	(105.1)	(146)	(25.1)				
LSD (P=0.05)		0.5	0.3	0.1	2.1	1.2	0.8		16.7	23.8

Table 3.2.3: Effect of herbicides on grain yield (t/ha) in direct-seeded rice at different coordinating centres

Treatment	Dose (g/ha)	Hyderabad	Bhubaneswar	Bengaluru	Ranchi	Palampur	Dapoli	Raipur	Pantnagar
Bispyribac-Na Pendimethalin* fb bispyribac	25 1000 fb 25	1.85 2.47	3.67 4.11	1.73 2.30	4.30 4.08	2.83 2.93	1.95 1.79	4.71 5.37	2.06 5.32
Oxadiargyl fb bispyribac	100 /25	2.81	4.33	2.02	4.15	2.97	1.79	5.12	4.90
Pyrazosulfuron fb bispyribac	20/25	3.02	4.28	2.13	3.80	2.85	1.64	4.74	3.10
Pendimethalin* fb bispyribac fb manual weeding	1000 fb 25	3.67	4.41	2.40	3.95	3.26	2.57	5.59	5.80
Pendimethalin* fb manual weeding	1000	2.63	4.02	1.94	3.76	1.74	2.32	4.88	5.23
Bispyribac + (chlorimuron + metsulfuron)	20+4	2.53	3.85	2.21	3.58	2.78	1.13	4.87	2.40
Three mechanical weedings (cono / rotary weeder)	-	3.72	3.80	2.32	4.23	2.15	1.78	4.86	0.30
HW at 20, 40 and 60 DAS	-	3.95	4.48	2.46	3.73	2.84	2.94	5.05	5.43
Weedy check LSD (P=0.05)	-	1.06 0.34	1.85 0.44	0.36 0.38	1.83 0.38	1.30 0.74	3.30 0.16	2.74 0.76	- 1.41

Table 3.2.4: Effect of herbicides on net returns and B:C ratio in rice

		Hydera	bad	Bhubane	swar	Rancl	ni	Pantna	gar
Treatment	Dose (g/ha)	Net returns (x10³₹/ha)	B:C	Net returns (x10³₹/ha)	B:C	Net returns (x10³₹/ha)	B:C	Net returns (x10³₹/ha)	B:C
Bispyribac-Na	25	8.25	1.59	10.50	1.40	52.759	3.12	10.93	0.69
Pendimethalin* fb bispyribac	1000 fb 25	13.97	1.89	13.90	1.51	46.391	2.52	51.01	2.85
Oxadiargyl <i>fb</i> bispyribac	100 /25	18.21	2.17	16.60	1.62	48.23	2.73	46.46	2.72
Pyrazosulfuron <i>fb</i> bispyribac	20/25	20.57	2.31	16.10	1.60	43.19	2.47	18.58	0.85
Pendimethalin* fb bispyribac fb manual weeding	1000 fb 25	24.27	2.39	17.90	1.68	45.92	2.49	48.99	1.91
Pendimethalin* fb manual weeding	1000	12.74	1.68	11.50	1.40	43.75	2.65	45.28	1.95
Bispyribac + (chlorimuron + metsulfuron)	20+4	14.49	1.91	12.30	1.47	40.29	2.32	11.64	0.59
Three mechanical weedings (cono / rotary weeder)	-	28.53	2.18	10.30	1.37	49.64	2.61	16.32	0.72
HW at 20, 40 and 60 DAS	-	27.70	1.69	11.10	1.33	32.97	1.18	33.98	0.93
Weedy check	-	0.72	1.06	1.20	0.94	16.47	1.13	-	-
LSD (P=0.05)	-	-	-	-	-	5.16	0.31	-	-

At Ranchi, application of bispyribac-Na @ 25 g/ha at 20 DAS being similar to pendimethalin @ 1000 g/ha at 0-2DAS fb bispyribac-Na @ 25 g/ha at 20 DAS, pendimethalin @1000 g/ha at 0-2 DAS fb bispyribac-Na @ 25 g/ha at 20 DAS fb manual weeding 20 DAS, and three mechanical weedings (cono/rotary weeder) at 20,40 & 60 DAS produced 134.6% significantly higher grain yield (4233 kg/ha) compared to weedy check (1833 kg/ha).

Application of bispyribac-Na @ 25 g/ha at 20 DAS being similar to oxadiargyl @ 100 g/ha at 0-2 DAS fb bispyribac @ 25 g/ha at 25 DAS) and three mechanical weeding (cono/rotary weeder) at 20,40 & 60 DAS recorded ₹ 36,285, ₹ 10,910 and

₹ 19,785/ha higher net return (₹ 52,759/ha) compared to weedy check, application of butachlor 1.5 kg/ha and weed free (HW at 20,40 and 60 DAS while maximum B:C ratio was recorded by application of bispyribac-Na @ 25 g/ha at 20 DAS.

At Palampur, weeds in unweeded check reduced the grain yield of paddy by 60.2% over pendimethalin fb bispyribac fb manual weed 1000 fb 25g/ha (0-2 fb 20 DAS fb 45 DAS). However, pendimethalin fb bispyribac fb manual weed 1000 fb 25g (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.

At Jorhat, application of pendimethalin 1.0 kg/ha followed by manual weeding 25 DAS caused reduction of weed density and dry weight throughout the growing season. The highest grain yield was achieved from weed free (3 hand weeding), mechanical weeding (thrice) and pendimethalin 1.0 kg/ha followed by hand weeding (25 DAS).

At Dapoli, the weed free check exhibited highest WCE in terms of weed density and growth of weeds The treatment pyrazosulfrom fb, bispyribac-Na combined with manual weeding at 40 DAS was the next treatment showing high WCE at 90 DAS resulting in least WCI (12.6%) followed by pendimethalin (PE) fb manual weeding. Pendimethalin fb manual weeding recorded higher number of panicles/m². The weed free check produced significantly higher yield over all other treatments followed by pyrazosulfrom fb bispyribac-Na fb manual weeding.

At Raipur, at harvest, the lowest weed dry matter was recorded under pendimethalin fb bispyribac–Na fb manual weeding 25 DAS which was statistically at par with pendimethalin fb by bispyribac @ 1000/25 g/ha, oxadiargyl fb bispyribac @ 100/25 g/ha and weed free, in descending order. The highest reduction in seed yield was to the tune of 50.98 % in weedy check as against minimum reduction of 3.93 % under combination of pendimethalin fb bispyribac–Na @ 1000/25 g/ha.

At Pantnagar, application of pendimethalin *fb* bispyribac-Na (1000/25g/ha) supplemented with one hand weeding at 45 DAS recorded the lowest weed density which was at par with application of pendimethalin 1000g/ha supplemented with one hand weeding at 25 DAS. The lowest dry matter accumulation was found with application of pendimethalin *fb* bispyribac-Na (1000/25 g/ha) + one hand weeding at 45 DAS which was at par with application of pendimethalin *fb* bispyribac-Na (1000/25 g/ha) and application of oxadiargyl *fb* bispyribac sodium (1000/25g/ha) + one hand weeding at 45 DAS which was at par with thrice hand weeding (20, 40 and 60 DAS). Among the herbicidal treatment 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 yield (5801 kg/ha) followed by thrice hand weeding at 20, 40 and 60 DAS (5439 kg/ha) which was at par with application of pendimethalin fb bispyribac-Na 1000/25g/ha (5324 kg/ha) followed by application of pendimethalin (1000 g/ha) pre-emergence supplemented with one hand weeding at 25 DAS (5324 kg/ha). Pendimethalin fb bispyribac sodium 1000/ 25g/ha recorded highest gross return (₹ 68913.4/ha), net return (₹ 51017.4/ha) and B:C ratio (2.85) followed by oxadiargyl fb bispyribac sodium 100/25 g/ha.

At Faizabad, a combination of bispyribac Na + Almix (20 + 4 g/ha) applied at 20 DAS of DSR proved superior to control the weeds effectively and gave higher grain and straw yields (4125 kg and 4405 kg/ha) and economics (net profit $\stackrel{?}{_{\sim}}$ 31105/ha) and BCR ($\stackrel{?}{_{\sim}}$ 2.13) fb pendimethalin 1000 g/ha along with bispyribac-Na (25 DAS + MW at 45 DAS). No phytotoxicity on the crop was recorded due to different pre and post emergence application of herbicides.

At Kanpur, weed population/m² and its dry weight were found minimum with application of pendimethalin (1000 g/ha) fb bispyribac (25 g/ha) and manual weeding (one) and significant maximum in weedy plot. The significantly higher yield (3.65 t/ha) was recorded with the application of pendimethalin (1000 g/ha) fb bispyribac (25 g/ha) and manual weeding (one) followed by application of bispyribac (25 g/ha) and chlorimuron + metsulfuron (4 g/ha).

At Coimbatore, among the different weed control treatments the application of pyrazosulfuron *fb* bispyribac sodium 20 fb 25 g a.i./ha was recorded lesser total weed density, dry weight and higher grain followed by oxadiargyl *fb* bispyribac sodium (100 *fb* 25 g/ha)

At Thrissur, for controlling complex weed flora of dry seeded rice, pre emergence application of pendimethalin 1000g followed by post emergence spray of bispyribac sodium at 25g/ha was effective as hand weeding three times.

At Pusa, 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 (HW at 20, 40 and 60 DAS) and pendimethalin fb bispyribac fb manual weeding which were significantly superior over rest of the treatments. However, weed free (HW at 20, 40 and 60 DAS) was significantly superior over pendimethalin fb bispyribac fb manual weeding with respect to weed count. The highest grain yield of rice (4.03 t/ha) was recorded under three mechanical weedings (cono/rotary weeder) with weed free (HW at 20, 40 and 60 DAS) and pendimethalin fb bispyribac fb manual weeding which were significantly superior over rest of the treatments.

WS 3.3: Weed management in turmeric

Herbicide recommendations for weed management in turmeric are required for its higher production.

Objectives:

- To study the bio-efficacy of different herbicides against weeds and their effect on growth and yield of turmeric
- To study the phytotoxic effects on the crop, if any.

Treatments:

- i. Metribuzin 0.7 kg/ha fb two hoeings
- ii. Metribuzin 0.7 kg/ha fb fenoxaprop at 67 g/ha+metsulfuron 4g/ha
- iii. Metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb one HW
- iv. Pendimethalin $1.0 \, kg/hafb$ two hoeings
- v. Pendimethalin 1.0 kg/ha *fb* fenoxaprop at 67 g/ha+ metsulfuron 4g/ha
- vi. Pendimethalin 1.0 kg/ha fb straw mulch 10 tones/ha fb one HW
- vii. Atrazine 0.75 kg/ha *fb* fenoxaprop at 67 g/ha+metsulfuron 4g/ha
- viii Atrazine 0.75 kg/ha *fb* straw mulch 10 tones/ha *fb* one HW

- ix. Weed-free (hand weeding at 25 and 45 DAS)
- x. Weedy check

(Metribuzin as pre-em and fenoxaprop + metsulfuron (RM) at 3-4 leaf stages of weeds)

Design: RBD Replications: 3

Observations:

- i. Weed population and dry matter at 60 DAT.
- ii. Crop growth parameters
- iii. Yield attributes and yield
- iv. Phytotoxicity on crop
- v. Economic analysis

Cooperating centres: CCSHAU, PAU, CSKHPKV, NDUAT, RAU (P), AAU(J), BAU, MAU, TNAU and UAS(B)

At Hisar, metribuzin 700 g/ha or pendimethalin 1000 g/ha or atrazine 750 g/ha fb straw mulching+ hand weeding were found most effective against all type of weeds with improvement in growth parameters of the crop. The next best treatments were metribuzin or pendimethalin fb two hoeing.

At Ludhiana, sequential application of pendimethalin 1.0 kg, metribuzin 0.7 kg or atrazine 0.75 kg/ha as pre-em followed immediately by paddy straw mulch 10 t/ha fb one hand weeding provided effective control of Dactyloctenium aegyptiacum, Acrachne racemose, Eleucine indica and suppressed Cyperus rotundus. The turmeric rhizomes exhibited complete emergence after one month of planting in straw mulch plots while it took two months in plots without mulch. The sequential combination of any of the three preherbicides, paddy straw mulch and hand weeding recorded the highest turmeric rhizome yield, net return and B:C ratio, which were at par to weed free treatment and significantly higher than the weedy check and other weed control treatments.

At Palampur, weeds in unweeded check reduced the rhizome yield of turmeric by 78.8% over the best treatment i.e. metribuzin 0.7 kg/ha fb

straw mulch 10 t/ha fb 1 hand weeding. However, metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb 1 hand weeding behaved statistically alike with pendimethalin 0.7 kg/ha fb straw mulch 10t / ha fb 1 hand weeding and atrazine 0.75 kg/ha fb straw mulch 10t / ha fb 1 hand weeding in this regard by effective control of weeds. All the weed control treatments where post emergence application of fenoxaprop 67 g/ha + metsulfuron methyl 4 g/ha was made with any of herbicide, caused phytotoxicity to the crop and resulted in significantly lower turmeric yield.

At Pusa, the lowest weed count and weed dry weight, and the highest plant height, No of tillers per plant, No of leaves per plant and grain yield of turmeric were recorded by the treatment

weed free (HW at 25 and 45 DAS). The lowest weed dry weight and highest no of tillers per plant were recorded by treatment weed free which was statistically at par with treatment atrazine 0.75 kg/hafb straw mulch 10 t/hafb one HW, atrazine 0.75 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4 g/ha, pendimethalin 1.0 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4 g/ha and metribuzin 0.7 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4g/ha and significantly superior over rest of the treatments. The highest rhizome yield (5.25 t/ha) was recorded under the treatment weed free which was statistically at par with atrazine 0.75 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4 g/ha, and pendimethalin 1.0 kg/ha fb fenoxaprop at $67 \, g/ha + metsulfuron 4 \, g/ha$.

Table 3.3.1 : Effect of herbicide on weed density (no./m²) at 60 DAS in turmeric at different coordinating centres

Treatment	Hisar	Palampur	Pusa	Jorhat	Ranchi	Parbhani	Coimbatore
Metribuzin 0.7 kg/ha fb two hoeing Metribuzin 0.7 kg/ha fb fenoxaprop at 67 g/ha+ Metsulfuron 4g/ha	1.0 (0.0) 4.9 (23.3)	4.7 (22.0) 4.3 (18.0)	12.9 7.2	25.3 34.7	5.5 (30.3) 6.5 (60.7)	2.0 2.3	3.2 (8.7) 4.5 (19.0)
Metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb one HW	1.0 (0.0)	4.7 (23.3)	10.6	38.0	4.5 (23.3)	1.3	4.8 (21.0)
Pendimethelin 1.0 kg/ha fb two hoeing	1.0 (0.0)	3.6 (12.0)	12.4	31.3	1.9 (6.6)	5.0	3.7 (12.3)
Pendimethalin 1.0 kg/ha fb fenoxaprop at 67 g/ha+ Metsulfuron 4g/ha	4.4 (19.3)	5.7 (32.7)	6.8	40.3	10.5 (118.0)	1.0	5.2 (26.0)
Pendimethelin 1.0 kg/ha fb straw mulch 10 t/ha fb one HW	1.0 (0.0)	3.1 (11.3)	10.7	33.3	4.8 (24.0)	1.0	5.3 (26.7)
Atrazine 0.75 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4g/ha	5.2 (27.3)	5.0 (24.7)	6.3	34.7	10.9 (122.0)	1.0	5.4 (27.7)
Atrazine 0.75 kg/ha fb straw mulch 10 t/ha fb one HW	1.0 (0.0)	3.6 (12.0)	9.5	**	5.6 (34.0)	1.3	6.0 (35.0)
Weed-free (hand weeding at 25 and 45 DAS)	1.0 (0.0)	4.8 (23.3)	4.2	17.3	0.7 (0.0)	1.3	**
Weedy check	8.1 (65.3)	8.7 (6.0)	35.8	76.3	15.8 (250.0)	1.3	7.1 (49.3)
LSD (P=0.05)	0.5	1.9	0.7	9.6	2.3	**	1.00

Table 3.3.2 : Effect of herbicide on weed dry biomass (g/m²) at 60 DAS in turmeric at different coordimnating centres

Treatment	Hisar	Ludhiana	Palampur	Pusa	Jorhat	Ranchi	Parbhani	Coimbatore
Metribuzin 0.7 kg/ha fb two hoeing	0.0	11.1 (128)	3.9 (14.5)	22.9	18.3	6.3 (15.8)	8.9	2.9 (6.6)
Metribuzin 0.7 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4g/ha	51.3	4.9 (30)	4.0 (15.8)	15.8	16.7	7.5 (83.2)	7.5	11.5 (130.2)
Metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb one HW	0.0	4.5 (26)	3.4 (13.4)	22.2	36.7	8.2 (30.1)	6.1	12.5 (156.2)
Pendimethelin 1.0 kg/ha fb two Hoeings	0.0	1.0 (0)	3.2 (9.6)	23.5	28.3	2.2 (9.6)	6.5	2.9 (6.8)
Pendimethalin 1.0 kg/ha fb fenoxaprop at 67 g/ha+ metsulfuron 4g/ha	41.8	1.0 (0)	4.7 (21.8)	13.8	38.3	12.2 (161)	3.8	14.9 (222.4)
Pendimethelin 1.0 kg/ha fb straw mulch 10 t/ha fb one HW	0.0	3.0 (16)	2.7 (7.1)	19.5	21.7	5.5 (31.3)	8.4	15.6 (241.8)
Atrazine 0.75 kg/ha fb fenoxaprop at 67 g/ha+metsulfuron 4g/ha	58.7	1.0 (0)	4.1 (15.5)	14.1	21.2	12.6 (165)	5.3	13.9 (193.0)
Atrazine 0.75 kg/ha fb straw mulch 10 t/ha fb one HW	0.0	5.8 (48)	2.9 (7.7)	17.1	**	6.5 (46.8)	6.0	17.7 (311.1)
Weed-free (hand weeding at 25 and 45 DAS)	0.0	1.0	4.2	10.23	20.0	0.71	5.0	**
Weedy check	469.5	17.3 (300)	7.7 (58.3)	63.5	46.7	18.3 (335)	7.0	20.3 (413.4)
LSD (P=0.05)	18.9	4.3	1.7	8.3	6.1	2.7	4.85	0.7

Table 3.3.3: Effect of herbicide on rhizome yield (t/ha) of turmeric at different coordinating centres

Treatment	Ludhiana	Palampur	Jorhat
Metribuzin 0.7 kg/ha fb two hoeings	10.80	5.40	13.12
Metribuzin 0.7 kg/ha fb fenoxaprop at 67 g/ha+	8.20	2.80	10.14
metsulfuron 4 g/ha			
Metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb one HW	18.20	13.70	11.65
Pendimethalin 1.0 kg/ha fb two hoeings	12.00	6.30	12.81
Pendimethalin 1.0 kg/ha fb fenoxaprop at 67 g/ha+	0.90	2.80	11.08
metsulfuron 4 g/ha			
Pendimethalin 1.0 kg/ha fb straw mulch 10 t/ha fb	16.80	13.40	12.78
one HW			
Atrazine 0.75 kg/ha <i>fb</i> fenoxaprop at 67 g/ha+ metsulfuron	9.80	2.30	10.47
4 g/ha			
Atrazine 0.75 kg/ha fb straw mulch 10 t/ha fb	16.70	12.00	12.61
one HW			
Hand weeding at 25 and 45 DAS	17.10	7.00	12.64
Weedy check	4.20	2.90	3.57
LSD (P=0.05)	4.70	2.40	2.35

Table 3.3.4 : Effect of different treaments on economics of turmeric cultivation at Ludhiana and Faizabad

	Ludhiana	Faiza	bad
Treatment	Net returns (x10³ ₹/ha)	Net returns (x10³ ₹/ha)	B:C ratio
Metribuzin 0.7 kg/ha fb two hoeings	55.70	28.83	2.04
Metribuzin 0.7 kg/ha <i>fb</i> fenoxaprop at 67 g/ha+ metsulfuron 4 g/ha	33.50	28.22	1.78
Metribuzin 0.7 kg/ha fb straw mulch 10 t/ha fb one HW	130.29	29.59	1.98
Pendimethalin 1.0 kg/ha fb two hoeings	66.86	26.76	1.82
Pendimethalin 1.0 kg/ha fb fenoxaprop at 67 g/ha+metsulfuron 4 g/ha	-38.88	28.23	1.58
Pendimethalin 1.0 kg/ha fb straw mulch 10 t/ha fb one HW	115.79	24.05	1.49
Atrazine 0.75 kg/ha <i>fb</i> fenoxaprop at 67 g/ha+ metsulfuron 4g/ha	49.44	31.10	1.49
Atrazine 0.75 kg/ha fb straw mulch 10 t/ha fb one HW	114.78	26.85	2.13
Hand weeding at 25 and 45 DAS	112.13	28.66	1.81
Weedy check	-3.75	19.04	1.55

At Jorhat, the highest number of mother, primary, secondary and total rhizomes per plant as well as yield of rhizomes were recorded with metribuzin 700 g/ha + hoeing 30 and 60 DAP or pendimethalin 1000 g/ha fb straw mulch 10 t/ha followed by hand weeding 60 DAP or pendimethalin 1000 g/ha + hoeing 30 and 60 DAP. The lowest density and dry weight of weeds at 90 DAP and harvest were recorded under the treatment with metribuzin 700 g/ha + hoeing 30 and 60 DAP. However at 25 and 60 DAT, the lowest values were found in the treatments with atrazine 750 g/ha + hoeing 30 and 60 DAP, hand weeding 25 and 45 DAP and pendimethalin 1000 g/ha + hoeing 30 and 60 DAP.

At Ranchi, among herbicide application of pendimethalin 1.0 kg/ha fb two hoeng recorded significantly reduced density and weed dry matter accumulation of all three categories of weeds i.e. grass, sedges and broad leaved weeds at 30 and 60 days after sowing.

At Parbhani, among broadleaved weeds Digera arvensis, Parthenium hysterophorus, Euphorbia geniculata and Acalypha indica were found to be dominant species. The dominant grassy weeds were Cynodon dactylon and Commelina benghalensis. The population of grassy weed was lowest in treatment metsulfuron 0.7 kg/ha PE fb straw mulch 10 t/ha fb one HW at 30 DAS and atrazine 0.75 kg/ha PE fb Fenoxaprop @67 g/ha + metsulfuron 4 g/ha at 60 DAS whereas broad leaved weed population was lowest in atrazine 0.75 kg/ha PE fb straw mulch 10 t/ha fb one HW at 30 as well as 60 DAS. At 60 DAS significantly lowest dry weed weight of broad leaved weeds was observed in weed free situation followed by atrazine 0.75 kg/ha PE fb fenoxaprop @ 67 g ha + metsulfuron 4 g/ha and atrazine 0.75 kg/ha PE fb straw mulch 10 t/ha fb one HW than rest of all the weed control treatments.

At Coimbatore, the grass weeds present in the experimental field were *Echinochloa crusgalli*, *Digitaria bicornis*, *Panicum repens*. *Cyperus rotundus* was only sedge and *Amaranthus viridis*, *Parthenium hysterophorus*, *Phyllanthus niruri* the broad leaved weeds. Pre-emergence application of metribuzin 0.7 kg/ ha + two hand weeding on 45 and 75 DAP recorded lesser total density and dry weight of weeds

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

There is lack of post emergence herbicides in black gram/green gram hence; a study was conducted with the following objectives

- To study the bioefficacy of different herbicides against weeds and their effect on growth and yield of blackgram / greengram
- To study the phytotoxic effects on the blackgram/greengram, if any
- To study the residual effect of herbicides applied in blackgram/greengram on succeeding mustard crop

Treatments:

	Time (DAS)
T_1	Pre-em
T ₂	20 DAS (3-4 leaf stage)
T ₃	20 DAS (3-4 leaf stage)
T_4	Pre-em
T ₅	Do
T_6	Do
T_7	20 DAS (3-4 leaf stage)
T ₈	20 DAS (3-4 leaf stage)
T ₉	-
T_{10}	-

Imazethapyr + pendimethalin (pre-mix) = Valor/ Squadron

Imazethapyr + imazamox (pre-mix) = Odissey

Observations:

Blackgram/ greengram

- i. Weed population and dry matter at 40 DAS
- ii. Growth parameters (height, dry matter, lead area, nodulation)
- iii. Yield attributes and yield
- iv. Phyto-toxicity on crop

Mustard

Weed population and dry matter at 40 DAS

- ii. Growth parameters (plant population, plant height, dry matter, leaf area)
- iii. Yield attributes and yield
- iv. Phytotoxicity on crop at 15, 30 DAS

Cooperating centres: RVSKVV, CCSHAU, PAU, SKRAU, CSKHPKV, AAU (A), GBPUAT, V.B. and SVBPUAT

At Palampur, weeds in unweeded check reduced the seed yield of black gram by 42% over the best treatment of imazethapyr + pendimethalin (Pre-mix) 1000 g/ha (pre emergence). However, imazethapyr + pendimethalin (Pre-mix) 1000 g/ha (pre-emergence) behaving statistically similar with pendimethalin 1000 g/ha (pre-emergence) and weed free (hand weeding at 20 and 40 DAS) resulted in significantly higher seed yield of black gram over remaining treatments by effective control of weeds. The residual effects of herbicide treatments on succeeding mustard crop were non phytotoxic.

At Anand, significantly 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 pre emergence 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. At harvest among herbicide treatments, post emergence application of imazethapyr @ 70 g/ha showed significantly lower weed dry matter which was at par with all the herbicidal treatments at harvest. Weed control efficiency varied between 96.5 to 83.0% and 87.4 to 73.8% at 40 DAS and at harvest, respectively. Post-emergence application of imazethapyr @ 50 and 70 g/ha and postemergence application of imazethapyr+ imazamox @ 60 and 70 g/ha showed toxicity on blackgram.

At Pantnagar, All the weed control treatments registered lower number of grassy weeds over the weedy check. All herbicidal treatments effectively control the BLW as

compared to grasses and sedges. The application of higher dose of imazethapyr + pendimethalin at 1000 g/ha and imazethapyr + imazamox at 70 g/ha was found more effective in reducing the density of weeds as compared to its lower dose. Significantly lower dry matter of weeds was found with application of imazethapyr + pendimethalin at 1000 g/ha, it might be due to

elimination of grassy and non grassy weeds resulting in highest weed control efficiency of 78.8%. imazethapyr + pendimethalin at 1000 g/ha recorded significantly higher grain yield 1663 kg/ha followed by its lower dose applied at 900 g/ha which were at par with alone application of pendimethalin 1000 g/ha.

Table 3.4.1 : Effect of herbicide on weed density (no./m²) at 60 DAS in greengram / blackgram at different coordinating centres

Treatment	Dose (g/ha)	Gwalior	Hisar	Ludhiana	Palampur	Anand	Pantnagar	Sriniketan	Meerut
Pendimethalin	1000	6.4	4.7 (22.0)	3.4 (11.0)	15.3	87.9	0.3 (0.7)	4.7 (22.0)	70.0
Imazethapyr	50	5.6	1.7 (2)	2.2 (7.0)	30.6	71.8	3.7 (40.0)	10.2 (104.0)	65
Imazethapyr	70	4.7	1.9 (3.3)	1.0 (0.0)	34.0	76.1	3.4 (30.0)	10.3 (105.7)	45.0
Imazethapyr + Pendimethalin (Pre-mix)	800	5.1	3.4 (10.7)	1.0 (0.0)	26.6	83.0	2.5 (12.0)	5.6 (31.7)	62.0
Imazethapyr + Pendimethalin (Pre-mix)	900	4.5	3.4 (11.3)	1.0 (0.0)	19.6	85.2	2.1 (8.0)	5.7 (32.0)	52.0
Imazethapyr + Pendimethalin (Pre-mix)	1000	4.0	3.8 (13.3)	1.0 (0.0)	15.0	88.8	1.2 (4.0)	4.9 (24.0)	68.0
Imazethapyr + imazamox (Pre-mix)	60	5.6	2.3 (4.7)	1.0 (0.0)	20.3	78.3	0.3 (0.7)	10.5 (112.0)	58.0
Imazethapyr + imazamox (Pre-mix)	70	3.1	1.2 (0.7)	1.0 (0.0)	23.0	81.6	0.3 (0.7)	10.2 (105.0)	42.0
Weed free (hand weeding at 20 and 40 DAS)	**	2.4	1.2 (0.7)	1.0 (0.0)	11.0	96.5	0.7 (1.3)	0.7 (0.0)	5.0
Weedy check	**	8.5	8.1 (64)	10.7 (119.0)	66.3	**	3.9 (53.3)	21.5 (463.0)	155.0
LSD (P=0.05)	**	**	1.1	1.8	3.5	**	0.9	1.5	3.6

Table 3.4.2 : Effect of herbicides on weed dry biomass (g/m^2) at 60 DAS in greengram / blackgram at different coordinating centres

Treatments	Dose (g/ha)	Gwalior	Hisar	Ludhinana	Palampur	Anand	Pantnagar	Sriniketan	Meerut
Pendimethalin	1000	74.3	15.3	7.7	4.0	13.5	26.9	4.7	4.5
			(233.3)	(62.0)				(7.3)	
Imazethapyr	50	65.5	8.6	2.8	7.8	31.5	30.5	10.2	4.1
			(72.7)	(14.0)				(27.3)	
Imazethapyr	70	38.1	7.8	1.0	7.8	26.7	25.2	10.3	4.5
·			(60.7)	(0.0)				(22.3)	
Imazethapyr + pendimethalin	800	49.1	14.5	1.0	7.5	19.0	23.5	5.6	6.8
(Pre-mix)			(212.7)	(0.0)				(11.0)	
Imazethapyr + pendimethalin	900	35.4	13	1.0	5.8	16.5	20.7	5.7	5.8
(Pre-mix)			(171.3)	(0.0)				(10.6)	
Imazethapyr + pendimethalin	1000	31.3	12.6	1.0	4.5	12.5	14.5	4.9	6.5
(Pre-mix)			(158.7)	(0.0)				(9.6)	
Imazethapyr + imazamox	60	34.0	8.6	1.0	5.5	24.2	36.7	10.5	5.1
(Pre-mix)			(73.3)	(0.0)				(26.5)	
Imazethapyr + imazamox	70	13.0	8.6	1.0	6.5	20.5	32.9	10.2	3.1
(Pre-mix)			(65.7)	(0.0)				(25.3)	
Hand weeding at 20 and	**	6.8	6.3	1.0	2.6	3.8	24.7	0.7	1.3
40 DAS			(39.3)	(0.0)				(0.0)	
Weedy check	**	126.9	18.5 (341.3)	20.6 (432.0)	10.8	112.2	68.4	21.5 (144.0)	19.42
LSD (P=0.05)	**	11.6	2.0	2.7	2.1	6.6	7.8	1.5	1.8

Table 3.4.3: Effect of herbicides on seed yield (kg/ha) of greengram / blackgram at different coordinating centres

Treatments	Dose (g/ha)	Gwalior	Hisar	Ludhiana	Palampur	Anand	Pantnagar	Sriniketan	Meerut
Pendimethalin	1000	548	909	192	824	2715	1482	837	920
Imazethapyr	50	536	1441	177	629	2693	1242	580	1078
Imazethapyr	70	667	1484	196	622	2389	1275	625	986
Imazethapyr + pendimethalin (Pre-mix)	800	726	1407	179	664	2442	1425	877	1048
Imazethapyr + Pendimethalin (Pre-mix)	900	734	1412	188	712	2519	1543	887	1080
Imazethapyr + Pendimethalin (Pre-mix)	1000	814	1429	188	861	2690	1663	891	891
Imazethapyr + Imazamox (Pre-mix)	60	754	1450	188	694	2297	1231	680	832
Imazethapyr + Imazamox (Pre-mix)	70	833	1372	188	664	1910	1317	708	790
Weed free (hand weeding at 20 and 40 DAS)	**	893	1504	188	851	2731	1624	868	1145
Weedy check	**	298	216	210	500	1335	569	473	640
LSD (P=0.05)	**	67	73	NS	1.3	293	166	86.5	78

Table 3.4.4:	Effect of herbicides on net return and B:C ratio in greengram / blackgram at different
	coordinating centres

		Gwal	ior	Sriniketan		
Treatment	Dose (g/ha)	Net returns (x10³ ₹/ha)	B:C	Net returns (x10³ ₹/ha)	B:C	
Pendimethalin	1000	-	-	-	-	
Imazethapyr	50	4.72	4.42	6.45	0.39	
Imazethapyr	70	8.58	1.75	7.92	0.46	
Imazethapyr + pendimethalin (Pre-mix)	800	9.92	1.84	18.75	1.15	
Imazethapyr + pendimethalin (Pre-mix)	900	10.08	1.84	19.09	1.17	
Imazethapyr + pendimethalin (Pre-mix)	1000	12.40	2.03	19.22	1.17	
Imazethapyr + imazamox (Pre-mix)	60	10.92	2.20	11.07	0.69	
Imazethapyr + imazamox (Pre-mix)	70	13.18	2.13	12.13	0.75	
Hand weeding at 20 and 40 DAS	**	13.60	1.82	15.22	0.78	
Weedy check	**	-1.76	0.86	3.43	0.22	

At Gwalior, results revealed that weed free treatment recorded higher seed yield and net return followed by pre mix herbicide i.e. imazethapyr + imazamox @ 0.050 kg/ha and pendimethalin + imazethapyr @ 1.00 kg/ha application.

At Hisar, imazethapyr 50-70 g, imazethapyr + imazamox (RM) 60-80 g, imazethapyr + pendimethalin 800-1000 g/ha provided effective control of *E. colona* in green gram. Pendimethalin 1000 g/ha as preemergence was effective against *D. aegyptium* and lost its efficacy 20 days after use. All the herbicides were safe to the crop except imazethapyr+imazamox (RM) 80 g/ha.

At Ludhiana, imazethapyr 70 g, imazethapyr + imazamox 40 and 50 g, imazethapyr + pendimethalin 800 g/ha recorded effective control of Dactyloctenum aegyptiacum, Cyperus rotundus, Commelina benghalensis, Digitaria sp and Acrachne racemose, Eleucine indica, Trianthema portulacastrum and Amaranthus viridis in greengram. Pendimethalin 1000 g/ha as preemergence was ineffective against sedges and lost

its efficacy after 20 days against grasses and broadleaf. All the herbicides were safe to the crop. The crop was heavily infested with yellow mosaic virus and hence the yields were very lower and differential effect of weed control treatments on seed yield disappeared.

At Sriniketan, in the experiment weed management in black gram and its residual effect on succeeding mustard crop 10 treatments were tested in RBD during *kharif* 2012. Pre-emergence application of imazethapyr + pendimethalin (premix) @ 800, 900 and 1000 g/ha was effective against mixed weed flora and registered higher yield in black gram which were equivalent with that of pendimethalin @ 1000 g/ha.

At Meerut, among the weed control treatments the lowest weed density was recorded in treatment weed free (hand weeding at 20 and 40 DAS) followed by treatment imazethapyr + imazamox (pre-mix) 70 g/ha and Imazethapyr 70 g/ha. As far as grain yield is concerned, all the weed control treatments maintained their superiority over weed check. The highest seed yield (11.45 q/ha) was recorded in weed free

treatment closely followed by application of preemergence imazethapyr + pendimethalin 900 g/ha and post-emergence application of imazethypyr 50g/ha. However, phytotoxic effect on crop was recorded in treatment mazethypyr + imazamox 70 g/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 Csequestration, changes in physico-chemical and biological properties of soil health under ricebased and non-rice-based cropping systems. Eight treatments consisting of five establishment methods, viz. T₁ - 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 herbicide + hand weeding at 45 DAS, W₃ - weedy check (control) in subplot was laid out in splitplot design with three replications. The experiment was conducted at Bhubaneswar, Faizabad, Thrissur, Coimbatore, Benagaluru, Dharwad, Anand, Bikaner 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 harvest stage were *Phalaris minor, Chenopodium album, Anagallis arvensis,* and *Melilotus alba at* Kanpur and Faizabad. 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.

Rice: The tillage methods did not show any definite trend on weed population and weed dry biomass across the coordinating centres. CT-CT method of tillage being at par with CT-ZT and ZT-CTmethods provided significantly lower total weed density and weed dry matter accumulation as compared to continuous ZT-ZT method at

Ranchi. The similar trend in respect to density and dry biomass of weeds were recorded at Kanpur, but the differences amongst the treatments were non-significant. However at Faizabad, density and dry weight of total weeds were not affected significantly due to different tillage. 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 and Kanpur. Weed control practices viz., hand weeding twice and pendimethalin (1.0 kg a.i/ha) fb almix (4.0 g a.i./ha) provided effective control of weeds over unweeded check at 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 Ranchi and Kanpur. While at Faizabad, the different tillage combinations did not influence the grain yield of rice. In case of weed control treatments, 2 hand weeding at 25 and 45 DAS during both the seasons provided highest grain yield of rice over herbicide and weedy check at all the cooperating centres. There was 50% increase in grain yield over weedy check.

Wheat: At Kanpur, lowest density of Phalaris minor was recorded under continuous ZT-ZT tillage system. Whereas, lowest density of Chenopodium album, A. arvensis, M. alba and C. didymus were observed in conventionalconventional tillage at 60 DAS and harvest of the crop. But the total density and dry biomass of weeds was recorded with continous zero tillage during both the seasons. Similarly, significantly lower density of total weeds and their dry weight was observed under zero tillage condition as compared to wheat sown under conventional tillage at Faizabad. 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 provided significant reduction in the growth of Chenopodium album, P. minor, Melilotus sp., Rumex spp. and Anagallis arvensis.

At Kanpur, continuous conventional tillage during both the season produced significantly higher straw (5370 kg/ha) and grain yield (5700 kg/ha) of wheat over rest of the tillage combinations. The yield reduction in zero-zero tillage sowing was in the tune of 19.6% as compared to conventional-conventional tillage. While at Faizabad, different tillage treatments had no effect on the grain yield of wheat but, 7.26% reduction in grain yield of wheat crop was noticed under conventional tillage over zero tillage. Among the weed control practices, the highest grain yield of wheat (5130 kg/ha at Kanpur) and (3822.5 kg/ha at Faizabad) 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 (₹ 14973/ha) and B: C ratio (0.82) was obtained under continuous conventional tillage followed during both the season in rice at Kanpur coordinating centre, respectively. However, at Ranchi centre, ZT-CT tillage system provided significantly highest net return (₹ 10006/ha) and B:C ration (0.92) which was at par with continuous conventional tillage in both the season. 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. 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.

Table 3.5.1: Effect of tillage and weed control methods on weed infestation in in rice at 60 DAS at different coordinating centres

Tillage	Weed	d density (no./	'm ²)	Weed	dry weight	(g/m ²)
Tillage	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad
ZT-ZT	12.3	11.63		14.0	6.36	-
	(217)	(134.8)	-	(268)	(39.9)	
ZT-CT	10.3			12.0	6.28	-
	(162)	7.06 (49.3)	-	(215)	(38.9)	
CT-ZT	9.18			10.5	6.15	6.00 (49.4)
	(142)	6.33 (39.6)	6.24 (38.4)	(178)	(37.3)	6.99 (48.4)
CT-CT	8.83			10.3	5.45	6.64 (43.6)
	(132)	5.99 (35.4)	7.82 (60.6)	(172)	(34.9)	0.04 (43.0)
LSD (P=0.05)	2.58	NS	NS	2.74	NS	NS
Weed control						
HW-HW	4.16	5.13 (25.8)	5.10 (25.5)	8.4	5.04	E 20 (20 4)
	(25.31)			(82.28)	(24.9)	5.38 (28.4)
RH-RH	3.10	6.12 (37.0)	5.60 (30.9)	4.51	6.02	4.54 (20.1)
	(14.06)			(24.12)	(35.8)	4.34 (20.1)
WC-WC	15.30	8.73 (75.8)	6.73 (44.8)	22.17	7.46	7.26 (52.2)
	(273.94)			(518.48)	(55.1)	7.26 (52.2)
LSD (P=0.05)	1.23	2.1	NS	1.21	0.6	0.81

Original values are given in parentheses

Table 3.5.2: Effect of tillage and weed control methods on total weed density and weed dry matter production in wheat at 60 DAS

Tillage	W	eed density (no./n	n ²)	Wee	d dry weigh	nt (g/m ²)
Timage	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad
ZT-ZT	-	14.27 (203.0)	-	-	16.81	-
					(282.0)	
ZT-CT	-	10.84 (116.9)	-	-	19.4	-
					(376.2)	
CT-ZT	-	11.79 (138.7)	8.75 (76.2)	-	17.43	5.38 (28.4)
					(303.3)	
CT-CT	-	10.06 (100.7)	11.1 (122.7)	-	18.68	9.28 (85.6)
					(348.4)	
LSD (P=0.05)	-	0.5	-		-	2.98
Weed control	-				-	
HW-HW	-	8.72 (75.5)	0.7 (0.0)	-	14.03	0.7 (00)
					(196.6)	
RH-RH	-	12.49 (155.6)	9.69 (93.4)	-	17.73	4.99 (24.4)
					(314.0)	
WC-WC	-	13.91 (192.9)	14.62	-	21.77	6.56 (42.5)
			(213.2)		(473.5)	
LSD (P=0.05)	-	0.79		-	3.7	1.89

Original values are given in parentheses

Table 3.5.3: Effect of tillage and weed control methods on grain yield and economics of rice at different coordinating centres

Treatment	Se	eed yield (t/ha)	Net	income (x10	³ ₹/ha)		B:C ratio	
	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad
Tillage									
ZT-ZT	0.96	2.75	-	1.72	12.07	-	0.13	0.67	-
ZT-CT	1.61	2.83	1	10.00	12.99	-	0.92	0.72	-
CT-ZT	1.34	3.02	4.12	5.41	14.26	-	0.44	0.77	-
CT-CT	1.64	3.09	4.19	9.14	14.97	-	0.79	0.82	-
LSD (P=0.05)	0.313	0.130	NS	4.00	0.631	-	0.34	0.04	-
Weed control						-			-
HW-HW	1.74	3.41	4.74	8.75	16.13	-	0.10	0.78	-
RH-RH	1.61	3.18	4.58	9.91	16.72	-	0.94	0.96	-
WC-WC	0.81	2.18	3.14	1.04	7.89	-	0.11	0.5	-
LSD (P=0.05)	0.129	0.110	NS	4.62	0.553	-	0.42	0.09	-

Table 3.5.4: Effect of tillage and weed control methods on grain yield, net return and B:C ratio in wheat at different coordinating centres

Treatments	Gra	in yield (l	kg/ha)	Net	income (₹	/ha)		B:C ratio)
	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad	Ranchi	Kanpur	Faizabad
Tillage									
ZT-ZT	-	4070		-	34005	-	-	1.43	-
ZT-CT	-	4380		-	35995	-	-	1.36	-
CT-ZT	-	4280	3585.3	-	36795	-	-	1.60	-
CT-CT	-	5070	3270.3	-	45653	-	-	1.74	-
LSD (P=0.05)	-	350	NS	-	1818	-	-	0.12	-
Weed control	-			ı		-	ı		1
HW-HW	-	5120	3822.5	-	40302	-	-	1.44	-
RH-RH	-	4760	3678.5	-	40950	-	-	1.71	-
WC-WC	-	4190	2782.5	-	33052	-	-	1.45	-
LSD (P=0.05)	-	420	198	-	1170	-	-	0.10	-

After completion of cycle, soil of different plots was collected for studying the impact of different treatments on physic-chemical viz. bulk density, pH, Ec and organic content. Results

revealed that neither different tillage combinations nor weed control measures influenced the pysico-chemical properties of soil.

Table 3.5.5: Effect of tillage and weed control treatments on physico-chemical properties of rhizospheric soil of wheat under rice-wheat cropping system at Faizabad centre.

	Bulk den	sity (g/cc)	рН	(1.25)	EC (dS/m)	Organ	ic C (%)
Treatment	Initial	At harvest	Initial	Initial At Initi harvest		At harvest	Initial	At harvest
Tillage								
ZT-ZT	1.45	1.44	8.00	8.10	0.22	0.21	0.38	0.35
ZT-CT	1.45	1.45	8.13	8.12	0.23	0.22	0.36	0.38
CT-ZT	1.45	1.45	8.10	8.10	0.24	0.24	0.35	0.33
CT-CT	1.46	1.45	8.15	8.17	0.23	0.22	0.36	0.35
LSD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed control								
HW-HW	1.46	1.46	8.10	8.12	0.23	0.22	0.35	0.34
RH-RH	1.45	1.46	8.14	8.13	0.23	0.23	0.35	0.34
WC-WC	1.45	1.44	8.13	8.13	0.22	0.23	0.35	0.33
LSD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Rice-rice cropping system (Bhubaneswar and Thrissur)

The experimental field was infested mainly with Panicum repens (22.5%), Echinochloa crusgalli (19.6%) and Echinochloa colona (10.7%) among grassres; Marselia quadrifolia (5.8%) and Alternanthera sessilis (3.2%) among broad leaf weeds; and Cyperus difformis (6.6%) and Cyperus iria (4.8%) among sedges at both the centre's. Besides these, few other weeds viz. Leptochloa chinensis, Sphenochloa zeylanica, Ludwigia parviflora, Cyperus rotundus, Dactyloctenium aegyptium and Paspalum scrobiculatum were also observed in the field at Bhubaneswar centre. While at Thrissure centre, Fimbristylis miliacea, Cyperus difformis, Eleocharis sp, Monochoria vaginalis, Ludwigia parviflora, Sphenocloa zeylanica, and Echinochloa crusgall were recorded.

At Bhubaneswar centre, practice of CT-CT tillage methods significantly reduced the weed densities by 29.5%, 32.3% and 44.1%, respectively at different growth stages in *rabi* rice; and by 29.6%, 25.2% and 39.4%, respectively in *kharif* rice over continuous ZT-ZT tillage practices. During the initial stages (25 DAP), application of butachlor (1.5 kg ha⁻¹) reduced the weed density by 62.9% and 62.5% over weedy check in *rabi* and *kharif*, respectively. Similar effect due to treatments in respect to weed dry biomass

production was also recorded. While at Thrissur, different tillage practices did not influence the weed growth. However, in the zero tillage plot a shift from common weeds to *Eleocharis*, a perennial sedge was recorded. Among weed control measures, application of recommended herbicide being at par with hand weeding reduced significantly the density and dry biomass of weeds over weedy check.

So far yield of rice is concerned, highest grain and straw yields were recorded under continuous CT-CT tillage practices over continuous ZT-ZT tillage system at both the coordinating centres. Reduction in grain yield under ZT-ZT method was in the tune of 24.6% as compared to CT-CT method at Bhubaneswar centre. However, highest B: C ratio was obtained under continuous ZT-ZT tillage practices. Among weed control measures, hand weeding twice at 25 and 45 DAS/DAP being at par with application of recommended herbicide produced significantly higher grain yield of rice over weedy check at both the coordinating centres. At Bhubaneswar, the composition of weed seed bank in ZT was dominated with grasses (63.6%) followed by broad-leaved weeds (23.6%) and sedges (12.8%). Similarly corresponding values of grasses, broadleaf and sedges under CT-CT tillage system were 64.5%, 23.6% and 12.1%.

Table 3.5.6: Effect of tillage and weed control methods on v	reed dynamics in rice at 60 DAS
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Treatment		Weed densit	ty (no./m²)			Weed dry ma	atter (g/m²)	
Treatment	Kharif ri	ice	Rabi ric	e	Kharif ri	ce	Rabi ric	e
Tillage	Bhubaneswar	Thrissur	Bhubaneswar Thrissur		Bhubaneswar	Thrissur	Bhubaneswar	Thrissur
ZT-ZT	52.8	25.3	50.1	-	16.5	247.0	15.3	-
ZT-CT	45.0	28.0	40.8	-	14.1	150.6	12.6	-
CT-ZT	47.6	-	45.9	-	14.9	-	13.1	-
CT-CT	39.5	25.3	33.9	-	12.1	183.2	11.0	-
LSD (P=0.05)	1.9	-	2.6	-	0.7	-	0.8	-
Weed control				-				-
HW-HW	20.6	18.6	19.9	-	8.2	64.4	6.9	-
RH-RH	35.7	13.3	32.9	-	9.8	59.8	9.3	-
WC-WC	82.3	46.6	76.2	-	25.2	456.8	22.7	-
LSD (P=0.05)	1.7	-	1.4	-	0.6	-	0.4	-

Table 3.5.7: Effect of tillage and weed control methods on grain yield of rice and B:C ratio.

Treatments		grain yiel	d (kg/ha)		В:С	Ratio
	Kharif r	ice	Rabi ric	e	Kharif rice	Rabi rice
Tillage	Bhubaneswar	Thrissur	ssur Bhubaneswar Thrissur		Bhubaneswar	Bhubaneswar
ZT-ZT	3080	2362	3150	-	1.42	1.48
ZT-CT	3670	3207	3730	-	1.28	1.33
CT-ZT	3480	-	3550	-	1.43	1.5
CT-CT	4070	3134	4190	-	1.32	1.37
LSD (P=0.05)	130	-	220	-	-	-
Weed control				-		
HW-HW	4280	3354	4380	-	1.51	1.58
RH-RH	4220	3231	4290	-	1.71	1.76
WC-WC	2230	2117	2300	-	0.86	0.91
LSD (P=0.05)	130	-	130	-	-	-

^{*}Flood fallow

Table 3.5.8: Economics of tillage practices at Thrissur centre

Tillage treatments	Cost for tillage / herbicide treatment (₹)	Grain yield (kg/ha)	Returns (₹ 14/ kg grain)	Returns after deducting cost for tillage (₹)
Conventional tillage	10000	3134	62680	52680
Conventional-Zero tillage in alternate years (conventional tillage in 2011)	10000	3207	64140	54140
Zero-Zero tillage	5000	2362	47240	42240

Pearlmillet-wheat cropping system (Anand)

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 Choris barbata. The major species of weeds as dicot were Euphorbia hirta, Boerhavia diffusa, Mollugo nudicaulis, Digera arvensis, Oldenlandia umbellata, Phyllanthus niruri, Trianthema monogyna, Tridex procumbens and Amaranthus spinosus. Cyperus rotundus and Cyperusiria were recorded as sedges.

Weed seed bank decreased with increasing depth of soil almost in all the treatments. However, the higher density of weed seeds was found in weedy check conditions under all the tillage systems. Highest weed seed bank was recorded under ZT-ZT-Weedy check followed by ZT-CT-Weedy check followed by CT-ZT-Weedy check, respectively.

Table 3.5.9: Effect of tillage and weed control measures on weed seed bank under Pearlmillet-wheat cropping system at Anand centre.

Weed species					Tr	eatme	nts*					
_	1	2	3	4	5	6	7	8	9	10	11	12
Soil depth: 0 - 5 cm												
Total Grasses	5	5	21	3	4	20	4	4	21	1	2	17
Total sedges	2	2	4	-	2	3	-	2	1	-	1	2
Total others	6	5	28	3	3	10	-	4	20	3	2	23
Grand Total	13	12	53	6	9	33	4	10	42	4	5	42
Soil depth: 5 -10 cm												
Total Grasses	3	3	7	3	3	11	1	3	9	3	3	7
Total sedges	1	1	4	-	1	2	-	1	3	1	-	3
Total others	5	6	13	4	5	15	4	6	11	3	3	7
Grand Total	9	10	24	7	9	18	5	10	23	7	6	17
Soil depth: 10 -1 5 cm												
Total Grasses	1	3	5	1	1	2	1	2	3	-	-	3
Total sedges	1	-	1	-	1	3	-	-	-	-	1	2
Total others	-	2	5	-	1	5	-	-	5	-	1	4
Grand Total	4	3	11	1	1	10	1	2	8	-	1	9

- *1 ZT-ZT+ handweeding
- 2 ZT-ZT+ Atrazine 0.50 kg/ha
- 3 ZT-ZT+ Weedy check
- 4 ZT-CT+ handweeding
- 5 ZT-CT+ Atrazine 0.50 kg/ha
- 6 ZT-CT+ Weedy check

- 7 CT-ZT+ handweeding
- 8 CT-ZT+ Atrazine 0.50 kg/ha
- 9 CT-ZT+ Weedy check
- 10 CT-CT+ handweeding
- 11 CT-CT+ Atrazine 0.50 kg/ha
- 12 CT-CT+ Weedy check

Maize-sunflower cropping system (Coimbatore and Bengaluru)

At Coimbatore centre, the predominant grassy weeds were Dactyloctenium aegyptium, Cynodon dactylon, Chloris barbata Dinebra retroflexa and Setaria verticiliata. Among broadleaf weeds, Trianthema portulacastrum, Digeria arvensis, Boerhaavia diffusa, Amaranthus viridis, Datura metal, Corchorus olitorius, Portulaca oleracea, and Parthenium hysterophorus; and among sedges, Cyperus rotundus were the dominant weedflora. Among all the weeds Daoctyloctenium aegyptium and Trianthema portulacastrum were the most predominant weed in the experimental field. Whereas, at Bengaluru centre, the maize field was infested mainly with Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium, Echinochloa colona among grasses; and Commelina

benghalensis, Euphorbia geniculata and Borreria articularis (from initial stages), Euphorbia hirta (from 60 DAS onwards) among broad-leaved weeds; and Cyperus rotundus as sedge.

Significantly lower density and dry biomass of weeds were recorded in CT-CT among different tillage combinations and with the application of atrazine 0.5 kg a.i./ha + Hand weeding on 45 DAS among weed control measures at Coimbatore centre. While at Bengaluru, zero tillage favoured the dominance of sedge (*C. rotundus*), annual grasses (*E. colona*) and broad leaf weeds (*E. geniculata*) as compared to conventional tillage. With advance in crop growth at 60 DAS, the density of all types of weed species showed an increasing trend as compared to previous stage of 30 DAS. Dry weight of broad leaf weeds and grasses was higher, closely

followed by sedge. At both the centres, plot under zero tillage had higher total weeds dry weight as compared to conventional tillage.

There was significant effect on grain yield of maize due to different tillage and weed management practices at both coordinating centres. At Coimbatore, among the tillage methods, the yield attributes and grain yield was significantly higher under continuous conventional tillage followed during both the seasons than all other treatments except CT-ZT tillage system. The treatment ZT-CT was registered to produce lowest grain yield. Similar effect of tillage was also observed at Bengaluru centre. Among the weed control treatments, herbicidal treatment was recorded significantly higher yield attributes and seed yield which was comparable with 2 hand weeding treatment given on 25 and 45 DAS at both centres. This was mainly due to weed free environment in the early stage of the crop growth with the application of preemergence herbicide of atrazine @ 0.5 kg a.i./ha, which facilitated better growth of the crop with pronounced yield attributes.

Seed yield of sunflower and economics of weed control treatments have been reported by Bengaluru centre only. Continuous conventional tillage in both seasons gave higher seed yield (1180 kg/ha) than the plot followed continuouszero tillage (624 kg/ha). However, the plots with alternating conventional tillage and zero tillage in kharif and summer, respectively gave seed yields (950 to 872 kg/ha), which was lower than continuous conventional tillage, but higher than continuous zero tillage. Among weed control measures, the highest seed yield of sunflower was recorded with 2 hand weeding given at 25 and 45 DAS. However, the plot treated with butachlor gave seed yield (977 kg/ha), lower than hand weeding (1329 kg/ha) and these two treatments were significantly superior to unweeded control (413 kg/ha).

Table 3.5.10: Effect of tillage and weed control methods on weed growth and weed control efficiency in maize at 60 DAS at Coimbatore and Bengaluru centre,

Treatment	Weed densi	ty (no./m ²)	Weed dry m	atter (g/ m ²)	Weed control	efficiency (%)
Tillage	Coimbatore*	Bengaluru**	Coimbatore*	Bengaluru**	Coimbatore*	Bengaluru**
ZT-ZT	5.03 (25.33)	1.84 (71.3)	4.20 (17.67)	1.32 (28.7)	65.09	47.00
ZT-CT	5.72 (32.67)	1.81 (66.1)	4.86 (23.67)	1.27 (24.0)	53.24	55.56
CT-ZT	5.42 (29.33)	1.75 (57.9)	4.47 (20.00)	1.19 (20.5)	60.49	62.04
CT-CT	4.24 (18.00)	1.70 (54.1)	3.70 (13.67)	1.12 (19.0)	73.00	64.82
LSD (P=0.05)	0.38	0.13	0.32	0.12	-	-
Weed control						
HW-HW	6.22 (38.67)	1.68 (47.4)	5.01 (25.07)	0.96 (7.4)	50.48	86.30
RH-RH	7.81 (61.00)	1.65 (44.3)	4.23 (17.90)	0.98 (7.8)	64.64	85.56
WC-WC	13.35 (178.33)	1.98 (95.5)	7.12 (50.63)	1.74 (54.0)	-	-
LSD (P=0.05)	0.69	0.07	0.41	0.06	-	-

^{*} Square root transformation, values in parentheses is original

^{**} Log transformation

		Sunfl	ower		Yield (kg/ha)				
Treatment		ed density no./m²)	Weed	d dry matter (g/ m²)		Maize	Sunflower		
	Coimba	Bengaluru**	Coim	Bengaluru**	Coimb Bengaluru**		Coimb	Bengaluru**	
	tore		batore				atore		
Tillage									
ZT-ZT	-	1.89 (87.8)	-	1.62 (55.2)	4267	1989	-	624	
ZT-CT	-	1.81 (78.7)	-	1.53 (47.2)	4063 2333		-	950	
CT-ZT	-	1.88 (87.0)	-	1.63 (56.5)	4745	2777	-	872	
CT-CT	-	1.75 (71.2)	-	1.47 (43.1)	5035	2956	-	1180	
LSD (P=0.05)	-	NS	-	NS	538.7	649	-	NS	
Weed control					•		•		
HW-HW	-	1.86 (72.1)	-	1.62 (40.6)	5046	3002	-	977	
RH-RH	-	1.51 (38.7)	-	1.07 (12.2)	5298 3335		-	1329	
WC-WC	-	2.13 (132.7)	-	2.00 (98.7)	3017 1205		-	413	
LSD (P=0.05)	-	0.18	-	0.15	516.2 529		-	151.64	

Table 3.5.11: Effect of tillage and weed control methods on weed growth in sunflower at 60 DAS and yield of maize and sunflower.

Shift in Weed Flora

At Bengaluru centre, under zero tillage, sedge density was more in summer season than conventional tillage during 2005, while the trend was reverse during kharif 2008, wherein sedge density was more in conventional tillage than zero tillage. In zero tillage, broad leaf weeds was low (17.3/m²) initially in 2005 summer and it increased to the tune of 76.3/m² in kharif 2008 (more emergence of Borreria articularis and Euphorbia geniculata) and then decreased to 34.3/m² during *kharif*, 2012. Whereas, in respect to grasses, the density was more with conventional tillage (82.7 grasses/m²) than zero tillage (26.7/m²) during initial period of 2005, while the density of grasses was higher in zero tillage $(40.7/\text{m}^2)$ than conventional tillage $(24.7/\text{m}^2)$ in kharif, 2012 at the end of 8th cycle of trial, perhaps due to build up of annual grasses - E. colona and D. marginata. Among grasses, density of Cynodon dactylon was slightly more in conventional tillage than zero tillage owing to distribution of root fragments due to tillage.

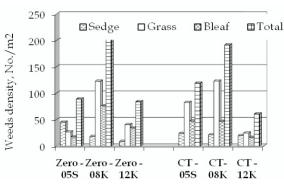


Fig.3.5.1: Shift in weed flora due to tillage practices under unweeded situation in sunflower – maize during *summer* 2005 to *kharif* 2012 at Bengaluru centre.

Maize-chickpea cropping system (Dharwad)

The major weed flora present in the experimental field was *Commelina benghalensis*, *Digera arvensis*, *Ageratum conyzoides*, *Corchorus sp*, *Phyllanthus sp.*, *Mollugo sp.*, *Cyanotis sp.* among BLWs; *Dinebra retroflexa* among grasses; *Cyperus rotundus* and *Cynodon dactylon* among perennial weeds.

During *rabi* 2011, chickpea yield was significantly higher in Conventional tillage (CT)

^{*} Log transformation, values in parentheses is original

than Zero tillage (ZT). Among weed control treatments, HW and recommended herbicide were on par with each other (850 and 808 kg/ha, respectively), but significantly higher than weedy check (707 kg/ha). The same trend was followed for weed density and weed dry matter.

For maize, only CT was followed. In *rabi* crop (Chickpea), tillage treatments viz., ZT and CT were imposed. The weed control treatments differed significantly. The maize yields obtained with HW (4576 kg/ha) were significantly higher than recommended herbicide i.e atrazine @ 1 kg/ha (4119 kg/ha). The weed density and weed dry matter at 60 DAS were significantly lower with HW. The net return was higher with HW (₹30910/ha) followed by RH (₹28090/ha).

In general the microbial load in soil during rabi season viz., free living N2 fixers and Mineral Phosphate Solubilizing Microorganisms (MPS) was found to be more in the treatment received ZT and HW (154.0 x 10 4 CFU g $^{-1}$ of soil and 50.50 x 10 4 CFU g⁻¹ of soil respectively) on 30 DAS, while CT and RH (alachlor at 1.5 kg/ha) recorded lowest population of free living N₂ fixers (12 X10⁴ CFU g⁻¹ of soil). Similar trend was noticed on 60 days stage of crop growth. However, on 60 DAS, the population of free living N2 fixers with ZT +HW (37.5 X10⁴ CFU g⁻¹ of soil) was statistically on par with ZT+RH (30 X10⁴ CFU g⁻¹ of soil). Increased population of P- solubilizers was noticed on 60 DAS in the plot received RH (38 X10⁴ CFU g⁻¹ of soil), which was on par with weedy check (48.5 X 10⁴ CFU g⁻¹ of soil). Highest respiration, dehydrogenase and phosphatase enzyme activity was recorded with ZT+HW (75.74 CO, per 100g soil d-1, 0.80 μg TPF formed $g^{\text{--}}$ soil d-1 and 30.17 μg pnp released g-1 soil ha-1 respectively), while the plots received CT and RH (atrazine 1.0 kg/ha) recorded lowest respiration, dehydrogenase and phosphatase activity(10.4 CO₂ per 100g soil d⁻¹, 0.19 μg TPF formed g⁻¹ soil d⁻¹ and 16.89 μg pnp released g⁻¹ soil ha⁻¹ respectively) on 30 DAS.

In *kharif* season, highest population of free living nitrogen fixing bacteria and mineral phosphate solubilizers were recorded with ZT + HW at 30, 60 and 90 DAS and lowest microbial load was recorded in the treatment received

CT+RH (18 X10 4 CFU g⁻¹ of soil). However, on 90 DAS the population of Mineral phosphate solubilizers in the treatment ZT+HW (61.33 X10⁴ CFU g⁻¹ of soil) and ZT+RH (57.52 X10⁴ CFU g⁻¹ of soil) were found to be on par with each other. The observations recorded on soil enzymes at 30 DAS revealed that the Dehydrogenase and Phosphatase activity was highest in the treatment ZT + HW (16.77 μg TPF formed g⁻¹ soil d⁻¹ and 73.44 µg pnp released g⁻¹ soil ha⁻¹ respectively) and lowest activity was noticed in CT + RH on 30th 60th and 90 DAS. However, the results at 90 DAS have revealed that an increased dehydrogenase and phosphatase enzyme activity was noticed in the treatment ZT + RH (51.69 µg TPF formed g⁻¹ soil d⁻¹ and 122.57 µg pnp released g⁻¹ soil ha⁻¹ respectively) and found to be on par with ZT + HW (56.86 μ g TPF formed g⁻¹ soil d⁻¹ and 134.76 μ g pnp released g⁻¹ soil ha⁻¹ respectively).

WS 3.6 : Weed management in conservation agriculture systems

Adequate food production for ever increasing global population can only be achieved through the implementation of sustainable growing practices that minimize environmental degradation and preserve resources while maintaining high yielding, profitable systems. Weeds are the major constraints in conservation agriculture. Any reduction in tillage intensity or frequency may, therefore, influence the weed infestation. The composition of weed species and their relative time of emergence differ between conservation agriculture systems (CAs) and soil inverting conventional tillage systems (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 physicochemical 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 Ludhiana, Pantanagar, Faizabad, Pusa, Jorhat, Sriniketan, hyderabad, and Bengaluru, Coimbatore in rice based cropping systems; and Palampur, Ranchi, Parbhani, Dharwad, Anand and Gwalior in nonrice based cropping systems

Rice-wheat cropping system

Dominant weed flora in rice were Echinochloa colona, Leptochloa chinensis, Echinochloa crus-galli and Panicum maximum among grasses; Alternanthera sessilis, Caesulia axillaris, Ammania baccifera among broad leaved weeds; and Cyperus iria, Cyperus difformis and Cyperus rotundus among the sedges at Pantnagar; Echinocloa crusgalli, E. colonam, Dactyloctenium aegyptium, Digitaria sanguinalis, Cynodon dactylon among grasses; Cyperus rotundus, Cyperus diformis, Fimbristylis miliaceae among sedges; and Caesulia axillaris, Lippia nodiflora, Ammania bacifera, Eclipta alba, Phyllanthus niruri and Ipomoea aquatic among broad-leaved weeds at Pusa; and Echinochloa colona, Panicum repens among grasses; Ludwigia parviflora, Spilanthus acmella, Dopatrium junceum, Marselia quadrifoliata, Eclipta alba, Rotala verticillaris among broad-leaved weeds; and Cyperus difformis, Scirpus sp, Fimbristylis miliacea among sedges at Bengaluru.

Different crop establishment techniques did not influence the total weed population. However, highest weed dry biomass was

recorded under ZT-DSR with retention of crop residue in rice at Pantnagar. While at Pusa and Bengaluru, conventional tilled-transplanted rice had significantly lower weed density and dry weight as compared to zero tillage at all stages. Lowest weed count (11.17/m²) and weed dry weight (22.79 g/m²) were recorded at 60 DAS under CT (Transplanted) - ZT-ZT being statistically at par with CT (Transplanted)-CT was significantly superior over rest of the treatments. Highest weed counts (23.78/m²) and weed dry weight (47.69 g/m²) was recorded under ZT (Direct-seeded) at Pusa centre. Zero tillage had more emergence of weeds particularly sedges (F. miliacea) and broad leaf weeds (E. alba) at Bengaluru centre. Transplanted rice and direct seeded rice under CT produce almost similar density and dry biomass production of weeds. 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 (4410 to 4413 kg/ha) or direct seeding of rice (4177 kg/ha) gave significantly higher yields than direct seeded rice (3318 to 3357 kg/ha) under zero tillage at Bengaluru. Similarly, at Pusa, highest grain yield of rice (4210 kg/ha) was recorded under CT (Transplanted) - CT which was statistically at par with CT (Transplanted) - ZT-ZT. However, there was no much difference in grain yield of rice due to crop establishment methods at Pantnagar centre. Under different weed control methods, integrated weed management practice produced the maximum grain yield (4020-5076 kg/ha) followed by recommended herbicides (3930-4701 kg/ha) at all the coordinating centres. However, lowest grain yield of rice (3070kg/ha) was obtained under ZT (Direct-seeded) - ZT- ZT at Pusa and Bangaluru centres.

	Weed o	density (N	$[o./m^2)$	Weed dry biomass (g/m²)		Grain yield (kg/ha)			Straw yield (kg/ha)			
Treatments	Bengalu- ru	Pusa	Pantnag- ar	Bengal- uru	Pusa	Pantna- gar	Beng- aluru	Pusa	Pantna- gar	Bengalu- ru	Pusa	Pantna- gar
Establishment												
techniques												
CT (Transplanted)-CT	1.91 (85.4)	12.22	27.6	1.62 (52.2)	24.86	81.8	4410	4210	3506	5715	6220	5039
CT (Transplanted)-ZT- ZT	1.91 (87.2)	11.17	33.3	1.61 (51.0)	22.79	27.8	4413	4070	4142	5788	5960	5775
CT (Direct -seeded)-CT- ZT	1.93 (87.4)	19.52	29.9	1.64 (52.8)	39.31	67.8	4177	3580	3869	5498	5180	5378
ZT (Direct -seeded)-ZT- ZT	2.04 (111.3)	23.78	24.9	1.81 (72.7)	47.69	55.3	3357	3070	3919	4696	4260	5550
ZT(Direct -seeded) + R-ZT+R-ZT	2.04 (109.3)	23.02	28.6	1.82 (70.5)	46.15	125.4	3318	3380	4025	4683	4740	5686
LSD (P=0.05)	NS	1.18	-	0.09	1.15	-	526.4	200	-	572.1	290	-
Weed control measures												
Recommended herbicides	1.92 (83.8)	14.12	21.8	1.66 (45.6)	29.41	36.9	4701	3930	4402	6050	5760	6040
IWM (herbicide + mechanical weeding +	1.86 (74.4)	12.86	8.4	1.39 (24.7)	26.32	8.61	5076	4020	4617	6422	5980	6428

52.75

1.92

169.3

2028

391.7

3030

100

2.04

(109.3)

0.06

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

The same long-term trial was also undertaken at Ludhiana and Faizabad coordinating centres. The experiment was laid out after leveling the fields using laser leveler. Rice crop grown under CT situation only during kharif season followed by wheat as per technical programme. The data on the different aspects of weed dynamics and crop parameters during rabi 2012-13 are being recorded. Experiments are in progress.

2 12

26.84

1.33

60.5

Rice-rice cropping system

intercrop)

Unweeded

LSD (P=0.05)

The experiment was conducted at Coimbatore centre. 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.

There was no significant effect on weed dry weight due to different tillage methods at 30, 60 DAS/T and at harvest. Lower weed dry weight was observed in conventional tillage (TPR) - conventional tillage system and conventional tillage (DSR) - CT-ZT. Higher weed dry weight (9.19 g/ m²) was observed in direct seeded zero

tillage + R at harvest stage of crop. Among the weed management methods, integrated weed management (IWM) recorded lower weed dry weight which was closely followed by chemical method of weed control. Higher weed dry weight was registered under un-weeded plot.

2658

3355

410.0

4070

140

3988

During 60 DAT/S, higher weed control efficiency was observed in conventional tillage (TPR) - Conventional tillage system (52.72%) and conventional tillage (DSR) - zero tillage (DSR) (51.46%) system. This was closely followed by TPR (CT)-DSR (ZT). However, lowest weed control efficiency was observed under direct seeded rice (ZT) with retention of crop residues (42.93%). Among the weed management measures, integrated weed management recorded higher weed control efficiency (55.94) which was followed by weed control through recommended herbicide (52.02%).

There was significant effect on tiller production due to different tillage methods. At 30 DAT/S higher tiller per hill was observed in DSR (ZT) + R - ZT + R - ZT and conventional tillage (DSR) - conventional tillage - zero tillage. This was closely followed by DSR under conventional

tillage - zero tillage - zero tillage. The lower tiller per hill was registered with transplanted conventional tillage-conventional tillage treatment. Among the weed management methods, integrated weed management was recorded higher tillers per hill which was on par with chemical method of weed control. Lower tiller per hill was registered with un-weeded check.

There was significant effect on grain yield due to different tillage methods and weed management methods. Higher grain yield was observed in conventional tillage - conventional tillage system (5603 kg/ha) and transplanted conventional tillage system (5278 kg/ha). This was closely followed by direct seeded rice under conventional tillage. Lower grain yield (4826kg/ha) of rice was registered with direct seeded zero tillage treatments. Among the weed management methods, integrated weed management method recorded higher grain yield (5520 kg/ha) which was on par under chemical method of weed control with the application of recommended herbicide. Lower grain yield was registered with un-weeded check.

Rice-maize cropping system (Hyderabad)

Since the experiment was initiated during

2012-13 only, during first year of experimentation i.e *kharif*, 2012, all the main plots were ploughed and leveled uniformly and instead of direct seeding of rice all the plots were transplanted uniformly irrespective of the treatments. In sub plots, treatments were imposed as per technical programme. In *rabi*, maize crop was taken up implementing all the treatments in main plots as per the technical programme.

Weed flora observed in the experimental rice field were Scripus supirus, Cyperus difformis, Ammania baccifera, Panicum spp and Bacopa spp, Echinochloa colona and Cyperus iria during kharif, 2012. Since the main plot treatmentrs were not imposed for kharif rice, there were no significant differences between the treatments with regard to weed dry matter and grain yield of rice. Weed dry matter recorded was ranged between 44.37 g/m² to 45.74 g/m². Grain yield of rice ranged between 4687 kg/ha to 4975 kg/ha. Regarding weed management practices all the treatments significantly influenced the weed dry matter and grain yield of rice. Lowest weed dry matter was recorded with early post-emergence application of bispyribac-sodium @ 20 g/ha fb mechanical weeding/hand weeding, which was followed by pre-emergence application of pretilachlor 0.5 kg/ha fb post-emergence application of

Table 3.6.2: Weed dry matter production and grain yield of rice as influenced by different treatments under conservation agriculture

Treatments		Weed dry weight (g/m²)	Yield (Kg/ha)
CT(TPR)-CT (winter maize)	Un-weeded	100.52	3390
	Recommended herbicide	20.24	4907
	IWM	12.35	5780
CT(TPR)- ZT (winter maize),-ZT	Un-weeded	102.72	3730
(cowpea/ greengram)	Recommended herbicide	19.82	5150
	IWM	12.74	5695
CT (DSR) -CT (winter maize)- ZT	Un-weeded	103.42	3725
(cowpea/ greengram	Recommended herbicide	21.05	5350
	IWM	12.75	5850
ZT (DSR) - ZT (winter maize) - ZT	Un-weeded	99.74	3718
(cowpea/ greengram)	Recommended herbicide	20.85	4873
	IWM	11.98	5518
ZT (DSR)+R - ZT+R (winter maize) -	Un-weeded	101.75	3308
ZT (cowpea/ greengram)	Recommended herbicide	21.35	4805
	IWM	13.02	5648

cyhalofop-p-butyl + Almix (metsulfuron methyl + chlorimuron ethyl) at 25 DAT (20.66 g/m²). Highest weed dry matter was recorded by unweeded control (101.63 g/m²). As far as grain yield of rice is concerned, higher rice grain yield was recorded with integrated management involving early post-emergence application of bispyribac sodium @ 20 g/ha fb mechanical/hand weeding at 40 DAT (5698 kg/ha) followed by pretilachlor 0.5 kg/ha as PE fb cyhalofop-p-butyl 100 g/ha + Almix 4 g/ha (metsulfuron methyl + chlorimuron ethyl) (5017 kg/ha). However, lowest grain yield of rice was recorded with un-weeded control (3574 kg/ha).

Rice-yellow sarson cropping system (Sriniketan)

The rice field was infested with Cynodon

dactylon, Digitaria sanguinalis, Echinochloa colona, Paspalum sp., Ludwigia parviflora, Gompherna celosioides, Lindernia crustacea, Lindernia ciliata, Oldenlandia corymbosa, Commelina diffusa, Spilanthes acmella, Phyllanthus simplex, Alternanthera sessilis, Commelina nudiflora, Melochia corchorifolia, Cyperus iria and Fimbristylis miliacea. Among all, the pre-dominant weed species were Cynodon dactylon, Ludwigia parviflora, Lindernia crustacea and Fimbristylis miliacea. Among weed control treatments, IWM (herbicide + mechanical weeding) was found most effective in reducing both number and dry matter of different categories of weeds; increasing the height, crop biomass, crop stand, yield attributes and yield of rice (Table 3.6.3).

Table 3.6.3: Effect of crop establishment techniques and weed control measures on weed growth and grain yield of rice

Treatments		Weed population (No./m²) at 60 DAT			Dry matter of weeds (g/m²) at 60 DAT				Effective tillers/m ²	Grain yield	
		Grass	BLWs	Sedge	Total	Grass	BLWs	Sedge	Total		(kg/ha)
CT (Transplant ed)-CT	Recommended herbicides	27.3	12.2	10.3	49.8	5.6	12.4	6.7	24.7	341	4183
CT (Transplant ed)-CT	IWM (herbicide + mechanical weeding + intercrop)	8.2	5.7	4.9	18.8	2.8	6.1	2.1	11	345	4401
CT (Transplant ed)-CT	Un-weeded	55.3	115.5	49.3	220.1	26.6	193.2	24.6	244.4	269	2674
CT (Transplant ed)-ZT-ZT	Recommended herbicides	21.4	10.4	9.3	41.1	5.5	10.9	5.9	22.3	337	4178
CT (Transplant ed)-ZT-ZT	IWM (herbicide + mechanical weeding + intercrop)	6.2	7.1	3.5	16.8	3.4	5.7	2.1	11.2	344	4448
CT (Transplant ed)-ZT-ZT	Un-weeded	48.3	105.2	51.0	204.5	30.2	197.8	26.5	254.5	281	2713

Table 3.6.4: Weed growth and yield parameters of winter rice as affected by treatments

Weed control measures	Weed density (No/m ²)	Weed dry weight (g/m ²)	Plant height (cm)	Panicle Number/hill	Panicle length (cm)	Grain yield (g/ha)
Pretilachlor @750 g/ha	21.6	11.58	85.3	12.6	20.6	26.7
Pretilachlor @750 g/ha + paddy weeder 30 DAT	18.6	10.23	92.8	13.2	21.1	27.1
Un-weeded control	32.8	23.18	92.1	8.8	18.2	19.6

Pearl millet-chickpea cropping system (Parbhani)

Since the experiment was initiated during 2012-13 only, during first year of experimentation i.e *kharif*, 2012, main plot treatments as per technical programme could not be imposed. However, in sub plots, treatments were imposed as per technical programme. Results of first season reveals that dry weed biomass of both grassy as well as broad-leaved weeds at 60 DAS were not influenced due to various tillage practices. Significantly lowest dry matter of grassy as well as broad-leaved weeds was recorded in plots treated with recommended herbicide and IWM (herbicide + hand weeding +

intercrop), which was found significantly superior over un-weeded check.

Similarly, the plant height, plant dry matter, grain and stover yield of pearl millet were not influenced due to various tillage practice treatments. However, the plant height, plant dry matter and yield of pearl-millet were significantly influenced due to various weed control treatments. Maximum plant height, crop dry biomass per plant, and grain and stover yield was recorded with recommended herbicide and IWM, which were significantly higher than un-weeded control. The succeeding chickpea crop was sown in November, 2012 and will be harvested in February, 2013.

Table 3.6.5: Weed dynamics, plant growth and grain yield of pearl millet as influenced by different treatment under conservation agriculture.

Treatment	Weed Dry (g/m²		Weed seed g per Kg of so	Seed yield	
	Broadleaved Grasses		Broadleaved	Grasses	(kg/ha)
	weeds		weeds		
Tillage					
Conventional - Conventional tillage	20.3	6.7	3.0	2.3	612
Conventional tillage - Zero tillage	25.8	8.4	3.0	2.3	623
Zero tillage – Zero tillage	25.7	6.2	2.6	1.9	684
Zero tillage – Zero tillage +R	29.6	8.8	3.0	2.6	674
Zero tillage +R – Zero tillage +R	19.4 5.8		3.3	2.0	622
LSD (P=0.05)	NS	NS	NS	NS	NS
Weed control treatments					
Recommended herbicides	15.4	6.2	2.0	1.3	
Integrated weed management	16.0	6.3	2.3	1.6	791
(herbicide + mechanical weeding +					
intercrop)					
Un-weeded control	30.1	8.3	4.6	3.8	820
LSD (P=0.05)	13.1	2.9	2.0	1.1	50

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

Long-term herbicide trials are been conducted in major cropping systems of the

respective centres in fixed plots to find out the effect of herbicide use on crop productivity, soil health, residues in soil and crop produce etc.

Rice-rice cropping system TNAU, Coimbatore Experimental details a) Treatments

Weed control methods	Source of nitrogen		
vveed control methods	Inorganic	Organic	
W₁N₁ - Hand weeding twice	100 %	-	
W₁N₂ - Hand weeding twice	75%	25%	
W_2N_1 - Butachlor 0.75 + 2,4-DEE 0.4 kg / ha	100%	-	
W_2N_2 - Butachlor 0.75 + 2,4-DEE 0.4 kg / ha	75%	25%	
W_3N_1 - Butachlor 0.75 + 2,4DEE 0.4 kg / haPretilachlor 0.75 + 2,4 DEE 0.4 kg / ha	100%	-	
W_3N_2 - Butachlor 0.75 + 2,4DEE 0.4 kg / ha- Pretilachlor 0.75+ 2,4 DEE 0.4 kg / ha	75%	25%	

W₁ & W₂: Same weed control methods for *kharif* & *rabi* crops

W₃: Herbicide rotation for kharif & rabi crops

Finding

- The effect on weed density and weed dry weight was minimum under rotational use of herbicides (butachlor in *kharif* and Pretilachlor in *rabi*) with integration of nutrients.
- Broad leaved weeds density were higher in Butachlor 0.75 + 2,4-DEE 0.4 kg/ ha with 100 % inorganic nitrogen of XXV crop (60 DAT) when compared to other treatment combinations.
- Integration of weed control by butachlor + 2,4-DEE with integration of nutrients recorded maximum yield which is on par with Hand weeding twice with integration of nutrients (W₁N₂), Butachlor + 2,4-DEE Pretilachlor rotation with 100% inorganic nitrogen (W₃N₂) and Butachlor + 2,4-DEE Pretilachlor rotation with integration of nutrients (W₃N₁).
- Weed shift from broad leaved weed (Marsilea quadrifolia) to grasses (Echinochloa crusgalli) and sedges (Cyperus difformis) was observed during Kharif, 2012 (XXV crop).

AAU, Jorhat

Treatment

 T_1 Farmer's practice (one HW)

- T₂ Butachlor + 2,4-D (100% NPK through chemical fertilizer)
- T₃ Butachlor + 2,4-D (75% NPK chemical fertilizer, 25% through organic source)
- T₄ Butachlor + 2,4-D rotated with pretilachlor (100% NPK chemical fertilizer)
- T₅ Butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source)

At Jorhat, rice-rice cropping system is one of the major cropping systems of Assam.

Kharif rice

The weed density and dry weight were significantly reduced due to weed and nutrient management practices compared to farmers' practice of two hand weeding at 30 and 60 DAT with recommended doses of fertilizer. The lowest values were recorded with butachlor + 2,4-D (75% NPK through chemical fertilizer, 25% through organic source) and butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer).

The highest grain yield was obtained from the treatment with butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) which was closely followed by Butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source).

Winter rice: The weed density and dry weight were significantly reduced due to weed and nutrient management practices compared to farmers' practice of two hand weeding at 30 and 60 DAT with recommended doses of fertilizer. Among the treatments, butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) and butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source) maintained a lower weed density and dry weight all throughout the growing season.

The highest grain yield was recorded with butachlor + 2,4-D rotated with pretilachlor (100% chemical fertilizer) and butachlor + 2,4-D rotated with pretilachlor (75% NPK through chemical fertilizer, 25% through organic source)

Weed flora dynamics:

Weed flora have been monitored since initiation of the trial at an interval of 30 days in the cropping period. The changes recorded during the critical period of crop weed competition were as follows:

- There was heavy reduction of grasses in the entire field. In autumn rice fields since 2009, only grass species recorded were *Leersia hexandra* and *Sacciolepis interrupta*.
- Amongst the other grass species once appeared in the experiment, *Echinochoa crusgalli*, *Isachne globosa*, *Oryza rufipogon* and *Rottboelia exeltata* were not noticed after 2008 in the autumn rice.
- Continuous rice cultivation in both the seasons has gradually eliminated several weed species from the permanent plots of the experiment viz. *Euphea balsamona*in autumn and *Fimbristylis littoralis* and *Scirpus maritims* in *kharif* season. It also reduced the population and soil seed bank of *Cyperus iria* and *Ceratophyllum-Utricularia* complex.
- Herbicide rotation has reduced the population of Monochoria vaginalis and Sagittaria quayanensis, Eleocharis dulcis and Cyperus iria.

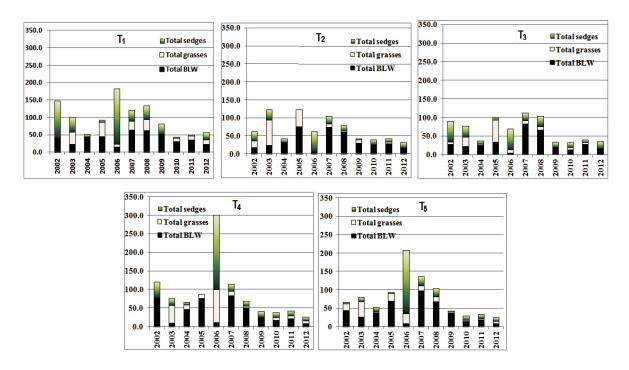


Fig. 3.7.1. Changes in weed population over the years at critical crop growth period in the autumn rice of the long-term herbicidal trial in rice-rice cropping sequence

UAS, Bengaluru

A. Summer rice - 2012 (Twenty sixth season)

The field experiment was conducted during summer 2012 as twenty-sixth crop cycle at the Agricultural Research Station, Kathalagere, Davanagere District. The soil type was sandy clay loam with average fertility level. The three weed control treatments tested were as follows:

- a) Weed Management practices: 3
- W1 Butachlor 0.75 kg ai/ha + 2,4-D EE 0.4 kg ai/ha (pre- emergence, within 3 days after planting {3 DAP}, applied in sequence) both during *kharif* and summer,
- W2 Butachlor 0.75 kg ai/ha + 2,4-D EE 0.4 kg ai/ha (pre-emergence, within 3 DAP, applied in sequence) during *kharif* followed by pretilachlor 0.75 kg ai/ha (pre-emergence within 3 DAP) during summer
- W3 Hand weeding twice (20 and 45 days after planting, DAP) during both the seasons

These three weed management practices were integrated with two sources of fertility levels, as follows

- b) Sources of Fertility: 2
- F1 75% NPK supplied through fertilizer + 25% NPK supplied through FYM (with organic matter, + OM).
- F2 100% NPK supplied through fertilizers only (without organic matter, OM) and

Treatment combinations were - 6

T1 - W1 +F1, T2 - W2 + F1, T3 - W3 + F1, T4 - W1 + F2, T5 - W2 + F2 and T6 - W3 + F2

Weed flora:

Major weed flora observed in the experimental plots was *Cyperus difformis*, *Fimbristylis miliacea*, *Scirpus* sp (from initial stages) (nearing harvest) (among sedges), *Paspalum dilatatum* (from initial stage) (among grasses). Where as among broad leaf weeds, major weeds were *Ludwigia parviflora*, *Eclipta alba*, *Dopatrium junceum*, *Glinus oppositifolius*, *Marselia quadrifoliata* (from initial stage); *Rotala verticillaris* (from 60 DAP). Other weeds observed in lower densities

were Cyperus iria, C. procerus (sedge); Panicum repens, Panicum tripheron, Echinochloa glabrescens (among grasses), Alternanthera sessilis, Monochoria vaginalis, Cyanotis axillaris, Lobelia olecinoides, Lindernia veronicaefolia, Spilanthes acmella (among broad leaf weeds). Among the weed species, the density of Scirpus sp, C. difformis, F. miliacea, P. dilatatum, E. alba, D. junceum, L. parviflora and M. quadrifoliata were higher than other weed species, indicating their dominance from the beginning or at any stage of the crop cycle.

Weed Density:

At 30 DAP, the density of broad leaf weeds (*L. parviflora*, *E. alba* and *D. junceum*) was higher, followed by sedge (particularly *C. difformis* and *Scirpus* sp) and grasses (*P. dilatatum*). Application of butachlor + 2,4-D EE in both the seasons or fb pretilachlor during summer showed slightly lower weeds' density – sedges and broad leaf weeds at 30, 60 DAP and harvest than the use of butachlor + 2,4-D EE in both the seasons, but higher than hand weeding treatment at 30 and 60 DAP. While the density of grasses was higher in pretilachlor treated plot than butachlor + 2,4-D EE treatment at 30 and 60 DAP.

With advance in crop growth at 60 DAP and harvest, the density of weeds' category showed much increase from 24.8 total weeds/m² at 30 DAP in hand weeding to 57.3/m² at 60 DAP. Broad leaf weeds maintained their dominance, followed by sedges and grasses (showed increase compared to 30 DAP). At this stage, weeds like *C. difformis, Scirpus* sp, *F. miliacea, P. dilatatum, L. parviflora, D. junceum and M. quadrifoliata* dominated over other weeds.

Shift in weed flora due to herbicide usage in rice-rice system:

During *kharif* 1999, the densities of sedge, grass and broad leaf weeds were similar between two butachlor + 2, 4-D EE treatments. However during summer 2002 (i.e. after 5th rice) and 2012 (after 13th rice crop), the density of sedge (particularly *Scirpus* sp, *Cyperus difformis*, *F. miliacea* and *C. iria*) was three times and 1½ times, respectively higher in application of butachlor + 2,4-D EE both during *kharif* and summer as

compared to plot receiving butachlor + 2,4-D EE during kharif and pretilachlor in summer. While such increase was two fold in grasses' density in the former treatment as compared to latter treatment during 2002 summer and it was reverse during 2012 summer. This suggested that continuous use of butachlor + 2,4-D EE paved way for build up of sedges and rotation with pretilachlor lowered the density of sedges. However, the density of broad leaf weeds was lower in treatment receiving pretilachlor during summer fb butachlor + 2,4-D EE during Kharif than the use of butachlor + 2,4-D EE during both Kharif and summer seasons during 1999 Kharif and 2012 summer. Further, generally weeds' density was higher in all treatments particularly during summer 2002 than the summer rice in 1999 and 2012.

Rice yield:

It is clear that usage of herbicide butachlor 0.75 kg + 2,4-D EE 0.4 kg ai/ha (3 DAP, applied in sequence) during *kharif fb* pretilachlor in summer (4979 kg/ha) resulted in grain yield similar to that hand weeding (5025 kg/ha) during 1999 to 2010, but these two treatments were slightly superior to treatment of butachlor + 2,4-D EE in both the seasons (4765 kg/ha). The beneficial effect of FYM on yield of rice was not observed initially. However, beneficial effect of FYM in producing slightly higher yield in 2010s (4937 kg/ha) than the use of fertilizer alone (4908 kg/ha) was observed from 2005 onwards, perhaps due to cumulative effect of FYM over a period of 26 seasons.

Long term effect of herbicides on soil physicochemical 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 2012

In the 26^{th} season of the experimentation, use of herbicide butachlor $0.75 \, kg + 2,4-D \, EE \, 0.4 \, kg$ ai/ha (3 DAP, applied in sequence) both in *kharif* and summer resulted in lower paddy yields $(4765 \, kg/ha)$ than pretilachlor $0.75 \, kg$ ai/ha

- during summer (4979 kg/ha) and hand weeding (5025 kg/ha), as a result of less control of sedges/broad leaf weeds particularly during summer season. The use of FYM + fertilizer gave paddy yield (4937 kg/ha) similar to plot applied with mere use of fertilizer alone (4908 kg/ha.

Application of FYM could not increase the weeds' density as well as growth. The use of herbicides continuously did not alter the soil physico-chemical properties or did not affect the microbial growth or beneficial micro-organisms like plant growth promoting bacteria, N-fixers, Urease activity, P solubilizers and cellulose decomposing fungi in rice – rice system over a period of fourteen years' crop cycle.

B. Kharif transplanted rice (2012)

The field experiment was conducted during *kharif* 2012 as fourteenth crop cycle at the Agricultural Research Station, Kathalagere, Davanagere District. The soil type was sandy clay loam with average fertility level.

Averaged over 27 seasons, rotational use of pretilachlor during summer fb butachlor + 2,4-D EE during *kharif* favoured 4.5% higher yield than the use of butachlor + 2,4-D EE both during *kharif* and summer (4792 kg/ha) and were comparable to hand weeding (5061 kg/ha). Use of FYM + fertilizer gave similar paddy yield as that of fertilizers only.

Herbicides proved to be cheaper than hand weeding and saved weeding cost by Rs. 9000 to 9300/ha over two seasons in rice – rice system, besides producing paddy yields similar to hand weeding.

Application of FYM did not increase the weeds' density as well as growth. Continuous use of butachlor $0.75~\rm kg + 2$, $4\text{-D}~\rm EE~0.4~\rm kg~ai/ha - 3$ DAP both during *kharif* and summer paved way for dominance of sedges (particularly *C. difformis* and *F. miliacea*) and grasses (*E. glabrascens*) during fourth summer crop of rice – rice system, as compared to the use of butachlor $0.75~\rm kg + 2$, $4\text{-D}~\rm EE~0.4~\rm kg~ai/ha - 3~\rm DAP~during~\it kharif~followed~by~pretilachlor~0.75~\rm kg~ai/ha~during~\it summer$. Thus, it indicates that the rotation of butachlor + 2, 4-D EE in *kharif~*followed~by~pretilachlor~in~summer~is

required to lower the menace of sedges and broad leaf weeds in long term rice- rice system. The use of herbicides continuously did not alter the soil physico-chemical properties or did not affect the microbial growth or beneficial micro-organisms like plant growth promoting bacteria, P solubilizer and cellulose decomposing fungi in rice – rice system over a period of thirteen crop cycle.

KAU, Thrissur

The trial was started in 2001 with two crops of rice per year in the paddy field of Agricultural Research Station, Mannuthy and continued during first (June-July to September- October) and second (Sept-Oct. to December- January) crop season of 2012. Rice- Var. Onam (short duration) was sown in plots of 100m^2 . Details of the treatments are furnished below.

Treatments

Treat- ment	Rice (1st crop)	Rice (2nd crop)
T1	HW (Farmer's practice)	HW (Farmer's practice)
T2	Butachlor @ 1.25kg/ha + 2,4-D @ 1.0	Butachlor @1.25kg/ha + 2,4-D @ 1.0
12	kg/ha.100% NPK-70: 35:35 kg/ha	kg/ha.100% NPK-70: 35:35 kg/ha
Т3	Butachlor + 2,4-D (100%NPK)	Pretilachlor @ 0.75 kg/ha + 2,4-D
13		(100%NPK)
T4	Butachlor + 2,4-D (75% NPK+25% through	Pretilachlor + 2,4-D (100%NPK)
14	FYM)	
T5	Pretilachlor (rotated with butachlor	Pretilachlor (rotated with butachlor previous
13	previous Year) + 2,4-D (100%NPK)	Year) + 2,4-D (100%NPK)
	Pretilachlor (rotated with butachlor	Pretilachlor (rotated with butachlor previous
T6	previous Year) +	Year) +
	2,4-D (75% NPK + 25% FYM)	+ 2,4-D (100%NPK)

Weed emergence and phytotoxicity

The results revealed that butachlor or pretilachlor application did not eliminate the *Echinochloa* from the rice field. A few *Echinochloa* remaining in the field are sufficient to bring about considerable build up in their number in the subsequent years. Under this situation, it is necessary to go for other herbicides like Cyhalofop butyl which can give 100% control.

Crop growth parameters and yield

Grain yield obtained in the different herbicide treatments during 2012 was lesser than that obtained in the previous year. Hand weeding treatment recorded the highst yield of 2.25 t/ha which was comparable with the previous year (2.28 t/ha). This was followed by pretilachlor application with FYM (both in the season wise rotation (T4: 1.80 t/ha) and year wise rotation

with pretilachlor (T6: 1.90 t/ha) which was attributed to the lesser population of $\it Echinochloa$ in these treatments. Superiority of the treatments T4 and T6 (application of herbicides with FYM) in reducing weed population and increasing grain yield has been observed in the previous years starting from 2005 onwards .

Reduction in the grain yield due to herbicide application was noticed from the year 2002 onwards i.e. with the increase in *Echinochloa* population, which was maximum in the year 2008. Due to the application of Cyhalofop butyl the magnitude of grain yield reduction was considerably less from the year 2009 onwards. Lack of proper rainfall resulted in intermittent wetting and drying of the field which favoured the emergence of *Echinochloa* in the herbicide applied plots.

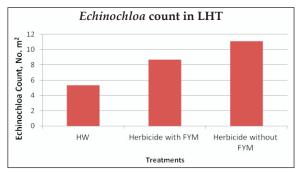


Fig 3.7.2: Influence of FYM on the effect of butachlor and retilachlor on *Echinochloa* population

Effect of herbicide on soil macrofauna (Earth worm)

Earth worm population was more at 1 month after spraying compared to two months after spraying. This is due to the higher moisture content of the soil moisture at 1 month after sparaying. Among the treatments, hand weeded plot recorded highest population (26.0) which was followed by herbicides with FYM. At two months after spraying, their population was highest in the plot with FYM. It was seen that organic manure and moisture content are the major factors affecting the growth of earth worm. It was also observed that, if herbicides are applied with FYM, the deleterious effect of herbicides on earth worm is considerably reduced.

Rice-wheat cropping system GBPUAT, Pantnagar

Treatments

Major weeds were *Phalaris minor* (47.5%) in grasses; *Polygonum plebejium* (21.7%), *Medicago denticulata* (15.3 %), *Rumex acestocella* (10.5 %), *Meliotus indica* (3.2%),%), *Coronopus didymus* and *Chenopodium album* were 0.8 % each at 60 days stage of crop growth.

Drastic reduction in weed density was recorded with combined application of isoproturon 1.0 + 2,4-D at 0.5 kg/ha. Among different management practices application of isoproturon 1.0 kg/ha, combination of isoproturon 1.0 kg/ha + 2, 4-D at 0.5 kg/ha and isoproturon 1.0 kg/ha supplemented with one hand weeding (45 DAS) were found more effective against broad leaved weeds compared with rest of the herbicidal treatments. The lowest dry matter of weeds was recorded in isoproturon 1.0 kg/ha followed by combination of isoproturon 1.0 + 2,4-D at 0.5 kg/ha over the weedy check.

During *kharif* season, Rice variety "Narendra 359" was transplanted on July 28, 2012 and harvested on Nov. 11, 2012.

Among various weed species *Echinochloa crus-galli* (9.9 %), *Paspalum disticum* (7.0 %) and *Echinochloa colona* (4.23 %) were pre-dominant in grasses. *Ammania baccifera*(48.7 %), *Alternenthera sessilis* (15.2 %) and *Caesulia axillaris* (1.4 %) were the important non - grassy weeds. *Cyperus difformis* (12.0%) and *Fimbristylis miliacea* (1.43%) were the important sedges in experimental plot.

Kharif (Ri	ice)	Rabi (Wheat)			
Farmer's practice (Butachlor 1.	5 kg/ha at 3-5 DAT) (PE)	Farmer's practice (Isoproturon 1.0 kg/ha 30 DAS) (POE))			
Butachlor 1.5 kg/ha (PE) fb 2,4	-D (0.5 kg/ha) at 20 DAT	Isoproturon 1.0 kg/ha (30 DAS)+2, 4-D at 0.5 kg/ha			
Butachlor 1.5 kg/ha (PE) fb 2,4	-D (0.5 kg/ha)	Isoproturon 1.0 kg/ha (30 DAS) +2, 4-D at 0.5 kg/ha			
20 DAT + OM (Dhencha)	, ,	(with green manuring in kharif)			
Treatment-2 rotation with Pres	tilachlar 0.7 kg/ha (PF)	Clodinafop 60 g/ha (POE) 30 DAS fb 2, 4 -D at 0.5			
Treatment-2 Totation with Fred	machior 0.7 kg/ma (1 E)	kg/ha (7 days after clodinafop spray)			
Treatment-4 and Dhencha		Clodinafop 60 g//ha (POE) 30 DAS fb 2,4 - D 0.5 kg/ha			
Treatment—4 and Dhenena		(7 days after clodinafop spray)			
Butachlor 1.5 kg/ha 3-5 DAT +	- HW at 20 DAT	Isoproturon 1.0 kg/ha (30 DAS) + HW (45DAS)			
Weedy		Weedy			
Bispyribac sodium 25 g/ha		Sulfosulfuron 25 g/ha			



At 30 DAS, all the herbicidal treatments were able to reduce the total density of all weeds species except the *P.disticum* over the weedy check. The density and dry weight of all the weeds except E. colona, C. axillaris and A. baccifera were influenced significantly due to different weed control treatments . At 30 DAT the maximum number of total weeds was found in weedy plots. The Population of E.colona and E. crus-galli among the grassy, C. axillaris and A. baccifera among the broad leaved weeds and C. difformis in sedges were completely controlled by all the herbicidal treatments. Weed dry matter was significantly less in plots treated with butachlor applied at 1.5 (PE) fb 2,4-D 0.5 kg/ha as compared to other treatments.

At 60 DAS, the density and dry weight of all weeds were influenced significantly due to various herbicidal treatments. Among the herbicidal treatments application of butachlor 1.5 fb 2,4-D 0.5 kg/ha + sesbania, T₄ + sesbania, butachlor 1.5 kg/ha (PE) supplemented with one hand weeding (40 DAT) and application of bispyribac sodium 20 g/ha have complete reduction over the density E. colona among the grassy weeds. Application of butachlor fb 2,4-D 0.5 kg/ha+sesbania, T₂ (rotation with pretilachlor 0.7 kg/ha and T₄ along with sesbania were found significantly superior in controlling the population of E. crusgalli as compared to other treatments.

AAU, Jorhat Treatments

Rice: M1. Weedy M2. Mechanical weeding (20&40 DAT)

Wheat:

S1. Weedy

S2. Mechanical weeding (25 DAS)

- M3.Butachlor @1.5 kg/ha M4. Pretilachlor @ 0.75 kg/ha
- S3. Isoproturan 1.0 kg/ha
- S4. Isoproturan 0.75 kg/ha tank mix 1% urea
- S5. Isoproturan 0.75 kg/ha tank mix 1% adjuvant

Wheat (12th crop):

Polygonum and Stellaria were the highest populated weeds in the field during rabi season. P. plebeium and Stellaria media emerged in the field within 7 to 14 days after emergence of wheat. Other common weeds in the early part of the crop were grasses like Cynodon dactylon and Eleusine indica, and broadleaved species like Vicia sativa, Oxalis corniculata and O. debilis var. corymbosa. Some other broadleaved weeds appeared late but prevailed in the field since active crop growth period to harvest were Ageratum houstonianum, Chenpopodium album, Lathyrus aphaca, etc. and the most troublesome weed at this stage was the Polygonum viscosum.

The weed management treatments in wheat crop significantly affected the weed population and weed dry weight recorded in wheat crop. At 30 DAS and at harvest, significantly lowest weed density was observed with isoproturon 750 g/ha + urea 1 % tank mixture followed by isoproturon 750 g/ha + 0.1 % adjuvant. However, the weed dry matter production recorded at 30 DAS and harvest were significantly lowest with isoproturon 750 g/ha + 1% adjuvant followed by the treatment isoproturon 750 g/ha + urea 1 % tank mixture.

The grain yield of wheat (1326 kg/ha) recorded under the treatment isoproturon 750 g/ha + 1 % adjuvant was significantly highest which was at par with isoproturon 750 g/ha + urea 1 % tank mixture (1318 kg/ha).

Rice (13th crop):

The linking species between wheat cropping and rice ecosystems that shown dominance in rice cropping were *Cynodon dactylon, Chenopodium album, Oxalis debilis* var. *crymbosa* and *Marsilea minuta*. Some marshland facultative weeds like *Cyperus brevifolius, Spilanthes paniculata, Alternanthera philoxeroides* and *Ludwigia linifolia* were also recorded in rice cropping during the active crop growth period.

Prevalence of the rice-mimic weed *Echinochloa crusgalli* was recorded when the weed started blooming and became visible amidst the rice crop.

Weed control treatments imposed on rice brought about significant changes in weed density in rice. Treatments given to previous wheat crop could not show any significant variation in respect of weed density in rice at any stages. Similar results were also noticed in case of weed dry weight. Treatment with butachlor 1000 g/ha or pretilachlor 750 g/ha in rice resulted significantly lower weed density and dry weight as compared to weedy check as well as mechanical weeding.

All the treatments imposed on rice were at par in respect of number of panicles and thousand grain weight but significantly higher number of filled grains along with lesser number of false grains per panicle was recorded with butachlor 1000 g/ha or pretilachlor 750 g/ha. Similarly a significantly higher grain yield was achieved under these two treatments.

BAU, Ranchi

Treatments

Rice	Wheat
W1 Butachlor 1.5 kg/haPE	Isoproturon 1.5 kg/ha
W2 Butachlor 1.5 kg/haPE	Isoproturon 1.5 kg/ha+2,4-D
W3 Almix 4g/ha PoE	Isoproturon 1.5 kg/ha
W4 Almix 4g/ha PoE	Isoproturon 1.5 kg/ha+2,4-D
W1 + W4	Isoproturon 1.5 kg/ha
W1 + W4	Isoproturon 1.5 kg/ha+2,4-D
Hand weeding	Hand weeding
Weedy Check	Weedy Check

- Application of butachlor 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5 kg/ha+2,4-D in wheat crop recorded reduced weed density of grassy, broad leaved and sedges as well as their dry matter accumulation.
- Application of butachlor 1.5 kg/ha PE in rice and isoproturon 1.5 kg/ha in wheat recorded maximum rice grain yield (3387 kg/ha),
- H Application of butachlor 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5 kg/ha+2,4-D in wheat cop recorded higher net return (₹34179/ha and B:C 2.17).

Butachlor 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5 kg/ha+2,4-D in wheat crop recorded significantly higher rice equivalent yield (11236 kg/ha), gross return (₹ 112362/ha), net return (₹ 101608/ha) and B:C ratio (3.15).

CCSHAU, Hisar

Rice-wheat sequence is the most dominant prevailing sysem in northeast Haryana. Continuous growing of high yielding dwarf varieties of rice and wheat without any rotation with legumes or green manuring crop for the last many years has affected the soil health and changed the weed flora in favour of grassy weeds in wheat (*P. minor* and rice (*Echinochloa crus-galli*.

The field experiment was initiated on a permanent plot at CCS Haryana Agricultural University, Regional Research Station, Karnal during kharif 1999 to study the effect of green manuring and continuous or rotational use of herbicides in rice and wheat and their weed control efficacy, shift in weed flora, development of resistance, growth and productivity of rice and wheat compared to rotation of herbicides and weedy check. The herbicidal treatments included fix herbicide (clodinafop 60 g/ha), rotationalerbicide (sequence of clodinafop 60 g/ha fb sulfosulfuron 25 g/ha fb fenoxaprop 120 g/ha) along with weed free and weedy checks. Sulfosulfuron was the rotational herbicide in rabi 2011-12.

After harvesting of wheat, Sesbania was sown on 25 May, 2012 in permanent plot of green manuring. It was incorporated in soil with harrowing on 12 July, 2012 followed by flooding with water for puddling. After puddling both the green manured and without green manured plots, 40 days old rice cv. HKR-47 was transplanted on 15 July 2012 with a spacing of 20 x 15 cm. The plot size was 3.5 m x 6.8 m. The herbicidal treatments included fix herbicide (butachlor 1500 g/ha), rotational herbicide (sequence of butachlor 1500 g/ha fb pretilachlor 1000 g/ha fb anilofos 400 g/ha) along with weed free and weedy checks. Pretilachlor was the rotational herbicide in kharif 2012. Herbicides were applied 3 DAT by broadcasting method after mixing in 150 kg sand/ha in a standing water of 5 cm and water was maintained for one week after herbicide application. Crop was raised according to package of practices of state University and harvested on 29 October 2012. Treatment wise permanent plots were maintained year after year. In plots with green manuring, 25 % nitrogen was reduced from the recoended dose in rice. However, under both regimes recommended doses of PK and ZnSO₄ were applied at sowing time.

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. The efficacy of rotational herbicide sulfosulfuron was less than clodinafop as fixed herbicide, however, the differences in terms of dry weight of P. minor were non-significant. 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 of P. minor under rotational herbicide was more than the weed free check, however, the differences were non-significant in respect of dry weight of grassy weeds. 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 respect of dry weight were non-signficant.

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. Yields under herbicide treated plots were lower than weed free plots. Plant height was not influenced by green manuring. Effective tillers were more under green manured plots however, the differences were not significant. The grain yields under different treatments were also more in green manured plots than non-green manured plots however, the differences were not always significant. The continuous or rotational use of clodinafop provided comparable yields with weed free plots under both the situations of green manuring.

Rice: Differences in rice crop were clearly visible between green manured and non green manured plots. The continuous use of butachlor or rotational use of pretilachlor provided almost complete control of all type of weeds under both the situations of green manuring. Under weedy checks, density and dry weight of *Echinochloa crus-galli* was less under green manuring. However, dry weight of *E. crus-galli* was more under green manuring. Broadleaf weeds were more under green manuring.

The number of tillers and grain yield under herbicide treated plots were significantly higher than weedy plots. Yields under herbicide treated plots were similar to weed free plots. Effective tillers and grain yields under different treatments under green manuring were higher than the nongreen manuring.

PAU, Ludhiana Treatments

Rice (dose kg/ha)	Wheat (dose kg/ha)
Butachlor 1.5 (C)	Trifluralin 1.2(C)
Pretilachlor 0.75 (C)	Trifluralin 1.2 fb 2,4-D 0.5(C)
Anilophos 0.4 (C)	Clodinafop 0.06 fb metsulfuron 0.005(C)
Anilophos*/Pretilachlor / Butachlor (R)	Clodinafop 0.06 fb 2,4-D 0.5(C)
Butachlor 1.5 fb Metsulfuron 0.015(C)	Sulfosulfuron 0.025(C)
Pretilachlor 0.75 fb Metsulfuron 0.015(C)	Sulfosulfuron 0.025 fb 2,4-D 0.5(C)
Anilophos 0.4 fb Metsulfuron 0.015 (C)	Trifluralin/Clodinafop*/Sulfo (R) fb 2,4-D 0.5
Weedy check	Weedy check

C- continuous; R- rotational use of herbicides; * herbicide used in current year

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 a 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 corps.

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 started in *kharif* 1993. The treatments were replaced as and when required. The present treatments are in operation from 1999 in rice and 2001-02 in wheat. 2002. Eight treatments starting with rice are kept for both rice and wheat on fixed plot basis. Rotation of the herbicides in rice is in the sequence of *butachlor/pretilachlor/anilophos* with anilophos applied during 2012.

Wheat (Rabi 2011-12):

Weed flora in experimental field included *Phalaris minor* among grasses, and *Rumex dentatus*, *Medicago denticulata*, *Anagallis arvensis*, *Chenopodium album, Coronopus didymus, Malva parviflora, Fumaria parviflora 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. Trifluralin was poor against *Medicago* and *Coronopus*; 2,4-D against *Coronopus*

and *Fumaira* and *Rumex*; sulfosulfuron against *Rumex* as compared to unweeded control. Metsulfuron and 2, 4-D showed poor performance as compared to earlier years. *Avena ludoviciana* has started appearing in trifluralin and Poa annua in clodinafop plots. The continuous of a single herbicide as well as rotational use of herbicides reduced the population and dry matter, both grassy and broadleaf weeds, significantly as compared to unweeded control. Sequential application of trifluralin and 2,4-D recorded the highest wheat grain yield, net returns and B:C ratio, it was closely followed by sequential application of sulfosulfuron and 2,4-D, and rotational herbicidal treatment.

Rice (kharif 2012): E. 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. All the three herbicides butachlor, pretlachlor and anilophos did not provide satisfactory weed control; butachlor and pretilachlor were poor against Echinochloa and Ischaemum while anilophos was poor on broadleaf and sedges. The follow up application of metsulfuron provided effective control of broadleaf and sedges and some effect was also observed on grasses. Sequential application of butachlor and metsulfuron recorded the highest rice grain yield and B:C ratio; it was at par with sequential application of anilophos and metsulfuron. The results indicated that the herbicides must be integrated with hand weeding/hand pulling for getting the optimum productivity from the rice crop, especially in dry years like 2012 when weed pressure became more intense as compared to during wet years.

CSKHPKV, Palampur

Treatments

Rice	Wheat
Farmer's practice	Farmer's practice
Butachlor 1.5 kg/ha fb 2,4 -DEE 1.0 kg/ha (100% N	Isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha
through fertilizer source)	
-do-	Clodinafop* 75 g/ha fb 2,4 -D 0.75 kg/ha/Isoproturon 1.0
	kg/ha + 2,4-D 0.75kg/ha
Butachlor 1.5 kg/ha fb 2,4 -DEE 1.0 kg/ha (75% N	Isoproturon 1.0 kg/ha + 2,4-D 0.75 kg/ha
through fertilizer source and 25% N through Lantana	
-do-	Clodinafop* 75 g/ha + 2,4 -D 0.75 kg/ha Isoproturon 1.0
	kg/ha + 2,4-D 0.75kg/ha
Cyhalofop butyl 90 g/ha fb 2,4-DEE 1.0 kg/ha,/	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)	
-do-	Clodinafop* 75 g/ha fb 2,4 -D 0.75 kg/ha/Isoproturon 1.0
	kg/ha + 2,4-D 0.75 kg/ha
Cyhalofop butyl 90 g/ha fb 2,4 - DEE 1.0 kg/ha,/	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 + 25% N through Lantana	
-do-	Clodinafop* 75 g/ha fb 2,4 -D 0.75 kg/ha/ Isoproturon 1.0
	kg/ha + 2,4-D 0.75 kg/ha

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.

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.

Rice: Major weeds of the experimental field were *Echinochloa colona, Ammania bassifera* and *cyperus iria* with minor population of *Erioclon spp., and* others. The population of broad leaved weeds was more than the grass weeds.

Among different weed species, the count and dry matter of *Echinochloa colona* was significantly influenced by different treatments at 60 DAS. 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*.

All the weed control treatments resulted in significantly lower count and dry weight of Ammania as compared to combination of continuous use of butachlor 1.5 kg/ha fb 2, 4-DEE with 100% N through fertilizer in rice and continuous use of herbicides in wheat, combinations of continuous use of butachlor 1.5 kg/ha fb 2,4-DEE in rice with 75% N through fertilizer and 25% N through Lantana in rice and rotational/continuous use of herbicides in wheat. Similarly, all the weed control treatments resulted in significantly lower count and dry weight of other broadleaf weeds as compared to combination of continuous use of butachlor 1.5 kg/ha fb 2,4-DEE with 100% N through fertilizer in rice and continuous use of herbicides in wheat and combination of continuous use of butachlor 1.5 kg/ha fb 2, 4-DEE in rice with 75% N through fertilizer and 25% N through Lantana in rice and continuous use of herbicides in wheat. In case of Erioclon spp., all the weed control treatments resulted in significantly lower count and dry weight as compared to Farmer's practice and rotational use of herbicides with 100% N through fertilizer in rice and continuous use of recommended herbicides in wheat.

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.

NDUAT, Faizabad

The experiment was conducted in a three replication split plot design keeping *kharif* season treatments in main plot and *rabi* season in subplot in the field in which layout was done in the starting year of the experiment *i.e.* 1991.

Phalaris minor among grasses and Anagallis arvensis, Chenopodium album, Melilotus spp. Coronopus didymus and Medicago denticulata in wheat field. Some other weeds eg. 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 during *rabi* season in wheat crop. The weed density counted in the plots in which mechanical weeding twice or chemical were applied, was noted reduced in number per unit area.

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 @ $1.0 \, \text{kg} + 2, 4\text{-D}$ Na salt @ $0.5 \, \text{kg/ha}$ (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 20 & 40 DAS being at par to butachlor @ $1.5 \, \text{kg/ha}$ encouraged the grain yield of wheat during rabi season.

A major shift in weed flora has not been observed. However, in herbicide treated plots few new weed spp. eg. *Polypogon monosplensis* and *Poa annua* among grassy and *Rumex spp.* and among BLWs were recorded.

Divergent weed flora was recorded in the experimental plot though their pressure was not so drastic. Among grassy weeds, *E. Colona*, *E. Crus-galli* and *Paspalum spp.* existed predominantly while *Fimbristylis dichotoma* and *C. iria* of sedges group existed with the highest population. BLWs included *Ammannia baccifera*, *Eclipta alba*, *Lindernia spp.* and *Phyllanthus niruri* were also recorded.

The results pertaining to weed density revealed that 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. The

effect of weed management practices i.e. HW 20 & 40 DAS and Tank mix application of isoproturon @ 1.0 kg + 2,4-D Na salt @ 0.5 kg/ha caused significant reduction in weed dry weight recorded in rice during *kharif* season. Interaction effect was not visible.

The results pertaining to grain yield make it clear that pre-emergence application of butachlor @ 1.5 kg/ha being at par to HW 20 & 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, few new weeds *viz.*, *C. auxillaris* and *Lindernia spp.* were recorded in the weedy plots.

It is obvious from the results that weed control treatments applied during *rabi* and *kharif* season did not show any significant effect on bulk density, pH, EC and organic carbon in the soil at initial and at harvest stage of the wheat and rice crop. However on microbial properties (free living N fixing bacteria, phosphate solubilizing microorganism, soil respiration rate per cent root colonization by AM, alkaline-P, acid-P and dehydrogenase activity) the significant impact were observed in between hand weeding and herbicidal treatments during *rabi* and *kharif* season at 50 DAS. While at harvest non significant variation were observed.

CSAUAT, Kanpur

A field experiment was conducted during *rabi*, season from 2006-07 to 2011-12 at Students'Instructional Farm of C.S. Azad university of Agriculture and Technology, Kanpur. The experiment consisted of treatments involving two herbicides viz., utachlor (1.50 kg a.i./ha), anilophos (0.5 kg a.i./ha), hand weeding twice (30 and 60 DAS) and weedy check in rice during *harif*season in Randomized Block Design replicated thrice. In wheat treatment consisted of herbicides viz., isoproturon (1.0 kg a.i./ha), isoproturon (0.75 kg a.i./ha) tank mixed 0.1% urea

and isoproturon (0.75 kg a.i./ha) tank mixed 0.1% surfactant as post emergence, hand weeding twice by khurpi at 30 DAS and 60 DAS and weedy check were super imposed over each treatment of rice in wheat during *rabi* season.

Wheat

It is concluded from the results the manual weeding twice in preceding rice crop significantly reduced the weed population and its dry weight at all the stages of crop. Among the weed control practices in wheat, hand weeding twice minimized the weed population and its dry weight at all the stages of crop followed by isoproturon (0.75kg a.i./ha) and (0.1% tank mix surfactant) application at 30 DAS.

Rice

- Application of butachlor 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5kg/ha2,4-D in wheat crop recorded reduced weed density of grassy, broad leaved and sedges weeds as well as weed dry matter accumulation.
- Application of butachlor 1.5 kg/ha PE in rice and isoproturon 1.5 kg/ha in wheat recorded recorded maximum rice grain yield (3387 g/ha),
- Application of butachlor 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5 kg/ha + 2,4-D in wheat crop recorded higher net return (₹ 34179/ha and B:C 2.17).
- Helder 1.5 kg/ha PE + Almix 4g/ha PoE in rice and isoproturon 1.5 kg/ha+2,4-D in wheat crop recorded significantly higher rice equivalent yield (11236 kg/ha), gross return (₹ 112362/ha), net return (₹ 101608/ha) and B:C ratio (3.15).

RAU, Pusa

The trial was conducted at Crop Research Centre, Rajendra Agricultural University, Pusa. The experiment comprised of four weed management treatments in rice and five weed management treatments in wheat with three replications in split plot design.

Treatments

Transplanted rice

- स Weedy check
- म Mechanical weeding (2)
- स Butachlor 1.5 kg/ha
- ₹ Anilophos 0.5 kg/ha

Wheat

- ₦ Weedy check
- ম Mechanical weeding
- ਥ Isoproturon 1.0 kg/ha
- Isoproturon 0.75 kg/ha tank mix. 1% urea

 □
- Isoproturon 0.75 kg/ha tank mix. 0.1% surfactant/adjuvant

The major weed flora observed in the experimental plots of rice were as follows:-

Grasses: Echinocloa crus-galli, E. colona, Dactyloctenium aegyptium, Digitaria sanguinalis

Sedges: Cyperus rotundus, Cyperus diformis, Fimbristylis miliaceae

Broad leaved weeds: Caesulia axillaris, Lippia nodiflora, Ammania bacifera, Eclipta alba and Phyllanthus niruri. In wheat crop the following weed flora were recorded:

Grasses: Cynodon dactylon, Polypogon monspliensis, Avena fatua, Phalaris minor

Sedges: Cyperus rotundus

Broad leaved weeds : Anagallis arvensis, Chenopodium album, Cirsium arvense, Melilotus alba, Rumex dentatus

In rice: The lowest weed count, weed dry wt. and highest grain yield of Rice were recorded under the treatment mechanical weeding (2) which were at par with treatment butachlor @ 1.5 kg/ha and they were significantly superior over treatments weedy check and application of anilophos @ 0.5 kg/ha. However, application of anilophos @ 0.5 kg/ha was also effective for minimizing weed density and increasing grain yield over weedy check.

In wheat: All the weed control treatments showed their effect on minimizing weed

population and weed dry weight and increasing the grain yield over weedy check in main plot treatments. The lowest weed count and weed dry weight and maximum grain yield were recorded under mechanical weeding which was significantly superior over weedy check and anilophos 0.5 kg/ha while at par with butachlor 1.5 kg/ha. Under sub plot treatments the lowest weed count and weed dry weight were recorded under mechanical weeding which were significantly lower over all the treatments except isoproturon 0.75 kg/ha (Tank mix 0.1% surfactant) which remained statistically at par with isoproturon 1.0 kg/ha.

Long-term effect of herbicide on physicochemical properties of soil and soil micro-flora in rice - wheat cropping system.

The highest bacterial population (22.89 and 23.80 x 10⁶ cfu/gm of soil) in initial and postharvest soil samples respectively were observed with anilophos 0.5kg/ha followed by butachlor 1.5kg/ha. Whereas the lowest bacterial population in main plot was observed with mechanical weeding treatments. Similarly the mechanical weeding in sub plot also resulted significantly lowest bacterial population. Increase in bacterial population in post-harvest soil as compared to initial soil samples were also observed. The actinomycetes and fungal population in main plot were significantly higher with weedy check followed by anilophos 0.5kg/ha. The lowest fungal and actinomycetes population in initial and post-harvest soil samples in main and sub plot were in mechanical weeding treatments. The CO₂ evolution mg/100gm of soil in main plot were recorded in initial and postharvest soil samples with the treatment weeding check (70.88 and 73.89 respectively) followed by anilophos 0.5 kg/ha. Similarly in sub plot weedy check resulted the significantly highest CO, evolution mg/100 g soil.

In general mechanical weeding resulted lowest total microbial population and microbial activity (CO₂ evolution mg/100g) soil. The highest being with weedy check.

Rice-groundnut cropping sytem DBSKKV, Dapoli

Treatments

A) Main plot treatments	:	Green manuring		
		M_1		Green manuring (Sesbania rostrata)
		M_2		Without Green manuring
B) Sub plot treatments	:	Weed control measures		
		For Rice (kharif)	:	For Groudnut (Rabi)
T _{1:} Fixed herbicide		Pretilachlor-S 50 EC @ 0.75		Pendimethalin 30EC @ 1.0 kg/ha
		kg/ha 3-7 DAT		PE
T ₂ : Rotational herbicide		Pyrazosulfuron 10 WP @ 0.25	:	Oxadiargyl 80 WP@0.12 kg/ha 0-2
sequence		kg/ha		DAS (Iyr), Butachlor 50 EC @ 1.0
		8-10 DAT(I yr), Fenoxaprop 10		kg/ha 0-3 DAS (IIyr), Alachlor 50
		EC @ 80 kg/ha 25 -30 DAT		EC @ 1.5 kg/ha 0-3 DAS (IIIyr)
		(IIyr), Oxadiargyl 80 WP @		
		0.100 kg/ha 0-5 DAT (IIIyr)		
T _{3:}		Weed free check	:	Weed free check
T _{4:}		Weedy check	:	Weedy check

Green manuring to *kharif* rice did not influence weed density and weed growth except weed density of monocots at 30 DAS. Various weed control measures significantly influence weed density of monocots at 30, 50 DAS and BLWs at 50 DAS. The weed density of monocots & BLWs was at par with use of fixed herbicide (pendimethalin) and use of rotational herbicide (oxadiargyl) and at 50 DAS. The weed density of monocots & BLWs significant least over weedy check.

The weed growth of BLWs at 50 DAS and at harvest in use of fix herbicide (pendimethalin) and rotational herbicide (oxadiargyl) which were at par with each other. Green manuring to *kharif* rice produced higher dry pod yield of groundnut However, weed free check produced significantly higher dry pod yield of groundnut and it was at par with fixed herbicide

Combined effect of green manuring and herbicides on soil microflora and their associated parameters

The population of bacteria in soil was significantly influenced by green manuring as compared to without green manure at 30DAS, 50DAS and at harvesting stage of the rice crop. They recorded significantly higher bacterial

population in green manuring treatment as compared to the without green manuring treatment.

The total bacteria in soil were significantly influenced by weed control measures at 30DAS, 50DAS and at harvesting stage. They were found significantly higher in weed free treatment as compared to the fixed herbicide, rotational herbicide and weedy check. The bacterial population in weedy check treatment was at par with fixed herbicide treatment and the rotational herbicide treatment.

The total fungal population, phosphate solubilisers and the free living nitrogen fixers in soil was significantly influenced by green manuring treatment as compared to without green manuring treatment at 30 DAS and at 50 DAS and at harvesting stage of groundnut crop. They recorded significantly higher fungal population in green manuring treatment as compared to the without green manuring treatment.

The microbial biomass carbon and dehydrogenase enzyme activity is significantly influenced at 30DAS, 50DAS and harvesting stage by green manuring treatment as compared to the without green manuring treatment. They

recorded significantly higher biomass in green manuring treatment as compared to the without green manuring treatment. However the biomass increases from 30 DAS, 50 DAS and at harvest.

The basal soil respiration was significantly influenced by weed control measures. It was significantly higher in weed free treatment as compared to the weedy check, rotational herbicide and fixed herbicide treatment at 30 DAT, 50 DAT and at harvesting stage of the rice crop. The basal soil respiration in weedy check was at par with the rest of the herbicide treatment. The status of basal soil respiration was lower in rotational herbicide (Fenoxaprop) treatment as compared to the fixed herbicide (Pretilachlor) treatment.

OUAT, Bhubaneswar

In Odisha, rice-groundnut is one of the dominant cropping system practiced in most of the command areas. The long-term herbicidal trial in rice-groundnut cropping system was initiated during 2001 *kharif* with direct sown rice as the first crop and groundnut as the second crop in the succeeding *rabi* season. The experiment is being conducted at Central Research Station, OUAT, Bhubaneswar. The experiment was laid out in split plot design with four replications.

Treatment

Main plot (Kharif rice)

- T₁- Hand weeding (twice) OM + inorganic fertilizers.
- T₂- Hand weeding (twice) + OM + inorganic fertilizer (N-adjusted)
- T_3 Butachlor 0.75 kg/ha + 2, 4-D EE 0.4 kg/ha OM + inorganic fertilizer
- T₄- Butachlor 0.75 kg/ha + 2, 4-D EE 0.4 kg/ha + OM + inorganic fertilizers (N-adjusted)
- T_5 Butachlor 0.75 kg/ha + 2, 4-D EE 0.4 kg/ha rotated with pretilachlor 0.75 kg/ha + OM + inorganic fertilizer.
- T₆- Butachlor 0.75 kg/ha + 2, 4-D EE 0.4 kg/ha rotated with pretilachlor 0.75 kg/ha + OM + inorganic fertilizer (N-adjusted)

OM - Organic matter

Sub-plot (Rabi groundnut)

- H_0 Hand weeding at 25 DAS and hoeing at 50 DAS
- H₁- Alachlor 1.0 kg/ha
- H₂- Butachlor 1.0 kg/ha.

Plot size : $12 \,\mathrm{m} \,\mathrm{x} \,8.5 \,\mathrm{m} \,(102 \,\mathrm{m}^2)$

Fertilizer dose : Rice-60:30:30 kg of NPK/ha

Groundnut-20:40:40 kg of

NPK/ha

Cultivars : Rice - Lalat (duration of 125

days), DAS: 23.06.2012

Groundnut-G.P.B.D-4, (duration of 120 days),DAS:

07.11.2011

Organic matter (OM) in the form of green manure crop *Sesbania aculeata* (of 35 days old) was incorporated at the rate of 6 t/ha in the required treatments of the main plot. Hand weeding in rice was conducted at 30 and 45 DAS. The composition of weed flora, weed densities, weed biomass at different growth stages of both crops were recorded to observe the changes and shift of weeds as a result of long term application of herbicides.

A) Rabi groundnut

The composition of weed flora in *rabi* groundnut was dominated with grasses (50.3%) followed by broad leaf (37.9%) and sedges (11.8%) at initial stages (25 DAS).

Use of butachlor \pm 2, 4-DEE rotated with pretilachlor without OM in rice along with application of alachlor in groundnut recorded significantly the lowest weed density (63.5 / m²) in groundnut during initial stages of crop growth (25 DAS).

There is 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 increases the weed population marginally (17.9%), is effective in increasing pod yield of groundnut in the tune of 8.4%.

Though hand weeding and earthing in

groundnut produced the highest yield (2.14 t/ha), application of alachlor 1.0 kg/ha to groundnut was found to be superior in terms of yield (2.06 t/ha) and weed control.

B) Kharif rice (2012)

During the initial stages of crop growth (25 DAS), use of herbicides reduced the weed density by 71.7 % over hand weeding and the treatment of butachlor $0.75 \, \text{kg/ha} + 2.4\text{-DEE} \, 0.4 \, \text{kg/ha}$ without OM recorded the lowest weed density of $42.0 \, \text{m}^2$.

The increase in weed biomass due to organic matter is in tune of 11.6 % at 25 DAS, 9.8 % at 60 DAS and by 7.1 % at harvest.

Incorporation of OM over the years increased the grain yield in the tune of 2.9 % 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 11.79 t/ha. But application of butachlor + 2,4D EE without.

Rice-Chickpea cropping system IGKV, Raipur

Treatments

Tillage	1st Crop	2 nd Crop
(Main Plot)	Conventional	Zero tillage
		Conventional
Weed Control	1st Crop (RBD)	2 nd Crop (Sub plot, Spli plot))
Hand weeding Herbicide (Oxadiargy @ 80 g/ha fb Bispyribac 25 g/ha) (Fenoxaprop @ 60 g/ ha + CME+ MSM 4 g/ha) (Pyrazosulfuron @ 25 g/ha) Weedy Check		

Plot size: $10.0 \times 11 = 110 \text{ m}^2$ Design: RBD (kharif)

Echinochloa colona, Ischaemum rugosum among grasses, Alternathera triandra, Cynotis axillaries among broad leaf weeds and Cyperus iria among sedges were the predominant weed species observed in the experimental field.

Data on weed population revealed that within the weed control measures, at 30 DAS, lowest population of weeds was recorded under the treatment of hand weeding but at later stages it was lowest under oxadiargyl @ 80 g/ha fb

bispyribac 25 g/ha . This was followed by preemergence application pyrazosulfuron 25 g/ha fb hand weeding at 25 DAS, in order. Weed population was highest under unweeded control at all the stages.

Dry matter recorded at 60 DAS and at harvest significantly influenced by weed control measures. At both the stages, dry matter of weeds was significantly lower in treatment of oxadiargyl @ 80 g/ ha fb bispyribac 25 g/ha than unweeded control but was at par with hand weeding and pyrazosulfuron 25 g/ha fb hand weeding at 25 DAS. Weed control efficiency also followed similar trend as that of weed dry matter at harvest

Weed Management treatments significantly affected the seed yield. Among various weed control measures, significantly higher seed yield was recorded from the treatment of pre emergence application of oxadiargyl 80 g/ha fb postemergence bispyribac 25 g/ha and this was at par with two hand weedings and both were significantly superior over weedy check. Seed yield was significantly lowest under un weeded control as compared to rest of the weed management treatments.

Medicago denticulata, Chenopodium album, Melilotus indica were the predominant weeds in the experimental field of chickpea. Other weeds existed in the flora were Alternanthera triandera, Anagalis arvensis, Echinochloa colona etc. However, broad leaf weeds completely dominated the weed flora through-out the growing period of the crop.

It was observed that 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. While, the dry matter was marginally lower under conventional tillage than zero 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. However, at harvest, the dry matter was significantly lowest under farmers' practice as compared to weedy check, but

was at par with pre-emergence application of pendimethalin@1.0 kg/ ha.

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, preemergence application of pendimethalin @ 1.0 kg/ ha produced significantly higher seed yield as compared to weedy check and farmers' practice, respectively. The plant height under preemergence application of pendimethalin @ 1.0 kg/ ha produced significantly taller plants than weedy check and farmers' practice, whereas, yield attributes like number of pods/plant also followed the trend as that of seed yield.

Microbiological study

At the time of sowing (0 DAS) all of the weed management practices were found non significant but after application of different pre & post emergence herbicides the above soil properties affected by applied herbicides at different levels. At 30 DAS all the applied herbicides i.e. oxadiargyl fb bispyribac, pyrazosulfuron and fenoxaprop + chlorimuron ethyl + metsulfuron methyl significantly reduced basal soil respiration rate (BSR), dehydrogenase enzyme activity (DHA) acid phosphatase activity (AP), microbial biomas carbon content (MBC)) and population of nitrogen fixers and phosphate solubilizers in soil.

At harvest stage the existance of oxadiargyl + bispyribac and fenoxaprop + chlorimuron + metsulfuron was observed in terms of the above measured parameters which indicates the persistance of above chemicals in soil at harvest stage of crop growth.

In the above study maximum inhibitory effect of fenoxaprop + chlorimuron ethyl +

metsulfuron methyl was found in comparison to other applied herbicides. Pyrazosulfuron was found rather safe to others wrt to its effect on soil microbes. The hand weeding practice and weedy check had positive effect to enhance the microbial population and their activities in soil in the entire growth period of crop.

The result of the study on the residual effect of different weed management practices on basal soil respiration rate (BSR) and dehydrogenase activity (DHA) in rhizosphere soil of chickpea revealed that there was no residual effect of kharif treatments on BSR & DHA activities in soil except the effect of (i) Oxadiargyl fb bispyribac and (ii) Combined application of fenoxaprop-p-ethyal, chlorimuron-ethyl and metsulfuron-methyl. The residual effect of above herbicides was visualized up to 0 DAS of rabi crop (chickpea). Studies on soil acid phosphatase activity (AP) and microbial biomass carbon content (MBC) also showed that pre-emergence application of oxadiargyl fb postemergence application of bispyribac and combined application of fenoxaprop-p-ethyal, chlorimuron-ethyl and metsulfuron-methyl at post-emergence stage of rice crop existed in succeeding chickpea crop up to sowing stage and there after no harmful effects of above herbicides were noticed. The data on population of total Nfixers in soil and chickpea nodulation also showed the similar trend. Hence, it can be concluded from the study that no harmful traces of applied rice herbicides existed in succeeding chickpea crop.

The study on the effect of different weed control practices (herbicides application and hand weeding) comparing with weedy check on BSR, DHA, AP, MBC, population of total N-fixers in soil & nodulation behaviour of chickpea crop envisaged that the application of pendimethalin at recommended dose inhibited the above microbial activities (BSR, DHA, AP, MBC) & population of total N-fixers in soil up to 30 DAS and after that no residual effect of above applied herbicide was visualized in the above studied parameters. Nodulation study (No. & dry weight of nodules at 50 DAS) also showed that application of pendimethalin at recommended dose did not affect nodulation of chickpea significantly.

Rice-mustard VB, Sriniketan

Treatments:

Rice (Kharif)	Mustard (Rabi)		
T ₁ - Farmer's Practice	T ₁ - Farmer's Practice + Fertilizer		
	T ₂ - Farmer's Practice + FYM		
T ₂ -Butachlor 1.0 kg <i>fb</i> 2,4 -D 0.4 kg. + fertilizer	T ₃ - Pendimethalin 1.0 kg + Fertilizer		
	T ₄ - Pendimethalin 1.0 kg + FYM		
T_3 -Butachlor 1.0 kg <i>fb</i> 2,4 -D 0.4 kg + O.M.	T ₅ - Pendimethalin 1.0 kg + Fertilizer		
	T ₆ - Pendimethalin 1.0 kg + FYM		
T ₄ - Pretilachlor / Butachlor 1.0 kg (Rw) fb	T ₇ - Isoproturon/Pendimethalin 1.0 kg (Rw) +		
2,4-D 0.4 kg + fertilizer	fertilizer		
	T_8 - Isoproturon/Pendimethalin 1.0 kg (Rw) +		
	FYM		
T ₅ - Pretilachlor / Butachlor 1.0 kg (Rw) fb	T ₉ - Isoproturon/Pendimethalin 1.0 kg (Rw) +		
2,4-D 0.4 kg + O.M.	fertilizer		
	T_{10} -Isoproturon/Pendimethalin 1.0 kg (Rw) +		
	FYM		

The permanent trial in rice-mustard cropping sequence was started from 1999 onwards in the same layout with rotational use of herbicides/treatments in rice-mustard in the Institute of Agricultural Farm, Visva-Bharati, Sriniketan. In rice, there was 5 treatments and in case of follow up crop of mustard, ten treatments were taken (dividing each plot of rice into two) to observe the differential effect of fertilizer and F.Y.M. on mustard in particular. Recommended dose of fertilizer @ 80-40-40 N, P₂O₅ and K₂O kg/ha was applied as per treatments. Green leaf manuring (with $Antigonon\ leptopus - a$ creeping weed of Polygonaceae family) @ 10 t/ha was applied one month before final puddling operation of rice field and in mustard, F.Y.M. @ 6 t/ha was applied as per treatments. Effect of herbicides and herbicide-fertilizer/organic matter combination on phyto-sociological characteristics of weeds, their shifting and their effects on grain yield of rice and mustard in initial (1999) and final year (2012) have been noted.

Note: (1) Butachlor as Machete 50 EC, (2) Pretilachlor as Rifit 50 EC, (3) 2,4-D (Na) as Fernoxone 80 WP, (4) Pendimethalin as Stomp 30 EC, (5) Isoproturon as Arelon 75 WP.

* In current year butachlor in rice and isoproturon in mustard were applied as rotation.

In the initial year (kharif 1999), Hydrolea zeylanica, Fimbristylis miliacea were pre-dominant whereas in final year (kharif 2012), Cynodon dactylon, and Ludwigia parviflora, appeared as pre-dominant in rice. In mustard, Digitaria sanguinalis was dominant in initial year (rabi 1999-2000) whereas in final year (rabi 2011-2012), Cynodon dactylon, Gnaphalium purpureum and Polygonum plebeium were predominant weed species along with Digitaria sanguinalis.

Repeated use of butachlor in addition to fertilizer or organic matter in kharif rice resulted in disappearance of Hydrolea zeylanica. Same result was observed in rotational use of pretilachlor/ butachlor. Decreasing tendency in number of Fimbristylis miliacea was also observed both in repeated use of butachlor and rotational use of pretilachlor / butachlor. It was noted that number of Cynodon dactylon and Digitaria sanguinalis was increased greatly both in repeated use of butachlor and rotational use of pretilachlor/ butachlor with fertilizer and/or organic matter. In mustard, repeated use of pendimethalin resulted in decrease of Digitaria sanguinalis but alternate use of isoproturon/pendimethalin had no such effect on Digitaria sanguinalis. New appearance of Polygonum plebeium and Solanum nigram was noticed. Cynodon dactylon came into dominant

group in the final year (*rabi* 2011-2012) in both repeated use of pendimethalin and alternate use of isoproturon/pendimethalin.

Mustard (Rabi 2011-12)

Weed population and dry matter of weeds: With regards to suppression of grassy weeds, there were no significant differences among the different treatments when observations were taken at 30 and 60 DAT but the number of grassy weeds at harvest differed significantly. Among the different treatments repeated use of pendimethalin + fertilizer controlled grassy weeds very effectively and it was closely followed by repeated use of pendimethalin + FYM (In previous kharif seasons repeated butachlor + fertilizer/OM were applied), in rotational use of isoproturon + fertilizer (In previous kharif seasons rotational use of pretilachlor/butachlor + fertilizer/OM exercised). Significant results were observed among the different treatments regarding suppression of broad leaved and total weed populations when observation were taken at 30 DAS, 60 DAS and at harvest. Repeated application of pendimethalin + fertilizer was found more effective as compared to repeated pendimethalin + FYM. It was also noticed that rotational application of isoproturon/pendimethalin irrespective to use of fertilizer/ FYM was less effective in controlling broad leaved weeds as compared to repeated application of pendimethalin.

Highest seed yield (1.242 t/ha) of mustard was recorded in rotational use of isoproturon/pendimethalin + FYM where alternate use of pretilachlor/butachlor + OM was practiced in previous *kharif* season and it was closely followed by farmer's practiced + FYM (1.200 t/ha) and rotational application of isoproturon/pendimethalin + FYM (1.192 t/ha) where alternate use of pretilachlor/butachlor + OM was practiced in previous *kharif* season.

Economics: The highest net return (₹ 28080/ha) and wider B:C ratio (1.30) were recorded under rotational application of isoproturon / pendimethalin + FYM (where rotational application of pretilachlor / butachlor + followed by 2, 4-D + O.M was applied in previous *kharif*

season) and it was closely followed by rotational application of isoproturon/pendimethalin + FYM (where rotational application of pretilachlor/butachlor + followed by 2, 4-D + O.M fertilizer was applied in previous *kharif* season).

Rice (*kharif* – 2012):

Weed population and dry matter: With regards to suppression of different categories of weed population, there were no significant differences when observations were taken at 30 DAT. The broad leaved population was controlled by rotational application of pretilachlor / butachlor (butachlor applied in present year) + organic matter + 2, 4-D when observations were taken at 60 DAT

Yield attributes and grain yield: Among the yield components, the number effective tillers/m² differed significantly but there were no significant differences in case of number of grains/panicle and test weight. Rotational application of butachlor/pretilachlor (butachlor applied in present year) followed by 2, 4-D + O.M recorded the highest number of effective tillers (371.7/m²) and it was statistically at par with repeated application of butachlor followed by 2, 4-D + O.M (362.3/m²). Though there were no significant differences in grain yield but the highest grain yield (4.285 t/ha) of rice was recorded in rotational use of butachlor / pretilachlor followed by 2, 4-D + OM. It is to be noted that use of herbicides with OM produced more grain yield as compared to with fertilizer alone

Economics: The highest net return and B:C ratio (Rs. 26720/ha and 1.08) was obtained in rotational use of pretilachlor / butachlor followed by 2, 4-D + O.M. Farmers' method of weed control gave minimum net return and B:C ratio (Rs. 22708/ha and 0.82).

Maize-chickpea cropping system.

MAU, Parbhani

A field experiment was conducted in split plot design with three replications. The gross and net plot size were 4.5 x 4.5 m and 3.6 x 3.6 m respectively for *kharif* maize crop & *rabi* chickpea crop. The maize crop was sown on 30/6/2012 at 60 x 30 cm spacing and *rabi* chickpea crop was sown

on 18/10/2012 at 45×10 cm spacing. The recommended dose of NPK and plant protection schedule was followed. The trial was started in 2007-2008.

Treatments:

Main plot Treatments (Maize)

- T1-Weedy check
- T2-Mechanical weeding (2)
- T3-Atrazine@0.75 kg/haPE
- T4-Atrazine@1.50kg/haPE
- T5-Atrazine@0.75 kg/ha PE fb.2,4-D@0.5 kg/ha

Sub plot Treatments (Chick pea)

- C1-Weedy check
- C2-Mechanical weeding (2)
- C3-Pendimethalin@1.0kg/haPE
- C4 Pendimethalin @ $0.75 \, kg/ha$ PE fb Mechanical weeding

Maize crop recorded significantly highest grain yield in plots weeded by Mechanical weedings (2HW) which was found at par with PE-Atrazine @ 1.5 kg/ha and significantly superior over rest of the treatments.

Second crop during *rabi* season i.e. chickpea recorded the highest pod yield (equivalent yield) under the weed control treatment of mechanical weedings (2HW) which was found at par with PE- pendimethalin @ 0.75

kg/ha fb 1 HW and found significantly superior over rest of the treatments.

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 tomat, brinjal etc.Its management strategy is not well developed hence a study was conducted.

WS 4.1a (i). Crop: mustard at CCSHAU, SKRAU and RVSKVV

- i. Glyphosate at 35 and 50 g/ha at 25 & 55-60 DAS
- ii. Glyphosate at 25 and 50 g/ha with 1% solution of NH₄SO₄ at 25 & 55-60 DAS
- iii. Neem cake 200 kg/ha at sowing fb pendimethalin 0.5 kg/ha -pre-em fb hand weeding (60 DAS)

Orobanche infestation in mustard has been observed in an alarming proportion in western Madhya Pradesh, Rajasthan, Haryana, Gujarat. Surrvey conducted in northern districts of M.P. (or western) bordering Rajasthan, viz., Gwalior, Morena and Bhind, indicated that the infestation of O. aegyptiaca increased under rainfed conditions or in marginal lands with loose sandy soils.

Table 4.1a: Orobanche sp. infestation in mustard in the north-western districts of M.P.

Name of district	Frequency	Density/m ²	Relative	Relative	IVI
			frequency (%)	density (%)	
Gwalior	31.1	3.2	50.9	45.6	96.6
Morena	38.6	2.9	52.2	46.8	99.1
Bhind	55.0	3.4	57.3	45.0	102.4

An experiment for the management of *Orobanche* was conducted in the sick plot at RVSKVV farm. Results indicated that trifluralin @ 1.5 kg/ha + neem oil 1% PPI followed by glyphosate @ 25 g/ha with 2% ammonium sulphate at 40 DAS resulted in the lowest number of *Orobanche* shoots in mustard. Further,

imazethapyr @ 30 g/ha as EPOE was observed to cause phytotoxicity on mustard.

At Hisar, On-Farm Trials (OFTs) were conducted in pearlmillet-mustard and fallow-mustard cropping systems. Results of 21 on farm trials conducted on 50 acres in different villages revealed that post-emergence application of

glyphosate @ 25 g/ha at 30 DAS followed by its use at 50 g/ha at 55 DAS provided effective control (79%) of *Orobanche* spp. in mustard crop. Although about 5-10% crop suppression was noticed with second application of glyphosate at 55 DAS at 2 sites, the crop plants recovered within 10-15 days after herbicide application with no yield reduction of mustard. This technology has been included in package of practices.

WS 4.1a (ii) Crops: tomato and brinjal, Cooperating centres: UAS(B), OUAT, ANGRAU and RVSKVV

Treatments:

- i. Neem cake 200 kg/ha at sowing fb oxyfluorfen 0.1 kg/ha as pre-em, 3 DAP
- ii. Neem cake 200 kg/ha at sowing fb pendimethalin 1.0 kg/ha as pre-em, 3 DAP
- iii. Neem cake 200 kg/ha at sowing fb metribuzin 0.5 kg/ha as pre-em, 3 DAP
- iv. Ethoxysulfuron 50 and 50 g/ha as PRE and at 45 DAT
- v. Sulfosulfuron 25 and 25 g/ha at 15 and 45 DAT

An OFT on management of *Orobanche* in tomato was conducted by Hyderabad centre in Rangareddy district. At Bhubaneswar, application of neem cake @ 200 kg/ha at sowing fb pendimethalin @ 1.0 kg/ha as pre-emergence resulted in the lowest number of *Orobanche* shoots in brinjal (3.5 and 7.8 per plant at 60 and 90 DAP, respectively).

Crop: Tobacco

Cooperating centre: TNAU and NDUAT

An experiment was conducted on *Orobanche* management in tobacco at Coimbatore and Faizabad centres. The treatments included neem cake @ 200 kg/ha at sowing, imazethapyr @ 30 g/ha at 55 DAP and glyphosate @ 2 g/l at 55 DAP. At Faizabad, farmer's practice (ITK) of application of urea after beheading the *Orobanche* shoots at 80 DAP was also included.

WS 4.1 b: Management of Striga in sugarcane

Cooperating centre: TNAU, ANGRAU and UAS (D)

Treatment:

Atrazine as pre-emergence 1.0 kg/ha 3 DAP+ HW on 45 DAP fb earthing-up on 60 DAP fb post-emergence spraying of 2,4-D sodium salt 5 g/l + urea 20 g/l on 90 DAP fb trash mulching @5t/ha on 120 DAP.

TNAU has observed that continuous mono-cropping of sugarcane has led to the buildup of Striga population in the cane fields. The biological characters of *Striga* infesting sugarcane were studied using pot culture experiments and accordingly S. asiatica seeds took an average of 46 days for emergence after planting of canes and each plant produced an average of 326.5 capsules per plant. In addition, several other parameters were recorded. The results (Table 4.1b.1) obtained from the OFT shows that pre-emergence application of atrazine 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 resulted in the lowest density of Striga (2/ m² on 240 DAP) and the cane yield increased substantially (162.7 t/ha) when compared to the control (42.6 t/ha) resulting in a net return of ₹ 1,54,160/ha compared to $\stackrel{?}{_{\sim}} 40,470/\text{ha}$ from the control plot.

At Dharwad, initial application of atrazine was not effective because of late emergence of *Striga* (110 to 120 DAP). Hence additional treatments with atrazine, metribuzin + 2, 4–D Na Salt, diuron + 2, 4–D Na were sprayed after 110-120 DAP coinciding with the emergence of *Striga*. This application effectively reduced the *Striga* incidence up to 150 DAP.

WS 4.1c: Management of Cuscuta

4.1. c. (i) Crops : **Niger, Cooperating centre:** OUAT and BAU

Table 4.1b.1: Effect of treatments on Striga shoots density and yield of cane at Coimbatore

		Striga sho	ots densi	ty (no./m²)	Cane	Yield	Net
Treatment	60	90	120	180	240	yield (t/ha)	increase (%)	returns (x10³₹/ha)
PE atrazine @ 1.0 kg/ha on 3rd DAP + HW on 30 and earthing up on 60 DAP.	68.5	95.6	102.5	103.6	78.5	124.6	92.5	118.15
HW on 30 and 60 DAP and earthing up on 90 DAP	86.7	106.5	122.6	125.8	83.5	103.8	43.7	98.45
PE atrazine @ 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	62.4	12.5	3.6	2. 5	2.0	162.7	181.9	154.16
Unsprayed control	126.8	138.3	156.5	178.9	152.7	42.6	-	40.47

Treatments:

- i. Pendimethalin 1.0 kg/ha pre-emergence
- ii. Stale seedbed *fb* pendimethalin 1.0 kg/ha pre-emergence
- iii. Imazethapyr 75 g/ha as PPI At Ranchi, there was no *Cuscuta* infestation

in the experimental plots. At Bhubaneswar, OFTs were conducted at Koraput. Results indicated that *Cuscuta* appeared as early as 14 DAS in the treatment stale seedbed *fb* pendimethalin 1.0 kg/ha and recorded the lowest density of *Cuscuta* under stale seedbed *fb* pendimethalin (Table 4.1c.1).

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

Treatment	Germination of Cuscuta			sity of cuta/m²	Yield of niger	B:C	
	(DAS)	No/ m ²	30 DAS	60 DAS	(kg/ha)	ratio	
Pendimethalin 1.0 kg/ha	15.2	1.4	3.3	10.7	810	1.82	
Stale seedbed fb pendimethalin 1.0 kg/ha	14.0	1.0	2.8	10.6	820	1.62	
Imazethapyr 75 g/ha	14.2	1.5	3.8	12.8	782	1.75	

Crop: Onion

Cooperating centres: UAS (D) and UAS (B)

Treatments:

- i. Pendimethalin 1.0 kg/ha pre-emergence
- ii. Stale seedbed *fb* pendimethalin 0.5 kg/ha pre-emergence

iii. Imazethapyr 100 g/ha as post-em., 20 DAP

At Dharwad, infestation of *C. chinensis* was observed in onion in OFTs at Chikkaballapura district and pendimethalin @ 0.75 kg/ha was applied. This treatment suppressed new emergence of *C. chinensis* but the existing twines were not killed.



Plate 1. Infestation of C. chinensis in onion, green gram and cowpea-finger millet mixed

Similarly, widespread occurrence of *C. chinensis* was observed in field beans (*Dolichos*), pigeonpea, greengram (Plate 1b) and cowpea (Plate 1c) crops in Hunsur Taluk, Mysore. Incidence of *Cuscuta* was found increasing in fields where field beans and cowpea were sown as relay crops in tobacco fields a month prior to harvest of tobacco.

WS 4.1d: Management of Loranthus

Infestation of *Loranthus* in trees in orchards is a serious problem reducing the yield, quality of fruit and also hinders in harvesting of the fruits. No effective chemical management is

available, hence a study was conducted to find out an effective chemical management of *Loranthus*.

Cooperating centre : KAU, UAS (B) and ANGRAU

An experiment was conducted on the farmer's field on sapota trees infested with *Dendrophthoe* near Bengaluru. Results indicated that padding of the stem with cotton soaked with the paste of 4 g copper sulphate + 0.5 g 2,4-D sodium salt 80 WP on the wounds of *Dendrophthoe* shoots caused 100% defoliation after 2 months without regeneration up to 6 months. The younger shoots showed drying after 2 months but bigger shoots took more time for drying.

Table 4.1d.1: Effect of herbicide treatments on mortality of	D.	falcata at	different	periods
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Treatment	Mortalit	y (%)	Remarks
	58 days	176 days	Keniarks
Padding of Cu SO ₄ + 2,4-D Na salt	75	100	Complete defoliation, no regeneration
Salt padding 1 g/l	0	0	No effect
Directed spray of paraquat 5 ml/l	50	50	Only leaves dried, regeneration occurred after 2 months
Directed spray of glyphosate 71 WP 1% solution	20	40	Leaves continued to dry
Directed spray of glyphosate 41 SL 1 ml/ 5 ml water	20	40	Leaves continued to dry

Taxillus cuneatus (Loranthus) was common in the high ranges of Kerala on fruit tress such as apples, peaches, plums, pomegranate *etc.* Ethrel

application @ 25 ml/L and padding with 2,4 D (1 g/20ml) was found effective.



Plate 2: *Taxillus cuneatus* on Pomegranate

Padding 2,4- D

Ethrel application

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

Parthenium has become a problematic weed throughout India. Earlier, it was not a menace in crop lands but now most of the crops are severely infested with the weed. A network programme was initiated to see the establishment and impact of Zygogramma bicolorata on Parthenium. The experiments were conducted on Parthenium infested sites in natural conditions on wastelands, road sides or in community lands. The adult beetles were collected from the already established sites or were supplied by Directorate of Weed Science Research, Jabalpur. The beetles were released and observations were taken on the number of adults, eggs and larvae at one month interval after release. The establishment of the beetle was also taken by visual observations. Damage was taken on 0-5 scale based on visual ranking.

Observations revealed that *Z. bicolorata* behaved differently at different places of its release. At Anand, adults laid eggs and grubs hatched out from the eggs and caused 5-10% defoliation. The full-grown grubs entered into the soil for pupation but the beetles were not emerged from soil. There was no establishment of the beetle at the released site. Similar observations were reported by Jorhat, Ranchi, Thrissur and Dapoli centres.

At Hisar, there was poor establishment of beetle during 2012. The beetle did not multiply to appreciable levels. However, the bioagent showed good control at some earlier established sites, revealing that it may behave differently at different places and times.

At Kanpur, beetle were found to establish at the released sites and caused about 65% defoliation (Table 4.2a.1).

Table 4.2a.1: The	population d	lynamics of M	exican beetles	s Zygogramma	biccolorata at Kanpur	
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Date of	Indra	Nagar	Budha	Park	Hasanpur		
observation	Larvae/ plant	Adult/ plant	Larvae/ plant	Adult/ plant	Larvae/ plant	Adult/ plant	
21.9.2012	10	16	8	14	12	12	
21.10.2012	8	8	6	8	6	8	
21.11.2012	3	2	4	3	3	2	

At Palampur, the bioagents were released during mid-July. The observations taken at monthly interval revealed progressive multiplication of the beetle along with increase in damage (Table 4.2a.2). The activity of beetles increased from July to September. Maximum

population of grubs was seen during July and August. The beetle population per *Parthenium* plant was more during September, which caused a damage ranging from 6-63%. The beetles caused complete defoliation of the *Parthenium* by the end of September and 1st fortnight of October.

Table 49: Population structure of Z. bicoloratra at Palampur after one month of release

		Site 1			Site 2	•		Sit	e3
S. No.	Egg	Grub	Adult	Egg	Grub	Adult	Eggs	Grub	Adult
1	2	7	15	3	6	6	2	4	6
2	3	8	12	2	4	4	2	4	7
3	3	5	4	2	3	5	3	4	4
4	3	4	4	0	2	4	4	4	5
5	3	3	5	2	6	5	3	3	6
6	3	7	3	0	5	6	1	5	5
7	3	6	12	2	4	4	3	4	6
8	3	5	5	3	2	4	2	5	8
9	3	4	6	3	1	5	3	3	4
10	2	3	3	3	2	4	4	3	5
Av.	2.8	5.2	6.9	2.0	3.5	4.7	2.7	3.9	5.6
Over all d	amage	(in per c	ent) at the	site: 28-	-63%			·	

At Pantnagar, bioagents were released at two sites infested with *Parthenium hysterophorus*. The extent of damage of *Parthenium* varied from 2-56% in

different months. The highest damage (45-56%) by *Zygogramma bicolorata* was observed in the month of September.

Table 4.2a.3: Egg, grub and adult population of Mexican beetles per plant and per cent damage to *Parthenium* at two sites during *Kharif*, 2012

	(behi		Site1. College,	Pantnagar)	Site-2 (D2 block CRC, Pantnagar)				
Month	Egg	Grub	Adult	Damage (%)	Egg	Grub	Adult	Damage (%)	
May	0	3	0	2	0	0	1	3	
June	2	5	1	8	9	5	10	12	
July	4	10	16	20	15	4	22	24	
August	25	20	30	39	18	28	35	41	
September	30	22	41	45	28	32	48	56	
October	18	12	22	26	10	22	15	38	
November	10	2	8	15	12	5	10	21	

At Prabhani, average *Parthenium* density per m² was 10.4 plants. The eggs, grubs and adult population per plant after one month of release

were 2.8, 2.60 and 4.00, respectively. About 70% *Parthenium* plants were completely defoliated after one month of release of beetles (Table 4.2a.4).

Table 4.2a.4: Parthenium population, beetle density and percent of plants damage

Parthenium density/m²	Popu	lation/plant		Damage (Scale)	Parthenium seeds*
	Egg	Larve	Adult		germinated/ 15 cm ²
8	4	2	7	5	0
12		4	2	5	0
9	3	1	6	5	0
13	3	2	5	5	0
10		4	3	4	0
15		3	5	5	0
8		3	2	4	0
14	2	2	3	5	0
5	2	2	4	5	0
10		3	3	4	0
10.4	2.8	2.6	4.0		0

At Faizabad, a trial was conducted at three upland sites of university area of 100 m². The density of the *Parthenium* plants at different sites varied from 52-70 plants/m². The population of adult beetle increased in the range of 18.3-23.5/plant in the

month of October. However, population of adult beetles declined to a considerable extent in November. At one site, beetle caused 75% defoliation, while at other two sites, 100% defoliation was recorded (Table 4.2a.5).

Table 4.2a.5: Density of *Parthenium* plants (no./m²) and population build up of beetle (no./plant)

	Density of	Date of	Population	n build-up of	f beetle (no./j	plant)
Site	Parthenium plants (no./m²)	release of 600 no. of adult beetles	September	October	Novemb er	Rating
Behind COA building	70.5	2.8.2012	10.2	23.5	12.7	4
Behind Kisan Bhawan	65.4	2.8.2012	12.5	18.3	10.3	5
Agronomy Research Farm	52.5	3.8.2012	14.3	22.4	9.3	5

Size the individual site: 100m², Release of adult beetle per site: 600 numbers

Rating: 4 = 75% foliage loss; 5 = 100% foliage loss

At Ludhiana, three new upland large sites with growth of Parthenium were selected. Parthenium density ranged from 56-78/m². Adult beetles were collected from established sites and released evenly on entire field. Damage of plants was reported to be in the scale of 2-3 at all sites.

At Pusa, the beetles were released at three sites. Mexican beetles remained active between July to September. The emergence of beetle depended on rainfall and environment. The damage varied from 7-73% (Table 4.2a.6).

Table 53: Egg, larvae and adult population of *Zygogramma bicolorata* and per cent damage to *Parthenium* at three sites

Month	Site I (Mirapur Middle School-Muzaffarpur)				Site II (Malinagar High School-Samastipur)				Site III (Balua Basic School- Muzaffarpur)			
	Eggs	Grub	Adu- lts	Dam- age (%)	Eggs	Grub	Adul- ts	Dam- age (%)	Eggs	Grub	Adul- ts	Damage (%) 0-5 scale
May	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	2	11	0	1	1	8	0	0	0	0
July	20	0	3	24	11	2	3	24	0	2	7	1
August	37	14	10	63	24	10	10	68	3	8	16	1
September	31	20	16	73	30	13	14	76	10	14	46	2
October	0	10	13	61	0	12	12	63	6	9	38	2
November	0	0	5	43	0	6	6	40	0	6	37	2
December	0	0	0	20	0	2	2	38	0	0	26	2
Mean	11.0	5.5	6.1	36.8	8.1	5.7	6.0	39.6	2.3	4.8	21.2	1.2

Table 4.2a.7: Parthenium morphology and relation with Mexican beetles at three selected sites in north Bihar

Particulars	Site I (Mirapur Middle School- Muzaffarpur)	Site II (Malinagar High School- Samastipur)	Site III (Balua Basic School- Muzaffarpur)	
Plant population/m ² area	08-13	09-13	8-12	
Plant height (m)	0.52-0.82	0.54-0.81	0.47-0.79	
Fresh biomass of plant (kg/m²)	0.65-0.94	0.70-0.92	0.68-0.91	
Adult population per plant	6.1	6.0	4.8	
Grubs / plant	5.5	5.7	2.3	
Eggs/plant	11.0	8.1	3.8	
Per cent damage (%)	36.8	39.6	21.2	

At Gwalior, Beetles were released at two sites. Observations revealed the establishment at both the sites. Maximum population of grub was observed during August to September. Overall damage was 10-50%.

In Coimbatore, beetles were released at three locations, viz. Vadavalli, Thondamuthur

and Mathampalayam. After a month of release, there were 3.4-4.9 eggs/plant with 3.6-6.0 grubs and 4.0-5.4 adults/plant. *Parthenium* damage was in the range of 25-55% during first month Enhanced *Parthenium* damage (60-65%) was observed from 3rd month onwards (Table 4.2a.8).

Table 4.2a.8: Zygogramma bicolorata infestation and Parthenium damage

Plant no.	Navavoor			Thaliyur		Chinnamathampalayam			Damage of Parthenium	
	Eggs	Grubs	Adults	Eggs	Grubs	Adults	Eggs	Grubs	Adults	(0-5 scale)
1	8	4	8	3	6	4	8	5	4	2.5
2	4	3	9	3	4	2	5	7	2	2.8
3	5	3	6	4	2	2	2	8	2	3.8
4	5	5	4	3	5	4	3	6	4	2.0
5	2	3	5	3	3	6	6	2	2	3.2
6	3	3	5	4	5	4	8	5	4	2.5
7	6	3	7	5	2	5	2	8	5	1.6
8	8	5	2	2	8	8	2	6	6	2.2
9	5	4	4	3	6	3	2	7	7	3.4
10	3	3	5	4	3	8	8	6	4	3.9
Mean	4.9	3.6	5.4	3.4	4.4	4.6	4.6	6.0	4.0	2.9

At Bengaluru, two sites, *viz*. Hadonahalli and Tubagere were selected. Due to lower rainfall (50% of normal) in 2012, the emergence of Mexican beetle was poor. Hence, the visual impact in causing defoliation of *Parthenium* could not be seen on *Parthenium*.

At Sriniketan, Mexican beetle (Zygogramma

bicolorata) was released on Parthenium during the last 7-8 years in West Bengal. The beetles have established in Sriniketan, Santiniketan and Shyambati area. In 2012, beetles were released in May, July and August at three sites (Table 4.2a.9). There was poor establishment of the bioagents at the released site during the first year.

Table 4.2a.9: Receive / collection and release of beetle

Receive fro Jaba	,		Release				
Date	Nos. in living condition	Date	Number	Site	Area of release (sq. m.)	population (No./m²) (Average)	
24.05.2012	456	25.05.2012	456	Ballavpur (site – I)	25	40	
01.07.2012	48	03.07.2012	48	Prantik (site II	5	52	
Collection establishe Srinik	ed site at		Release				
Date	Numbers	Date	Oate Numbers Site Area of release (sq. m.)				
30.08.2012	250	30.08.2012	250	Taltore (site – III)	15	41	

Table 4.2a.10: Population of egg, grub, adult of Zygogramma and damage of Parthenium

Site	Month	Popula	tion (average No.	/plant)	Damage (0-5 scale)
Site	WIOIRI	Egg	Grub	Adult	Daniage (0-3 scare)
	June	0	0	1	0
	July	0	0	0	0
I	August	0	0	0	0
Ballavpur	September	0	0	0	0
	October	0	0	0	0
	November	0	0	0	0
	August	14	2	1	1
II	September	10	3	2	2
Prantik	October	4	2	1	2
	November	0	0	1	1
III	September	10	3	3	1
Taltore	October	4	2	2	2
rantore	November	0	0	1	1

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

Cassia tora has been considered a most suitable competitive plant for the biological management of *Parthenium*. Keeping in view its various attributes, it was recommended to replace *Parthenium* at the desired site. It was decided to conduct a net working trial during 2012-13 at all

the centers of AICRPWC to find out the effectiveness of *Parthenium* in different climatic conditions. Many AICRP-WC conducted this experiment.

At AAU, Anand (Gujrat), *C. tora* was found effective to control *Parthenium* by 49% at the seed rate of even 15 kg/ha (Table 4.2b.1).

Table 4.2b.1 58: Effect of Cassia tora on plant stand of Parthenium hysterophorus at maturity stage

Treatments	Cassia tora (no./m²)	Parthenium hysterophorus (no./m²)	Parthenium hysterophorus Control (%)
Cassia tora 10.0 kg/ha	33	98	25
Cassia tora 12.5 kg/ha	41	82	37
Cassia tora 15 .0kg/ha	54	66	49
Control (<i>P.hysterophorus</i>) Only	0	130	

At Hyderbad, seeds of *C. tora* were broadcasted during April-May i.e before onset of monsoon at three sites on road side, already demarcated for



Parthenium infestation. Cassia tora was germinated after the onset of monsoon and successfully replaced Parthenium by September-October.



At Palampur, the seeds of *Cassia tora* mixed with FYM 60 kg/ha were broadcasted during February-March at three selected sits which were severely infested with *Parthenium*. In most of the

sites, there was good germination of *C. tora*/m² which gradually suppressed the *Parthenium* in due course (Table 4.2b.2).

Table 4.2b.2: C. tora and Parthenium population/m2 at three sites during August 2012.

S.No.	Site1		Site 1 Site 2		Site 3		
5.INU.	Cassia	Parthenium	Cassia	Parthenium	Cassia	Parthenium	
1	-	17	3	29	2	26	
2	22	7	50	2	26	2	
3	31	5	33	4	28	4	
4	26	4	42	3	23	4	

In Coimbatore, three locations namely Navavoor, Thaliyur, Chinnamathampalayam villages under Vadavalli, Thondamuthur and Mathampalayam blocks, respectively were selected. Initial infestation of *Parthenium hystrrophorus* were assessed during *Kharif* 2012 (July) and the seeds of *Cassia sericea* at 75 kg/ha were broadcasted on 30th August, 2012 in an area 600 m² in each location at under non-crop situation. However due to scanty rainfall in all the three locations *Cassia sericea* germinated and dried for want of moisture. Hence, the same locations are being observed for the establishment of *Cassia sericea* in the subsequent seasons and years.

Most of the AICRPWC centers have collected the seeds of *C. tora* during October –November 2012 and have selected the suitable *Parthenium* infested sites for broadcasting the

seeds of *C.tora* during February to April 2013.

WS 4.2c : Biological control of water hyacinth

During 2011, Neochetina spp. were obtained from DWSR, Jabalpur and released in the Mir Alam Tank, Rajendranagar which was fully infested with water hyacinth. In due course of time, the weevils multiplied and excellent control of water hyacinth was observed in Mir Alam Tank. By March 2013, the whole tank was cleared from Water hyacinth due to action of Neochetina spp. Very low population of water hyacinth was found on the bank side. The bioagents were found on this left water hyacinth. It was visualized that the remaining low infestation will also be succumbed to the pressure of bioagents. Alligator weed replaced the niche vacated by water hyacinth.



Fig. 4.2c.1 : Sequence of control of water hyacinth by action of *Neochetina* spp.

During 2012, an another pond namely Cheruvu in Uppal area of Ranga reddy district severely infested with Water hyacinth was selected. On survey of the pond, *Neochetina* spp. Was found but in very low density. Thousands of weevils were collected from Mir Alam Tank and were augmented in the pond. This augmentation helped the population builup which controlled most of the water hyacinth in the pond by March 2013. This was the good example of control of water hyacinth by augmentative release of bioagents.

Neochtina spp. obtained from DWSR, Jabalpur were released *d*uring September, 2012 at Hisar and Sirsa for control of water hyacinth. Feeding scars were recorded at both the sites indicating its process of multiplication.

In Kerala, weevils *Neochetina eichhorniae* and *N. Bruchi* have already been introduced and have established in most of the places of release *viz.*, Ernakulam, Alleppey, Kottayam and Thrissur districts. Therefore, an experiment was initiated in concrete tanks. Un-infested *Eichhornia* plants were collected from certain pockets of Alappad Kole lands (submerged paddy fields) and introduced 10 plants into each concrete tank of size 1x 1 x1 m. Three replications were maintained. Ten beetles/tank were introduced along with one *Eichhornia* leaf infested with 10 *Orthogalumna terebrantis*.



DWSR center of UAS, Bengaluru initiated work on Biological control of *Salvinia molesta*. The new aqbuatic weed, *Salvinia molesta* has been noticed around Thekkatte and Kota villages, Udupi district in coastal zone (400 km from Bangalore) since 3-4 years. Initially, the weed was

confined to ponds around these villages. However, floods, which occurred during 2010, caused the spread of *Salvinia* to adjoining paddy fields and posing problems in rice cultivation. The bioagents *Cyrtobagous salvinae* were collected from Thrissur and released at Udupi district in Karnataka.

About three thousand weevils were released in five ponds in Thekkatte villages. The released weevils – *Cyrtobagus salviniae* could not cause visual impact by March 2012 . In Barkur, Udupi District, about two thousand weevils, were released during Ocotober 2011. Mile establishment of the bioagents was observed which caused about 20-30% damage to *Salvinia* plants.

The Coimbatore centre selected three ponds *viz.*, Krishnampathy, Sungam and Singanallur predominantly infested with water hyacinth for the study. The density varied from 38 to 55/m² and it was programmed to release the beetle during September 2012. However, due to poor rainfall all the ponds have dried up consequently water hyacinth also. In the place of water hyacinth other semi aquatic weeds like *Alternanthra philoxeroids*, *Brachiaria reptans* have dominated the ponds.

Neochetina weevil released in the water hyacinth infested pond showed the symptoms of multiplication after 90 days of release.

Faizabad, Sriniketan and Jorhat centre also made efforts to select the suitable aquatic bodies infested with water hyacinth.

WS 5 : Herbicide residues and environmental quality

WS-5.1: Herbicide residues in long-term herbicide trial

Use of herbicides in long-term is expected to increase 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 plants at harvest in rice-wheat, pearlmillet-groundnut, groundnut-fingermillet,

maize-pea, sorghum-wheat, rice-rice and rice-groundnut cropping systems in different agroclimatic zones.

(i) Rice-wheat

At Palampur, post-harvest soil, grain and straw samples were collected for the estimation of isoproturon and butachlor residues in rice-wheat cropping system. In all the samples, isoproturon, and butachlor residues were found below detectable limits (0.001 µg/g). Similarly, At Kanpur, cucumber was used as an indicator plant to assess herbicides residue in soil of wheat and rice crops. Application of sulfosulfuron and clodinafop as post-emergence in wheat and anilofos in rice at recommended and double of recommended did not show any adverse effect on cucumber germinations, height, fresh and dry weight compared to control. At Faizabad, butachlor (1.5 kg/ha) application as preemergence in rice did not leave residues in soil. Application of 2,4-D Na salt at 0.5 and 0.8 kg/ha as post-emergence persisted up to 30 and 45 days, respectively in soil of wheat crop. Isoproturon residues (1.0 kg/ha) in wheat, butachlor (1.5 kg/ha), anilofos (0.4 kg/ha), and pendimethalin (1.0 kg/ha) residues were analysed in soil of ricewheat cropping system at Pantnagar. Rice grain and straw samples collected from rice-wheat field at harvest. Residues were non-detectable (0.001 g/g and 0.005 g/g) at the time of harvest of wheat and rice.

(ii) Pearl millet-groundnut and groundnutfingermillet cropping systems

Pendimethalin residues in soil and kernels of groundnut were analyzed by GC at Hebbal, Bangaluru. Residues of pendimethalin were below detectable level (0.01 mg/kg) in both soil and kernels of groundnut at recommended (1.0 kg/ha) and double the recommended levels of application (2.0 kg/ha). Similarly, butachlor residues were assessed in soil at harvest, and 113 days after herbicide application in finger millet crop. Residues of butachlor were found below detectable level (0.01 ppm), in soil, grain and straw samples. While at Anand, atrazine residues in surface soil were decreased as the stage of sampling advanced in pearl millet crop. Atrazine

residues were detected up to 30 days in soil after its application in pearl millet. Atrazine residues were found below detection limit in grain and straw of pearl millet at harvest. Pendimethalin residues were detected at all the time of sampling up to the harvest in sandy loam soil under wheat crop. However, residues were below detection limit in grain and straw of wheat at harvest.

(iii) Maize-pea cropping system

At Palampur, post-harvest soil, grain and straw samples from maize-peas system were assessed for pendimethalin residues. In all the samples pendimethalin residues were found below detectable limits (0.001 µg/g). At harvest soil samples from chickpea, peas and mustard crops were collected during Rabi to assess terminal residues of pendimethalin by GLC method. Residues of pendimethalin were below detectable level. Similarly post harvest soil samples were collected to assess residues in maize field of Palampur where atrazine (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) was applied at various doses. Atrazine residues were found 0.006, 0.010 and $0.005 \mu g/g$ in soil in three different weed control treatments.

(iv) Sorghum-wheat cropping system

At Parbhani, soil samples were collected at 30, 60 days after spaying and at harvest from herbicide treated plots of *kharif* sorghum where atrazine at 0.75, 0.50 kg/ha and oxyfluorfen at 0.100 and 0.125 kg/ha were applied in wheat. At harvest, atrazine residues were found 0.010 to 0.007 ppm and 0.017 to 0.014 ppm in soil and grains, respectively, in those samples where atrazine was applied at 0.75, 0.50 kg/ha, respectively. Oxyfluorfen residues in wheat were 0.002 and 0.001 ppm in wheat grains in both the doses. At harvest, atrazine and oxyfluorfen residues in wheat and sorghum were under the maximum permissible limit (0.10 and 0.05 ppm) in grains in both the treatments.

(v) Rice-rice

At Trissur, butachlor and pretilachlor residues were estimated in the soil samples of first crop and second crop from rice field at 60 days

after spraying. Residues of butachlor and pretilachlor in soil at 60 days were found below the detection levels (<0.01 and 0.02 respectively). At AAU, Jorhat, surface (0–15 cm) soil samples were collected at periodic intervals and analyzed for butachlor, pretilachlor and 2, 4-D residue in rice in autumn rice-winter rice cropping sequence Butachlor residues in soil ranged from 0.16 to 0.21 ppm on the day of spray and reduced to 0.016 to 0.020 ppm after 15 days of application. Residues were below detectable level (0.01 ppm) after 30 days of its application, irrespective of the treatments. Pretilachlor residues in soil were found below detectable level (0.01 ppm) after 15 and 30 days of application in a treatment, where butachlor + 2,4-D rotated with pretilachlor. However, irrespective of herbicides, highest concentration was observed on the day of application, which was decreased continuously and found below detectable level (0.01 ppm) after 45 days of application. In soils, where organic manure was applied, both herbicides were detected up to 30 days. In rice grain and straw, residues were below detectable level.

At Hyderabad, butachlor was applied to transplanted rice as pre-emergence herbicide at 1.0 kg/ha after 3 days of transplanting. Cyhalofop-p-butyl was applied as postemergence after 20 days of transplanting at 0.1

kg/ha. Residues were analyzed in soil collected at 0, 15, 30, 45 days of transplanting and at harvest. Detection limit (LOD) of butachlor and cyhalofop-butyl were 0.02 mg/kg and LOQ was 0.05 mg/kg. After two hours, initial residues of butachlor, and cyhalofop were 0.367 and 0.481 mg/kg, respectively. Butachlor and cyhalofop degraded to 0.057 and 0.165 mg/kg at 30 days. Residues reached to below detection level (0.02 mg/kg) by 45 days. Residues of butachlor and cyhalofop could not be detected in the rice grain or straw samples at harvest.

Similarly, soil, plants and grains samples from paddy field were analyzed for butachlor, 2, 4-D and pretilachlor residues, at TNAU. progressive decline in butachlor residue content was observed with advancement of crop growth. More than 90% of applied butachlor degraded from the soil within 45 days of application in both the seasons. About 80% of applied 2, 4-D degraded from the soil within 7 days of its application. 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. Residues of all the applied herbicides were found below detectable limits (0.01ppm).

Table 5.1.1: Butachlor residues in soil at different days after application and in rice grain and straw at harvest

Treatment	Butach	lor residu after apı	at days	Butachlor residue (ppm) at harvest		
Treatment	0	15	30	45	Grain	Straw
Autumn rice						0 120211
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

(vi) Rice-groundnut cropping system

At Bhubaneswar, soil samples were collected at 0 days and continued up to harvest and plant samples were collected at harvest from various treatments where butachlor+2,4D in rice and alachlor and pretilachlor were applied in

groundnut with various combinations of fertilizers. Butachlor residues were detected up to 60 days, however pretilachlor and alachlor were detected up to 30 and 60 days (Table 5.1.2a4 and 5.1.3). Addition of organic matter decreased the persistence of both the herbicides.

Table 5.1.2: Residue of herbicides in rice

Days after application	Residue in mg/kg as per treatment							
	Т3	T4	T5	T6				
0	0.436	0.428	0.446	0.426				
15	0.274	0.264	0.274	0.254				
30	0.095	0.085	0.095	0.095				
60	0.007	0.007	0.007	0.007				
90	BDL	BDL	BDL	BDL				
Harvest	BDL	BDL	BDL	BDL				

LOQ=0.01mg/kg; LOD=0.001mg/kg

Table 5.1.3: Residue of alachlor and pretilachlor in rice

Days after	Residue (mg/kg)											
application			Alac	hlor			Pretilachlor					
(DAA)	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
0	0.336	0.326	0.325	0.316	0.329	0.319	0.436	0.428	0.446	0.426	0.436	0.428
15	0.269	0.249	0.267	0.247	0.269	0.249	0.274	0.264	0.274	0.254	0.274	0.264
30	0.099	0.089	0.114	0.099	0.099	0.099	BDL	BDL	BDL	BDL	BDL	BDL
60	0.004	0.004	0.004	0.004	0.004	0.004	0.007	0.007	BDL	BDL	BDL	BDL
90	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Harvest	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note:

- T₁ Hand weeding (twice) OM + inorganic fertilizers (N:P₂O₅:K₂O 60:30:30)
- T₂ Hand weeding (twice) + OM + inorganic fertilizers (N-adjusted)
- T₃ Butachlor 0.75kg/ha + 2,4-DEE 0.4 kg/ha OM + inorganic fertilizers
- T₄ Butachlor 0.75 kg/ha + 2,4-DEE 0.4 kg/ha. + OM + inorganic fertilizers (N-adjusted)
- T₅ Butachlor 0.75 kg/ha + 2,4 -DEE 0.4 kg/ha rotated with pretilachlor 0.75 kg/ha- OM + inorganic fertilizers
- T₆ Butachlor 0.75 kg/ha + 2,4 -DEE 0.4 kg/ha rotated with pretilachlor 0.75kg/ha. + OM + inorganic fertilizers (N-adjusted)

WS-5.2: Studies on herbicide persistence in water

This experiment was initiated to determine the herbicide persistence in water under field conditions and their effect on aquatics. Water samples near agricultural land were collected after one week and one month of herbicide spray from the agriculture field to see herbicide persistence in water. At Anand, paraquat residues in water were decreased as the stage of sampling advanced in application rates of 0.5 and 1.0 kg/ha. Paraquat residues were less at all the intervals in water in low application rate of paraguat. Paraguat 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 paraguat used for management of water hyacinth. Similarly, residue of butachlor and pretilachlor were found below detectable level in all the samples collected from pond, adjacent to fields where herbicides are applied in rice crop at Jorhat. At UAS, Bengaluru, residue of pyrazosulfuron ethyl were seen up to 4th week after application in underground water at level of 0.0052 and 0.0061 ppm at 25g and 50 g/ha dose (Table 5.2.1. However, after 45 days, residues of pyrazosulfuron ethyl were found below detectable limits in underground water of rice cultivated field both at 25 and 50 g/ha during summer 2011-12. Similarly, after one month of herbicide spray butachlor residues were not observed in water samples at Palampur.

Table 5.2.1: Persistence of pyrazosulfuron-ethyl in underground water (ppm) under transplanted rice at Kathalagere during summer 2012

Days after treatment	Dose of pyrazosulfuron (g/ha)				
Days arter treatment	25	50			
0	0	0			
15	0.0084	0.0178			
30	0.0052	0.0061			
45	BDL	BDL			
Harvest	BDL	BDL			

At Thrissue, water samples were collected after one week and one month after spraying from the field outlet to irrigation channel adjoining the LHT rice field to see 2,4-D (1, 2 and 4.0 kg/ha) persistence in water and its effect on water quality. Residues data were compared with experiment conducted under controlled conditions in concrete tanks and aquariums. Residues were found below the detectable limits, after one week of herbicide application in the field outlet to irrigation channel adjoining the paddy field. Under field conditions, 2,4-D residues varied from 0.0014 ppm to 0.030 ppm and degraded to 0.00054 to 0.025 ppm. To see adverse effect of 2, 4-D, 6-8 cm length and 2-2.5 cm width fishes (Tilapia) were

analyzed which were grown in aquariums. In fishes, no visible changes were observed. However, histopathological studies of fishes showed necrosis of liver cells. When 2,4-D was sprayed in the glass aquarium tanks, Residues of 2,4-D persisted in the water up to 7 days, and residues were ranged from 0.25–1.12 ppm depending on the levels of application.

At Parbhani, water samples were collected after one week and after one month of herbicide spray from the agriculture field. Atrazine residues were found 0.08 and 0.02 ppm in water samples collected after one week and one month, from well nearby the experimental plots where atrazine was applied (0.5 kg/ha) as pre emergence for weed control in sorghum. Whereas at Hyderabad, initial water samples from two bore wells were collected to analyze atrazine residues in water from farmer's fields which have large area under maize crop in Polampally village in Keshampet mandal of Mahabubnagar District during June 2012. Bore wells which were selected to assess herbicide residues were near to the fields where maize was cultivated. Atrazine residues were found below detection limit in samples collected from the farmers field. pH and EC of the water samples did not vary significantly during different sampling stages.

At Pantnagar, water samples were collected near the agricultural field, within one week of herbicide spray and after one month to see persistence and change in water quality. Isoproturon, 2,4-D, clodinafop, pretilachlor, butachlor, anilophos, atrazine, and pendimethalin residues were found below detectable limits in water samples drawn from water bodies at 0 to 5, 15 to 20 and 30 to 35 days after application. However study conducted under laboratory conditions showed persistence and presence of isoproturon, atrazine, and pendimethalin residues even after 60 days of application. At TNAU, 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 herbicides application. Residues of pretilachlor, butachlor, alachlor, bensulfuron methyl, 2,4-D, pyrzosulfuron ethyl, bispyribac sodium were found below detection limit in water samples collected from garden land area even after 3 days of application. Under submerged ecosystem, residues of herbicides were below detectable limit on 3rd day after application irrespective of source of water except for 2,4DEE, 2,4-D acid and bispyribac sodium in field water.

WS 5.3: Characterization of leaching behaviour of herbicide in soil

This exsperiemnt was initiated to evaluate leaching behaviour of herbicides in different agroclimatric region and effect of environmental factors, soil, rainfall/ irrigation etc. at recommended and double the recommended doses. Leaching studies were conducted in PVC tubes (dia 10-15 cm and 60 cm long) with simulated rain. Leaching behaviour of quizalofop, anilofos, butachlor, metribuzib, pretilachlor, quizalofop, cyhalofop, pyrazosulfuron, oryzylin, 2,4-D and bspyribac-sodium were determined in different soil type.

Herbicide	Centre
Quizalofop	AAU (A)
Anilofos,	NDUAT
Butachlor, Metribuzin	RVSKVV
Quizalofop	OUAT
Metribuzin	CSKHPKV, AAU (J) and ANGRAU
Pretilachlor	ANGRAU and PAU
Oryzylin	GBPUAT
Pyrazosulfuron	UAS (B), TNAU, KAU and MAU
Cyhalofop	CSKHPKV
Bispyribac-Sodium	TNAU
2,4-D	NDUAT and MAU

At Anand, quizalofop-ethyl residues were detected up to 5 cm depth in sandy loam soil after 0, 1 and 3 days of its application at 50 and 100 g/ha rates. In sandy loam soil residues were found up to 10 cm depth after one day of its application, while, residues were not detected in later stages in different depths in sandy loam soil. In another study carried out in silty clay loam of Palampur, cyhalofop-butyl and metribuzin were leached up to 15 cm depth under soil columns using cucumber plant bioassay. However, 2,4 D leached up to 60 cm depth in vertisols of Parbhani

using cucumber plants as indicator of 2,4-D movement. Cucumber plants germination, height, root length and biomass were drastically reduced due to 2, 4 D residues up to 30 cm depths in both X and 2X doses. Metribuzin detected up to 25-30 cm in X and 2X doses in the soil of Hyderabad. 78.9 % in X dose and 80.42 in 2x dose of the total herbicide were detected in 0 to 20 cm depth of the soil column. However higher concentration of the herbicide was detected in 10-15 cm layer in both doses (23.1% in x dose and 26.1% in 2X dose). Beyond 30 cm herbicide leached to below detection limit, hence could not detected with LOQ of 0.05 ppm.

Pretilachlor applied at 1.0 g/ha leached up to 15-20 and 20-25 cm depths in X and 2X dose in the soil of Hyderabad. 45.9 and 39.0 % of the total herbicide delectated in top 0-5 cm layer of soil. Stronger adsorption of herbicide in the top layers of soil indicated adsorption of herbicide strongly on the soil particles. Anilofos at 0.4 and 0.8 kg/ha was detected up to 15 and 30 cm soil depths in sandy loam soil. 2, 4-D Na salt applied at 0.5 and 1.0 kg/ha leached up to 10 and 20 cm soil depths in sandy loam soil. Germination of sensitive cucumber was influenced by both the levels of 2, 4-D Na salt 0.5 kg/ha at postemergence.

Leaching behaviour of oryzalin was studied with an application of 1.5 and 3.0 kg/ha under laboratory conditions in silty clay loam and sandy loam soils of Pantnagar. Residue of oryzalin was not detected in leachates. Oryzalin was retained in upper soil layer 0-10 cm in both silty clay loam and sandy loam soils at both doses. 68.9 and 80.0% and 31.1 and 20.0% residues of oryzalin remained at 0-5 cm soil depth in sandy loam soil at recommended and double recommended doses, respectively. Whereas in case of silty clay loam 78.6 and 84.4% of applied herbicides remained at 0-5 cm depth and 21.4 and 15.6% leached to 5-10 cm depths in recommended and double recommended doses, respectively, revealing its low mobility (Fig. 5).

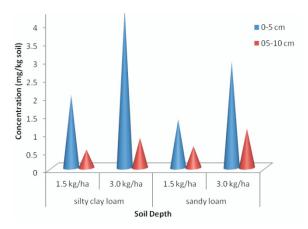


Figure 5.3.1: Distribution of oryzalin in different depth of soil column

Leaching studies conducted at Coimbatore showed that bispyribac-sodium and pyra-

zosulfuron-ethyl distribution at various depths was equivalent in silty loam soil than in clayey soil. Pyrazosulfuron ethyl residues were detected up to 60 cm depth under both levels of application (150 and 300 g/ha) irrespective of soil types. Bispyribac downward movement increased with depths and maximum at 45-60 cm depths under both the levels of application. Retention of bispyribac sodium was higher in silty loam soil than in clayey soil irrespective of dose of application. While more than 10% of the applied pyrazosulfuron-ethyl retained in the top 0-15 cm depths. However, in case of bispyribac sodium, only 4.4% was retained at 0-15 cm which showed that bispyribac was comparatively more mobile than pyrazosulfuron in the soils studied (Table 5.3.1 and 5.3.2).

Table 5.3.1: Concentration of pyrazosulfuron-ethyl in various soil types at different depths

Soil depth (cm)	10	razosulfuron ethyl in soil (ppm)	Concentration of pyrazosulfuron ethyl in clayey soil (ppm)			
(CIII)	150 g/ha	300 g/ha	150 g/ha	300 g/ha		
0 - 15	0.0627	0.1591	0.0925	0.0534		
15 - 30	0.0418	0.0533	0.0276	0.0460		
30 - 45	0.0060	0.0176	0.0164	0.0387		
45- 60	0.0017	0.0156	0.0078	0.0799		

Detection limit: 0.001 µg/g

Table 5.3.2: Concentration of bispyribac-Na in various soil types at different depths

Soil depth (cm)		ispyribac sodium in soil (ppm)	Concentration of bispyribac sodium in clayey soil (ppm)			
(CIII)	20 g/ha	40 g/ha	20 g/ha	40 g/ha		
0 - 15	0.0032	0.0071	0.0031	0.0086		
15 - 30	0.0052	0.0108	0.0036	0.0058		
30 - 45	0.0025	0.0194	0.0074	0.0183		
45- 60	0.0075	0.0220	0.0065	0.0097		

Detection limit: 0.001 μg/g

WS 5.4 Testing of herbicide residue at farmer's field

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

This was initiated to determine herbicide

persistence in the farmer's field. soil and plant samples were colected from farmers field at harvest and processed for residue analysis.

Residues of pendimethalin in wheat and quizalofop ethyl in soybean were found below detection limit in seeds and straw samples at harvest at farmers field, at Anand. Butachlor residues in the rice soil at 60 days after spraying were below detectable level (0.01 ppm) in the field of Kole area (Pullu) of Thrissur District, Kerala. Residues of pyrazosulfuron ethyl were not observed after 45 days at 25 and 50 g/ha in soil of transplanted rice at Kathalagere, Bangalore. Pretilachlor residues were below detectable level in surface soil (0-15 cm) samples collected in the month of November 2012 from farmers' field growing transplanted winter rice at Jorhat. Similarly, at harvest of the crop, atrazine and butachlor residues were below detectable limits in soil and grains samples collected from the herbicides treated fields of five farmers of Kangra district, Palampur. However, samples taken at randomly showed 0.003, 0.001 and 0.02 ppm residues of atrazine in sorghum plants, straw and soil, respectively at Parbhani, Nanded and Beed Districts.

Freshly harvested tomato fruit and Soil samples at harvest were collected from farmers fields in Chenvelly village in Chevella mandal Ranga Reddy district, Hyderabad during *rabi* season. Among the six soil samples of the tomato

fruits, residues of metribuzin were below BDL in four samples (<0.05 mg/kg). In two samples, residues were found 0.068 and 0.071 mg/kg. At harvest, atrazine residues were below detection limit in in sweet corn plants during kharif 2012 at Hyderabad. Butachlor (1.5 kg/ha), and oxadiargyl (0.1 kg/ha at pre-emergence) persisted up to 30 days in soil of rice while pretilachlor (0.78 kg/ha) and anilofos (0.400 kg/ha) persisted up to 45 days in the soil of rice at Faizabad. While isoproturon and 2, 4-D Na salt persisted up to 30 days in soil of wheat. Residue of sulfosulfuron, clodinafop isoproturon and, clodinafoppropargyl in wheat and butachlor and pretilachlor in rice, atrazine and 2,4-D in sugarcane were found below detectable limits (0.002 g/g) in all sample at the time of harvest, at Pantnagar. Similar to maize, residues of bispyribac sodium and alachlor were not detected in the different matrices of groundnut and soil at TNAU. Pendimethalin residues were found below detection limit in sandy clay and sandy clay loam soils. In clay loam and clayey soils pendimethalin persisted up to harvest at level of 0.021 and 0.037ppm (Table 5.4.1).

Table 5.4.1: Persistence of herbicides in maize growing soils of farmer's field

Soil types	Days after herbicide application	2,4-DEE residue after harvest (ppm)	Atrazine residue after harvest (ppm)		
Sandy clay soil	110	< 0.05	<0.01		
Sandy clay loam soil	110	< 0.05	< 0.01		
Clay loam soil	115	< 0.05	0.021		
Clayey soil	90	< 0.05	0.037		

WS 5.5: Studies on secondary metabolites of herbicides

Cooperating centres: TNAU, CSKHPKV, KAU, AAU(A) and AAU(J)

Plant samples were collected from wheat field experiment at Wheat Research Station, Wellington, Ooty. Carfentrazone ethyl 50%DF was applied at 25 and 50 g/ha along with the control. Plant samples were subjected to herbicide residues analysis using GC-ECD to assess persistence of carfentrazone- ethyl and its metabolite namely chloropropionic acid. Carfentrazone-ethyl were detected in wheat

foliage up to 30 days after application, and 3.36-4.06 and 0.148-1.291 ppm of its metabolite chloropropionic acid was detected at 0 and 7 days, respectively (Table 5.5.1).

Table 5.5.1: Persistence of carfentrazone ethyl and its metabolite chloropropionic acid in wheat

Davis after harbiside	Residue (ppm)				
Days after herbicide application	Carfentrazone ethyl				
application	25 g/ha	50g/ha			
0	0.089	0.112			
7	0.061	0.076			
30	0.04	0.097			
Harvest	BDL	BDL			

WS-5.6 : Adsorption and desorption behavior of herbicides

Adsorption-desorption of quizalofop, pendimethalinm, metribuzin, pretilachlor, pyrazosulfuron, oryzylin, oxyfluorfenm and bspyribac-sodium were determined in different soil types using batch equilibrium method.

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

Higher adsorption of oxyfluorfen in soil was reported at KAU. Adsorption of pyrazosulfuron-ethyl in different soils of Karnataka were in the decreasing order of Kathalagere> Mandya> Mudigere> Mangalore which is also the order for organic carbon in these soils. Freundlich constant (K) values ranges from 5045 to 9.52 and found to increase in organic matter content (Table 5.6.1). Sorption coefficient (K_{∞}) is commonly a measure of pesticide sorption to soil organic carbon. Though the absolute quantity of pyrazosulfuronethyl adsorbed per unit of soil was highest in

Kathalagere soil, contribution towards adsorption per unit of organic carbon was less as observed by lowest K_{oc} values among the soils. This may be due to higher organic matter-clay interaction and subsequent stabilization of organic matter, thereby, reducing the number of adsorption sites on the native organic fraction. Percent cumulative desorption of pyrazosulfuron-ethyl was found to increase with increase in initial concentrations in all the soils however, desorption of pyrazosulfuron-ethyl in soils decreased in the order of Mudigere >Mangalore >Mandya >Kathalagere which was also in the increasing order for organic carbon content of the soil. This showed that there was an increase in adsorption with lesser percent desorption when related to the organic matter content of the soils. When the adsorption was carried out from soils where only 5 to 11 mg/kg of pyrazosulfuron-ethyl was present, desorption isotherms were very close to the adsorption isotherms. This showed that the degree of irreversibility in the adsorption process increased with increase in sorbed pyrazosulfuron-ethyl.

Table 5.6.1: Freundlich constant (K and 1/n), determination coefficient (r²) and sorption for pyrazosulfuron-ethyl adsorption in different agro-climatic soils of Southern Karnataka

Soils	K	I/n	\mathbb{R}^2	Koc	Kc
Mudigere	8.05	0.085	0.968	1238.46	43.31
Kathalagere	9.52	0.104	0.999	1436.12	49.07
Mandya	8.79	0.101	0.981	1389.41	42.05
Mangalore	5.45	0.165	0.969	1099.46	32.24

At Anand, in an adsorption desorption study, 0.325 ppm pendimethalin residues were detected in solution following adsorption, while 0.251 ppm residues of pendimethalin were found in solution following desorption in clayey soil. 15.960 ppm residues of pendimethalin were found in soil following adsorption, while 14.528 ppm residues of pendimethalin were detected in soil following desorption in clayey soil. Maximum adsorption of metribuzin was observed after 4 hours in clay loam soil and 4 to 7 hours in silt loam soil (AAU, Jorhat). Adsorption-desorption of oryzalin in soils were determined using batch equilibrium method at Pantnagar.

Adsorption coefficient (Kf) for silty clay loam and sandy loam soil were found 2.454 and 2.728, respectively and desorption coefficient (Kf') for both silty clay loam and sandy loam soil were 0.468 and 0.404, respectively in soil of Pantnagar (Fig. 5.6.1).

Adsorption and desorption behavior of pyrazosulfuron ethyl and bispyribac was studied in clayey soil at TNAU. Increase in concentration of pyrazosulfuron-ethyl and bispyribac-sodium increased adsorption of pyrazosulfuron ethyl and bispyribac sodium in soils. Type of the pyrazosulfuron ethyl and bispyribac sodium adsorption isotherm in all the soils were 'S'

and C, respectively. Amount of adsorbed pyrazosulfuron ethyl desorbed from soil was in the range of 0.001 to 0.068 per cent across different concentrations of bispyribac sodium applied to different soils. In this study adsorption-desorption coefficient showed extensive hysteric behavior resulting from discrepancies between adsorption-desorption isotherms. The hysteresis may be attributed to the length of the shaking period in reaching true equilibrium. Similarly, adsorption behaviour of pretilachlor and

metribuzin was studied in silty clay loam soil of Palampur. Total amount of pretilachlor and metribuzin adsorption increased with increasing initial concentration from 2.5-25 g/ml of equilibrium solution (25 g-250 μ g/g soil). The amount of pretilachlor adsorption varied from 18.8-150.4 μ g/g. Amount of metribuzin adsorption varied from 13.0-105.2 μ g/g. However, per cent adsorption data did not show much difference at different concentrations.

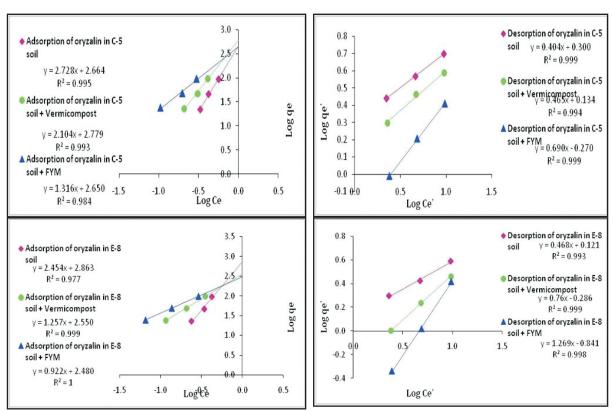


Figure 5.6.1: Freundlich adsorption-desorption isotherm of oryzalin

WS 5.7 Persistence / dissipation and residue analysis studies of herbicides

At Pantnagar, soil, rice and wheat plants were collected to assess 2,4-D (0.5 and 1.0 kg/ha) and pendimethalin (1.0 kg/ha and 2.0 kg/ha) residues. 2, 4-D and pendimethalin were found below detection limit (<0.001 g/g, and <0.0003 g/g) in soil after 45 and 60 days in 0.5 and 1.0 kg/ka of application rates. Pendimethalin

residues were observed up to 90 days of application. A Chilli (variety *Kharika*) crop was grown during *rabi* 2011 in a sandy clay loam soil after harvest of winter rice at Jorhat and metribuzin was applied as pre-emergence at 0.5 and 1.0 g/ha rates. Metribuzin residues decreased with time in surface soil and were found below detectable limit (0.01 ppm) in soil after 60 days of its spray and at first harvest of fruit samples.

WS 6: Transfer of technology WS 6.1: On-Farm Trials (OFT)

Appropriate technologies are roots of agrarian development. However, any agricultural technology can not perform equally in every micro agro-climatic situation. On farm trials (OFT) of weed management technologies are mainly focused to test/evaluate, already developed technologies in terms of location specific and need based sustainable crop and land use system and helpful to solve the most important and widely spread weed problems of farmers in a defined area within their farming system perspective with their active participation and management. The objective of on farm trials is to test and evaluate the finding of research station at the farmers field and to refine and modify the technologies as per particular farming situation. Accordingly, OFTs are formulated by the AICRP-WC centres based on weed problems faced by the farmers and priority of the problems. Economically viable, operationally feasible weed management technologies matching with farmers needs are identified by the AICRP-WC Centres and OFT has been conducted on this aspect to solve the weed problem as given below:

At Ludhiana, two technologies in respect to weed management in wheat were evaluated. Efficacy of fenoxaprop + metribuzin (Accord plus 22 EC) against mixed weed flora in wheat were conducted at 5 locations. Fenoxaprop + metribuzin @ 275 g/ha at 35 DAS, mesosulfuron + iodosulfuron 14.4 g/ha at 35 DAS were applied besides a weedy check. In another OFT, efficacy of tembotrione (Laudis 48 SC) against mixed weed flora in maize were evaluated at 5 locations. The technology tembotrione @ 110 g ai/ha at 25 DAS was compared with farmer practice (atrazine 1.0 kg/ha as PE/interculture 25 DAS) and weedy check.

At Gwalior, two technologies in wheat and one in pearl millet were evaluated. In wheat, OFTs were conducted at farmers field at eight locations of Morena and Gwalior districts during *rabi* 2011-12. Clodinafop @ 60 g/ha and sulfosulfuron @ 25 g/ha were tested, and

compared with farmers weed management practices. It was observed that both the herbicides gave lower weed population and higher yield/income over farmers practices. The maximum yield was obtained with the application of sulfosulfuron (5203 kg/ha) followed by clodinafop (yield 5088 kg/ha), although the yields were statistically at par. The grain yield of wheat under farmers practice, i.e. hand weeding, was 4669 kg/ha. It was concluded that the application of sulfosulfuron was most effective and economically viable.

In pearl millet, atrazine @ 0.5 kg/ha was compared with farmer practices during *kharif* 2012 at 5 locations. The chemical weed management cost ranged between ₹ 1470 to 1650/ha, which was cheaper than manual weeding cost and hence economically more viable. It was significantly superior over farmers practice in terms of increased grain yield (10 to 30% higher yield). It also reduced drudgery and dependency on labour supply.

At Bengaluru, on-farm trials using bensulfuron methyl 0.6% G at 60 g ai/ha + pretilachlor 6% G at 600 g ai/ha - 3 DAP and pyrazosulfuron ethyl 25 g ai/ha - 3 DAS were conducted in transplanted rice in southern dry zone which gave 12 - 17% higher yield than hand weeding (15-20 & 35-40 DAS, 5100-5350 kg/ha), besides saving weeding cost by ₹4700 to 6150/ha over hand weeding and gave additional returns of ₹8590 to 12,930/ha over farmers' practice.

At Pantnagar, on-farm trials were conducted at five farmers field in different locations of Distt. U.S.Nagar. The readymix combinations of clodinafop-propargyl (15%) + metsulfuron methyl (MSM) (1%) @ 60g/ha and sulfosulfuron methyl (75%) + metsulfuron methyl (5%) @ 32 g/ha were applied at 30-35 DAS. Application of clodinafop – propargyl 60 g/ha 30-35 DAS was considered as farmer's practice. Compare to weed free situation, on an average, reduction in grain yield due to presence of weeds were 3.3 and 12.1%, respectively, under recommended and farmer's practice.

Four OFTs using bispyribac-Na (20 g/ha) and Pretilachlor (1000 g/ha) $\it fb$ CME (10%)+MSM

(10%) (4 g/ha) were conducted in transplanted rice at various locations of Distt U.S.Nagar. These technologies were compared with farmer's practice and weedy check. The application of pretilachlor fb CME 10%+MSM 10% produced highest grain yield (5158 kg/ha) followed by bispyribac-Na (5005 kg/ha) and farmer's practice (4820 kg/ha). The higher yield of rice with application of pretilachlor fb CME 10%+MSM 10% and bispyribac-Na over farmer's practice might be due to effective broad spectrum weed control.

Bio-efficacy of different herbicides was also compared in transplanted rice at farmer's field under four different locations of Almora and Bageshwar District. Total four sets of treatment comprising of bispyribac-Na (200 g/ha), pretilachlor (1500 g/ha) fb Almix (20 g/ha), anilofos (1200 g/ha) fb Almix (20 g/ha) and farmer's practice (Manual weeding or butachlor) were evaluated. The plot size for each treatment was 0.04/ha at each location. Major weeds in weedy plot were Echinochloa colona, Ischaemum rugosum, Caesulia axillaries and Cyperus iria. Spray of anilofos and pretichalor fb Almix increased the grain yield by 27.8 and 26.8 %, respectively, as compared to farmer's practice. Highest benefit cost ratio was obtained with anilofos (1200 g/ha) fb Almix whereas the farmer's practices showed lowest value.

Five OFTs were conducted to demonstrate the efficacy of imazethapyr 0.1 kg/ha (EPOE) 15 DAS and fluchloralin (PPI) 1.0 kg/ha for weed control in soybean and compared with the existing farmers practice of alachlor 2.5 kg/ha.

The reduction in grain yield of soybean due to weeds in untreated plot was 55.3% and in farmer's practice 34.2% as compared to application of imazethapyr. The highest grain yield was obtained with early post emergence application of imazethapyr followed by pre-planting incorporation of fluchloralin and farmer's practice. Weed control efficiency and B:C ratio of imazethapyr, fluchloralin and alachlor were 74.9, 65.8 and 58.4%, and 2.28, 1.80 and 0.66, respectively.

At Palampur, on-farm trials using quizalofop +chlorimuron ethyl was conducted at two locations for weed management in soybean. The tested technology gave higher seed yield over farmers practice. Similarly bispyribac 25 g/ha showed higher grain yield over farmers practices in OFTs conducted on weed management in rice at three locations.

At Parbhani, 15 on-farm trials were conducted during *kharif* season of 2012 using integrated weed management technologies for weed management in soybean, cotton and sorghum at various places in Marathwada Region. On an average 20.0, 23.4 and 22.7% 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 Anand, OFT 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 Coimbatore, 10 On-farm trials have been carried out in groundnut. Results revealed that pre-emergence application of oxyflourfen 250 g/ha followed by imazethapyr 100 g/ha + quizalofop ethyl 50 g/ha PO at 15 DAS was superior to farmers practice in terms of broad spectrum weed control and seed yield and economic returns.

At Faizabad, on-farm trials were conducted in transplanted rice during *kharif* 2012 at four farmers' field in Milkipur Tehsil of Faizabad district. In each trial 5 weed control treatments, namely, butachlor 1500 g/ha, pretilachlor 1000 g/ha, oxadiargyl 100 g/ha, farmers practice (HW at 30 & 60 DAT) and weedy check were evaluated. Pretilachlor recorded maximum yield (5220 kg/ha) and net return of ₹45880/ha followed by oxadiargyl (₹42415/-) and butachlor (₹41355/-). Farmers practice recorded lowest level of net return (₹39348/ha) and BCR (₹2.21) were among the different treatments.

On farm trials conducted on weed control in wheat at 5 farmers fields of two villages in Faizabad district during *rabi* season of 2011-12. Sulfosulfuron 25 g/ha proved its superiority in controlling the weeds effectively and gave highest grain yield (4460 kg/ha), net return (₹ 41326/ha) and BCR (₹ 2.81/-) followed by metribuzin 175 g/ha (4300 kg/ha, ₹ 40775 and 2.81).

At Sriniketan, 15 OFTs were demonstrated in farmers' field with improved weed management practices in different crops in Birbhum, Bankura and Burdwan districts of West Bengal. Five OFTs in *kharif* rice, 4 in *boro* rice, 3 in sesame, 2 in onion and 1 in potato were conducted during the reporting period. In all the cases farmers were satisfied with improved weed management technology as these technologies were more effective in managing weeds and giving more yield and economic return as compared to existing technologies.

At Ranchi, 5 farmers were selected for

conducting on farm trial in paddy crop to compare the efficacy of chemical weed control with farmers practice. The chemical weed control comprised of application of pyrazosulfuron 20 g/ha fb bisparibac sodium @ 25 g/ha, while the farmers practice involved 2 manual weeding at 30 and 50 days after transplanting. The chemical weed control reduced weed density by 39.8 and 82.4%, and weed dry matter accumulation by 39.8 and 44.6% at 30 and 60 DAS, respectively, as compared to farmers practice. Similarly the chemical technology also recorded 17.6% higher grain (4540 kg/ha) and 17.0% higher straw yield (5590 kg/ha), 50.9% higher net return (₹40781/ha) and 93.3% higher B:C (2.30) ratio compared to farmers practice.

At Kanpur, on-farm trials conducted for weed control in wheat at 3 farmers fields during *rabi* 2011-12 using atlantis 400 g/ha, clodinafop (60 g/ha) follwed by 2,4-D (500 g/ha) sulfosulfuron (25 g/ha), isoproturon (1.0 kg/ha) + 2,4-D (500 g/ha) and farmers' practice (No weeding). Among all the treatments atlantis 400 g/ha effectively controlled weeds and gave more yied and net return.

Similarly, on farm trials conducted at 6 farmers fields during *kharif* 2012 using anilophos (0.5 kg/ha) + one hand weeding, pretilachlor (0.75 kg/ha) + one hand weeding, pyrazosulfuron (25 g/ha) followed by one hand weeding and farmers practices (no weeding) for weed control in rice. Among all the treatments anilophos (0.5 kg/ha) + one hand weeding effectively controlled weeds and gave more yield and net return.

At Thrissur, the trials conducted during *kharif* 2012 in the farmers fields at Chithali and Nochulli of Palakkad district showed better control of broad leaved weeds by pretilachlor, while cyhalofop butyl was more effective against grassy weeds. Both these herbicides resulted in considerable increase in the grain and straw

yields, compared to the unweeded control. Hand weeding recorded the highest yield. However, the herbicides pretilachlor and cyhalofop-butyl resulted in grain yield almost near to the hand weeded plot. Considering the shortage and high cost of labourers in Kerala, herbicidal weed control was preferred by farmers.

At Bhubaneswar, 10 OFTs on transplanted rice were conducted during *rabi* 2011-12 at Panipoi villages of Fhatagaon block in Keonjhar districts. The results revealed that maximum yield of 3.86 t/ha was recorded in the plot applied with oxadiargyl 0.065 kg/ha followed by pyrazosulfuron 0.02 kg/ha (3.70 t/ha). A net saving of ₹ 1800 - 1950/ ha was obtained in the plots treated with herbicides.

On Farm trials conducted on transplanted rice during *kharif* 2012 in Pubasasan (Puri), Manapur (Khurda), Bhagabanpur Sasan (Khurda), revealed that maximum yield of 3.8 t/ha in the plot applied with oxadiargyl 0.6 kg/ha with a net saving of ₹ 1750-1980 /ha over farmers' practice. Similarly, the OFTs conducted on groundnut in Katakmada Khamar village of Dhenkanal district during 2012 revealed that highest yield under oxyfluorfen 0.05 kg/ha (1.8 t/ha) followed by pendimethalin 0.5 kg/ha (1.7 t/ha). The saving in weeding cost over farmers practice was in the tune of ₹ 2100 to ₹ 2125/ ha.

At Hisar, results of 21 OFTs conducted on 50 acres in 7 villages of Bhiwani district revealed that post-emergence application of glyphosate 25 g/ha at 30 DAS followed by its repeated application at 50 g/ha at 55 DAS provided effective control (79%) of *Orobanche* spp. in mustard. Crop suppression (5-10%) was noticed with second application of glyphosate at 55 DAS at 2 sites which recovered within 10-15 days after herbicide application with no yield penality.

On-farm trials conducted at 4 locations revealed that new herbicide tembotrione at 100 g/ha is very effective to control weeds viz. *Brachiaria reptans, Commelina benghalensis* and

Elusine indica in maize crop. These weeds are not controlled by the existing farmers practice of atrazine application.

At Pusa, on-farm trials were conducted using the chemical weed management technologies for various crops in different farmers field. Pyrazosulfuron 200 g/ha in rice, metribuzin 500 g/ha in *kharif* maize, and pendimethalin 1.0 kg/ha in lentil were found superior in terms of grain yield over the farmer's practices.

At Raipur, the recommended technology package of line sowing of seed @ 60 kg/ha using seed drill + bispyribac @ 25 g/ha at 20-25 DAS increased yield by 51% over farmers practice in the OFTs conducted on rice in Sesdevari village of Baloda Bazar district.

At Dharwad, OFTs were conducted in Dharwad, Gadag, Bagalkot and Belgaum districts on major crops like sugarcane, rice, groundnut and sunflower. Metribuzin in sugarcane, butachlor in groundnut and sunflower, bispyribac and Almix (chlorimuron+metsulfuron methyl) in rice performed better compared to the existing herbicides as recommended in the state Package of Practices with respect to weed control and yields.

WS 6.2: Front Line Demonstrations (FLD)

Improved weed management technologies are in great demand by the farmers. This is because of the acute labour scarcity and high cost of manual weeding throughout the country. Unfortunately, there is not enough awareness among the farmers about improved weed management practices, even in the areas not far away from the research institutions. The demonstration (FLD) is a powerful tool for convincing and motivating farmers, to utilized available weed management technologies in scientific manner. 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 far enhanced crop productivity, following FLD has been conducted by AICRP-WC Centres during the year 2012-13 through farmers participatory approach.

At Bengaluru, the results of 9 FLDs conducted on transplanted rice in Mandya Taluk showed that bispyribac-Na 20 g/ha at 20 DAT provided 18% more grain yield, a saving of `3900/ha as weeding cost and an increase in income by ₹ 6900/ha as compared to farmes' practice of two hand weeding at 20 and 45 DAT (5.52 t/ha grain yield, weeding cost ₹ 6020/ha).

At Pantnagar, FLDs were conducted to show comparative performance of bispyribac-sodium for control of weeds over farmer's practice in rice at five locations of distt. U.S.Nagar. The application of bisyribac-sodium at 20 g/ha produced almost same yield as reported in case of farmers practice.

During 2012, to demonstrate the improved technology for control the weeds of soybean, eight front line demonstration were conducted at cultivators fields. Imazethapyr 0.1 kg/ha (as EPOE) was used as improved technology, while alachlor 2.5 kg/ha PE as existing farmer's practice. The major weeds found at farmer's field were Eleusine indica, Eleusine aegypticum, Degitaeria sanguinalis, Commelina benghalensis and Celosia argentia. Weed control efficiency of imazethapyr 0.1 kg/ha was 33.0% higher than farmers practice and produced 45.2% higher grain yield (900 kg/ha) compared to farmer practice (620 kg/ha). Benefit cost ratio of improved practice was recorded 1.37, whereas it was 0.53 under farmer's practice.

At Parbhani, during *kharif* season 2012, 5 FLDs were conducted on weed management technology for cotton at various places in Marathwada Region. The recommended weed management technology pendimethalin @ 2.5 l/ha PE + 1 HW and 1 H at 6 WAS was compared with farmers practice. On an average, integrated

weed management practices gave 1395 kg/ha seed cotton yield with 1.88 B:C ratio and $\stackrel{?}{\stackrel{?}{\sim}}$ 26372 as net monetary return.

At Anand, two FLDs on weed management in soybean were conducted at Varod of Dahod district. On an average 2343 kg/ha seed yield was recorded with 2.1 B:C ratio and ₹ 32429 as net return.



At Coimbatore, 10 FLDs have been carried out in onion crops at Viraliyur Taluk of Coimbatore District. Due to adoption of improved weed management technology (oxyflourfen 250 g a.i /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% over farmers practice (two hand weeding). The highest income also obtained in improved practice over farmers practice. Seventy percent of the farmers were fully satisfied with the performance of improved weed management technology.

At Faizabad, 21 FLDs were conducted during 2011-12 covering wheat (15), gram (2) and potato (4) using 0.4 ha land for each FLD in Faizabad and Sultanpur districts. Compared to the farmers practices, yield increase ranged from 12.5 to 31.4% (average 18.9%) in wheat, 18.7 to 34.47% (average 25.2%) in gram, and 23.6 to 31.3% (average 27.5%) in potato. In general, pulses were more sensitive to weeds and yield increase ranged from 28.9% to 36.3% under demonstrated technology. The cost incurred on herbicides varied from ₹ 800-2000 /ha in different crops, which gave additional returns of ₹ 6939-33000/ha.



During the *kharif* season of 2012, twelve FLDs were conducted on rice to show the weed control potential of herbicides. Pretilachlor 1000 g/ha PE, oxadiargyl 100 g/ha PE and bispyribac 25 g/ha PO were demonstrated. The increase in yield of rice due to herbicides varied from 9.6 to 24.4% in different farmers fields with an average increase of 15.6%. Additional returns of ₹ 4840-9812/ha (average ₹ 6839/ha) were obtained for an expenditure of ₹ 800-1900/ha incurred towards cost of herbicides.

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 9.6% to 29.8% due to herbicide application. The farmers showed keen interest for using herbicides to control weeds in wheat crop.

Similarly, 6 FLDs conducted on rice at farmers field in different locations showed grain yield increase of 16.8 to 28.4% due to integrated weed management practices. Chemical weed management practices showed an increase in seed yield by 33.8% in blackgram (2 FLDs), 46.20% in maize (2 FLDs). The farmers showed keen interest for using herbicides to control weeds in rice, blackgram and maize crop.

At Bhubaneswar, 10 FLDs were carried out in the village Kuaput, Khurda on transplanted rice during *kharif* 2012. The additional net return of ₹ 13500-17000/ was obtained with oxadiargyl (0.065 kg/ha) over farmers practice (two hand weeding).

At Ranchi, 20 FLDs were conducted in transplanted rice in Aadki area using

pyrazosulfuron @ 0.02 kg/ha. The demonstrated technology performed better than farmers practice (hand weeding) and recorded 33.2% higher grain (3447 kg/ha) and 62.8% higher straw (5355 kg/ha) yields, 39.7% higher net return (₹28061/ha) and 79.4% higher B: C ratio.



At Sriniketan, 10 FLDs in *kharif* rice were conducted in different locations under Birbhum and Burdwan districts. The weed management was selected from the OFTs considering the specific situation in the farmer's field. The response of farmers' to the demonstrated technologies was recorded and economic analysis was done in each case. The herbicides demonstrated were pretilachlor, metsulfuron methyl + chlorimuron ethyl, bispyribac sodium and paraquat and glyphosate (separately) before puddling followed by metsulfuron methyl + chlorimuron ethyl.

At Hyderabad, FLDs were conducted in Nalgonda and Mahaboobnagar districts using the technologies generated at Weed Science research Centre, Hyderabad, for rice, groundnut and cotton.

In rice, FLDs were conducted at five farmers field in Nalgonda district. The integrated weed management involving pre-emergence application of bensulfuron methyl + pretilachlor S (Londax power) *fb* hand weeding at 50 DAT resulted in higher B:C ratio (2.05-2.14) compared to farmers practice (1.90-2.02) of hand weeding twice at 20 and 50 DAT, indicating the superiority of the demonstrated technology.

In cotton, FLDs were conducted at five farmers field in Mahaboobnagar district. The integrated weed management involving post emergence application of pyrithiobac sodium + propaquizafop *fb* intercultivation resulted in higher B:C ratio (1.74-1.20) compared to farmers practice (1.62-1.21).

In groundnut, FLDs were conducted at five farmers field in Mahaboobnagar district. The integrated weed management involving imazethapyr @ 100 g/ha fb hand weeding at 40 DAS resulted in higher B:C ratio (2.26-2.42) compared to farmers practice (2.01-2.34) of hand weeding twice at 20 and 40 DAS, indicating the superiority of the demonstrated technology.

At Pusa, 10 farmers were selected from Sheohar district for FLDs during *rabi* maize 2011-12 to demonstrate performance of metribuzine @ 500 g/ha. Total area for this demonstration was 10 ha. The data revealed that highest grain yield of *rabi* maize (4.18 t/ha) was recorded with the metribuzine, which was 54.2% higher than weedy check and 17.4% higher than farmers practice.

FLDs were conducted in 10 farmers fields using carfentrazone @ 20 g a.i./ha and sulfosulfuron @ 25 g a.i./ha for managing weeds in wheat in Sheohar district. Compared to farmers practice, wheat yield was 28.2% and 27.7% higher with carfentrazone (4.46 t/ha) and sulfosulfuron.

At Raipur, several FLDs were conducted on weed management in rice in 18 tribal villages of Bastar, Kondagaon, Mahasamund and Sarguja districts. In transplanted rice 136 and in direct broadcast seeded rice 45 demonstrations were conducted during *kharif* 2012 with help of KVK Bastar and Sarguja. The overall average benefit: cost ratio of recommended weed management practices was 29.2 and 28.84 % in transplanted and direct broadcast seeded rice, respectively, and these values were higher than observed in farmer's practices.

At Dharwad, 25 FLDs on weed management in sugarcane, rice, sunflower and wheat, and on Cynodon control in field were conducted in different districts. Better weed control was achieved through herbicides which reduced cost of cultivation. The performance of bispyribac sodium in rice and metsufuron-methyl in wheat was excellent over 2,4-D sodium salt. In sunflower, better weed control was achieved through butachlor. The sugarcane farmers are happy with the excellent performance of metribuzin over their traditional practice of weed control. Cynodon dactylon control, which was cumbersome and was not possible earlier, through glyphosate resulted in the successful cultivation of the subsequent crops.

Extension Activities

Centre	Training imparted	Radio talks	TV Programmes	Kisan Melas	Handouts/ Folders/Pamphlets	Bulletins/ Booklet	Training Programmes	Front Line Demonstrations	Parthenium Awareness Week
PAU, Ludhiana		-	1	2	-	-	-	-	✓
UAS, Bangalore		1	2	-	-	-	1	-	✓
RVSKVV, Gwalior		-	-	-	-	-	-	-	√
GBPUAT, Pantnagar		12	-	1	-	1	1	25	✓
CSKHPKV, Palampur		-	-	-	-	-	-	5	✓
AAU, Jorhat	7	1	-	-	-	4	2	2	√
MAU, Parbhani		2	1	-	-	1	-	5	✓
AAU, Anand		1	2	-	3	-	2	2	✓
TNAU, Coimbatore		-	-	-	-	-	3	10	✓
NDUAT, Faizabad		6	-	-	-	-	4	33	√
VB, Sriniketan		1	2	-	-	5	3	10	✓
BAU, Ranchi		-	-	-	-	6	2	20	√
CSAUAT, Kanpur		-	-	-	-	-	-	20	✓
KAU, Thrissur		-	-	-	-	-	-	-	√
OUAT, Bhubaneswar	2	1	2	-	-	1	-	5	√
ANGRAU, Hyderabad		1	1	-	-	-	8	15	√
CCSHAU, Hisar		1	1	-	-	1	3	1	✓
RAU, Pusa			1	-	-	2	7	10	1
DBSKKV, Dapoli		2	-	-	-	-	1	-	√
IGKVV, Raipur		-	-	1	1	-	-	181	√
UAS, Dharwad		-	8	2	3	-	14	25	√
RAU, Bikaner		-	-	-	-	-	-	-	✓

Parthenium Awareness Week (16-22 August, 2012)

To create awareness about the menace of *Parthenium* and the ways of its management, an appeal was made to all the centers, KVKs, and ICAR organizations to organize some activities during the week. Many programmes were organized throughout the week. Each center did some activities like demonstrations, photo exhibitions, film shows, rallies, corner meetings, lectures, uprooting of *Parthenium* etc. The activities organized by each AICRP centre are briefly given below:

Anand centre organized programmes at polytechnic College of Agriculture, Anand, Krushi Vignan Kendra, Dahod, Polytechnic College at Vaso. Special lectures were delivered to Government officials to create awareness on management of parthenium in fields, noncropped area and in public area

Jorhat centre organized programmes in Golaghat district in collaboration with Krishi Vigyan Kendra (KVK), Golaghat of Assam Agricultural University. The district is situated on the southern valley of river Brahmaputra, almost middle of the state. A interactive meeting was also

done with the authorities of Kaziranga National Park to make aware them about the danger of Parthenium. A Public Awareness Meeting was organized at Sarupathar College campus along with *Krishi Vigyan Kendra* (KVK), AAU . An exhibition outside the public meeting was organized in collaboration with KVK, Golaghat. Posters were affixed at several public places of the district mostly along the National Highways, including educational institutes, shops, bus stoppages, etc. The week was well covered by print and electronic medida.



Young, curious visitors at the exhibition



Hyderabad centre organized *Parthenium* Awareness Week - 2012 in collaboration with different research stations, *Krishi Vigyan Kendras* and DAATTCs (District Agro-advisory and Technology transfer centers) of ANGRAU from 16th to 22nd August 2012. Eight different programmes at different places and dates were organized where hundreds of students and farmers participated. Dr. M. Madhavi gave a programmed in Doordarshan on "Importance of

Parthenium eradication and methods of management'. A phone in live Radio programme on Parthenium was also given by Dr. D. Subramanyam of KVK, Kalikiri. The programme was well covered by print media





Ranchi centre organized many programmes like a rally of NSS students, student debate, uprooting, demonstration and exhibition etc.



Hisar centre in collaboration with various KVKs of state celebrated 'Parthenium Awareness Week' with good success and grandeur. About 11 programmes were organized in different dates and places. Rallies, demonstrations, exhibitions and uprooting programmes were done. The programmes were well covered by print media.



Palampur centre organized many programmes during *Parthenium* awareness week-2012. The programmes were organized at Govt. Middle School, Bhatillu and Govt. Middle School Bodhal, Teh. Palampur, District Kangra. On 21st August, the awareness function was organized at Baijnath, Tehsil Baijnath. On 22nd August, the awareness day was organized at Maniara, Teh. Palampur, District Kangra. On 23rd August, the awareness day was organized at Upper Bari, Govt. Primary School Samana and at CSK Himachal Pradesh Krishi Vishvavidyalaya, Teh. Palampur, District Kangra.





Dapoli centre organized Programme at Makunsar Tal Palghar Dist. Thane

Pantnagar centre organized several activities during the week at various places including schools, colleges, and villages involving students, farmers and local residents. A technical extension bulletin titled "Gajar ghas (Parthenium hysteropforus) ke prakop evam Prabandhan" in Hindi was also prepared by the centre. It contains detailed description of the weed, its hazardous effects, management options and utilization. Banners prepared for the purpose were displayed at colleges and entry gates as well as at various places where awareness campaigns were held.During this week, three radio talks were aired on the Pantnagar Community Radio Service "Pantnagar Janvani" (90.8 FM). These radio talks covered various aspects of the health and environmental hazards caused by Parthenium, its management options and prospects of utilization. Local dailies (hindi) such as Amar Ujala, Dainik Jagaran, Hindustan gave wide coverage to the awareness campaigns during this week. This helped to spread the message far and wide throughout the state.



Raipur centre celeberated the PAW-2012 with great enthusiasm. Department of Agronomy visited the many school/colleges and other organizations and organized some events on Parthenium. The week was inaugurated on 16th of August by Dr. S.K.Patil, Hon'ble Vice-Chancellor, IGKV, Raipur. Many programmes were held on different dates at different places, some of them are T.P.L. Panchayat Avam Gramin Vikas Sansthan, Nimora, Raipur while and St. Joseph Higher Secondary School, Amlidih, Raipur. The programmes were widely covered by print and electronic media.



Thrissur centre organized Parthenium awareness programme in the dry region of the state where weed is prevalent in the chitoor taluk palakkad district lying close to Tamil Nadu. PG students were taken to the area and the biological control agent *Zygograma* beetles received from DWSR, Jabalpur were released in the area. Farmers of the locality were apprised of the menace of the weed and its control. In collaboration with K.V.K-Thrissur an awareness programme was arranged for farmers. About 50 farmers attend the programme. Dr. T. Girija. Took class on the Parthenium and its management.

Faizabad centre celebrated the week with great success and grandeur on the appeal of the

Directorate of Weed Science Research, ICAR, Jabalpur. The main objective of the celebration was to create awareness among the public, students and authorities about the ill effects of Parthenium and its management in different ecosystem. This year centre covered both urban and rural areas in Faizabad, Gonda, Balrampur and Bahraich districts. During August 16-22 and August 28-31, 2012, a series of events like lectures, documentary film show on Parthenium management, exhibition on ill effects of Parthenium weed, distribution of literature and awareness rally were organized in the different district of eastern Uttar Pradesh with the collaboration of various KVKs located at district Head quarters under the leadership of Dr. Jaidev Sharma, PI of the project. In these events students, farmers, farm women, extension officers of the KVKs, KGKs and NGO (DRI), participated. Such 14 programmes were held during the week where hundred of students and farmers participated.

Bhubaneswar centre organized many events on this occasion at two different places (i). Kalyanapur UGME school, Nayagarh district (17.08.2012) and at (ii) Gurujanga village, Khurda (19.08.2012). AICRP in weed control, Bhubaneswar center also received very good feed back of the programme by securing queries on *Parthenium* over telephone, letters and personal visits to the project office. Thus the observation of "Parthenium Awareness Week, 2012" was a great success at Bhubaneswar Centre.

Ludhiana centre organized two *Parthenium* Awareness days. The first awareness day was organized at PAU, Ludhiana on August 17, 2012 and second was organised at the village Nangal salala, Block Bhogpur, Distt Jalandhar on August 21, 2012. The wide publicity was given about this programme by putting posters on *Parthenium* awareness in the villages and this event was covered by vernacular and national news papers of this region to create awareness against *Parthenium* amongst people of the state. The hand outs were distributed to the College students and village Panchayat Members for awareness and strong actions for its removal. Also, during weed survey at different villages in

districts named Kapurthala, Jalandhar and Ludhiana conducted, special emphasis was given on the awareness about this weed among the farmers. They were educated to uproot and destroy this weed and keep their surroundings clean and free of *Parthenium*. In addition to this, the lectures were delivered in the *Kisan Mela* at Faridkot, Gurdaspur, Patiala, Amritsar, Bathinda and Ludhiana about *Parthenium* eradication.







Pusa centre celeberated the week by organizing several activities. The Hon'ble Vice-Chancellor, Dr. R.K. Mittal inaugurated the programme by uprooting the *Parthenium hysterophorus* at University gate, R.A.U. Pusa. On different dates various programmes were held in different schools and colleges. In continuation of this programme, a seminar on Parthenium was also organised in the seminar hall of Department of Agronomy on 22.08.2012. Teaching and Non teaching staffs and students participated in this

seminar. Mr. Dharminder, Jr. Agronomist of the project explained in details about different aspects of Parthenium.



Gwalior centre celebrated the *Parthenium* awareness week with the collaboration of College Scientists and different KVK centre of Gird Zone from 16th to 22nd August, 2012 with great success. During this occasion team of DWSR-RVSKVV centre and KVK staff, Scientists, technical staff of Department of Agronomy visited villages, KVKs centre, College Farm and other organizations. For this purpose the wide publicity was given through pamphlet, news papers/ TV / Sangoshti lectures, documentary films on *Parthenium* & exhibition on management of *Parthenium* to aware the public regarding the hazards of this serious national weed.







Parthenium Awareness week was also organized at Dharwad, Coimbatore and Bengaluru centres with grand success. The programmes were well covered by electronic and print media.



Sriniketan centre observed the *Parthenium* Awareness Week from 16th to 22nd August, 2012 with various activities through awareness and action oriented programmes involving Farmers' Club, Gram Panchayet, NGOs, Department of Agriculture, Govt. of West Bengal, village people, school and college students. Posters in English, Hindi and local language were affixed at different location particularly in the areas with large public gathering so as to make common people aware of the menace of the weed of National importance. The programme was covered by newspaper and TV channels.

4.0 STATION TRIALS

Weed management in individual crops

Weed management in rice nursery and its effect in main field

At Jorhat, the highest grain yield was achieved from application of pretilachlor 500 g/ha in rice nursery. But application of pretilachlor 750 g/ha in main rice field brought significant increase in number of panicle/hill and number of filled grains/ panicle which led to significantly higher grain yield over hand weeding at 30 DAT.

Establishment techniques and weed management practices in rice

At Pantnagar, the highest grain yield (4978 kg/ha) of rice was found with transplanting method (TPR) followed by wet seeded rice (WSR) (2445 kg/ha) which was also significantly higher than DSR (2121 kg/ha). Weed free situation produced maximum grain yield (4854 kg/ha). Herbicides applied either alone or in combination with one hand weeding, penoxsulam (22.5 g/ha) at 2-3 leaf stage of weeds followed by one hand weeding at 35 DAS/DAT recorded the maximum grain yield of rice (4446 kg/ha) being at par with application of bispyribac-Na (20 g/ha) at 15 DAS/20 DAT followed by one hand weeding at 35 DAS/40 DAT (4328 kg/ha).

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

At Jorhat, the weed dry weight recorded at different growth stages were significantly lowest under the treatment of pretilachlor 750 g/ha + incorporation of inter-row cowpea-dhaincha (20 DAS) + HW 40 DAS with 50% recommended fertilizers applied as vermicompost (2 t/ha) mixture (20 and 40 DAS) which was followed by the treatment of application of pretilachlor 750 g/ha + HW 20 and 40 DAS. Significantly highest grain yield (2153 kg/ha) was recorded

under the treatment of pretilachlor 750 g/ha + HW 20 and 40 DAS which was followed by application of pretilachlor 750 g/ha + incorporation of inter-row cowpea-dhaincha (20 DAS) + HW 40 DAS with 50% recommended fertilizers applied as vermicompost (2 t/ha) mixture (20 and 40 DAS).

Efficacy of herbicides for controlling weeds in direct-seeded rice

At Parbhani, highest rice grain yield was recorded in 2 HW which was found at par with fenoxaprop + (chlorimuron+metsulfuron) and POE spray of azimsulfuron and significantly superior over rest of all the treatments.

Time of sowing and weed control methods in direct-seeded dibbled rice

At Dapoli, sowing times did not significantly influence weed density of monocots and BLWs at 60 & 90 DAS. The weed growth of monocots was significantly lower at 60 DAS & 90 DAS, when crop was sown one week after onset of monsoon. Use of butachlor @ 1.5 kg/ha PE + 1 hand weeding (40 DAS) significantly reduced the growth of grasses & sedges at 60 DAS than all other treatments, except POE use of fenoxaprop-p-ethyl @ 60 g/ha and cyhalofop p butyl 90 g/ha. The weed growth of BLWs was significantly reduced due to use of azimsulfuron @ 35 g/ha.

Among the herbicide treatment use of cyhalofop p butyl @ 90 g/ha and butachlor @ 1.5 kg/ha PE + one hand weeding (40 DAS) recorded significantly highest grain yield over other treatments and which were at par with each other.

At Dharwad, among the dates of sowing, the grain yields were significantly higher (2.94 t/ha) with sowing taken up before the onset of monsoon compared to sowings taken up after onset of monsoon (2.62 t/ha). The grain yields were significantly higher with weed free check (4.12 t/ha). The next best treatment was butachlor

PE+1 HW (3.73 t/ha) which was on par with bispyribac-Na (3.62 t/ha). The performance of chlorimuron + metsulfuron-methyl was also quite satisfactory (3.30 t/ha) which was on par with pretilachlor (3.23 t/ha).

Bio-efficacy evaluation of fenoxaprop-p-ethyl 9.3% w/w EC against grass weeds in transplanted rice

At Ludhiana, the experimental field had population of both grass and broadleaf weeds i.e. *Echinocloa crusgalli*, *E. colonum*, *Cyeprus spp. Caesulea axillaries*, *Sphenoclea zeylanica*, *Ammania* sp. Fenoxaprop at 56.2 g/ha recorded effective control of all the grassy weeds, however, it was phytotoxic to rice foliage at all the levels; phytotoxicity increased with each increment of fenoxaprop upto 75 g/ha due to which rice grain yield was at par with weedy check and significantly low as compared to pretilachlor. The results indicated that fenoxaprop at the doses tested is not safe for use in transplanted rice crop.

Integrated approaches for controlling weeds in transplanted rice

At Pantnagar, application of pretilachlor @ 750 g/ha applied as pre-emergence with no irrigation (one week) fb post-emergence application of bispyribac-sodium (20 g/ha) recorded the highest grain yield than the alone application of bispyribac-sodium 20 g/ha and twice hand weeding.

Integrated weed and nutrient management in transplanted rice through herbicide-compostfertilizer mixture

At Jorhat, higher grain yield due to better crop growth and yield attributes was recorded with 25% RD fertilizer + 600 kg/ha biofertilizer-enriched vermicompost applied as mixture at 3, 30 and 60 DAT, pretilachlor 750 g ha⁻¹ applied by mixing with first application, 30% RD fertilizer + 600 kg/ha biofertilizer-enriched vermicompost applied as mixture at 3, 30 and 60 DAT, pretilachlor 750 g/ha applied by mixing with first application and 20% RD fertilizer + 600 kg/ha biofertilizer-enriched vermicompost applied as

mixture at 3,30 and 60 DAT, pretilachlor 750 g/ha applied by mixing with first application.

Herbicide-compost-fertilizer mixture for weed and nutrient management in winter rice

At Jorhat, in winter rice, the highest grain and straw yields were obtained in the treatment with 75% recommended dose (RD) of fertilizer-vermicompost (2 t/ha) mixture in three splits(3, 30 and 60 DAT), pretilachlor 750 g/ha mixed with the first fertilizer split + hand weeding 30 DAT and 60% RD fertilizer-vermicompost (2 t/ha) mixture (3, 30 and 60 DAT), pretilachlor 750 g/ha mixed with the first split + hand weeding 30 DAT.

Effect of rice establishment methods under different weed management practices on performance of rice

At Dapoli, under konkan condition *kharif* rice may be established by normal transplanting with urea DAP application and for effective weed control pre-emergence application of oxadiargyl @ 0.120 kg/ha + Japanese weeder one way hoeing followed by hand weeding or two hand weeding at 20 &40 DAS can be done for obtaining higher grain yield with net monitory returns and B:C ratio.

Studies on bio-efficacy of XDE-729 methyl ester 10.4% w/w + florasulam 10.0 % w/w WG for broad leaf weed control in wheat

At Pantnagar, application of XDE-729 methyl ester + florasulam along with polyglycol 12.76 g/ha recorded more number of spikes, grains per spike and higher 1000 grain weight resulting in higher grain yield as compared to other herbicidal treatments. Addition of polyglycol with XDE 729 methyl ester + florasulam at 10.2 and 7.7 g/ha recorded higher weed control efficiency (95.9 and 95.2%, respectively).

Bio-efficacy evaluation of UPH-110 against weeds in wheat

At Hissar, on the basis of bio-efficacy study undertaken during *rabi* 2010-11 and 2011-12, it was found that post-emergence(35 DAS)

application of UPH 110 at 500 g/ha along with surfactant 1250 ml/ha is very effective against grassy as well as broadleaf weeds in wheat without causing any crop phytotoxicity. Herbicide should be sprayed with flat fan nozzle using 375 litres of water /ha.

Bioefficacy of quizalofop-p-ethyl 5% EC in soybean

At Ludhiana, post-emergence application of quizalofop-p-ethyl at 37.5 g/ha recorded effective control of all the grasses and resulted in significant reduction in population as well as in dry matter of weeds as compared to lower dose 25 g/ha and unweeded control. The highest seed yield of soybean was recorded at quizalofop 75 g/ha which was at par with its lower dose of 37.5 g/ha. The herbicide was safe to the soybean crop at the rates evaluated in the trial.

At Akola, combination of imazethapyr @ 0.100 kg/ha PoE 15 DAS + quizalofop- ethyl @ 0.075 kg/ha PoE 15 DAS proved better in controlling weed, dry matter accumulation, weed control efficiency, weed index, grain yield and NMR but found at par with all herbicidal treatments except quizalofop-ethyl @ 0.075 kg/ha PoE 15 DAS and imazethapyr + imazamox (Pre mix)) @ 0.070 kg/ha PoE 15 DAS while imazethapyr + imazamox (Pre mix) @ 0.080 kg/ha PoE 15 DAS recorded highest B:C ratio.

Weed management in field pea

At Ranchi, application of imazethapyr @ 75.0 g/ha at 30 DAS being similar to hand weeding recorded significantly higher weed dry matter compared to rest of the weed control methods. However, application of pendimethalin + imazethapyr @ 1.0 kg/ha as PE was similar to quizalofop ethyl @ 60 g/ha at 30 DAS, and imazethapyr @ 50.0 g/ha at 30 DAS and was significantly higher than quizalofop ethyl @ 50 g/ha at 30 DAS, chlorimuron ethyl @ 4 g/ha as PPI, pendimethalin @ 1 kg/ha as PE and pendimethalin+ imazethapyr @ 0.75 kg/ha as PE. The maximum seed yield was recorded under hand weeding at 20 and 40 DAS (1557 kg/ha)

which was similar to imazethapyr @ 50.0 g/ha at 30 DAS, imazethapyr @ 75.0 g/ha at 30 DAS, quizalofop ethyl @ 60 g/ha at 30 DAS.

Bio-efficacy of acetachlor for weed control in maize

At Pantnagar, increasing the dose of acetachlor (1250-3125 g/ha) reduced weed density as well as dry weight of weeds. Maximum grain yield of maize (6.2 t/ha) was obtained with application of higher dose of acetachlor 3125 g/ha fb its lower dose 2500 g/ha as pre-emergence.

Integrated weed management in maize

At Dharwad, the maize grain yield obtained with the application of oxyfluorfen + mechanical weeding (4561 kg/ha) was on par with hand weeding twice (4748 kg/ha). The grain yield with atrazine + mechanical weeding (4354 kg/ha) was on par with oxyfluorfen + mechanical weeding but was significantly lower compared to HW. The net returns were higher with hand weedings (₹39224/ha) followed by oxyfluorfen + mechanical weeding (₹37393/ha).

Studies on the bioefficacy and phytotoxicity of oxyfluorfen 23.5 EC in potato

At Pantnagar, application of oxyflurofen at 200 g/ha was found most effective against the density and dry weight of weeds in potato crop as compared to its lower doses.

Weed management in chilli after winter rice

At Jorhat, results revealed that metribuzin 500 g/ha followed by use of garden hoe either at 30, 50 & 80 DAP or 30, 60 & 60 DAP resulted significantly higher yield over rest of the treatments.

Weed management in gerbera

At Jorhat, application of oxadiargyl 90 g/ha followed by use of grubber 50,75,100 and 125 DAP resulted in improved values of yield attributes like days to flower initiation, flower diameter, flower disc diameter, flower length, stalk length, number of ray floret and number of suckers per plant as compared to other

treatments. It was closely followed by use of grubber 20, 40,60, 80, 100, 120 and 125 DAP. The highest flower yield was resulted by oxadiargyl 90 g/ha followed by grubber 50, 75,100 and 125 DAP.

Weed Management in Bt cotton

At Anand, weed density of monocot, dicot and total weeds were significantly lower in IC + HW carried out at 15, 30 and 45 DAS. 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 cotton were significantly influenced by weed management practices in Bt cotton. Significantly maximum seed cotton yield was recorded in IC + HW carried out at 15, 30 and 45 DAS treatment which was at par with pendimethalin @ 900 g/ha fb IC + HW at 30 DAS and 60 DAS treatment. Germination count recorded at 10 DAS, plant height and plant dry matter accumulation recorded at 30 DAS of succeeding crops viz., chickpea, wheat and mustard were not significantly influenced by residual effect of herbicides applied in cotton as pre or post emergence.

At Akola, two hand weeding + 1 Hoeing followed by pyrithiobac sodium @ 0.062 kg/ha PoE 20-40 DAS + Hoeing at 40 DAS proved better in controlling weed, dry matter accumulation, weed control efficiency, weed index, higher grain yield, NMR and B:C ratio.

Weed management in cropping systems Weed Management in maize-chickpea cropping system

At Anand, grain and straw yield of maize were significantly highest and lowest weed dry weight were recorded in mechanical weeding carried out at 20 and 40 DAS. At harvest, significantly the lowest weed biomass was recorded with pre emergence application of atrazine (0.75 kg/ha) followed by 2, 4-D @ 0.50 kg/ha. Seed yield of succeeding chickpea was significantly influenced by weed management

practices. Significantly the highest seed yield was recorded in pre emergence application of pendimethalin (0.75 kg/ha) with mechanical weeding carried out at 20 DAS.

Conservation agriculture practices (tillage and nutrients) and weed management for enhancing productivity of chickpea based cropping systems in rain-fed areas

At Ranchi, chickpea grown with conventional tillage recorded 11.9% significantly higher grain yield compared to reduced tillage (1198 kg/ha). While FYM @ 5 t/ha + half the nutrient registered 11.7% higher grain yield compared to recommended nutrient N, P, K. Among weed control methods manual weeding twice produced 24.09% higher grain yield of chickpea (1406 kg/ha) compared to application of pendimethalin@1 kg ai/ha

Competitive behaviour of early mustard varieties against weeds

At Ranchi, variety Shivani (early mustard) is more competitive to weeds than the other varieties. It produced maximum seed yield 933 kg/ha and straw yield 3601 kg/ha under weed free condition. This is due to maximum LAI, plant biomass and CGR of variety Shivani. It also recorded maximum net return of Rs.6773/ha and B:C ratio 0.53.

Problematic weed management

Evaluation of post-emergence herbicides to manage *Ambrosia*

At Bangalore, spraying of glyphosate 41 SL 10ml/liter of water or glyphosate 71 WP 7.5 g /liter of water caused higher top kill of shoots (62 to 80%) in 67 days after spraying, while paraquat 24 SL at 7.5 ml/liter of water caused 52% top kill. The regeneration of the weed was observed in all herbicide sprayed plots, after initial desiccation. Thus, there is need to spray the weed infested area once in 2 to 3 months periodically to totally contain the weed.

Application of glyphosate 41 SL 10 ml + oxyfluorfen 23.5 EC 0.5 ml /liter of water,

glyphosate 71 WP 7.5 g/liter of water caused 62 to 69 % top kill of Ambrosia as compared to 2,4-D sodium salt at 2 to 4 g/liter of water which caused higher top kill (74 to 76%) after 50 days of spraying. In unsprayed control, there was no increase in the number of shoots of $Ambrosia/m^2$ (115.5/ m^2 on 22-06-2012 as against 142.5/ m^2 on 03-05-2012). Thus, glyphosate 41 SL at 10 ml/liter of water, glyphosate 71 WP 7.5 g/liter of water and 2,4-D sodium salt 80 WP 2 to 4 g/liter of water appeared to lower the menace of the weed.

Use of post-emergence herbicides namely

glyphosate 10.0 to 12.5 ml/liter of water, 2,4-D amine salt 3.45 ml/liter of water, glyphosate 71 WP 6.25 g/liter of water, 2,4-D sodium 80 WP at 2.0 g along with glyphosate 71 WP 5 g/liter of water or 41 SL 10 ml/liter of water and 2,4-D sodium salt 80 WP 2.5 g/liter of water appeared to be effective in lowering the shoots of *Ambrosia* up to 65 days after spraying during November – January months. Though most of these herbicides caused 96% top kill in 23 days after spraying, there were more emergences of new shoots from the underground rhizomes due to precipitation.

5.0 RECOMMENDATIONS FOR PACKAGE OF PRACTICES

Recommendations passed on to state package of practices

PAU, Ludhiana

Wheat: Control of mixed weed flora (annual grasses and broadleaves) in wheat (*Triticum aestivum*) through post-emergence (30-35 days after sowing) application of fenoxaprop + metribuzin 275 g/ha applied by dissolving in 375 litres of water.

Autumn potato: Spreading paddy straw mulch 6 t/ha uniformly in the field after planting provides effective control of annual grasses and broadleaf weeds in autumn potato (*Solanum tuberosum*).

Kharif maize: Post-emergence application of tembotrione @ 110 g/ha + surfactant 1000 ml/ha applied by dissolving in 375 litres of water for effective control of all type of weeds including annual grasses, broadleaves and perennial Cyperus rotundus in kharif maize. Adaptive trials have been successfully conducted; the registration of the herbicide is awaited for its inclusion in the state package of practices.

UAS, Bengaluru

Transplanted rice: Post-emergence application of bispyribac-Na @ 20 g/ha at 20 DAP in southern transition zone of Karnataka.

Transplanted onion: Post-emergence herbicides, viz. quizalofop-p-ethyl @ 37.5 g/ha and fenoxaprop-p-ethyl @ 67.5 g ai/ha at 15-20 DAP in central dry and eastern dry zones of Karnataka.

Groundnut: Post-emergence, viz. quizalofop-pethyl @ 37.5 g/ha for control of grassy weeds, and imazethapyr @ 125 g/ha for broad-spectrum of weeds at 15-20 DAP in central dry and eastern dry zones of Karnataka.

CSKHPKV, Palampur

Rice: Bispyribac-Na @ 20 g/ha on emerged weeds at 25-30 days (4-5 leaf stage of weeds) after sowing in direct-seeded and transplanted rice.

AAU, Jorhat

Tuberose: Application of metribuzin @ 500 g/ha+hoeing at 30, 60, 90 and 120 DAP or oxadiargyl 150 g/ha + hoeing at 30, 60, 90 and 120 DAP.

MAU, Parbhani

Direct-seeded upland rice: Pre-emergence application of butachlor @ 1.5 kg/ha + 1 HW at 30 DAS.

NDUAT, Faizabad

Wheat: Clodinafop-propargyl @ 400 g/ha at 25-35 DAS; for BLWs, carfentrazone-ethyl @ 50 g/ha, and for grassy + BLWs, sulfosulfuron + metsulfuron-methyl @ 40 g/ha for controlling *Phalaris minor* and *Avena fatua*.

BAU, Ranchi

Direct-seeded rice: Pyrazosulfuron @ 25 g/ha 3-7DAS, pretilachlor–S 50EC 750 g/ha 0-5 DAS.

KAU, Thrissur

Rice: Fenoxaprop-p-ethyl @ 60 g/ha, azimsulfuron @ 35 g/ha and penoxsulam @ 25 g/ha at 2-4 leaf stage against *Echinochloa crusgalli*. Penoxsulam and azimsulfuron are effective against dicots and sedges.

Loranthus: Spraying ethrel @ 25 ml/l on Loranthus leaves. In case of regrowth, padding with 2,4-D @ 1 g/20ml water in major attachment points is recommended.

OUAT, Bhubaneswar

Rice: Pre-emergence application of pyrazosulfuron-ethyl @ 0.02 kg/ha effective against broad spectrum of weeds.

Transplanted rice: Pre-emergence application of oxadiargyl @ 0.06 kg/ha to control broad spectrum of weeds. Post-emergence application of chlorimuron + metsufuron @ 4 g a.i./ha to control dicot weeds and to some extent sedges.

Groundnut Pre-emergence application of

oxyfluorfen @ 0.04 kg/ha against broad spectrum weed including *Celosia argentea*.

Sugarcane: Atrazine @ 2.0 kg/ha or metribuzin @ 1.5 kg/ha at 3-5 DAT or glyphosate @ 1.0 kg/ha as directed spray at 20-25 DAT.

Jute: Quizalofop-p-ethyl @ 0.075 kg/ha at 20-25 DAS or pendimethalin @ 1.0 kg/ha or 0-3 DAS in moist soil.

Cotton: Pendimethalin @ 1.0 kg/ha or oxyfluorfen @ 0.05 kg/ha at 0-3 DAS in moist soil or glyphosate @ 1.0 kg/ha as directed spray at 30-35 DAS.

Tomato: Pre-emergence application of metribuzin @ 0.5 kg/ha or butachlor @ 1.0 kg/ha (3 DAS).

Okra: Pre-emergence application of alachlor @ 0.75 kg/ha or metolachlor @ 0.75 kg/ha (3 DAS) with one hand weeding.

Eichhornia crassipes: Application of glyphosate

@ 2.0 kg/ha or paraquat @ 0.8 kg/ha + 2,4 D Na Salt @ 1.0 kg/ha at active growth stage.

Scirpus grossus: Paraquat @ 1.2 kg/ha or paraquat @ 0.8 kg/ha + 2,4 D Na salt @ 1.0 kg/ha at active growth stage.

CCSHAU, Hisar

Orobanche management in mustard: Two sprays of glyphosate at 25 g/ha at 30 DAS fb second application at 50 g/ha at 55 DAS in 300 litres of water using flat fan nozzle. Crop should not be under moisture stress at the time of spray.

Transplanted rice: Post-emergence application (15-25 DAT) of bispyribac-Na @ 25 g/ha by mixing in 300 litres of water / ha.

SKRAU, Bikaner

Lucerne: Application of pendimethalin @ 1.0 kg/ha as sand-mix with deep ploughing in summer.

6.0 TRIBAL SUB PLAN PROGRAMME

Details of various activities undertaken at different centres are given below:

AAU, Anand

In Dahod district, weed management equipments like 50 Bakpak sprayer pumps, 120 hand hoes, 50 spray nozzles XL-54 and 60 spray nozzles FFP/95/900 were distributed to tribal farmers. Programmes on weed management were also conducted in which folders, leaflets and booklets on weed management technologies were distributed. Special lectures were delivered by the scientists of the project in farmers day and meetings organized by KVK, Dahod and KVK, Devgadh Baria in tribal area.



Inputs distribution in TSP Programme at Devgadh baria and KVK, Dahod

BAU, Ranchi

A training programme on weed control was organized at Birsa Agricultural University, Ranchi from 5 to 7 March, 2013. Forty farmers from different tribal districts of Jharkhand, viz., Lohardaga, Ranchi and East Singhbhumi districts participated in this training programme. Before start of training programme, a pre-training evaluation of farmers was performed to assess the level of knowledge about weed control. Farmers were provided with training materials and a book on weed control written in hindi language. Farmers were also shown the results of long-term fertilizer use and its impact on weed density. 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.



Weeding tools distribution among the farmers

AAU, Jorhat

Twenty eight field demonstrations on weed management in winter rice were carried out in Borhola and Titabor locations under Jorhat district. At each location, agri-inputs like fertilizer, herbicide, spray pumps and protective gadgets for spray were distributed to the farmers.

A training programme was organized in each location and the participating farmers were trained on "Weed management in crops" in general and application technique of herbicide in transplanted rice, in particular. Thirty two farmers participated at Kakodongahabi, Borhola and thirty one in Silikha Sanatan, Titabor.



A field day was organized in each location in which 61 farmers participated. Farmers expressed their satisfaction at the initiative and efforts taken by the centre in collaboration with state agriculture department. Highest rice yield of 59.6 q/ha was observed in the field of Mr. Jitu Saikia of Titabor, while the lowest was reported by Mr. Muhidhar Kachari (48.9 q/ha) of Bohola. The average yield recorded in the demonstration was 54.11 q/ha, which was 26.1 to 57.7% higher over the yields achieved in the area (34.3 to 42.9 q/ha).

GBPUAT, Pantnagar

Front line demonstrations on weed management in transplanted rice were conducted during *kharif* 2012 in 1.0 acre area each of 11 tribal farmers in Gadarpur and Khatima tehsils of Udham Singh Nagar district. Herbicide, spray pumps, nozzles were distributed to the selected farmers. The yield of rice was increased around five quintals per hectare with the adoption of weed management technology developed from the center at every location.

CSKHPKV, Palampur

TSP programme was under taken in Lahaul & Spiti district in which, fifteen training programmes were conducted on weed management in different villages. More than five hundred farmers were made aware of the losses caused by weeds in commercial crops like green pea, potato, cole crops, french bean, hops etc. and field crops like wheat, barley rajmash, as well as in grasslands/pastures. They were educated to minimize these losses through integrated weed management. One hundred fifty knapsack sprayers and protective spray kits were distributed during the training programme.

UAS, Bengaluru

Weed control equipments/ tools to farmers in seven villages, (viz. Naaganaapura (Soligas 10 familes & Betta Kurubas 60 families), Khothanahally (Soligas, Jenu Kurubas and Betta kurubas 10 families each) from Nanjanagudu taluk; Netkalhundi (25 families), Sollepura (60 families) and Vaddara gudi (10 families) from HD Kote taluk all of them Jenu Kurubas; Panjahalli colony (16 families), Pakshirajpura (17 families) of Jenu kurubas from Hunsur taluk) at Vaddara gudi village, Budakattu Krishikara Sangha, HB Road, HD Kote, Mysore, district were distributed.

MAU, Parbhani

The tribal sub-plan was started in July 2012 at Chikali (Khurd), Taluk. Kinwat, District Nanded. On-farm demonstrations were conducted on selected 42 scheduled tribe farmers field in soybean and cotton. The integrated weed

management was compared with farmer's practices. The herbicides and spray pumps were given to the farmers. In soybean, farmers practice was compared with improved weed management i.e. stale seed bed *fb* post-emergence application of imazethapyr @ 0.10 kg/ha. In cotton, farmers practice was compared with stale seed bed *fb* post-emergence application of pyrithiobac sodium @ 0.075 kg/ha. Results indicated that the average soybean grain yield increased by 18.8% with IWM, where as seed cotton yield was increased by 21.0% with IWM as compared to farmers practice.

One-day training programmae was also conducted at farmers field to guide the farmers for proper adoption of IWM, use of pre- and post-emergence herbicides, precautions to be taken while using herbicides, residue management, use of sprayers, soil health etc.

OUAT, Bhubaneswar

Tribal sub-plan programme was initiated during *kharif* 2012 in the tribal dominated areas of Angul district for the overall development of their livelihood by supplying inputs like herbicides, weed control tools and implements. About 105 farmers were trained regarding weed management in rice through FLDs. An increase in rice yield up to 25 % by improved weed management over farmers practice was obtained.

ANGRAU, Hyderabad

Under the Tribal Sub-Plan programme, 390 trainings on weed management in transplanted rice, groundnut, castor, sorghum, maize, oil seeds and millets, and 365 on-farm demonstrations on weed management in rice, castor, groundnut, oilseeds and maize were organized in the tribal dominated areas in different districts of the state *viz*. Warangal, Mahabubnagar, Vizianagaram, Anantapur and Ranga Reddy. Agri-inputs like seed fertilizer, herbicides etc. were provided to the farmers.

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 use of herbicide, hand hoes and weeding hook. About 250 farmers participated in one-day weed management awareness programme. Tools like spray pumps, weeding hooks, toothed spades and hand hoes and herbicides were distributed to the ST farmers in tribal areas of Raigad, Thane and Ratnagiri districts.

IGKV, Raipur

Front Line Demonstrations on weed management in rice were laid down in 13 tribal villages in districts of Bastar and Kondagaon, 01 village in district of Mahasamund and 04 villages in district of Sarguja. 136 demonstrations were taken on transplanted rice and 45 were laid down in direct seeded rice i.e. Beushening. A total of 181 farmers participated. The demonstrations were conducted by KVK, Jagdalpur, Ambikapur and AICRP-Weed Control, Raipur. In transplanted rice, per cent increase under farmers practice and recommended practice over control was 59.5 and 84.5%.

Distribution of knap-sack sprayers, flat fan Nozzles, herbicides to the participating farmers were also done.

In an area of 75 acres, Front Line Demonstrations were laid down in tribal village



Glimpses of TSP at Bastar

Parsadih in district of Mahasamund. The demonstrations were conducted on weed management in rice, of which, 36 were taken on transplanted rice with 4 different cultivars and 10 were laid down in direct seeded rice i.e. Beushening. A total of 46 farmers were the beneficiaries. The per cent increase under farmers practice and recommended practice over control was 24.38 and 40.27%

7.0 PUBLICATIONS

Research Publications

PAU, Ludhiana

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UAS, Bengaluru

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GBPUAT, Pantnagar

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- Tandon, S. 2012. Residue analysis of isoproturon and butachlor in long-term trial of rice-wheat system. *Pestology XXXVI*(1): 27-29.

TNAU, Coimbatore

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CSKHPKV, Palampur

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AAU, Jorhat

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MAU, Parbhani

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AAU, Anand

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KAU, Thrissur

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CCSHAU, Hisar

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IGKV, Raipur

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Publications by the coordinating centres

Centres	Research Papers	Popular articles	Papers presented in seminars/symposia/ conferences	Books	Book Chapters	Lectures delivered during training	Students guided	
PAU, Ludhiana	2	3	10	1	_	12	M.Sc.	Ph. D.
·				1	_		-	- 1
UAS, Bengaluru	4	-	24			5	7	1
RVSKVV, Gwalior	-	-	8			-	5	-
GBPUAT, Pantnagar	9	13	30			-	7	9
CSKHPKV, Palampur	9	-	13			10	3	-
AAU, Jorhat	1	3	9	1	3	15	3	3
MAU, Parbhani	1	5	5		1	3	5	2
AAU, Anand	1	2	6	1		13	7	
TNAU, Coimbatore	7	1	56	1	10	19	10	2
NDUAT, Faizabad	-	3	9			-	7	3
VB, Sriniketan	-	1	19		1	17	2	7
BAU, Ranchi	-	-	1	1		-	-	-
CSAUAT, Kanpur	-	1	4			1	5	1
KAU, Thrissur	2	-	12			18	3	2
OUAT, Bhubaneswar	-	1				2	1	-
ANGRAU, Hyderabad	-	3	7			13	-	-
CCSHAU, Hisar	7	3	16	-	-	43	3	-
RAU, Pusa	-	3	2	2	4	-	-	-
DBSKKV, Dapoli	-	-	3			-	-	-
IGKVV, Raipur	2	-	11	-	-	11	-	-
UAS, Dharwad	-	3				-	-	-
RAU, Bikaner	-	-	12	-	-	-	1	-

8.0 AWARDS/RECOGNITIONS

UAS, Bengaluru

- Dr. R. Devendra was awarded Best Research Paper Presentation Award at the 8th *Kannada Vignana Sammelana* held at UAS, Dharwad, 15-17 September, 2012.
- The Dr. M.T. Sanjay was awarded Best Research Paper Presentation Award and Young Scientist Award at the 8th Kannada Vignana Sammelana held at UAS, Dharwad, 15-17 September, 2012.

GBPUAT, Pantnagar

The Tr. Rohitashva Singh was awarded Fellow of Indian Society of Weed Science (2010-11).

AAU, Jorhat

The Dr. I.C. Barua was awarded Fellow of Indian Society of Weed Science (2010-11).

MAU, Parbhani

Tr. A. S. Jadhav received Vasantrao Naik Agricultural Scientist Award – 2012 from Vasantrao Naik Smriti Prathisthan, Pusad for his contribution in Research and Extension of Weed Management and use of weedicides at Pusad, Dist. Youtmal, Vidharbha.

TNAU, Coimbatore

- The Dr. P. Murali Arthanari, Dr. C. Chinnusamy, Dr. R. Kanimozhi, Dr. N. K. Prabhakaran and Dr. P. Veeramani (2012) received Best Poster Award on "Integrated Weed Management in Direct Wet Seeded Rice" III Prize during the ISWS Biennial Conference held at KAU, Thrissur.
- Dr. S. T. Kumaran, Dr. G. Kathiresan, Dr. C. Chinnusamy, Dr. P. Murali Arthanari (2012) received Best Poster Award on "Evaluation of Bispyribac Sodium 10% SC on Weed Control in Direct Seeded Rice" I Prize during the ISWS Biennial Conference held at KAU, Thrissur.

9.0 RECOMMENDATIONS OF AICRP-WC BIENNIAL WORKSHOP

Recommendations of XX Biennial Workshop of All India Coordinated Research Project on Weed Control held at Kerala Agricultural University, Thrissur (Kerala) during 17-18 April, 2012



Overall Recommendations

I. Research

10 Weed survey and surveillance

- Weed survey work is going on for the last several years. It is essential to compile this information in a systematic manner and computerize for uploading on the website.
- ii. Some routine weed survey related activities can be dispensed with emphasis may be given to weed surveillance to monitor appearance of new weed species, and weed shifts due to weed management practices.
- iii. Prescribed guidelines / protocols are not followed for weed survey / surveillance at more centres, and the observations / records are made in a very casual and unscientific manner. Information collected should be scientific through GPS, continuous and properly tabulated and analyzed.
- iv. GPS should be used while conducting

- /reporting weed survey and surveillance studies, which would be useful in developing appropriate location-specific, weed management strategies.
- v. Visible effects on weed dynamics due to changes in weather/climate changes over the years should be documented.
- vi. Useful qualities of specific weeds should be identified and put to some practical use.

2. Weed biology and physiology

- All centres should identity 5 major species in cropped/non-cropped lands of their jurisdiction/state. An article on the current state of knowledge with respect to their infestation, biology and manage-ment should be prepared.
- A compilation on major weeds of India should be compiled based on the information available from different states/regions.
- iii. Centres where facilities exist should take up studies on the effect of climate change (CO₂, temperature, UV radiations) on the identified weeds species, and on crop-weed associations.
- iv. Weeds showing resistance to continued use of a herbicide should be identified.
 A scientific analysis of herbicide resistance *vis-a-vis* herbicide efficacy should be made.
- Basic physiological studies should be planned on resistance development and its management.

3. Weed management in crops and cropping systems

i. The centres which have not initiated long-term herbicide trials, should do the same now.

- ii. Effects on soil physico-chemical and biological/microbiological properties, crop performance and weed dynamics should be properly monitored in long-term experiments. Accordingly, seasonal/yearly change in these parameters over a period should be scientifically presented.
- iii. At most places, zero tillage has shown good results. Such studies should be continued for indefinite period in fixed plots. Emphasis should be given to integrated weed management in conservation agriculture systems considering all the relevant principles i.e. minimum soil disturbance, residue/cover management, and dynamic crop rotations.
- iv. Station trials may be undertaken on location-specific problems in individual crops.
- Studies on weed management in organic farming systems should be taken-up in high-value crops.
- vi. Weed management should also be undertaken in horticulture (fruits, vegetables, ornamentals)/plantation cropsbased systems in the relevant centres/universities.
- vii. Studies on canopy development, rhizospheric environment and nutrient uptake patterns of both crops and weeds should be made.
- viii. Economic analysis is a must in all field trials including OFTs and FLDs. The benefits or otherwise of any weed management practice should be clearly quantified in realistic economic terms.
- ix. Data on crop and weed growth parameters should be recorded periodically, and scientific growth analysis should be done. Regression analysis can be done to work out cropweed relationships.
- x. A compiled report on the previously

- conducted and concluded experiments including long-term tillage / herbicide trials should be presented in the annual reports of the respective centres and submitted to the coordinating unit.
- xi. Data must be collected systematically, and only statistically analyzed quantitative data should be presented.
- xii. In long-term experiments, base year data and yearly variations in treatment responses should be recorded and presented.
- xiii. A system-based approach to weed management should be pursued. The direct, residual and cumulative effects of weed management practices/herbicides should be investigated in a system mode on a long-term basis.
- xiv. An experiment on conservation agriculture will be formulated and finalized after feedback from all the centres.

4. Herbicide residues and environmental quality

- i. In all long-term field trials, the herbicide residues including secondary metabolites in soil and plant (grain, stover/fodder) should be monitored on a continuous long-term basis, at least in the selected herbicidal treatments.
- ii. Controlled studies on leaching behavior, persistence, adsorption etc. should be carried out using commonly used herbicides.
- iii. Herbicide residues in water bodies should be monitored, along with effects on aquatic flora and fauna.
- iv. Bioassay studies should normally be avoided. The centres which do not have facilities for herbicide residue analysis, they can collaborate with nearby centres or avail the facilities at HQs.
- v. It is also desirable to collect herbicide samples of different brands from the

- market on regular basis and analyzed for their active ingredient.
- vi. Herbicide residue data, especially in case of long-term experiments, should be presented as per the treatments enlisted in the technical programme for better interpretation of results.
- vii. Herbicides residue experiments should be formulated and conducted to assess the threat posed by herbicides and metabolites by their entry into food chain and thus causing health hazards to the people. Depth of leaching, insoluble nature of the herbicides, degradation products of the herbicide in environment, and residues in organic manures should be considered.

5. Management of problematic/invasive/ parasitic/aquatic weeds

- i. Centres having similar weed problems should work together in a network/ mission mode, study their biology/ ecology and integrated management including through biological means.
 - (a) <u>Orobanche</u> Hissar, Bikaner, Gwalior, Bangaluru, Coimbatore, Bhuba-neswar, Hyderabad centres-with coordination from DWSR/DRMR
 - (b) <u>Striga</u> -Hyderabad, Dharwad, Bangalore, Coimbatore, Gwalior centres
 - (c) <u>Cuscuta</u> Coimbatore, Bhubaneswar, Parbhani, Bengaluru, Dharwad, Pusa, Hyderabad, Dapoli
 - (d) <u>Weedy rice and Echinochloa</u>— Thrissur, Coimbatore, Raipur, Faizabad, Palampur, Gwalior, Bhubaneswar centres
 - (e) <u>Aquatic weeds</u> (water hyacinth and others) – Thrissur, Jorhat, Bhubaneswar, Coimbatore, Bengaluru, Pusa centres
 - (f) Phalaris minor Ludhiana,

- Pantnagar, Hissar, Palampur, Faizabad, Gwalior centres
- (g) <u>Parthenium</u> All centres
- (h) <u>Tea gardens</u> Jorhat, Palampur, Coimbatore, Thrissur centres
- (i) <u>Coconut and rubber</u> Thrissur, Coimbatore, Bhubaneswar, Hyderabad, Dharwad centres
- (j) <u>Fruit crops</u> Anand, Dapoli, Parbhani centres
- (h) <u>Hill ecosystem</u> Palampur, Pantnagar, Ludhiana, Jorhat centres
- ii. Aquatic weed management experiments should also be conducted in actual field conditions on long-term basis, besides laboratory conditions.

6. Transfer of technology

- Scientists of all centers should devote a minimum of 25% of their time for training/extension activities, including on-farm trials, front line demonstrations and impact analysis.
- ii. Emphasis should be given on disadvantageous/tribal areas for dissemination of technologies.
- iii. Effective collaboration must be made with other disciplines, AICRPs in the same university, KVKs, NGOs and GOs (state department of agriculture/ horticulture) for dissemination of technologies.
- iv. Concept of weed free-village should be developed, and 4-5 such villages may be adopted for a period of 2 years.
- v. Productivity, profitability and impact analysis of weed management interventions should be worked out. Impact analysis should indicate the coverage of area, improvements in livelihood security and rural transformation, etc.
- vi. OFTs should include not only herbicidal treatments for weed control but also

- the mechanical tools including power weeders for integrated weed management.
- vii. Herbicide residue analysis can also be done in some of the OFTs and aquatic bodies where a particular herbicide has been used over a period.
- viii. Biological control of *Parthenium* and water hyacinth should be demonstrated in the city premises and in villages at prominent locations. Select 1-2 large ponds / water bodies in the city / village infested with water hyacinth and show the effect of biological control.
- ix. Extensive reliance on herbicides alone is not desirable; and hence an effective extension strategy for integrated weed management involving chemical and non-chemical approaches should be followed.

II. Administrative

- i. Vacant positions at coordinating centres should be filled immediately by the respective SAUs.
- ii. Frequent shifting of scientists from the project should be avoided.
- iii. Funds and vehicle provided for the project should not be used in other works by the SAUs.
- iv. Separate provision for funds should be proposed under XII plan for conducting FLDs and OFTs under transfer of technology.
- v. Performance of some centres is not up to the mark as they did not conduct the allotted experiments as per protocol, and also did not publish papers. Such centres must improve their performance, failing which, appropriate action including shifting / closure of these centers will be recommended to the ICAR.

III. General points

i. Research articles published by most

- scientists of coordination centres are not high quality. We must generate quality data and publish articles in high ranked journals.
- ii. Efforts must be made to win awards / recognitions at the national / state level.We must also contest for the ICAR's Award for AICRPs.
- iii. Centers with significant contributions during the year / biennium should be recognized. Those not performing so well should also be identified and exposed.
- iv. Centers should not merely become a testing agency for herbicides and HTCs of MNCs, and provide results according to their liking. We must become equal partners in the development, evaluation and dissemination of a herbicide technology with the industry.
- v. Data of long-term experiments conducted by different centers should be sent to the HQs for pooled/combined analysis and working out location x treatment interactions.
- vi. A statistician has been appointed at the HQs and can be associated with the planning, design, layout and analysis of network experiments.
- vii. Annual reports are submitted by some centres very late and that too in a very poor shape. Good quality reports with properly analyzed data should be submitted well before the due date. Reports submitted after the last date and those of very poor quality will not be considered.
- viii. There shall be a proper system of monitoring of work of different centres from the HQs.
- ix. Voluntary centers should undertake trials of their relevance under the guidance of Nodal Officer from the HQs.

- x. Resources and facilities available at different centres including HQs should be mutually-shared. Centres not having adequate facilities for residues analysis can avail the same at other nearby centres or the HQs.
- xi. A proforma for data recording based on the protocol for each experiment / study should be prepared. The records of data collected from different experiments should be should be made available for verification by the monitoring team.
- xii. Number of trials should be fixed for each centre depending on the strength of research personnel.
- xiii. All the scientists of the coordinating centre, irrespective of discipline, must be actively involved in transfer of technology.

- xiv. For all concluded experiments, a comprehensive report highlighting salient research findings along with tables, figures should be presented. Conclusions/recommendations and future lines of work should be mentioned.
- xv. A profoma for recording data should be developed, and followed uniformly by all participating centres.
- xvi. Number of experiments including stations, OFT and FLDs for each centre should be specified based on the manpower available at the centre.
- xvii. Studies on weed utilization are very few. This area also requires strengthening.

10. RECOMMENDATIONS OF QRT

Major recommendations of QRT after reviewing the work done by AICRP-Weed Control during 2006-March, 2012 are as follows:

Administrative

- Centre-wise recommendations of the QRT must be communicated to different centres of AICRP on weeds after approval by the Council without any delay.
- 2. The scientific and other posts lying vacant at centres should be filled without further delay.
- 3. Frequent shifting of scientists in the AICRP should be stopped as this adversely affects the continuity and performance of the centre.
- 4. A post of Jr. Agronomist (Weed Science) may be included at all the coordinating centres.
- 5. The recurring contingency may be enhanced from ₹ 80,000 to ₹ 2.5 lakhs/ scientist/year. Financial discipline by coordinating centres has to be followed.
- Adequate contingency for hiring vehicles may be proposed in the XII Plan EFC proposal.

Research and related issues

- 1º Based on surveillance data, each coordinating centre may identify at least five emerging weeds which are likely to become major problem in the next five years and work out their management strategies.
- ²⁰ Greater emphasis may be laid on weed management in plantations, orchards, vegetables, floriculture and other horticultural crops at the relevant centres.
- 3º IWM packages need to be spelt out clearly for different crops and cropping systems region-wise.
- 4. It has been observed that most of the results

- of experiments on persistence, environmental distribution and contamination, safety and allied aspects relating to herbicides are interpreted based on qualitative data generated by bioassay method. It is, therefore, recommended that centres which are already equipped with Gas Liquid Chromatograph (GLC) or High Performance Liquid Chromatograph (HPLC) should be strengthened by providing GC-MS/LC-MS, either as independent units or MS units compatible with the existing Chromatographs. The centres lacking GC/LC at present be provided these equipments.
- 5. Coordinating centres must not deviate from the methodology/technical programme approved by the PC unit.
- 6. Analysis of weed survey data in respect to weed shift should be compiled over the years/ decades and inferences drawn by the coordinating centres.
- 7. In states with higher tribal population and hill regions like North Eastern Hills region, Chhattisgarh, Odisha, Jharkhand, Himachal Pradesh and Uttarakhand, weed management has all together a different social dimension. Weeding is mostly done for fodder purposes in these regions. Besides studying the economics of weeding, social factors for weeding and characterization of weed problems may also be taken up. Sustainability of weeding vis-a-vis no weeding, and weeding only for fodder in tribal and hill region may be studied with proper reasoning. The role of weed management practices on biodiversity of flora and fauna may also be studied.
- 8. OFTs/FLDs must be conducted before passing on weed management recommendations to farmers. Technology demonstrations should be based on validated

- results coming out of OFTs and FLDs.
- Participatory research for developing weed management technologies should be adopted.
- 10. The details of the farmers' practices as mentioned in technical programme need to be specified.
- 11. Awareness amongst the farmers needs to be created for utilizing ICTs.
- 12. The committee has suggested impact analysis of weed management technologies released to the farmers (format given *in Annexure-V*(. The same should be followed by AICRP-WC centres.
- 13. Scientists should publish research papers only in NAAS rated journals.

Collaboration and linkages

 Scientists of the coordinating centres should collaborate with relevant disciplines like entomology, pathology, economics, agricultural engineering and others within the SAUs / NARS, which is found lacking.

Human Resource Development

 Capacity building of scientists in new emerging areas like climate change, herbicide resistance, conservation agricultural practices, residue analysis, GIS should be undertaken on a periodic basis.

Rating of AICRP-WC Centres by the QRT

The QRT reviewed the work done by AICRP-WC centres and rated their performance based on research output, impact, timely utilization of funds and submission of different reports and queries from the HQ. Comments of the QRT on research achievements of the centres were taken into consideration for rating of the centres given below:

Rating	AICRP-WC Coordinating Centres
A (Very Good)	PAU, Ludhiana; CCSHAU, Hisar; CSHPKV, Palampur; GBPUAT, Pantnagar; TNAU, Coimbatore; UAS Bengaluru; AAU Anand; ANGRAU, Hyderabad
B (Good)	KAU, Thrissur; NDUAT, Faizabad; AAU Jorhat; VB, Sriniketan; OUAT, Bhubaneswar; IGKV, Raipur; RAU, Pusa
C (Average)	RVSKV, Gwalior; DBSKV, Dapoli; BAU, Ranchi
D (Below Average)	SKRAU, Bikaner; CSAUAT, Kanpur; MAU, Parbhani; UAS, Dharwad

It is recommended that the centre at RAU, Bikaner may be shifted to MPUAT, Udaipur since the performance of the centre has been assessed as 'below average' by the present QRT. The new centre will focus on weed management in different agro-ecological zones of Rajasthan. Similarly, the performance of the centre at CSAUAT, Kanpur has also been poor consistently for the last 10 years, during the present as well as the previous QRT. It is recommended that this centre may be shifted to CAU, Pasighat with the mandate to develop weed management technologies in hill ecosystems of NEH region. These two centres (Bikaner and Kanpur) have not responded positively in spite of repeated alerts.

The present QRT has found the performance of the centre at UAS, Dharwad to be 'Below average'; and hence, it is recommended that it can be shifted to UAS, Raichur. The centre at MAU, Parbhani)MH(with four scientists also deserves closure being 'Below average'; and hence, it is recommended that this may be closed and staff redeployed as follows:

- i. New centre to be created at PDKV, Akola (MH) with two scientists (Agronomist and Jr. microbiologist) and two technical staff.
- ii. Strengthening existing centres at Hisar and Hyderabad, with one Jr. Microbiologist at each centre.

11. LIST OF SCIENTIFIC STAFF

DWSR, Jabalpur Coordination



Dr. A.R. Sharma, Director, DWSR & Project Coordinator, AICRP-Weed Control



Dr. R.P. Dubey, Principal Scientist (Agronomy) & Incharge, AICRP-WC

Nodal officers



Dr. D.K. Pandey, Principal Scientist (Plant Physiology)



Dr. Ved Prakash Singh, Principal Scientist (Agronomy)



Dr. C. Kannan, Senior Scientist (Plant Pathology)



Dr. Sushil Kumar, Principal Scientist (Entomology)



Dr. Shobha Sondhia, Senior Scientist (Organic Chemistry)



Dr. P. K. Singh, Principal Scientist (Agril. Extn.)

Regular Centres

PAU, Ludhiana



Dr. MS Bhullar, Agronomist & Principal Investigator
Mrs Simarjeet Kaur, Assistant Agronomist - On study leave
Dr (Mrs) Navjyot Kaur, Assistant Plant Physiologist
Dr. (Mrs) Pervinder Kaur, Assistant Residue Chemist

UAS, Bengaluru



Dr. R. Devendra, Professor (Plant physiology) & Principal Investigator
Dr. M.T. Sanjay, Jr. Scientist (Agronomy)
Dr. G. R. Hareesh, Jr. Scientist (Residue chemistry)

RVS KVV, Gwalior



Dr. J.P. Dixit, Principal Scientist & Principal Investigator
Dr. K.S. Yadav, Principal Scientist (Agronomy)
Dr. Asha Arora, Principal Scientist (Residue Chemist)
Dr. A.M. Jaulkar, Principal Scientist (Agri. Economics)

GBPUAT, Pantnagar



 $\label{lem:condition} {\it Dr. V. Pratap Singh, Professor (Agronomy) \& Principal Investigator} \\ \textit{(Not drawing salary from the Project)}$

Dr. T.P. Singh, S.R.O. (Agronomy)
Dr. S.P. Singh, JRO, (Agronomy)

Dr. S.K. Guru, S.R.O. (Physiology)

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CSKHPKV, Palampur



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AAU, Jorhat



Dr. Jayanta Deka, Principal Scientist & Principal Investigator Dr. Nikunja Ch Deka, Principal Scientist (Agronomy) Dr. Iswar Chandra Barua, Principal Scientist (Ecology) Dr. Nilay Borah, Senior Scientist (Residue Chemistry

MAU, Parbhani



Dr. A.S..Jadhav, Agronomist & Principal Investigator Prof. (Mrs). M.G.Patil, Jr. Microbiologist, (on study leave) Prof. N.S. Jadhav, Jr. Residue chemist

AAU, Anand



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Dr. R. B. Patel, Principal Investigator (upto 28.02.2013)

Shri M. I. Meisuriya, Jr. Physiologist

Shri B.T. Sheta, Residue Chemist

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Dr. K. Govindarajan, Jr. Economist
Dr. P. Janaki, Jr. Scientist (Residue chem.)

NDUAT, Faizabad



Dr. Jaidev Sharma, Agronomist & Principal Investigator
Dr. A.K. Singh, Jr. Agronomist
Dr. S.S. Singh, Jr. Residue chemist
Dr. R.K. Pathak, Jr. Microbiologist

VB, Sriniketan



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BAU, Ranchi



Dr. R.R. Upasani, Agronomist & Principal Investigator Sri. A.N. Puran, Jr. Microbiologist

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Dr. R.A. Yadav, Assoc. Prof. (Agronomy) & Principal Investigator Dr. Mohd. Zafar Siddiqui, Jr. Agronomist Shri K.N. Singh, Jr. Residue chemist

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OUAT, Bhubaneswar



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Dr. S.S. Mishra, Agronomist (Retired on 31.10.2012)

Mr. C.R. Sarangi, Jr. Scientist (Res. Chemist)- Transferred on 17.12.2012

Dr. A.K. Mohanty, Jr Agronomist-Transferred on 31.10.2012

ANGRAU, Hyderabad



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CCSHAU, Hisar



Dr. S. S. Punia, Sr. Agronomist & Principal Investigator Dr. Dharam Bir Yadav, Sr. Agronomist Dr. Anil Duhan, Asstt. Residue Chemist

RAU, Pusa



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RAU, Bikaner



Dr. R.S. Yadav, Professor & Principal Investigator
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Sh. Vikas Sharma, Jr. Microbiologist

Coordinating Centres

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Dr. Anil Kumar, Professor & Principal Investigator

SVBPUAT, Meerut



Dr. Raghuvir Singh, Professor & Principal Investigator

PDKV, Akola



Dr. J.P. Deshmukh, Assoc. Professor & Principal Investigator

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