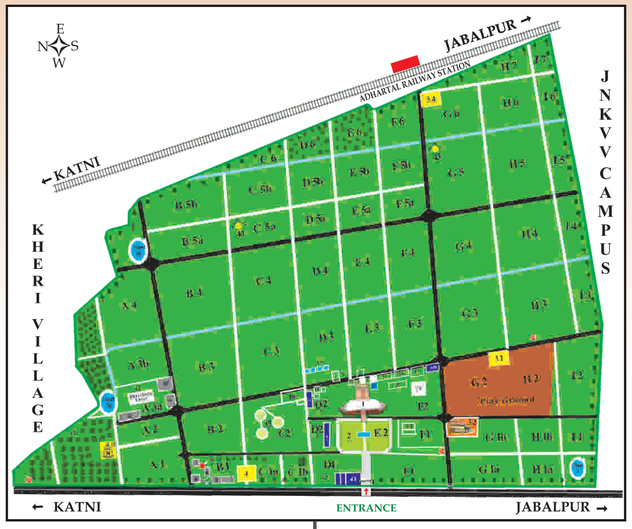
निदेशालय परिसर मानचित्र
DWR CAMPUS MAP



प्रशासनिक भवन	1	Administrative Building	केन्द्रीय भण्डार	24	Central Store
फव्वारा एवं उद्यान	2	Fountain & Lawn	पॉली हाउस	25	Poly House
कार पार्किंग	3	Car Parking	नेट हाउस - 1	26	Net House-1
प्रक्षेत्र भण्डार - 1	4	Farm Store-1	जलीय प्लेटफार्म	27	Aquatic Platform
कार्यशाला	5	Workshop	नेट हाउस - 2	28	Net House-2
ट्रैक्टर शेड	6	Tractor Shed	खरपतवार केफेटेरिया	29	Weed Cafeteria
प्रक्षेत्र अनुभाग	7	Farm Section	विद्युत उपकेंद्र	30	Electric Substation
मनोरंजन सदन	8	Recreation Club	क्रीडांगन	31	Play Ground
प्रक्षेत्र भण्डार - 2	9	Farm Store-2	निदेशक आवास	32	Director's Residence
वर्मीकम्पोस्ट इकाई	10	Vermicompost Unit	जलीय खरपतवार हौज़	33	Aquatic Weed Tank
बागदाना बाबा मंदिर	11	Bagdana Baba Temple	फायटोरेमेडियेशन इकाई	34	Phytoremediation Unit
बागान	12	Orchard	तालाब - 1	35	Pond-1
खलिहान	13	Threshing Floor	तालाब- 2	36	Pond-2
उपकरण शेड	14	Implement Shed	ट्यूब वैल नं. 3	37	Tube Well No. 3
फेस सुविधा	15	FACE Facility	ट्यूब वैल नं. 2	38	Tube Well No. 2
कंटेनमेंट सुविधा	16	Containment Facility	ट्यूब वैल नं. 1	39	Tube Well No. 1
फील्ड प्रयोगशालायें	17	Field Laboratories	ट्यूब वैल नं. 4	40	Tube Well No. 4
इनसेक्टरी	18	Insectory	सुरक्षा चौकी	41	Security Office
मत्स्य संवर्धन कुण्ड	19	Fish Culture Pond	विक्रय केन्द्र एवं एस बी आई एटीएम	42	Sale Counter & SBI ATM
लाईसीमीटर	20	Lysimeter	पर्यवेक्षण टॉवर- 1	43	Watch Tower-1
रिप्रोग्राफिक यूनिट	21	Reprographic Unit	पर्यवेक्षण टॉवर - 2	44	Watch Tower-2
ओ.टी.सी. यूनिट	22	OTC Unit	दुपहिया स्टैण्ड	45	Two Wheeler Stand
कार्बन डाय ऑक्साइड चैम्बर	23	CO_2 Chamber	तालाब- 3	46	Pond-3

भा कृ अनु प - खरपतवार अनुसंधान निदेशालय
ICAR - Directorate of Weed Research

वार्षिक प्रतिवेदन
Annual Report
2014-15

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Correct Citation: Annual Report. 2014-15. ICAR-Directorate of Weed Research, Jabalpur, 116 p.

Published by
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Cover theme

Directorate is a unique research institute devoted to the cause of weed management. Its main building is designed in 'W' shape meaning weed. The alphabet 'W' on the front cover presents the activities and infrastructure related to weed research (in sequence) : zero-till wheat, power spraying of herbicides, mechanical weeding, on-farm research trial, Mexican beetle for *Parthenium* control, FACE for climate change studies, weed-free crop of sunflower, phytoremediation through aquatic weeds, containment facility for studies under controlled environments, runoff tanks for herbicidal effect on fish, and weed cafeteria.

DWR

PREFACE

Research (DWR) and AICRP on Weed Control as AICRP on Weed Management. The SFC for the XII Plan was approved with a handsome increase in the budgetary proposals for infrastructure development.

AICRP on Weed Management has been a major strength of the Directorate, which was further revamped during the year. In fact it is through the AICRP-WM that we claim an all India presence. Five low-performing centres were closed, and 5 new centres were opened. Budgetary allocation was made based on performance, and an effective system of monitoring and evaluation was developed. Quality herbicide residue research was lacking, for which a training-cum-workshop for the concerned scientists was organized. 'Best Centre Award' was instituted and given additional funding support.

I have great pleasure in presenting the Annual Report of the Directorate for the year 2014-15, which contains the achievements made in research, extension, teaching / training, linkages and collaboration, publications, awards, events and meetings organized etc. All this has been possible due to the untiring efforts of the staff members, who deserve appreciation for taking the Directorate to greater heights. I am highly grateful to Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE as well as Dr. A.K. Sikka, Deputy Director General (NRM) for their keen interest and providing needed support and visionary thoughts for improving the activities of this Directorate. I also thank Dr. B. Mohan Kumar, Assistant Director General (Agronomy, Agroforestry and Climate Change) and Dr. S.K. Chaudhari, Assistant Director General (Soil and Water Management) for their guidance and support. The efforts made by Dr. P.K. Singh, Principal Scientist (Agricultural Extension) and editorial team for bringing out this document are also acknowledged.

June, 2015

(A.R. Sharma)
Director

DWR

CONTENTS

विशिष्ट सारांश

निदेशालय ने अनुसंधान और प्रौद्यौगिकी के हस्तातंरण में अपने लक्ष्यों को प्राप्त करने के लिये 2012–13 में प्रभावी खरपतवार प्रबंधन रणनीति के लिए बुनियादी, सामरिक और अनुप्रयुक्त अनुसंधान का कार्य करने के लिये पांच प्रमुख कार्यक्रमों को आरंभ किया। अनुसंधान कार्यक्रमों में विविध फसल प्रणाली में दीर्घकालिक खरपतवार प्रबंधन तकनीकों का विकास, जलवायु परिवर्तन और शाकनाशी प्रतिरोध की व्यवस्था के तहत् खरपतवार की गतिशीलता और प्रबंधन, फसलीय और गैर फसलीय क्षेत्रों में समस्यात्मक खरपतवारों का जीव विज्ञान एवं प्रबंधन, पर्यावरण में शाकनाशी अवशेषों एवं प्रदूषकों की निगरानी, निम्नीकरण एवं उनका अल्पीकरण और खरपतवार प्रबंधन तकनीकों का प्रक्षेत्र शोध एवं प्रदर्शन तथा उनके प्रभाव का मूल्यांकन शामिल है। निदेशालय के ठोस प्रयासों द्वारा देश भर में गाजरघास का मैक्सिकन बीटल द्वारा प्रबंधन का राज्य कृषि विश्वविद्यालयों की भागीदारी के माध्यम से प्रचार एवं प्रसार किया गया। किसानों के खेत पर संरक्षण कृषि के तहत् प्रभावी खरपतवार प्रबंधन तकनीकों का प्रदर्शन किया गया। जिसके परिणामस्वरूप इसको बहुत उत्साहपूर्वक ग्रहण किया गया। विभिन्न आई.सी.ए.आर. संस्थानों और राज्य कृषि विश्वविद्यालयों, कृषि विज्ञान केन्द्रों और गैर सरकारी संगठनों के साथ प्रभावी संबंधों और सहयोग के द्वारा क्षेत्र–विशेष खरपतवारों की समस्याओं से निपटा गया। किसानों और अन्य हितधारकों को शिक्षित करने के लिये विभिन्न कार्यक्रमों जैसे प्रशिक्षण क्षेत्र–दिन/किसान संगोष्ठी, कृषि शिक्षा दिवस, खरपतवार प्रतियोगिता, उद्योग दिवस ओर वैज्ञानिक, अधिकारी एवं किसान अंतराफलक बैठक का आयोजन किया गया। वर्ष 2014–15 के दौरान निदेशालय द्वारा अनुसंधान एवं प्रौद्योगिकी के हस्तातंरण में अपने लक्ष्यों को पूरा किया गया।

विभिन्न अनुसंधान कार्यक्रमों के तहत् मुख्य अनुसंधान उपलब्धियां संक्षेप में निम्नानुसार है :–

विविध फसल प्रणाली में दीर्घकालिक खरपतवार प्रबंधन तकनीकों का विकास –

वर्ष 2012 के बाद से दीर्घकालिक प्रयोग, धान आधारित और गैर धान आधारित फसल तंत्रों में संरक्षण कृषि प्रणाली के तहत् फसल स्थापना तकनीक और खरपतवार नियंत्रण के उपायों के प्रभाव पर शुरू किया गया।

- धान में विभिन्न प्रकार की फसलों के स्थापना तकनीकें, खरपतवार के उद्भव और साथ ही कुल खरपतवार संख्या एवं शुष्क पदार्थ संचय को प्रभावित करती है। सबसे कम कुल खरपतवार घनत्व के साथ ही खरपतवार शुष्क बायोमास सी. टी. (टी. पी. आर.) के साथ दर्ज की गई।
- डी. एस. आर. गेहूं मूंग अनुक्रम में जुताई विधियों ने मृदा सूक्ष्म जीवों को काफी प्रभावित किया। विभिन्न जुताई विधियों की तुलना में, डी. एस. आर. जेड. टी. + आर. + एस. में बैक्टीरिया, कवक, एक्टिनोबैक्टीरिया और डायएजोट्रोपस की संख्या अधिक अवलोकित की गई। डी. एस. आर. जेड. टी. + आर. + एस. में उच्चतम नाइट्राईट आक्सीडाईजर जबकि डी. एस. आर. सी. टी. + एस. में उच्चतम पी. सोल्यूब्लाईजर अवलोकित किया गया। खरपतवार प्रबंधन विधियों का मिट्टी कार्यात्मक समूहों पर कोई महत्वपूर्ण प्रभाव नहीं था।
- संसाधन संरक्षण प्रौद्यौगिकी से पारंपरिक जुताई पद्धति के साथ प्रतिरोपित धान की अपेक्षा मिट्टी के स्वास्थ्य में अधिक सुधार हुआ। खरपतवार प्रबंधन के तरीकों का मिट्टी के स्वास्थ्य मानकों पर कोई प्रभाव नहीं पाया गया।
- विभिन्न फसल प्रणालियों ने कुल खरपतवार जैव भार उत्पादन को अधिक प्रभावित नहीं किया है। अन्य फसल प्रणालियों की तुलना में डी. एस. आर. – शीतकालीन मक्का फसल प्रणाली के अंतर्गत उच्च धान समतुल्य पैदावार दर्ज की गई। खरपतवार एकीकृत प्रबंधन में धान समतुल्य पैदावार सबसे अधिक पाई गई।
- मृदा स्वास्थ्य मानक जैसे मृदा– वसन, मृदा कार्बनिक पदार्थ और उपलब्ध नाइट्रोजन जुताई और फसल अव ोषों को मिलाने से अधिक प्रभावित पायी गई। परिणामस्वरूप पांरपरिक विधियों की तुलना में संसाधन संरक्षण प्रौद्यौगिकी मिट्टी के स्वास्थ्य पर लाभकारी प्रभाव डालती है।
- समग्र परिणाम प्रदर्शित करते हैं कि संसाधन संरक्षण प्रौद्यौगिकी, जैसे जेड. टी. और फसल अवशेषों का पुनः चक्रण मटर में नोड्यूल (गाठों) के निर्माण में मददगार है।
- कटाई के पश्चात् धान के भूसे और अनाज के नमूनों का विश्लेषण करने पर शाकनाशी (विसपायरिवेक–सोडियम, 2,4–डी और फिनॉक्सोप्रॉप) के अवशेषों की उपस्थिति नही पाई गई।
- सोयाबीन–गेहूं–मूंग फसल अनुक्रम में जेड. टी. को अपनाने से सी. टी. की तुलना में सोयाबीन की अधिक उपज प्राप्त हुई। खरपतवार नियंत्रण के दोनों उपचारों (पेण्डीमेथिलीन तत्पश्चात् इमेजेथापायर और मेट्रीब्यूजिन तत्पश्चात हाथों द्वारा निराई) के प्रयोग के साथ अधिक उपज दर्ज की गई और साथ ही खरपतवारों के घनत्व एवं शुष्क भार में भी कमी पाई गई।
- गेहूं की फसल में विभिन्न प्रकार की फसल स्थापना तकनीकों का उपज पर कोई खास प्रभाव नही पाया गया। विभिन्न खरपतवार नियंत्रण उपायों में, क्लोडिनाफाप+मेटसल्फ्यूरॉन (60 + 4 ग्रा./हे.) का प्रयोग खरपवातर वृद्धि एवं उपज के मध्य नजर सबसे प्रभावी पाया गया। खरपतवार प्रबंधन उपायों का मृदा सूक्ष्म जीवों की संख्या पर कोई प्रभाव नही पाया गया। संसाधन संरक्षण तकनीकों जैसे जेड. टी. एवं अव ोषों का अवधारण द्वारा मृदा सूक्ष्म जीवियों की संख्या एवं मृदीय एंजाइम गतिविधियों में सुधार पाया गया।
- मक्का–चना फसल प्रणाली के तहत् दीर्घकालिक शाकनाशियों के परीक्षण में एट्राजिन (500 ग्रा./हे.)+ पेण्डीमेथिलीन (750 ग्रा./हे.) एवं उसके बाद हाथ से 1 निराई

करने से प्रभावी खरपतवार नियंत्रण एवं मक्का की अधिक उपज प्राप्त हुई। मृदा सूक्ष्म जीवियों एवं एंजाईमों पर शाकनाशियों के उपचार का कोई भी हानिकारक प्रभाव नहीं पाया गया।

- धान की विभिन्न फसल स्थापना पद्धतियों के कारण क्रमागत गेहूं की उपज एवं उपज गुणकारकों पर काफी प्रभाव पाया गया। पडलिंग की तुलना में डीएसआर विधि से बोये गये धान वाले क्षेत्र में गेहूं की अधिक पैदावार हुई। खरपतवार प्रबंधन से गेहूं की उपज एवं उपज गुणकारकों में काफी सुधार दर्ज किया गया।
- धान में फसल स्थापना विधियों का उपज गुणकारकों पर प्रभाव पड़ा। गौरतलब है कि एस. आर. आई. के अंतर्गत बालियों की लंबाई, 1000 दानों का वजन एवं उपज अन्य फसल स्थापना विधियों की अपेक्षा अधिक दर्ज की गई। खरपतवार प्रबंधन के अंतर्गत अधिकतम उपज दो बार हाथों से निराई करने पर प्राप्त हुई। जो कि विसपायरीबेक के पश्चात् एक बार हाथों से निराई करने के लगभग बराबर थी।
- गेहूं की फसल में शाकनाशियों का मिश्रण के रूप में प्रयोग करने पर दर प्रतिक्रिया वक्र विकसित करने के उद्देश्य से प्रक्षेत्र में एक प्रयोग किया गया। अन्य कई मॉडलों की तुलना में हिल मॉडल दर प्रतिक्रिया वक्र के लिये सबसे उपयुक्त पाया गया। विश्लेषणतः 2,4–डी का प्रयोग अकेले और मिश्रण के रूप में करने से 2,4–डी का ई.डी. 50 मान क्रमशः 495.45 एवं 713.94 ग्रा./हे. अंकलित किया गया।
- मक्का में एट्राजिन + पेण्डीमेथिलीन के प्रयोग की तुलना में लोबिया इंटरक्रॉपिंग + पेण्डीमेथिलीन का प्रयोग खरपतवार प्रबंधन की दृष्टि से एक बेहतर विकल्प पाया गया।
- सूरजमुखी में पेण्डीमेथिलीन + इमेजेथेपायर (900 ग्रा./हे.) और पेण्डीमेथिलीन (750 ग्रा./हे.) तत्पश्चात् क्यूजालोफोप (100 ग्रा./हे.) का प्रयोग करने से खरपतवारों की संख्या एवं भार में कमी एवं अधिक उपज भी आंकलित की गई।

जलवायु परिवर्तन और शाकनाशी प्रतिरोध की व्यवस्था के तहत् खरपतवार की गतिशीलता एवं प्रबंधन –

- उच्च वायुमण्डलीय कार्बन–डाईआक्साइड का गेहूं एवं फैलेरस माइनर की वृद्धि एवं विकास पर सकारात्मक प्रभाव पाया गया। जबकि सामान्य की अपेक्षा उच्च तापमान का अकेले में अथवा उच्च कार्बन–डाईआक्साइड के संयोजन में दोनों प्रजातियों की वृद्धि एवं विकास पर प्रतिकूल प्रभाव अंकलित किया गया। तुलनात्मक वृद्धि दर के परिणाम दर्शाते हैं कि उच्च तापमान अकेले में अथवा उच्च कार्बन–डाईआक्साइड के संयोजन में फैलेरिस माइनर की अपेक्षा गेहूं में ज्यादा विपरीत प्रभाव डालता है। जो कि जलवायु परिवर्तन की अवस्था में खरपतवार के प्रतिस्पर्धात्मक लाभ को दर्शाता है। सामान्य तापमान की अपेक्षा उच्च तापमान पर गेहूं की उपज कम प्राप्त हुई। हांलाकि उच्च कार्बन–डाई–आक्साइड पर गेहूं की उपज अधिक प्राप्त हुई।
- एंटीऑक्सीडेंट एंजाइमों के समरूपों की गतिविधियों के अध्ययन से पता चला कि उच्च तापमान एवं उच्च वायुमंडलीय कार्बन–डाईआक्साइड के कारण समरूपों का विनियमन एवं प्रेरण होता है। जो कि जलवायु परिवर्तन के अनुकूलन में एंटीआक्सीडेंट प्रणाली के शामिल होने की ओर संकेत करता है। गेहूं की तुलना में फैलेरिस माइनर में ज्यादा मजबूत एंटीआक्सीडेंट रक्षात्मक प्रणाली पाई गई।
- *फैलेरिस माइनर* के विरूद्ध सल्फोसल्फ्यूरान की प्रभावकारिता उच्च कार्बन–डाईआक्साइड, उच्च तापमान और दोनों कारकों के संयोजन में काफी कम पाई गई। उपरोक्त परिणाम जलवायु परिवर्तन के रासायनिक खरपतवार प्रबंधन पर संभावित प्रभाव को इंगित करता है।
- शाकनाशी एलीलोकैमिलो कूड को बनाने के लिये प्रोटोकाल को मानकीकृत किया गया। निष्कर्षों से प्रदर्शित होता है कि पार्थेनियम की पत्तियों के अवशेषों से अधिक मात्रा में एलीलोकैमिकल क्रूड निकायी के लिये एसीटोन + पानी (1:1 आयतन/आयतन) सबसे उपयुक्त है।
- पार्थेनियम पत्ती के एलीलोकैमिकल्स कूड का 200 मि.ग्रा./100 मि.ली. की दर से 1–5 जलकुम्भी के पौधों को (10–60 ग्रा. भार के साथ) 5–10 दिनों में मारने के लिये पर्याप्त पाया गया। इस प्रणाली में एलीलोकैमिकल के अवशिष्ट में अतिरिक्त पानी मिलाने पर 1–3 जलकुम्भी के पौधों (10–30 ग्रा. भार के साथ) को भी मारने में सक्षम पाया गया।
- एक तरल परिरक्षी 20 प्रति ात (भार/आयतन) कैल्शियम क्लोराइड को ग्लिसरॉल में मिलाकर तैयार किया गया है, जो कि फसल एवं खरपतवारों के बीजों को (लगभग 10 प्रतिशत नमीं पर) 3–8 गुना ज्यादा समय के लिये संरक्षित करने में प्रभावी पाया गया।

फसलीय और गैर फसलीय क्षेत्रों में समस्यात्मक खरपतवारों का जीव विज्ञान एवं प्रबंधन –

- वीडी राइस समरूपों के परिपक्व अनाज के 100 दानों का वजन, लंबाई एवं चौड़ाई का अनुपात और उनकी लंबाई के रूपात्मक मापदण्डो के लिये अध्ययन किया गया। अध्ययन किये गये मापदंडो के संबंध में विभिन्न मोरफोटाइपस के बीच अच्छी मात्रा में विभिन्नता की पायी गई।
- कृषि जलवायु क्षेत्रों के आधार पर किसी भी संभावित कलस्टरिंग करने के लिये विभिन्न वीडी राइस मोरफोटाइपस की आण्विक फिंगर प्रिटिंग की गई। NTSYS-PC साफ्टवेयर का उपयोग कर डेड्रोग्राम बनाया गया जो दर्शाता है कि वीडी राइस कलस्टर, भौगोलिक या जलवायु क्षेत्रों पर आधारित नहीं थे।
- वीडी राइस मोरफोटाइपस के 99 में से 4 ने 15 सेमी. खड़े पानी में > 57 प्रतिशत अंकुरण दिखाया।
- चावल की किस्म 'नवीन' वीडी राइस प्रभावित क्षेत्र में प्रतिस्पर्धी पायी गयी।

- वीडी राइस के प्रबंधन के लिये कल्चरल विधियां जैसे कि स्टेल सीड बेड प्रभावी पायी गई।
- *ओरोबैंकी क्रिनेटा* एवं *सेरनुआ* के फूलों से ताजे निकले बीज 20–30 दिनों की प्रिकंडिशनिंग के बिना अंकुरित नहीं हुए। प्रिकंडिशन्ड बीज, 10 दिनों की अवधि के लिये 70 प्रतिशत सापेक्ष आर्द्रता के साथ 23 ± 2°C पर उगने जर्म ट्यूब उत्पादन और मेजबान जड़ तक पहुंचने में सक्षम थे। जब तापमान 40 ± 2°C से ऊपर और 5 ± 2°C के नीचे रहा तो बीज अंकुरित नहीं हुए।
- *पेनिसिलियम ओक्सेलिक्म* डी.डब्ल्यू.एस.आर.–I के बीजाणुओ के घोल को दो बार प्रयोग के परिणामस्वरूप बैंगन के खेत में *ओरोबेंकी* का कम संक्रमण हुआ।
- *ओरोबेंकी* के प्रबंधन पर अधिक ध्यान केंद्रित करने के उद्देश्य के साथ डी.डब्ल्यू.आर. शोध प्रक्षेत्र में *ओरोबेंकी* सेरनुआ के लिये सरसों और *ओ. क्रिनेटा* के लिये टमाटर एवं बैंगन का एक संक्रमित क्षेत्र विकसित किया गया।
- 2014 के दौरान किये गये सर्वेक्षण में *क्रोमोलिना ओडोरेटा* पर गॉल फ्लाईज की उपस्थिति इस ब्रायोएजेंट की स्थापना की शुरूआत का संकेत बताता है कि गॉल उत्पत्ति के लिये नौ अलग– अलग भूखंडों से नमूनें लिये गये, जिससे औसतन 1.67 से 7.08 प्रति 25 मी^{2} गॉलस की उपस्थिति का पता चला।
- *केसिया तोरा* बीज का 80 कि.ग्रा./हे. की दर से छिड़कने पर 75 दिन में यह *क्रोमोलिना ओडोरेटा* का स्थान लेने के लिये प्रभावी पाया गया। खरपतवारनाशियों में मेट्रिब्युजिन (2 कि.ग्रा./हे), 2,4–डी (2 कि.ग्रा./हे.) और ग्लाईफोसेट की अपेक्षा 75 दिनों के बाद ज्यादा बेहतर पाया गया।
- खरपतवार अनुसंधान निदेशालय में बायोऐजेंट के बड़े पैमाने पर वृद्धि के लिये *क्रोमोलिना ओडोरेटा* को स्थापित करने के लिये नेट हाउस और खेत अवस्था में प्रयास किये गये थे, परंतु अल्प सफलता ही मिली।
- *अल्टरनेरिया अल्टरनेटा* का टाल्क फोरमुलेशन (गुड़, खमीर, अगार माध्यम) में बड़े पैमाने पर वृद्धि की गई और संस्थान के तलाब में जलकुंभी पर छिड़काव किया गया। फंगस की वजह से रोग की तीव्रता और गंभीरता से 5 दिनों के बाद जलकुंभी पौधों की बीमारी में प्रगतिशील वृद्धि देखी गई। संक्रमित पौधों में फूल नही बनें और उनकी वृद्धि एवं विकास भी अवरूद्ध रहा।
- *स्पोडोप्टेरा पेक्टीनीकोरनिस* का 33 प्रजातियों के पौधों पर मेजबान विशिष्टता परीक्षण किया, जिससे पता चला कि न ही लार्वा विकसित हुआ और न ही लार्वा से कोई वयस्क बना। जो कीट के मेजबान–विशिष्ट होने को दर्शाता है।
- बरसात के मौसम के दौरान, लार्वा पत्तियों पर खाते हुये पाये गये। वे प्रारंभ में कोमल ऊतकों को और बाद में पत्तियों के बाहरी हिस्से को खाते हैं। लार्वा की जनसंख्या वृद्धि पर 70 प्रतिशत खरपतवार ने घुटने टेक दिये, किन्तु पिस्टिया मेट पूरी तरह से समाप्त नही हुआ। बायोएजेंट की संख्या में कमी से पिस्टिया की शेष आबादी के घनत्व में पुनः वृद्धि पाई गई।
- तीन खरपतवारनाशी जैसे 2,4–डी, ग्लाइफोसेट और मेटासल्फ्यूरान मिथाइल की अलग–अलग सांद्रता का पिस्टिया पर परीक्षण किया गया। मेटासल्फ्यूरान मिथाइल (6 ग्रा./हे.) सबसे प्रभावी शाकनाशी के रूप में उभरा, इसके उपरांत ग्लाइफोसेट (2.0 कि.ग्रा./हे.) प्रभावी रहा जबकि 2,4–डी (1.5 कि.ग्रा./हे.) से इस खरपतवार का नियंत्रण नही हुआ।

पर्यावरण में शाकनाशी अवशेषों एवं प्रदूषकों की निगरानी, निम्नीकरण एवं उनका अल्पीकरण –

- चावल के खेत की मिट्टी में 0–60 दिन के बीच में मेटसल्फ्यूरान मिथाइल एवं क्लोरीम्यूरॉन के अवशेष 0–60 दिन के बीच में 0.040–0.0013 माइक्रो ग्रा./ग्रा. पाये गये। 90 दिनों के बाद मेटसल्फ्यूरान मिथाइल और क्लोरीम्यूरान के अवशेष मिट्टी में नहीं पाये गये। चावल के पौधों में 0–30 दिनों के बीच में अवशेषों की मात्रा 0.295–0.0017 माइक्रो ग्रा./ग्रा. और 30 दिनों के बाद <0.001 माइक्रो ग्रा./ग्रा. पाई गई। बगल के तालाब के पानी में 1–20 दिनों के बीच मेटसल्फ्यूरान मिथाइल और क्लोरीम्यूरान के अवशेषों की मात्रा 0.0832 से 0.0171 माइक्रो ग्रा./मिली. पाई गई।
- बिसपायरीबैक और पेंडीमेथेलिन के अवशेष 0–30 दिनों के बीच 0.32–0.013 माइक्रो ग्रा./ग्रा. की सीमा में पाये गये। 90 दिनों के बाद अवशेष मिट्टी में नही पाये गये।
- प्रायोगिक क्षेत्र से सटे तालाब की मछलियों में 30 दिनों के बाद मेटसल्फ्यूरान मिथाइल, बिसपायरीबेक और पेण्डीमिथेलिन क्रमशः 0.007, 0.0691 और 0.0376 माइक्रो ग्रा./ग्रा. अवशेष पाये गये। मछलियों की मृत्यु शाकनाशी उपचार की वजह से नही देखी गई। शाकनाशी उपचार से तालाब के पानी की गुणवत्ता में कोई महत्वपूर्ण बदलाव नही हुआ।
- प्राकृतिक वर्षा की स्थिति में खरपतवारनाशी की गतिशीलता और लीचिंग सामर्थ्य का लाइसीमीटर में मूल्यांकन किया गया। प्रेटिलाक्लोर अवशेष मिट्टी की सतह पर अधिक थे और विभिन्न गहराई में 60 दिनों तक पाये गये। प्रेटिलाक्लोर के प्रयोग के बाद लीचिंग से मिट्टी की विभिन्न गहराई में पी. एच. (7.1 से 8.4) में वृद्धि हुई। तीन दिनों के बाद लाइसीमीटर में विभिन्न गहराई में 2.482–0.0239 माइक्रो ग्रा./ग्रा. प्रेटिलाक्लोर के अवशेष पाये गये। जबकि 0.0688–0.0014 माइक्रो ग्रा./ग्रा. प्रेटिलोक्लोर अवशेष मिट्टी में पाये गये।
- बिसपायरीबेक सोडियम का आसानी से प्रत्यक्ष फोटालायसिस नहीं होता। क्वार्ट्ज ट्यूब की बंद व्यवस्था के तहत आसुत जल में इसका फोटोलायटिक आधा जीवन (टी 1/2) 232 दिनों के रूप में पाया गया। जबकि खुले सतह की स्थिति में इसकी टी 1/2 (आधा जीवन) केवल 32 दिन पाया गया। शायद पानी में घुली हुई कार्बन–डाई–आक्साइड खुले सतह की स्थिति में उपलब्ध हो जाती है जो फोटोलाइसिस की दर में वृद्धि कर सकती है।

- बिसपायरीबेक के लिये टी 1/2 (आधा जीवन) ह्यूमिक पदार्थ और सोडियम नाइट्रेट की उपस्थिति में क्रमशः 8 और 10 दिन पाये गये।
- बिसपायरीबेक विघटनकारी सूक्ष्मजीवियों को शाकनाशी संवर्धन तकनीक द्वारा चावल राइजोस्फीयर की मिट्टी से अलग किये गये। जीवाणु जो शाकनाशी को विघटित करता है 16 एस.आर.आर.एन.ए. (16S rRNA) से अनुक्रमण से *स्युडोमोनास* प्रजाति, *बेसीलस मेगाटेरियम* और *लाइसीनिबेसिलस स्फेरिकस* के रूप में पहचान हुई। इसी तरह बिसपायरीबेक विघटनकारी कवक *सकेरोमायकोपिस मेलागाना, एसपरजिलस फ्लेवस, एसपरजिलस ओरायजि* और *एसपरजिलस फ्लेवस* ई. जी. वाई 1 रूप में 18 एस. आर. एन.ए. (18S RNA) अनुक्रमण से चरित्रित किये गये।
- अपशिष्ट जल प्रदान करने पर मिट्टी में धातु संचय और टमाटर में भारी धातु उद्ग्रहण का आंकलन करने के लिये एक प्रयोग किया गया। आठ प्रशोधन संयोजन लगाये गये जिनमें चार मुख्य (नलकूप पानी, फिल्टर पानी–1 (टायफा आधारित) और फिल्टर पानी–2 (वेटिवेरिआ आधारित) और निकास पानी को नियंत्रण सिंचाई के रूप में) प्रशोधन को ई.डी.टी.ए. के साथ और ई.डी.टी.ए के बिना विभाजित किया गया। नलकूप के पानी की तुलना में, अनुपचारित नालों के पानी से सिंचित भू–खंडों में जहां तक भारी धातुओं के संचय का संबंध है, डी. टी.पी.ए. निष्कर्षित भारी धातुओं की मात्रा अधिक पाई गई।

खरपतवार प्रबंधन तकनीकों का प्रक्षेत्र शोध एवं प्रदर्शन तथा उनके प्रभाव का मूल्यांकन –

- जबलपुर और आस–पास के क्षेत्रों में राइजोनिस्पंदन प्रायोगिक संयंत्र की स्थापना की उपयुक्तता के लिये एवं इसमें खरपतवार प्रजातियों की उपयोगिता को देखते हुये कई दूषित क्षेत्रों का सर्वेक्षण किया गया। अमखेरा, खैरी/उरदुआ और कछपुरा के नालों से एकत्र अपशिष्ट पानी के नमूनों का प्रदूषकों के लिये विश्लेषण किया गया।
- धनवाही, महंगवां, भरदा, शहपुरा और भादोम गांव (जिला जबलपुर), कल्याणपुर (खुक्खम क्षेत्र) में ओ.एफ.आर. परीक्षण गेहूं की फसल में किये गये। पिछली फसल के किसी भी अवशेषों को जलाये बिना, हैप्पी सीडर के साथ गेहूं की बुआई की गई। प्राप्त परिणाम यह दर्शाते हैं, कि डी.डब्ल्यू.आर. द्वारा निर्धारित खरपतवार नियंत्रण तकनीक खरपतवार प्रबंधन में काफी प्रभावी है, और किसानों को उच्च बी.सी. अनुपात के साथ उच्च सकल वापसी प्राप्त हो सकी।
- पनागर इलाके के भरदा, निपनिया और पड़रिया गांव में तीन किसानों के खेतों में संरक्षित कृषि के तहत् मूंग पर ओ.एफ. आर. परीक्षणों को किया गया। परिणाम दर्शाते हैं कि इमेजेथापायर (100 ग्रा./हे.) व्यापक खरपतवार नियंत्रण, उच्च उपज, शुद्ध लाभ के रूप में किसानों के अभ्यास की तुलना में प्रभावी पाया गया।
- सिहोरा क्षेत्र के सिमरिया गांव में चार किसानों के खेतों में धान 'क्रांति' पर ओ.एफ.आर. परीक्षण किये गये। ऐसा पाया गया कि सिफारिश की गयी उर्वरकों की मात्रा के साथ शाकनाशी का प्रयोग (पायराजोसल्फ्यूरान (25 ग्रा./हे.) तत्पश्चात् बिसपायरीबेक (25 ग्रा./हे.) अधिक प्रभावी था और परिणामतः उच्च अनाज उपज और बी.सी. अनुपात, किसान अभ्यास की तुलना में अधिक था।
- गांव रागरतोला (तहसील–कुंडम) में आठ किसानों के खेतों में 2014 के बरसात के मौसम के दौरान मक्का (संकर) पर ओ. एफ.आर. परीक्षण किये गये। यह पाया गया कि उर्वरक की सिफारिश खुराक शाकनाशी (एट्राजीन/1 कि.ग्रा./हे. पी.ई. और तत्पश्चात् 35 दिनों पर हाथ निराई) के प्रयोग के साथ प्रभावी था और किसान अभ्यास की तुलना में उपज बी.सी अनुपात प्राप्त हुआ।
- 2013–14 के दौरान सामाजिक–आर्थिक अध्ययनों से डी. डब्ल्यू.आर. द्वारा अपनाये गये क्षेत्रों में देखा गया कि अधिकतर किसानों द्वारा धान–गेहूं की फसल पद्धति को अपनाया गया है। ओ.एफ.आर. कार्यक्रम के परिणामतः प्रदर्शित होता है कि आधुनिक कृषि पद्धति को अपनाने के साथ–साथ आई.डब्ल्यू. एम प्रौद्योगिकियों की वजह से उत्पादकता और स्थिरता में सुधार हुआ है।
- मध्यप्रदेश में विभिन्न फसल प्रणालियों के लिये खरपवतार प्रबंधन में सुधार के लिये प्रक्षेत्र प्रदर्शनों का आयोजन कृषि विज्ञान केन्द्र, जोनल परियोजना निदेशालय (जोन VII) के साथ डी.डब्ल्यू.आर. ने संयुक्त रूप से सहयोग किया।
- प्रगतिशील किसानों की एक इंटरफेस बैठक, राज्य के विभागों के अधिकारियों और वैज्ञानिकों के साथ, 29/04/2014 को डी.डब्ल्यू.आर. में आयोजित की गई। मार्च 2015 के दौरान पनागर, गोसलपुर, कटनी, शहपुरा और नरसिंहपुर क्षेत्रों में क्षेत्र दिवस/संगोष्ठी का आयोजन किया गया।
- मध्यप्रदेश सरकार द्वारा ''किसान तीर्थ योजना'' के केन्द्र के रूप में डी.डब्ल्यू.आर. को पहचाना गया। वर्ष 2014–15 में मध्यप्रदेश के विभिन्न हिस्सों से 5000 से अधिक किसानों ने डी.डब्ल्यू.आर. के अनुसंधान फार्म का दौरा किया और डी. डब्ल्यू.आर के वैज्ञानिकों के साथ बातचीत की।
- देश के किसानों को खरपतवार प्रबंधन तकनीकों का प्रसार के लिये ज्ञान–प्रबंधन सेवा एस.एम.एस. के माध्यम से दी गई, जोकि प्रशंसनीय रही।

EXECUTIVE SUMMARY

To undertake basic, strategic and applied research for efficient weed management strategies, Directorate launched five major programmes in 2012-13 to achieve its targets in research and transfer of technology. Research programmes include development of sustainable weed management practices in diversified cropping systems; weed dynamics and management under the regime of climate change and herbicide resistance; biology and management of problematic weeds in cropped and non-cropped areas; monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment; and on-farm research and demonstration of weed management technologies and impact assessment. Concerted efforts are being made by the Directorate to create awareness about *Parthenium* and its management by Mexican beetle (*Zygogramma bicolorata*) throughout the country through involvement of SAUs. Efficient weed management technologies under conservation agriculture were demonstrated at farmers fields which resulted very encouraging adoption at farmers' level. Effective linkages and collaboration had been developed with different ICAR institutes and SAUs, KVKs and NGOs to tackle location area-specific weed problems. Various programmes i.e. trainings, field day/kisan sangoshthi, agriculture education day, weed contest, industry day, and scientists-farmers-officials interface meeting were organized to educate farmers and other stakeholders. Directorate has accomplished its targets in research and transfer of technology during 2014-15.

Salient research achievements under different research programmes are summarized below:

Development of sustainable weed management practices in diversified cropping systems

A long-term experiment on the effect of crop establishment techniques and weed control measures under conservation agriculture system in rice-based and non-rice based cropping sequences has been initiated since 2012.

- In rice, different crop establishment techniques significantly influenced the emergence of different weed flora, and as well as total weed population and dry matter accumulation. Lowest total weed density as well as weed dry biomass was recorded with CT (TPR).
- In DSR-wheat-greengram sequence, soil microbes were significantly influenced by tillage practices. Among the different tillage practices, higher number of bacterial, fungal, actinobacteria and diazotrophs population were observed in DSR-ZT + R + S. Higher nitrite oxidizers were observed in DSR-ZT + S. While, higher P-solubilizers were observed in DSR-CT + S. Weed management practices did not have any significant impact on soil functional groups.
- Resource conservation technologies improved soil health over traditional practice of transplanted rice with conventional tillage. No effect of weed management practices were observed on these soil health parameters.
- Different cropping systems did not influence significantly the total weed dry biomass production. Highest rice equivalent yield was recorded under DSR – winter maize cropping system over rest of the cropping system. Amongst weed control treatments integrated weed management produced higher rice equivalent yield than weedy check.
- Soil health parameters, viz. soil respiration, soil organic carbon and available N content were significantly affected by tillage and crop residue treatments. Results indicated that the resource conservation technologies had beneficial effect on soil health compared to conventional practices.
- The overall results showed that the resource conservation technologies like ZT and crop residue recycling favoured nodulation in pea.
- Analysis of straw and grain samples of rice after harvest revealed no detectable residue of herbicides (bispyribac-sodium, 2,4-D and fenoxaprop).
- In soybean-wheat-greengram cropping sequence, adoption of ZT produced significantly higher seed yield of soybean over CT. Both the weed management treatments (Pendimethalin *fb* imazathapyr and Metribuzin + 1 hand weeding) reduced the weed density and dry biomass as compared to unweeded control, and gave higher seed yield of soybean.
- In wheat, different crop establishment techniques did not influence the grain yield of wheat significantly. Amongst weed control measures, lowest weed growth and highest grain yield of wheat was recorded with the post-emergence application of coldinafop+ metsulfuron (60+4 g/ha). No adverse effect of weed management

practices was observed on soil microbial population. Resource conservation technologies like ZT and retention of residues further improved the microbial population and soil enzyme activities.

- In long-term herbicides trial in maize-chickpea cropping system under conservation agriculture system, atrazine (500 g/ha) + pendimethalin (750 g/ha) followed by 1 HW managed the weed more efficiently and gave maximum yield of maize. Herbicide treatments at the levels tested were not harmful to soil microbes and enzymes.
- Different crop establishment practices of rice significantly affected, the yield and yield attributing characters of succeeding wheat crop. The yield was higher after DSR as compared to puddling treatments. However, the weed management techniques significantly improved yield and yield attributing characters as compared to unweeded control.
- Crop establishment methods in rice had significant effect on yield and yield attributing characters. Significantly higher panicle length, 1000-seed weight and yield was recorded under SRI as compared to other crop establishment practices (TPR, DSR PBSR). Among weed management practices, highest grain yield was recorded with 2 HW which was at par with bispyribac + 1 HW and bispyribac alone.
- A field experiment in wheat crop was conducted in order to develop dose response curve of herbicides when used in mixture. Among many models tried, 'Dose Response Hill model' was found to be best fit for the data. Analysis revealed that ED_{50} value of 2,4-D was estimated as 495.45 and 713.94 g/ha when used alone and in mixture, respectively.
- Cowpea intercropping + pendimethalin was a superior weed management option in maize over application of atrazine + pendimethalin.
- In sunflower, pendimethalin + imazethapyr (900 g/ha), and pendimethalin 750 g/ha *fb* quizalofop 100 g/ha significantly reduced the weed population and weed biomass, and produced higher seed yield as compared to unweeded control.

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

- Enrichment of atmospheric CO_2 had a positive effect on overall growth of wheat as well as *P. minor* plants, however, elevated temperature alone or in combination of elevated CO_2 had adverse effect on growth and development of both the species. Results on RGR showed that elevated temperature alone or in combination of elevated CO_2 adversely affect two species and more severely of wheat as compared to *P. minor* suggesting a competitive advantage to weed as compared to wheat under elevated temperature alone or in combination of elevated CO_2. Yield of wheat was decreased considerably at elevated temperature as compared to ambient conditions. However, at elevated CO_2 alone, yield of wheat was increased.
- Isoenzymes activity profile of antioxidant enzymes exhibited differential regulation as well as induction of new iso-forms in response to elevated CO_2 and elevated temperature and combination of these two factors. In general, *P. minor* showed stronger antioxidant defence as compared to wheat pointing towards involvement of antioxidant defence system in adaptation to climate change.
- Efficacy of sulfosulfuron against *P. minor* reduced at elevated CO_2, elevated temperature and more drastically at combination of these two factors indicating towards possible impact climate change on chemical weed management.
- Protocol for preparation of the herbicidal allelochemical crude was standardized. The findings showed that acetone : water (1:1, v/v) was suitable for bulk extraction of the allelochemical crude from *Parthenium* leaf residue.
- *Parthenium* leaf allelochemical crude at 200 mg/100 ml was sufficient to kill 10-60 g of 1-5 water hyacinth plants in 5-10 days. The residual toxicity for subsequent additions of water hyacinth to the system killed the plants where 10-30 g or 1-3 water hyacinth plants were placed.
- A liquid preservative 20% (w/w) $CaCl_2$ in glycerol extended longevity of seeds of crops and weeds (with mean moisture content about 10%) to varying degrees broadly by 8 and 3 folds at ambient temperatures 30 ± 15^0C.

Biology and management of problematic weeds in cropped and non-cropped areas

- Mature grains of weedy rice morphotypes were studied for morphological parameters like 100 seed weight, grain length-breadth ratio and length of awns. Good amount of variation was evident among different morphotypes with respect to parameters studied.
- Molecular fingerprinting of different weedy rice morphotypes was done to observe any possible clustering based on the agro-climatic zones they had been collected from. The dendogram generated using NTSYS-pc software revealed that weedy rice did not cluster based either on geographical regions or agro-climatic zones.
- Four out of 99 weedy rice morphotypes showed >57% germination under 15 cm standing water.
- Rice cultivar 'Naveen' was found to be competitive in weedy rice infested field.
- Cultural methods like stale seed bed were found effective for management of weedy rice.
- Fresh seeds of *Orobanche crenata* and *O. cernua* immediately harvested from the flowers did not germinate without a period of 20-30 days of preconditioning. Preconditioned seeds, at 23 ± 2^0C with 70% relative humidity for a period of 10 days, were able to germinate, produce germ tube and reach host root. Seeds did not germinate when the temperature was above 40 ± 2^0C and below 5 ± 2^0C.
- Two time application of spore suspension of *Penicillium oxalicum* DWSR1 resulted less *Orobanche* infestation in brinjal field.
- A sick plot of *O. cernua* attacking mustard and *O. crenata* attacking tomato and brinjal was developed at DWR farm with an aim to have more focused work on the management of *Orobanche*.
- Survey done during 2014 revealed the presence of gall flies on *Chromolaena odorata* indicating the start of establishment of bioagent. Samples taken from nine different plots for gall formation, revealed the presence of galls varying from mean 1.67 to 7.08 per 25 m^2.
- *Cassia tora* broadcasting at the rate of 80 kg/ha was found effective to replace *C. odorata* after 75 days. Among herbicides, metribuzin 2.0 kg/ha was found superior over and 2,4-D 2.kg/ha and glyphosate after 75 days.
- *A. alternata,* mass multiplied in talc formulation (molasses yeast agar medium) was sprayed on water hyacinth in the institute pond. Disease intensity and severity due to fungus showed progressive increase in the disease of the water hyacinth plants from 5 days onwards. The infected plants remained stunted and did not flower.
- Host specificity test of *S. pectinicornis* on 33 plant species revealed no complete development of larvae and subsequent emergence of adult from larva which reflected that insect is host specific.
- During rainy season, larvae were found feeding the leaves. Initially, they feed on soft tissues and subsequently feeds on the outer portion of leaves. On increase in population, up to 70% of the weeds were succumbed to the pressure of larvae but *Pistia* mat was not completely killed. On reduction of population, *Pistia* increased its density from the remaining population.
- Three herbicides namely 2,4-D, glyphosate and metsulfuron-methyl were tested on *Pistia* in different concentrations. Metsulfuron-methyl (6 g/ha) emerged most effective herbicide followed by glyphosate (2.0 kg/ha), while. 2, 4-D (1.5 kg/ha) did not control the weed.

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

- Metsulfuron-methyl and chlorimuron residues in the soil of rice field were found in the range of 0.040-0.0013 µg/g between 0-60 days. After 90 days metsulfuron-methyl and chlorimuron residues were not detected in the soil. In rice plants, residues were found in the range of 0.295-0.0017 µg/g between 0-30 days and below 0.001µg/g after 30 days. Residues of metsulfuron-methyl and chlorimuron were found 0.0832 to 0.0171 µg/ml in the water of adjoining pond between 1-20 days.
- Bispyribac and pendimethalin residues were found in the range of 0.32-0.013 µg/g and 0.258-0.001 µg/g between 0-30 days. After 90 days residues were not detected in the soil.
- In the fishes from the pond adjoining to the experimental field, 0.007, 0.0691 and 0.0376 µg/g residues of metsulfuron-methyl, bispyribac and pendimethelin were found after 30 days. No mortality of fishes was observed due to any herbicide treatment. Herbicides treatments did not altered quality of water in pond significantly.
- Mobility and leaching potential of herbicides under natural rainfall conditions were evaluated in lysimeter. Pretilachlor residues were higher in surface soil and were found up to 60 days in soil at various depths. Pretilachlor leaching increased the soil pH (7.1 to 8.4) at various depths after its application. After 3-days, 2.482-0.0239 µg/g pretilachlor residues were detected at various depths in the lysimeter. Whereas 0.0688-0.0014 µg/g pretilachlor residues were detected in soil at 60 days.
- Bispyribac-sodium did not undergo direct photolysis readily. The photolytic half-life ($T_{1/2}$) of it in distilled water under closed system of quartz

EXECUTIVE SUMMARY

tube was found as 232 days. Whereas, the $T_{1/2}$ of it in distilled water under open surface condition was only 32 days. Probably, dissolved CO_2, which becomes available in open surface condition, could enhance the rate of photolysis of bispyribac.

- The $T_{1/2}$ values for bispyribac were 8 and 10 days in presence of humic substances and sodium nitrate, respectively.
- The bispyribac-degrading microbes were isolated from rice rhizospheric soil by herbicide enrichment technique. The bacteria, which degraded the herbicide are characterized by 16s rRNA sequencing as *Pseudomonas* sp., *Bacillus megaterium* and *Lycinibacillis sphaericus*. Similarly, the bispyribac-degrading fungi were characterized by 18s RNA sequencing as *Saccharomycopis malanga, Aspergillus flavus, A. oryzae* and *A. flavus* EGY 1.
- An experiment was carried out to find out effect of waste water application on metal accumulation in soil and to assess heavy metal uptake in tomato. The eight treatment combinations were made including four main [tube well water, filtered water-I (*Typha* based) and filtered water-II (*Vetiveria* based) and drain water as control] as irrigation treatment which were split -up with two treatments with and without EDTA. As far as accumulation of heavy metals in soil is concerned, higher concentration of DTPA extractable heavy metals cadmium and lead were observed in plots irrigated with untreated drain water as compared to tube well water.

On-farm research and demonstration of weed management technologies, and impact assessment

- Survey of many contaminated sites was carried out in Jabalpur and adjoining area for suitability of setting-up of rhizo-filtration pilot plant utilizing weed species. Waste water samples collected from drain sites: Amkhera, Khairi/ Urdua and Kachpura were analysed for pollutants. The collected samples were analysed for various pollutants.
- OFR trials conducted at Dhanwahi, Mahagawa and Bharda, Shahpura and Bhadom villages (Jabalpur district) Kalyanpur (Khukham area) in wheat crop. Sowing of wheat was done with Happy seeder without burning of any residue of the previous crop. The results obtained indicated that the weed management technology prescribed by the DWR was effective in managing the weeds and farmers could obtain a higher gross return with higher a B:C ratio.
- OFR trials were conducted on green gram under conservation agriculture at three farmer's fields in the Bharda, Nipania and Padaria villages of Panagar locality. Result revealed that Imazethapyr @ 100 g/ha was effective and gave broad spectrum weed control, higher yield, net return and B:C ratio as compared to farmers practice.
- OFR trials were undertaken on rice '*Kranti*' at four farmer's fields in the village Simariya of Sihora area. It was found out that recommended fertilizer doses along with the application of herbicide (pyrazosulfuron 25 g *fb* bispyribac-Na 25 g/ha) was more effective and resulted higher grain yield, and B:C ratio over farmers' practice.
- OFR trials were undertaken on maize (Hybrid) during rainy season of 2014 at eight farmer's fields in the village Ragertola (Kundam tehsil). It was found that recommended fertilizer doses along with the application of herbicide (atrazine @ 1.0 kg/ha PE *fb* one hand weeding at 35 DAS) was more effective and resulted higher yield and B:C ratio as compared to farmers' practice.
- Socio-economic studies conducted in DWR adopted localities during 2013-14 revealed that most of the farmers adopted the rice-wheat cropping pattern. Results of OFR programme revealed that there is significant improvement in productivity and sustainability due to adoption of modern agricultural technologies along with IWM technologies.
- DWR collaborated with KVKs of Zonal Project Directorate (Zone VII) to introduce and demonstrate the improved weed management technologies for different cropping systems through different KVKs across Madhya Pradesh.
- An interface meeting of progressive farmers, officers of state departments and scientists was organized at DWR on 29/4/2014. Organized field day-cum-sanghosthi at Panager, Gosalpur, Katni, Sahapura and Narsinghpur localities during March 2015.
- DWR has been recognized as centre of 'Kisan Teerth Yojna' by Govt. of Madhya Pradesh. In year 2014-15, more than 5000 farmers from different parts of Madhya Pradesh visited DWR research farm and interacted with scientists of DWR.
- Knowledge Management Service (KMS) through SMS for disseminating weed management technologies to farmers of the country received appreciation.

INTRODUCTION

The Directorate of Weed Research came into existence as National Research Centre for Weed Science (NRCWS). Functioning of this centre started with the joining of Dr. V.M. Bhan as its founder Director on 22 April, 1989. This centre was further upgraded as Directorate of Weed Science Research on 23 January, 2009; and again renamed as ICAR-Directorate of Weed Research on 26 November, 2014.

This directorate is a unique institute not only in the National Agricultural Research System, but probably the only one of its own kind in the whole world dealing exclusively with the existing and emerging weed problems in different situations and systems. Directorate act as a nodal centre for basic, strategic and applied research in weed science and provide leadership at national level through coordinated network programmes with state agricultural universities for generating location-specific technologies for weed management. Besides, trainings to different stakeholders, consultancy, collaborative programmes on weed management and participatory research at farmers' fields are also being undertaken. Directorate obtained the ISO 9001: 2008 certification by implementing the Quality Management System in the organization.

Jabalpur is one of the most important cities of Madhya Pradesh and also known as the cultural capital (Sanskardhani) of state. The city is famous for its major tourist attractions such as Dhuandhar Falls, Bhedaghat and Chausat Yogini Temple, Balancing rocks and many others. It is situated at the center of India in the Mahakoshal region and surrounded by a spectacular variety of nature including holy river Narmada, marble rocks of Bhedaghat and waterfall called "Dhuandhar". It falls under the agroclimatic region of Kymore plateau and Satpura hills zone. Directorate is located on the national highway (NH-7) at 23.90^{0}N latitude, 79.58^{0}E longitude and altitude of 411.78 m above mean sea level and well connected by railways (10 km from Jabalpur railway station) and airways (23 km from Dumna airport). The climate of the region is sub-tropical, with average rainfall of 1400 mm. Soils are mostly black and crops grown are rice, soybean, sugarcane, pigeonpea and blackgram during *Kharif* season, and wheat, chickpea, lentil, pea and mustard in *Rabi* season.

Over the last 26 years, the Directorate has played a pioneering role in weed management at national level through its research programmes focused on survey and surveillance, development of weed management technologies for diversified cropping systems, herbicide resistance in weeds, biology and management of problem weeds, and environmental impact of herbicides. Adoption of these technologies has been promoted on large areas through on-farm research and demonstrations, which has resulted a boost in agricultural productivity and livelihood security of the farmers. Efforts are being made to address emerging issues related to management of weeds in diversified ecosystems, threat posed by noxious invasive weeds, parasitic weeds, aquatic weeds, changes in weed dynamics in climate change scenario, herbicide resistance, monitoring of impact of herbicides on environment. Considering the challenges ahead, Directorate has fully adopted conservation agriculture system for sustainable weed management.

Vision

Developing innovative, economic and eco-friendly weed management technologies to contain challenges ahead for sustainable agriculture and other societal benefits

Mission

To provide scientific research and technology in weed management for maximizing the economic, environmental and societal benefits for the people of India

Mandate

- To undertake basic, strategic and applied researches for developing efficient weed management strategies in different agro-ecological zones
- To provide leadership at country level in weed science and coordinate the network research with state agricultural universities for generating location-specific technologies for weed management in different crops, cropping and farming systems
- To act as a repository of information in weed science
- To act as a centre for training on research methodologies in the area of weed science and weed management
- To collaborate with national and international agencies in achieving the above mentioned objectives
- To provide consultancy

Organization and Management

The Directorate comes under the administrative control of the Director. Quinquennial Review Team (QRT), Research Advisory Committee (RAC), Institute Management Committee (IMC) and Institute Research Council (IRC) are other advisory bodies for research, teaching/training and extension activities. There are 5 major research sections, 4 administrative sections, and 12 other units and cells for smooth functioning and effective co-ordination.

Laboratories and Equipments

The Directorate has dedicated laboratories for research work on agronomy, soil science, plant physiology, microbiology, pathology, entomology and residue analysis. Besides, one central laboratory is also in place housing all common equipments like ice maker machine, leaf area meter, root scanner, spectrophotometers, pH meters, conductivity meters and BOD incubators etc. Laboratories at the Directorate are well-furnished and equipped with modern and sophisticated scientific instruments like LC-MS/MS System, GC, HPLC, IRGA, lyophilizer, thermal cycler, gel documentation unit, atomic absorption spectrometer, N-auto-analyzer, osmometer, solid phase extraction unit, vaccum evaporator, UV-visible double beam spectro-photometer, high speed refrigerated centrifuge, HPLC grade water purification system, line quantum sensors with data-logger, spectroradiometer etc. Sample storage facilities include liquid nitrogen containers, ultra freezer (-80 °C) and deep freezers (-20 °C). It has containment facility and two controlled environmental chambers to facilitate research under controlled environmental conditions. Directorate has specialized facilities like Free Air CO_2 Enrichment (FACE) facility and four open top chambers to study possible impact of futuristic climate change on crop-weed interaction, and phytoremediation unit and Mexican beetles rearing unit. The Directorate has a well-developed agricultural engineering workshop with facilities for repair, fabrication, designing and development of weed control tools and implements.

HPLC system

Gel documentation unit

AKMU, Library and Information centre

Agriculture Knowledge Management Unit (AKMU) is well equipped with computers, LAN facilities, video conferencing facility, color xerox-cum-printer and plotter. All the scientists and co-ordination units have been provided with internet connection and Wi-Fi connectivity. Library has a total collection of 3060 books related to weed science, 20 Indian- and 4 foreign- journals in its subscription, newspapers section and sufficient reading area for students and employees. Reprographic and documentation facilities have also been created for the preparation of documents and reports. One information centre has been developed to display the updated information regarding weed science and management technologies. Directorate's publications, prototypes of weed management tools and live specimen of weed seeds are also on display using sophisticated display systems.

Library

Farm/containment/ net house/other facilities

The Directorate possesses 61.5 ha well laid fully-irrigated experimental farm well connected with approach roads. Whole farm is laser-leveled and with an effective drainage systems. Since last two years, almost complete farming area has been developed as a model for conservation agriculture with ample crop diversification. Practice of burning of residues of crops/weeds is completely stopped which earned a lot appreciation and also adoption at farmers fields. Farm is equipped with modern farm machineries like high power tractors, small tractor, power-weeders, tractor-driven sprayers, laser land-leveler, happy seeder, no-till seed drill, multi-crop seed drill, multi-crop thrashers, tube wells, underground irrigation pipelines and sprinkler system etc. In addition, Directorate also has containment facility, net houses, lysimeters, phytoremediation unit, aquatic tanks, runoff tanks for studies on herbicides toxicity to non-target organisms, biomass composting unit, weed cafeteria for *in situ* demonstration and conservation of weed germplasm, and fully developed technology park.

Technology park

Networking and Collaboration

Directorate co-ordinates its network programmes through All India Coordinated Research Project on Weed management (AICRP-WM) which has 23 centres at SAUs located in different agro-climatic zones of the country. Six network programmes (viz. Weed surveillance and monitoring, Weed biology and physiology, Weed management in crops and cropping systems, Management of problematic weeds, Herbicide residues and environmental quality, and On-farm research and impact assessment) are in operation. Besides, Directorate also collaborates with other educational and research institutions, viz. Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur; Rani Durgawati Vishva Vidyalaya, Jabalpur; IGKV, Raipur; and other colleges from different universities for M.Sc/Ph.D research work. Active collaboration has been developed with several ICAR Institutes and other research organizations like Borlaug Institute for South Asia (BISA), herbicide industries, NGOs, National Seed Corporation, ZPDs and KVKs. In addition, the Directorate has initiated a significant step towards more effective collaboration with ICAR institutes and SAUs, and nominated five nodal scientists to look after the same in the field of weed management and to avoid duplication of research in weed management. In addition, four adhoc projects also in operation in collaboration with universities and institute like IARI. Directorate organizes advance training programmes on weed management for students, officers of state agriculture departments, and scientists of SAUs and ICAR institutes. Besides, organization of Farmers' field days/sangoshti, Industry day, Education day, Foundation day and Scientists-Agriculture Officers-Farmers interface meetings are the regular features since last two years.

Budget during 2014-15 (₹ *in lakhs)*

Particulars	Plan		Non Plan		Network project	
	Receipt	Expenditure	Receipt	Expenditure	Receipt	Expenditure
(A) Recurring						
Establishment expenses	0.00	0.00	520.00	519.52	720.00	719.29
Pension	0.00	0.00	50.00	44.90	0.00	0.00
P-Loan & advances	0.00	0.00	0.00	0.00	0.00	0.00
Travelling allowances	4.50	4.17	3.50	3.20	0.00	0.00
HRD/IT	2.50	2.48	0.00	0.00	0.00	0.00
Research and operational expenses	91.00	91.01	128.69	161.18	25.00	24.81
Miscellaneous expenses	2.00	1.57	5.50	5.31	0.00	0.00
Tribal Sub -Plan	0.00	0.00	0.00	0.00	0.00	0.00
Total (A)	**100.00**	**99.23**	**707.69**	**734.11**	**745.00**	**744.1**
(B) Non-Recurring						
Equipment	28.10	27.84	8.31	8.31	0.00	0.00
Works	4.39	4.14	0.00	0.00	0.00	0.00
Library	5.00	5.11	0.00	0.00	0.00	0.00
Land	0.00	0.00	0.00	0.00	0.00	0.00
Vehicle	0.00	0.00	0.00	0.00	0.00	0.00
Livestock	0.00	0.00	0.00	0.00	0.00	0.00
Others	2.51	2.25	0.00	0.00	0.00	0.00
Total (B)	**40.00**	**39.34**	**8.31**	**8.31**	**0.00**	**0.00**
Grand total (A+B)	**140.00**	**138.57**	**716.00**	**742.42**	**745.00**	**744.10**

Resource generation (₹ in lakhs)

Particulars	Amount
Contract research	2.15
Consultancy services	0
Sale of farm produce	27.34
Others (auction, guest house, use of transport, tender paper, RTI, interests, license fee, water charges, dissertation fees, etc.)	20.58
Total	**50.08**

Staff position (as on 31.3.2015)

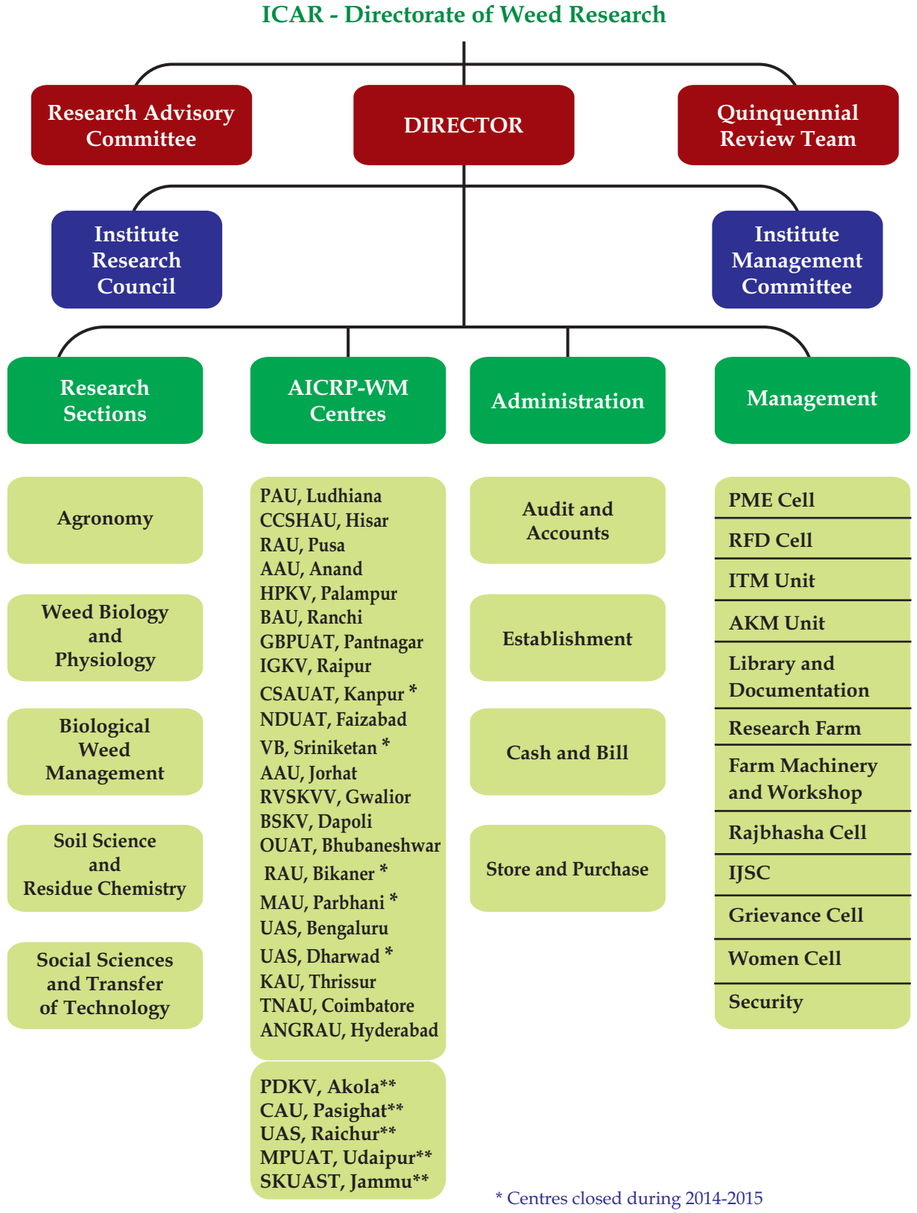
Category	Sanctioned	Filled	Vacant
Scientist	27	16	11
Technical	23	21	02
Administrative	13	09	04
Supporting	22	21	01

Discipline-wise staff position

Disciplines	Sanctioned			In Position			Vacant		
	PS	SS	S	PS	SS	S	PS	SS	S
Agricultural Biotechnology	-	01	01	-	01	-	-	-	01
Agricultural Chemicals	01	01	01	-	01	01	01	-	-
Agricultural Economics	-	-	01	-	-	-	-	-	01
Agricultural Entomology	-	01	-	-	01	-	-	-	-
Agricultural Extension	-	01	01	-	01	-	-	-	01
Agricultural Microbiology	-	-	01	-	-	01	-	-	-
Agricultural Statistics	-	-	01	-	-	01	-	-	-
Agronomy	02	01	03	-	01	02	02	-	01
Economic Botany & Plant Genetic Resources	-	01	01	-	-	01	-	01	-
Farm Machinery and Power	-	-	02	-	-	-	-	-	02
Plant Pathology	-	01	-	-	01	-	-	-	-
Plant Physiology	01	01	-	01	01	-	-	-	-
Soil Science	-	01	01	-	01	01	-	-	-
Plant Biochemistry	-	-	01	-	-	-	-	-	01
Total	**04**	**09**	**14**	**01**	**08**	**07**	**03**	**01**	**07**

PS – Principal Scientist, SS – Senior Scientist, S – Scientist

ORGANOGRAM



* Centres closed during 2014-2015
** New centres opened during 2015-16

Chapter - 1

RESEARCH PROGRAMME -1

DEVELOPMENT OF SUSTAINABLE WEED MANAGEMENT PRACTICES IN DIVERSIFIED CROPPING SYSTEMS

Weed problems have increased with high-input agriculture. These necessitate continuous monitoring and upscaling of weed management strategies on a long-term basis. Conservation agriculture is being talked of as a new paradigm in resource management research but weeds are a serious problem in such a system. Diversification and continuous cropping have largely changed the weed communities and, in some cases, these become resistant to commonly used herbicides. Therefore, use of the herbicides has to be investigated in a system perspective. Weed population density and biomass production may be markedly reduced using crop rotation (temporal diversification) and intercropping (spatial diversification) strategies. Weed management practices strongly influence use efficiency of other production factors like water, nutrients etc. Further, herbicide use efficiency is also influenced by adjuvants as well as other pesticides. In recent years, several low dose high potency herbicide molecules have become available, for which, spraying machines and techniques need to be standardized. Hence, this research programme has been initiated since 2012 to address these issues and develop sustainable weed management practices in diversified cropping systems.

Sub-programmes	Experiments	Associates
1.1 Weed management under long term conservation agriculture systems	1.1.1 Long term impact of herbicides in rice - wheat-green gram sequence under conservation agriculture systems	V.P. Singh, K.K. Barman, Raghwendra Singh, Dibakar Ghosh, P.P. Choudhury, C. Sarathambal, Yogita Gharde and A.R. Sharma
	1.1.2 Long term impact of weed control measures in DSR -based crop ping systems under conservation agriculture	V.P. Singh, K.K. Barman, Raghwendra Singh, Dibakar Ghosh, P.P. Choudhury, C. Sarathambal, Yogita Gharde and A.R. Sharma
	1.1.5 Long term impact of herbicides in soybean-wheat-green gram sequence under conser vation agriculture systems	V.P. Singh, K.K. Barman, Raghwendra Singh, Dibakar Ghosh, P.P. Choudhury, C. Sarathambal, Yogita Gharde and A.R. Sharma
	1.1.6 Long term impact of weed control measures in maize-wheat-green gram cropping systems under conservation agriculture	R.P. Dubey, K.K. Barman, C. Sarathambal, P.P. Choudhury and A.R. Sharma
	1.1.7 Long term impact of weed control measures in maize-chickpea-cropping systems under conservation agriculture	Dibakar Ghosh, V.P. Singh, Raghwendra Singh, P.P. Choudhury, C. Sarathambal K.K. Barman and A.R. Sharma
	1.1.8 Long term impact of weed control measures in cotton -wheat cropping systems under conservation agriculture	Raghwendra Singh, Dibakar Ghosh, V. P. Singh, P. P. Choudhury K. K. Barman and C. Sarathambal
1.2 System-based approach to weed management	1.2.4 Effect of crop establishment techniques and weed management practices on growth and yield of rice under rice–wheat cropping system	Raghwendra Singh, V P Singh, Dibakar Ghosh and K K Barman.
	1.2.5 Long term effect of weed management practices on weed dynamics and crop productivity in soybean -wheat cropping system	R.P. Dubey, K.K. Barman, P.P. Choudhury and C. Sarathambal
	1.2.6 Cropping system approach for weed management in mango orchard	R.P. Dubey, K.K. Barman, and C. Sarathambal
1.3 Improving input use efficiency through efficient weed management	1.3.7 Deciding optimum dose of herbicides in mixture using dose response curve	Yogita Gharde, Dibakar Ghosh and Raghwendra Singh
	1.3.8 Leguminous intercropping for weed management in maize	K.K. Barman
	1.3.9 Scsbania and biogar slurry M weed infistation and yield of rice	K.K. Barman
	1.3.10 Weed management in sunflower	R. P. Dubey

1.1 Weed management under long-term conservation agriculture systems

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

A long-term experiment on the effect of crop establishment techniques and weed control measures under conservation agriculture system has been initiated from 2012 to monitor weed dynamics, crop productivity, herbicide residues, and to study C-sequestration, changes in physico-chemical and biological properties of soil health under rice-based and non-rice-based cropping systems. Total eight treatments consisting of five establishment methods viz., (i) CT(DSR)+S-CT (Wheat)-ZT (greengram), (ii) CT(DSR)+S+R-CT(wheat)+R-ZT (greengram)+R, (iii) ZR (DSR)+S-ZT (wheat)-ZT (greengram), (iv) ZT (DSR)+S+R-ZT (wheat)+R-ZT (greengram)+R, (v) CT(TPR)-CT (wheat) and three weed control measures viz., continuous use of bispyribac-sodium+pre-sowing non-selective herbicides in ZT, rotational use of herbicides + pre-sowing non-selective herbicides in ZT, and unweeded (control) as sub plots were laid out in split plot design with three replications.

Rice

Dominant weed flora in rice were: *Echinochloa colona,* and *Dinbera retroflexa* among grasses; *Physalis minima,* and *Ceasulia axillaris* among broadleaved weeds; and *Cyperus iria* among sedges. Different crop establishment techniques significantly influenced the emergence of different weed flora, and as well as total weed population and dry matter accumulation at 60 DAS (Table 1.1). Significantly lowest density of *E. colona* was recorded under ZT (DSR)+S with retention of previous season crop residue compared to CT (DSR) or CT (TPR). Whereas, significantly lowest population of *D. retroflexa* was recorded either with CT (DSR) or ZT(DSR) with incorporation/retention of previous season crop residue. ZT (DSR)+S without crop residue recorded significantly higher population of C. *axillaris.* CT (TPR) or CT (DSR) in absence of previous season crop residue recorded lowest population of *P. minima* during rice. So far as the total weed population and weed dry matter accumulation is concerned, lowest total weed density as well as weed dry biomass was recorded with CT (TPR. However, CT (DSR) being at par with ZT (DSR) + retention of residue of previous season crop recorded lower density and weed dry matter production compared to the same crop establishment without previous season crop residue. Amongst the weed control measures, rotational use of herbicide + pre-sowing non-selective herbicides in ZT recorded significantly lowest weed population and weed dry matter over weedy check.

Different crop establishment techniques influenced significantly the crop parameters *viz.*, plant height, effective tillers, panicle length, and grain yield of rice. Significantly higher plant height and panicles per running m row were recorded with ZT (DSR) + previous crop residue. However, highest panicle length (21.0 cm) and grains/panicle (122) was recorded under CT (TPR). Highest grain yield of rice was recorded with CT-TPR (4.3 t/ha) which was significantly higher over rest of the crop establishment techniques. However, crop establishment technique for DSR, ZT (DSR)+ S± previous season crop residue provided significantly higher plant height, panicles per row length, panicle length, and as well as grain yield of rice compared to CT (DSR)+S± crop residue. Amongst weed control treatments, rotational use of herbicide at 25 DAS being statistically at par with continuous use of bispyribac-sodium 25 g/ha, recorded significantly higher grain and straw yield of rice compared to weedy check (Table 1.2).

Table 1.1: Weed density and weed dry matter production in rice as influenced by different tillage systems and weed management measures (2014)

Treatment	Density (no./m^2)					Total	Weed dry weight (g/m^2)
	E. colona	*D. retroflexa*	*P. minima*	*C. axillaris*	*C. iria*		
Tillage and crop establishment							
CT (DSR) + S – CT (wheat) – ZT (greengram)	2.9 (7.9)	2.2 (4.3)	0.7 (0.0)	3.2 (9.7)	2.2 (4.3)	5.2 (26.5)	6.5 (41.8)
CT (DSR) + R + S – CT (wheat) + R –ZT (greengram) + R	2.2 (4.3)	1.1 (0.7)	0.9 (0.3)	0.9 (0.3)	3.9 (14.7)	4.8 (22.5)	4.9 (23.5)
ZT (DSR) + S – ZT (wheat) – ZT (greengram)	2.8 (7.3)	2.3 (4.8)	1.2 (0.9)	1.3 (1.2)	4.5 (19.8)	5.5 (29.8)	6.6 (43.1)
ZT (DSR) + R + S – ZT (wheat) + R –ZT (greengram) + R	1.9 (3.1)	1.3 (1.2)	1.2 (0.9)	0.9 (0.3)	3.3 (10.4)	5.1 (25.5)	5.4 (28.7)
CT(TPR) – CT (wheat)	2.2 (4.3)	2.1 (3.9)	0.7 (0.0)	0.7 (0.0)	2.0 (3.5)	3.6 (12.5)	4.4 (18.9)
LSD (P=0.05)	0.8	0.6	0.4	0.4	0.6	0.7	1.3
Weed management							
Weedy check	4.5 (19.8)	2.2 ((4.3)	1.3 (1.2)	1.1 (0.7)	7.3 (52.8)	9.5 (89.8)	11.2 (125.0)
Continuous bispyribac + pre - sowing non -selective herbicides in ZT	1.1 (0.7)	1.6 (2.1)	0.8 (0.1)	1.8 (0.1)	1.4 (1.5)	2.7 (6.8)	3.1 (9.1)
Herbicide rotation	1.6 (2.1)	1.6 (2.1)	0.7 (0.0)	1.3 (1.2)	0.9 (0.3)	2.3 (4.8)	2.4 (5.3)
LSD (P=0.05)	0.8	0.3	0.3	0.2	0.7	0.5	1.0

DSR – direct-seeded rice, TPR – transplanted rice, S – *Sesbania* brown manuring, CT – conventional tillage, ZT – zero tillage, R – residue, *Data subjected to $\sqrt{x+0.5}$ transformation. Figures in parentheses are original values.

Table 1.2: Crop growth and grain yield of rice as influenced by different tillage systems and weed management measures (2014)

Treatment	Plant height (cm)	Panicles/ running m row	Panicle length (cm)	Grains/ panicle	100 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage and crop establishment							
CT (DSR) + S – CT (wheat) – ZT (greengram)	54.2	42.7	18.7	93.7	2.14	3.0	4.4
CT (DSR) + R + S – CT (wheat) + R-ZT (greengram) + R	53.9	51.7	18.7	84.9	2.19	3.1	4.4
ZT (DSR) + S – ZT (wheat) – ZT (greengram)	57.9	50.3	19.5	93.8	2.28	3.1	4.4
ZT (DSR) + R + S – ZT (wheat) + R-ZT ZT (greengram) + R	60.1	52.1	20.0	105.0	2.32	3.3	4.5
CT(TPR) – CT (wheat)	60.1	46.6	21.8	122.0	2.26	4.3	5.3
LSD (P=0.05)	1.5	1.9	1.2	13.8	0.11	0.26	0.3
Weed management							
Weedy check	55.5	36.2	18.1	87.0	2.22	2.0	3.5
Continuous bispyribac + pre-sowing non-selective herbicides in ZT	56.2	54.5	20.9	108.6	2.23	3.7	4.8
Herbicide rotation	60.1	55.3	20.2	104.0	2.26	4.3	5.6
LSD (P=0.05)	1.4	2.1	0.7	8.5	0.07	0.1	0.2

DSR – direct-seeded rice, TPR – transplanted rice, S – *Sesbania* brown manuring, CT – conventional tillage, ZT – zero tillage, R – residue

Wheat

Dominant weed flora in wheat were *Phalaris minor* and *Avena ludoviciana* among grasses, and *Medicago denticulata, Chenopodium album* and *Lathyrus aphaca* amongst broad-leaved weeds. Different crop establishment methods influenced significantly the distribution of weed flora. Significantly lowest population of *P. minor* and *C. album* was noticed in ZT (DSR)+S+R-ZT (wheat), statistically at par with ZT (DSR)+S-ZT (wheat) over CT (DSR/TPR)-CT (wheat). On the other hand, lowest *A. ludoviciana* population was recorded with CT (TPR)-CT (wheat) and CT (DSR)-CT (wheat), respectively. However, CT/ZT (DSR)+S+R-CT/ZT (wheat) recorded significantly lowest population of *M. denticulata*. Whereas, significantly lowest weed population and weed dry matter was recorded with CT (wheat) sown after CT (DSR). Amongst weed control measures, significantly lowest population and weed dry biomass was recorded with recommended herbicide + pre-sowing non-selective herbicide in ZT, statistically at par with IWM (Table 1.3).

Yield attributes and yield of wheat were also influenced significantly due to different crop establishment techniques. Higher plant height of wheat was recorded under ZT (wheat) compared to other crop establishment techniques. Significantly higher spikes per m row length was recorded with CT/ZT (DSR)-wheat compared to CT (TPR)- wheat (Table 1.4). The wheat grown after direct seeded rice combined with either crop residue incorporation or retention significantly produced higher grain yield of wheat in both CT/ ZT (wheat). However, highest grain yield of wheat (4.13 t/ha) was recorded in ZT (DSR)+S+R-ZT (wheat). Amongst weed control treatments, application of recommended herbicides + pre-sowing non-selective herbicide in ZT produced significantly higher grain yield over herbicide + 1 HW and weedy check, respectively.

Table 1.3: Weed density and weed dry matter production in wheat as influenced by different tillage systems and weed management measures (2013-14)

Treatment	Density (no./m^2)						Weed dry weight (g/m^2)
	P. minor	*A. ludoviciana*	*M. denticulata*	*L. aphaca*	*C. album*	Total	
Tillage and crop establishment							
CT (DSR) + S – CT (wheat) – ZT (greengram)	4.6 (20.7)	1.1 (0.7)	8.1 (65.1)	1.7 (2.4)	5.2 (26.5)	11.2 (124.9)	5.1 (25.5)
CT (DSR) + R + S – CT (wheat) + R –ZT (greengram) + R	4.9 (23.5)	1.1 (0.7)	6.4 (40.5)	3.1 (9.1)	3.3 (10.4)	8.9 (78.7)	5.2 (26.5)
ZT (DSR) + S – ZT (wheat)– ZT (greengram)	3.5 (11.8)	4.6 (20.7)	9.2 (84.1)	3.6 (12.5)	2.5 (5.8)	13.0 (168.5)	7.0 (48.5)
ZT (DSR) + R + S – ZT (wheat) + R –ZT (greengram) + R	2.4 (5.3)	3.2 (9.7)	7.2 (51.3)	3.3 (10.4)	2.4 (5.3)	10.0 (99.5)	7.0 (48.5)
CT(TPR) – CT (wheat)	4.4 (18.9)	0.7 (0.0)	6.3 (39.2)	3.1 (9.1)	6.4 (40.5)	11.7 (136.4)	4.7 (21.6)
LSD (P=0.05)	1.6	0.5	1.6	1.1	2.2	1.4	2.0
Weed management							
Weedy check	4.6 (20.7)	2.3	10.9	2.9	4.0	13.5	9.7
Recommended herbicide + pre-sowing non-selective herbicides in ZT	2.6 (6.3)	2.7 (6.8)	5.9 (34.3)	1.8 (2.7)	5.9 (34.3)	10.1 (101.5)	3.6 (12.5)
Recommended herbicide + manual / mechanical weeding	4.7 (21.6)	1.4 (1.5)	5.5 (29.8)	4.2 (17.1)	1.9 (3.1)	9.3 (86.0)	4.0 (15.5)
LSD (P=0.05)	1.1	0.6	1.0	0.8	1.0	0.8	1.1

DSR – direct-seeded rice, TPR – transplanted rice, S – *Sesbania* brown manuring, CT – conventional tillage, ZT – zero tillage, R – residue, *Data subjected to $\sqrt{x+0.5}$ transformation. Figures in parentheses are original values.

Table 1.4: Yield attributes and grain yield of wheat as influenced by different tillage systems and weed management measures (2013-14)

Treatment	Plant height (cm)	Spikes/m row length	Grains/ spike	100-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage and crop establishment						
CT (DSR) + S – CT (wheat) – ZT (greengram)	77.4	63.3	53	4.36	3.86	8.01
CT (DSR) + R + S – CT (wheat) + R – ZT (greengram) + R	78.6	62.4	50	4.37	3.84	9.69
ZT (DSR) + S – ZT (wheat) – ZT (greengram)	81.6	59.6	46	4.44	3.89	8.51
ZT (DSR) + R + S – ZT (wheat) + R – ZT (greengram) + R	81.5	63.4	48	4.43	4.13	7.93
TPR – CT (wheat)	78.8	54.9	51	4.75	3.59	8.16
LSD (P=0.05)	NS	5.5	4	NS	0.2	2.05
Weed management						
Weedy check	80.5	50.6	46	4.46	3.28	7.22
Recommended herbicide + pre-sowing non-selective herbicides in ZT	78.9	66.1	54	4.53	4.44	9.38
Recommended herbicide + manual / mechanical weeding	79.4	65.3	50	4.42	3.85	8.78
LSD (P=0.05)	NS	3.1	2	0.1	0.13	1.38

DSR – direct-seeded rice, TPR – transplanted rice, S – *Sesbania* brown manuring, CT – conventional tillage, ZT – zero tillage, R – residue

Microbial activity of soil as influenced by weed management and tillage practices under long term conservation agriculture

DSR-wheat-greengram (2013-14)

Soil microbes such as fungi, actinobacteria and P solubilizers were significantly influenced by tillage practices (Table 1.5). Among the different tillage practices higher number of bacterial (8.5 log cfu/g soil), fungal (5.0 log cfu /g soil), actinobacteria (5.5 log cfu /g soil) and diazotrophs population (6.9 log cfu /g soil) were observed in DSR-ZT+R+S. Higher nitrite oxidizer (6.4 log cfu/g soil) were observed in DSR-ZT+S followed by DSR-ZT+R+S-ZT-ZT (6.3 log cfu /g soil). While, higher phosphorus solubilizers (5.8 log cfu/g soil) were observed in DSR-CT+S. Weed management practices did not have any significant impact on soil functional groups. However, among the weed management practices, the continuous use of bispyribac sodium (25 g/ha) treatments showed higher microbial activity as compared with other treatments.

Table 1.5: Tillage and weed management practices on soil microbial activity under DSR-wheat-greengram

Treatment	Basic and functional microbial groups (log cfu /g dry weight of soil)						Soil enzyme activity
	Bacteria	fungi	Actino bacteria	Diazotrophs	Nitrite oxidizers	P-solubilizers	Dehydrogenase (µg TPF/g soil/24 hr)
Tillage and crop establishment							
DSR-CT+S-CT-ZT	7.7	3.5	4.4	6.6	5.4	5.8	34.3
DSR-CT-R+S-CT+R-ZT+R	7.5	3.9	4.7	6.8	5.8	4.3	35.4
DSR-ZT+S-ZT-ZT	7.7	4.5	4.9	6.7	6.4	5.3	36.4
DSR-ZT+R+S-ZT-ZT	8.5	5.0	5.5	6.9	6.3	4.9	35.1
Transplanted rice-CT	7.8	3.0	4.5	6.1	5.4	4.3	31.2
LSD(P=0.05)	1.10	0.61	0.68	0.96	0.87	0.74	4.9
Weed management							
Weedy check	7.9	4.1	4.8	6.7	5.8	4.8	33.8
Cont.use of bispyribac sodium 25g/ha	8.02	4.1	4.9	6.6	5.9	4.9	34.6
Non-continuous use of herbicide	7.6	4.3	5.2	6.6	5.9	5.1	33.7
LSD (P=0.05)	0.76	0.38	0.47	0.63	0.54	0.49	3.32

DWR

Soil health parameters

Soil health parameters, viz. soil respiration, soil organic carbon (SOC) and available N content were significantly affected by tillage and crop residue treatments. ZT+S-ZT-ZT showed significantly lower total microbial activity than in CT+S-CT-ZT sequence. Crop residue recycling increased microbial activity in soil, but the increase was more prominent under ZT than in CT. The organic C and available N contents of the soil were significantly higher under ZT+S-ZT-ZT, ZT+S+R-ZT-ZT and CT+S+R-CT-ZT treatments, compared to transplanted rice-CT. overall, the results indicated that resource conservation technologies improved soil health over traditional practice of transplanted rice – CT system. No effect of weed management practices were observed on these soil health parameters (Table 1.6).

Table 1.6: Effect of resource conservation technologies on soil health parameters under DSR-wheat-greengram system

Treatment	Soil respiration (mg CO_2/h)	SOC (%)	Available N (kg/ha)
DSR -CT+S -CT -ZT	5.04	0.63	156.8
DSR -CT -R+S -CT+R -ZT+R	5.57	0.65	164.6
DSR -ZT+S -ZT -ZT	4.06	0.67	164.6
DSR -ZT+R+S -ZT +R -ZT +R	5.06	0.72	163.1
CT (TPR) -CT	4.42	0.53	130.7
LSD (P= 0.05)	0.87	0.10	21.7

Herbicide residue studies

Straw and grain samples of rice after harvest were extracted in suitable solvents following standard protocol. Extracts were cleaned up chromatographically and analysed by LC-MS/MS. No residue of bispyribac-sodium and fenoxaprop was detected on mass spectra. Straw and grain samples of wheat after harvest were extracted in suitable solvents following standard protocol. Extracts were cleaned up and analysed chromato-graphically and residues of clodinafop, metsulfuron-methyl and sulfosulfuron were below detectable limit. Similarly, residues pendimethalin and metribuzin, and pendimethalin and isoproturon were not detected in pea seed and mustard seed, respectively.

1.1.2 Weed management in DSR-based cropping systems under conservation agriculture

Total fifteen treatments consisting of five establishment methods viz., (i) CT(DSR)-CT (mustard/chickpea/winter maize–ZT (greengram), (ii) CT (DSR) +R–ZT+R (mustard/chickpea/winter maize)–ZT+R (cowpea/greengram), (iii) ZT(DSR)–CT (mustard/chickpea/winter maize)–ZT (greengram), (iv) ZT(DSR)+R–ZT+R (mustard/chickpea / winter maize)–ZT+R (greengram), and (v) CT(TPR)–CT (mustard/chickpea/winter maize), as main plots; three cropping systems viz., DSR-Mustard, DSR-Chickpea and DSR-winter maize as sub plot treatments; and three weed control measures *viz.*, recommended herbicides, integrated weed management (herbicide + mechanical/manual weeding) and unweeded (control) as sub-sub plots were laid out in split-split plot design with three replications.

Predominant weed species in rice were *Echinochloa colona* and *Dinebra retroflexa* among grasses; *Caesulia axillaris* and *Alternanthera sessilis* among broadleaved weeds; and *Cyperus iria* among sedges. There was significant effect on weed flora distribution, total weed population and weed dry matter production due to different crop establishment techniques. Significantly lowest *E. colona* and *D. retroflexa* was recorded with transplanted rice. Whereas, adoption of zero tillage for direct-seeded rice + retention of previous season crop residues recorded lower population of *C. iria* and *P. minima* compared to adoption of conventional tillage for transplanting. Significantly lowest weed growth (density and dry biomass) and highest grain yield of rice were recorded with adoption of conventional tillage for transplanting, which was at par with the adoption of ZT (DSR) (Table 1.7). Amongst direct-seeding of rice, adoption of zero tillage for seeding of rice produced higher grain yield than conventional tillage. Different cropping systems also significantly influenced the weed distribution, weed dry matter production and grain yield of rice. Significantly lowest population of E. colona and C. iria was noticed with DSR-Winter maize cropping system. Similarly, lowest weed biomass and highest grain yield of rice was recorded under DSR-Winter maize and DSR – Mustard, respectively. Amongst weed control treatments, post-emergence application bisphyribac-sodium @ 25 g/ha recorded lowest weed growth and highest grain yield of rice, which was statistically at par with application of recommended herbicide followed by 1 HW at 40 DAS (Table 1. 7).

Dominant weed flora in chickpea, mustard and winter maize were: *Phalaris minor* and *Avena ludoviciana* among grasses, and *Medicago hispida, Lathyrus sativa* and *Chenopodium album* among broadleaved weeds. Different crop establishment techniques significantly influenced the weed flora distribution, total weed density and weed dry biomass production during *Rabi* season. Significantly

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lowest population *C. album, L. sativa* and *P. minor* were recorded with adopting conventional tillage for sowing of *Rabi* crops without previous season crop residues. However, adoption of conventional tillage for transplanting recorded lower population of *A. ludoviciana* and *M. hispida*.

Table 1.7: Weed growth and grain yield of rice as influenced by different crop establishment techniques and weed management measures under rice-based cropping systems (2013-14)

Treatment	Weed density (Number/m²)		Weed dry weight (g/m²)		Yield (t/ha)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	Rice	Rice equivalent
Tillage and crop establishment						
CT (DSR) + S – CT – ZT	6.29 (39.06)	13.31 (171.90)	8.18 (66.41)	8.29 (68.22)	2.92	3.9
CT (DSR) + S + R – CT + R – ZT	6.58 (42.80)	14.16 (200.00)	7.43 (54.70)	8.37 (69.56)	3.17	4.1
ZT (DSR) + S - ZT - ZT	6.67 (43.99)	15.54 (241.00)	9.55 (90.70)	9.97 (98.90)	3.14	4.1
ZT (DSR) + S + R - ZT +R - ZT	5.51 (29.86)	14.37 (206.00)	7.58 (60.34)	8.87 (78.18)	3.46	4.1
CT (TPR) - CT	4.24 (17.48)	12.88 (165.40)	4.48 (19.57)	7.51 (55.90)	3.65	3.6
LSD (P= 0.05)	0.97	0.83	1.53	1.13	0.09	0.10
Cropping system						
DSR - Pea	6.21 (38.06)	15.15 (229.00)	7.47 (55.30)	8.50 (71.75)	3.05	3.1
DSR - Mustard	6.60 (43.06)	17.50 (305.75)	7.69 (58.64)	8.48 (71.41)	3.61	3.2
DSR - Winter maize	4.77 (22.25)	9.50 (89.75)	7.17 (50.90)	8.82 (77.29)	3.15	5.6
LSD (P=0.05)	0.85	0.57	0.85	0.67	0.06	0.14
Weed control						
Weedy check	12.27 (150.05)	19.36 (374.69)	16.24 (263.24)	12.78 (162.82)	2.42	3.0
Herbicide	2.37 (5.12)	12.78 (162.83)	2.35 (5.02)	7.78 (60.02)	3.77	4.0
Herbicide + HW	3.00 (8.50)	10.02 (99.90)	3.73 (13.41)	5.26 (27.17)	3.62	4.7
LSD (P=0.05)	0.73	0.72	0.88	0.62	0.06	0.09

DSR – direct-seeded rice, TPR – transplanted rice, S – *Sesbania* brown manuring, CT – conventional tillage, ZT – zero tillage, R – residue, *Data subjected to $\sqrt{x+0.5}$ transformation. Figures in parentheses are original values.

Significantly highest rice equivalent yield (4.1 t/ha) was obtained with adoption of conventional/ zero tillage ± of previous season crop residues over CT (TPR)-CT crop establishment techniques. Amongst cropping systems, significantly lowest population of *M. denticulata*, *P. minor,* and *L. aphaca* were recorded under DSR – winter maize cropping system. However, lowest population of *A. ludoviciana* and *C. album* was recorded with DSR – mustard system. Different cropping systems did not influence significantly the total weed dry biomass production. So far rice equivalent yield is concerned; significantly highest yield was recorded under DSR – winter maize cropping system over rest of the cropping system (Table 1.7). Amongst weed control treatments integrated weed management produced significantly higher rice equivalent yield (4.7 t/ha) than weedy check (3.0 t/ha).

Soil health parameters

The observations recorded on soil health parameters, viz. soil respiration, soil organic carbon (SOC) and available N content were significantly affected by tillage and crop residue treatments. The lowest soil respiration was recorded in DSR-ZT+R+S-ZT-ZT and it was statistically similar to DSR-CT+S-CT-ZT. Crop residue recycling significantly increased CO_2 evolution from soil in both CT and ZT indicating greater microbial activity in presence crop residue. Lowest SOC content was recorded in CT (TPR)-CT and it was statistically similar to DSR-CT+S-CT-ZT and DSR-ZT+S-ZT-ZT, but significantly lower than that as observed under DSR-CT+R+S-CT-ZT and DSR-ZT+R+S-ZT-ZT. Similarly, available N content was also lowest in CT (TPR)-CT and it was significantly lower than that recorded under DSR-ZT+S-ZT-ZT, DSR-ZT+R+S-ZT-ZT and DSR-CT+R+S-CT-ZT. This indicated that the resource conservation technologies had beneficial effect on soil health compared to CT (TPR) –CT (Table 1.8).

Table 1.8: Effect of resource conservation technologies on soil health parameters under DSR- based cropping system

Treatment	Soil respiration (mg CO_2/h)	SOC (%)	Available N (kg/ha)
DSR -CT+S -CT -ZT	1.72	0.64	145
DSR -CT -R+S -CT+R -ZT+R	2.38	0.72	154
DSR _ZT+S _ZT _ZT	1.63	0.63	152
DSR -ZT +R+S -ZT+R -ZT+R	2.12	0.71	159
CT (TPR) -CT	2.07	0.60	135
LSD (P=0.05)	0.40	0.10	12

The observation was recorded on the effect of crop establishment techniques and weed management practices on nodulation in pea in the DSR-pea-green gram system. Compared to DSR-CT+S-CT-ZT (CTS), nodulation in pea was higher under DSR-ZT+S-ZT-ZT (ZTS). Crop residue recycling increased nodulation, but the increase was more prominent between DSR-ZT+S-ZT-ZT and DSR-ZT+R+S-ZT-ZT (ZTSR) than between DSR-CT+S-CT-ZT and DSR-CT+R+S-CT-ZT (CTSR). Significantly higher nodule count was recorded in metribuzin treatment, compared to pendimethalin and weedy treatments. The overall results showed that the RCTs like ZT and crop residue recycling favoured nodulation, and metribuzin was safer than pendimethalin in terms of pea nodulation (Figure 1.1)

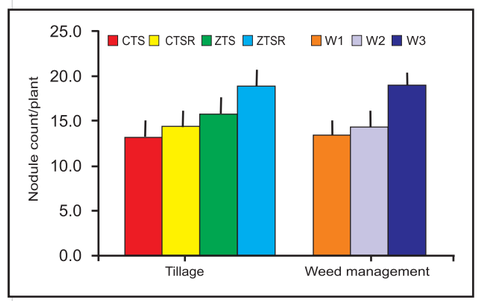

Figure 1.1: Effect of crop establishment techniques and weed management practices on nodulation in pea.

Herbicide residue studies

Straw and grain samples of rice after harvest were extracted in suitable solvents following standard protocol. Extracts were cleaned up chromatographically and analysed by LC-MS/MS. No residue of bispyribac-sodium, 2,4-D and fenoxaprop was detected on mass spectra.

1.1.5 Weed management in soybean-wheat-greengram cropping systems under conservation agriculture

A long-term field experiment on the effect of crop establishment techniques and weed management under conservation agriculture was initiated from April, 2013 with the objectives to monitor weed dynamics, crop productivity, herbicide residues, C-sequestration, physico-chemical and biological properties of soil under soybean-wheat cropping system. Total fifteen treatment combinations consisting of five establishment methods viz., (i) CT(soybean)-CT (Wheat), (ii) CT(soybean)-ZT (Wheat)-ZT (greengram), (iii) ZT (Soybean)+R-ZT (wheat)-ZT (greengram), (iv) ZT (soybean)-ZT (wheat)+R-ZT (greengram), (v) ZT (soybean) + R-ZT (wheat)+R-ZT (greengram)+R; and three weed control measures viz., Weedy check, Pendimethalin *fb* imazathapyr and Metribuzin + 1 hand weeding during rainy season, which was super imposed by mesosulfuron+idosulfuron and clodinafop+metsulfuron during winter season; laid out in split-plot design with three replications.

Soybean

Dominant weed flora were: *Echinochloa colona, Digera retroflexa, Cyperus eragrastis, Cyperus iria, Eclipta alba,* and *Oldenlandia sp.* Different tillage practices significantly influenced the distribution of weed flora, total weed density and weed dry matter production at 60 DAS (Table 1.9). Significantly lowest population of *E. colona* and *D. retroflexa* was recorded under ZT (Soybean)-ZT+R (Wheat), while lowest population of *C. iria* was noticed with CT (Soybean). ZT+R (Soybean) recorded the lowest population of *E. alba* and *Oldenlandia* sp. So far total weed density is concerned, significantly lowest density was observed under CT (Soybean). However, ZT+R (Soybean) produced significantly lowest weed dry biomass at 60 DAS. Adoption of ZT produced significantly higher seed yield of soybean over CT. Both the weed

management treatments significantly reduced the weed density and dry biomass as compared to unweeded control, and gave highest seed yield of soybean.

Wheat

Dominant weed flora in wheat were *Medicago hispida*, *Chenopodium album*, *Cichorium intybus*, *Physalis minima*, *Vicia sativa* and *Phalaris minor*. Different tillage practices significantly influenced the species wise distribution of weed flora. Lowest population of *M. hispida*, *C. album*, *V. sativa* and *C. intybus* were recorded with CT (Wheat) over ZT (Wheat); whereas, lowest population of *P. minor* and *P. minima* was noticed under ZT (Wheat). CT (Soybean)-CT (Wheat) produced significantly lowest total weed growth over rest of the tillage practices. Different crop establishment techniques did not influencethe grain yield of wheat significantly, but the highest grain yield of wheat (4.74 t/ha) was obtained under ZT (Wheat) + retention of previous season crop residue (Table 1.10). Amongst weed control measures, lowest weed growth and highest grain yield of wheat was recorded with the post-emergence application of coldinafop + metsulfuron (60+4 g/ha)

Table 1.9: Weed density and weed dry matter production in soybean as influenced by different tillage systems and weed management measures (2014)

Treatment	Density (Number/m²)						Total weed dry biomass (g/m²)	Seed yield (t/ha)
	Echinochloa colona	*Dinebra retroflexa*	*Cyperus iria*	*Eclipta alba*	*Oldenlandia* sp.	Total		
Tillage and crop establishment								
CT(soybean)-CT(wheat)	2.3 (5.1)	4.4 (18.9)	3.5 (12.3)	1.6 (2.1)	1.7 (2.6)	6.8 (46.8)	9.7 (94.7)	0.77
CT(soybean)-ZT(wheat)-ZT(Green gram)	3.2 (9.8)	3.5 (11.8)	4.1 (16.7)	1.4 (1.4)	2.4 (5.5)	7.0 (48.7)	8.1 (65.2)	0.80
ZT+R(soybean)-ZT(wheat)-ZT+R(Green gram)	2.8 (7.8)	4.8 (23.3)	4.7 (21.8)	1.3 (1.4)	1.2 (1.1)	8.0 (64.9)	7.7 (59.4)	0.89
ZT(soybean)-ZT +R(wheat)-ZT+R (Green gram)	2.9 (8.0)	3.4 (11.4)	5.7 (32.3)	1.9 (3.3)	1.3 (1.2)	7.6 (58.4)	7.3 (53.3)	1.02
ZT+R (Soybean)-ZT+R (wheat) ZT+R(Green gram)	3.7 (13.3)	4.2 (17.3)	4.3 (18.1)	1.7 (2.7)	1.4 (1.7)	7.5 (56.9)	6.6 (43.8)	1.43
LSD (P= 0.05)	0.89	0.38	0.81	0.3	0.35	0.72	0.69	0.39
Weed control								
Weedy check	5.7 (32.3)	6.0 (36.5)	7.6 (58.0)	1.5 (2.0)	1.0 (0.6)	11.6 (135.4)	12.8 (165.6)	0.36
Pendimethalin fb imazathapyr	1.2 (1.0)	2.6 (6.2)	1.5 (1.9)	1.1 (0.8)	0.7 (0.0)	3.5 (11.7)	2.1 (3.9)	1.31
Metribuzin+ 1HW	2.0 (3.8)	3.5 (12.3)	4.2 (17.9)	2.1 (4.1)	3.2 (9.8)	7.1 (51.2)	8.7 (76.2)	1.28
LSD (P=0.05)	0.68	0.36	0.46	0.29	0.2	0.5	0.4	0.26

Weed data subjected to $\sqrt{x+0.5}$ transformation, original values are in parentheses

Table 1.10: Weed density and weed dry matter production in wheat as influenced by different tillage systems and weed management measures (2014)

Treatment	Density (Number/m²)							Total weed dry biomass (g/m²)	Grain yield (t/ha)
	Medicago sativa	*Chenopodium album*	*Vicia sativa*	*Cichorium intybus*	*Physalis minima*	*Phalaris minor*	Total		
Tillage and crop establishment									
CT(soybean)-CT(wheat)	3.5 (12.3)	2.3 (4.4)	0.8 (0.1)	1.0 (0.6)	1.52 (1.81)	2.5 (5.8)	5.0 (24.6)	2.2 (4.6)	4.4
CT(soybean)-ZT(wheat)-ZT(Green gram)	5.0 (24.8)	1.2 (0.9)	1.2 (0.9)	1.2 (0.9)	1.54 (1.87)	2.5 (6.1)	6.1 (37.8)	2.1 (4.3)	4.7
ZT+R(soybean)-ZT(wheat)-ZT+R(Green gram)	5.2 (26.9)	1.7 (0.8)	1.0 (0.6)	1.4 (1.5)	0.70 (0.00)	1.6 (2.0)	5.8 (33.1)	2.7 (7.1)	4.5

Table Cont..

Treatment	Density (Number/m²)							Total weed dry biomass (g/m²)	Grain yield (t/ha)
	Medicago sativa	*Chenopodium album*	*Vicia sativa*	*Cichorium intybus*	*Physalis minima*	*Phalaris minor*	Total		
ZT(soybean)-ZT +R(wheat)-ZT+R (Green gram)	4.8 (23.2)	1.4 (1.4)	1.0 (0.5)	1.6 (2.1)	0.84 (0.21)	2.0 (3.7)	5.7 (32.9)	2.2 (4.3)	4.3
ZT+R (Soybean)-ZT+R (wheat)-ZT+R(Green gram)	4.4 (19.5)	1.4 (1.6)	0.8 (0.1)	1.7 (2.4)	0.86 (0.24)	2.0 (3.7)	5.9 (34.5)	2.4 (5.6)	4.3
LSD (P= 0.05)	0.76	0.28	0.53	0.41	0.33	0.42	0.35	0.39	0.5
Weed control									
Weedy check	6.5 (42.9)	2.4 (5.3)	1.0 (0.6)	1.3 (1.3)	1.4 (1.6)	1.7 (2.4)	7.5 (56.3)	4.2 (17.5)	4.2
Mesosulfuron+iodosulfuron	3.3 (10.4)	1.1 (0.8)	0.9 (0.4)	1.3 (1.2)	0.9 (0.3)	2.1 (4.2)	4.4 (19.6)	1.2 (0.9)	4.4
Clodinofop + metsulfuron	4.0 (15.6)	0.9 (0.4)	0.9 (0.4)	1.5 (1.9)	0.9 (0.3)	2.5 (6.2)	5.1 (26.4)	1.6 (2.3)	4.7
LSD (P=0.05)	0.32	0.25	0.28	0.23	0.30	0.31	0.32	0.35	0.59

Weed data subjected to $\sqrt{x+0.5}$ transformation, original values are in parentheses

Microbiological studies in soybean-wheat–greengram

The basic and functional bacterial counts of the soil samples of soybean - wheat – greengram cropping system are presented in table. The total culturable bacteria population were higher in ZT-ZT+R-ZT+R with 7.5 log cfu/g soil. Interestingly, the tillage practice, ZT + R- ZT –ZT + R registered more number of fungi (4.7 log cfu/g soil), actinobacteria (5.7 log cfu /g soil), diazotrophs (6.7 log cfu/g soil), nitrite oxidiser (5.7 log cfu/g soil) population. On the other hand, higher P- solubilizers (5.8 log cfu/g soil) were recorded in CT-ZT-ZT treatment. Dehydrogenase activity in the soil were significantly influenced by the different tillage practices. Among the different tillage practices, maximum dehydrogenase activity (35.3µg TPF/g soil/24hr) was observed in ZT+R-ZT+RZT+R treatment. There was no harmful effect of weed management measures on soil microbial population (Table 1.11).

Table 1.11: Tillage and weed management practices on soil microbial activity under soybean-wheat cropping system

Treatment	Basic and functional microbial groups (log cfu /g dry weight of soil)						Soil enzyme activity
	Bacteria	fungi	Actino bacteria	Diazotrophs	Nitrite oxidizers	P-solubilizers	Dehydrogenase (µg TPF/g soil/24hr)
Tillage and crop establishment							
CT- CT	6.7	4.4	4.5	6.6	5.3	5.4	22.5
CT- ZT- ZT	6.9	4.0	5.5	6.4	5.6	5.8	31.2
ZT + R- ZT –ZT + R	7.4	4.7	5.7	6.7	5.7	5.7	26.6
ZT- ZT + R- ZT + R	7.5	4.3	5.5	6.2	5.3	4.8	34.5
ZT + R- ZT + R- ZT + R	6.9	4.3	5.5	6.2	5.3	4.9	35.3
LSD(P=0.05)	1.03	NS	0.80	0.94	0.79	0.79	4.04
Weed management							
Weedy check	6.9	4.4	5.3	6.4	5.4	5.4	29.7
Pendimethalin 750 g/ha *fb* imazethapyr 100 g/ha	7.2	4.3	5.4	6.6	5.5	5.3	31.4
Metribuzin 0.5 kg/ha +1HW at 45 DAS	7.2	4.3	5.4	6.5	5.5	5.3	29.1
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

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

A field experiment was initiated in rainy season 2013 to study the long-term effects of conventional tillage, zero tillage with and without crop residues and weed management on weeds and crop productivity in maize-wheat-green gram cropping system.

Wheat (*Rabi*, 2013-14)

The major weed flora observed in the wheat crop grown in *Rabi*, 2013-14, comprised of *Medicago denticulata, Chenopodium album, Cichorium intybus, Vicia sativa, Physalis minima, Sonchus arvensis etc.* Weed

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biomass was least under ZT+R and under application of meso+iodosulfuron. Grain yield was more or less similar among tillage treatments (3.81 to 4.42 t/ha). Application of meso+iodosulfuron produced the highest grain yield (4.53 t/ha).

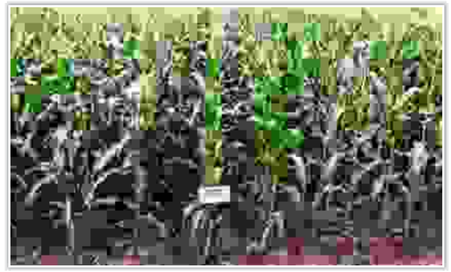
Green gram (Summer, 2014)

The major weed flora observed in the green gram crop grown in S*ummer*, 2014, comprised of *Paspalidium sp., Physalis minima, Echinochloa colona, Dinebra retroflexa, Cyperus iria, Eclipta alba,. and others.* The lowest weed biomass (4.6 g/m^2) was recorded in ZT (maize) – ZT+R (wheat) –ZT+R (green gram). The treatment CT (maize) – ZT (wheat) –ZT (green gram) produced seed yield of 0.37 t/ha.

Maize (*Kharif*, 2014)

The major weed flora observed in the maize crop grown in *Kharif*, 2014, comprised of *Echinochloa colona*, *Dinebra retroflexa, Cyperus iria, Phyllanthus niruri, Eclipta alba, Paspalidium sp. and others.*

Among the tillage treatments, the lowest weed dry biomass (6.8 g/m^2) was observed in ZT+R (maize) whereas, the weed management treatment, atrazine + pendimethalin(0.5+0.5 kg/ha) PE *fb* 1 hand weeding 25 DAS recorded the lowest weed dry biomass (2.4 g/m^2). The grain yield of maize was highest (5.98 t/ha) under CT (maize) – CT (wheat), which was comparable with other tillage treatments except CT (maize)–ZT (wheat)–ZT (green gram) (4.83 t/ha) (Table 1.12). The treatment, atrazine + pendimethalin (0.5+0.5 kg/ha) PE *fb* 1 hand weeding 25 DAS recorded the significantly highest grain yield of 6.07 t/ha than unweeded control (4.78 t/ha).



Maize crop under CT

Table 1.12: Weed biomass and grain yield of crops as influenced by different tillage systems and weed management methods (*Rabi*, 2013-14, summer, 2014 and *Kharif*, 2014)

Treatment	Weed dry biomass (g/m²)			Grain yield (t/ha)		
	Wheat	Green gram	Maize	Wheat	Green gram	Maize
Tillage						
CT (maize) – CT (wheat)	2.8 (7.3)	-	7.2 (51.3)	4.42	-	5.98
CT (maize) – ZT (wheat) –ZT (green gram)	2.7 (6.8)	6.4 (48.2)	6.9 (47.1)	3.81	0.37	4.83
ZT+R (maize) – ZT (wheat) – ZT+R (green gram)	3.5 (11.8)	5.2 (29.3)	6.8 (45.7)	3.98	0.25	5.87
ZT (maize) – ZT+R (wheat) –ZT+R (green gram)	2.1(3.9)	4.6 (21.4)	8.1 (65.1)	4.10	0.08	5.46
ZT+R (maize) – ZT+R (wheat) –ZT+R (green gram)	2.5 (5.8)	4.8 (26.0)	9.2 (84.1)	4.32	0.15	5.27
LSD (P=0.05)	0.80	0.85	0.53	0.41	0.13	0.78
Weed management						
Unweeded	4.8 (22.5)	7.7 (61.2)	14.0 (195.5)	3.68	0.14	4.78
Atrazine+pendimethalin(0.5+0.5 kg/ha) PE *fb* 2,4-D (0.5 kg/ha)	2.0 (3.5)	4.4 (19.8)	6.4 (40.5)	4.18	0.22	5.60
Atrazine+pendimethalin(0.5+0.5 kg/ha) PE *fb* 1 hand weeding 25 DAS	1.4 (1.5)	3.6 (12.7)	2.4 (5.3)	4.53	0.28	6.07
LSD (P=0.05)	0.55	0.80	0.86	0.25	0.06	0.49

CT – conventional tillage, ZT – zero tillage, R – residue
Weed data subjected to $\sqrt{x+0.5}$ transformation, original values are in parentheses

Microbiological studies in maize - wheat - greengram

Maximum amount of basic microbial population such as bacteria (8.1 log cfu /g soil), fungi (5.3 log cfu /g soil) and actinobacteria (6.0 log cfu /g soil) were observed in ZT+R-ZT-ZT+R. Among the tillage practices, ZT+R-ZT+R-ZT+R recorded the higher diazotrophs (6.9 log cfu /g soil) and P solubilizers (4.7 log cfu /g soil). On the other hand, higher nitrite oxidizer (5.6 log cfu /g soil) received by the CT-ZT-ZT treatment. The soil dehydrogenase activity was significantly influenced by both tillage and weed management practices in the maize -wheat-green gram cropping system (Table 1.13). Interestingly, application of herbicide marked influence on soil dehydrogenase activity. Among the weed management treatments, the lower dehydrogenase (30.1 3µg TPF/g soil/24 hr) activity was observed in the atrazine+ pendimethalin applied soil.

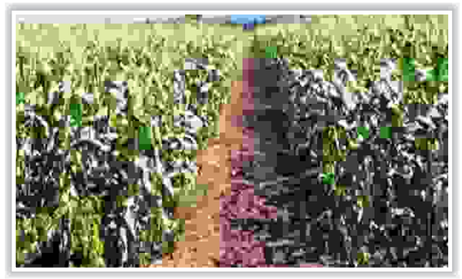
Table 1.13: Tillage and weed management practices on soil microbial activity under Maize -wheat-green gram cropping system

Treatment	Basic and functional microbial groups (log cfu /g dry weight of soil)						Dehydrogenase activity (µg TPF/g soil/24 hr)
	Bacteria	Fungi	Actino bacteria	Diazotrophs	Nitrite oxidizers	P-solubilizers	
Tillage and crop establishment							
CT- CT	6.7	4.5	4.7	6.6	5.4	4.4	27.8
CT- ZT- ZT	7.1	4.8	5.3	6.6	5.6	4.2	30.67
ZT + R- ZT –ZT + R	8.1	5.3	6.0	6.7	5.3	4.5	31.0
ZT- ZT + R- ZT + R	7.6	4.7	5.8	6.8	5.5	4.4	33.8
ZT + R- ZT + R- ZT + R	7.3	5.0	5.6	6.9	5.3	4.7	38.6
LSD (P=0.05)	1.12	0.73	0.81	0.94	0.75	0.63	4.46
Weed management							
Weedy check	7.3	4.8	5.3	6.8	5.4	4.5	34.6
Atrazine + pendimethalin – (500 g + 500 g/ha) *fb* 2,4-D 500/ha	7.5	4.9	5.6	6.7	5.3	4.4	33.5
Atrazine + Pendimethalin– (500 g + 500 g/ha) *fb* 1HW @ 25 DAS	7.4	4.9	5.6	6.8	5.5	4.4	30.1
LSD (P=0.05)	0.69	0.45	0.51	0.64	0.52	0.42	3.10

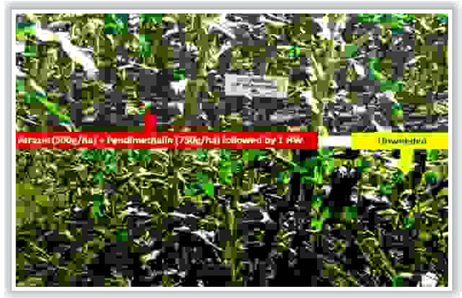
1.1.7 Long-term impact of herbicides in maize-chickpea green gram cropping system under conservation agriculture systems

A long-term field experiment on the effect of crop establishment techniques and weed management under conservation agriculture was carried out with the objectives to monitor weed dynamics, crop productivity, physico-chemical and biological properties of soil, and herbicide residues under maize-chickpea cropping systems. The experiment was laid out in bigger plots in split plot design with five main treatments (tillage methods) *i.e.*(i) conventional tillage- conventional tillage (CT-CT), conventional tillage-zero tillage- zero tillage (CT-ZT-ZT), zero tillage + residue -zero tillage-zero tillage + residue (ZT+R-ZT-ZT+R), zero tillage- zero tillage + residue- zero tillage + residue, (ZT-ZT + R-ZT + R), zero tillage + residue- zero tillage + residue- zero tillage + residue (ZT + R- ZT + R- ZT + R) and three sub treatments (weed management practices) (weedy, atrazine+pendimethalin (PE) *fb* 2,4-D at 30 DAS, atrazine+pendimethalin (PE) *fb* 1 HW at 25 DAS) as main- and sub-treatment, respectively.

Major weed flora were *Echinochloa colona, Dinebra retroflexa, Cyperus iria, Eclipta alba, Phyllanthus niruri* and *Physalis minima*. Among the tillage weed infestation was higher with zero tillage treated plots as compared to conventional tillage. weed management practices significantly reduce the weed density and dry biomass accumulation at different crop growth stages as compare to un-weeded situation. Conventional tillage reduces the weed population and increased the yield. All the weed management practices controlled the weeds significantly as compared to weedy check. Among weed management practices Atrazin (500 g/ha) + Pendimethalin (750 g/ha) followed by 1 HW managed the weed more efficiently and yielded maximum (6.52 ton/ha) (Figure 1.2).



Overview of experimental plot



Comparison between weed management practices and unweeded control

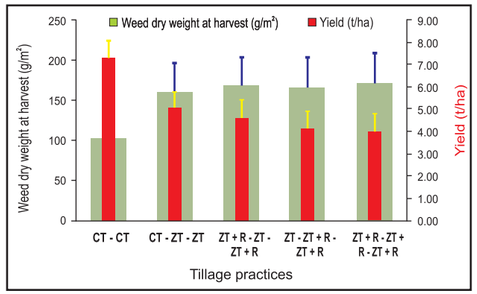


Figure 1.2: Tillage and weed management affecting weed biomass and maize yield

Microbiological studies

Maximum amount of bacteria (7.8 log cfu /g soil), diazotrophs (7.2 log cfu /g soil), dehydrogenase activity (38.0 µg TPF/g soil/24hr) were observed in soils of ZT+R-ZT+R-ZT+R treatment. Whereas, higher amount of fungi (5.4 log cfu /g soil) and nitrite oxidiser (6.6 log cfu /g soil), P solubilizers (4.7 log cfu /g soil) were found in ZT+R-ZT-ZT+R treatment. While, more actinobacteria population were observed in ZT-ZT+R-ZT+R followed by ZT+R-ZT+R-ZT+R (Table 1.14). Herbicide treatments at the level tested were not harmful to soil microbes and enzymes.

Table 1.14: Tillage and weed management practices on soil microbial activity under maize-chickpea-greengram cropping system

Treatment	Basic and functional microbial groups (log cfu /g dry weight of soil)						Dehydrogenase activity (µg TPF/g soil/24 hr)
	Bacteria	Fungi	Actinobacteria	Diazotrophs	Nitrite oxidizers	P-solubilizers	
Tillage and crop establishment							
CT- CT	6.7	4.4	4.5	6.6	6.1	4.6	30.4
CT- ZT- ZT	6.9	4.8	5.2	6.6	6.1	4.4	32.6
ZT + R- ZT -ZT + R	7.7	5.4	5.2	6.8	6.6	4.7	33.0
ZT- ZT + R- ZT + R	7.5	5.3	5.8	7.0	6.2	4.5	33.8
ZT + R- ZT + R- ZT + R	7.8	5.3	5.4	7.2	6.4	4.4	38.0
LSD(P=0.05)	1.07	0.74	0.73	0.94	0.92	0.65	4.71
Weed management							
Weedy check	7.2	5.0	5.1	6.9	6.2	4.5	34.5
Atrazine + pendimethalin – (500 g + 750 g/ha) *fb* 2,4-D 500 g/ha	7.3	5.0	5.4	6.7	6.3	4.4	33.1
Atrazine + pendimethalin - (500 g + 750 g/ha) *fb* 1HW @ 25 DAS	7.5	5.1	5.2	6.9	6.4	4.6	33.7
LSD (P=0.05)	0.69	0.47	0.49	0.64	0.60	0.43	3.19

1.1.8 Impact of conservation tillage and weed management practices on growth and yield under cotton- wheat cropping system.

The long term experiment was conducted to study the growth and yield of cotton with respect to different crop establishment methods and weed management practices. The experiment was laid out in split plot design with bigger plot size (18 x 9 m). The main treatment consists of 5 main treatments (raised bed (T_1), permanent raised bed (T_2), convetional tillage (CT) + *Sesbania* (T_3), zero tillage (ZT) + residue (T_4), and conventional tillage (CT). The sub plot treatment comprises 4 treatments (unweeded control (S_1), pendimethalin *fb* Pendimethalin *fb* quizalofop (S_2), pendimethalin *fb* pendimethalin *fb* pyrithiobac *fb* quizalofop (S_3) and pendimethalin *fb* directed spray of glyphosate.

Comparison between weed management practices and unweeded control

Dominant weeds in the field were: *Echinochloa colona, Cyperus spp,, Phyllanthus niruri* and *Commelina*. The results revealed that the crop establishment techniques and weed management practices significantly affected the population of different weed species. Lower population of *Echinochloa colona* was recorded with conventional tillage (CT) + *Sesbania* than conventional tillage (CT) alone. Higher seed cotton yield (SCY) (1.59 t/ha) was found with raised bed. The sub treatments had significant effect on different weed species and weed dry weight at 60 days after sowing (45 DAS). Significantly lower weed count and weed dry weight was recorded with the application of pendimethalin *fb* pyrithiobac *fb* quizalofop thus recorded higher SCY (1.19 t/ha) (Figure 1.3).

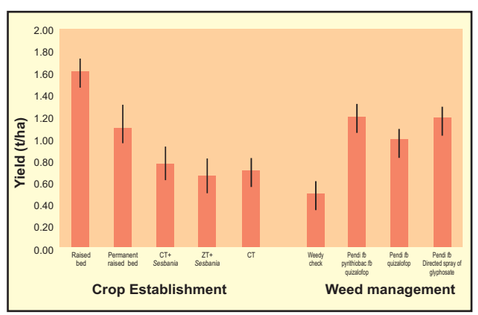


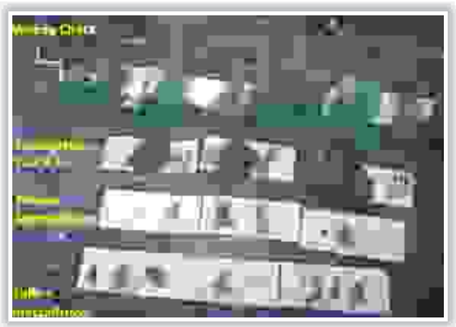
Figure 1.3: Effect of crop establishment and weed management practices on seed cotton yield

1.2 System-based approach to weed management

1.2.4 Effects of crop establishment practices of rice, tillage and weed management practices on yield and yield attributing characters of wheat.

Wheat

After harvest of rice, wheat was grown during *rabi* season 2013-14 to study the effect of crop establishment methods practiced in of rice on ZT and CT wheat under different weed management practices. The experiment was designed in spilt spilt plot, comprised of main treatments (Transplanting (TP), Puddled broadcast sowing with sprouted seed (PBSR), Direct Seeded Rice (DSR) and System of Rice Intensification (SRI) during *kharif* season), sub treatment (conventional tillage (CT) and zero tillage (ZT) in wheat) and sub sub treatment (mesosulfuron + iodosulfuron, sulfosulfuron + metsulfuron, clodinafop + 2,4-D and weedy check).



Effect of different weed management practices on different weed flora

The field was infested with *Phalaris minor*, *Medicago denticulta*, and *Chenopodium album*. Preceding treatments of crop establishment during *kharif* season did not showed significant effect on wheat yield and infestation of weeds. Whereas, tillage practices in wheat zero tillage (ZT) and conventional tillage (CT) resulted in significant effect on weed population and weed dry weight. Significantly higher population of *Medicago denticulata* was recorded with ZT while CT recorded significantly higher population of *Chenopodium album*. Both the tillage practices were significantly similar for the population of *Phalaris minor* / m^2. Significantly higher weed dry weight was recorded with ZT as compared to CT. Among weed management treatments sulfosulfuron + metsulfuron and mesosulfuron + iodosulfuron significantly

reduced the population of *Phalaris minor* as compared to clodinafop + 2,4-D (Table 1.15). All the weed management techniques significantly reduced the population of *Medicago denticulata*, and *Chenopodium album*.

Different crop establishment practices of rice affected significantly, the yield and yield attributing characters of wheat. The yield was higher after DSR as compared to puddling treatments. The tillage treatments in wheat also had no effect on yield and yield attributing characters. However, the weed management techniques differ significantly for yield and yield attributing characters. Significantly higher number of spike/m^2 and yield was observed with all the weed management techniques as compared to unweeded control (Table 1.15).

Table 1.15: Effect of crop establishment practices of rice and tillage and weed management practices in wheat on yield and yield attributing characters of wheat

Treatment	Spike length (cm)	Plant height (cm)	No. of spike/m^2	No. of seed/spike	Yield (t/ha)	Total weed dry wt. (g/m^2)
Treatments to rice						
DSR	11.9	84.8	285	65.7	5.49	18.3
Transplanting	11.2	81.0	265	61.0	5.03	18.2
SRI	11.3	80.4	263	58.9	4.77	19.9
PBSR	11.5	82.6	265	59.8	5.12	17.8
LSD (P=0.05)	NS	NS	NS	5.3	0.51	NS
Treatments to wheat						
Weedy check	11.6	83.0	257	60.8	4.68	41.9
Sulfosulfuron + metsulfuron	11.3	81.7	274	61.2	5.34	8.6
Clodinafop +2,4-D	11.6	85.6	274	59.5	5.24	13.4
Mesosulfuron + iodosulfuron	11.5	79.8	278	64.6	5.21	9.6
LSD (P=0.05)	NS	2.4	13	NS	0.36	6.1
Treatments to wheat						
ZT	11.5	82 .6	268	60.4	5.04	22.6
CT	11.4	82.5	274	62.7	5.19	14.1
LSD (P=0.05)	NS	NS	NS	NS	NS	5.2

Rice

An experiment was initiated in *Kharif* 2011 and continued in 2014 to study the effect of crop establishment methods and weed management techniques on weeds and productivity of rice wheat system. The experiment was laid out in split plot design the main treatments consisted of four rice cultures *viz*. Transplanting (TP), Puddled broadcast sowing with sprouted seed (PBSR), direct seeded rice (DSR) and System of Rice Intensification (SRI) and the sub treatment comprises four weed management practices *i.e.* Weedy Check, Herbicide alone (Bispyribac-sodium 25 g /ha), Herbicide (Bispyribac-sodium 25 g/ha) + 1 Hand weeding (20 DAS DAT/ DAS) and 2 Handweeding (20 & 45 DAS/DAT)

The dominant weed flora of the field were *Echninochloa colona, Cyperus spp, Eclipta alba* and *Caesulia axillaris*. Different crop establishment practices significantly affected the weed population of different species. Significantly higher population of *Echninochloa colona* was recorded under DSR while lowest population of *Cyperus spp* was observed with DSR. Significantly lower population of *Echninochloa colona* was recorded with SRI, TP and PBSR. Higher population of *Cyperus spp* was observed with PBSR as compared to DSR. PBSR also accounted for higher weed dry weight. Under weed management practices bispyribac alone and bispyribac+ 1 HW significantly reduced the population of *Echninochloa colona* and *Cyperus spp*. The close perusal of the data revealed that the bispyribac has lesser impact on controlling *Eclipta alba* and *Caesulia axillaris*. All the weed management practices and 2HW recorded significantly lower weed dry weight as compared to unweeded control (Table 1.16).

Table 1.16: Effect of different crop establishment techniques and weed management on growth and yield of rice

Treatment	Yield t/ha	Plant Height (cm)	Panicle length (cm)	1000 seed wt	Effective tillers/m^2	Total weed dry wt (g/m^2)
Crop establishment methods						
DSR	3.81	88.6	20.8	29.9	262	85.8
Transplanting	4.23	89.7	23.8	31.3	223	54.2
SRI	4.88	95.5	25.1	32.1	210	63.8
PBSR	3.96	86.3	22.3	31.0	242	76.5
LSD (P=0.05)	0.39	7.81	0.98	1.35	30.8	38.7
Weed management						
Weedy Check	3.46	122	22.8	31.3	201	136.2
Bispyribac	4.20	123	22.5	31.1	232	60.3
Bispyribac + 1 HW	4.48	129	22.8	30.9	253	42.1
2 HW	4.74	125	23.9	31.0	263	36.3
LSD (P=0.05)	0.4	7.11	NS	NS	24.4	34.6

Crop establishment methods had significant effect on yield and yield attributing characters. Minimum effective tillers per m^2 were recorded with SRI which was at par with TP and significantly lower to PBSR and DSR. The reverse trend was observed for 1000 seed weight, panicle length and plant height. Significantly higher panicle length, 1000 seed weight and plant height was recorded under SRI leads to significantly higher yield (4.88 t/ha) as compared to other crop establishment practices (Table 1.16). Among weed management practices significant difference was observed for plant height, effective tillers/m^2 and grain yield. The highest value for these characters were recorded with 2 HW which was at par with bispyribac + 1 HW and bispyribac alone and all were significantly superior over unweeded control (Table 1.16). The maximum net return (₹ 30385/-) was recorded with SRI + bispyribac while B:C ratio was maximum in treatment PBSR+2HW (Figure 1.4). Different crop establishment practices affected root area significantly. Maximum tip count, root area and root volume was recorded under SRI (Figure 1.5)

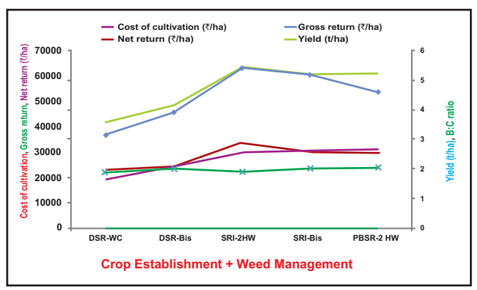


Figure 1.4: Economics of different Treatments

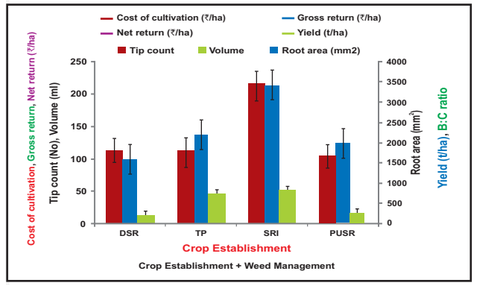


Figure 1.5: Effect of different crop establishment techniques on root growth of rice

1.2.5 Long term effect of weed management practices on weed dynamics and crop productivity in soybean-wheat cropping system

A field experiment was initiated during rainy season of 2014 in soybean–wheat system to study the effect of herbicides on weed and crop yields.

Soybean

The major weed flora consisted of *Echinochloa colona, Cyperus iria, Phyllanthus niruri, Mollugo sp.,*

Pendimethalin *fb* imazethapyr in soybean

Convolvulus arvensis, Dinebra sp., Euphorbia geniculata etc. The lowest weed population and weed dry weight (18.3 no./m^2 and 1.8 g/m^2) were observed with the application of pendimethalin 750 g *fb* imazethapyr 100 g/ha, and metribuzin 500 g *fb* imazethapyr 100 g/ha. The highest seed yield of soybean (1.39 t/ha) was obtained by the treatment metribuzin 500 g *fb* imazethapyr 100 g/ha (Table 1.17).

Table 1.17: Effect of treatments on weed density, weed dry biomass at 60 DAS and seed yield in soybean (rainy season, 2014)

Treatment	*Weed density (no./m^2)	*Weed dry biomass (g/m^2)	Seed yield (t/ha)
Pendimethalin 750 g/ha PE	9.8 (101.7)	7.7(65.1)	0.75
Pendimethalin 750 g/ha PE *fb* imazethapyr 100 g/ha 20 DAS	4.1 (18.3)	1.8 (2.7)	1.21
Pendimethalin 750 g/ha PE *fb* 1 HW 4 0 DAS	9.0 (82.3)	4.4 (20.9)	1.37
Metribuzin 500 g/ha	7.1 (51.0)	4.6 (21.9)	1.33
Metribuzin 500 g/ha PE *fb* imazethapyr 100 g/ha 20 DAS	5.1 (27.0)	2.2 (4.8)	1.39
Metribuzin 500 g/ha PE *fb* 1 HW 40 DAS	8.6 (74.3)	3.7 (13.7)	1.38
Imazethapyr 100 g/ha 20 DAS	8.1 (66.3)	4.8 (23.0)	0.71
Imazethapyr 100 g/ha 20 DAS *fb* 1 HW 40 DAS	5.4 (30.0)	2.1 (4.1)	0.93
2 hand weeding 20 & 40 DAS	7.9 (63.3)	2.6 (6.2)	1.29
Unweeded	10.3 (108.3)	10.8 (119.9)	0.45
LSD (P=0.05)	2.96	2.79	0.31

Weed data subjected to $\sqrt{x+0.5}$ transformation, original values are in parentheses

1.2.6 Cropping system approach for weed management in mango orchard

An experiment was initiated in rainy season 2013 to evaluate various intercrops in sequence for weed suppression in mango orchard.

Winter, 2013-14

The major weed flora infesting the mango orchard was *Medicago denticulata, Chenopodium album, Vicia sativa, Dinebra retroflexa, Sonchus arvensis, Alternanthera sessilis* etc. The results revealed that Sesbania(R)-pea(W)-cowpea(S) treatment recorded lowest weed dry biomass (16.0 g/m^2) compared to unweeded control (118.7 g/m^2) (Table 1.18).

Summer, 2014

The major weed flora infesting the mango orchard was *Echinochloa colona, Dinebra retroflexa, Cyperus iria, Commelina benghalensis, Euphorbia geniculata, Alternanthera sessilis,* etc. The results revealed that *Sesbania* (R)-pea (W)-cowpea(S) treatment recorded lowest weed dry biomass (8.0 g/m^2) compared to unweeded control (45.6 g/m^2).

Rainy, 2014

The major weed flora infesting the mango orchard was *Echinochloa colona, Dinebra retroflexa, Cyperus iria, Commelina benghalensis, Euphorbia geniculata, Alternanthera sessilis* etc. The results revealed that Sunhemp(R)- pea(W)- green gram(S) treatment recorded lowest weed dry biomass (10.1 g/m^2) compared to unweeded control (160.4 g/m^2) (Table 1.18).

Weed management in mango orchard

Table 1.18: Effect of treatments on weed density and weed dry biomass at 60 DAS in mango orchard

Treatment	Weed density (no./m^2)			Weed dry biomass (g/m^2)		
	Winter, 2013 -14	Summer, 2014	Rainy, 2014	Winter, 2013 -14	Summer, 2014	Rainy, 2014
Sesbania(R) - pea(W) -cowpea(S)	33.0	35.3	18.5	16.0	10.8	10.2
Sunhemp(R) -pea(W) - green gram(S)	29.3	34.3	11.5	17.7	8.0	10.1
Soybean (R) -pea (W) -sesbania (S)	49.3	37.3	64.5	19.3	10.1	34.9
Sorghum (R) -pea (W) -sunhemp (S)	65.0	39.3	107.5	23.7	14.4	83.7
Glyphosate 2.0 kg/ha (R-W-S)	0.0	33.0	59.0	0.0	18.3	101.5
Unweeded	84.0	45.7	201.5	118.7	45.6	160.4
LSD (P=0.05)	5.67	10.20	22.31	9.42	2.71	12.19

R- rainy season; W-winter season; S-summer season

1.3.7. Deciding optimum dose of herbicides in mixture using dose response curve

A field experiment was conducted in *Rabi* 2013-14 to decide dose of herbicides when used in mixture using dose response curve in wheat crop. The experiment comprised of treatment combinations of two herbicides clodinofop and 2,4-D at different doses 45, 50, 55, 60 g/ha and 500, 480, 440, 400 g/ha respectively to control grassy and broad leaved weeds. The experiment was laid out in 5^2 factorial Randomized Block design with 3 replications. There was diverse weed flora in the field. Among them dominant weeds in the field were: *Chenopodium album, Medicago denticulata, Cichorium intybus,Physalis minima, Vicia sativa* and *Phalaris minor*. 2,4-D failed to control all the weeds at recommended dose only 60-70% control was observed at recommended dose. On the other hand, clodinofop controls all grassy weeds significantly even at lower dose but due to less number of weeds (sometimes 0) it was not possible to analyze data on clodinofop. Data on % weed control by different doses of two herbicides was observed and dose response models were fitted to data. Among many models, Dose response Hill model was found to be best fit for the data.

Dose-Response Hill function is given by: $y = \delta + \frac{\alpha x^{\theta}}{\varphi^{\theta} + x^{\theta}}$

where, y is the % weed control, ? is intercept, ?=ymax, x denote the dose, ? is the hill coefficient of sigmoidicity and ? denote the ED50 value or the dose for which 50% control is obtained. Before fitting the model, error assumptions (normality, randomness and homogeneity of the error variance) were confirmed with studentized residuals and Shapiro-Wilk normality test (Onofri et al. 2010). Data was found to be non-normal, therefore arc sine transformation was applied to data to make it normal. Hill model describes the relationship between the dose and %weed control for the present data. From the investigation of 2,4-D with doses 400, 440, 480 and 500g/ha, a hill model was fitted to 2,4-D alone as well as in mixture data.

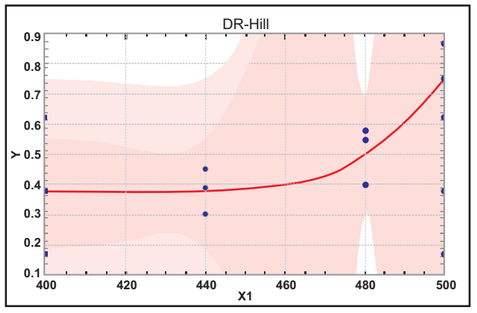


Figure 1.6 (a): Dose response curve of % weed control (arc sine value) of broad leaved weeds in wheat crop with 2,4-D alone. 2,4-D alone dose response curve Hill equation: y=(0.37*dose^0.617)/(495.45^43.8+ dose^43.8).

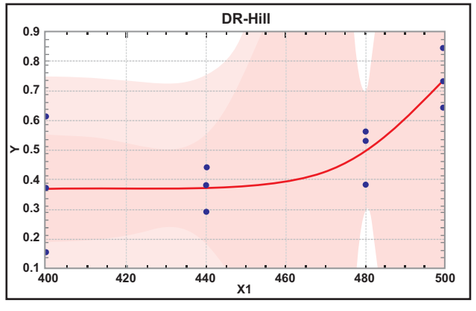


Figure 1.6 (b): Dose response curve of % weed control (arc sine value) of broad leaved weeds in wheat crop with 2,4-D in mixture. 2,4-D in mixture dose response curve Hill equation: y=(0.32*dose^78.3)/(713.94^15.4+ dose^15.4).

Analysis revealed that ED50 value of 2,4 D was estimated as 495.45 g/ha and 713.94 when used alone and in mixture respectively.

1.3.8 Leguminous intercropping for weed management in maize

A field experiment was conducted during *Kharif* 2014 to study the beneficial effect of leguminous and allelopathic intercrops in terms of weed infestation and productivity of maize-based cropping system. The treatments consisted of IWMs viz. cowpea intercropping+herbicide, *Sesbania* brown manuring and sole chemical weed control measure, beside a weedy control. The results recorded during *Kharif* 2014 showed that all the 3 weed control measures were equally effective and significantly reduced both count and dry matter production of weeds in maize compared to weedy check. Among the treatments, highest maize yield was recorded in atrazine+pendimethalin treatment followed by cowpea intercrop + pendimethalin, *Sesbania* brown manuring + pendimethalin+2,4-D and weedy control. *Sesbania* brown manuring treatment was inferior to both maize-cowpea intercropping and sole maize in terms of maize yield. The maize yield as recorded in the cowpea inter cropping + pendimethalin treatment was statistically similar to the that recorded under sole maize with atrazine+pendimethalin treatment and also produced 6.24 tonnes of green fodder. Hence, it was concluded that cowpea intercropping + pendimethalin was a superior weed management option over application of atrazine+pendimethalin (Table 1.19).

Table 1.19: Effect of cowpea intercropping and *Sesbania* brown manuring on weed infestation and yield of maize under ZT.

Treatment	Weed count (no./m²)		Weed dry matter (g/m²)		Grain yield (t/ha)
	30 DAS	60 DAS	30 DAS	60 DAS	
Maize –Cowpea @ intercropping + pendimethalin PE	6.1	6.5	6.5	9.74	5.25*
Maize + *Sesbania* * + pendimethalin PE *fb* 2,4-D (30 DAS)	6.3	6.4	6.4	9.28	4.53
Atrazine+pendimethalin PE +2,4-D (30 DAS)	4.4	5.6	5.6	8.97	5.29
Weedy	10.9	12.9	12.9	12.8	3.85
LSD (P=0.05)	4.4	1.9	1.9	2.73	0.62

* Provided 6.24 tonnes of green fodder.

1.3.9 *Sesbania* and biogas slurry on weed infestation and yield of rice

An experiment was conducted in field during *Kharif* 2014 to study the effect of N sources on weed infestation and yield of direct seeded rice under ZT. The experiment consisted of three organic N sources, viz. no manure, *Sesbania* and biogas gas slurry in main plotas; combination of 2 levels of fertilizer N, viz, 18 and 120 kg/ha, and two levels herbicide, viz. 0 and 1 kg pretilachlor/ha PE, in sub-plots. *Sesbania* and biogas slurry contributed 30 kg N /ha, and were spread over the field at the time of rice seeding.

The result (Table 1.20) showed that the N_{18} and $H+N_{18}$ treatments did not differ in terms of grain yield, indicating that there was no beneficial effect of pretilachlor in terms of grain yield obtained at low level of fertilizer N (N_{18}). However, at high level of fertilizer N (N_{120}), application of pretilachlor significantly improved grain yield in unammended and biogas slurry ammended plots; but such effect was not significant in *Sesbania* ammended plots. Increase in fertilizer N level from N_{18} to N_{120} significantly increased rice yield by 65.5, 49.0, 47.4% without herbicide application, and by 45.4, 69.5 and 104.7% with herbicide application under *Sesbania*, biogas slurry and no manure treatments, respectively. This showed that the effect of herbicide in terms of increased grain yield with increasing N level was relatively more prominent under no manure and biogas slurry treatments, compared to *Sesbania*. The probable reason for these observations could be that the weed infestation increased significantly as N level was increased from N_{18} to N_{120} under no manure and biogas slurry treatments, but such increase in weed infestation was insignificant under *Sesbania* treatment.

Among the treatments, lowest weed dry matter was recorded under *Sesbania*+pretilachlor combination. When herbicide was not applied, there were no differences among no manure, biogas slurry and *Sesbania* in terms of total weed dry matter. However, with herbicide application, significant reduction in weed dry matter production was recorded in *Sesbania* treatment compared to no manure treatment. This indicated that *Sesbania* alone was not enough to control weed infestation in DSR, but it has increased the efficiency of pretilachlor.

Table 1.20. Effect of *Sesbania* and biogas slurry on weed infestation and yield of DSR under ZT.

Sub plot treatment	Main plot treatments		
	Sesbania	BGS	No manure
Rice yield (t/ha)			
$H+N_{120}$	4.39	4.22	4.34
$H+N_{18}$	3.02	2.49	2.12
N_{120}	3.69	3.13	3.08
N_{18}	2.23	2.10	2.09
LSD (P=0.05)	Main x Sub -plot: 0.81		
Weed dry matter at harvest (t/ha)			
$H+N_{120}$	0.21	0.53	1.31
$H+N_{18}$	0.49	0.82	1.64
N_{120}	2.34	2.63	2.41
N_{18}	1.74	1.65	1.49
Mean	1.20	1.41	1.71
LSD (P=0.05)	Main x Sub -plot: 0.91		

H: Pretilachlor

1.3.10 Weed management in sunflower

A field experiment was conducted during 2014 to find out promising weed control practice in sunflower. Results revealed that two hand weeding was most effective to control the weeds and obtaining higher seed yield (3.13 t/ha). Among herbicides, pendimethalin + imazethapyr 900 g, pendimethalin 750 g *fb* quizalofop 100 g/ha significantly reduced the weed population and weight, and produced seed yield of 2.28 and 2.34 t/ha as compared to unweeded control (2.06 t/ha)(Table 1.21).

Weed management in sunflower (2014)

Table 1.21: Effect of weed management practices on weeds and sunflower yield (*Rabi*, 2014)

Treatment	*Weed density (no./m²)	*Weed dry biomass (g/m²)	Seed yield (t/ha)
Pendimethalin 750 g/ha	5.5 (30.0)	3.2 (9.7)	2.36
Pendimethalin + imazethapyr 900 g/ha	4.9 (24.0)	2.3 (4.9)	2.28
Quizalofop-p-ethyl 100 g/ha	4.6 (20.7)	2.6 (6.4)	2.27
Pendimethalin 750 g/ha *fb* quizalofop-p-ethyl 100 g/ha	5.2 (27.7)	2.7 (6.1)	2.24
Pendimethalin 750 g/ha + 1 HW	4.2 (17.7)	1.6 (2.2)	2.72
Sunflower + green gram	5.0 (25.0)	2.0 (3.7)	2.79
Sunflower + *Sesbania*	5.1(26.7)	1.9 (3.8)	2.69
Ridging 25 DAS	7.9 (68.0)	3.5 (11.9)	2.62
2 hand weedings 20 & 40 DAS	3.4 (11.7)	1.2 (1.0)	3.13
Unweeded	15.4 (237.3)	7.2 (53.4)	2.06
LSD (P=0.05)	2.19	12.41	0.61

*Weed data subjected to $\sqrt{x+0.5}$ transformation, original values are in parentheses

Chapter - 2

RESEARCH PROGRAMME -2

WEED DYNAMICS AND MANAGEMENT UNDER THE REGIME OF CLIMATE CHANGE AND HERBICIDE RESISTANCE

Changes in global climate associated with global warming and increasing atmospheric carbon dioxide are likely to influence the weed dynamics in different ecosystems. A complex set of interactions among crops, weeds and their environment determines the impact of weed interference on crop productivity. Despite being a potential threat, impact of climate change on crop-weed interaction with changing climate is poorly understood, though it is of potential importance for production and protection of agriculture and, for human and animal health, environment and natural biodiversity. Greater genetic variability and/or sustained selection pressures due to repeated use of herbicides and herbicides with similar sites of action may prompt recurrence of herbicide resistances in weeds. Changing climatic factors further complicate the puzzle of crop-weed interaction and hence effectiveness of weed management practices. Thus, understanding behaviour of weeds and development of herbicide resistance under the regime of climate change is an urgent need for the development of weed management strategies. Weed risk analysis and weed seed/seedling identification are crucial for the seed producers, scientists, farmers and policymakers. In order to make weed seed identification user-friendly for stakeholders, it is desirable to develop interactive software for identification of weed seeds/seedlings. Keeping in view these aspects, the research programme has been focused on understanding complex behaviour of crop and weed interactions and development of herbicide resistance in weeds under the regime of climate change.

Sub-programme	Experiments	Associates
2.1 Effect of climate change on crop-weed interactions, herbicide efficacy and bioagents	2.1.1 Effect of elevated CO_2 and temperature on physiological, biochemical and molecular aspects in wheat and dominant weed species	Bhumesh Kumar Meenal Rathore Raghwendra Singh
	2.1.2 Effect of elevated CO_2 and temperature on physiological, biochemical and molecular aspects of rice and weedy rice biotypes	Meenal Rathore Bhumesh Kumar Raghwendra Singh
	2.1.3 Effect of elevated CO_2 and temperature on activity of soil enzymes in rhizosphere of rice, wild rice, weedy rice and *Echinochloa crus-galli*	C. Sarathambal Bhumesh Kumar
	2.1.4 Effect of elevated CO_2 and temperature on efficacy of sulfo sulfuron against *Phalaris minor*	Bhumesh Kumar Raghwendra Singh Meenal Rathore
2.2 Physiological and molecular basis of herbicide resistance development in weeds and evaluation of herbicide-tolerant crops	2.2.1 Evaluation herbicide resistance in resistant and susceptible biotypes of *Phalaris minor*	Bhumesh Kumar Meenal Rathore Raghwendra Singh
	2.2.2. 2,4-D tolerance status in broadleaf *Rabi* weed plants raised from seeds obtained from x, 2x and 3x tolerant plants in 2014 *Rabi*	D.K. Pandey
	2.2.3. Bispyribac sodium tolerance status in *Echinochloa* sp. raised from seeds obtained from x, 2x and 4x tolerant plants of 2013 *Kharif*	D.K. Pandey

Sub-programme	Experiments	Associates
2.3 Development of weed seed identification tools and weed risk analysis.	2.3.1 Development of weed seed identification tools	Bhumesh Kumar Meenal Rathore Raghwendra Singh
	2.3.2 Weed spread risk potential of seeds of some of the important weeds	D.K. Pandey
2.4 Other experiments	2.4.1 Demonstration of herbicidal activity of *Parthenium* leaf allelochemical crude	D.K. Pandey
	2.4.2 Evaluation of seed storage method at ambient temperature	D.K. Pandey

2.1 Effect of climate change on crop-weed interactions, herbicide efficacy and bioagents.

2.1.1 Effect of elevated CO_2 and temperature on physiological, biochemical and molecular aspects in wheat and dominant weed species.

Effect of elevated CO_2 and elevated temperature (Ambient + 3.0 ± 0.5° C) on wheat and weed (*Phalaris minor*) was studied in open top chambers (OTCs). Wheat (GW-273) was sown following recommended practices. Weed population was maintained 15 plants/m^2. Plants of both the species were exposed to AC+AT [ambient CO_2 (385±5 ppm) + ambient temperature], AC+ET [ambient CO_2 (385 ± 5 ppm) + elevated temperature (ambient + 3.0 ± 0.5° C)], EC+AT [elevated CO_2 (550 ± 50 ppm) + ambient temperature] and EC+ET [elevated CO_2 (550 ± 50 ppm) + elevated temperature (ambient + 3.0 ± 0.5° C)] from emergence to physiological maturity of the crop. Observations were noted at 30 and 60 days after treatment (DAT). Salient findings of the experiment are given below.

Enrichment of atmospheric CO_2 had a positive effect on overall growth of wheat as well as *P. minor* plants, however, elevated temperature alone or in combination of elevated CO_2 had adverse effect on growth and development of both the species. Effect of different treatments on growth in term of relative growth rate (RGR) in wheat and *P. minor* is depicted in (Figure 2.1A). In case of wheat, RGR was calculated 701, 596, 818 and 613 mg dry weight/plant/day under AC+AT, AC+ET, EC+AT and EC+ET, respectively. In *P. minor*, RGR was calculated 687, 651, 742 and 686 mg dry weight/plant/day under AC+AT, AC+ET, EC+AT and EC+ET, respectively. Data on RGR clearly showed that elevated temperature alone (AC+ET) or in combination of elevated CO_2 (EC+ET) adversely affected two species and more severely wheat as compared to *P. minor* suggesting a competitive advantage to weed as compared to wheat under elevated temperature alone or in combination of elevated CO_2. Yield of wheat was decreased considerably at elevated temperature (AC+ET) by 24.19%, and (EC+ET) by 5.78% as compared to ambient conditions (At+AC). However, at elevated CO_2 alone (EC+AT), yield of wheat was increased by 10-25% (Figure 2.1B). Similarly, test weight (1000-grains weight) was also less when plants were exposed to either elevated temperature alone or in combination with elevated CO_2 (Figure 2.1B), and may be contributing factor for observed yield reduction in such conditions.

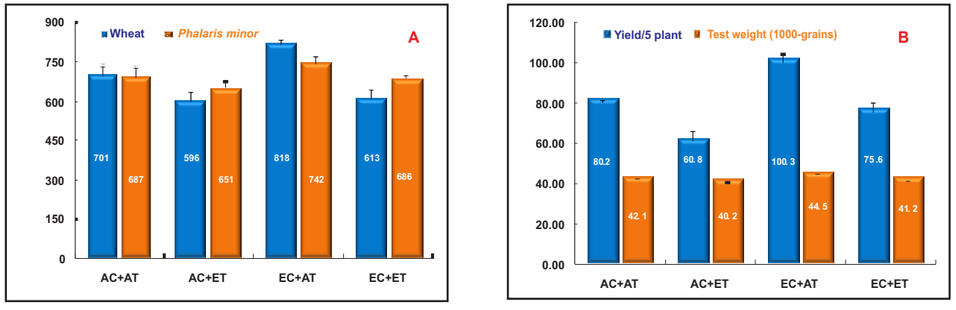


Figure 2.1: Effect of elevated CO_2 and temperature on
(A) Relative growth rate in wheat and *P. minor* (B) Yield and 1000-grain weight of wheat
[Data are means of three replications and bar at top indicates standard deviation]

Isoenzymes activity profile (native PAGE) of antioxidant enzymes superoxide dismutase, guaiacol peroxidase, ascorbate peroxidase, glutathione peroxidase and glutathione reductase was studied at 30 DAT. Differential regulation as well as induction of new iso-forms in response to elevated CO_2 and elevated temperature and combination of these two was evident (Figure 2.2). *Phalaris minor* exhibited stronger antioxidant defence as compared to wheat pointing towards involvement of antioxidant defence system in adaptation to climate change conditions.

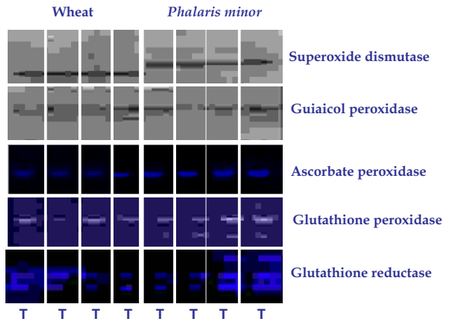


Figure 2.2: Effect of elevated CO_2 and temperature on isoenzymes pattern of antioxidant enzymes in wheat and *P. minor* at 30 DAT. (ACAT = Ambient CO_2 + Ambient temperature; ACET = Ambient CO_2 + Elevated temperature; ECAT = Elevated CO_2 + Ambient temperature; ECET = Elevated CO_2+ Elevated temperature).

Expression of genes involved in photosynthesis and defence pathways was found to be altered in wheat and *P. minor* at elevated CO_2 and elevated temperature alone and in combination at 30 DAT (Fig. 2.3) Altogether, species-specific as well as treatment-specific differential expression of genes was evident. For example, a marked up-regulation of *MDH* was observed in wheat at elevated temperature, however, no such up-regulation was found in *P. minor*. Similarly, up-regulation of *APX2* was evident only in wheat at elevated CO_2 alone or in combination of elevated temperature. On the other hand, up-regulation of GR was noticed at elevated temperature alone or in combination with elevated CO_2 only in *P. minor*. Down-regulation of *CAT1* was observed at elevated CO_2 alone or in combination of temperature in wheat, however. On the other hand, up-regulation was noticed in *P. minor*. Down-regulation of chloroplastic *CuZnSOD* was evident only at elevated CO_2 in wheat. Transcript level of cytoplasmic *CuZnSOD, FeSOD, APX1 and CAT2* was unaffected at elevated CO_2 as well as at elevated temperature. In general, *P. minor* exhibited stronger response to all the three treatments as compared to wheat showing its adaptive potential to changing environment. Differential regulation of genes involved in antioxidants defence pathway point towards possible involvement of these genes in adaptation to high temperature high CO_2 environment.

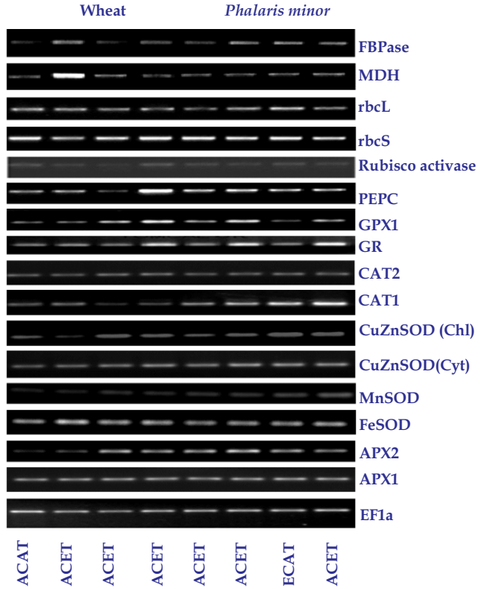


Figure 2.3: Effect of elevated CO_2 and elevated temperature on transcript level of genes involved in photosynthesis and antioxidant defence pathway in what and *P. minor* at 30 DAT. [FBPase = Fructose 1,6-bisphosphatase; MDH = malate dehydrogenase; rbcL and rbcS = large and small subunit of Rubisco; PEPC = PEP carboxylase; GPX = glutathione peroxidase; GR = Glutathione reductase; CuZnSOD, MnSOD, FeSOD = superoxide dismutases specific to Cu-Zn and Mn and Fe; CAT = Catalase, APX = Ascorbate peroxidase; EF1α = elongation factor 1α (loading control)]

2.1.2. Effect of elevated CO_2 and temperature on rice and weedy rice

Weedy rice, a natural hybrid between cultivated and wild rice, is thought to be more problematic in forthcoming regime of climate change. The effect of climate change (enhanced temperature and CO_2 and a combination of both in comparison to ambient conditions) on a morphotype of weedy rice, a wild rice and cultivated rice was studied till maturity.

Interaction studies revealed effect on tiller number, root length, root volume, shoot fresh weight and difference in leaf-air temperature 45 DAS; plant height, tiller number and difference in leaf-air temperature 60 DAS and effective tillers, panicle length, grains per panicle, yield per plant (Fig. 2.4), plant height, grain length and root area at harvest. An important observation was that elevated temperature and CO_2 in combination delayed panicle maturity in all rice.

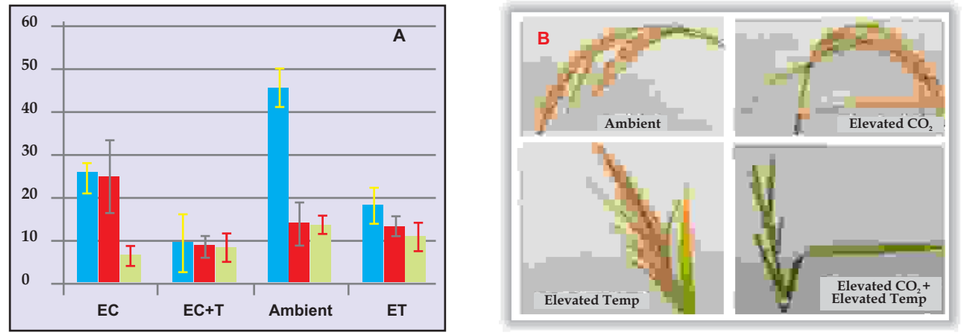


Figure 2.4: (A) Variations in yield per plant in weedy rice, cultivated rice and wild rice under changing parameters of climate. (E: elevated, C: CO_2, T: temperature; Blue block: cultivated rice, Red block: wild rice; Green block: weedy rice). (B) Effect on phenology (commencement of reproductive stage) of cultivated rice under changing parameters of climate.

2.1.3 Effect of elevated CO_2 and temperature on activity of soil enzymes in rhizosphere of rice, wild rice, weedy rice and *Echinochloa crus-galli*

Soil samples were collected from the OTCs at physiological maturity stage. The influence of elevated CO_2 and temperature on activity of soil enzymes was analysed in the soil samples and the results obtained are given in (Table 2.1). The results showed that the exposure of elevated CO_2 increased the activity of all the three soil enzymes, whereas, elevated temperature led to decrease in the activity of enzymes. Among the plant species tested, *E. crus-galli* responded positively to elevated CO_2 and temperature. Higher FDA hydrolysis rate (an indication of overall microbial activity) was noticed in *Echinochloa crus-galli* at elevated CO_2 alone and in combination of elevated temperature. Dehydrogenase activity was higher at elevated CO_2 in *E. crus-galli* followed by that at elevated CO_2andelevated temperature. Urease is the key enzyme which hydrolyses urea to ammonia. Elevated CO_2 resulted significantly higher activity of urease in soil collected from rhizosphere of *E. crus-galli* followed by cultivated rice. Altogether, it can be inferred that *E. crus-galli* responded positively to elevated CO_2 with respect to all the three soil enzymes when exposed to elevated CO_2 alone or in combination of temperature.

Table 2.1: Effect of elevated CO_2 and temperature on the activity of soil enzymes

Activity of soil enzymes	Crop/weed	Treatment			
		Ambient	Elevated CQ	Elevated temperature	Elevated CO_2+ Elevated temperature
Fluorescein diacetate (FDA) hydrolysis rate (µg fluorescein /g soil/h)	Weedy rice	9.6^{ef}	12.3^{d}	6.5^{g}	12.8^{d}
	Wild rice	8.9^{efg}	15.6^{c}	9.6^{ef}	18.2^{ab}
	Cultivated rice	7.6^{fg}	11.2^{de}	8.7^{efg}	16.4^{bc}
	E. crus-galli	8.7^{efg}	18.5^{ab}	6.9^{g}	19.7^{a}
Dehydrogenase (µg TPF/g soil/24 h)	Weedy rice	26.5^{b-e}	28.6^{bc}	25.8^{c-f}	22.3^{d-g}
	Wild rice	27.6^{bcd}	29.8^{bc}	20.6^{efg}	18.9^{g}
	Cultivated rice	18.9^{g}	19.5^{g}	22.3^{d-g}	16.9^{g}
	E. crus -galli	32.4^{b}	39.8^{a}	18.9^{g}	34.8^{b}
Urease (µg NH_4/g soil / 24 h)	Weedy rice	39.1^{abc}	39.8^{abc}	23.6^{e}	34.6^{bcd}
	Wild rice	33.9^{bcd}	36.9^{a-d}	29.8^{de}	29.5^{de}
	Cultivated rice	36.5^{bcd}	42.9^{ab}	32.8^{cd}	28.9^{de}
	E. crus -galli	36.5^{bcd}	45.6^{a}	33.6^{cd}	35.5^{bcd}

Values represent mean of three replications. Values followed by same letter in a row are not significantly different from each other as analysed by DMRT (P=0.05)

2.1.3 Effect of elevated CO_2 and temperature on efficacy of sulfosulfuron against *P. minor*

Efficacy of sulfosulfuron was tested against *P. minor* in OTC. Seeds of *P. minor* were sown in pots and kept in OTC for treatments viz. elevated temperature (ambient + 3.0 ± 0.5 °C), elevated CO_2 (550 ± 50 ppm) and elevated CO_2 + elevated temperature. Different doses of sulfosulfuron (0, 0.5X, 1X, 1.5X and 2X) were sprayed at 25 days after emergence. Photographs were taken after 20 days of herbicide application. At ambient condition (ACAT), sulfosulfuron was effective to kill 100% population of *P. minor* even at 0.5X dose. At elevated temperature (ACET) as well as elevated CO_2 (ECAT), escape about 30-40% population of the *P. minor* was noticed at recommended dose (1X) of sulfosulfuron, however, higher doses (1.5 and 2X) were effective to kill 100% population. At elevated CO_2 + elevated temperature (ECET), plant escaped at all the doses of sulfosulfuron (0.5X, 1X, 1.5X and 2X), however, growth inhibition was noticed with the increasing dose of sulfosulfuron (Fig. 2.5). It can be inferred from the results that efficacy of sulfosulfuron may be reduced with predicted climate changes (elevated CO_2 and elevated temperature), hence, weed management may be affected considerably.

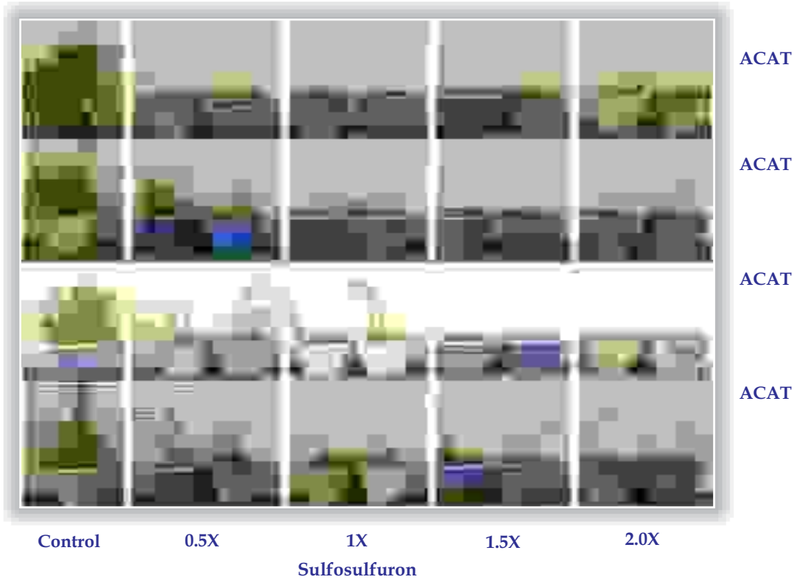


Figure 2.5: Effect of elevated CO_2 and temperature on efficacy of sulfosulfuron against *P. **minor***. (ACAT = Ambient CO_2 + Ambient temperature; ACET = Ambient CO_2 + Elevated temperature; ECAT = Elevated CO_2 + Ambient temperature; ECET = Elevated CO_2 + Elevated temperature).

2.2 Physiological and molecular basis of herbicide resistance development in weeds and evaluation of herbicide-tolerant crops.

2.2.1 Evaluation herbicide resistance in resistant and susceptible biotypes of *Phalaris minor*

On the basis of screening experiment conducted last year, one isoproturon-sensitive (IPU-sensitive and one isoproturon-resistant (IPU-resistant) biotypes were selected. Plants of both the biotypes were grown in pots with uniform population. At 21 days after emergence, varying doses (0, 0.5X, 1X, 1.5X, 2X) of different herbicides (isoproturon, clodinafop, sulfosulfuron, metsulfuron+iodosulfuron and metribuzin) were sprayed. All the above herbicides showed almost 100% control of IPU-sensitive biotype of *P. minor* at recommended doses and obviously at higher doses. However, IPU-resistant biotype of *P. minor* showed very high degree of resistance against isoproturon, clodinafop and sulfosulfuron at recommended doses (1X) even at higher doses (1.5X and 2 X) and produced healthy seeds. Alternate herbicides viz. metsulfuron+iodosulfuron and metribuzin provided effective control of *P. minor* at recommended doses (Fig. 3.6) suggesting that these herbicides are effective in management of IPU-resistant biotype of *P. minor*.

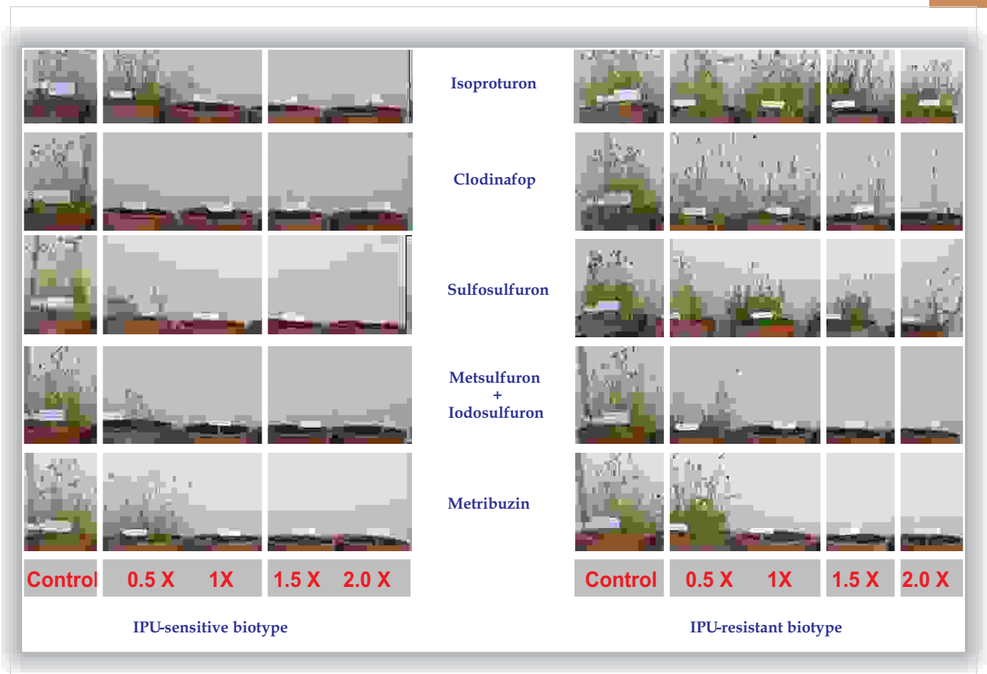


Figure 2.6: Evaluation of *Phalaris minor* for resistance against different herbicides.

2.2.2 2,4-D tolerance status in broadleaf *Rabi* weed plants raised from seeds obtained from x, 2x and 3x tolerant plants in 2014 *Rabi*

The seeds collected from herbicide 2,4-D tolerant plants of the weeds were planted in micro-plots (1 m^2). The herbicide 2, 4-D amine was applied to the stands and mortality of the treated plants and flowering and seed formation were monitored. The results on *Euphorbia geniculata* (Table 2.2), *Amaranthus viridis* (Table 2.3) and *Rumex dentatus* (Table 2.4) showed that there was no apparent quantitative relationship in the herbicide tolerance in subsequent generation of the weeds.

Table 2.2: Herbicide 2, 4-D amine tolerance in different population types of *Euphorbia geniculata* during 2014

Population type	Herbicide levels employed	Survival of plants 20 DAT	Flowering (%)	Seed formation (%)
I. Normal	0	100±0	100±0	100±0
	x	30±10	0	0
	2x	30±10	0	0
	4x	0	0	0
II. x 2,4 -D tolerant	0	100±0	100±0	100±0
	x	75±13.5	56±21.2	56±21.2
	2x	65±2.6	63±17.3	63±17.3
	4x	0	0	0
III. 2x 2, 4 -D tolerant	0	100±0	100±0	100±0
	x	94±9.8	63±32. 1	63±32.1
	2x	61±34.8	28±47.9	28±47.9
	4x	0	0	0
IV. 3x 2, 4 -D tolerant	0	97±4.7	100±0	100±0
	x	21±10.9	0	0
	2x	50±7.0	0	0
	4x	0	0	0

Values are means ± standard deviations of 3 replications.

Table 2.3: Herbicide 2, 4-D amine tolerance in different population types of *Amaranthus viridis* during 2014

Population type	Herbicide levels employed	Survival of plants 20 DAT	Flowering (%)	Seed formation (%)
Normal	0	97±5.7	100±0	100±0
	x	14±2.0	78±19.2	78±19.2
	2x	5±0.5	0	0
	4x	0	0	0
x 2,4-D tolerant	0	95±5.0	100±0	100±0
	x	28±2.0	100±0	100±0
	2x	89±11.0	100±0	100±0
	4x	0	0	0
2x 2, 4-D tolerant	0	100±0	100±0	100±0
	x	91±7.7	100±0	100±0
	2x	96±3.2	100±0	100±0
	4x	7±4.0	100±0	100±0
3x 2, 4-D tolerant	0	97±5.7	100±0	100±0
	x	100±0	100±0	100±0
	2x	100±0	100±0	100±
	4x	7±3.2	0	0

Values are means ± SD of 3 replications.

Table 2.4: Herbicide 2, 4-D amine tolerance in different population types of *Rumex dentatus* during summer of 2014

Population type	Herbicide levels employed	Survival of plants 20 DAT	Flowering (%)	Seed formation (%)
Normal	0	98±2.8	98±2.8	100±2.8
	x	8±3.7	100±0	100±0
	2x	0	0	0
	4x	0	0	0
x 4-D tolerant	0	100±0	100±0	100±0
	x	13±3.7	100±0	100±0
	2x	14±3.0	100±0	100±0
	4x	0	0	0
2x 2, 4-D tolerant	0	97±0.6	100±0	100±0
	x	0	0	0
	2x	13±2.5	0	0
	4x	0	0	0
3x 2, 4-D tolerant	0	91±8.3	0	0
	x	0	0	0
	2x	0	0	0
	4x	0	0	0

Values are means ± standard deviations of 3 replications.

2.2.3 Herbicide bispyribac sodium tolerance status in *Echinochloa* sp. raised from seeds obtained from x, 2x and 4x tolerant plants of 2014 *Kharif*

Herbicide bispyribac sodium tolerance was evaluated in the *Echinochloa crus-galli*, *E. glabrescens* and *E. colona* seeds collected from the stands of 2014 *Kharif* in micro-plots in field. The herbicide was applied at x, 2x and 4x on 12 lines of the species and also on x, 2x and 4x tolerant lines. Seedling survival, tillering, and fresh and dry weights of plants were observed. While herbicide tolerance was verified in some of the lines corroborating earlier year's findings, there was no definite trend in herbicide tolerance in the plants raised from the seeds collected from herbicide tolerant lines during 2014.

2.3 Development of weed seed identification tools and weed risk analysis.

2.3.1 Development of weed seed identification tools

Images of different weeds at different stages (i.e. seeds, imbibed seeds, and their reproductive parts) have been taken for the purpose of develop weed identification software and weed atlas. Information regarding 40 weeds has been compiled for weed atlas.

2.3.2 Weed spread risk potential of seeds of some of the important weeds

Weed spread risk potential through seeds (extent of viability of weed seeds at or near ambient conditions) of 34 prominent weeds of central India was studied. The seeds of the weeds were collected in 1991-92, dried under ambient conditions and kept in glass bottles at ambient temperature 30 ± 15° C and germination was tested at intervals. The seeds of different weeds lost viability in 5 -12 years, depending on the species. Approximate period for viability loss was 5 years for 5 species, up to 10 years for 26 species and 12 years for 3 species. The viability loss period was irrespective of their being monocot or dicot and season of infestation. The weeds appear to have high spread risk potential through seeds for many years and this warrants the necessity of quarantine and sanitation to ward off both the weed spread through seeds to newer areas and intensification of the weed infestation in the areas where they have already spread. This has special relevance to Indian context where many weeds have infestations confined to particular areas and are waiting for invasion to other areas yet to be infested.

2.4 Other experiments

2.4.1 Demonstration of herbicidal activity of parthenium leaf allelochemical crude

2.4.1.1 Standardization of suitable solvent for preparation of the herbicidal allelochemical crude.

Suitable solvent for preparation of the herbicidal allelochemical crude was found out and its composition was standardized. Water, acetone, acetone : water at 25:5, 20:10, 15:15 (all v/v), etc. were tried and yield and herbicidal activity of the solutes obtained on drying were measured. The acetone was better suited solvent for it extracted good amount of herbicidal principle and was quick evaporating and appeared to avoid bulk of non bioactive constituents. The acetone : water, 1:1, v/v extracted maximum solutes with herbicidal activity. The findings showed that acetone : water, 1:1, v/v was suitable for bulk extraction of the allelochemical crude from parthenium leaf residue (Table 2.5).

Table 2.5: Solubilization of herbicidal constituents from parthenium leaf residue by different solvents

Solvent system	Yield (%) of herbicidal constituents	% Change in biomass over initial value (loss of 100% biomass shows death of the plants) days after initiation of the treatments			
		5	10	15	20
Acetone	5.0±0.3	-22±11	-39±6	64±3	-100
Acetone : water(25:5, v/v)	16.8±0.2	-54±22	-74±3	-100	100
Acetone : water (20:10, v/v)	18.6±1.0	38±6	67±4	-100	-100
Acetone : water (15:15, v/v)	22.5±1.2	-100	-100	-100	-100
Water	12.6±0.2	-7±2	-7±6	11±5	-13±6

Values are means ± SD of three replications.

2.4.1.2 Standardization of suitable solute (parthenium leaf powder, PLP) to solvent ratio.

The PLP was extracted with solvent acetone : water (1:1, w/v) mixture at 1:5, 1:10, 1:20, 1:30, 1:40, and 1:60 (w/v) for 30 minutes and herbicidal constituent yield was monitored. The herbicidal constituent extraction was maximum with 1:30 ratio (Table 2.6). The herbicidal activity on water hyacinth was also appreciable at this ratio of leaf residue to solvent. The solvent to solute ratio of 1:30 was most appropriate for the extraction of the allelochemical crude.

Table 2.6: Effect of solute – parthenium leaf powder- to solvent ratio on yield of allelochemical crude (AAC) and its herbicidal activity subsequent to extraction for 30 minutes at ambient temperature

Solute to solvent ratio (w/v)	Yield of allelochemical crude		% Change in biomass of water hyacinth over initial level days after initiation of the treatment at ACC obtained from 1 g in 100 ml water equivalent		
	mg/g residue	% (w/w)	5	10	15
Control (water)	-	-	6±3.9	16±3.8	24±6.6
1:5 (acetone:water, 1:1)	152±7	15.2	-10±2.9	-16±3.2	-99±0.7
1:10 (acetone:water, 1:1)	223±13	22.3	-7±2.9	-23±5	-100
1:20 (acetone:water, 1:1)	220±10	22.0	-10±7.8	-32±19.2	-100
1:30 (acetone:water, 1:1)	229±8	22.9	-15±6.9	-27±3.4	-100
1:40 (acetone:water, 1:1)	242±10	24.2	-27±5.4	-34±5.5	-100
1:60 (acetone:water, 1:1)	244±6	24.4	-31±12.5	-49±12	-100

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2.4.1.3 Standardization of suitable time duration for extraction of the allelochemical crude from parthenium leaf residue.

The extraction time 5, 10, 20, 30, 40, 50, 60, 90, 120, 180 and 240 minutes were used for parthenium leaf allelochemical crude extractions with stirring following solute (leaf residue) to solvent ratio of 1:30 (w/v). The 30 minute extraction duration was optimum when yield and herbicidal activity on water hyacinth outdoors were considered (Table 2.7).

Table 2.7: Effect of duration of extraction of parthenium leaf powder with acetone : water, 1:1, v/v on yield of allelochemical crude (AAC) and its herbicidal activity

Extraction duration (min)	Yield of ACC		% Change in biomass of water hyacinth over initial level days after initiation of the treatment at ACC obtained from 1 g in 100 ml water equivalent		
	mg/g	% (w/w)	5	10	15
5	210±7.6	21±0.7	59±28.1	-100	-100
10	204±3.2	21±0.3	-53±27.3	-100	-100
20	196±9.8	20±0.9	-41±9.3	-100	-100
30	228±4.0	23±0.4	-45±20.2	-81±17.4	-100
40	230±4.5	23±0.4	-62±33.7	-100	-100
50	233±7.6	23±0.7	-52±16.6	-93±12.4	-100
60	231±4.1	23±0.4	-56±39.4	-100	-100
90	217±6.2	22±0.6	-39±15.5	-89±18.2	-100
120	229±2.0	23±0.2	-52±25.9	-100	-100
180	223±6.0	22±0.6	-60±19.8	-100	-100
240	190±4.3	19±0.4	-51±19.7	-100	-100
Control	-	-	11±4.2	24±8.7	34±14.7

Values are means ± SD of three replications. Loss of 100% biomass shows death of the plants

2.4.1.4 Effect of surfactant sorbitan mononucleate (SMN) on extraction of herbicidal constituents from parthenium leaf residue.

Sorbitan mononucleate, a surfactant, was added to the parthenium leaf allelochemical crude extraction medium (acetone : water) at 0.01, 0.05 and 0.1% (v/v) and yield of the herbicidal allelochemical crude and herbicidal activity of the crude were monitored. The SMN was also tested for its inhibitory activity on water hyacinth. The findings showed that the SMN was not inhibitory to water hyacinth at 0.1%. Addition of SMN to extraction medium at 0.1, 0.05 and 0.01 % did not affect extraction of herbicidal constituents and their yields from parthenium leaf residue.

2.4.1.5 Effect of target plant biomass on fate of the herbicidal activity of parthenium leaf allelochemical crude.

Parthenium leaf allelochemical crude was tested for different numbers and biomass of water hyacinth plants outdoors for investigating effect of the target plant biomass on herbicidal activity of the allelochemical crude. The findings (Table 2.8) showed that allelochemical crude at 200 mg / 100 ml was sufficient to kill 10-60 g of 1-5 water hyacinth plants in 5-10 days. The residual toxicity for subsequent additions of water hyacinth to the system killed the weed where 10-30 g or 1-3 water hyacinth plants were placed. Where 4-5 plants (50-60 g) were placed, the residual toxicity was inhibitory, but not to lethal level. Beyond a critical level, herbicidal activity and its persistence depended on water hyacinth biomass.

Table 2.8: Effect of target plant biomass on parthenium leaf allelochemical crude herbicidal activity and persistence of the herbicidal activity outdoors

Treatment	Fresh weight of plants (g)	% Change in biomass of water hyacinth over initial level days after initiation of the treatment					
		I. Assay of herbicidal activity		II. Assay of herbicidal activity- plants placed immediately after 10 days in the medium of I			
Water hyacinth plants / 100 ml medium		5	10	Initial biomass of each plant	5	10	15
1	13.0±2.4	-85.0±6.7	-100	13.6±2.1	-18±1.9	-82.0±2.8	-100
2	15.2±4.4	-85.0±1.8	-100	14.8±2.4	-33.0±13.3	-88.0±2.4	-100
3	33.3±3.6	-94.0±2.2	-100	17.6±1.5	-55.0±8.5	-84.0±1.0	-100
4	51.3±1.6	-95.0±1.0	-100	17.5±2.9	-38.0±9.6	-62.0±19.3	-83.0±5.5
5	57.0±1.1	-84.0±19.4	-100	12.9±1.6	-32.0±2.1	-48.0±12.4	-58.0±10.7
1	23.0±3.5	10.0±0.7	21.0±3.2	17.2±5.6	11.0±6.8	25.0±9.8	31.0±11.3

Values are means ± SD of three replications. Minus 100% biomass shows death of the plants

2.4.1.6 Formulation of parthenium leaf allelochemical crude for use as herbicide on prominent weeds

Parthenium leaf allelochemical crude formulation was prepared with suitable solvents and surfactants and was applied on different terrestrial and aquatic weeds. Phytotoxicity was monitored. The preparation caused necrotic lesions at the place of application (Figure 2.7) and the plants were not killed. The plants recovered subsequently and grew normal. Water hyacinth leaves sprayed with the allelochemical crude also showed necrotic lesions and plants recovered subsequently. The allelochemical crude did not appear a suitable material for use as a herbicide as sprays.

2.4.2 Evaluation of seed storage method at ambient temperature

A liquid preservative 20% (w/w) $CaCl_2$ in glycerol extended longevity of seeds of crops and weeds (with mean moisture content, MC, about 10%, fresh weight basis) to varying degrees broadly by 8 and 3 folds, evaluated for 24 and 21 years, respectively at ambient temperatures 30±15°C. The experimental data suggested that that storing seeds in the liquid preservative ($CaCl_2$ in glycerol) is a promising, alternative, long-term storage method at ambient temperature by ultra-drying the seeds and removing air (oxygen) from the seed environment.

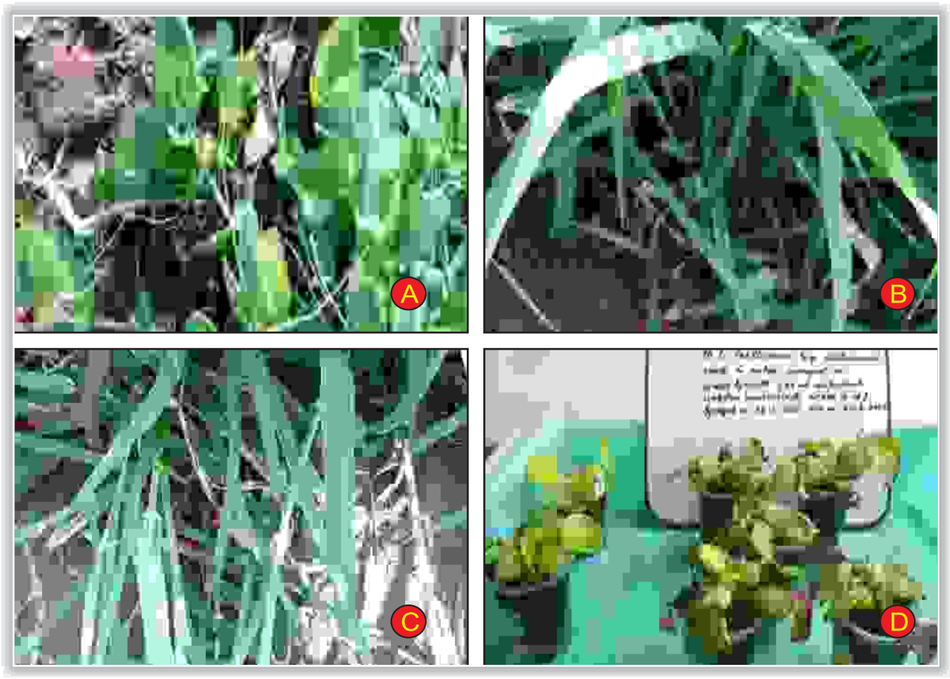

Figure 2.7: Necrotic lesions on different weeds and subsequent recovery of the necrotic lesions cause by parthenium allelochemical crude application as an herbicide

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RESEARCH PROGRAMME - 3

BIOLOGY AND MANAGEMENT OF PROBLEMATIC WEEDS IN CROPPED AND NON-CROPPED AREAS

Some weeds have assumed serious proportions in cropped and non-cropped situations. The weeds like wild oat (*Avena fatua*), canary grass (*Phalaris minor*), lambsquarters (*Chenopodium* sp.), purple nut sedge (*Cyperus rotundus*), field bind weed (*Convolvulus arvensis*), *Echinochloa* spp., weedy rice, *Orobanche*, *Cuscuta*, *etc.* are well known problematic weeds in different cropping situations. In non-cropped situations also, weeds like *Parthenium hysterophorus*, *Lantana camara*, *Eupatorium adenophorum*, *Chromolaena odorata*, *Saccharum spontaneum*, *Mikania micrantha*, *etc.* have gained national importance. In aquatic situations, troublesome weeds like water hyacinth, alligator weed, *Pistia stratiotes*, *Ipomoea aquatica*, *etc.* have gained the status of worst weeds. Further, submerged weed like *Hydrilla verticillata* is a big menace in aquatic situation. In recent years, weedy rice in rice has become problematic in many states of India. *Orobanche* has emerged as one of the most problematic weeds in mustard and tobacco besides tomato and brinjal. Recently, *Chromolaena odorata* has become a problematic weed in Jagdalpur area of Chhattisgarh. The weed is spreading its tentacles in larger area of Chhattisgarh and it is feared that it may enter into Maharashtra and Madhya Pradesh in due course. Among the aquatic weeds, *Pistia stratiotes* is one of the most problematic weeds which has spread fast in many parts of Madhya Pradesh. The programme has been taken to address biology and management of these problematic weeds.

Sub-programme	Experiments	Associates
3.1 Biology and management of problematic weeds in cropped areas	3.1.1 Characterization of weedy rice biosimilars	Meenal Rathore, Raghwendra Singh, Bhumesh Kumar
	3.1.2 Incidence of *Orobanche* on different varieties of mustard	C. Kannan
3.2 Biology and management of problematic weeds in non-cropped areas	3.2.1 Integrated management of *Chromolaena odorata*	Sushil Kumar, Adikant Pradhan
3.3. Biology and management of aquatic weeds	3.3.1 Effect of inoculation of *Alternaria alternata* and *A. eichhorniae* on water hyacinth and fishes	C. Kannan, Sushil Kumar
	3.3.2 Integrated management of *Pistia stratiotes*	Sushil Kumar

3.1 Biology and management of problematic weeds in cropped areas

3.1.1 Characterization of weedy rice biosimilars

Mature grains of weedy rice morphotypes were studied for morphological parameters like 100 seed weight, grain length-breadth ratio and length of awns. Expected variations were recorded amongst parameters studied. Amongst the 82 morphotypes studied, 76% had awns though varying in length (Figure 3.1). Majority of awn lengths were in the range of 3.0-4.0 cm (14%). Majority of morphotypes (76.8%) had grain length - breadth ratio below 3.0 while only 1% had it between 4-5 (Figure 3.2). Hundred seed weight was broadly demarcated into a range of 2.0 -2.5 wherein 50% morphotypes fell. The remaining 50% had a 100 seed weight <2.0 (22%) and >2.5 (28%) (Figure 3.3).

DWR

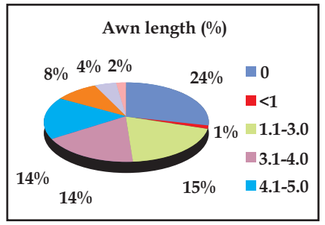


Figure 3.1: Varying awn length amongst weedy rice morphotypes

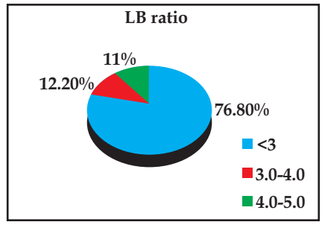


Figure 3.2: Majority of weedy rice has grain length-breadth ratio below 3.0

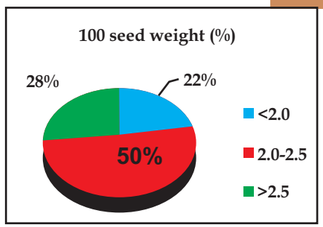


Figure 3.3: Variations in 100 seed weight amongst weedy rice morphotypes

3.1.1.1 Molecular fingerprinting of weedy rice morphotypes

Molecular fingerprinting of weedy rice morphotypes collected was done to observe any possible clustering based on the agro-climatic zones they had been collected from. The dendogram generated (Figure 3.4) using NTSYS-pc software revealed that weedy rice did not cluster based either on geographical regions or agro-climatic zones.

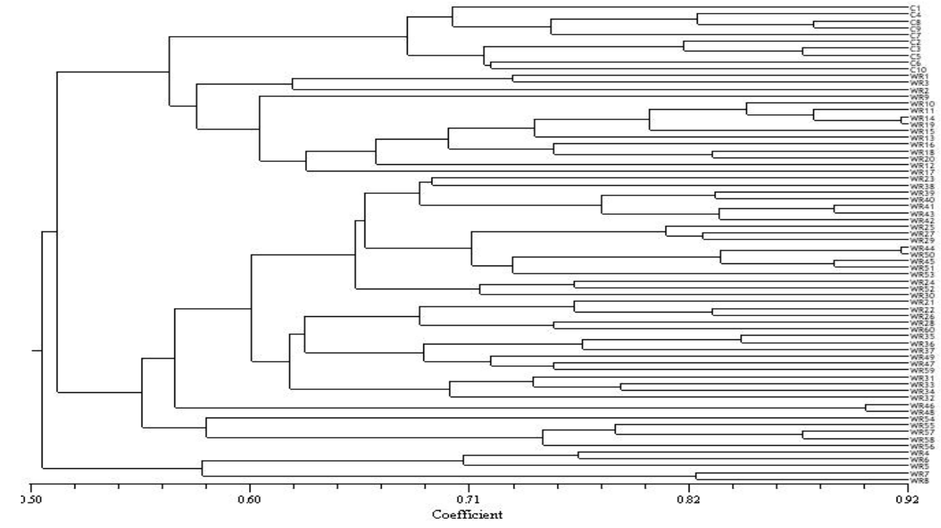
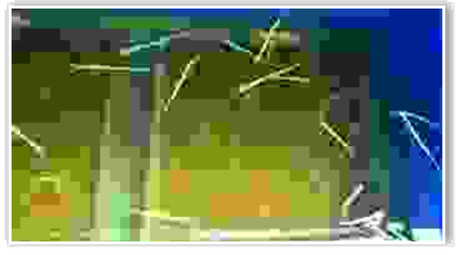


Fig. 3.4: Dendogram generated by molecular fingerprinting of weedy rice

3.1.1.2 Germination of weedy rice in standing water

Earlier studies revealed ability of weedy rice to germinate under anaerobic conditions with 6cm standing water and seeds below soil surface. Hence, germination ability under more stringent conditions of 15 cm standing water was assessed. It was found that 4 of the 99 weedy rice morphotypes screened germinated by >57%. And the germination percentage decreased rapidly to as low as 3 % with increasing seed depths.



Germination of weedy rice under 15 cm standing water

RESEARCH PROGRAMME - 3

3.1.1.3 Screening of rice cultivars for competitive ability

Nowadays weeds are generally managed by use of herbicides, but with selective herbicides available for weedy rice, its control is difficult and relies solely on cultural practices. In this context, a study was initiated to screen rice cultivars for their competitive ability against weedy rice. Ten popular rice cultivars were screened in a field experiment during *Kharif* 2014 by comparing agronomically important parameters in weed free and weedy rice infested plots. Interaction study revealed significant difference amongst genotypes in weedy rice infested field in comparison to control (weed free) for all parameters studied except for root length, shoot dry weight, SPAD, hills and tillers/running meter at 70 DAS. Considering a competitive line to mature earlier than weedy rice and have lesser yield loss, variety '*Naveen*' was found to record a lower yield loss in the first year of experiment (Figure 3.5).

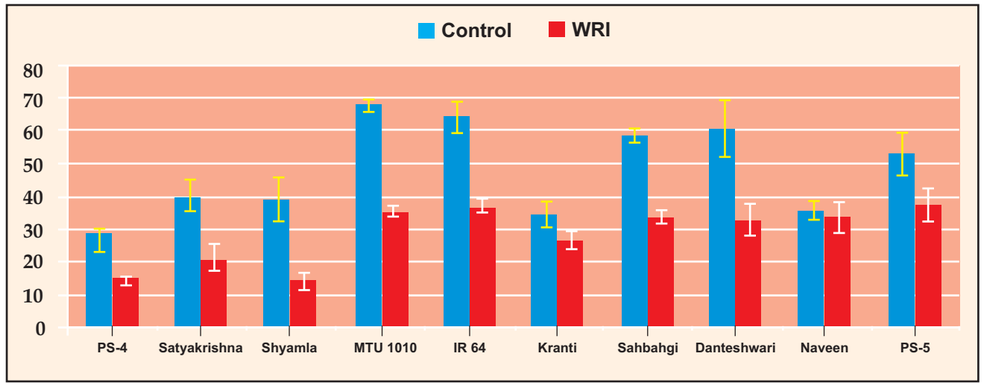


Figure 3.5: Yields in rice cultivars screened for competitive ability against weedy rice

3.1.1.4 Management of weedy rice through cultural interventions

With no specific herbicide available for weedy rice, management is possible only through land preparation, mechanical tools and other cultural practices. Keeping in view the above, a field experiment was carried out for management of weedy rice during *Kharif* 2014.

The dominant weed flora of the field were *Echninochloa colona, Cyperus* spp, *Eclipta alba*, *Ammania baccifera* and *Caesulia axillaris*. All the cultural methods significantly reduced the dry weight/m^2 of weedy rice except green manuring alone. The yield of purple rice was also significantly affected by different cultural practices. The maximum yield was observed with transplanting + 1 HW (2.93 t/ha) followed by transplanting alone, double stale seed bed + 1 HW, stale seed bed + 1 HW and green manuring + 1 HW (Table 3.1). Puddling for transplanting lower down the population of weedy rice in *Kranti* and also produced maximum yield (4.14 t/ha) followed by '*DSSB*' (3.68 t/ha) and reduced weedy rice population.

Table 3.1. Effect of different cultural treatments on weedy rice and yield of rice

Treatment	Purple rice (var. '*Shyamla*')		Green rice (Kranti)	
	Dry wt. of weedy rice (g/m^2) at 60 DAS	Yield (t/ha)	Dry wt. of weedy rice (g/m^2) at 60 DAS	Yield (t/ha)
SSB	32.7	1.86	43.2	2.82
SSB+ HW	32.1	2.31		
DSSB	35.2	2.10	23.7	3.68
DSSB+ HW	25.3	2.41		
GM	44.6	1.57	28.8	3.12
GM+ HW	23.6	2.03		
Weedy check	46.3	1.26	52.7	1.93
TP	24.7	2.68	11.9	4.14
TP + HW	11.7	2.93		
LSD (P=0.05)	10.70	0.512	38.65	1.86

Weedy rice infestation in purple rice (initial stage)

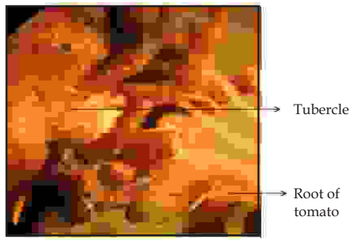
Purple rice with transplanting and 1 HW at later stage

3.1.2 Incidence of *Orobanche* on different varities of mustard

A study was conducted to find out the conditions *viz.*, temperature requirements and moisture conditions for germinations of *Orobanche*. The study was conducted under laboratory and pot culture conditions of simulated temperature and moisture requirements. The study of germination with or without preconditioning and use of synthetic germination stimulant Nijmegen 1 indicated that the fresh seeds of *O. crenata* and *O. cernua* immediately harvested from the flowers did not germinate without a period of 20-30 days of preconditioning. Preconditioned seeds, at 23 ± 2 ^{0}C with 70% relative humidity for a period of 10 days, were able to germinate, produce germ tube and reach host root. Seeds did not germinate when the temperature was above 40 ± 2 ^{0}C and below 5 ± 2 ^{0}C.

Orobanchecrenata seeds, brown colour unconditioned and white colour conditioned and water imbibed ready to germinate seed

The preconditioned seeds germinated with the swelling of seed coat after absorbing moisture during the conditioning period. The color of the coat changes from light brown to dark brown after two days and the proximal end of the imbibed seeds became more pointed and protruded from the base. The testa gets ruptured and germ-tube protrudes after which it elongates in size to reach the host root and attach. After attachment to the host, the parasite draws the nutrients and forms the tubercle. The tubercle then produces the flowering stalks.



Tubercles of *Orobanche* attached to the roots of tomato

The floral stalks of *O. crenata* are of different sizes, varying from as small as 10 to 40 cm above ground, depending upon the condition of the host.

Different floral stalk size of *O. crenata* on tomato

3.1.2.1 Germination of *Orobanche*

The nitrogen content was analyzed from soil samples collected from the *Orobanche* infested sites at Jabalpur, Gwalior, Murena *etc.* It was found that high available N content had less incidence of *Orobanche*. Continuous flooding for more than 1 day or excess moisture for more than 2 days reduced germination to 20% and 40%, respectively. Excess moisture and temperature more than 35 ± 2 ^{0}C for more than 2 days reduced the germination to 20%.

3.1.2.2 Effect of various treatment on *Orobanche* in brinjal field

Effect of various treatments on *Orobanche* was studied at Khinni village near Jabalpur. This study was performed in a plot size of 10.8 m^2 with three

replications having six treatments and one control (T_7). Brinjal seeds were sown at the end of October 2014. First four treatments *viz.* (T_1- *Fusarium* spp. DWSR1 20 ml of 50% spore suspension/plant; T_2- *Penicillium oxalicum* DWSR1 20ml of 50% spore suspension/plant; T_3- Borax 10 ml/plant @ 5 mM and T_4- Thiourea 10 ml/plant @ 5 mM) were given at 30-40 DAP (days after plantation) whereas two treatments *viz.* T_5- Propiconazole fungicide @ 0.2% and T_6- Imazathapyr @ 75 g/ha *i.e.*, 0.81 ml for 10.8 m^2 plot size was given at 40-60 DAP. Second treatment was given after 30 days of first treatment where it was observed that herbicide imazathapyr 75 g/ha was causing phytotoxicity hence herbicide treatment was not applied in the secondary treatment. Results revealed that *Orobanche* infestation was less in *P. oxalicum* DWSR1 in comparison to *Fusarium* spp. DWSR1 whereas borax @ 5 mM has shown less infestation (Figure 3.6). Maximum and minimum stalk height of *Orobanche* was recorded 8.71 and 4.57 cm, respectively.

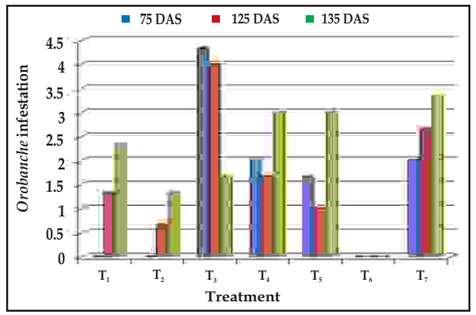


Figure 3.6: Number of *Orobanche* infestations under various treatments on brinjal

3.1.2.3 Effect of various treatments on *Orobanche* in the mustard

Effect of various treatments on *Orobanche* was studied at Gwalior in mustard field with five treatments and four replications in a plot of size 3.6 x 2.7= 9.72 m^2. Sowing of mustard seed was done at the end of November 2014. After 30 days of sowing, treatments *viz.*, T_1- *Fusarium oxysporum* DWSR1 30 ml of 50% spore suspension/plant, T_2- *Penicillium oxalicum* DWSR1 30 ml of 50% spore suspension/plant, T_3- Borax 10 ml/plant @ 5 mM, T_4- Thiourea10 ml/plant @ 5 mM, T_5- Sulfosulfuron herbicide treatment @ 13.5 g/acre *i.e.*, for plot size 9.72 m^2, 0.02 g were applied. Second treatment was given after 30 days of first treatment. Results indicated that in borax and thiourea treated plots, infestation was less (12.50 and 14.75, respectively) compared to the bioagents *viz.*, *F. oxysporum* DWSR1 (19.25) and *P. oxalicum* DWSR1 (21.75). Sulfosulfuron applied at 13.5 g/acre resulted in complete mortality of 30 days old plants of mustard (Figure 3.7). Maximum and minimum stalk height of *Orobanche* was recorded 8.0 and 2.3 cm, respectively

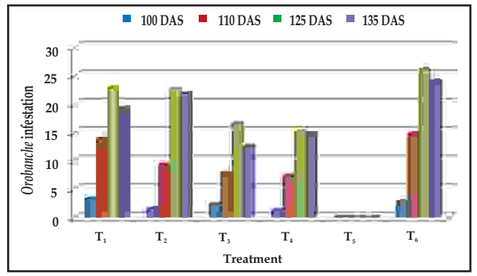


Figure 3.7: Number of *Orobanche* infestations for various treatments on mustard

3.1.2.4 Effect of borax and thiourea on *Orobanche* germination

It was found that the aqueous solutions of either borax or thiourea rapidly decompose the germination stimulants (*e.g.* GR24 and Nijmegen-1). This action in natural conditions would deprive the essential germination stimulants in seeds and thus will not allow them to germinate. The phytotoxicity reference scale is very useful for quantifying the effect of a chemical on the health of a plant. The scale '0' means no harm to plant while its progressive increase will indicate progressive harm and scale '5' will indicate death of the plant. Testing of different concentration of borex and thiourea on tomato seedlings revealed 5 mM concentration safe on tomato seedlings. Therefore, concentration of borax and thiourea should not exceed 5 mM for the planned quenching experiments.

A study was conducted to see the effect of borex and thourea on germination stimulants and *Orobanche* germination Results indicated that reasonable percentage of seeds germinated after incubating with the stimulant Nijmegen-1. Borax solution (1 mM) was added to the medium containing the *O. crenata* seeds, followed by Nijmegen-1 after 48 h of incubation. In this case, no germination was observed, even not after a long exposure time. The same was observed when Thiourea (1 mM) was used instead of borax. When the stimulant Nijmegen-1 and borax (1 mM) were applied simultaneously, no germination was observed either. The same holds when thiourea (1 mM) was used instead of borax. This revealed that effective quenching of the stimulant can be achieved at a concentration level of 1 mM. This effective concentration is much lower than the critical range of 5 mM for any phytotoxic effect. Contacting *O. crenata* seeds with the roots of tomato seedlings revealed a reasonable germination. When borax (1 mM) was added to the medium before bringing in the tomato roots, followed by the tomato seedlings after an incubation time of 48 h, no germination was observed at all (Table 3.2a). When thiourea (1mM) was used instead of borax, also no germination of seeds was observed (Table 3.2b). By exposing the *O. crenata* seeds simultaneously to the tomato seedlings and either borax (1mM) or thiourea (1mM), no germination was observed in either case.

Table 3.2a: Effect of borax and thiourea on the germination of *O. crenata* seeds induced by Nijmegen-1 (Nijm)

Treatment	No. of seeds germinated after days of application					
	5	10	15	20	25	30
Borax (1 mM) + nijm (0.1mM) after 48 h	0* (0.71) #b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Thiourea (1 mM)+nijm (0.1 mM) after 48 h	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Nijm (0.1 mM) + borax (1 mM) (simultaneous)	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Nijm (0.1 mM) + thiourea (0.1 mM) (simultaneous)	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Control (distilled water only)	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Nijm 0.1mM in water	0.33(0.88)a	15.58(4.0)a	23.66(4.91)a	27.33(5.28)a	30.66(5.58)a	41.66(6.49)a

Table 3.2b: Effect of borax and/or thiourea on the germination of *O. crenata* seeds induced by tomato seedlings

Treatment	No. of seeds germinated after days of application				
	10	20	30	40	50
Tomato seedlings in water	0* (0.71)#a@	15.3(3.97)a	21.3(4.67)a	31.6(5.67)a	34.6(5.93)a
Borax + tomato seedlings after 24 h	0 (0.7 1)a	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Thiourea (1 mM) + tomato seedlings after 24 h	0 (0.71)a	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Tomato seedlings + borax(1 mM) (simultaneous)	0 (0.71)a	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Tomato seedlings + thiourea (1 mM) (simultaneous)	0 (0.71)a	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b
Control (distilled water only)	0 (0.71)a	0 (0.71)b	0 (0.71)b	0 (0.71)b	0 (0.71)b

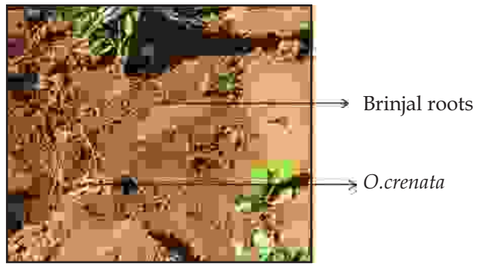
* The number outside the bracket is the phytotoxicity index values
\# Number inside the bracket are the transformed values of the original values given outside the bracket,
@Same letter in the same column indicates that the values are not significantly different from each other at 0.05% level of significance

3.1.2.5 Development of sick plot

A sick plot of *Orobanche cernua* attacking mustard and *O. crenata* attacking tomato and brinjal was developed with an aim to have more focused work on the management of *Orobanche*. Infested soil was brought from a farmer's field infested with *O. crenata*. The surface soil upto about 10 cms depth was removed and brought to the Directorate farm on August 2014. The infested soil was spread using spreader and left as such for natural preconditioning of the seeds in the soil. The seeds of *O. cernua* collected from our pot cultutre experiments were also spread in the same field.

After the end of rains, the host crops mustard and brinjal/tomato were sown in September. The *Orobanche* infestation appeared from the month of October last week in brinjal and the floral stalks were seen by end of November on mustard. Observations

on *Orobanche* population and the analysis of soil nutrients were conducted. Number of *Orobanche* infestation observed in a week interval is given (Table 3.3).



Reach of the roots of brinjal and the infection of *O. crenata*

Table 3.3: *Orobanche* population in sick plot at ICAR-DWR Jabalpur

Day of observation	No. of *Orobanche* infestation	
	Brinjal	Mustard
12 th week	6	0
13 th week	8	2
14 th week	12	2
15 th week	20	3
16 th week	23	6
17 th week	28	11
18 th week	37	14
19 th week	42	16
20 th week	46	21
21 th week	85	38
22 th week	113	70

3.2 Biology and management of problematic weeds in non-cropped areas

3.2.1 Integrated management of *Chromolaena odorata* in Chhattisgarh

Cromolaena odorata, a problematic weed of North-East, Western Ghat, Karnataka and Tamil Nadu has spread its tentacles in Baster area of Chhattisgarh. Earlier, it was not considered a problematic weeds of this region but in a sort span of about 15 years, it has infested large area of community land, wasteland and forest lands in and around Bastar region. Survey in 2014 revealed increase in its infestation area during last two years. Keeping in view of its seriousness and to check its further invasion from this region of Chhattisgarh to Maharastra and Madhya Pradesh, the present study has been taken up.

Severe infestation of *Choromolaena odorata* in teak plantation

In this region, the first attempt of classical biological control was made in 2012, when about 3000 galls infested with gall fly were released in the infested area. Symptoms of establishment of bioagent were not observed in 2013. Therefore, again 1500 infested galls were released in the three different sites of Jagdalpur area in September 2013. Again in 2014, about 500 galls were released in teak plantation site. Survey done during 2014 revealed the presence of galls on *Chromolaena odorata* indicating the start of establishment process. Samples taken from nine different plots for gall formation, revealed the presence of galls varying from mean 1.67 to 7.08 per 25 m^2

An experiment was laid out to see the effect of different seed rat of *Cassia tora* and different dose of herbicides in *Chormolaena* replacement and control, respectively. There were 10 treatments replicated four time in a plot area of 5 x 5 m each. The *Cassia tora* was shown on 11 July, 2014 and herbicide was sprayed on 24 July, 2014.

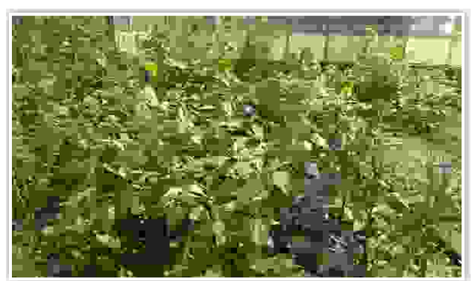
Cassia tora broadcasting at the rate of 80 kg/ha was found effective to replace *Chromolaena odorata* (WCE 64.01%) after 75 days. Among herbicides, metribuzin 2.0 kg/ha was found superior (WCE 92.35%) over 2,4-D 2.kg/ha (WC 58.325%) and glyphosate(83.89 %) after 75 days (Table 3.4)

Table 3.4: Effect of different treatments on density and dry matter accumulation of *Chromolaena odorata*

Treatment	Density (no./m^2)		Dry matter (g/m^2)		WCE (%)	
	50 DAT	75 DAT	50 DAT	75 DAT	50 DAT	75 DAT
Cassia tora @ 40 kg/ha	17.13 (4.14)	20.44 (4.53)	8.57 (2.94)	10.22 (3.20)	41.86	37.64
Cassia tora @ 60 kg/ha	11.72 (3.43)	15.03 (3.88)	5.86 (2.43)	7.52 (2.75)	60.24	54.13
Cassia tora @ 80 kg/ha	8.49 (2.92)	11.79 (3.44)	4.25 (2.07)	5.90 (2.44)	71.18	64.01
Glyphosate 1.5 kg/ha	2.07 (1.45)	5.75 (2.41)	1.03 (1.04)	2.87 (1.71)	92.99	82.47
Glyphosate 2.0 kg/ha	1.97 (1.42)	5.28 (2.31)	0.98 (1.02)	2.64 (1.64)	93.33	83.89
2,4 -D ester 1.5 kg/ha	10.30 (3.22)	13.61 (3.70)	5.15 (2.28)	6.80 (2.62)	65.07	58.48
2,4 -D ester 2.0 kg/ha	10.35 (2.56)	13.66 (2.94)	5.17 (1.81)	6.83 (2.08)	64.90	58.32
Metribuzin 0.50 kg/ha	3.98 (1.59)	7.28 (2.15)	1.98 (1.13)	3.64 (1.52)	86.53	77.78
Metribuzin 0.75 kg/ha	1.28 (1.15)	1.48 (1.24)	1.08 (1.07)	1.25 (1.14)	92.64 0	92.35 0
Control	29.47 (5.43)	32.78 (5.73)	14.74 (3.85)	16.39 (4.05)	- -	- -
LSD (P=0.05)	0.16	0.05	0.30	0.21	-	-

Figure in parentheses are original values

Attempts were made to establish *C. odorata* in net house and field conditions at DWR for mass multiplication of bioagent but only meager success achieved. Only about 15 galls formed in the net house after release of about 55 galls brought from Bengaluru. There was mild germination of *C. odorata* from seeds in the net house but germinated well from root stock brought from Jagdalpur. However, in field conditions at DWR, only 21% plants emerged from the roots and buried in the soil. There was no gall formation in the field conditions.



Chromolaena establishment in net house

3.3 Biology and management of aquatic weeds

3.3.1 Effect of inoculation of *Alternaria alternata* and *A. eichhorniae* on water hyacinth and fishes

3.3.1.1 Demonstration of biological control of water hyacinth using *Alternaria alternata*

A. alternata, mass multiplied in talc formulation (molasses yeast agar medium) was sprayed on water hyacinth in the institute pond. About 1 kg of talc formulation was miced in 50 litres of water and 250 ml starch solution (rice solution) was added as stickening agent. The solution was mixed thoroughly and contents was filtered to remove the settled talc. The filtrate was then sprayed with large nozzle in knapsac sprayer at 1 kg/100 m^2. The spraying was done during the evening time to take advantage of the humidity and to avoid sunlight. The fungus would establish well under such conditions. The experiment started with the healthy water hyacinth plants collected from the natural ponds near Jabalpur during the month of

September, 2015. Disease intensity and severity (DI and DS) calculated showed progressive increase in the disease of the plants from 5 days onwards. The infected plants remained stunted and did not flower. The DI increased from 0.16 in first week to 8.5 % after 8 weeks. The DS increased from 0.14 to 11.62 during the same period.

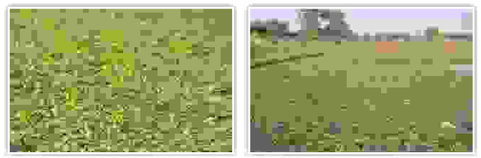
The following disease and host growth variables were quantified in every 30 days for 120 days (Table 3.5): number of green (=live) original leaves (NGOL); number of diseased original leaves (NIOL); disease severity on original leaves (DSOL); number of new, live leaves produced on original ramet (NNL); number of new leaves that become diseased on original ramet (NNIL); disease severity on new leaves of original ramets (DSNL); number of new, secondary ramets (NNR); number of live leaves on new ramet (NLNR); number of diseased leaves on new ramet (NILNR); disease severity on leaves of new ramet (DSLNR); number of dead non-original leaves (NDL) and disease incidence on new leaves of original ramet (DINL). Average Disease severity (DS) and disese index (DI) for whole plant was also calculated (Table 3.6)

Table 3.5: Effect of *Alternaria alternata* DWSR 1 on water hyacinth

Parameter	6 DAS	30 DAS	60 DAS	90 DAS	120 DAS
NGOL	5.00	3.60	2.60	2.60	2.00
NIOL	0.00	1.40	4.80	3.60	4.00
DSOL	1.40	1.60	2.00	2.60	2.80
NNL	1.60	2.20	2.40	2.80	2.80
NNIL	0.40	1.60	2.40	3.00	3.40
NNR	0.60	1.00	1.00	1.00	1.00
DSNL	0.00	1.80	2.40	2.60	2.80
NLNR	1.40	2.60	2.00	1.60	1.40
NILNR	0.80	1.80	2.00	2.60	2.80
DSLNR	0.00	1.60	1.80	1.80	2.60
NDL	0.00	0.00	0.20	0.60	1.40
DINL	1.40	1.80	2.40	2.60	2.60
DS	0.16	0.54	6.95	7.45	8.50
DI	0.14	1.65	8.99	10.29	11.62

Table 3.6: Disease severity and disease incidence of *Alternaria alternata* DWSR1 on water hyacinth

Days after spraying (DAS)	DS	DI
6	0.16	0.14
30	0.54	1.65
60	6.95	8.99
90	7.45	10.29
120	8.5	11.62



Before spraying | 30 days of spraying

60 days of spraying | 90 days of spraying

120 days of spraying | Intact leaves submerged due to fungal rotting of the air sacs

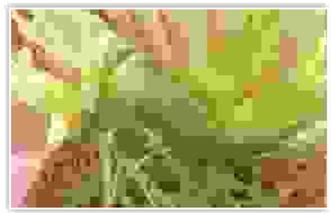
Demonstration on efficacy of fungal bioagent *Alternaria alternata* DWSR1 and *Neochetina* spp. on water hyacinth plant at DWR pond.

3.3.2 Integrated management of *Pistia stratiotes*

Pistia stratiotes, commonly called water lettuce, has become an emerging problem in aquatic bodies in Jabalpur and surrounding areas. During survey, *Pistia* infestation was found in many other ponds and aquatic bodies in and around Jabalpur indicating its fast spread in the area. Earlier, no such large infestation of *Pistia* was observed.

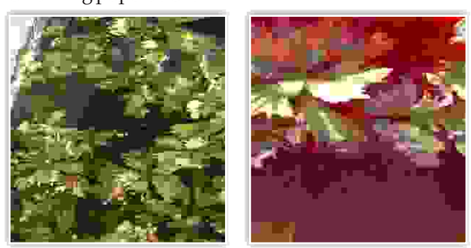
To find out effective indigenous bioagents for biological control of *Pistia*, surveys were made in aquatic bodies of Jabalpur. During survey, a few species of insects feeding on *Pistia* were collected namely aphid (2), grass hopper (2), coleopteran beetle (1), larvae (2) but they were of polyphagpus nature. Larvae of one another species feeding voraciously on *P. stratiotes* were collected and brought to the laboratory. The larvae were reared and moth was obtained and identified as *Spodoptera pectinicornis.* Biology of this species was studied. Female laid eggs in masses and each egg mass contained eggs varying from 110 to 130. The average fecundity was recorded 533/female and maximum 700 eggs were laid by single female. Oviposition period was 2-7 days while 3-6 days was incubation period. Larval, pupal and total development period was recorded 17- 21, 3-5.5 and 28-30 days, respectively.

Host specificity test on 33 plant species revealed no complete development of larvae and subsequent emergence of adult which reflected that insect is host specific. First instar larvae fed slightly on two plant species and moderately on one, while, third instars fed slightly on four, moderately on two, and heavily on one plant species. Fifth instars fed slightly on three, moderately on four, and heavily on two plant species. In all tests, no larvae lived longer than 5 days except on *P. stratiotes*. In multichoice oviposition tests, moths laid over 78% of their egg masses on *Pisita,* 14% on water hyacinth, 2% each on alligator weed, brinjal, tomato and *Trianthema portulacastrum*.



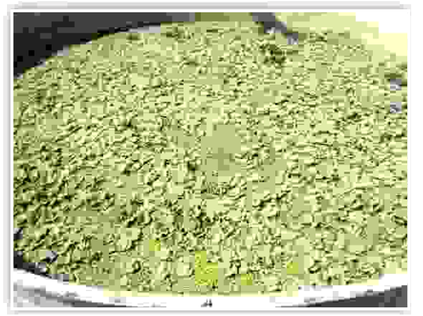
Moth and larvae of *Spodoptera pectinicornis*

During rainy season, larvae were found feeding the leaves. Initially, they feed on soft tissues and subsequently feeds on the outer portion of leaves. On increase in population, up to 70% of the weeds were succumbed to the pressure of larvae but *Pistia* mat was not completerly killed. On reduction of population, *Pistia* again increased its density from the remaining population.

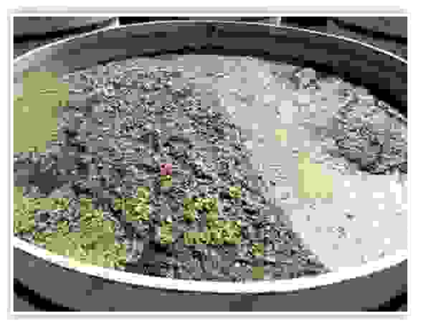


Impact of bioagent on *Pistia stratiotes*

Three herbicides namely 2,4-D, glyphosate and metsulfuron-methyl were tested on *Pistia* in different concentrations. Metsulfuron-methyl 6 g/ha emerged most effective herbicide followed by glyphosate (2.0 kg/ha), while 2,4-D (1.5 kg/ha) did not control the weed. It was found that *Pistia* has great capacity to regrow fast from the uncontrolled plants.



Herbicide spray on mat of *Pistia*



Killing of *Pistia* by metsulfuron-methyl

Regneration from a few uncontrolled *Pistia*

Chapter - 4

RESEARCH PROGRAMME - 4

MONITORING, DEGRADATION AND MITIGATION OF HERBICIDE RESIDUES AND OTHER POLLUTANTS IN THE ENVIRONMENT

Persistence of herbicide residues is of great concern as presence of herbicide residues in the soil may not only damage the sensitive succeeding crops but also adversely affect human and animal health due to bioaccumulation of residues in crop produce. Due to rain and irrigation persisting residues are likely to move towards subsurface soil and may contaminate ground water. Thus project on monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment has been initiated. Crop, water and soil samples were evaluated to determine persistence and bioaccumulation of various herbicides in fishes and crops under field conditions.

Sub -programme	Experiments	Associates
4.1 Impact of herbicides in soil, water and non targeted organisms and herbicide mitigation measures	4.1.1 Residues of metsulfuron - methyl, chlorimuron, bispyribac and pendimethelin in the soil of rice field	Shobha Sondhia, R. P. Dubey
	4.1.2 Effect of metsulfuron-methyl, chlorimuron, bispyribac and pendimethelin on water quality and fish mortality in ponds	Shobha Sondhia, P. J. Khankhane
	4.1.3 Evaluation of major degradation products of carfentrazone-ethyl, metsulfuron-methyl and bispyribac sodium in field soil by LC/MS/MS	Shobha Sondhia
	4.1.4 Evaluation of risk of ground water contamination by the continuous use of herbicides	Shobha Sondhia
	4.1.5 Change in pH and EC of leachates after pretilachlor application and following rain in *Kharif* 2014	Shobha Sondhia P. J. Khankhane
	4.1.6 Identification of metabolites/transformation products of pretilachlor in soil and water at various depths in lysimeter of 1-3 m depths	Shobha Sondhia
4.2 Degradation of herbicides in the environment	4.2.1 Phototransformation of bispyribac-sodium in soil-water biphasic system	P.P Choudhary
	4.2.2 Bispyribac-microbes interaction in rice rhizospheric soil	P.P Choudhary
4.3 Bio-remediation of pollutants using terrestrial / aquatic weeds	4.3.1 Testing of terrestrial weed based phytoremediation system for waste water treatment for irrigation.	P.J. Khankhane, Shobha Sondhia, R.P. Dubey

4.1 Impact of herbicides in soil, water and non-targeted organisms and herbicide mitigation measures

4.1.1 Residues of metsulfuron-methyl, bispyribac, chlorimuron and pendimethelin in the soil of rice field

Almix, bispyribac-sodium and pendimethelin were applied at 20, 25 and 750 g/ha to the paddy crop in *Kharif* and clodinafop+metsulfuron-methyl (60+4 g/ha), sulfosulfuron+metsulfuron-methyl (28+4g/ha) and pendimethelin (750 g/ha) were applied in *Rabi* to wheat plots at recommended doses.

Herbicide residues/dissipation was determined in water, soil and plants at zero days to till harvest. Water and fishes samples were collected after herbicide application and rain events in *Kharif* and after flood irrigation in *Rabi* between 0 to 100 days to see bioaccumulation and persistence of herbicides. Effect of herbicides on fishes mortality and water quality was also evaluated in the respective days. All samples were processed and analyzed for residues by HPLC.

Metsulfuron-methyl and chlorimuron residues in the soil of rice field were found in the range of 0.040-0.0013 µg/g between 0-60 days. After 90 days metsulfuron-methyl and chlorimuron residues were not detected in the soil. As a herbicide mixture, a combined 0.0796 to 0.0305 µg/g residues of metsulfuron-methyl and chlorimuron were detected in the soil up to 20 days. Metsulfuron-methyl and chlorimuron residues were found in the range of 0.295-0.0017 µg/g between 0-30 days in the rice plants. After 30 days metsulfuron-methyl and chlorimuron residues were found below 0.001µg/g in the rice plants. As a herbicide mixture, a combined 0.3504 to 0.0057 µg/g residues of metsulfuron-methyl and chlorimuron were detected in the rice plants up to 30 days. Residues of metsulfuron-methyl and chlorimuron were found 0.0832 to 0.0171 µg/mL in the pond water between 1-20 days. Bispyribac and pendimethalin residues were found in the range of 0.32-0.013 µg/g and 0.258-0.001 µg/g between 0-30 days. After 90 days residues were not detected in the soil. Bispyribac-sodium residues were found in the range of 2.865-0.0267 µg/g between 0-30 days. Pendimethalin residues were found in the range of 4.078- 0.0075 µg/g between 0-90 days. After 90 days pendimethalin residues were found below 0.001 µg/g in the soil (Fig. 4.1).

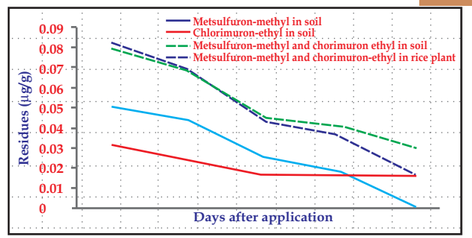


Figure 4.1 Dissipation of metsulfuron-methyl and chlorimuron-ethyl in the soil

4.1.2 Effect of metsulfuron-methyl, chlorimuron, bispyribac and pendimethelin on water quality and fish mortality in ponds water

In the fishes, 0.007, 0.0691 and 0.0376 µg/g residues of metsulfuron-methyl, bispyribac and pendimethelin were found after 30 days in fishes. Herbicides treatments did not altered water quality significantly (Table 4.1 and 4.2). Mortality of fishes was not observed due to bispyribac-sodium, metsulfuron-methyl+chlorimuron-ethyl and pendimethain in *Kharif* season. At 60 days bispyribac-sodium, metsulfuron-methyl+chlorimuron-ethyl and pendimethain residues in fishes were <0.001 in the fish.

Table 4.1: Change in pH and EC of the soil due to herbicides application in paddy field (*Kharif* 2014)

Days	Control		Metsulfuron-methyl+ chlorimuron		Bispyribac sodium		Pendimethalin	
	EC	pH	EC	pH	EC	pH	EC	pH
0	71.2	7.00	82.1	6.05	78.5	5.85	115.4	5.95
5	126.7	6.65	69.0	6.00	125.8	5.90	96.4	6.00
10	104.8	6.60	99.4	6.10	114.0	5.95	174.3	6.15
20	103.7	6.75	64.0	6.80	107.2	6.80	111.6	6.10
30	104.4	7.15	115.5	6.85	94.6	6.80	122.1	7.40
60	108.0	7.50	100.1	7.15	111.4	7.30	130.3	6.85
90	70.2	7.20	72.9	7.25	95.7	7.00	171.8	7.05
At harvest	135.7	7.55	118.0	6.65	143.05	6.60	141.0	6.90

Table 4.2: Change in pH and EC of the pond water due to herbicides application in paddy field (*Kharif* 2014)

Day	Control		Metsulfuron-methyl+ chlorimuron		Bispyribac sodium		Pendimethalin	
	EC	pH	EC	pH	EC	pH	EC	pH
0	521.5	6.65	547.5	6.65	532.0	6.55	465.5	6.70
5	494.9	7.50	363.5	8.05	447.5	7.90	404.3	7.80
10	461.1	7.55	575.2	7.75	613.0	7.70	407.4	8.05
20	426.5	7.80	349.5	7.75	410.2	7.30	388.5	7.75
30	419.3	7.60	437.2	8.05	582.1	7.65	419.5	7.05
60	545.5	7.62	406.5	8.10	609.4	7.70	378.7	7.70
90	696.2	7.95	480.5	7.45	607.3	7.50	546.5	7.80
At harvest	673.5	7.70	467.5	7.75	692.5	7.50	510.4	7.60

4.1.3 Evaluation of major degradation products of carfentrazone-ethyl, metsulfuron methyl and bispyribac-sodium in field soil by LC/MS/MS

Two metabolites of carfentrazone were isolated and identified from soil of wheat field by LC-MS/MS in the soil and characterized as carfentrazone-chloropropanoic acid (I) and 3-desmethyl-carfentrazone - chloropropanoic acid (II).

Three metabolites of metsulfuron-methyl were identified by LC-MS/MS in the soil as 2-amino-4-methoxy-6-methyl-1,3,5- triazine -2yl urea, 2-amino-4-methoxy-6-methyl-1,3,5- triazine and 2-amino- 4-hydoxy-6-methyl-1,3,5- triazine (Figure 4.2, 4.3 and 4.4).

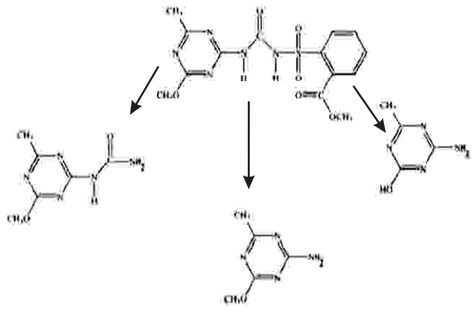


Figure 4.2: Identification of metabolites of metsulfuron-methyl

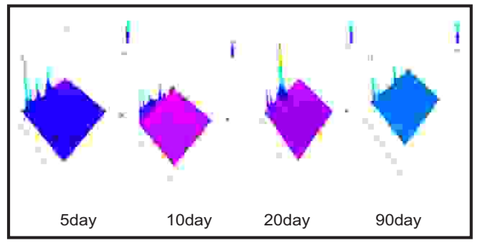


Figure 4.3: Identification of metsulfuron-methyl metabolites in soil

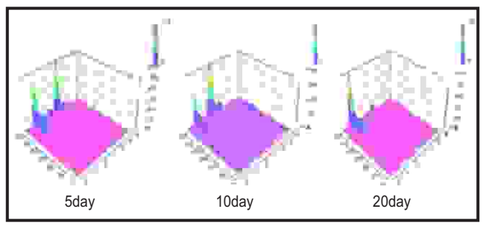


Figure 4.4: Identification of metsulfuron-methyl metabolites in fishes

The three degradation products of bispyribac-sodium in the soil, rice plants and water were identified as 2,4-dihydroxy benzoic acid, 2-hydroxy-6-[-4-hydroxy-6-methoxy pyrimidine-2-yl)oxy] benzoic acid and 2-[4,6-dimethoxy pyrimidine-2-yl)oxy]-6-hydroxy benzoic acid (Figure 4.5).

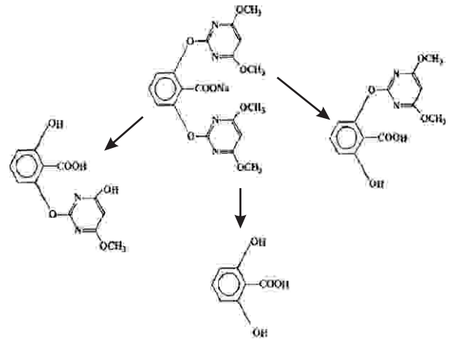


Figure 4.5: Identification of metabolites bispyribac-sodium

Three major metabolites of iodosulfuron were detected from soil and two from rice plants were: identified as 2-amino-4-methoxy-6-methyl 1,3,5 triazine, 2-amino-4-methoxy-6-methyl 1,3,5 triazine urea hydroxy-1,3,5 triazine methyl-4-iodo-2[3-(4-methoxy-6-methyl 1,3,5 triazine -2yl) uridosulfomyl] benzoate. *Aspergillus niger* was found to degrade higher concentration of iodosulfuron in soil.

4.1.4 Evaluation of risk of ground water contamination by the continuous use of herbicides

Pretilachlor was sprayed at 750 and 1500 g/ha doses to the surface of each lysimeter under field conditions and allowed to receive natural rain (approximately 1520 mm). Soil samples at 0-25, 25-50, 50-75, 75-100, 100-125, 125-150, 150-175, 175-200 and 200-225 cm depths were collected and analyzed by HPLC to see the movement of pretilachlor in the soil and to predict possible risk of ground water contamination through herbicides. Leachates were also collected and analyzed to see the movement of pretilachlor.

Pretilachlor residues were higher in surface soil and were found up to 60 days in soil at various depths. Pretilachlor leaching increased the soil pH (7.1 to 8.4) at various depths after its application. After 3-days, 2.482-0.0239 µg/g pretilachlor residues were detected at various depths in the lysimeter where rice plants were grown. Whereas 0.0688-0.0014 µg/g pretilachlor residues were detected in the various soil depths at 60 days. In leachates 0.8344-0.0052 µg/g pretilachlor residues were found from 22 July to 15 September showed that under saturated moisture conditions it may leach to lower depths. Afterwards pretilachlor residues were not detected in the leachates.

4.1.5 Change in pH and EC of leachates after pretilachlor application and following rain in *Kharif* 2014

pH (7.1 to 8.4) and electrical conductivity (420-2000 µS/cm) were changed significantly in the leachates after each rain events (Table 4.3).

Table 4.3: Change in physico-chemical parameter due to pretilachlor application in the leachates of soil lysimeters

Date	1M				2M				3M			
	T1		T2		T1		T2		T1		T2	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
22/07/14	7.5	1710	7.6	1290	7.6	1400	7.1	560	7.3	420	7.5	1210
23/07/14	7.6	1270	7.8	1040	7.8	1000	7.6	260	7.6	840	7.6	1165
30/07/14	7.8	1925	7.8	1400	7.9	1693	8.0	1889	7.8	1270	8.2	1290
05/08/14	7.6	1592	7.6	1413	7.6	1678	7.9	1734	7.8	1953	8.1	1490
06/08/14	7.6	1512	7.4	1445	7.5	1587	7.6	1739	7.6	1483	7.5	1776
11/08/14	8.2	1601	8.1	1608	8.1	1236	8.3	1409	8.2	1259	8.4	1978
04/09/14	8.2	2000	8.0	1984	8.0	1415	7.8	1653	7.6	1391	8.0	1116
09/09/14	8.2	1935	8.2	1796	8.2	1535	8.1	1764	8.1	1526	8.4	1589
15/09/14	8.3	1737	8.3	1302	8.4	1460	8.3	1661	Nil	Nil	Nil	Nil

4.1.6 Identification of metabolites/transformation products of pretilachlor in soil and water at various depths in lysimeter of 1-3 meter depths

Metabolites/transformation products of pretilachlor were found in soil and leachates were identified as, 2',6'-diethyl-N-(propoxyethyl)acetanilide; 2',6'-diethyl-N-(2-hydroxyethyl)aniline; 2',6'-diethyl-N-(ethoxyethyl)aniline; 2',6'-diethyl-N-(ethyl)aniline; acetanilide; 2-chloro-2',6'(diethyl)-N-methyl acetanilide; 2-chloro-2(1-hydroxyethyl,6'-ethyl)-N-(2-propoxyethyl acetanilide; 2-chloro-1-(9-ethyl-3-hydroxy-2,3,4,5-tetrahydro-1H-1benzazapin-1-yl)ethanone; (diethyl)-N-methyl acetanilide; and 2-chloro-1(-9-ethyl-3-hydroxy-2,3,4,5-tetrahydro-1H-1benzazapin-1-yl)ethanone.

4.2 Degradation of herbicides in the environment

4.2.1. Phototransformation of bispyribac-sodium in soil-water biphasic system

A study was conducted on the phototransformation of bispyribac-sodium in a biphasic soil-water system simulating soil-water environment of rice field. The experiment consisted of eight treatments each replicated thrice. In each soil-water system 4.5 cm of water was maintained on the soil layer of 4 cm depth. In case of the treatment containing water only a depth of 4.5 cm was always maintained. Bispyribac-sodium was applied on to the soil-water or water at the rate of 0.2 mg/kg of soil. All the treatments with open surface of water were exposed to sunlight in outdoor situation. A set of all the treatments was also maintained in the dark conditions. Another set of experiment on the photolysis of bispyribac-sodium was also carried out in closed system, i.e. in quartz flask containing distilled water and irrigation water spiked with the herbicide resulting in a solution of 10 ppm. During the exposure under sunlight sampling was done in regular interval. Soil and water samples were analyzed on high performance liquid chromatograph.

Bispyribac-sodium did not undergo direct photolysis readily. The photolytic half-life ($T_{1/2}$) of it in distilled water under closed system of quartz tube was found as 232 days. Whereas, the $T_{1/2}$ of it in distilled water under open surface condition was 32 days. Probably, dissolved CO_2, which becomes available in open surface condition, could enhance the rate of photolysis of bispyribac. Even during the irradiation of bispyribac dissolved in irrigation water, the $T_{1/2}$ was found to be 28 days in closed quartz flask. The enhanced rate of the photolysis of the herbicide in irrigation water, when compared to that in distilled water is due to the sensitization action offered by the dissolved organic matter and inorganic substances. This photochemical sensitization process was further revealed in the treatments containing the herbicide along with the humic substances and sodium nitrate, separately in sterilized distilled water. The $T_{1/2}$ values for bispyribac were 8 and 10 days in presence of humic substances and sodium nitrate, respectively.

Table 4.4: Photolytic half-life values of bispyribac-sodium in soil-water biphasic system and in different aqueous phases

System	Treatment	Half life (day)	R^{2*}
Open surface	Natural soil and water	5.52	0.83
	Sterilised soil and water	10.73	0.77
	Organic matter free soil and water (sterilized)	12.07	0.79
	Organic matter free soil + humic acid and water (sterilized)	7.36	0.81
	Distilled water	32.2	0.89
	Distilled water + humic acid	8.12	0.98
	Distilled water + sodium nitrate	9.61	0.76
	Distilled water + humic acid + sodium nitrate	8.46	0.89
Closed	Distilled water (in quartz flask)	232.60	0.90
	Irrigation water (in quartz flask)	28.02	0.95

The sensitizing effect of humic substances and inorganic compounds in the photolysis of bispyribac-sodium was revealed in the experiment conducted in a biphasic system of soil-water under natural light (Fig.4.6) through hydrolysis of bispyribac-sodium salt to its acid, i.e. bispyribac (2,6-bis[(4,6-dimethoxy-2-pyrimidinyl)oxy]benzoate). Different radicals were formed from bispyribac during irradiation in biphasic system. These radicals might also be formed from the chemical interaction between bispyribac and active species like super oxide, singlet oxygen and peroxides, which were generated from the irradiation of humic and inorganic substances in soil and water. These radicals formed from the herbicide reunited randomly making bonds of different combination with the formation of various photoproducts, *viz.*, 4,6-dimethoxypyrimidinyl phthalate, 2-(3-methoxy phenoxy)-4,6-dimethoxy pyrimidine, 2-methoxy methyl benzoate, 2,4,6-trimethoxypyrimidine, 2-(3-hydroxy phenoxy)pyrimidin-4,6-diol and pyrimidin-2,4,6-triol. Any degraded product of pyrimidintriol was not detected in this experiment.

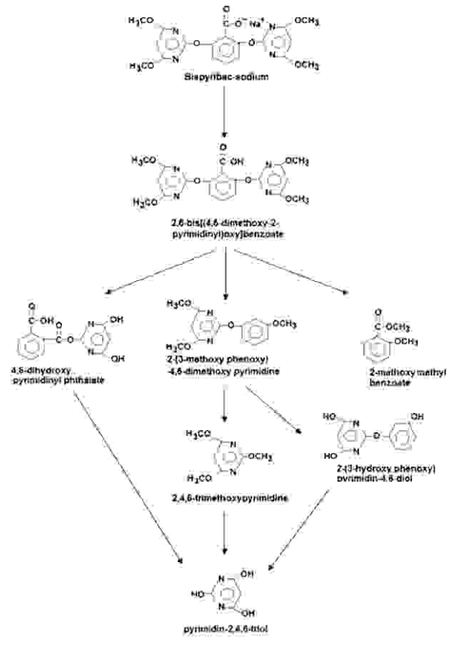


Figure 4.6: Degradation of bispyribac-sodium in the soil-water biphasic system

4.2.2 Bispyribac-microbes interaction in rice rhizospheric soil

Microbial degradation of bispyribac-sodium is reported as the major mode of degradation in rice ecosystem. The bispyribac-degrading microbes were isolated from rice rhizospheric soil by herbicide enrichment technique. The bacteria, which degraded the herbicide are characterized by 16s rRNA sequencing as *Pseudomonas* sp., *Bacillus megaterium* and *Lycinibacillis sphaericus*. Similarly, the bispyribac-degrading fungi were characterized by 18s RNA sequencing as *Saccharomycopis malanga, Aspergillus flavus, Aspergillus oryzae* and *Aspergillus flavus* EGY 1.

4.3 Bioremediation of pollutants using terrestrial/ aquatic weeds.

4.3.1 Testing of terrestrial weed based phyto-remediation system for waste water treatment for irrigation

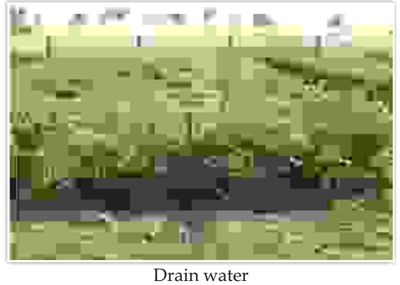
An experiment was carried out to find out effect of waste water application on metal accumulation in soil and to assess heavy metal uptake in tomato at farm. The eight treatments combinations were made including four main (tube well water, filtered water-I (*Typha* based) and filtered water-II (*Vetiveria* based) and drain water as control as irrigation treatment which were split -up with two treatment of with and without EDTA.

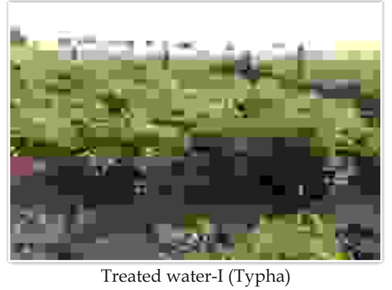
As far as accumulation of heavy metals in soil was concerned, higher concentration of DTPA extractable heavy metals cadmium and lead were observed in plots irrigated with untreated drain water as compared to tube well water. The values of Cd in soils was 0.15, 0.22, 0.24 and 0.30 mg/kg in surface soil under tube well water, filtered –I (*Typh*a treated), filtere treated-II (*Vetiveria* treated) and drain water irrigated plots respectively. The Pb accumulation in soils was 2.59, 2.67, 2.71 and 3.08 mg/kg in surface soil under tube well water, filtered – (*Typha* treated)I, filtered -II (*Vetiveria* treated) and drain water irrigated plots respectively.

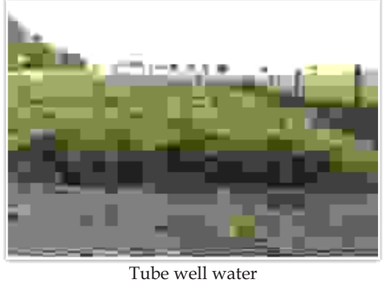
After irrigation with drain water tomato absorbed higher concentration of heavy metal than tube well water irrigation (Table 4.5). Comparatively lower concentration of heavy metals were retained in fruits of tomato than its shoot part. Nearly two fold increase in concentration of heavy metals was observed in tomato shoot. EDTA application enhanced the translocation of heavy metals in tomato. Significantly higher tomato yield was observed under plots irrigated with drain water.

Table 4.5: Effect of waste water on cadmium and lead concentration in different parts of plant.

Treatment	Cd (mg/kg)			Pb (mg/kg)		
	Root	Shoot	Fruit	Root	Shoot	Fruit
Main treatment						
Tubewell water	0.10	0.19	0.06	1.51	2.15	0.62
Filtered water- I (Typha based)	0.23	0.37	0.12	3.10	4.77	1.33
Filtered water-II (Vetiveria based)	0.24	0.39	0.13	3.27	4.92	1.33
Drain water	0.41	0.56	0.23	5.44	7.37	2.12
LSD (P=0.05)	0.03	0.05	0.03	0.56	0.44	0.16
Sub treatment						
Control	0.23	0.38	0.12	2.94	4.59	1.26
EDTA	0.27	0.37	0.15	3.72	5.01	1.44
LSD (P=0.05)	0.02	NS	0.01	0.22	0.18	0.06


Drain water


Treated water-I (Typha)


Tube well water


Treated water-II (Vetiveria)

Chapter - 5

RESEARCH PROGRAMME - 5

ON-FARM RESEARCH AND DEMONSTRATION OF WEED MANAGEMENT TECHNOLOGIES AND IMPACT ASSESSMENT

Technology transfer is equally important as technology development for sustenance of agriculture. Farmers fail to benefit from technological advances due to communication gap between research organization(s) and the end-users along with lack of technical know-how. Surveys carried out earlier revealed significant gap between available improved technologies and their adoption levels. However, no technology can perform equally in every agro-climatic situation. On-farm research (OFR) aims to test a new technology at farmer's field. It should help to develop innovations compatible with the actual farming system and corresponding to farmers' goal and preferences. Accordingly, the on farm research programme has been initiated to understand farmers' problems and undertake necessary interventions through farmer participatory approach to develop, test and evaluate cost effective solutions to their weed management related problems and probable ways of weed utilization.

Sub-programme	Experiments	Associates
5.1 On- farm research and demonstration of weed management technologies for higher productivity and income	5.1.1 Weed utilization for rhizo-filtration of low quality water for irrigation (Amkhera, Khairi / Urdua and Kachpura locality)	P.J. Khankhane Shobha Sondhia C. Sarathamble
	5.1.2 On-farm research and demonstration of weed management & weed utilization technologies (Dhanwahi and Khinni locality)	C. Kannan Meenal Rathore
	5.1.3 On-farm research and demonstration of weed management technologies in rice-based cropping system (Panagar locality)	H.S. Bisen Dibakar Ghosh Bhumesh Kumar
	5.1.4 On-farm research and demonstration of weed management technologies in rice-based cropping system (Shahpura locality)	Sushil Kumar Raghwendra Singh Yogita Gharde
	5.1.5 On-farm research and demonstration of weed management technologies in rice-based cropping system (Gosalpur / Sihora locality)	D.K. Pandey R. P. Dubey P.P. Choudhary
	5.1.6 On-farm research and demonstration of weed management technologies in rice-based cropping system (Kundam locality)	P.K. Singh V. P. Singh K.K. Barman
5.2 Impact assessment of weed management technologies on social upliftment and livelihood security	5.2.1 Impact assessment and adoptions of weed management technologies	P.K. Singh Yogita Gharde

5.1 On farm research and demonstration of weed management technologies for higher productivity and income

Initially, different localities of Jabalpur district were indentified and surveyed with regard to cropping pattern, location-specific weed problems and management practices being adopted. Accordingly, villages/farmers with little technical knowhow in terms of existing agricultural practices were selected. Subsequently, 5-6 farmers representing various sections were selected randomly in each locality. The OFR / demonstrations using IWM technologies were laid out in wheat & chickpea during winter season, and rice, soybean and maize during rainy season greengram during summer season. Similarly OFR/ demonstrations on weed utilization and composting of weed biomass were also conducted. Trials were conducted in a participatory mode with active involvement of the farmers.

5.1.1 Weed utilization for rhizo-filtration of low quality water for irrigation

Survey of multi-contaminated sites was carried out. in Jabalpur and adjoing area. Waste water samples were collected from drain sites: Amkhera, Khairi / Urdua and Kachpura. The collected samples were analysed for various pollutants (Table 5.1) Among the contaminated sites, higher COD, BOD, potassium, chloride and chromium was recorded at the Khairi site. Among the tested heavy metals, higher chromium (0.06 mg/l) was observed at the khairi site than Amkhera (0.0273 mg/l) and Katchpura (0.0115 mg/l). The total bacteria, fungi, diazotrophic and *E. coli* population were enumerated from different soils, water and vegetables of farmer's field in different location of Jabalpur and adjoining area (Table 5.2).

It is observed that the soils of Kachpura harboured more number of bacteria (43.0 cfu×10^6), fungi (15.0 cfu×10^3) and *E.coli* . The increase in *E.coli* count could be the result of their water contaminated by high level of *E. coli* (65.35 cfu×10^3). Among the different vegetable tested phyllosphere of methi collected from Kachpura area recorded the maximum total bacteria population of 32.3 × 10^6cfu per gram of dry soil. On other hand, higher numbers of epiphytic flora of *E.coli* were observed in radish (32.5 cfu ×10^3).

Table 5.1: Water quality parameters of contaminated sites in Jabalpur

Parameters	Units	Amkhera Drain	Khairi	Katchpura Drain
Total solids	mg/l	534.0	396.0	693.0
Oil & grease	mg/l	Nd	3.0	18.0
COD	mg/l	16.8	212	14.0
BOD (3 Days 27^0C)	mg/l	2.4	54	7.8
Total Hardness $CaCO_3$	mg/l	190.0	10.0	24.0
Sodium	mg/l	10.0	1.0	8.0
Potassium	mg/l	1.0	68.1	66.0
Calcium	mg/l	58.6	11.52	20.0
Magnesium	mg/l	12.96	38.91	193.0
Chloride	mg/l	43.78	77.6	20.0
Chromium	mg/l	0.0273	0.06	0.0115
Boron	mg/l	ND	ND	ND
Mercury	mg/l	ND	ND	ND
Arsenic	mg/l	ND	0.006	ND
Total Bacteria(cfu×10^6)	cfu×10^6	18.6 ± 2.19	15.6 ± 0.67	23.6 ± 1.76
E. coli (cfu×10^3)	cfu×10^3	28.0 ± 2.15	25.2 ± 3.58	65.3 ± 3.88
Fungi	cfu×10^3	NA	NA	NA
Total diazotrophs	cfu×10^5	NA	NA	NA

Table. 5.2: Assessment of micro -flora from multi-contaminated sites in Jabalpur and adjoining area

Type of sample/ place		cfu / g of soil on dry weight basis			
		Total Bacteria (cfu×10^6)	Fungi (cfu×10^3)	Total diazotrophs (cfu×10^5)	*E. coli* (cfu×10^3)
Soil	Urdua	33.5 ± 1.45	6.33 ± 0.67	26.67 ± 3.18	10.0 ± 0.58
	Amkhera	30.3 ± 1.86	9.33 ± 0.88	40.00 ± 2.00	8.00 ± 1.00
	Kachpura	43.0 ± 2.65	15.0 ± 2.08	32.67 ± 0.88	15.3 ± 0.88
Vegetable	Radish	25.0 ± 1.62	NA	NA	32.5± 2.10
	Palak	29.5 ± 2.40	NA	NA	19.4± 1.23
	Methi	32.3 ± 2.85	NA	NA	32.5± 4.15
	Pudhina	23.0 ± 1.65	NA	NA	24.8± 3.12

NA-not analyzed; Values are mean ± SE of three replicates

RESEARCH PROGRAMME - 5
DWR

5.1.2(a) On-farm research and demonstration of weed management technologies (Dhanwahi locality)

An OFR trial was conducted during rabi 2013-14 at Dhanwahi village, 45 Kms from Jabalpur. Wheat crop was sown on 05 December, 2013, in the presence of the scientists. The farmers viz., Kishore Singh, Bhadur Singh, S.K. Dubey, Shiv Singh were given quality seeds, fertilizers (120:70:40 NPK kg/ha) and the recommended herbicides (2, 4-D amine salt 58%, 500 g ai/ha). The major weeds present in the farmers fields were *Medicago hispida, Vicia sativa, Lathyrus sp., Chenopodium album.* The crop was harvested on 10 April, 2014. Samples were taken using the standard quartet at 5 points in each plot. The crop was then thrashed and the grains weighed (Table 5.3).

Table 5.3: Evaluation of on-farm improved weed management technology at Dhanwahi locality during *Rabi* 2013-14

Treatment	Weed population/ m^2	Weed dry weight g/m^2	Yield (t/ha)	Cost of cultivation /ha (₹)	Gross return/ha (₹)	Benefit: cost ratio
T_1 - Farmers practice	45.25	16.67	2.95	19150	41230	2.15
T_2 - Weedy	78.25	35.25	3.65	17400	51184	2.94
T_3 - No fertilizer + herbicide	36.25	28.5	2.47	17280	34608	2.00
T_4 - Recommended fertilizer dose + herbicide	20.5	13.15	4.25	15600	59598	3.82

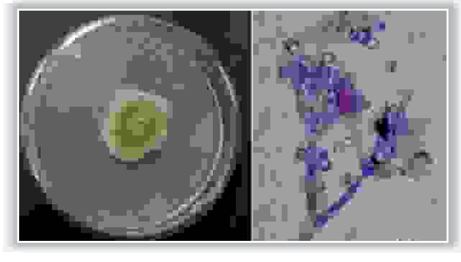
Mean values of from 4 fields

The results indicated that the weed technology prescribed by the DWR was effective in managing the weeds. The farmer could obtain a gross return of ₹ 59,598 with a B:C ratio of 3.82 when compared to the farmers practice (₹ 41,230 and B:C ratio of 2.15). In the treatment where fertilizers were not applied (T_3), the yield was very low (2.47 t/ha) mainly because of the high weed dry weight (28.5 g/m^2) next only to weedy plot (35.25 g/m^2). This may be mainly because of the unfertilized crop were very weak and could not compete with the weeds resulting in lesser yields. Thus it is clear that timely management of weeds with appropriate herbicides and application of fertilizers would help in managing the weeds and getting significantly higher yields.

On-farm research and demonstration of weed management technologies in wheat.

5.1.2(b) On -farm research and demonstrations on composting of weed biomass (Khinni locality).

An OFR was conducted on the composting of weed biomass obtained from the farmer's field. Two farmers viz., Mr. Kishorilal and Mr. Manoj were interested to participate and hence their fields were selected. The methodology prescribed to the farmer was as follows: *Trichoderma viride* was multiplied in potato dextrose broth solutions in large flasks, for about 15 days and entire mat of fungi with broth was mixed and used as the fungal inoculants. A shaded area of size 5 x 2.5 m^2 in the corner of the field, where there is no water logging was selected and cleaned of any debris. Weeds were segregated into cellulosic weeds for example *Parthenium*, *Alernanthera* and leguminous weeds such as *Medicago*. About 10 kg of finely chopped weed pieces are placed in alternating layers of cellulosic weeds and leguminous weeds, one over the other. In between two layers weeds, cow dung slurry (about 20 kg/pile) and *T. viride* inoculants were sprinkled uniformly. Up to six such layers were made and the top layer was covered with a gunny bag to maintain moisture. The layers were turned upside down after 35 days to provide aeration and at the end of the period, the compost material brown in colour was obtained. Care was taken not to excess moisture the pile. About 60 days were required for one cycle of composting.



Colony and conidial photograph of *Trichoderma viride*

The advantages of composting as explained to the farmers included improvement of the soil structure, improvement of overall plant growth by increasing the beneficial micro-flora in soil and availability of nutrients from compost is faster due to its narrow C: N ratio. The farmers were able to get 40 to 45 kg per compost pile. The compost was applied in brinjal plants of 60 days old. Since this is the first time application there was no significant increase in the growth of the plants. The farmer was apprised about the other advantages like water conservation.

5.1.3 On-Farm research trials of weed management technologies at farmers' field in wheat at Panagar locality

On-farm research trials were carried out to transfer the weed management technologies to progressive farmers and evaluate the technology at farmers' fields. OFR trials were undertaken at five locations in Mahagawa and Bharda villages in wheat crop during *Rabi* 2013-14. The good quality seed, fertilizers and herbicides were applied in selected farmers' fields. In all farmers' fields, the sowing of wheat crop was done by happy seeder machine without removal of previous crop residues (rice stubbles and straw) to demonstrate the conservation agriculture technology.

The herbicides used in these OFR trials were 2,4-D and mesosulfuron + iodosulfuron. Good germination and establishment of wheat crop had occurred. Framers practices include all except weed management. Weed counts, weed biomass was found to be less under both the herbicide treatments as compared to farmers' practitice. Major weeds were *Lathyrous sativa*, *Vicia sativa, Chenopodium album*, *Medicago denticulata* and *Melilotus alba* among broad leaved and *Avena* sp (wild oat) and *Phalaris minor* among grasses. In all the herbicide treated fields, very effective weed control was evident leading to the increased yield of wheat compared to the farmers practice. The results revealed that post emergence application of herbicides controlled *rabi* weeds effectively and gave higher cost benefit ratio (Table 5.4).

Table 5.4: Weed count, dry weight and seed yield and economics of wheat during *Rabi* 2013-14 in Panagar locality

Treatment	Weed count (no/m^2)	Dry weight (g/m^2)	Grain yield (t/ha)	Total income (₹ /ha)	Cost of production (₹ /ha)	B:C ratio
2,4-D	29.8	13.6	2.8	40056	18800	2.13
Mesosulfuron + iodosulfuron	26.0	13.6	2.9	41869	19875	2.11
Farmers' practice (FP)	69.9	54.8	1.8	26294	18000	1.46

Values are mean of five independent locations.

Rice at Panagar locality (*Kharif* 2014)

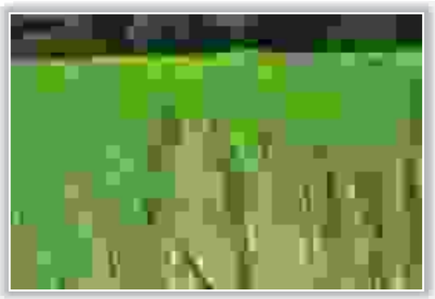
On-farm research (OFR) trials were undertaken on management of weedy rice through cultural interventions in Panagar locality. Purple colored variety 'Shyamla' with three treatments ((i) brown manuring followed by hand weeding at 40 DAS (ii) Hand weeding at 45 and 60 DAS and (iii) Farmers' practice. The crop was shown under DSR in weedy rice infested farmers' field. By growing colured variety of rice in weedy rice infested field. The identification of weedy rice became easy and can be easily removed through hand wedding. Brown manuring followed by hand weeding at 40 DAS and hand weeding at 45 and 60 DAS reduced the weedy rice population thus the crop yield was increased (Table 5.5)

Table 5.5: Effect of different cultural treatments on weedy rice and yield of rice

Treatment	Dry wt. of weedy rice g/m^2 at 60 DAS	Yield (t/ha)
Brown manuring followed by hand weeding at 40 DAS	36.7	2.07
Hand weeding at 45 and 60 DAS	34.2	1.75
Weedy Check	67.1	1.08
LSD (P=0.05)	15.5	0.44

Green Gram at Panager locality (Summer 2014)

On-farm research (OFR) trials were undertaken on green gram under conservation agriculture during summer season of 2014 at three farmers' fields in the Bharda, Nipania and Padaria villages of Panager locality. Happy Seeder was used to sow summer green gram and sowing was done just after harvesting wheat crop without removing or burning the standing crop stubbles. Result revealed that CA + imazethapyr 100 g/ha was effective and gave broad spectrum weed control and seed yield of 1.3 t/ha, as compared to 0.74 t/ha under FP (CT + no weeding) and provided an additional net return with higher B:C ratio over farmers practice. Beside this use of Happy seeder saved time and favoured early sowing which helped to utilize residual soil moisture, and saved field preparation cost. Unlike ZT Seed drill, Happy seeder utilized the wheat crop residue to mulch the field and thereby also helped in managing weed menace and improved soil condition (Table 5.6).



Sesbania alongwith rice for brown manuring

Farmers Practice field (Greengram)

Heavy infestation of weedy rice

OFR - Trial field (Greengram)

Table 5.6: OFR-cum-demonstration of weed management technologies under conservation tillage in summer greengram

	Treatment	Weed count (no./m²)	Dry weight (g/m²)	Control on dry matter basis	Grain yield (t/ha)	Cost of production ₹/ha	Gross income ₹/ha	B : C ratio
Location 1	Imazethapyr @ 100 g/ha (PO)	27	13.61	77	1.47	19850	66060	2.96
	Farmer Practice (CT+no weeding)	79	59.34	-	0.69	23406	30960	1.54
Location 2	Imazethapyr @ 100 g/ha (PO)	51	39.78	34	1.11	19850	49725	2.46
	Farmer practice (CT+ no weeding)	85	60.34	-	0.71	23400	31500	1.54
Location 3	Imazethapyr @ 100 g/ha (PO)	54	31.15	59	1.32	19850	59400	2.66
	Farmer practice (CT+ no weeding)	138	77.23	-	0.81	23400	36450	1.96
Average value of 3 locations								
Improved Practice		44	28.18	57	1.33	19850	58395	2.69
Farmer Practice		101	65.63	-	0.74	23400	32970	1.68

5.1.4 On-farm research and demonstration of weed management technologies in wheat

(Shahpura locality)

During *Rabi* 2013-14 four on-farm trials were conducted in Shahpura locality. Four treatments viz. (i) Farmer's practice (60 kg N/ha + metsulfuron 4 g/ha (ii) RFD (Recommended Fertilizer dose 120: 60: 40 N, P_2O_5, K_2O kg/ha) + Unweeded (iii) No RFD + (meso+iodosulfuron 400g/ha) and (iv) RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (meso+iodosulfuron 400g/ha) were tested at farmers field. The major broad leaved weeds at farmers' field were *Medicago denticulata, Chenopodium album, Cichorium intybus Vicia sativa* and *Lathyrus sativa*. The major grassy weeds were *Phalaris minor* and *Avena* sp. Standard package of practices for growing of wheat was followed, herbicides were applied at 25 days after sowing. It was found out that RFD (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of herbicide (meso+iodosulfuron 400g/ha) was more effective (weed dry weight, 4.5 g/m^2 ; grain yield, 3.78 t/ha; BCR:2.91) over farmer's practice (60 kg N + metsulfuron 4 g/ha) (weed dry weight, 5.91 g/m^2

Interaction with farmer and data recording of initial weed population

Table 5.7: Comparative weed growth, grain yield and economics of OFR during *Rabi* 2013-14 in Shahpura locality

Treatment	Weed density (No./ m²)	Weed biomass (g/m²)	Grain yield (t/ha)	B:C ratio
Farmer's practice (60 kg N/ha + metsulfuron 4 g/ha)	17	8.6	2.91	2.45
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + Unweeded	39	7.1	3.06	2.68
No RFD + (meso+iodosulfuron 400 g/ha)	16	4.9	2.50	2.29
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (meso+iodosulfuron 400 g/ha)	12	4.5	3.78	2.91

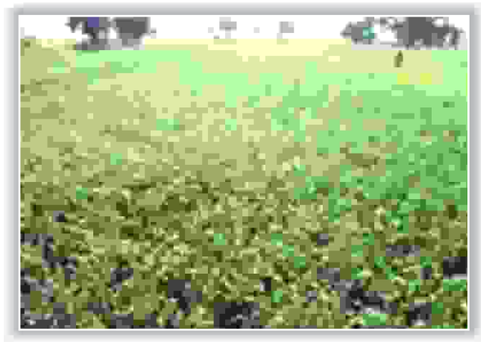
5.1.5 On-farm research and demonstration of weed management technologies in rice-based cropping system

Wheat at Gosalpur area (*Rabi* 2013-14)

On-farm research (OFR) trials were undertaken on wheat 'GW 273' during winter season of 2013-14 at four farmers fields in the village Bhadom of Gosalpur area. Weed management through herbicides with or without recommended fertilizer dose (RFD) was compared with the farmer's practice. The major weed flora observed was *Phalaris minor, Avena sp. Cichorium intybus Vicia sativa, Medicago denticulata, Lathyrus sativa, Chenopodium album* and others. It was found out that RFD (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of herbicide (meso+iodosulfuron 400g/ha) was more effective (weed dry weight, 3.54 g/m^2 ; grain yield, 4.14 t/ha; BCR:3.42) over farmer's practice (60 kg N + metsulfuron 4 g/ha) (weed dry weight, 5.91 g/m^2 ;grain yield, 2.54 t/ha; BCR: 2.08) (Table 5.8).

Table 5.8: Comparison of productivity of wheat in OFR at Bhadom, Gosalpur during *Rabi* 2013-14

Treatment	Weed density (no. / m²)	Weed biomass (g / m²)	Grain yield (t /ha)	B:C ratio
Farmer's practice (60 kg N/ha + metsulfuron 4 g/ha)	15	5.9	2.55	2.08
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + Unweeded	34	5.7	2.68	2.27
No RFD + (meso+iodosulfuron 14.4 g/ha)	14	3.9	2.19	1.94
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (meso+iodosulfuron 14.4 g/ha)	10	3.6	4.14	3.42



OFR cum demonstration in wheat at Bhadom, Gosalpur

Rice at Sihora area (*Kharif* 2014)

On-farm research (OFR) trials were undertaken on rice '*Kranti*' during rainy season of 2014 at four farmer's fields in the village Simariya of Sihora area. Weed management through herbicides with or without recommended fertilizer dose (RFD) was compared with the farmer's practice. The major weed flora observed was *Echinochloa colona*, *Eleusine indica, Ischaemum rugosum, Ludwigia parviflora, Alternanthera sessilis, Physalis minima, Cyperus iria* and others. It was found out that RFD (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of herbicide (pyrazosulfuron 25g *fb* bispyribac-Na 25 g/ha) was more effective (weed dry weight, 30 g/m^2; grain yield,6.25 t/ha; BCR:3.25) over farmer's practice (60 kg N + bispyribac-Na 25 g/ha) (weed dry weight, 119 g/m^2 ;grain yield,4.0 t/ha; BCR: 2.17) (Table 5.9).

Table 5.9: Comparison of productivity of rice in OFR at Simariya, Sihora during *Kharif* 2014

Treatment	Weed density (no./ m^2)	Weed biomass (g/m^2)	Grain yield (t/ha)	B:C ratio
Farmer's practice (60 kg N/ha + bispyribac Na 25 g/ha)	73	119	4.00	2.17
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + unweeded	108	97	2.50	1.47
No RFD + (pyrazosulfuron 25 g *fb* bispyribac - Na 25 g/ha)	27	25	2.50	1.74
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (pyrazosulfuron 25 g *fb* bispyribac-Na 25 g/ha)	16	30	6.25	3.25

5.1.6 On-farm research and demonstration of weed management technologies in maize and rice-based cropping system (Kundam locality)

Wheat (*Rabi* 2013-14)

On-farm research (OFR) trials were undertaken on wheat 'GW 273' during winter season of 2013-14 at six farmers fields in the village Kalyanpur of Khukham area. Weed management through herbicides with or without recommended fertilizer dose (RFD) was compared with the farmer's practice. The major weed flora observed was *Phalaris minor, Avena sp. Cichorium intybus Vicia sativa, Medicago denticulata, Lathyrus sativa, Chenopodium album* and others. Result revealed that RFD (120:60:40 N, P_2O_5, K_2O kg/ha) along with the application of pre mix herbicide (clodinofop+metsulfuron 60 + 4g/ha) gave more effective broad spectrum weed control (weed dry weight, 24.87 g/m^2 ; grain yield, 4.03 t/ha; BCR:3.43) over farmer's practice (60 kg N + 2,4-D 500 g/ha) (weed dry weight, 70.98 g/m^2; grain yield, 2.36 t/ha; BCR: 2.25) (Table 5.10).

Table 5.10: Comparison of productivity of wheat in OFR at Kalyanpur (Khukham locality) during *Rabi* 2013-14

Treatment	Weed density (No./m^2)	Weed biomass (g/m^2)	Grain yield (t/ha)	B:C ratio
Farmer's practice (60 kg N/ha +2,4 -D 500 g/ha)	157	70.9	4.03	2.25
RFD (120:60:40 N, P_2O_5, K_2O kg/ha)+ Unweeded	179	90.7	3.09	2.95
No RFD + (clodinofop+metsulfuron 64 g/ha)	38	16.6	2.74	2.50
RFD (120:60:40 N, P_2O_5, K_2O kg/ha)+ (clodinofop+metsulfuron 64 g/ha)	50	24.8	4.14	3.43

Farmer practics in wheat at Kalyanpur of Khukham

OFR in wheat at Kalyanpur of Khukham locality

Maize at Kundam locality (*Kharif* 2014)

On-farm research (OFR) trials were undertaken on maize (Hybrid) during rainy season of 2014 at eight farmer's fields in the village ragertola of kundam tehsil. Weed management through herbicides with or without recommended fertilizer dose (RFD) was compared with the farmer's practice. The crop was infested with mixed weed flora viz. *Echinochloa colona, Dinebra retroblexa, Ischaemum rugosum, Ludwigia parviflora Cyperus* spp., *Commelina communis, Ageratum conizodies, Physalis minima* and others. It was found out that RFD (100:50:40 N, P_2O_5, K_2O kg/ha) along with the application of herbicide (atrazine @1.0 kg/ha as PE fb one hand weeding at 35 DAS) was more effective (weed dry weight, 39 g/m^2; grain yield, 2.67 t/ha; BCR:2.31) over farmer's practice (40 kg N + Hand weeding) (weed dry weight, 119 g/m^2 ;grain yield, 0.75 t/ha; BCR: 1.47) (Table 5.11).

Table 5.11: Comparison of productivity of maize in OFR at *ragertola, kundam* during *Kharif* 2014

Treatment	Weed density (No./m^2)	Weed biomass (g/m^2)	Grain yield (t/ha)	B:C ratio
Farmer's practice (40 kg N/ha + HW)	169	119	0.75	1.47
No RFD + (atrazine @ 1.0 kg/ha as PE *fb* one hand weeding at 35 DAS)	66	36	2.10	2.02
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + Unweeded	215	147	1.85	1.78
RFD (120:60:40 N, P_2O_5, K_2O kg/ha) + (atrazine @ 1.0 kg/ha as PE *fb* one hand weeding at 35 DAS)	63	33	2.67	2.31

Mean values of from 8 fields.

Farmer Practice (Manual weeding)

OFR trial field (Herbicide treated)

5.2 Impact assessment of weed management technologies on social upliftment and livelihood security

A study was carried out during 2013-14 with 70 crop grower (35 each from adopted and non adopted localities of Jabalpur under OFR cum Demonstration programme). Result revealed that 37% of the crop growers fell in the age group of 20-40 years, 46% in the medium age group (40-60 years) and rest 17% belonged to the high age group (60-80 years), respectively. The distribution pattern in respect of education showed that 23% of the respondents were illiterates. Majority of the crop growers had education level between middle to intermediate (56%). A scrutiny of the result showed that 64% of the crop growers hailed from joint families while the

remaining 36% belong to nuclear families. 46% of crop growers fell in to small land holding (1-5 acre) category, 38% belong to medium (5-10 acre) category while only 16% of them had operational holding size 10 acre and above. 57% of the crop growers had low contacts with extension personnel; majority of the crop growers 53% had low and 32% had medium exposure to various communication media/sources. Broad leaved weeds were the dominant weed flora with a share of 48.5 percent in general. This was followed by grasses with a share of nearly 35 percent. A comparison of cost of weed management in general has revealed that the IWM has needed ₹ 2500-3000/ha while the farmers practice required ₹ 5500-6000/ha. Most of the small (50%) and medium (42%) farmers possessed only low level of knowledge about modern weed management technology. Half of the big farmers possessed high level of knowledge, in contrast to this only 4% of small farmers and ¼ of medium farmers had high level of knowledge. The total area sown by the selected farmers was 926 acre, out of which 365 acre (39%) received improved weed control technology. It was amply clear from the findings that lack of proper knowledge was the leading constraint in adoption of improved weed control technologies. 87% of the respondents pointed out this constraint. 75% of respondents reported non-availability of herbicide in time as well as lack of technical guidance (74%) are major constraints in adoption on WMT and were ranked at number 2 & 3. Results of OFR programme revealed that there is significant improvement in productivity and sustainability due to adoption of modern agricultural technologies along with IWM technologies. 39 percent of the farmers of the OFR locality have changed their traditional farming practices. Now they are using improved seed, fertilizer, implements for line sowing on custom hiring basis, plant protection measure and improved weed management technologies.

Overview of OFR activities

Chapter - 6

EXTERNALLY-FUNDED PROJECTS

Externally-funded projects were undertaken in frontier areas of weed science as outlined below :

Project	PI	Funding agency	Collaborating institutions	Period	Budget (₹ lakhs)
1. Development and formulation of microbial metabolites for the management of root parasite weed *Orobanche* in mustard	C. Kannan	MPBT Council, Bhopal	None	2012-15	15.05
2. Study of domestication trails of two weed species	Bhumesh Kumar	NFBSFARA, ICAR	AAU, Jorhat, UAS, Bengaluru, GBPUAT, Pantnagar	2013-16	119.50
3. Bioremediation of contaminants in polluted sites, use of weedy plants	P. J. Khankhane	NFBSFARA RA, ICAR	IARI, New Delhi; DU, New Delhi	2013-17	206.31

6.1 Development and formulation of microbial metabolites for the management of root parasitic weed, *Orobanche* spp. in mustard

6.1.1 Molecular identification of two potential fungi

Apart from identifying the fungi based on the morphological characters, the following procedure was followed to identify the DNA pattern to confirm the identity using the conserved pattern of 18SrDNA. DNA was isolated and quality checked. Fragment of 18SrDNA gene was amplified by PCR from the above isolated DNA. A single discrete PCR amplicon band of 900 bp was observed when resolved on Agarose Gel (Gel Image-1). The PCR amplicon was purified to remove contaminants. Forward and reverse DNA sequencing reaction of PCR amplicon was carried out with 1F and 4R primers using BDT v3.1 Cycle sequencing kit on ABI 3730xl Genetic Analyzer. Consensus sequence of 850bp 18SrDNA gene was generated from forward and reverse sequence data using Aligner software. The 18SrDNA gene sequence was used to carry out BLAST with the database of NCBI genbank. Based on maximum identity score, first ten sequences were selected and aligned using multiple alignment software program. Cluster W. Distance matrix was generated using RDP database and the phylogenetic tree was constructed using MEGA 5. Based on the studies, two potential fungi were identified as *Penicillium oxalicum* DWSR1 and *Fusarium oxysporum* DWSR1.

6.1.2 Bioassay screening of the crude fractions for their direct action on *Orobanche* and to elicit systemic resistance in mustard

The mustard plants were grown under containment conditions on pots with preconditioned *Orobanche* seeds. The plants were then given the following treatments: (T_1) *Fusarium oxysporum* DWSR1 applied as seed treatment *fb* foliar spray on 30 and 60 DAS, (T_2) *Penicillium oxalicum* DWSR1 applied as seed treatment *fb* foliar spray on 30 and 60 DAS, (T_3) *Fusarium* spp. Gwalior applied as seed treatment *fb* foliar spray on 30 and 60 DAS, (T_4) *Fusarium oxysporum* DWSR1 metabolite (25%, 10 ml) applied as root drenching on 330 and 60 DAS, (T_5) *Fusarium* spp. metabolite (25%, 10 ml) applied as root drenching on 330 and 60 DAS, (T_6) *Penicillium oxalicum* DWSR1 metabolite (25%, 10 ml) applied as root drenching on 330 and 60 DAS, (T_7) Negative control host + *Orobanche* and (T_8) Positive control only host.

The observations were recorded as numbers of *Orobanche* shoots at an interval of 5 days from the day of application of the treatment. Results indicated that the metabolite of *Fusarium oxysporum* DWSR1 (T_1) applied as root drenching resulted in less *Orobanche* infestation (1.6 shoots per pot) as compare to the

metabolites of *P. oxalicum* DWSR1 (3.6) and *Fusarium* sp. (5.3). It is interesting to note that the fungus as such applied were not as effective as the metabolites (Figure 6.1).

6.1.3. Analysis of induced systemic resistance in host plants

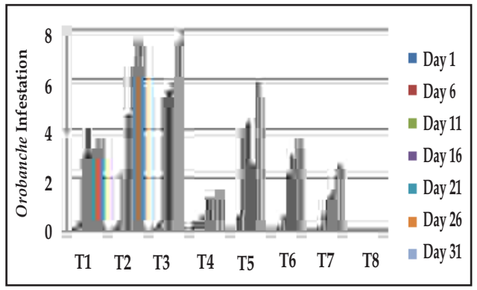


Figure 6.1: Effect of microbial treatments against *Orobanche* infestation on mustard

Systemic resistance in host plant was quantified by the estimation of the enhanced activities of the defense enzymes *viz.*, peroxidases, polyphenol oxidases, catalases and phenylalanine ammonia lyase, upon application of the crude fraction of the metabolites of the two potential fungi. These enzymes are inherently produced in the plants, but their activities are enhanced when the applied fungal pathogens act as elicitors to induce their production. The enzyme values as recorded on 2nd day of applications of the treatment *viz.*, metabolites, 25%, 10 ml of *Fusarium oxysporum* DWSR1 and *Penicillum oxalicum* on 30 days of sowing (DAS)in mustard are given in (Table 6.1).

The results indicated that the enzymes activities did not differs significantly in the treated plants and thus these metabolite fractions were not able to elicit systemic resistance in the plants.

Table 6.1: Defense enzymes activity estimated from mustard after elicitation by the bioagents

Treatment	Peroxidase activity (ΔOD/mg of protein/min)	Phenylalanine ammonia lyase activity (µmol of transcinnamic acid/mg protein/h)	Polyphenol oxidase activity (ΔOD/mg of protein/min)	Catalase activity (µ mol of H_2O_2/ min/mg of protein)
Fusarium DWSR1	10.10	7.04	4.75	2.60
Penicillium oxalicum DWSR2	9.95	7.10	4.45	2.70
Control	10.20	7.50	4.70	2.75
LSD (P=0.05)	0.82	0.65	0.45	0.30

6.1.4 Formulations of the crude fractions of the potential metabolites

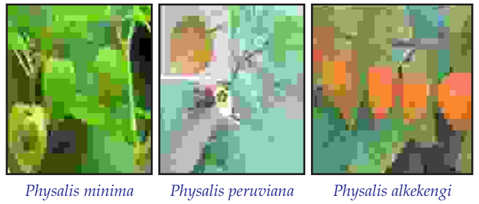
The bioactive crude microbial metabolites obtained separately from *Penicillium oxalicum* DWSR1 and *Fusarium oxysporum* DWSR1 were converted to two separate 25% (w/v) EC formulations, which passed the key quality control tests, *viz.* emulsion stability, cold storage stability and accelerated storage stability.

25% (w/v) EC formulations of crude extracts of *F. oxysporum DWSR1* (F) and *P. oxalicum* crude extract (P)

6.2 Study of domestication traits of two weed species

6.2.1 Characterization of different collections of *Physalis* species

Extensive surveys were conducted for collection of seeds of *Physalis* species. Samples were collected from the different locations across the agro-climatic zones. A total of 50 collections of *Physalis* species (3 distinct species) have been collected so far.



Physalis minima *Physalis peruviana* *Physalis alkekengi*

Different species of *Physalis* collected during survey

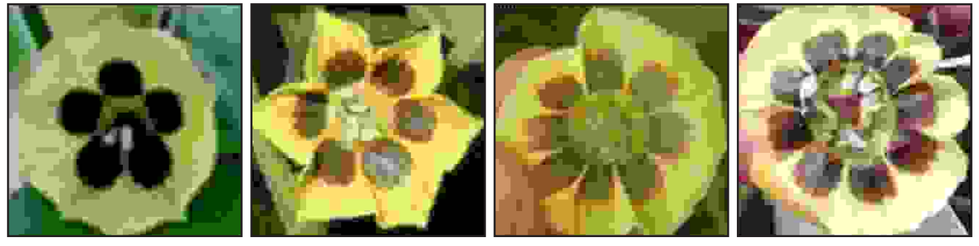
Twenty one accessions of *Physalis peruviana* were grown under field conditions in order to see variation among different accessions. Rate of photosynthesis, transpiration were measured at 60 days after transplanting. Fruit yield of individual plants were also collected to evaluate the yield potetential of different accessions. Results obtained are given (Table 6.2).

Vast variation in morphological and physiological traits as well as yield attributes was noticed. Number of fruits/plant, and fruits size/colour and shape also varied in different accessions. Considerable variation was evident .in rate of photosynthesis (16.2 to 24.3 µmoles/m^2/s^1), transpiration (1.03 to 1.60 mmoles/m^2/s^1) and fruit yield (316 ± 67.9 to 1058 ± 87.8 (g/plant).

Flowers are the key to identify any plant species. Huge variation was noticed in flower colours/shape/pigmentation and orientation of petals. Some of important variations are depicted in photograph given below:

Table 6.2: Evaluation of photosynthesis, transpiration and yield of different accessions of *Physalis peruviana*

Accessions	Photosynthesis (µmoles/m^2/s^1)	Transpiration (mmoles/m^2/s^1)	Fruit yield (g/plant)
DWR-NGP	16.6±1.4	1.24±0.16	735±46.9
DWR-MOD	17.9±1.6	1.34±0.54	598±55.3
DWR-PUN (L)	17.7±1.0	1.47±0.15	784±99.6
DWR-NSK (S)	20.7±1.0	1.46±0.06	582±91.8
DWR-LKO	20.4±2.0	1.31±0.37	701±31.0
DWR-JBP (L)	20.2±1.3	1.21±0.19	887±58.9
DWR-VAR (XL)	20.5±1.4	1.24±0.15	368±13.7
DWR-JAI	21.6±1.1	1.41±0.22	488±33.6
DWR-JOD	21.6±1.2	1.59±0.24	633±51.2
DWR-MUM	23.1±1.4	1.60±0.25	433±41.4
DWR-NSK (B)	23.0±1.6	1.47±0.12	687±14.5
DWR-GOA	16.2±1.7	1.22±0.31	569±54.1
DWR-KOL	18.9±1.3	1.23±0.55	771±51.1
DWR-NGP (S)	20.3±1.4	1.24±0.43	850±34.5
DWR-JBP(R)	22.6±1.2	1.48±0.27	670±79.4
DWR_AGR (S)	20.7±1.7	1.30±0.39	626±62.9
DWR_PUN(R)	23.7±0.9	1.39±0.13	442±29.4
DWR-AGR (B)	21.4±1.5	1.03±0.26	462±30.5
DWR_SJP	22.5±1.8	1.28±0.18	638±66.1
DWR_SAO	21.5±1.5	1.17±0.14	1058±87.8
DWR-DEL	24.3±1.1	1.52±0.16	316±67.9
Data given are the mean of atleast three or more individual plants			



Physalis peruviana

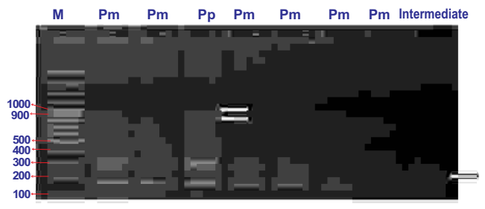
Physalis minima *Intermediate* *Physalis alkekengi*

Variation in shape, colour and pigmentation of flowers of different species

Variation in different flower parts was also evident in different accessions. Important variations in androecium and gynoecium are depicted in photograph below.

Variation in reproductive parts of different collections of *Physalis peruviana*

Molecular diversity of different accessions was assessed using RAPD primers. OPA-18 is found suitable to distinguish between *peruviana* and *Physalis minima* as shown in photograph given below.



Electrophoretic banding pattern of *Physalis* accessions using RAPD (OPA-18) marker, M=100bp DNA ladder

6.3 Bioremediation of contaminants in polluted sites: use of weedy plants

6.3.1 Isolation and characterization of plant growth promoting rhizobacteria from weed species

Soil and plant samples were collected from different heavy metal contaminated areas of Jabalpur district. Based on their predominance in each region, a total of 9 different grass species *viz.*, *Typha latifolia, Rumex crispus, Ageratum conyzoides, Chenopodium album, Eichhornia crassipes, Ammannia auriculata, Sida acuta* and *Cyperus rotundus* were sampled. Plant growth promoting rhizobacteria were isolated using serial dilution technique on King's B medium. Aliquots (0.1 ml) from the serially diluted samples (10^{-3} to 10^{-6}) were added to four different media in Petri plates and kept in an incubator at 30 ^{0}C. Two days after incubation, colonies growing on media were counted and grouped according to their morphological characteristics and isolate code were also given (Table 6.3). Single colonies were picked from the Petri dishes and sub-cultured to obtain pure cultures. Stock cultures were made in nutrient broth containing 50% (w/v) glycerol and stored at –80 ^{0}C. Isolates were subjected to a set of morphological for tentative identification such as colour and colony character and gram staining.

Among 58 bacterial colonies, 12 were gram positive and reaming were gram negative. They mostly circular, irregular and were mostly yellow, creamy white and orange color.

Table 6.3: Selected PGPR isolates from rhizosphere of weed species *collected from* heavy metal affected areas of Jabalpur

Weed species	Isolate code	Total number of isolates
Typha latifolia	TLB	7
Rumex crispus	RCB	6
Ageratum conyzoides	ACR	8
Rumex crispus	RCP	5
Chenopodium album	CAP	7
Eichhornia crassipes	ECU	6
Ammannia auriculata	AAP	4
Eryngium foetidum	EFP	2
Sida acuta	SAU	6
Cyperus rotundus	CRP	7

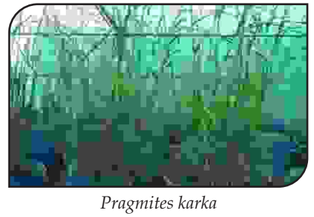
The maximum tolerance concentration (MTC) of various heavy metals by diazotrophic isolates was determined. For this, stock solutions of selected heavy metals *viz.*, Cd^{2+}, Zn^{2+}, Cu^{2+}, Mn^{2+} and Ni^{2+} were prepared by dissolving the respective salts *i.e.* $Cd(NO_3)_2$, $ZnSo_4$, $CuSO_4$, $MnCl_2$ and $NiNO_3$ in distilled water so as to obtain µg/ml concentration of each heavy metal. From this, appropriate quantity was added to LB medium to obtain 100, 200, 400, 600, 800 and 1000 ppm concentration. The cultures were streaked on to king's B plates and incubated at 30 ^{0}C for 2 days and growth was observed and presented in (Table 6.4).

Table 6.4: Maximum tolerable concentration (MTC) of heavy metals by isolates from *grass species*

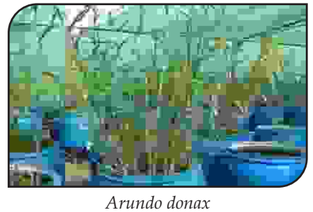
S.No	Heavy metal (1000ppm)				
	Cd^{2+}	Cu^{2+}	Zn^{2+}	Mn^{2+}	Ni^{2+}
1.	AAP1	TLB1	TLB1	TLB1	TLB1
2.	AAP2	TLB2	RCB2	TLB2	ACR1
3.	AAP3	ACR1	ACR1	CAP2	ACR2
4.	AAP4	ACR3	ACR2	ACR1	ACR3
5.	RCB2	ACR4	ACR3	ACR2	ACR4
6.	RCB4	ACR5	ACR4	ACR3	ACR5
7.	RCB5	ACR6	ACR5	ACR4	ACR6
8.	ACR2	ACR7	ACR6	ACR5	CAP2
9.	ACR4	ACR8	ACR7	ACR6	CAP3
10.	ACR6	RCB2	ACR8	ACR7	CAP4
11.	ACR8	CAP1	RCP1	ACR8	CAP5
12.	CAP1	CAP2	RCB2	CAP1	CRP1
13.	CAP2	EFP1	CAP1	CAP2	ECU2
14.	ECU2	EFP2	CAP2	CAP3	-
15.	ECU3	ECU2	CAP3	CAP4	-
16.	ECU4	CRP1	CAP4	CAP5	-
17.	ECU5	-	CAP5	AAP1	-
18.	-	-	CAP6	AAP2	-
19.	-	-	ECU2	-	-
20.	-	-	AAP1	-	-

Photo showing heavy metal tolerance level of isolates

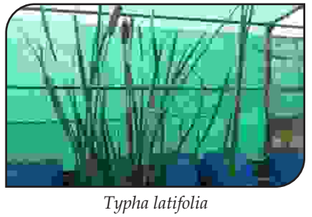
Testing Cd, Mn, Fe removal efficiency of weedy plants grown in porous media



Pragmites karka



Arundo donax



Typha latifolia

EXTERNALLY-FUNDED PROJE

Chapter - 7

SERVICE PROJECTS

Service–oriented projects were undertaken at the Directorate. Details of these projects taken up during 2014-15 are given below:

Title	Principal Investigator
7.1. Analysis of soil and plant samples for herbicide residues	Shobha Sondhia
7.2. Supply of Mexican beetles and monitoring at the sites of their release	Sushil Kumar
7.3. Vermi-compost from weed and agro-waste biomass	Sushil Kumar

7.1 Analysis of soil and plant samples for herbicide residues

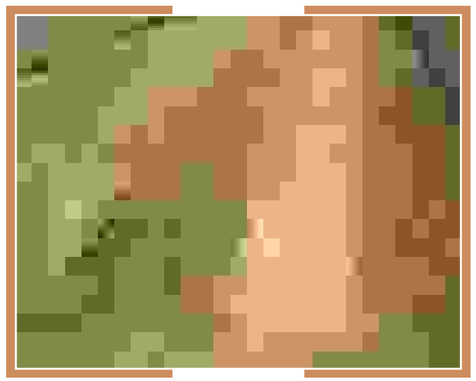
Samples were obtained from farmers field of Chhindwara and Raisen for determination of herbicide residues of fenoxaprop-ethyl and chlorimuron in green soybean and paddy plants and soil. Green fodder samples were obtained from IGFRI, Jhansi for determination of imazethapyr residues. Plants and soil samples were processed for extraction of fenoxaprop-p-ethyl, chlorimuron and imazethapyr residues and analysed by HPLC and TLC. Fenoxaprop-p-ethyl and chlorimuron residues were found below the detection limit (<0.01µg/g) in soil and plants. Imazethapyr residues in fodder were found in the range of 0.064-0.011 µg/g in green fodder samples. Imazethapyr CODEX MRL is not available for fodder, however it is 0.1 ppm for beans, 5.5 for alfalfa and 3 ppm for forage (animal feed) by US EPA. Imazethapyr residues were found below the maximum residue limit set for forage (animal feed) by EPA.

7.2 Supply of Mexican beetles and monitoring at sites of release

Mexican beetles were mass reared in net houses of the Directorate during 2014-15. About 90,000 beetles were supplied by postal services and personal delivery to different AICRP-WM centres, KVKs, farmers, municipalities, NGOs, colony residents, *etc* throughout the country. On the request of Project Director, ATMA, Patiala (Punjab), Dr. Sushil Kumar imparted training on 28-29 August, 2014 to the staff of Agriculture department and farmers from nearby villages of district Patiala. During this programme, about 20,000 beetles were distributed to farmers representing different villages. In a workshop cum training programme organized by Gram Jan Vikas Samiti and Eco Vikas Samiti on 25 August, 2014 for *Parthenium* management at village Garhi of Tehsil Behar in district Balaghat, about 25,000 beetles were distributed to participants representing different villages with the appeal to release the bioagents in their respective area for eco-friendly biological control of *Parthenium*. On 20 September, 2014, about 5000 Mexican beetles were distiribtued among NSS students. Report received from various stake holders confirmed establishment of the bioagents in different parts of the country, viz. in eastern and western Uttar Pradesh, Bihar, lower Uttrakhand and many parts of Madhya Pradesh, Andhra Pradesh, Punjab, Delhi, Haryana, Maharashtra, Orissa, and Jharkhand. Good population build-up of Mexican beetle was also observed during March-April in Uttar Pradesh, Madhya Pradesh, Bihar and Jharkhand due to intermittent rains.

7.3 Compost and vermi-compost preparation from weeds and agro-waste biomass

Composting and vermi-composting was undertaken at the experimental farm of the Directorate using weeds and agrowaste of different crops. To reduce the labour cost, vermicompost unit was mechanized. The turning of huge biomass is being done by hired JCB machine instead of labourers. A dung slurry spray device has been developed to replace the labourers in order to make this technology more cost effective. This year about 40 tonnes of



Vermicomposting beds prepared from agrowaste

Chapter - 8

STUDENTS RESEARCH PROGRAMME

The Directorate has collaboration with Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur for research, teaching and extension. It is also recognized by other universities like VIT Unversity, Vellore as a post graduate research centre. The following students from these universities did their thesis research work at the Directorate.

Name of Student	Degree/ Subject	Title of thesis	College/ University	Chairman/Co-chairman
1. Abhishek Mishra	M. Tech. (Biotechnology)	Molecular fingerprinting of weedy rice using SSR markers	School of Bioscience and Technology, VIT University, Vellore	Meenal Rathore
2. Ankita Pathak	M.Sc. (Microbiology)	Effect of pendimethalin on growth of *Azotobacter* in sesame (*Sesamum indicum* L.) rhizosphere	Department of Microbiology, Govt. Home Science College, Jabalpur	K.K. Barman

8.1 Molecular fingerprinting of weedy rice using SSR markers

A study was carried out to assess existing genetic diversity amongst weedy, wild and cultivated rice accession collected from different agro ecosystems of India. Efforts were also made to assess genetic similarity between weedy rice and cultivated/wild rice accessions collected. A total of 34 (13 weedy, 12 cultivated and 9 wild) accessions were used for genetic diversity analysis using rice SSR markers. Initially, 12 SSR markers were tried for amplification with all accessions but only 5 markers (RM206, RM167, RM13, RM276 and RM413) amplified successfully. Among them RM206, RM276 and RM167 amplified three polymorphic alleles while RM13 and RM413 amplified only two. These SSR markers revealed variable genetic diversity amongst wild, weedy and cultivated rice accessions at the molecular level. The dendogram clustered all accessions into 6 groups and revealed weedy rice to cluster up with wild or cultivated rice and also with both rice types. Our results concluded that weedy rice may have evolved by natural hybridization between cultivated rice and wild rice, may be a result of de-domestication and/or an adaptive evolutionary process.

8.2 Effect of pendimethalin on growth of *Azotobacter* in sesame (*Sesamum indicum* L.) rhizosphere

The investigation was carried out to study the effect of pendimethalin on *Azotobacter* population in the rhizosphere of sesame in different soils and also in pure culture medium. The experiment was conducted in a net house using physico-chemically dissimilar soils collected from different locations of India. *Azotobacter* growth was affected by pendimethalin above 5 ppm concentration, which is not expected to occur under field condition at recommended level of application. Susceptibility of *Azotobacter* to pendimethalin was not influenced due to its previous exposure to this herbicide in sesame field. Irrespective of soil type, *Azotobacter* growth in sesame rhizosphere was not affected by pendimethalin applied upto 150% of recommended dose. Pendimethalin can safely be used for chemical weed control programme in sesame without harming the growth of *Azotobacter*.

Growth of *Azotobacter* was not affected by textural class, but was influenced by soil fertility parameters. A neutral soil, rich in organic carbon content with high level of available P and K content appeared ideal for *Azotobacter* growth. In general, pendimethalin application up to 150% of its recommended dose has been found safe in different soils in terms of *Azotobacter* population count in sesame rhizosphere. Further investigations may be conducted to study the effect of this herbicide on the nitrogenase activity, nitrogen fixing and plant growth promoting ability of resident *Azotobacter* population of different soils in sesame rhizosphere. Such studies would help to characterize and isolate the efficient strains of *Azotobacter* for effective use as PGPR in sesame under chemical weed management practice.

Chapter - 9

TRANSFER OF TECHNOLOGY

9.1 Knowledge management service

Directorate efficiently utilized its facility of Kisan Mobile Advisory Service (KMAS), a Knowledge Management Service (KMS) through SMS, for disseminating weed management technologies to the farmers of the country. The messages, termed as *kisan mobile sandesh,* containing real time agricultural information and customized knowledge on weed management approaches/ technologies were routinely delivered during the initial period of cropping seasons and thereby enabling the farmers' to make a strategy to manage weeds to increase their production and productivity. The *kisan mobile sandesh were* delivered during both *kharif* and *rabi* cropping seasons to the registered farmers and other stake holders (Table 9.1)

Registration is free for all interested stakeholders of the country and can be done by sending an e-mail to dirdwsr@icar.org.in / Director.weed@icar.gov.in

Table 9.1: Details of the *Kisan mobile sandesh* delivered during 2014-15.

Kisan mobile sandesh	Delivery Date
इमेजेथापायर (परश्यूट या लगाम) 400 मिली/एकड़ 25 दिन की मूंग/उड़द फसल में सभी प्रकार के खरपतवारों के नियंत्रण के लिये प्रयोग करें।	06/05/2014
क्यूजालोफाप ईथाइल (टरगा सुपर) 400 मिली/एकड़ 25 दिन की फसल में घास कुल के खरपतवारों के नियंत्रण हेतु प्रयोग करें।	06/05/2014
असामान्य पानी की स्थिति को देखते हुए जहां पर वर्षा कम हुई है वहां खेतों में मूंग, उड़द एवं तिल का समायोजन कर तत्काल बुवाई करे ।	18/07/2014
जबलपुर असमान्य वर्षा की स्थिति में कम समय में पककर तैयार होने वाली धान प्रजाति/संकर धान की रोपणी तैयार कर रोपाई करे ।	18/07/2014
धान की फसल में उचित खरपतवार प्रबंधन के लिये विसपायरीबेक सोडियम 80–100 मिली प्रति एकड़ 25 दिन पर प्रयोग करे ।	18/07/2014
सोयाबीन में खरपतवार नियंत्रण हेतु इमेजथापायर + इमेजामोक्स (आडिसी) 40 ग्राम/एकड़ का प्रयोग 20 दिन पर करे	19/07/2014
सोयाबीन में खरपतवार नियंत्रण हेतु सोडियम एसिफलोरफेन, क्लोडिनाफाप प्रोपारजील (आयरिश) 400 मिली एकड़ का प्रयोग 20 दिन पर करे ।	19/07/2014
मूंग, उड़द, मूंगफली एवं अरहर में खरपतवार नियंत्रण हेतु इमेजाथापायर (परस्युट) 400 ग्राम/एकड़ का प्रयोग 18–20 दिन पर करे ।	19/07/2014
मूंग, उड़द, मूंगफली एवं अरहर में खरपतवार नियंत्रण हेतु क्यूजालोफापईथाइल (टरगासुपर) 300–400 ग्राम/मिली प्रति एकड़ प्रयोग 18–20 दिन पर करे।	19/07/2014
मक्का, ज्वार एवं बाजरा में प्रभावी खरपतवार नियंत्रण के लिये एट्रीजीन 600 ग्राम/एकड़ बुवाई के 3 दिन के अंदर प्रयोग करे ।	19/07/2014
चना, मटर, गेहूँ की फसल में खरपतवारों के नियंत्रण हेतु पेन्डीमेथेलिन 38.7 प्रतिशत का बोनी के 3 दिन के भीतर 700 मि.ली./एकड़ की दर से छिड़काव करें।	11/11/2014
गेहूं में उचित खरपतवार प्रबंधन के लिये सल्फोसल्फ्यूरान+मेटसल्फ्यूरान (टोटल) 40 ग्राम/है0 अथवा मिजोसल्फ्यूरान+आइडोसल्फ्यूरान (अटलांटिस) 400 ग्राम/है0 की दर से बुवाई के 25–30 दिन पर प्रयोग करें।	13/01/2015
गेहूं में खरपतवार प्रबंधन के लिये क्लोडिनोफाप+मेटस ल्फ्यूरान (वेस्टा) 400 ग्राम/है0 की दर से बुवाई के 25–30 दिन पर प्रयोग करें।	13/01/2015

9.2 Farmers' visits

A large number of farmers (including farm women) and agricultural officers from different parts of the country visited this Directorate during the year to get acquainted to latest weed management technologies (Table 9.2). While visiting the experimental/demonstration fields, they interacted with scientists and put up queries related to weed management. At the end interactive meetings with scientific staff were organized in the Directorate's conference hall, where lectures were delivered on the theme of their interest. Suitable recommendations in response to the questions on location-specific weed problems were also given for managing their weed problems.

Table 9.2: Details of farmers visit to the Directorate during 2014-15

States/Districts	Number of farmers/EO	Date	States/Districts	Number of farmers	Date
Narsinghpur (MP)	12	17.10.14	Chhindwara (MP)	17	26.02.15
Jabalpur (MP)	22	18.10.14	Dindori (MP)	62	26.02.15
Chhatarpur (MP)	80	21.10.14	Tikamgarh (MP)	21	28.02.15
Chhatarpur (MP)	28	09.11.14	Narsinghpur (MP)	15	13.03.15
Jabalpur (MP)	10	30.11.14	Kota (Raj)	9	13.03.15
Jabalpur (MP)	100	16.12.14	Damoh (MP)	24	17.03.15
Sidhi (MP)	16	17.12.14	Dindori (MP)	36	17.03.15
Dindori (MP)	50	19.01.15	Jabalpur (MP)	15	17.03.15
Dindori (MP)	50	24.01.14	Sagar (MP)	17	18.03.15
Narsinghpur (MP)	12	28.01.15	Bundi (Raj)	80	19.03.15
Narsinghpur (MP)	18	06.02.15	Satna (MP)	24	20.03.15
Sagar (MP)	15	11.02.15	Sehore (MP)	35	20.03.15
Lucknow (UP)	45	12.02.15	Rewa (MP)	11	21.03.15
Sehore (MP)	10	15.02.15	Balod (CG)	70	23.03.15
Sehore (MP)	51	17.02.15	Dindori (MP)	28	23.03.15
Sehore (MP)	21	19.02.15	Satna (MP)	21	24.03.15
Dindori (MP)	30	20.02.15	Narsinghpur (MP)	49	24.03.15
IFFCO Farmers	40	20.02.15	Umaria (MP)	33	24.03.15
Jabalpur (MP)	50	22.02.15	Narsinghpur (MP)	24	25.03.15
Jabalpur (MP)	50	23.02.15	Chhindwara (MP)	18	25.03.15
Sagar (MP)	28	24.02.15	Narsinghpur (MP)	30	26.03.15
Jabalpur (MP)	18	25.02.15	Mandla (MP)	15	26.03.15
Mandla (MP)	10	25.02.15	Betul (MP)	17	26.03.15
Surajpur (CG)	30	26.02.15	Chandrapur (MH)	16	27.03.15

Farmers' visiting experimental/demonstration sites at the Directorate

9.3 On-Farm Research programme

DWR has successfully demonstrated the performance of improved weed management technologies in a participatory mode in the adopted localities (Table 9.3), situated within 100 km from Jabalpur, under On-Farm Research (OFR) programme. A multi-disciplinary team of 3-4 scientists along with technical staff visited each of these localities on a given day of the week, provided detailed technical-knowhow, and involved the farmers to practically impose the techniques/ technologies in their fields to facilitate better adoption of weed management technologies. These teams also identified the specific weed problems and suggested the solutions for managing them. Farmers are highly satisfied with the performances of the improved technologies.

Table 9.3: Farmers' participated in OFR programme

Localities	Villages	Major cropping system	Farmers involved
Panagar	Mahagwa, Bharda	Wheat	Satish Dubey, Mukesh Dubey, Harishankar Dubey, Mahesh Tiwari, Vishnu Tiwari, Yogendra Kumar, MK Tiwari.
Panagar	Bharda	Rice	Satish Dubey
Shahpura	Magarmuha, Tipra, Noni	Wheat	Bhurelal Patel, Vijay Patel, Prakash Chakravarty, Shyam Patel
Gosalpur	Bhadam, Khajri	Wheat	Udayram Tiwari, Ramvishal Patel, Bal Kishan Dahiya, Panjilal Barman, Chandra Bhan Barman, Ayodhya Prasad
Gosalpur	Simariya	Rice	Manish Paliwal, Rajendra Rajak, Mohan Singh, Kamlesh Rajak
Kundam	Kalyanpur	Wheat	Pramod Patel, Jage Patel, Ganesh Ban, Dayaram, Sewaram Yadava.
Kundam	Khukham, Ragartola	Maize	Ganesh Maravi, Thaan Singh, Devi Singh, Kallo Bai, Lachman Singh
Sehora	Khinni	Brinjal	Kishore Barman, Pradeep Patel, Ramdas Barman
Sewage irrigated area (JBP)	Kachhpura, Khairi/Urdua, Amkhera	Tomato, cabbage, brinjal, radish spinech	Jagdish Prasad Gotia, Munna Patel, Ajay Kalodiya

Weed management in maize under OFR programme at Ragartola village (*Kharif* 2014)

Weed management in rice under OFR programme at Simariya village (*Kharif* 2014)

9.4 Awareness campaigns

The Directorate has been running *Parthenium* Awareness Campaign since 2002 with the objective of creating public awareness about the ill effects and management of this problematic/ invasive weed.

On the request of Project Director, ATMA, Patiala (Punjab), a two day training programme on the "Biological Control of *Parthenium*" was organized during 28-29 August, 2014. Dr. Sushil Kumar imparted training to the staff of Agriculture department and farmers from nearby villages of district Patiala. The programme was inaugurated by The District Collector, Patiala and co-ordinated by Project Director, ATMA, Patiala. During the programme, about 20,000 beetles were distributed to farmers representing different villages.

Gram Jan Vikas Samiti and Eco Vikas Samiti organized a workshop cum training programme on 25 August, 2014 for *Parthenium* management at village Garhi of Tehsil Behar in district Balaghat. Dr. Sushil Kumar and Dr. P.K. Singh from DWSR gave training on *Parthenium* management to stake holders. On this occasion, about 5,000 beetles were distributed to participants representing different villages with the appeal to release the bioagents in their respective area for eco-friendly biological control of *Parthenium*.

Dr. Sushil Kumar imparted training to students of National Service Scheme in a workshop on '*Parthenium* Eradication" organized by District Unit of NSS on 20 September, 2014 at Shri Janki Sharan Maha-vidhyalaya, Jabalpur. After the workshop, all *Parthenium* was uprooted from the college campus.

Release of Mexican beetles for *Parthenium* management

9.5 Television and radio talks

Talks on various aspects of weed management are occasionally delivered by the scientists of the Directorate.

Name	Date	Topic	Radio/TV station
Dr. P.K. Singh	21 July, 2014	गाजरघास का नियंत्रण	Jabalpur station of AIR
Dr. P.K. Singh	2 March, 2015	फसलों में खरपतवार नियंत्रण	Jabalpur station of AIR
Mr. Dibakar Ghosh	17 October, 2014	International Day for the Eradication of Poverty	Krishi Darshan, Doordarshan Kolkata (Live)

Chapter - 10

TRAINING AND CAPACITY BUILDING

10.1 Participation in training programmes

Scientists of the Directorate participated in training programmes to enrich their knowledge and acquire expertise in the discipline. Details of such exposure visits are given below:

Name of Scientist/staff	Training /workshop attended	Institution	Dates
Bhumesh Kumar	Mass spectrometry-based metabolomics	Institute of Bioinformatics, Bengaluru	17-18 June, 2014
	Refresher course on Agricultural Research Management	NAARM, Hyderabad	14-26 July, 2014
C. Kannan	International training on pest risk analysis	NIPHM, Hyderabad	1-5 September, 2014
C. Sarathambal	Management of soil health: challenges and opportunities	JNKVV, Jabalpur	29 September - 19 October, 2014
	Waste recycling and resource management through rapid composting techniques	IISS, Bhopal	3- 23 December, 2014
Meenal Rathore	Refresher course on Agricultural Research Management	NAARM, Hyderabad	14-26 July, 2014
Mukesh Meena	Gahan Hindi Prashikshan	CHTI, New Delhi	1-5 December, 2014
Pankaj Shukla	Training on IPV 6	DOT(GOI), BSNL, Jabalpur	23 January, 2015
	Office automation using oracle ERP system (FMS/MIS)	IASRI, New Delhi	9-13 March, 2015
P.K. Singh	Training cum review meeting of vigilance officer	ICAR, Krishi Bhawan, New Delhi	21-22 March, 2014
	Training cum workshop of nodal officer (HRD)	NAARM, Hyderabad	26 March, 2015
P.P. Choudhury	Refresher course on Agricultural Research Management	NAARM, Hyderabad	14-26 July, 2014
Raghwendra Singh	Refresher course on Agricultural Research Management	NAARM, Hyderabad	14-26 July, 2014
R.P. Dubey	NAIP & IFPRI workshop on PME	NASC, New Delhi	27 May, 2014
	MDP on Priority setting, Monitoring and Evaluation of Agricultural Research Projects	NAARM, Hyderabad	4-8 August, 2014
R. S. Upadhyay	Conservation agriculture	CSSRI, Karnal	27 September – 4 October, 2014
Sandeep Dhagat	Training on IPV 6	DOT(GOI), BSNL, Jabalpur	23 January, 2015
Shobha Sondia	Workshop on "Impact of Capacity Building"	NAIP, New Delhi	6-7 June, 2014
Sushil Kumar	XXIII workshop of AICRP on Biological Control of Crop Pests	OUAT, Bhubaneswar	27-28 June, 2014
V.P. Singh	Management Development Programme on Leadership Development	NAARM, Hyderabad	15-26 July, 2014
	Regional workshop on "Strengthening partnerships between AICRP-WM, Jabalpur ad AICRP on IFS, Modipuram"	AAU, Jorhat	26 May, 2014
	Regional workshop on "Strengthening partnerships between AICRP-WM, Jabalpur ad AICRP on IFS, Meerut"	ICAR-RCER, Patna	9 June, 2014

10.2 Organization of training programmes

Following training programmes were organized during the year

Training programme	Sponsor	Dates	No. of participants	Course Director	Coordinators
Weed management	DWR & ZPD VII	19-21 May, 2014	40	-	P.K. Singh
Advances in weed management	CAFT	14 October, 2014	22	-	P.K. Singh
Review of research - cum-herbicide residue training workshop of AICRP-WC Centres	AICRP (WM)	11-17 November, 2014	10	-	Shobha Sondhia P.P. Choudhury
Weed management for sustainable oilseed and pulse production	ICAR	16-23 December, 2014	30	P.K. Singh	K.K. Barman Raghwendra Singh
Non-chemical approaches of weed management	ICAR	30 December, 2014 8 January, 2015	17	Sushil Kumar	Shobha Sondhia C. Kannan
Bioherbicides with special emphasis to microbial biotechnology	MPBC	27 January - 10 February, 2015	13	C. Kannan	Meenal Rathore
Advances in weed management	ICAR	19-28 March, 2015	24	Sushil Kumar	Bhumesh Kumar Raghwendra Singh

10.3 Lectures delivered by scientists in other institutions

Scientists of the Directorate were invited by many organizations to deliver lectures in different programmes. The details are given below:

Speaker	Topic	Institute / meeting	Date
A.R. Sharma	Integrated weed and pest management	ZPD, Bengaluru	23 July, 2014
	Weed management	Workshop on IPM, COA,Puducherry	11 September, 2014
	Weed management in conservation agriculture	National Symposium on Agricultural Diversification for Sustainable Livelihood & Environmental Security, PAU, Ludhiana	18 November, 2014
	Weed management in conservation agriculture systems	Second International Conference on "Bioresource and Stress Management" PJTSAU, Hyderabad	8 January, 2015
	Climate Resilient Agriculture	IFFCO, New Delhi	11 February, 2015
Bhumesh Kumar	Climate change and weed management: Recent Advances, challenges and potential strategies	CAFT, JNKVV, Jabalpur	14 October, 2014
K.K. Barman	Weed management in conservation agriculture systems in black cotton soil	National Conference on Soil health: A key to unlock and sustain production Potential. JNKVV, Jabalpur	3-4 September, 2014
	Managing herbicide persistence	CAFT, JNKVV, Jabalpur	14 October, 2014
	Management of crop residues for sustainable productivity and soil health	Workshop on crop residue management, JNKVV, Jabalpur	29 December, 2014
P.K. Singh	Importance of weed management	State Level Workshop for Agriculture and Horticulture officers at JNKVV, Jabalpur	30-31 August, 2014
	Weed management in cropped and non cropped area	XXI zonal workshop of KVKs, under zone VII, ICAR at IGKVV, Raipur (C.G.)	05-07 September, 2014
	Improved weed management technology	Field Level Orientation Programme for Tribal Farmers organized by SRIDA Centre, at Ramanpur Bargi Block, Jabalpur	15 September, 2014
	खरपतवार प्रबंधन क्यों जरूरी	Agri fest of BISA, Jabalpur	29 September, 20 14
	Conservation agriculture and weed management	National Fair on organic Agriculture at Mandla, MP	18-20 October, 2014
	संरक्षित खेती की विशेषताएं	State level training cum workshop of agriculture officers organized by MP Govt. at JNKVV, Jabalpur	19-20 January, 2015
	Weed management	5 days training of ATMA officers at FTC, Jabalpur	8 February, 2015
	खरपतवारों का उचित प्रबंधन	Kisan Gosthi at CCSHAU, Hissar, Haryana,	12-13 March, 2015
	Importance of conservation agriculture and weed management	Kisan Gosthi Cum Field day organized by ZPD Zone-VII, KVKs Narshingpur and Bioversity International, New Delhi at Narshingpur	31 March, 2015
R.P. Dubey	Herbicide use and IWM in pulse crops	National Conference on Pulses : Challenges and Opportunities under Climate Change Scenario" JNKVV, Jabalpur.	29-30 September, 2014
	IWM- an approach	CAFT, JNKVV, Jabalpur	14 October, 2014
	Weed management in vegetables	Rashtra staryiya jaivik krishi mela, Mandla, M.P.	18-20 October, 2014
Sandeep Dhagat	DWR e-modules on weeds	CAFT, JNKVV, Jabalpur	14 October, 2014
Shobha Sondhia	Residues of pretilachlor in rice ecosystem and effects on non targeted organisms	National Symposium on Agrochemicals for Food and Environment Safety. IARI, New Delhi	28-30 January, 2015
	Herbicide residues in environment and mitigation measures	CAFT, JNKVV, Jabalpur	14 October, 2014
Sushil Kumar	Integrated management of *Parthenium*	Eco-development Society at village Garhi, Balaghat (MP).	25 August, 2014
	Biological management of *Parthenium*	Project Director, ATMA, Patiala (Punjab).	28-29 August, 2014
	Integrated management of *Parthenium*	Raja Mansingh Tomar Music & Arts University, Gwalior	09 September, 2014
	Integrated management of *Parthenium*	Shri Janki Sharan Mahavidhyalaya, Jabalpur.	20 September, 2014
	Biological based integrated management of *Parthenium*	Govt Home Science Girls PG College, Hoshangabad, MP	15 November, 2014

Contd...

10.4 Technical Seminars

Following technical seminars were delivered by the scientists during the reported period

Date	Scientist	Topic
15 April, 2014	A.R. Sharma	Advanced Leadership/Management Development Programme
28 June, 2014	V.P. Singh	Weed flora shift & crop rotation
04 August, 2014	C. Sarathambal	Bioprospecting of weed rhizosphere
24 January, 2015	A.R. Sharma	Production technology of flood prone lowland rice
30 March, 2015	P.K. Singh	Effective technologies for transferring weed management technologies

Chapter - 11

LINKAGES AND COLLABORATION

Directorate is the nodal agency for coordination of research and training in the field of weed management, and also acts as a repository of information in weed science in the country. It offers research and training to research scholars, shares expertise and provides consultancy to the staff and students of SAUs, ICAR Institutes, NGOs, herbicide industries, and other stakeholders etc.

11.1 Collaboration with SAUs

Besides coordinating research and extension programmes on weed management with 22 centres of All India Coordinated Research Project on Weed Management, there are a large number of volunteer centres located in different state agricultural universities. Six nodal officers have been identified from the headquarter for effective collaboration and monitoring of the research and extension programmes of these centres.The Director and the nodal officers monitor these centres and provide feedback to the SAUs for improvement of their research and extension programmes.

Visits by the Director and Nodal Officers to different AICRP–WM centres

Date	Visits by Director	Visits by Nodal officers
05 April, 2014	-	ANGRAU, Hyderabad
07-April, 2014	ANGRAU, Hyderabad	-
11-12 May, 2014	RVSKVV, Gwalior	-
25 May, 2014	-	AAU, Jorhat
28-29 May, 2014	-	VB, Sriniketan
28 June, 2014	-	OUAT, Bhubaneshwar
10-11 July, 2014	-	ANGRAU, Hyderabad
12-14 July, 2014	-	UAS, Bengaluru
24 July, 2014	UAS, Bengaluru	-
26-27 July, 2014	AAU, Anand	-
09-13 August, 2014	-	CCSHAU, Hisar
05-07 September, 2014	-	IGKV, Raipur
11 September, 2014	COA, Puduchery	-
12-13 September, 2014	TNAU, Coimbatore	-
23 December, 2014	-	TNAU, Coimbatore
09-10 February, 2015	CCSHAU, Hisar	-
11-13 March, 2015	-	CCSHAU , Hisar
19-20 March, 2015	-	OUAT, Bhubaneshwar
21 March, 2015	-	IGKV, Raipur

11.2 Crop and horticultural institutes

The Directorate has initiated collaboration programmes with ICAR institutes, especially those dealing with field and horticultural crops. Nodal scientists were also identified for providing necessary guidance for refining the weed management research and extension programmes in these institutes. Scientists from this Directorate participated in annual group meeting of AICRIP and AICRP-IFS and took role in finalization of technical programme in respect to weed management. Collaboration with scientists of CRIJAF, Barrackpore and IIPR, Kanpur was made for improving their technical programme on weed research.

Eleven common centres of both the AICRP-Weed Management and AICRP-IFS were identified for collaborative research in weed management in the farming system models being developed at on-station. Emphasis will be given on on-farm utilization of weed biomass and need based capacity building of the AICRP staff.

11.3 Collaboration with KVKs

Two scientists of the Directorate participated in the Zonal Workshop of KVKs of Zone-VII involving the states of Madhya Pradesh, Odisha and Chhattisgarh organized at IGKV, Raipur from 05-07 September, 2014. Dr VP Singh, Pr. Scientist of this Directorate made a presentation focusing major weeds in different crops and their management practices. Three days workshop-cum-training on weed management for Programme Coordinators of KVKs under Zone-VII was held during 19-21 May, 2014 in collaboration with ZPD, Jabalpur.

11.4 Education and training programmes

The Directorate collaborates with several other educational and research institutions. MoUs have been signed with Jawaharlal Nehru Krishi Vishva Vidyalaya, Jabalpur and Indira Gandhi Krishi Vishva Vidyalaya, Raipur for better collaboration in the area of research, teaching and extension. This Directorate has also been recognized by Rani Durgavati Vishva Vidyalaya, Jabalpur, AKS University, Satna, and APS University, Rewa, as a post-graduate research centre for their students. Post-graduate students and research scholars of these institutions are doing their research work at the Directorate.

Training programs on advanced techniques in weed management have been organized for the scientists, subject matter specialists, extension personnel, state government officials, progressive farmers, and NGOs. Overwhelming responses have been received from various states and institutions for such collaboration.

Scientists visiting experimental/demonstration sites of different ACRP-WM Centre

Chapter - 12

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संस्थान में राजभाषा हिन्दी के कार्यान्वयन, इसकी प्रगति एवं समय–समय पर इसके प्रयोग एवं प्रगति की समीक्षा करने हेतु राजभाषा कार्यान्वयन समिति का गठन किया गया है। समिति के प्रयासों के परिणामस्वरूप संस्थान के विभागों/अनुभागों में हिन्दी में कार्य करने के लिये जो उत्साह पैदा हुआ है, वह निःसंदेह राष्ट्रीय गौरव एवं स्वाभिमान का विषय है।

वर्ष 2014–15 में खरपतवार अनुसंधान निदेशालय की राजभाषा कार्यान्वयन समिति के माध्यम से निदेशालय द्वारा हिन्दी में की गई प्रगति का विवरण इस प्रकार है –

12.1 त्रैमासिक बैठकों का आयोजन

निदेशालय की राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठकों का नियमित आयोजन किया गया। हिन्दी राजभाषा कार्यान्वयन समिति की अप्रैल से जून 2014 तिमाही की बैठक दिनांक 30/06/2014 को निदेशालय के सभागार में आयोजित की गई। जुलाई से सितम्बर 2014 की तिमाही बैठक का आयोजन दिनांक 05/09/2014 को किया गया। अक्टूबर से दिसम्बर 2014 तिमाही की बैठक दिनांक 27/12/2014 को आयोजित की गई एवं जनवरी से मार्च 2015 को समाप्त तिमाही की बैठक 30/03/2015 को आयोजित की गई।

उक्त बैठकों में निदेशालय के समस्त अनुभाग प्रभारियों, अधिकारियों एवं समिति के पदाधिकारियों ने भाग लिया। बैठक में कार्यान्वयन से संबंधित बिंदुओं पर विचार किया गया एवं पिछली बैठक के कार्यवृत्त को पारित किया गया। राजभाषा कार्यान्वयन समिति के सचिव श्री एम.पी. तिवारी द्वारा पिछली तिमाहियों का विस्तृत ब्यौरा प्रस्तुत किया गया जिसमें राजभाषा अधिनियम 1963 की धारा 3(3) के अनुपालन की स्थिति के संदर्भ में बताया गया, तत्पश्चात् पिछली तिमाहियों के अंतर्गत जारी त्रैमासिक प्रतिवेदनों, कागजातों, मांगपत्रों एवं जांच बिन्दुओं इत्यादि से संबंधित चर्चायें की गई, साथ ही माननीय संसदीय राजभाषा समिति को दिये गये आश्वासनों के संबंध में संबंधित अनुभागों को उचित कार्यवाही करने हेतु पत्र भी जारी किये।

बैठकों में राजभाषा वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने तथा राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद से प्राप्त निर्देशों/आदेशों के अनुपालन पर चर्चा की गई और इन बैठकों में लिए गये निर्णयों को लागू करने के लिए कार्यवाही की गई।

12.2 त्रैमासिक हिन्दी प्रतिवेदन का संकलन

भारत सरकार के राजभाषा विभाग, गृह मंत्रालय रिपोर्ट के प्रोफार्मा में निदेशालय के विभिन्न अनुभागों से उनके द्वारा किये जा रहे हिन्दी कार्यों की प्रगति तथा हिन्दी पत्राचार के आंकड़े तिमाही की समाप्ति पर मंगाये गए और उनको समेकित कर समेकित प्रतिवेदन को भारतीय कृषि अनुसंधान परिषद नई दिल्ली, क्षेत्रीय कार्यान्वयन कार्यालय भोपाल तथा नगर राजभाषा कार्यान्वयन समिति को प्रेषित किये गये। त्रैमासिक प्रतिवेदनों से प्राप्त समीक्षा के अनुसार उठाये गये बिन्दुओं पर कार्यवाही की गई तथा संबंधित अनुभाग को पृष्ठांकित किया गया।

12.3 राजभाषा वार्षिक कार्यक्रम पर क्रियान्वयन

भारत सरकार की राजभाषा नीति के अनुसार संस्थान द्वारा संपादित कार्यों में हिन्दी का क्रियान्वयन सुनिश्चित करने के लिए गृह मंत्रालय, राजभाषा विभाग द्वारा जारी राजभाषा वार्षिक कार्यक्रम में दिये गये निर्देशों के अनुसार कार्यवाही के लिए सभी अनुभागों को राजभाषा संबंधी नियमों/निर्देशों से अवगत कराया गया तथा इन नियमों के अनुसार कार्यवाही सुनिश्चित करने का अनुरोध किया गया।

12.4 हिन्दी पखवाड़े का आयोजन

निदेशालय में राजभाषा कार्यान्वयन समिति द्वारा दिनांक 12 सितम्बर 2014 को हिन्दी दिवस तथा दिनांक 16 से 30 सितम्बर 2014 तक हिन्दी पखवाड़े का आयोजन किया गया। जिसमें कार्यालय के समस्त अधिकारियों/कर्मचारियों ने भाग लिया। हिन्दी दिवस के अवसर पर कार्यक्रम का उद्घाटन डॉ. पी. के. सिंह, प्रभारी निदेशक ने दीप प्रज्जवलित कर किया।

हिन्दी पखवाड़े के विभिन्न परिदृश्य

पखवाड़े के दौरान निदेशालय में आलेखन एवं टिप्पण प्रतियोगिता, शुद्धलेखन प्रतियोगिता, पत्र लेखन प्रतियोगिता एवं हिन्दी में क्विज कांटेस्ट का आयोजन किया गया। हिन्दी पखवाड़े का समापन/पुरस्कार वितरण समारोह दिनांक 30 सितम्बर 2014 को आयोजित किया गया। इस समापन समारोह में विजयी प्रतियोगियों को पुरस्कार वितरण किये गये।

हिन्दी पखवाड़े के दौरान निदेशालय में विभिन्न प्रतियोगिताऍं संपन्न कराई गई। जिनमें विजयी प्रतियोगियों के नामों की सूची निम्नानुसार है –

1. शुद्ध लेखन प्रतियोगिता		
समूह	नाम	स्थान
"अ"1	श्री नीरज त्रिपाठी	प्रथम पुरस्कार
2	श्री अभिषेक दुबे	द्वितीय पुरस्कार
3	श्री रोहित पटेरिया	तृतीय पुरस्कार
"ब"1	श्रीमति कुंदा विरूलकर	प्रथम पुरस्कार
2	सुश्री कविता रोहितास	द्वितीय पुरस्कार
2. पत्र लेखन प्रतियोगिता		
"ब"1.	श्री अश्विनी तिवारी	प्रथम पुरस्कार
2.	श्री मोहन लाल दुबे	द्वितीय पुरस्कार
3.	सुश्री कविता रोहितास	तृतीय पुरस्कार
3. आलेखन एवं टिप्पण प्रतियोगिता		
1	श्री जी. आर. डोंगरे	प्रथम पुरस्कार
2	डॉ. सुशील कुमार	द्वितीय पुरस्कार
3	डॉ. मीनल राठौर	तृतीय पुरस्कार

4. हिन्दी में क्विज प्रतियोगिता		
समूह	नाम	स्थान
समूह 'अ'	श्री एस.के. पारे, श्री एस.के. बोस, श्री अभिषेक दुबे, श्री रोहित पटेरिया,	विजेता
समूह 'ब'	डॉ. सुशील कुमार, डॉ. शोभा सोंधिया, श्री जी.आर. डोंगरे, श्री टी. लखेरा	उपविजेता

5. नगद पुरस्कार हेतु चयनित अधिकारी/कर्मचारी			
	अधिकारी/कर्मचारी का नाम	स्थान	(₹) राशि
1	श्री बी.पी. उरिया	प्रथम पुरस्कार	800/–
2	श्री वीर सिंह	द्वितीय पुरस्कार	600/–
3	श्री घनश्याम विश्वकर्मा	तृतीय पुरस्कार	400/–

6. वर्षभर हिन्दी में सर्वाधिक काम करने वाले अनुभाग को चलित शील्ड		
1	क्रय एवं भण्डार अनुभाग	प्रथम
2	प्रक्षेत्र अनुभाग	द्वितीय
3	संपदा अनुभाग	तृतीय

पुरस्कार वितरण का परिदृश्य

12.5 हिन्दी कार्यशालाओं का आयोजन

राजभाषा कार्यान्वयन समिति द्वारा वित्तीय वर्ष 2014–15 के दौरान चार विभिन्न कार्यशालाओं का आयोजन किया गया, जिनका विवरण निम्नानुसार है –

क्र.	तिमाही	दिनांक	कार्यशाला का विषय	व्याख्याता
1	अप्रैल से जून, 2014	24/06/2014	सकारात्मक विचार	श्री आलोक दवे, मुख्य अभियंता, मैकेनिकल भारतीय रेल्वे, जबलपुर
2	जुलाई से सितम्बर, 2014	22/09/2014	पर्यावरण संरक्षण और नर्मदा	श्रीमति साधना उपाध्याय, भूतपूर्व प्राचार्या, विदाम बाई हायर सेकेण्डरी स्कूल, जबलपुर
3	अक्टूबर से दिसम्बर, 2014	12/12/2014	वैज्ञानिक विधि से मौन (मधुमक्खी) पालन	डॉ. राघवेन्द्र सिंह, वरिष्ठ वैज्ञानिक
4	जनवरी से मार्च, 2014	27/03/2015	ऑफिस ऑटोमेशन यूसिंग ऑरिकल ई.आर.पी.	श्री पंकज शुक्ला, तकनीकी अधिकारी

निदेशालय में हिन्दी कार्यशालाओं का आयोजन

12.6 राजभाषा पत्रिका के दशम् अंक का प्रकाशन

तृण संदेश पत्रिका के दशम् अंक 2014 का प्रकाशन किया गया जिसमें खरपतवार प्रबंधन से संबंधित लेख, सामान्य खेती से संबंधित लेख एवं सामाजिक एवं साहित्यिक गतिविधियों को स्थान दिया गया था। पत्रिका को स्लोगन एवं महापुरूषों के वचन इत्यादि से प्रभावशाली बनाया गया।

Chapter - 13

AWARDS AND RECOGNITIONS

- Dr. Sushil Kumar, Mr. Sandeep Dhagat, Smt. Nidhi Sharma, Sh. Shankar Lal Koshta obtained Best Worker Awards (2013-14) on the occation of 26th Foundation Day held on 22 April, 2014 at DWR.




- Dr. Sushil Kumar, Principal Scientist (Entomology) was conferred Crystal National Agri Award 2014 under the Research Scientist category by Krishi Anusandhan & Kisan Vikas Foundation, New Delhi on 27 August, 2014 for his outstanding contribution on *Parthenium* Management. The Award was given by Shri Radha Mohan Singh, Hon'ble Minister of Agriculture, Government of India and Shri Nitin Gadkari, Hon'ble Minister of Transport & Rural Development, Government of India.

- Dr. Sushil Kumar, Principal Scientist (Entomology) received seven invitation from different parts of the country to train scientists, farmers, agriculture officers and students for biological control of *Parthenium*.
- Dr. C. Sarathambal received Best Publication Award -2014 from the Society for Advancement of Human and Nature (SADHNA), Solan, Himachal Pradesh.
- Dr. C. Sarathambal was recognized as honorary board member by Society for Advancement of Human and Nature (SADHNA), Solan, Himachal Pradesh.
- Dr. A.R. Sharma, Director, DWR received Award of Honour from Mr. J.C. Rana, Director of Agriculture, Himachal Pradesh at the Alumni Meet of CSK HPKVV, Palampur on 22 November, 2014

- Dr. Meenal Rathore won first position in Shotput-Women and second position in Discus throw-Women events in ICAR Zonal Sports 2014 (Central zone) held at NBSS&LUP, Nagpur during 16-20 September, 2014. Sh. Veer Singh won first position in the event of Carom-Men.

Chapter - 14

PUBLICATIONS

14.1 Research Articles

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- Choudhary A.K., Chelladurai H. and Kannan C. 2015. Performance of diesel engine using Bioethanol (Water hyacinth) by response surface methodology *Applied Mechanics and Materials*, 737: 53-59.
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- Kannan C., Pathak A. and Sushil Kumar 2014. Natural incidence of the agromyzid fly on Orobanche. *Indian Journal of Weed Science* **46**(3): 295-296.
- Kannan C., Kumar B., Pathak A. and Gharde Y. 2014. Effect of native *Trichoderma viride* and *Pseudomonas fluorescens* on the development of *Cuscuta campestris* on chickpea, *Cicer arietinum*. *Journal of Applied and Natural Science* 6: 844–851.
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- Khare R.R. and Sondhia S. 2014. Cyhalofop-p-butyl mobility and distribution of residues in soil at various depths. *Journal of Environmental Science and Health*, Part B **49**(6): 391-399.
- Naidu V.S.G.R, Deriya A., Naik S, Paroha S. and Khankhane P.J. 2014. Water use efficiency and phyto-remediation potential of *Eichhornia crassipes* under elevated CO_2. *Indian Journal of Weed Science* **46**(3): 273-276.
- Naidu V.S.G.R., Ravisankar H., Dhagat S., Kamala Vansi V. and Sharma A.R. 2014. Expert System for Identification of Weeds. *International Journal of Applied Research on Information Technology and Computing* **5**(1): 48-54.
- Patel R. K., Sondhia S. and Dwivedi A. K. 2014. Effect of imazethapyr and varying level of fertilizer on soybean crop quality. *Journal of Research in Environmental Science and Toxicology* **3**(2): 21-24.
- Pathak A. and Kannan C. 2014. A new cost-effective method for quantification of seed bank of *Orobanche* in soil. *Indian Journal of Weed Science* 46: 151–154.
- Sarathambal C., Ilamurugu K., Balachandar D., Chinnadurai C. and Gharde Y. 2015. Characterization and crop production efficiency of diazotrophic isolates from the rhizosphere of semi-arid tropical grasses of India. *Applied Soil Ecology* 87: 1-10.
- Sarathambal C., Ilamurugu K., Srimathi Priya L. and Barman K. K. 2014. A review on weeds as source of novel plant growth promoting microbes for crop improvement. *Journal of Applied and Natural Science* **6**(2): 880–886.
- Sarathambal C. and Ilamurugu K. 2014. Phosphate solubilising diazotrophic bacteria associated with rhizosphere of weedy grasses in India. *Indian Journal of Weed Science* 46(4): 364-379.
- Sarathambal C., Ilamurugu K. and Prabhu G. 2014. Diazotrophic endophytes from the weedy grasses of different physiographic regions of southern India. *Journal of Pure and Applied Microbiology* **8**(6): 4783-4792.
- Sharma A.R. and Singh V.P. 2014. Integrated weed management in conservation agriculture systems. *Indian Journal of Weed Science* **46**(1): 23–30.
- Sondhia S. 2014. Herbicides residues in soil, water, plants and non-targeted organisms and human health implications: an Indian perspective. *Indian Journal of Weed Science* **46**(1): 66-85.
- Sondhia S. and Khare R.R. 2014. Soil adsorption studies of a rice herbicide, cyhalofop-butyl, in two texturally different soils of India. *Environmental Monitoring and Assessment* **186**(10): 5969-5976.
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15.2 Paper Presented

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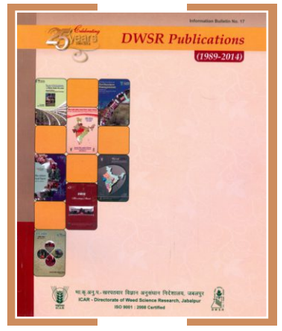

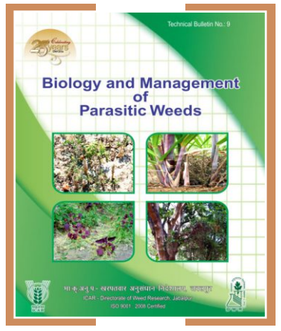

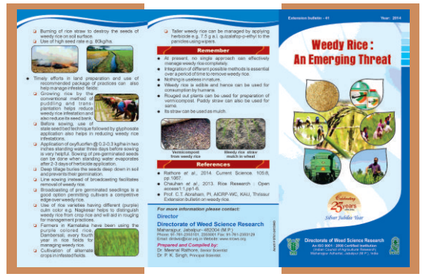

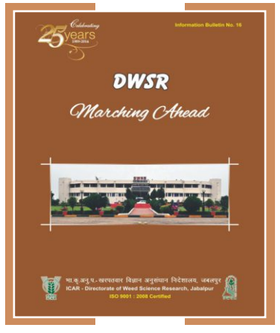

Chapter - 15

MONITORING AND REVIEW OF RESEARCH PROGRAMMES

Research programmes of the Directorate were monitored and reviewed during 2014-15 by different committees as per the norms of the Council. Adequate actions were taken against the recommendations of the various committees. The following meetings of various committees were held during the year:

15.1 XVII Research Advisory Committee Meeting

The XVII RAC meeting was conducted on 18-19th April, 2014 under the chairmanship of Dr. R.K. Malik, CIMMYT, New Delhi and in presence of Dr. R.S. Balyan, Ex-Professor, Agronomy, CCS H.A.U., Hisar, Dr. B.L. Jalali, Ex-Director Research,CCS HAU, Hisar (Haryana), Dr. B.S. Parmar, Ex-Joint Director(Research), IARI, Dr. A.R. Sharma, Director, DWR and Dr. V.P. Singh, Member Secretary, RAC, DWR. Director made a brief presentation on the salient achievements of the Directorate and major initiatives undertaken during 2013-14. Dr. R.K. Malik in his opening remarks emphasized on priority setting based on past Dr. B.L. Jalali remarked that performance indicators must be developed for impact assessment. Dr. B.S. Parmar opined that problem-solving research work should be undertaken on priority basis. Dr. R.S. Balyan emphasized on development of mechanical tools for row crops. Dr. V.P. Singh presented the action taken report on the recommendations made in the XVI RAC meeting. Dr. R.P. Dubey, Member Secretary QRT, and Dr. Bhumesh Kumar, Member Secretary IRC, presented the action taken report (ATRs) on the recommendations made by respective committees last year. Research work carried out under different programmes was presented by the programme leaders. At the end, RAC committee appreciated a visible change during the year and emphasized that such efforts should continue further to develop DWR as a model farm on weed management.

15.2 Institute Research Council Meeting

The IRC meeting was conducted on 2-3 May, 2014 under the chairmanship of Dr. A.R. Sharma, Director, DWR. Dr. N.T. Yaduraju, President, ISWS and Dr. A.N. Rao, Visiting Scientist, IRRI/ICRISAT, Hyderabad were invited as resource persons. Dr. Sharma briefed about Directorate's mandate, objectives, available infrastructure, ongoing research programmes and new initiatives taken during the year. Dr. Yaduraju, in his initial remarks, remarked that DWR is the only institute in the world which is solely devoted to research aspects related to weed management and hence outputs should be visible in terms of impactful technologies. Dr. Rao emphasized on need to strengthen basic research in weed biology and ecology based on realistic problems like weed shift and herbicide resistance. Dr. Bhumesh Kumar, Member Secretary, IRC presented the action taken report on general recommendations of last IRC-2013. Research work carried out by scientists during 2013-14 was reviewed in the meeting.

15.3 Review Meeting of National Fund Project

Review Meeting of National Fund Project on "Study of domestication traits of two weed species" was held on 6 September, 2014 under the chairmanship of Professor C.R. Babu. Professor R. Geeta (Member Advisory Committee), Dr A.R. Sharma (Director, DWR), principal investigators from co-operating centres, co-investigators from DWR, Administrative Officer, AF&AO and other project associates participated in the meeting. Dr. Bhumesh Kumar (Member Secretary & Principal Investigator) presented the finding of the research work followed by presentations made by scientists from co-operating centres. Review committee critically discussed the detail and progress made during last year and made recommendations for the improvement. Chairman appreciated the research work.

15.4 Institute Management Committee Meeting

Meeting of the XXIII Institute Management Committee (IMC) was convened on 27 September, 2014 under the chairmanship of the Director, DWR. The other members who attended the meeting were: Dr. A.K. Vyas, Assistant Director General (HRD), ICAR, New Delhi; Sh. B.P. Tripathi, Joint Director, DFWAD, Govt. of M.P., Bhopal; Dr. S.S. Tomar, Director Research Services, JNKVV, Jabalpur; Professor S.D. Upadhyay, JNKVV, Jabalpur; Dr. Prem Kishore, Chief Editor, Crop Care & Vice President, Cristal Crop Protection Pvt. Ltd., New Delhi. The Chairman IMC briefed about the historical background, mandate, networking and collaboration, farm facilities, discipline-wise staff strength, major research programmes in XII plan, and contract research / consultancy services in respect of this Directorate. Five Programme Leaders also presented the salient research achievements of 2013-14 and future research programme for 2014-15. Discussion on the other agenda items, *viz*. budget and status of works and equipments proposals was also held. The members also visited research farm and laboratories and appreciated the work being done at DWR.

15.5 XVIII Research Advisory Committee Meeting

The XVIII RAC meeting was conducted on 7-8th March, 2015 under the Chairmanship of Dr. R.K. Malik, CIMMYT, New Delhi and in the presence of Dr. B. Mohan Kumar, ADG (AA & CC), Dr. R.S. Balyan, Ex-Professor, Agronomy, CCS H.A.U., Hisar, Dr. B.L. Jalali, Ex-Director Research,CCS HAU, Hisar (Haryana), Dr. B.S. Parmar, Ex-Joint Director (Research), IARI, Dr. A.R. Sharma, Director, DWR and Dr. Shobha Sondhia, Member Secretary, RAC, DWR. Director made a brief presentation on the salient achievements of the Directorate and major initiatives undertaken during 2014-15. Dr. R.K. Malik in his opening remarks emphasized for the priority setting, based on the past achievements and out- come needed. He stressed that DWR should develop well-defined impact pathways for key priority areas like weed identification. He further added that recommendation should come with tangible outcome, highlights and impacts. We need to create an environment to encourage scientists to start with team energy. Dr. B. Mohan Kumar emphasized to focus work on invasive alien weed species. Parthenium activity can be continued with its awareness program. Dr. B.L. Jalali remarked that Directorate should publish some good success stories of technologies, which had made major tangible impact to the agriculture related to weed science based on completion of 25 years of the establishment of the Directorate. Dr. B.S. Parmar suggested to prepare next 5 year plan with new scenario. Dr. R.S. Balyan emphasized on extension need for testing of eco-friendly molecules in crops.

Dr. Shobha Sondhia presented the action taken report on the recommendations made in the XVII RAC meeting. Research work carried out under different programmes was presented by the programme leaders and individual scientists. At the end, RAC committee remarked that the overall outcome is very good and congratulated each scientist for doing good work.

Chapter - 16

EVENTS ORGANISED

16.1 Celebration of Foundation day

The Directorate celebrated 26th Foundation Day (Silver Jubilee year 1989-2014) on 22 April, 2014 in the presence of Dr. A.K. Sikka, Deputy Director General (NRM), ICAR, and Dr. V.S. Tomar, Vice Chancellor, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur. Dr. A.R. Sharma, in his welcome address, briefed the dignitaries about research and development activities at the Directorate. Dr. V.N. Saraswat and Dr. Jay G. Varshney informed about the gradual establishment of the Directorate and its face lifting in terms of infrastructure development and prioritization of research programmes. Dr. V.S. Tomar emphasized the indispensable need of continuous research on weed science for the farmer community. Chief Guest of the function and DDG, NRM Dr. A.K. Sikka revealed importance and need of efficient weed management technologies for sustainable production and highlighted the importance of the Directorate. On this occasion, 'Best Worker Awards' in the category of skilled supporting staff, administrative staff, technical officers and scientists were conferred upon Shri S.L.Koshta, Shri Sandeep Dhagat, Smt. Nidhi Sharma and Dr. Sushil Kumar respectively by certificate and memento. Extension bulletins on "Weedy rice and their management" and "Biology and management of parasitic weeds" were also released by dignitaries during the event.

16.2 Interface Meeting with Progressive Farmers and Agriculture Officers

Interface Meeting of progressive farmers with State Department officers and DWR scientists was organized on 29 April, 2014 to discuss various aspects of weed management and problems faced by stakeholders. Total 120 achiever/progressive farmers, 40 officers of state departments from 13 districts of Jabalpur, Rewa and Satna Divisions of Madhya Pradesh and 16 scientists from DWR participated in this meet. Dr A.R. Sharma Director, DWR presided over the function, Dr P.K. Singh Principal Scientist (Agril. Extension) coordinated the programme. A visit to experimental farm was organized to show encouraging results under conservation agriculture with use of improved farm

machinery. Packets of *Sesbania* seeds were also presented to the representatives of different districts.

16.3 Trainings organized

- Training on **'Weed Management'** for 40 scientists of KVKs from Madhya Pradesh, Chhattisgarh and Odisha was organized during 19-21 May, 2014. Dr. Anupam Mishra, Director, ZPD, Zone VII explained the strength and opportunity of KVKs to disseminate technologies on weed management among farmers. Dr. P.K. Mishra, Director, Extension Services, JNKVV, Jabalpur emphasized the importance of weed management in present situation of labor scarcity.

- One-day training on **'Advances in Weed Management'** was conducted on 14 October, 2014 for scientists attending the 21 days Career Advancement Faculty Training (CAFT) programme of JNKVV. A total of eight lectures broadly covering cultural, mechanical, biological, chemical methods of weed managements, spraying techniques, climate change, weed utilization, herbicide residue analysis, and integrated weed management were delivered by the scientists/experts from the Directorate. Participants were also taken to research farm for interactive discussions.

- A Review of Research-cum-Herbicide Residue Training Workshop of AICRP-WM Centres was organized from 11-17 November, 2014 in which the research work conducted by the AICRP-Weed Management centres during last 5 years under the Programme **"Environmental impact of herbicides"** was reviewed. During his welcome address, Dr. A.R. Sharma, Director, DWR emphasized the need and importance of this workshop-cum-training programme. He presented a detailed account on 'Herbicide residue research in AICRP-WM' and expressed his concern over the growing belief in common people that herbicides are harming health of humans, domestic animals, wildlife, etc. He urged the need of collective research on herbicide residues and publication of research outputs. Dr. V.P. Singh presented an overview of the network trials on herbicide residues. He drew special attention to RAC recommendation on verification of data before reporting it. Dr. Shobha Sondhia urged chemists to follow the guidelines and report data accordingly. Dr. R.P. Dubey suggested that centres must prepare a bulletin on herbicide residues based on their own research.

The workshop was followed by an extensive hands-on training for all AICRP-WM

residue chemists from 13 to 17 November, 2014. Various lectures and practicals relevant to herbicide residue analysis like general methodology of herbicide residue analysis, sample preparation and separation techniques, phase extraction and column chromatography were arranged by Dr. Shobha Sondhia and Dr. P.P. Choudhury. The participants appreciated the course content covered in this training and expressed the utility of this training.

- An eight-day Model Training Course (MTC) on **"Weed management for sustainable oilseed and pulse production"** was organized during 16-23 December, 2014. Dr. V.S. Tomar, Vice Chancellor, JNKVV emphasized the need of advanced knowledge on weed management for making agriculture a profitable venture. Welcoming the participants and guests, Dr. P.K. Singh, Principal Scientist and Course Director briefed about the content of the programme. Dr. A.R. Sharma, Director, DWR, focused on the purpose of the training programme. A total of 35 lectures covering cultural, mechanical, biological, chemical and integrated weed management were delivered by the scientists/experts of the Directorate and other institutions. Total seven practical sessions were conducted covering important aspects of weed management techniques, viz., weed identification, herbicide spraying techniques, mechanical weeding tools, weed utilization, bio-control agents, herbicide residue analysis, and conservation agriculture. Dr. P.K. Mishra, Director Extension services, JNKVV chaired the closing ceremony on December 23, 2014 and distributed certificate to trainees. The training programme was coordinated by Dr. K.K. Barman, Principal Scientist, and Dr. Raghwendra Singh, Senior Scientist.

- Directorate of Weed Research organized ICAR sponsored ten days Short Course on **"Non chemical approaches of weed management"** during 30 December, 2014 to 8 January, 2015. Dr. R.P. Singh, In-charge of Regional Organic Fertilizer Development inaugurated the programme by lighting of lamp. Speaking on the occasion, Dr. Singh emphasized the need to opt non-chemical approaches for the management of different pest including weeds to lower down the excessive use of pesticides. He stressed on organic farming to reduce the chemical load in the environment. Dr. Sushil Kumar, Course Director informed the house that this course is being attended by 17 particiapnts from 10 different states.

  The valedictory function was held on 8 January 2015 and graced by Dr. Neeru Singh, Director, National Institute of Research for Tribal Health (NIRTH) and Dr. S. Sambwat, Incharge, Zoological Survey of India, Jabalpur. Dr. Singh informed that aquatic weeds, one of the greatest suitable niche of mosquito breeding, lead to increase in many mosquito born diseases. Dr. Sambwat told that many species of birds and butterflies are under threat of extinction due to excessive use of pesticides. The programme was convened and vote of thanks was proposed by Dr. Shobha Sondhia, Sr. Scientist. On this occasion, a 'family get together' was organized in the lawn of the Directorate.

- A training course on **"Bioherbicides with special emphasis to microbial biotechnology"** was conducted at this Directorate from 27 January to 10 February, 2015. The training programme was sponsored by the Madhya Pradesh Biotechnology Council, Bhopal. Dr. C. Kannan, Sr. Scientist, was the course director and Dr.Meenal Rathore acted as the coordinator for this training. Total 13 students from the Universities/colleges around Jabalpur, Satna and Rewa districts participated in the training programme. The training programme included expert lectures by the scientists of the Directorate and also from other Universities/ colleges and research institutes around Jabalpur. Dr. A.R. Sharma, Director, DWR presided over the inaugural function and Dr. Vazhan Arasu, Principal, St. Aloysius College, Jabalpur was the chief guest of the valedictory function.

- A one-day training programme was organized on 19 March, 2015 for 55 achiever farmers including 8 IFFCO officials from their adopted villages covering 9 district of MP. In this training programme Mr. J.S. Rathi, Chief Divisional Manager, IFFCO highlighted the achievements made by their farmers' in practicing SWI and green manuring using sunhemp. He urged the need of technical know-how regarding weed management and conservation agriculture so that their adopted farmers can derive full benefit of modern agricultural practices. Dr. A.R. Sharma

spoke about techniques and benefits of CA practices. Dr. P.K. Singh delivered a lecture on improved weed management practices in the crops being cultivated in MP. The participants were taken to the experimental and on-station demonstration sites and shown the essential farm implements like laser leveler, happy seeder and tractor mounted sprayer needed for practicing CA.

- A ten days 3rd National Training Course on **"Advances in Weed Management"** was organized during 19-28 March, 2015. Total 24 trainees, representing 15 states participated in the programme. The participants were exposed to the recent technologies on weed management for improving productivity of field/horticulture crops, developed at this Directorate and elsewhere. The training course involved theory classes as well as practical exercises by the faculty of this Directorate and the experts invited from other Institutions. The trainees were also taken to farmers fields where DWR demonstrated the weed management technologies. In the valedictory function held on 28 March, Dr. A.R. Sharma, DWR urged the need of integrated weed management for sustainable crop production. He emphasized on need of interdisciplinary research and focused on the importance and purpose of the training. He hoped that after taking this training, participants will be able to deal with weed management problems in their respective fields.

Dr. Sushil Kumar, Principal Scientist was the Course Director and Dr. Bhumesh Kumar and Dr. Raghwendra Singh, Senior Scientist were 'Course Coordinator' of this training programme.

16.4 Kisan Day - cum- Goshthi

Field visits were organized at Sihora, Panagar and Ragartola (Khukham) localities on 22-23 September, 2014 to review the progress of ongoing on-farm research trials conducted during *kharif* season. Director and other scientists participated in field visits. During visit, scientists and farmers shared their views on various issues related to weed management. Director extended knowledge-based support to the farmers and encouraged them to adopt improved weed management practices.

Field Day cum Sangosthis were also organized during 10-18 March, 2015 to show the performance of *rabi* season OFR trials conducted at Simariya, Bijora and Bharda villages. Farmers from these and also from nearby villages participated in the Sangosthis and visited the wheat fields grown following the principles of conservation agriculture which reduces the cost of cultivation by ₹ 2500 per acre besides conserving the resources, soil fertility and environment. The farmers interacted with the scientists and were given technical know-how by the scientists. Practical demonstration of crop sowing by "Happy Seeder" was also undertaken. Dr. A.R. Sharma, urged the farmers to adopt improved

technologies, and assured all possible support and guidance from the Directorate. The adopted farmers who had used the happy seeder and are following conservation agriculture technology also shared their experiences to the participating farming community.

16.5 Vigilance Awareness Week

Directorate observed Vigilance Awareness Week from 27 October - 01 November, 2014. This year the main focus of observing Vigilance Awareness Week is "Combating Corruption – Technology as an enabler". On the occasion, DWR displayed posters as well as arranged interactive session to make staff aware of the importance of this week. All staff members took a pledge to eradicate corruption from all spheres of life and bring pride to our organization.

16.6 Agriculture Education Day

The third Agriculture Education Day was celebrated on 10 December, 2014 to promote the spirit of agricultural science among school children. Thirty seven students along with their teachers from 5 different schools located in rural areas of Jabalpur, took part in the day-long activities. Inspirational talks, quiz competition and visits to information centre, laboratories and research fields were organized to mark the day. Participating students were enlightened about the National agricultural research and education system in India by Director, Dr. A.R. Sharma. He also highlighted the opportunities existing for students pursuing their career in agricultural education. Dr. P.K. Singh, Pr. Scientist, told about the modern weed control methodologies. Dr. Sushil Kumar, Pr. Scientist, demonstrated how weed biomass and crop residues could be converted to highly valuable manure using vermi-composting technique. A quiz competition involving all the students was conducted by Dr. Shobha Sondhia and Dr. P.P. Choudhury, Sr. Scientists. In the closing ceremony, students were given Certificate of Participation and prizes were distributed to successful participants by the Director. The programme ended with vote of thanks given by Dr. K.K. Barman, Pr. Scientist and Programme Convener.

16.7 Industry Day

Industry Day was organized on 26 March, 2015 at the Directorate in order to further strengthen the linkages for effective collaboration with the herbicide industry for testing of new molecules/formulations as well as those dealing with farm machinery, spraying equipments and instrumentation. Speaking on the occasion, Dr A.R. Sharma, Director, DWR, emphasized that the context of scientific enterprising is changing in the era of globalization and same with the weeds. Dr Sharma also made an introductory presentation in which he highlighted important research programs, technologies and initiative being taken at DWR, Jabalpur. Dr R.P. Dubey, Principal Scientist of this Directorate gave a brief presentation on the 'DWR-herbicide industry linkages' which was followed by discussion with herbicides industries. Concern had been raised by DWR scientists for weedy rice, and requirement of new post emergence molecules for weed control in pulses and aquatic bodies.

Dr Subhash Chander from Plant protection Quarantine, Faridabad gave an account of the 'pesticide registration process and policy' and highlighted important processes and requirement for pesticide registration in the country. He informed the house that in each state pesticide inspectors are appointed by the Central Insecticidal board for regulation and control of spurious pesticides. He also informed about pesticide formulation testing laboratory in each state where spurious pesticides can be tested. Dr Shobha Sondhia, Senior Scientist of DWR, Jabalpur gave a brief presentation on the topic, "Herbicide residues, spurious herbicides & adulteration and safety requirements". She mentioned that as per ICAR estimates around 40% of pesticides used in the country are spurious and the total market for pesticides in the country is estimated to be around Rs 7,000 crore.

Farmers from Bharda, Padariya, and Luhari villages also participated in the Industry day program. Farmers raised problem of spurious pesticides and other plant protection chemicals. Mr. Sachin Dubey, from NPL, Mumbai said that some progress has been made to develop new molecule for control of post emergence weeds in pulses. He said that Iris is a good herbicide for weed control in soybean. Representative from BASF (Herbicide Company) informed that Toproamizone is registered and soon will be available in the market for commercial use. Mr. Sanweer Lal Yadav from ADAMA India Pvt. Ltd, Hyderabad informed about post emergence herbicides in pulses. Scientists from DWR suggested herbicide industry persons to orient pesticide dealers to further disseminate knowledge to stakeholder's about safe use of herbicides and disposal of containers. It was also suggested that some initiative should be made by government and CIB, Faridabad to check spurious pesticides in India.

Mr. Piyush Tiwari informed the house about improved varieties of banana, sugarcane, tomato, brinjal, cauliflower etc. developed by tissue culture techniques. Scientists from Dr.B.S.K. Krishi Vidyapeeth, Dapoli, JNKVV, Jabalpur, GBPUAT, Pantnagar, HAU, Hisar, IGKV, Raipur, IACR-CRIJAF, Kolkata, MPUAT, Udaipur, KAU, Trissur, HPAU, Palampur, PAU, Ludhiana, NDUAT, Faizabad, SKUAST Jammu, Plant Protection and Quarantine, Faridabad, BAU, Jharkhand, Regional Plant Quarantine Station, Chennai, Dr. M.L. Kewat, Professor, Agronomy, JNKVV Jabalpur, Mr. Sanjay Sharma from Sameer Science Lab and Supplements, Jabalpur, person from herbicide Industries, such as, BASF, UPL, EXCEL, Bayer, DuPont, IFFCO, Kisan Call centre, Exclusior Engineering Company, Jain Irrigation system and Tissue Culture participated in the program. The programme was co-ordinated by Dr. Shobha Sondhia and Dr. P.K. Singh.

16.8 National Science Day

National Science Day was celebrated on 28 February, 2015. Objective type science knowledge awareness competitions were arranged for scientific, technical, administrative, and supporting staff to mark the occasion. Dr. Tapas Chakma, Deputy Director, NIR in Tribal Health, ICMR, Jabalpur presided over the function and also delivered a lecture on 'Fluorosis: medical and scientific perspectives'. Dr. Meenal Rathore, Senior Scientist conducted the proceedings highlighting the importance of the day in national context. Dr. D.K. Pandey, Principal Scientist addressed the house keeping in view the theme "Science for Nation Building" and its relevance in Indian context. He stressed that food and nutrition security for rising population, depleting quality and quantity of resources and challenges compounded by the climate change have to be dealt with the help of science for better life. Dr. P.P. Choudhury, Dr. Meenal Rathore, Abhishek Dubey, Kavita Rohitas, Shiv Prasad, Mohanlal Dubey, Priyanka Tiwari and Shraddha Rawat were given prizes for winning the science awareness competition in their respective categories. The programme ended with the vote of thanks given

EVENTS ORGANISED

by Dr. C. Kannan.

16.9 Cleanliness Drive

Under the Swachh Bharat Mission of Union Government, special cleanliness drive at DWR has been launched at DWR on 25 September, 2014. Dr. A.R. Sharma, Director, DWR motivated the staff members for their contribution in making the campus clean. All the staff members were given responsibility to clean the identified places within the premise. The staff members participated in the cleanliness exercise with enthusiasm and cleaned the corridors, floors, basement, parking area, lawn and farm roads of the campus. During this, *Parthenium*, newspapers, polythene stuffs and other garbage were removed from the premises for disposal at proper place. On the occasion of Gandhi Jayanti, all the staff members again cleaned the different adjoining areas outside the campus and also convinced the local people for their contribution in Swachh Bharat Mission.

16.10 Celebration of Independence Day

Directorate celebrated Independence Day on 15 August, 2014. The Director hoisted the National flag and addressed the gathering. He recalled the sacrifices made by the freedom fighters for independence of the nation, and also briefed about contribution made and future challenges to be addressed by ICAR-DWR. On this occasion, staff of the Directorate participated in mass plantation campaign and planted Teak saplings at different locations within DWR campus.

16.11 Celebration of Republic day

Directorate celebrated the Republic day on 26 January, 2015 with great enthusiasm. Director greeted the members of the staff on these occasions. He highlighted the achievements made and also the initiatives taken during the preceding year to further strengthen the research and extension activities of the Directorate. He appealed to all to work wholeheartedly to raise the image of the Directorate. Sports and cultural activities were organized involving the staffs and their kids on these occasions.

16.12 Guest Lectures

The Directorate arranged following lectures by outstanding/eminent scientists:

Date	Scientist	Topic
01.08.2014	Dr. M.D. Reddy	Agriculture development in Telangana
04.09.2014	Dr. D.K. Benbi	Carbon sequestration and soil health
17.02.2015	Dr. P.K. Nair	How to write research paper

Chapter - 17

PARTICIPATION IN SEMINARS AND WORKSHOPS

Dr A.R. Sharma

- NAAS Foundation Day at New Delhi on 5 June, 2014
- Meeting for presentation of EFC proposal during 14-15 July, 2014 at ICAR, New Delhi.
- Special convocation of IARI on 8 September, 2014 at ICAR, New Delhi
- Selection committee meeting for recruitment of faculty positions on 15 September, 2014 at IIT, Kharagpur
- Workshop on IPM on 16 September, 2014 organized by NCIPM, New Delhi at Puduchery
- XXIII meeting of Regional Committee No. VII comprising the states of Maharashtra, Madhya Pradesh, Chhattisgarh and Goa from 17-18 October, 2014 at Raipur
- National Symposium on Agricultural Diversification for sustainable livelihood & environmental security from 18-20 November, 2014 at PAU, Ludhiana
- Alumini Meet, and reviewed the progress of research work of AICRP – Weed management centre on 22 November, 2014 at CSK HPKVV, Palampur
- XII Agricultural Science Congress during 3-6 February, 2015 at National Dairy Research Institute, Karnal
- Core group meeting of 'CRP on Conservation Agriculture' during 22 March, 2015 at New Delhi

Dr P.K. Singh

- Workshop cum training programme for *Parthenium* management organized by Gram Jan Vikas Samiti and EcoVikas Samiti on 25 August, 2014 at village Garhi of Tehsil Behar in district Balaghat
- State level workshop on agriculture and horticulture on 30-31 August, 2014 at JNKVV, Jabalpur
- National conference on soil health: A key to unlock and sustain production potential during 3-4 September, 2014 at JNKVV, Jabalpur
- XXI Zonal Workshop for scientists' of KVKs, zone VII during 5-7 September, 2014, at IGKV, Raipur.
- Field level orientation programme for tribal farmers on 15 September, 2014 organized by SRIDA Centre, Jabalpur at Ramanpur (Bargi Block)
- 'Farmers Fest' on 29 September, 2014 at BISA, Jabalpur
- 'Rashtra staryiya jaivik krishi mela' at Mandla M.P. during 18-20 October, 2014
- Kisan Gosthi organized by Biodiversity International and KVK, Narshinghpur at Narshinghpur on 31 March, 2015

Dr V.P. Singh

- Strengthening partnerships between AICRP-WC, Jabalpur and AICRP on IFS, Modipuram running in Assam, Meghalaya and W.B states, 26 May, 2014 at AAU, Jorhat (Assam)
- Strengthening partnerships between AICRP-WC, Jabalpur and AICRP on IFS, Meerut running in Bihar, Chhatisgarh, Odisha, Jharkhand and MP states, 09 June, 2014 at ICAR Res Complex for Eastern Region, Patna
- Strengthening partnerships between AICRP-WC, Jabalpur and AICRP on IFS, Modipuram running in A.P, Karnataka, Tamilnadu, 09 July, 2014 at ANGRAU, Hyderabad
- Strengthening partnerships between AICRP-WC, Jabalpur and AICRP on IFS, Modipuram running in U.P, Uttarakhand, Haryana, Punjab and H.P. 11 August, 2014 at CCSHAU, Hisar
- XXI Zonal Workshop for Scientists of KVKs, Zone VII during 5-7 September, 2014, at IGKV, Raipur.
- Farmers' Fest on 29 September, 2014 at BISA, Jabalpur

Dr Sushil Kumar

- Participated in XXIII workshop of AICRP on biological control of crop pests held at OUAT, Bhubaneswar on 27-28 June, 2014
- Workshop-cum training on biological control of *Parthenium* organized by Project Director, ATMA, Patiala 28-29 August, 2014
- Workshop cum training programme for *Parthenium* management organized by Gram Jan Vikas Samiti and EcoVikas Samiti on 25 August, 2014 at village Garhi of Tehsil Behar in district Balaghat
- Presentation of EFC proposal during 14-15, July, 2014 at ICAR, New Delhi
- 'Farmers Fest' on 29 September, 2014 at BISA, Jabalpur

Dr K.K. Barman

- National conference on soil health: A key to unlock and sustain production potential. 3-4 September, 2014, JNKVV, Jabalpur
- Workshop on crop residue management, JNKVV, Jabalpur, 29 December, 2014

Dr R.P. Dubey

- NAIP & IFPRI workshop on PME at NASC, 27 May, 2014 at New Delhi
- Management development programme on priority setting, monitoring and evaluation (PME) of agricultural research projects during 4-8 August, 2014 at NAARM, Hyderabad
- State level workshop on agriculture and horticulture on 30-31 August, 2014 at JNKVV, Jabalpur
- ICAR-regional committee-IV meeting during 5-6 September, 2014 at IISR, Lucknow
- 'Farmers Fest' on 29 September, 2014 at BISA, Jabalpur
- National Conference on Pulses: Challenges and opportunities under climate change scenario" during 29-30 September, 2014 at JNKVV, Jabalpur
- 'Rashtra staryiya jaivik krishi mela' during 18-20 October, 2014 at Mandla M.P.
- Biennial workshop of AICRP-IFS during 22-24 December, 2014 at Coimbatore
- Kisan Gosthi organized by Biodiversity International and KVK, Narshinghpur at Narshinghpur on 31 March, 2015

Dr P.J. Khankhane

- National Conference on Soil Health: A key to unlock and sustain production potential during 3-4 September, 2014 at JNKVV, Jabalpur

Dr Shobha Sondhia

- National Symposium on agrochemicals for food and environment safety during 28-30 January, 2015 at IARI, New Delhi
- Two days workshop on impact of capacity building program under NAIP during 6-7 June 2014 at New Delhi

Dr P.P. Choudhury

- National Symposium of society of pesticide science- India during 27-29, January, 2015 at IARI, New Delhi

Dr Bhumesh Kumar

- National Conference on biotechnology for sustainable agriculture" during 8-9 September, 2014 at JNKVV, Jabalpur
- National seminar on "Technologies for sustainable production through climate Resilient agriculture" during 8-9 August, 2014 at JNKVV, Jabalpur

Dr Raghwendra Singh

- Field Level orientation programme for tribal farmers" on 15 September, 2014 organized by SRIDA Centre, Jabalpur at Ramanpur (Bargi Block)
- 'Farmers Fest' on 29 September, 2014 at BISA, Jabalpur
- National Conference on agricultural diversification for sustainable livelihood and environmental security during 18-20 November, 2014 at PAU Ludhiana
- International conference on natural resource management for food security and rural livelihoods 10-13 February,2015 at New Delhi.
- Core group meeting of 'CRP on conservation agriculture' during 22 March, 2015 at New Delhi
- Kisan Gosthi organized by Bioversity International and K.V.K. Narshingpur at Narshingpur on 31 March, 2015

Dr Meenal Rathore

- National Conference on 'Biotechnology for sustainable agriculture' during 8-9 September, 2014 at JNKVV, Jabalpur
- National Seminar on 'Technologies for sustainable production through climate resilient agriculture' during 8-9 August, 2014 at JNKVV, Jabalpur

Dr C. Sarathambal

- Attended centre of advanced faculty training on 'Management of soil health: challenges and opportunities' conducted by JNKVV, Jabalpur during 29 September to 19 October, 2014
- Attended winter school on "Waste recycling and resource management through rapid composting techniques' conducted by IISS, Bhopal during 3-23 December, 2014.

Dr R.S. Upadhyay

- Attended training programme on conservation agriculture held during 27 September to 4 October, 2014 at CSSRI, Karnal.

Mr Sandeep Dhagat

- Meeting for presentation of EFC proposal during 14-15 July, 2014 at ICAR, New Delhi
- One day Seminar on IPv6 on 23 January, 2015 at Office of General Manager, BSNL, Jabalpur organized by Department of Telecommunication, Govt. of India, Bhopal

Mr Pankaj Shukla

- One day Seminar on IPv6 on 23 January, 2015 at Office of General Manager, BSNL, Jabalpur organized by Department of Telecommunication, Govt. of India, Bhopal
- Attended 5 days training programme on Office automation using oracle ERP system (FMS/MIS) in ICAR at IASRI, New Delhi from 9-13 March, 2015

Mr Mukesh Meena

- 'Farmers Fest' on 29 September, 2014 at BISA, Jabalpur

Chapter - 18

ALL INDIA COORDINATED RESEARCH PROJECT ON WEED MANAGEMENT

WS-1: Weed surveillance and monitoring

- Tomato and brinjal crops in of Bhiwani district were severely infested with *Orobanche spp.* causing 15-45 % decrease in yield. Some other crop, even taramira, radish, turnip, gobhia sarson and cabbage were also found infested with *Orobanche* at Hisar.
- Mustard crop sown in November was less infested with *Orobanche* as compared to October sown crop. Sporadic incidence of *Orobanche* was also observed in brinjal and tomato crops under the vegetable tracts of Cuttack and Khurda district along river Mahanadi.
- *Coronopus didymus, Polypogon monspliensis* and *Poa annua* have become major weeds of berseem crop.
- In Sirsa, Fatehbad and Hisar areas of Haryana, *Ipomoea spp.* has started infesting cotton crop and the infestation is increasing every year causing economic losses to the cotton growers.
- Weed survey conducted in the high ranges of Kerala showed that new invasive weeds *Tithonia diversifolia*, *Ludwigia peruviana* and *Sphagneticola* are spreading in the region and replacing *Lantana camara*, *Mimosa invisa* and *Pennisetum* species.
- *Mikania micrantha, Chromolena odorata, Mimosa Pudica, Parthenium hysterophorus, Saccharum spontaneum* and *Lantana camera* were prominent weeds observed in North central plateau Zone of Odisha.
- *Celosia argentea* was found as a severe problem in *upland rice* and *rabi* pulses in the districts of Keonjhar. The weed is invading mostly the upland areas nearer to the foothills with the soil types belonging to light textured red soils.
- In Coimbatore district, *Parthenium hysterophorus* was the dominant (SDR 24.1) broad leaved weed as compared to dominance of *Trianthema portulacas* trum (SDR 12.7) in cropped area.
- *Ambrosia psilostachya* a quarantine weed infested in 12 villages of Turuvekere in farmer's field, road side, irrigation canals and guntas.
- Infestation of *Euphorbia dracunculoides* is increasing in mustard and chickpea crop planted under rainfed or limited irrigation conditions.
- *Kharif* crops in south Haryana grown under light textured soils was heavily infested with broadleaf weed *Leucas aspera* which was not controlled by pendimethalin and atrazine used by the farmers.
- *Poa annua* and *Avena ludoviciana* among grasses and *Medicago denticulata, Anagallis arvensis, Chenopodium album, Cornopus didymus, Malva parviflora* and *Fumaria parviflora* among broadleaf weeds are also emerging as new weed species in wheat crop at Ludhiana.
- During *Kharif* season, *Caesulia auxillaris* and *Cleome viscosa* were emerged as dominant weeds in transplanted rice crop at Pusa.
- *Cynadon dectylon, Commelina bengalensis, Conyza bonareinsis* was found to be resistant to glyphosate and 2,4-D.
- *P. minor* has developed resistance against clodinafop-propargyl herbicide in Kaithal, Kurukshetra, Karnal, Jind, Panipat and parts of Sonipat, Fatehbad, Ambala and Sirsa districts of Haryana state.
- In wheat crop, dicotyledonous weed *Solanum nigrum* is spreading fast as troublesome weed and only carfentrazone was found effective to control this weed in north-eastern Haryana.
- The reduction in dry matter of *P. minor* biotypes with herbicides was 82.3% in case of susceptible and 53.7% in case of resistant biotype, when compared to unsprayed control.

WS-2: Weed biology and physiology

- *Digera* and *Parthenium* seed germination was influenced by depth of sowing.
- *Orobanche* panicles appeared above soil on an average 45-54 days after sowing of mustard. Violet cream colored flowers started to appear 11-13 days after panicle emergence of *Orobanche*.
- *E. colonum* and *D. aegyptium* recorded the highest germination at surface and 2.0 cm depths respectively. *Echinochloa glabrescens* and *Echinochloa crusgalli* recorded higher emergence in 2 cm sowing depth (56%) and lower in 10 cm depth (41%). Sequential application of 2,4-D amine salt and glyphosate was found effective against *C. rotundus*.

- *Phalaris minor* not germinated below 5.0 cm depth.
- *Trianthema portulacastrum* was having quick multiplication rate in shorter period of 45 days and produces about 7000 seeds per plant. *Amaranthus viridis* flowering started at six weeks after emergence and completed its life cycle within 65 days.
- Weedy rice infestation was highest in direct seeded rice and least in transplanted rice in Khorda district of Odisha and Bihar.
- Pinoxaden, fenoxaprop-p-ethyl and clodinafop recorded <40% control of *P. minor* biotypes (20 DAS) indicating the development of cross-resistance in *P. minor* to these herbicides.
- Glyposate and 2,4-D alone or in combination had no effect on the tuber viability of *C.rotundus* at Pantnagar.
- Application of 2,4-D @ 125 g/ha fb glyphosate 750 ml/ha after 48 hrs gave good control of *Cyperus rotundus.*

WS-3: Weed management in crops and cropping systems

- Addition of ethoxysulfuron, chlorimuron+ metsulfuron or azimsulfuron as tank-mix or as sequential application with grass herbicides like bispyribac or pretilachlor controled of broadleaf weeds and sedges in transplanted rice. Also the ready-mix combination like triafamone + ethoxysulfuron, penoxsulam + cyhalofop and pretilachlor + pyrazosulfuron provided almost complete control of complex weed flora.
- Sequential application of pendimethalin 1000 g/ha (pre) *fb* bispyribac-Na (post) recorded the highest grain yield in rice which was at par with twice hand weeding at 25 and 45 DAT and application of pretilachlor fb ethoxysulfuron.
- In direct sown dry seeded rice, pendimethalin fb hand weeded resulted in highest yield. Pendimethalin *fb* bispyribac sodium resulted in higher B/C ratio due to lesser labour charges.
- In turmeric, fenoxaprop provided effective control of grassy weeds as post-emergence herbicide. Glyphosate @ 7.5 ml/liter of water (directed spray) provided effective control of most of the weeds at the time of its application. Metribuzin 700 g/ha or pendimethalin 1000 g/ha or atrazine 750 g/ha *fb* mulching+ hand weeding at 45 DAS provided complete control of weeds (100%) in turmeric with improved crop growth.
- Application of glyphosate 0.80 kg/ha + oxyfluorfen 0.2 kg/ha just before emergence of sprouts of ginger was found effective in reducing density as well as dry matter accumulation by all three categories of weeds.
- Pre emergence use of pendimethalin + imazethapyr provided effective control of *T. portulacastrum* and *E. colona* in green gram with 80% control of weeds even up to 45 DAS without any crop suppression.
- Integrated weed management experiment in long duration crop like cotton, combination of pendimethalin with manual weeding or pyrithiobac-sodium + quizalofop-p-ethyl with directed spray of glyphosate gave broad spectrum and long duration weed control leading to higher net returns and B:C ratio.
- Among weed management practices, grain and straw yield were significantly higher with atrazine @ 0.50 kg/ ha as PE *fb* IC at 30 DAS in *Kharif* Pearlmillet.
- In maize-wheat cropping system zero tillage - zero tillage sequence recorded 46.47% more grain and straw yield compared to conventional-conventional tillage (CT-CT) sequence owing to reduced weed density and dry matter accumulation by all categories of weeds.
- Among the different establishment methods in rice and wheat cropping system, the highest grain yield of wheat was recorded under DSR (ZT)+ R-Wheat (ZT)+ R- Sesbania (ZT) (4.7 t/ha) while in rice it was with TPR (CT)-wheat (CT) (4.6 t/ha).
- In conservation agriculture systems, chickpea in conventional/zero tillage after conventional tillage rice performed better as compared to chickpea under zero tillage. Similar performance was noticed in summer green gram.
- The grain yield of wheat under different treatments was similar or higher under green manuring as compared to non-green manuring in long-term trial continued since 1999. Infestation of *P.minor* in weedy check plots under green manuring was similar to non-green manuring in respect of its dry weight, but significantly higher density under green manuring.
- Green manuring to kharif rice did not influence the weed density and growth of monocots and broad leaved weeds in Rabi groundnut.
- The soil microflora such as bacteria, fungi, free living nitrogen fixers and phosphate solubilisers, biomass carbon, basal soil respiration, dehydrogenase enzyme and phosphatase enzyme activity were found significantly higher in green manuring treatment as compared to the without green manuring treatment in *rabi* groundnut crop at all the stages of the crops.
- Green manuring with Dhaincha did not influence the weed density and weed growth at 30-50, DAT and at harvest in *Kharif* rice. Similarly it was not influenced the yield attributes and yield of rice.
- Conventional tillage found better than zero tillage to improve the microbial and biochemical properties of soil at initial stage of experimentation. Conventional tillage significantly increased the nodule biomass of chickpea over zero tillage at 50 days after sowing of crop.
- Application of oxyfluorfen or pendimethalin was found to be effective in reducing grassy, broad leaf and sedges weeds in carrot and egg plant.

WS-4: Management of problematic weeds

- Neem cake 200 kg/ha at sowing fb soil drenching of metalaxyl MZ 0.2% at 20 DAP reduced *Orobanche* shoot density with better weed control and higher tobacco leaf yield.
- Pendimethalin alone or in combination with neem cake did not prove useful in minimizing population of *Orobanche aegyptiaca*. Use of Trichoderma viridae at 5 kg/ha and neem cake at 200 and 400 kg/ha did not cause any inhibition of *Orobanche* emergence.
- Glyphosate application at 25 g/ha at 30 DAS and 50 g/ha at 55 DAS alone or with 1% with $(NH_4)_2SO_4$ provided good (75-80%) control of *Orobanche* up to 120 days ofr sowing.
- Although use of glyphosate alone at 50 g/ha at 40 DAS provided 60 % control of *Orobanche* but 10% crop suppression in terms of chlorosis and necrosis resulted in poor yield.
- Application of pendimethalin 0.50 kg/ha (sand mix) as PE showed phytotoxic effect on Lucerne crop and only 10% plants were survived after germination in pendimethalin application.
- Butachlor as PE and foliar spray metalaxyl 20 DAS did not show any positive effect to control *Cuscuta*.
- Application of pendimethalin as pre emergence did not influence niger plant adversely. However application of imazathapyre affected not only *Cuscuta* but also affected plant germination as well as growth of niger. Pendimethalin did not show adverse effect on niger.
- The germination of *Cuscuta* was less in stale seedbed fb pendimethalin 1.0 kg/ha – pre-emergence which resulted in the highest grain yield of niger
- Mustard crop irrigated with sprinkler and grown under rainfed conditions had more infestation of *Orobanche* as compared to irrigated with flooding method.
- 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 could be recommended for effective control of *Striga asiatica* in sugarcane and for higher productivity and profitability was released as technology.
- *Neochetina bruchi* were released during September 2014 at Hisar. Multiplication of these weevils was observed but caused only scars on water hyacinth leaves complete feeding of leaves was not observed.

WS-5: Herbicide residues and environmental quality

- Residues of butachlor dissipated faster under green manuring than under non-green manuring conditions in paddy crop. The half life of butachlor was found 9.2 days and 13.3 days, under non-green manuring and green manuring condition respectively. There were no residues of butachlor and clodinafop in grains and straw.
- There was no build up of herbicide residues at Thrissur continuous application of butachlor in rice crop for 26 seasons.
- Addition of organic matter decreased the persistence of butachlor and pretilachlor.
- Oxadiargyl along with bispyribac persisted in soil up to harvest stage. Residual effect of fenoxaprop-p-ethyl, chlorimuron-ethyl and metsulfuron-methyl (applied in *kharif* rice) was observed during *rabi* experimentation up to showing time of chickpea.
- Residue of cladinofop and pendimethalin in soil and wheat were found below detectable limit at harvest. Residues of butachlor and anilophos in soil were 0.056 and 0.083 µg/g, respectively at 60 days. The residues of pretilachlor in continuous and rotational use treatments were 0.071 and 0.049 µg/g respectively at 60 days.

- Use of pyrazosulfuron ethyl 25 to 50 g/ha in rice resulted in residue up to 35 to 45 days in the soil and residues were not found in soil, grain, straw and under ground water at the time of harvest of crops.
- Clodinafop residues were detected in out of 9 sites of Haryana were having only two sites out of 50 were detetcetd with pretilachlor residues in the range of 0.092 and 0.066 µg/ml at village Nabipur of Karnal. No oxadiargyl, butachlor and anilofos residues were detected at any site out of 50 sites from were samples were taken.
- Among 17 sites, 8 were having sulfosulfuron residues in soil in the range of 0.015 to 0.044 µg/g in districts of Haryana. No residues of sulfosulfron were detected in wheat grains and straw. Similarly, 3 out of 21 sites were having pretilachlor residues ranging between 0.016 – 0.058 µg/g in soil, paddy grain and straw. No residues of oxadiargyl were observed in soil, paddy grain and straw samples.

WS-6: On Farm Research

- On the basis of 8 on farm trials, tembotrione provided effective (92%) control of *Cyperus rotundus, Brachiaria reptans, Commelina benghalensis, Digitaria sanguanalis, Sorghum helepense Elusine indica* which were not being controlled by atrazine being used by the farmers.
- The bioefficacy of ready mix combination of clodinafop+ metribuzin against complex weed flora in wheat provided more than 87% control of *P. minor* but decreased yield. Toxicity to some of varieties viz: PBW 550, HD 2967, HD 2891 and Barbat under high moisture conditions and regeneration of *P. minor* in some cases was also observed.
- In tarai regions of Uttarakhand, application of ready mix of clodinafop-propargyl and metsulfuron methyl (60+4 g/ha) in wheat crop was found more effective to control the weeds at farmer's field as compared to application of clodinafop-propargyl and metsulfuron methyl alone whereas in hilly areas ready mix combination of sulfosulfuron + MSM 30+2 g/ha was found more effective.
- Penoxsulam at 25 g/ha applied at 8-10 days after transplanting recorded effective control of annual grasses, broadleaved and sedges weeds and recorded similar rice grain yield and economic return to already recommended herbicides bispyribac and pretilachlor at all locations.
- Metsulfuron + carfentrazone + 0.2% NIS at 25 g/ha recorded effective control of all broadleaved weeds including hardy ones in wheat.
- Pre-emergence application of oxyflourfen 250 g/ha followed by imazethapyr 100 g/ha + quizalofop ethyl 50 g/ha on 15 DAS was found effective for broad, spectrum weed control and higher seed yield and economic returns in groundnut.
- Use of glyphosate twice at 25 and 55-60 DAS provided on an average 66% control of *Orobanche aegyptiaca* in mustard with yield increase of 14.6% over untreated control.
- Application of imazethapyr alone (100 g/ha) gave highest WCE (90.3%) and produced 41.6% higher yield of soybean over the farmer's practice.
- In groundnut four FLDs at Puri district revealed that application of pendimethalin @ 1.0 kg/ha increased yield by 21.6 - 39.4% over farmers practice.
- Demonstrations on weed management in wheat using ZT sowing with residues + herbicides recorded effective weed control and higher wheat grain yield and net returns than farmers practice (CT sowing + herbicides).

TSP programme

- Under tribal development programme a fruit based land use system has been developed with following to acquaint farmers about improved method of orchard development, introduce intercropping in orchard to utilize interspace for cultivation of field crops, suppress weeds by intercropping in newly developed orchard and to evaluate the economics of farmers.
- Front line demonstrations on weed management in rice were laid down in 28 tribal villages in districts of Bastar, Kondagaon, Kanker, Bilaspur, Balrampur, Balrampur and Mahasamund. A total of 248 farmers of there districts were benefitted by this programme.
- An average increase of 15.8% in benefit :cost ratio was obtained due to recommended practice over farmers practice in rice crop established either in direct line seeded or puddle rice.
- Farmar of Sundargarh and Keonjhar districts of Odissa and Chattishgarh were given different farm machineries implements and agricultural inputs. About 225 farmers were directly benefitted under this programme.

Chapter - 19

DISTINGUISHED VISITORS

Dr. R.K. Malik, Co-ordinator, CIMMYT-India, New Delhi	18-19 April, 2014 and 7-8 March, 2015
Dr. B.L. Jalali, Ex-Director of Research, CCS HAU, Hisar	18-19 April, 2014 and 7-8 March, 2015
Dr. R.S. Balyan, Ex-Professor, Agronomy, CCS HAU, Hisar	18-19 April, 2014 and 7-8 March, 2015
Dr. B.S. Parmar, Ex-Director Research, IARI, New Delhi	18-19 April, 2014 and 7-8 March, 2015
Dr. A.K. Sikka, Deputy Director General (NRM), ICAR, New Delhi	21-22 April, 2014 and 3 September 2014
Dr. V.S. Tomar, Vice Chancellor, JNKVV, Jabalpur	22 April, 2014
Dr. S.S. Tomar, Director Research, JNKVV, Jabalpur	22 April, 2014
Dr. V.N. Saraswat, Former Director, DWR, Jabalpur	22 April, 2014
Dr. Jay G. Varshney, Former Director, DWR, Jabalpur	22 April, 2014
Sh. A.K. Khare, Joint Director of Horticulture, Jabalpur Division	29 April, 2014
Sh. S.K. Chourasia, Divisional Agril. Engineer, Jabalpur	29 April, 2014
Sh. B.P. Tripathi, Joint Director of Agriculture, Jabalpur Division	29 April, 2014
Sh. Rajesh Tiwari, Divisional Agril. Engineer, Satna	29 April, 2014
Dr. N.T. Yaduraju, President, ISWS	2-3 May, 2014
Dr. A.N. Rao, Visiting Scientist, IRRI/ICRISAT, Hyderabad	2-3 May, 2014
Dr. Anupam Mishra, Director, ZPD, Zone VII, Jabalpur	19 May, 2014
Dr. P.K. Mishra, Director, Extension Services, JNKVV, Jabalpur	19 May, 2014
Dr. M.D. Reddy, Ex-Director, WTC, ANGRAU, Hyderabad	1 August, 2014
Dr. O.P. Singh, President, Danuka Agritech Ltd., New Delhi	17 August, 2014
Dr. Samresh Diwivedi, Principal Scientist, ITC LSTC, Hyderabad	23 August, 2014
Dr. A.K. Vyas, Assistant Director General (HRM), ICAR, New Delhi	27 August, 2014
Dr. D.K. Benbi, National Professor, PAU, Ludhiana	4 September, 2014
Dr. C.R. Babu, Professor Emeritus & Ex-Pro-Vice Chancellor, Delhi University, New Delhi	6 September, 2014
Dr. R. Geeta, Professor Botany, Delhi University, New Delhi	6 September, 2014
Dr. S. Ayyappan, Secretary, DARE & Director General, ICAR, New Delhi	29 September, 2014
Dr. P.K. Agrawal, Assistant Director General (NFBSFARA), ICAR, New Delhi	30 September, 2014
Dr R.C. Gautam, Former Dean & Joint Director (Education), IARI, New Delhi	15 December, 2014
Dr U.K Behera Principal Scientist (Agronomy), IARI, New Delhi	15 December, 2014
Dr D. S. Rana Principal Scientist (Agronomy), IARI, New Delhi	20 December, 2014
Dr. S.K. Bandhopadhya, Member, ASRB, New Delhi	14 February, 2015
Dr. P.K.R. Nair, Distinguished Professor, University of Florida, USA	17 February, 2015



Chapter - 20

PERSONALIA

20.1 Scientific Staff

	Names	Specialization
	**Dr. A.R. Sharma** Director Email: sharma.ar@rediffmail.com Mobile:- 09425807290	Weed management, conservation agriculture and nutrient management
	**Er. H.S. Bisen** Principal Scientist (Agricultural Engineering) Email: erhsbien@gmail.com Mobile: 09425388101	Mechanical weeding tools, spraying techniques and machinery
	**Dr. P.K. Singh** Principal Scientist (Agril. Extension) Email: drsinghpk@gmail.com Mobile: 09425388721	Technology transfer, demonstration, adoption and impact assessment
	**Dr. V.P. Singh** Principal Scientist (Agronomy) Email : vpsinghnrcws@gmail.com Mobile: 09424306051	Weed management in cropping systems, orchards, and conservation agriculture
	**Dr. Sushil Kumar** Principal Scientist (Entomology) Email: sknrcws@gmail.com Mobile: 09425186747	Biological control of weeds, aquatic weed management in crops and cropping systems, herbicide tolerant crops
	**Dr. K.K. Barman** Principal Scientist (Soil Science) Email: barmankk@gmail.com Mobile: 09826811536	Integrated weed management and environmental quality
	**Dr. R.P. Dubey** Principal Scientist (Agronomy) Email: dubeyrp@gmail.com Mobile: 09425412041	Integrated weed management and organic agriculture
	**Dr. D.K. Pandey** Principal Scientist (Plant Physiology) Email: dayapandey@hotmail.com Mobile: 09893659994	Allelopathy, natural herbicidal molecule isolation, seed biology and aquatic weeds
	**Dr. P.J. Khankhane** Senior Scientist (Soil Science) Email: pjkhankhane@yahoo.com.ph Mobile: 09926715757	Bioremediation, soil and water quality, weed utilization and plant biomass management, wetland management

	Names	Specialization
	**Dr. Shobha Sondhia** Senior Scientist (Org. Chemistry) Email: shobhasondia@yahoo.com Mobile: 0761-2353934	Environmental impact of herbicide, mode of degradation, bio-molecules, method development for herbicide residues and herbicide mitigation measures
	**Dr. C. Kannan** Senior Scientist (Plant Pathology) Email: agrikannan@gmail.com Mobile: 09425865057	Biological management of water hyacinth and parasitic weeds, systemic induced resistance in host, microbial composting and bio-ethanol
	**Dr. Partha Pratim Choudhury** Senior Scientist (Residue Chemistry) Email: parthatinku@yahoo.com Mobile: 09179457045	Fate of herbicides in the environment, decontamination techniques, impact of solar UV-fraction small organic molecules
	**Dr. Bhumesh Kumar** Senior Scientist (Plant Physio.) Email: kumarbhumesh@yahoo.com Mobile: 09806622307	Weed dynamics and management under the regime of climate change, herbicide resistance and bio-propection of weed species
	**Dr. Raghwendra Singh** Senior Scientist (Agronomy) Email: singhraghu75@gmail.com Mobile: 09806637031	Weed ecology, integrated weed management and conservation agriculture
	**Dr. Meenal Rathore** Senior Scientist (Biotechnology) Email: mr10@rediffmail.com Mobile: 08989755865	Molecular tools to assess diversity and study biology of weeds, characterization of weedy rice bio-similars
	**Dr. Yogita Gharde** Scientist (Agril. Statistics) Email: yogita_iasri@rediffmail.com Mobile: 09425412748	Modelling on crop weed associations
	**Dr. Sarathambal C.** Scientist (Microbiology) Email: csaratha@yahoo.co.in Mobile: 0761-2353934	Soil microbiology
	**Mr. Dibakar Ghosh** Scientist (Agronomy) Email: dghoshagro@gmail.com Mobile: 08989190213	Weed ecology and weed management in conservation agriculture
	**Mr. Subhash Chander** Scientist Email: singhariya43@gmail.com Mobile: 08871877162 **Newly joined on 13 October, 2014**	Plant genetic resources

20.2. Technical staff

Name	Designation
Sh. R.S. Upadhyay	T-9, Chief TO (Farm Manager)
Sh. Sandeep Dhagat	T-7-8, Assistant Chief Technical Officer (Computer)
Sh. M.K. Bhatt	T-6, Senior Technical Officer (Artist Cum Photographer)
Sh. V.K.S. Meshram	T-6, Senior Tech Officer (Artist)
Sh. G.R. Dongre	T-6, Senior Technical Officer
Sh. M.P. Tiwari	T-6, Senior Technical Officer
Sh. Basant Mishra	T-5, Technical Officer
Sh. O.N. Tiwari	T-5, Technical Officer
Sh. Pankaj Shukla	T-5, Technical Officer
Sh. S.K. Parey	T-5, Technical Officer

Name	Designation
Sh. J.N. Sen	T-5, Technical Officer
Sh. S.K. Tiwari	T-5, Technical Officer
Sh. S.K. Bose	T-5, Technical Officer
Sh. G. Vishwakarma	T-5, Technical Officer
Sh. K.K. Tiwari	T-5, Technical Officer
Sh. Mukesh K. Meena	T-5, Technical Officer
Sh. Ajay Pal Singh	T-4, Sr. Technical Assistant
Sh. Bhagunte Prasad	T-3, Technician (Tractor Driver)
Sh. Premlal Dahiya	T-3, Technician (Driver)
Sh. Dilip Sahu	T-3, Technician (Driver)
Sh. Sebestene Das	T-3, Technician (Driver)

20.3. Administrative staff

Sh. R.K. Giri	Administrative Officer
Sh. R. Hadge	Assistant Administrative Officer
Sh. M.S. Hadeu	Asstt. Finance and Account Officer **Joined on 13 October 2014**
Smt. Nidhi Sharma	PS to Director

Sh. Manoj Gupta	PA
Sh. T. Lakhera	Assistant
Sh. Beni Prasad Uriya	Assistant
Ku. Sri Vidya	Assistant
Sh. Francis Xavier	Senior Clerk

20.4. Skilled support staff

Sh. Veer Singh	Skilled Support Staff
Sh. Raju Prasad	Skilled Suppo rt Staff
Sh. Jagoli Prasad	Skilled Support Staff
Sh. Jagat Singh	Skilled Support Staff
Sh. Chhoteylal Yadav	Skilled Suppo rt Staff
Sh. Anil Sharma	Skilled Support Staff
Sh. Naresh Singh	Skilled Support Staff
Sh. Shankar Lal Koshta	Skilled Support Staff
Sh. J.P. Dahiya	Skilled Support Staff
Sh. Madan Sharma	Skilled Support Staff

Sh. Jethuram Viswakarma	Skilled Support Staff
Sh. Shiv Kumar Patel	Skilled Suppo rt Staff
Sh. Ashwani Tiwari	Skilled Support Staff
Sh. Suresh Chand Rajak	Skilled Support Staff
Sh. Gajjulal	Skilled Suppo rt Staff
Sh. Gangaram	Skilled Support Staff
Sh. Sant Lal	Skilled Support Staff
Sh. Mahendra Patel	Skilled Support Staff
Sh. Santosh Kumar	Skilled Support Staff
Sh. Nemichand Kurmi	Skilled Support Staff
Sh. Mohan Lal Dubey	Skilled Support Staff

20.5 Promotions

i	Mr. M.P. Tiwari was promoted to Senior Technical officer (T-6) w.e.f. 01 January, 2011
ii	Mr. R.S. Upadhayaya was promoted to Chief Technical officer (T-9) w.e.f. 03 February, 2012
iii	Mr. M.K. Meena was promoted to Technical officer (T-5) w.e.f. 22 February, 2015

20.6 Farewell to staff members

Er. H.S. Bisen, Principal Scientist (Agricultural Engineering) sought voluntary retirement from service on 30 August, 2014

Dr V.P. Singh, Principal Scientist (Agronomy) was transferred on 06 December, 2014 from DWR, Jabalpur to Indian Institute of Sugarcane, Lucknow (U.P.)

Chapter - 21

ON-GOING RESEARCH PROGRAMMES

List of research programmes and sub-programmes during 2014-15

Research programmes and sub-programmes	Co-Principal Investigator	Associates
1. Development of sustainable weed management practices in diversified cropping systems **Programme Leader: Dr. V.P. Singh**		
Sub-programmes		
1.1. Weed management under long-term conservation agriculture systems	Dr. V.P. Singh	Dr. Raghwendra Singh Mr. Dibakar Ghosh Dr. K.K. Barman Dr. R.P. Dubey Dr. Yogita Gharde Dr. P.P. Choudhury Dr. C. Sarathambal Dr. A.R. Sharma
1.2. Systems approach to weed management	Dr. R.P. Dubey	Dr. V.P. Singh Dr. K.K. Barman Dr. P.P. Choudhury Dr. Raghwendra Singh Dr. Yogita Gharde Mr. Dibakar Ghosh Dr. C. Sarathambal
1.3. Improving input-use efficiency through weed management	Dr. Raghwendra Singh	Dr R.P. Dubey Dr. V.P. Singh Dr. K.K. Barman Dr. P.P. Choudhury Dr. Yogita Gharde Dr. C. Sarathambal
1.4. Standardization of spraying techniques and mechanical tools for weed management	Er. H.S. Bisen	Dr V.P. Singh Mr. Dibakar Ghosh
2. Crop-weed dynamics and management under the regime of climate change and herbicide resistance **Programme Leader: Dr. D.K. Pandey**		
2.1. Effect of climate change on crop-weed interactions, herbicide activity and bioagents	Dr. Bhumesh Kumar	Dr. D.K. Pandey Dr. P.P. Choudhury Dr. Raghwendra Singh Dr. Sushil Kumar Dr. Meenal Rathore Dr. C. Sarathambal
2.2. Physiological and molecular basis of herbicide resistance development in weeds and evaluation of herbicide tolerant crops	Dr. D.K. Pandey	Dr. Bhumesh Kumar Dr. Meenal Rahore Dr. Raghwendra Singh
2.3. Development of weed seed identification tools and weed risk analysis	Dr. D.K. Pandey	Dr. Bhumesh Kumar Dr. Raghwendra Singh Dr. Meenal rathore
3. Biology and management of problematic weeds in cropped and non-cropped areas **Programme Leader: Dr. Sushil Kumar**		
3.1. Biology and management of problematic weeds in cropped areas	Dr. C. Kannan	Dr. Meenal Rathore Dr. Sushil Kumar Mr. Dibakar Ghosh Dr. Raghwendra Singh Dr. P.J. Khankhane Dr. Bhumesh Kumar Dr. A.R. Sharma

Research programmes and sub-programmes	Co-Principal Investigator	Associates
3.2. Biology and management of problematic weeds in non-cropped areas	Dr. Sushil Kumar	Dr. Yogita Gharde
3.3. Biology and management of aquatic weeds	Dr. Sushil Kumar	Dr. C. Kannan Dr. Shobha Sondhia
4. Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment **Programme Leader: Dr. Shobha Sondhia**		
4.1. Impact of herbicides in soil, water and non targeted organisms and herbicide mitigation measures	Dr. Shobha Sondhia	Dr. R.P. Dubey Dr. P.J. Khankhane Dr. K.K. Barman Dr. Sushil Kumar
4.2. Degradation of herbicides in the environment	Dr. P.P. Choudhury	Dr. Meenal Rathore Dr. K.K. Barman Dr. Shobha Sondhia Dr. C. Sarathambal
4.3. Bio-remediation of pollutants using terrestrial / aquatic weeds	Dr. P.J. Khankhane	Er. H.S. Bisen Dr. Shobha Sondhia Dr. R.P. Dubey
5. On-farm research and demonstration of weed management technologies, and impact assessment **Programme Leader: Dr. P.K. Singh**		
5.1. On-farm research and demonstration of weed management technologies for enhanced productivity and income	Dr. P.K. Singh Dr. V.P. Singh Er. H.S. Bisen Dr. Sushil Kumar Dr. D.K. Pandey	Dr. A.R. Sharma Dr. R.P. Dubey Dr. P.J. Khankhane Dr. Shobha Sondhia Dr. C. Kannan Dr. Bhumesh Kumar Dr. Meenal Rathore Mr. Dibakar Ghosh Dr. Raghwendra Singh Dr. Yogita Gharde Dr. P.P. Choudhury Dr. K.K. Barman Dr. C. Sarathambal
5.2. Impact assessment of adoption of weed management technologies on socio-economic upliftment and livelihood security	Dr. P.K. Singh	Dr. Yogita Gharde

Chapter - 22

RECOMMENDATIONS OF REVIEW COMMITTEES

22.1 Research Advisory Committee

XVII RAC meeting was held on 18-19 April, 2014 and following recommendations were made:

1. It was realized that some of the recommendations made in the past meeting were not adequately addressed by the concerned scientists. Hence, all those recommendations will also be part of the proceedings of this meeting as well.
2. Publication record of the Directorate as a whole is very poor. It was emphasized that all scientists should bring out research publications in highly rated journals during the next year. Thematic and Silver Jubilee publications initiated by the Directorate should also be completed during the year.
3. RAC took serious note of the ATR pertaining to testing of allelochemicals under field conditions. It was decided that Dr. D.K. Pandey should henceforth devote his full time for evaluation of *Parthenin* and other such allelochemicals identified by him over the years in the real field conditions. The activity–wise plan prepared by him for such testing during the next one year was approved. All the required facilities should be provided to him for carrying out large scale testing under the field conditions.
4. Database management should be strengthened. All data of a given experiment should be computerized and maintained by the lead author.
5. There is limited scientific manpower at the Directorate in some disciplines like Plant Physiology, Economic Botany, and Economics due to which the work on climate change, quarantine weeds, impact assessment etc. is suffering. In fact, all the 10 vacant positions should be filled-up on priority by the Council so that all the emerging challenges in weed management can be effectively tackled.
6. Data generated on weedy rice accessions from all over the country should be compiled and made available to all SAUs for reference.
7. Extension-oriented research on weed management is lacking. Information on herbicide use pattern, impact assessment and constraints in adoption of improved weed management technologies at the farmers' level should be documented.
8. Weed management research should be undertaken in a systems perspective, and all the reporting should be done on a cropping system basis.
9. A systematic protocol for weed surveillance should be developed and followed by all the AICRP-WM centres.
10. Research farm of the Directorate has shown a visible change during the year. Such efforts should be continued further to develop it as a model farm on weed management.

22.2 Institute Research Council

Recommendations of IRC meeting held on 2-3 May, 2014 are as follows:

1. ATR on recommendations of IRC-2012 and 2013 was still not satisfactory in some cases as the responses are vague and indicated little or no action by the concerned scientist. The ATR should be convincing with phrases like 'was done', 'has been completed' – and the progress made / data generated should be clearly shown in the presentation.
2. It was regretted that publication record of most scientists has not shown any improvement since IRC-2012 when it was specifically emphasized that each scientist should bring out 2 research papers each year as a senior author. While analyzing the publication record of the Directorate over the last 5 years, it was found that some scientists have not published a single article in the last several years since their joining. This is unacceptable and requires serious introspection by all the concerned scientists.
3. It was proposed that '2014' may be named as a 'Publication Year', during which the research publications should be brought out by all the scientists. This will be the major criteria for assessment and grading of scientists for HYPM and APAR.
4. Thematic and Silver Jubilee Publications planned since August 2012 should be completed at the earliest. Some publications should be ready for release on the ICAR Foundation Day (16 July, 2014) as also instructed by the DDG (NRM).
5. Resources of the Directorate including manpower, farm and laboratory facilities should be utilized effectively for productive purposes only. These resources should not be wasted on those showing no visible output in terms of quality research and its applicability in the field situation.
6. Dr. D.K. Pandey and Er. H.S. Bisen were advised to compile the data generated over the last more than 2 decades at this Directorate, bring out research articles and other documents, and also show the applicability of their findings in the field. They need not undertake any new experiment in view of the limited time left before their retirement.
7. It was regretted that some scientists are very casual in their approach, lack initiative, and do not adhere to the time schedule and delay the work assigned to them for indefinite periods. It was suggested that such unwilling scientists who have served for many

years at the Directorate and are not able to exhibit their full potential, may seek their transfer elsewhere.

8. Quality of research data needs considerable improvement. It is better to do limited work but generate quality information.
9. Statistical and economic analysis of the data, and its scientific interpretation was found lacking in most presentations. For uniformity in economic analysis, a common format should be developed in consultation with economists of JNKVV, and followed by all including the AICRP-WM centres.
10. There is still a lot of scope for improvement in inter-institutional collaboration. The concerned scientists should engage in effective partnership with other institutions including ICAR institutes.
11. Number of externally-funded projects is few at the Directorate. Efforts must be made by all scientists to submit projects to ICAR, DST, DBT and others
12. Impact assessment of weed management technologies must be done at the national level by involving AICRP-WM centres.
13. Single scientist / discipline-based experiments will not be allowed. It is desirable to involve at least two scientists of the same discipline (if available) along with other related disciplines in order to really address the problem in a multi-disciplinary manner and ensure continuity of the programme.
14. Data of long-term experiments including those under AICRP on Weed Management must be documented, analyzed and suitable inferences drawn for practicality.
15. A brain storming session with limited participation should be organized to decide priorities for climate change research.
16. DWR should take leadership in herbicide residue research. A training programme should be organized for residue chemists of AICRP on Weed Management and other centres.
17. Information Centre' of the Directorate must be updated with all possible information on weeds and other related aspects as per instructions in May, 2013.
18. Participation of scientists in seminars/conferences /training courses should be encouraged. Each should participate in at least one international conference and one national conference during a year, within the country.
19. DWR should not become merely a service-centre for providing trainings, supplying Mexican beetles, and offering consultancy services but it should undertake serious research in view of the emerging challenges such as climate change, invasive weeds, herbicide residues, herbicide tolerant crops and conservation agriculture.

22.3 Institute Management Committee

Recommendations of XXIII IMC meeting held on 27 September, 2014 are as follows:

1. It was recommended that all the vacant positions of scientific and other staff should be filled-up so that the mandated activities of the Directorate can be taken up. The position of Assistant Finance and Accounts Officer should be filled-up on priority.
2. Target fixed by the Council for resource generation during 2014-15 is nearly double of that achieved in 2013-14. It cannot be achieved unless additional resources are generated through contract research and consultancy-based projects. Hence, it was suggested that the recommendation made by the RAC not to undertake such projects at the Directorate may be relooked.
3. The weed management technologies developed at the Directorate and AICRP-WM centres should be tested on farmers' fields. Studies on yield loss estimation, economic benefits accured to the farmers, and impact assessment of weed management technologies should be undertaken for each state and further extrapolated to the national level.
4. It was suggested to undertake sufficient number of on-farm trials at prominent locations in the village so that entire village can be covered. Awareness programmes should be organized so that farmers can adopt the improved practices on their own after seeing the performance of crops in the demonstrations.
5. It was suggested that the flagship programme on weed management in conservation agriculture systems should be strengthened further and the technology should be demonstrated on the farmers' fields. CA-based technologies should be tested in different soil types. It was proposed that DWR will collaborate with state department of agriculture for effective dissemination of these technologies during the next season.
6. E-modules developed at the Directorate should be translated into Hindi so that these can be used by the farmers.
7. It was pointed out that spurious herbicides are available in the market. DWR should undertake testing of these chemicals for their purity and advise the farmers accordingly.
8. Proposals for purchase of equipments approved in the EFC document, viz. nano-drop UV spectrophotometer, micro wave digestion system, column and accessories for LC/MS-MS system and preparation kit, drip irrigation, Kjel-Tec Auto Analyzer and core sampler for a total amount of Rs. 50.25 lakhs were approved.
9. Proposals for works, viz. c/o boundary wall at Director's Residence, and farm development works, viz. c/o murum road, r/o boundary wall and c/o implement shed for a total amount of Rs. 40 lakhs were approved.

Chapter - 23

WEATHER REPORT

The climate of Jabalpur is broadly classified as sub-tropical, characterized by very hot summers and cold winters maximum temperature ranges from 39–45^{o}C during April–June, while the coldest months are December–January when the minimum temperature often goes below 5^{o}C. The average annual rainfall is 1380 mm, most of which (90%) is received during June–September. In the year 2014, total annual evaporation was 1564 mm, while the total annual rainfall was only 1094 mm. The rainfall was less then average of last 45 years and the distribution was also erratic. There was good rainfall in the month of February and March, which was more than normal. April and May moths were almost dry. Normal rain was recorded during June (119 mm) and July (317 mm) but long dry spells were recorded in the month of August, when the rainfall was almost half of the normal. The second fortnight of August was almost dry, resulted less yield of rice. This year the soybean crop survived because flooding not occurred in the field. The cotton crop also yielded better than the previous year due to non-flooding situation in the field. The mean maximum relative humidity during hot weather (April-June) ranged from 56-83% and mean minimum relative humidity was 18-31%. The mean maximum daily sunshine of 9.3 hr was in May and mean minimum of 3.8 hr in July. Weather data obtained from the adjacent meteorological observatory of JNKVV, Jabalpur are presented in Figure 23.1 and Table 23.1.

The unusual rains and hail storms during 2nd fortnight of February, 2014 adversely affected the rabi season crop. It was estimated that 80,000 ha area in Mandla District, 35000 ha in Jabalpur was badly affected due to unprecedented rain and hailstorm.

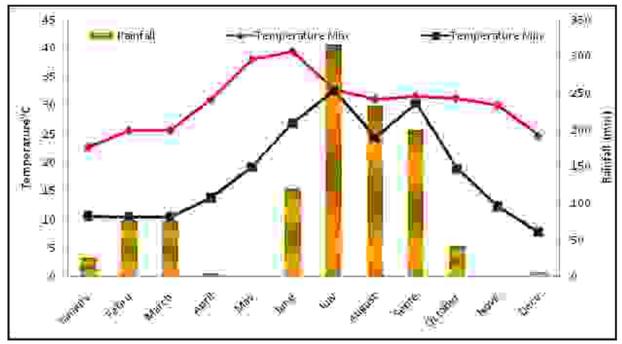

Figure 23.1: Mean monthly maximum and minimum air temperature, and total monthly rainfall at DWR, Jabalpur during 2014

Table 23.1: Monthly mean maximum and minimum air temperature, rainfall, sunshine and evaporation at DWR, Jabalpur during 2014

Month	Temperatute %		Relative humidity %		Rainfall (mm)		Sunshine (hr/day)	Evaporation (mm)
	Maximum	Minimum	Maximum	Minimum	Average (46 years)	2014		
January	22.6	10.5	93	58	20	25	5.1	55.1
February	25.6	10.4	91	45	23	76	7.8	73.3
March	25.6	10.4	91	45	15	76	7.8	100.9
April	31.0	13.7	83	36	4	4	8.1	210.9
May	38.0	19.2	56	18	10	0	9.3	270.1
June	39.4	26.8	59	34	178	119	7.0	245.0
July	32.7	32.5	82	64	393	317	3.8	148.4
August	31.0	24.3	86	67	454	232	4.5	119.3
September	31.5	30.2	89	61	216	199	6.1	93.9
October	31.2	18.8	86	45	39	42	7.8	97.3
November	30.0	12.2	84	25	13	0	7.8	83.8
December	24.6	7.7	87	35	15	5	7.4	66.2
Total					**1379**	**1094**		**1564.2**

Chapter - 24

New Initiatives and Major Achievements during 2014-15

- Five focused research programmes launched in a multi-disciplinary mode during 2012-13 were effectively implemented. Flagship programme on "Weed management in conservation agriculture systems" showed remarkable success at the research farm as well as on the farmers' fields.
- Collaboration with various ICAR institutes was taken up and the working of AICRP-Weed Management centres in various SAUs was effectively monitored.
- On-farm research trials were reorganized based on the specific technologies developed by the concerned scientists and shifted to new localities from 2014-15.
- Effective collobration was started with KVKs of Zone-VII for promotion of resource conservation technologies including zero till wheat and summer greengram.
- Technologies developed by the scientists based on several years of experimentation were displayed on a larger area (1 ha) at the research farm to show their performance and economic feasibility.
- 'Model' research farm was further developed based on the principles of conservation agriculture. All crops during *rabi* and summer seasons were grown exclusively under zero-till condition with residue retained on soil surface. About 10 ha area was also grown under zero-till rice, which performed exceedingly well.
- Research farm was fully covered under precision laser leveling, all internal roads were laid with morum / stone dust, and 100% coverage with crops during *Kharif* and *Rabi* season, and 50% coverage during summer season.
- Aquaculture and apiculture units were established for full utilization of the available resources and generation of additional revenue.
- Unproductive mango and aonla orchards were rejuvenated through stump and topwork technology. Grafting with superior varieties will be done during the rainy season.
- Transplanting of mustard varieties, 'RP-09' and 'Pusa Swarnima' was undertaken, which gave high yields of 3.5 t/ha in on-station trials, and 4.0 t/ha in the on-farm trials.
- Rice varieties for excessively waterlogged situations were screened, and 'Jaldubi' was identified as a potential variety for water depth up to 1 m.
- Two laboratories of 'Microbiology' and 'Herbicide Residues' were renovated.
- A new project funded by MP Biotechnology Council on "Phenotypic studies and genetic characterization of weedy rice based on SSR markers' was initiated. Further, a collaborative project on "Biological control based integrated *Parthenium* management for saving environment, health and biodiversity in north-east India" with CAU, Imphal funded by DBT was also launched.
- Five training progarmmes were organized including the 3rd National Training Course on "Advances in Weed Management", and second time training programme for the PG students on biological weed management.
- A record number of farmers (3200) visited the Directorate under *Khet Tirath Yojna* of Madhya Pradesh Government and also from other states, who were exposed to the latest technologies on weed management.
- A movement for ensuring 'Parthenium - free' campus was started across SAUs, ICAR Institutes, KVKs, villages, schools and other such establishments.
- Mass plantation programme of teak saplings was undertaken by all the staff members on the occasion of the 68th Independence Day. Teak and eucalyptus plantation was also undertaken all along the boundary of the Directorate.
- SFC was approved with an appreciable increase in budgetary proposals for the XII Plan (+47% for the Directorate, and +85% for AICRP on Weed Management). Proposals for construction of Training-cum-Farmers' Hostel and side wing of the Directorate were approved.
- *Swatchh Bharat Abhiyan* was launched w.e.f. 25 September, 2014 and the entire campus including the surroundings of the Directorate were cleaned. All staff members are devoting two hours every week for this noble cause.
- Mid-term review meetings were organized with all staff during October-November, 2014 to review the progress of various initiatives and plan future strategies.
- Silver Jubilee celebrations were organized throughout the year. The main function was held on the 26th Foundation Day and graced by the presence of DDG (NRM). DG, ICAR also paid a visit on 29th September, 2014.
- Special publications commemorating Silver Jubilee of the Directorate such as 'DWSR Calendar', 'DWSR Marching Ahead', 'DWSR Souvenir' and 'DWSR Publications' were brought out.
- Important days were organized with great enthusiasm and participation of a large number of stakeholders: Foundation Day (22 April, 2014), Farm Innovators Day (29 April, 2014), Agricultural Education Day (10 December, 2014), National Science Day (28 February, 2015), and Industry Day (26 March, 2015).
- Directorate was renamed as 'ICAR-Directorate of Weed Research' (ICAR-DWR) w.e.f. from November, 2014. Similarly, AICRP on Weed Control was renamed as 'AICRP on Weed Management'.

Section-2 : Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Development of efficient weed management packages	69	Evaluating weed management practices	Efficient weed management package of practices for field crops developed	No.	54	19	17	15	13	11
				Efficient weed management package of practices for horticultural crops and non-arable lands developed	No.	5	7	6	5	4	3
			Monitoring herbicides in environment	Herbicide residues assessed in different situations	No.	10	60	56	52	48	44
2	Creation of awareness & knowledge in respect to improved weed management	20	Transfer of technology	On-farm research trials/ FLDs conducted	No.	10	410	400	390	380	370
				Zygogramma beetle mass multiplied and supplied	No.	4	45000	40000	35000	30000	25000
			HRD & capacity building	Trainings organized	No.	6	72	69	66	63	60
3	Efficient functioning of RFD system	3	Timely submission of Draft RFD (2013 -14) for approval	On-time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1 2013	May 2 2013	May 5 2013	May 6, 2013	May 7, 2013
4	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On- time submission	Date	2	Jul 30, 2013	Aug 10, 2013	Aug 20, 2013	Aug 30, 2013	Sept 10, 2013
5	Improving internal efficiency/ responsiveness/ service delivery of Ministry/ Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3. Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 2011-12	Actual Value for FY 2012-13	Target Value for FY 2013-14	Projected Values for FY 2014-15	Projected Values for FY 2015-16
1	Development of efficient weed management packages	Evaluating weed management practices	Efficient weed management package of practices for field crops developed	No	16	17	17	18	19
			Efficient weed management package of practices for horticultural crops and non-arable lands developed	No.	3	6	6	6	6
		Monitoring herbicides in environment	Herbicide residues assessed in different situations	No.	52	51	56	58	60
2	Creation of awareness & knowledge in respect to improved weed management	Transfer of technology	On-farm research trials/ FLDs conducted	No.	210	390	400	410	420
			Zygogramma beetle mass multiplied and supplied	No.	30000	35000	40000	45000	50000
		HRD & capacity building	Trainings organized	No.	68	60	69	72	75
3	Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	May 16, 2013	-	-
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	May 2 2013	-	-
4	Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
		Prepare an action plan for Innovation	On-time submission	Date	-	-	Aug 10, 2013	-	-
5	Improving internal efficiency /responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	-	-	95	-	-
			Independent Audit of implementation of public grievance redressal system	%	-	-	95	-	-

Section 4 a: Acronym

S. No	Acronym	Description
1.	FLD	Front-line demonstration
2.	DWR	Directorate of Weed Research
3.	HRD	Human Resource Development
4.	IWM	Integrated Weed Management
5.	AICRP	All India Coordinated Research Project

Section 4 b: Description and definition of success indicators and proposed measurement methodology

S. No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Efficient weed management package of practices for field crops developed	Evaluating various weed control measures involving chemical, mechanical and cultural methods for field crops	The management practices that control weed effectively, increase productivity and provide additional economic benefit, over the traditional weed control methods will be identified as `efficient weed management practices' and recommended by DWSR	By conducting experiments in field	
2	Efficient weed management package of practices for horticultural crops and non-arable land developed	Evaluating various weed control measures involving chemical, mechanical, cultural methods and bioagents for horticultural crops and non-arable lands	The management practices that control weed effectively, increase productivity and provide additional economic benefit, over the traditional weed control methods will be identified as `efficient weed management practices' and recommended by DWSR	By conducting experiments in field	
3	Herbicide residues assessed in different situations	Evaluating dissipation patterns of herbicides in different production systems	Assessment of unutilized amounts of applied herbicides and degradation products in soil, water and plant in different production systems	By analyzing soil, water and plant samples from field and laboratory experiments	
4	On-farm research trials/ FLDs conducted	Evaluating recommended package of practices for weed control in farmer's fields in a participatory mode	Demonstration of recommended package of practices and experimental results on farmer's fields	Number of farm research trials/FLDs conducted	
5	Zygogramma beetle mass multiplied and supplied	Multiplying the bioagents at DWSR and supply to end-users	Zygogramma are microorganisms is an insects having the ability to control parthenium weed without harming the crop plants	Number	
6	Trainings organized	Imparting knowledge on weed management through lectures, visuals, demonstrations and discussions	Educating the end-user and stakeholders about the benefit of recommended package of practices for managing weeds	Trainings, workshops, awareness programmes, etc. will be organized by DWSR involving state officials, scientists, industry personnel and farmers	

Section 5 : Specific performance requirements from other departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Section 6: Outcome/ Impact of activities of Organization/ Ministry

S. No.	Outcome impact of organization	Jointly responsible for influencing this outcome / impact with the following department (s) / ministry(ies)	Success Indicator	Unit	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
1	Profitability due to adoption of improved weed management technologies	Impact assessment reported is based on IWM packages/ technologies demonstrated by DWSR and its AICRP-Weed control centers located in different states	Additional economic benefit to farmer over existing weed management practices in field crops	Rs./ha	10,000	10,500	11,000	11,500	12,000

Performance Evaluation Report in respect of RFD (2013-2014) in report of DWR, Jabalpur

S. No.	Objective (s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
1	Development of efficient weed management packages	**69**	Evaluating weed management practices	Efficient weed management package of practices for field crops developed	No.	54	19	17	15	13	11	**19**	**100.0**	**54**	**111.8**	Efforts were made to achieve 100% of the target. In terms of technology the difference between 90% to 100% target/criteria value is very small, but it amounts to a high figure in terms of percentage
				Efficient weed management package of practices for horticultural crops and non-arable lands developed.	No.	5	7	6	5	4	3	**7**	**100.0**	**5**	**111.7**	
			Monitoring herbicides in environment	Herbicide residues assessed in different situations	No.	10	60	56	52	48	44	**61**	**100.0**	**10**	**108.9**	
2	Creation of awareness & knowledge in respect to improved weed management	**20**	Transfer of technology	On-farm research trials/ FLDs conducted	No.	10	410	400	390	380	370	**414**	**100.0**	**10**	**103.5**	
				Zygogramma beetle mass multiplied and supplied	No.	4	45000	40000	35000	30000	25000	**45000**	**100.0**	**4**	**112.5**	
			HRD & capacity building	Trainings organized	No.	6	72	69	66	63	60	**70**	**93.3**	**5.60**	**101.4**	
3	Efficient functioning of RFD system	**3**	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15, 2013	May 16, 2013	May 17, 2013	May 20, 2013	May 21, 2013	May 02, 2013	**100.0**	**2**	-	
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1 2013	May 2 2013	May 5 2013	May 6, 2013	May 7, 2013	April 15, 2013	**100.0**	**1**	-	
4	Administrative Reforms	**4**	Implement ISO 9001 as per the approved action plan.	% Implementation	%	2	100	95	90	85	80	100	**100.0**	**2**	-	
			Prepare an action plan for Innovation	On time submission	Date	2	Jul 30, 2013	Aug 10, 2013	Aug 20, 2013	Aug 30, 2013	Sept 10, 2013	January 9, 2014	**0**	**0**	-	
5	Improving Internal Improving Internal Efficiency /responsiveness / service delivery of Ministry / Department	**4**	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	100	**100.0**	**2**	-	
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	100	**100.0**	**2**	-	

Total Composite Score: 97.6
Rating: Excellent

APPENDIX-III

Acronyms

AAS	:	Atomic Absorption Spectrophotometer
AAU	:	Anand Agricultural University
AAU	:	Assam Agricultural University
AICRP	:	All India Coordinated Research Project
ANGRAU	:	Acharya NG Ranga Agricultural University
APX	:	Ascorbate peroxidase
AKMU	:	Agriculture Knowledge Management Unit
BAU	:	Birsa Agricultural University
BSKV	:	Baba Saheb Ambedkar Krishi Vidhya Peeth
CAU	:	Central Agricultural University
CAZRI	:	Central Arid Zone Research Institute
CCSHAU	:	Choudhary Charan Singh Haryana Agricultural University
CeRA	:	Consortium for e-Resources in Agriculture
CIAE	:	Central Institute of Agricultural Engineering
cm	:	Centimeter
CO_2	:	Carbon di-oxide
CRRI	:	Central Rice Research Institute
CSAUAT	:	Chandra Shekher Azad University of Agriculture and Technology
CTRI	:	Central Tobacco Research Institute
DAA	:	Days after application
DARE	:	Department of Agriculture Research and Education
DAS	:	Days after sowing
DAT	:	Days after transplanting
DBT	:	Department of Biotechnology
DOR	:	Directorate of Oilseed Research
DRDO	:	Defense Research and Development Organization
DRMR	:	Directorate of Rapeseed-Mustard Research
DSR	:	Direct-seeded rice
DST	:	Department of Science and Technology
EC	:	Emulsifiable Concentrate
FACE	:	Free Air CO_2 Enrichment
FYM	:	Farm yard manure
GBPUAT	:	Govind Ballabh Pant University of Agriculture and Technology
GC	:	Gas Chromatograph
GLC	:	Gas Liquid Chromatograph
GPX	:	Glutathione peroxidase
GR	:	Glutathione reductase
HPLC	:	High Performance Liquid Chromatography
HRD	:	Human resource development
HW	:	Hand weeding
IARI	:	Indian Agricultural Research Institute
ICAR	:	Indian Council of Agricultural Research
IGKV	:	Indira Gandhi Krishi Vishwa Vidyalaya
IJSC	:	Institute Joint Staff Council
IMC	:	Institute Management Committee
IRC	:	Institute Research Council
IRGA	:	Infra Red Gas Analyzer
ISWS	:	Indian Society of Weed Science
ITMU	:	Institute Technology Mission Unit
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidyalaya
KAU	:	Kerala Agricultural University
KVK	:	Krishi Vigyan Kendra
LAN	:	Line Area Network
LC-MS/MS	:	Liquid Chromatography–Mass Spectroscopy/ Mass Spectroscopy
LD	:	Lethal dose
LSD	:	Least square difference
MAU	:	Maharashtra Agricultural University
MPBT	:	Madhya Pradesh Biotechnology
NAIP	:	National Agricultural Innovative Program
NBAII	:	National Bureau of Agriculturally Important Insects
NDUAT	:	Narendra Dev University of Agriculture and Technology
NGO	:	Non-Governmental Organization
NPK	:	Nitrogen, phosphorous, potash
NRM	:	Natural Resource Management
OUAT	:	Orissa University of Agriculture and Technology
PAU	:	Punjab Agricultural University
PBSR	:	Puddled broadcast sowing with sprouted seeds
PE	:	Pre-emergence
PME	:	Prioritization, Monitoring and Evaluation
PO	:	Post emergence
QRT	:	Quinquennial Review Team
RAC	:	Research Advisory Committee
RAU	:	Rajendra Agricultural University
RAU	:	Rajasthan Agricultural University
RDVV	:	Rani Durgavati Vishwa Vidyalaya
RFD	:	Results Framework Documents
RVSKVV	:	Rajmata Vijayaraje Sindhia Krishi Vishwa Vidyalaya
SAU	:	State Agricultural University
SKHPKV	:	Shravan Kumar Himachal Pradesh Krishi Vishwa Vidyalaya
SKUAST	:	Sher-e-Kashmir University of Agricultural Science and Technology
SOD	:	Superoxide dismutase
SRI	:	System of rice intensification
TNAU	:	Tamil Nadu Agricultural University
TP	:	Transplanted rice
TSP	:	Tribal sub-plan
UAS	:	University of Agricultural Sciences
VB	:	Vishwa Bharati
VSAT	:	Very small aperture terminal
WAS	:	Weeks after sowing
WCE	:	Weed control efficiency
WP	:	Wettable powder

ICAR - DWR in the NEWS