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All India Coordinated Research Project on Weed Management

वार्षिक प्रतिवेदन
ANNUAL REPORT
2016-2017

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ICAR - Directorate of Weed Research, Jabalpur

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AICRP-WM activities

All India Coordinated Research Project on Weed Management

Annual Report

2016-17

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Cover page photographs (Left to Right)

A. Infestation of *Cuscuta* in onion.
B. Infestation of *Orobanche* in brinjal.
C. Infestation of *Water hyacinth* in water bodies.
D. Infestation of *Striga asiatica* in sugarcane.

Preface

All India Coordinated Research Project on Weed Management (AICRP-WM) was launched in 1978 to undertake the systematic research on weed management in the country. Initially, there were 6 centres in different parts of the country, which grew to 23 centres in 2014, almost in all the Agricultural Universities of the country. Over the last 39 years, information relating to weeds in different cropped and non-cropped situations, management practices, herbicide residues and utilization aspects of weeds has been generated. Location-specific improved technologies on weed management have been developed and adopted in large areas throughout the country.

We can claim that weed management technologies are now available for almost all crops and cropping systems as well as for non-cropped situations which have the potential to increase productivity and profitability, and ensure environmental sustainability and biodiversity.

Several initiatives were taken to improve and strengthen the research programmes on weed management under this project. Research themes were reorganized and technical program for 2017-18 has made in tune with the research programmes of the Directorate based on the emerging challenges in weed management. XXIII Annual Review Meeting was organized for the first time outside the ICAR/ SAU system at Jain Irrigation Systems Limited, Jalagaon (MH) to expose the participants to corporate culture. XXIV Annual Review was organized at MPUAT, Udaipur. Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency and herbicide use in cropping systems were proposed. The recommendations made by the Quinquennial Review Team (2006-12) were also effectively implemented. Nodal Officers were identified for providing technical guidance, monitoring and evaluation of the work done at different centres. Norms of the ICAR for posting of staff and release of funds were followed. Collaborations were initiated with other AICRPs at the same University. On-farm research was given greater emphasis and impact assessment of weed management technologies was undertaken.

The proposals of EFC in terms of infrastructure development, contingencies, staff restructuring and new research programmes were made. I express my sincere gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR; Dr. K. Alagusundaram, Deputy Director General (Agril. Engg. and NRM); Dr. A.K. Sikka, Ex. Deputy Director General (NRM) and Dr. A.R. Sharma, Ex. Director (ICAR-DWR) for providing constant encouragement and guidance. I am also thankful to Dr. S. Bhaskar, Assistant Director General (Agronomy, Agroforestry and Climate Change) for his keen interest and support in running the project. I thank Dr. Shobha Sondhia, Incharge, AICRP-WM for her keen interest and help in running the project activities. Thanks are also due to the Nodal Officers namely, Dr. Sushil Kumar, Dr. R.P. Dubey, Dr. Bhumesh Kumar; Dr. P.J. Khankhane, and Technical Officers, Mr. O.N. Tiwari, Mr. Pankaj Shukla and Mr. Sandeep Dhagat.

This report contains consolidated information on the research achievements and other related activities undertaken at all the centres of the project during the reported period. I hope this document will be useful to all our stakeholders.

Comments and suggestions are welcome for further improvement.

Date: 30.06.2017

Place: Jabalpur

(P.K. Singh)

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- mn;iqj e] xg dh Qly e vdj.k d i'pkr jMhfeDl lYQkslY¶;jku $ eVlY¶;jku ¼30+2 xk-@g-½ l xg dh Qly e mit fd;s tkus dh i)fr ¼42-9 D;-@g-½ dh ryuk e 62-5% vf/kd nt dh xbA [kjhQ e eDdk e 15 fnuk dh cokbZ d ckn VEckVvku ¼0-125 fd-xk-@g-½ d mi;kx l eDdk dh mit e fd;s tkus dh i)fr l 54-5% of) ikbZ xbA
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EXECUTIVE SUMMARY

WP 1 Development of sustainable weed management practices in diversified cropping systems

- At Bengaluru, use of pre-emergence herbicide-pyrazosulfuron-ethyl (25 g/ha-3) at DAS/P alone or followed by passing cono weeder (45 DAS/P) reduced the weeds' density as compared to unweeded control in the rice-green gram- rice system on 60 DAP/S. Conventional tillage had slightly lower weed density and weed dry weight as compared to zero tillage at 60 DAP/S. Transplanted and direct-seeded rice had almost similar weeds' dry weight under conventional tillage during *Kharif*, 2016.
- At Bhubaneswar, CT(trans)-ZT-ZT system of tillage recorded higher grain yield in *Rabi* (4.2 t/ha) and *Kharif* (4.1 t/ha). ZT(DSR)-ZT+R-ZT system resulted the lowest grain yield as compared to CT-CT method in both the seasons. Integration of ZT method with butachlor resulted in the maximum B: C ratio in the *Kharif* rice.
- At Dapoli, application of pendimethalin + 1 HW at 40 DAS exhibited highest WCE in terms of growth of weeds and consequently grain and straw yield of mustard. Weed growth of monocots at all stages of observation was significantly least in conventional tillage over all other tillage practices and resulted in increase in yield attributes and yield of mustard.
- At Faizabad, the highest grain yield of wheat was obtained under TPR (CT)- wheat (CT) under rice-wheat system. However, in rice, maximum grain and straw yield was recorded in CT-ZT-ZT treatment. Among various conservation systems maximum microbial properties were observed under ZT+R, ZT+R and ZT treatment.
- At Ludhiana, ZT wheat + rice residues recorded lowest seed bank of both *P. minor* and *R. dentatus* in rice-wheat cropping system. Wheat grain yield under ZT with residues was higher than ZT without residues. In direct seeded rice (DSR), higher seed bank of *E. crus-galli*, *E. colona* and *D. aegyptiaum* was found than transplanted rice.
- At Pantnagar, maximum yield of wheat was achieved by the conventional direct-seeded rice- conventional wheat along with incorporation of *Sesbania* before rice seeding in rice-wheat establishment methods in *Rabi*. Whereas, in *Kharif*, among the weed management approaches, integrated (herbicide+ HW) as well as alone application of broad spectrum herbicide (bispyribac-Na) was found effective in achieving the better yield of rice.
- At Raipur, weed dry matter was significantly low under CT-(transplanted) than CT/ZT-direct seeded treatments at all the stages. Significantly higher seed yield of rice was recorded under recommended practice i.e. pyrazosulfuron (20 g/ha) *fb* pinoxsulam (22.5 g/ha) POE than unweeded check. The net income and B:C ratio was higher under CT (transplanted).
- At Coimbatore, significantly higher grain yield and economics were recorded in zero tillage in ZT-ZT+R system and in PE pendimethalin at 1.0 kg/ha + HW on 45 DAS in sunflower crop. Whereas, in maize, CT-CT system and PE atrazine at 0.5 kg/ha + HW on 45 DAS recorded higher productivity as well as high income. The total bacteria, fungi, actinobacteria, phosphobacteria and soil enzymes viz., alkaline phosphatase and dehydrogenase were significantly higher in zero tillage in ZT-ZT+R system in sunflower.
- At Gwalior, integrated weed management (oxyfluorfen + 1 HW) gave maximum seed yield (1.26 t/ha) of mustard followed by pendimethalin (1.0 kg/ha) PE. In case of weed management practices, the highest B:C ratio was obtained in pendimethalin (3.65) followed by IWM practices (3.48).
- At Jammu, in basmati rice-potato-french bean cropping system, *Cyperus* spp. and *Echinochloa* spp. were effectively controlled by mustard seed meal (2.5 t/ha) in transplanted basmati rice under organic weed management. However, highest rice grain yield was recorded with mustard seed meal + one hand weeding.
- At Palampur, inter cropping of soybean in maize was found an effective mean of suppressing grasses, sedges and broad-leaved weeds under organically managed maize – garlic cropping system. Bacteria count was significantly higher under intercropping (soybean) + hoeing (2.19 x10^6) followed by raised stale seed bed + hoeing + earthing (2.14 x10^6).

- At Ranchi, placement of plastic mulch in okra recorded significantly higher fresh okra yield (20.7 t/ha), net return (Rs. 2,50,543/ha) and B:C ratio (1.53).
- At Thrissur, mulching with polythene resulted in highest fruit number, yield and weed control efficiency in brinjal followed by spade weeding and hand weeding. However, B:C ratio was highest with chemical weed control.
- At Pasighat, hand weedings at 25 and 50 days after sowing in maize + soybean (1:1) and maize + black gram (1:1) intercropping were effective in controlling weeds and resulted in higher number of green cob per hectare.
- At Raichur, one intercultivation and hand weeding at 20 and 40 DAS recorded significantly the lowest total weed density, dry biomass, and yield of blackgram. Post-emergence application of imazethapyr + imazamox (75 g/ha) applied at 3-4 leaf stage of weed was found best in suppressing weeds and getting higher grain and stover yield of maize.
- At Akola, integrated use of straw mulch either with pendimethalin (1.0 kg/ha) or by metribuzin (0.7 kg/ha) (0-5 DAP) *fb* straw mulch 10 t/ha (10 DAP) *fb* one HW (75 DAP) was found effective for weed control and attaining the highest productivity and profitability in turmeric.
- At Jorhat, 75 % RD fertilizer + vermicompost (2 t/ha) mixture at 3 splits (before sowing, 30 and 60 DAS) + pretilachlor 750 g/ha mixed with the first split followed by HW at 30 DAS resulted better growth, yield attributes and grain yield of upland direct seeded rice.

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

- Intensity of new weed *Celosia argentea* was found on different *Kharif* fields' crops like maize, pigeonpea, soybean and pulses in many parts of Gujarat.
- *Ludwigia peruviana* has spread from Dhansiri catchment area to several places of Morigaon and Kamrup districts between 2010 to 2016.
- *Avena ludoviciana* intensity in wheat crop is increasing in Bhiwani district. Infestation of parasitic weed *Orobanche aegyptiaca* in mustard crop is spreading in Balsamand, Adampur, Barwala areas of Hisar.
- Intensity of *Lolium* spp., is increasing in Sirsa and Fatehba district. Pea crop in north-eastern districts of state was severely infested with grassy as well as broadleaf weeds viz. *P. minor*, *Poa annua*, *Polypogon monspeliensis*, *Coronopus didymus*, *Malwa parviflora*, *Medicago denticulata* etc. due to addition of FYM and its succession after rice.
- A new weed *Nicotiana plumbaginifolia* was observed in wheat fields in district Ludhiana. *Cyperus rotundus* was recorded in wheat and *Rabi* vegetables in Ludhiana.
- *Cassytha filiformis* was found as a new weed in Bengaluru.
- *Celosia argentea* was observed to be a severe problem in upland rice and *Rabi* pulses in the districts of Keonjhar. The weed was invading mostly the upland areas nearer to the foothills with the soil types belonging to light textured red soils.
- Seven isoproturon resistant *P. minor* populations have shown signs of cross resistance to fenoxaprop-p-ethyl and clodinafop; two populations were found resistant to pinoxaden. Sulfosulfuron and mesosulfuron+ iodosulfuron provided satisfactory control of all biotypes in Ludhiana.

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

- Germination of *I. rugosum* seeds was completely inhibited by 320 mm. mole NaCl. Seeds of *I. rugosum* were able to germinate over a wide pH range of 3-10.
- *Alternanthera bettzickiana* had higher growth rate and greater seed production potential than *Alternanthera brasiliana*, which accounts for its greater spread in Thrissur.
- Biological studies of *Melochia corchorifolia* revealed that its seed exhibited dormancy which could be classified as seed coat dormancy. The time of emergence of the weed is June-July and highest seed emergence was from the soil surface to a depth of 5 cm.
- In berseem fodder, *Coronopus didymus* was replacing *Chichorium intybus* as a major weed. *Cuscuta* sp. was emerging as a new weed. Sowing of mixture of berseem seed with Chinese cabbage/oats is common to suppress the weeds.
- At Coimbatore, post-emergence directed application of paraquat at 0.80 kg/ha resulted in lower weed coverage of *Cuscuta* and other weeds and weed dry weight among the herbicidal management in lucerne. Higher

green fodder yield and better economic returns could be obtained with PE pendimethalin (1.0 kg/ha) + hand weeding on 25 DAS followed by PE oxyfluorfen 250 g/ha + hand weeding at 25 DAS.

- At Jammu, complete control of parasitic weed *Dendrophthoe* spp. was achieved with cotton padding of 4 g copper sulphate + 0.5 g 2, 4-D sodium salt but it was slightly phytotoxic on host fruit plants.
- Fresh leaf leachates of eucalyptus and prosopis were found promising in inhibiting germination and seedling growth of *Parthenium hysterophorus* under laboratory conditions.
- After 3 month of release of beetles, on an average 16 feeding scars/leaf were observed in water hyacinth infested pond at Tanda village and nearly 5-10% (1 scale) die back symptoms were observed at Jammu.
- Heavy infestation of sucking pest was observed on water hyacinth plant in pond and 40 to 60 % plants were dried at Gwalior.

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

- At Ludhiana, residues of pendimethalin and clodinafop applied continuously to wheat in the rice-wheat cropping sequence were below the detectable limit (0.01µg/g) in soil, grain and straw at harvest.
- Residues of atrazine and pendimethalin in soil and maize grains were below 0.01 mg/kg irrespective of the tillage management practices followed for weed control at Coimbatore and Palampur.
- At Coimbatore, quizalofop-ethyl residues were below detectable level (0.01 mg/kg) in harvest samples of onion plant, bulb and field-soil irrespective of doses of applications.
- Addition of organic matter decreased persistence of butachlor and pretilachlor. No residues could be detected from 60 days after application at Bhubaneswar.
- Adsorption equilibrium of penoxsulam was attained within 6 hrs and adsorption increased with increase in initial concentration of penoxsulam. The adsorption was positively correlated with organic matter and clay content.
- At Palampur, preliminary kinetic studies revealed maximum bispyribac-sodium adsorption within first 24 hrs. The isotherm expressed an increasing trend in the adsorbed content Cs (µg/g) with respect to increase in the equilibrium concentration of bispyribac-sodium Ce (µg/ml) in solution.
- Butachlor and pretilachlor residues were found below detectable limit (BDL) in soil, grains and straw after harvest of summer and winter rice at Jorhat.
- Residues of 2,4-D, atrazine and pendimethalin were below detectable limits in water, soil and maize grains at Coimbatore.

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

On-farm research

- At Jorhat, application of pendimethalin (750 g/ha) pre-em (PE) was superior to farmers' practice (2 hand weedings) in terms of weed management and seed yield rice.
- At Pantnagar, clodinafop-propargyl + metsulfuron-methyl (60+4 g/ha) performed better than sulfosulfuron + metsulfuron-methyl (30+2 g/ha) during *Rabi* 2015-16 in Tarai and Bhabar areas of Uttarakhand in wheat crop.
- At Udaipur, application of ready-mix sulfosulfuron metsulfuron (30+2 g/ha) on wheat crop as post-emergence increased the wheat grain yield by 62.5 % over farmers practice (42.9 q/ha). During *Kharif*, weed management in maize through tembotrion at 3-4 leaf stage (15 DAS) increased the maize grain yield by 54.5% over farmers practice.
- At Faizabad, application of neem cake 200 kg/ha + soil drenching of metalaxyl MZ 0.2% at 20 DAP on tobacco to control the *Orobanche cernua* recorded higher tobacco leaf yield (265.9 g/plant), followed by imazethapyr 0.03 kg/ha at 20 DAP (240 g/plant).
- At Ludhiana, pre-mix herbicide, sulfosulfuron+ carfentrazone-ethyl at 100 g/ha and metribuzin+ clodinafop at 500 g/ha as post-emergence provided effective control of broadleaf and grass weeds and recorded similar wheat grain yield and economic return compared to earlier recommended herbicides.
- At Gwalior, application of imazethapyr + imazamox (RM) 80 g/ha PoE gave 64.5% increase of blackgram over farmer practice with B:C ratio of 2.9 over 1.8 in farmer practice in *Kharif* 2016 in blackgram.
- Application of pinoxsulam 20 g/ha as post-emergence increased 23.6% grain yield over farmers' practice

along with a B:C ratio of 3.71 in direct line seeded rice at Raipur.

- At Jammu, stale seed-bed technique with subsequent use of glyphosate at1.5 kg/ha or paraquat at 0.8 kg/ha prior to transplanting was found to be most effective in controlling the weedy rice infestations in transplanted rice cultivated areas.

Front line demonstration

- At, Hisar, pretilachlor+pyrazosulfuron provided more than 91.5% control of complex weed flora as against 83% by use of pretilachlor with 7.6 % increase in yield over FP.
- At Bhubaneshwar, six on farm trials were conducted on transplanted rice during *Rabi* 2015-16 in Alsua village of cuttack district revealed maximum yield of 4.2 t/ha in pretilachlor applied field. A net saving of ` 2500 - 3500/ ha was obtained in the plots treated with herbicides.
- At Pusa, ten OFRs were conducted using the chemical weed management technologies for rice crop (5 OFR) in *Kharif* and wheat (5 OFR) in *Rabi* at different farmers' field. Pretilachlor (750 g/ha) *fb* chlorimuron + metsulfuron at 4 g/ha at 25 DAT in rice and clodinafop + metsulfuron (Premix) (60+4 g/ha) in wheat were found effective in term of grain yield and B:C ratio over farmers practices.
- At Thrissur, farmers were convinced with efficacy of oxyfluorfen as an alternative herbicide for diuron in pineapple at very low concentrations.
- At Ludhiana, use of tractor operated multi-boom sprayer for enhancing herbicides efficacy was demonstrated in wheat at 109 locations in Sri Muktsar Sahib, Patiala, Bathinda, Jalandhar, Moga and Amritsar districts. Improved spray technology recorded 4.3% higher wheat grain yield, 11.2% higher weed control and ` 3627/ha higher net returns than conventional spray technology.
- Ten FLDs were conducted on farmer's field using clodinafop + metsulfuron (Pre-mix) (60+4 g/ha) in wheat crop in Bihar. The highest grain yield of wheat (46.5 q/ha) was recorded by clodinafop + metsulfuron. The net returns and B:C ratio of farmer practice were ` 23,413 per hectare & 1.89, respectively and the net return and B:C ratio of technology demonstrated were ` 47,500 per hectare and 3.07, respectively.
- Ten FLDs were conducted on farmer's field in Bihar during *Kharif* 2016. The highest grain yield of rice (4.1 q/ha) was recorded with pretilachlor (750 g/ha) *fb* chlorimuron + metsulfuron (4 g/ha) at 25 DAT Mean net return and B:C ratio of technology were ` 40,505/ha and 2.61, respectively.

1. ORGANIZATION AND FUNCTIONING

1.1 Introduction

Weeds are present everywhere in cropped lands, non-cropped lands, aquatic situations, city dwellings, and concern not only the farmers but virtually every citizen of the country and are limiting crop production, and degrade quality of produce besides raising cost of production. Of the total losses caused by the agricultural pests, weeds alone contribute to as high as 37% loss in productivity. The composition and competition by weeds is dynamic, and is dependent on the soil, climate, cropping and management factors. This is due to a variety of factors, such as changing cropping practices, input-intensive cropping systems, changing climate and more aggressive crop-weed associations, development of herbicide resistance in weeds and emergence of new biotypes, invasion by alien weeds due to globalization etc. Some of the weed species have assumed serious proportions in many ecosystems, threatening not only agricultural productivity but also biodiversity, human and animal health. Accordingly, weed management strategies require continuous refinement and up gradation in order to meet the emerging challenges.

Systematic research work on weed management in the country started with the launching of All India Coordinated Research Project on Weed Control by the ICAR in collaboration with the United States Department of Agriculture (USDA) at six locations, viz. Punjab Agricultural University, Ludhiana (Punjab); University of Agricultural Sciences, Bangaluru (Karnataka); Indian Institute of Technology, Kharagpur (West Bengal); Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.); Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (U.P.); and Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur (H.P.). The project came into operation in April, 1978 with the financial outlay of ` 42.97 lakhs for five years. The tenure of the project was, however, extended for one more year till March, 1984 with the savings. Further work was continued at these centres with the AP Cess fund of ICAR till the implementation of VII Plan in April, 1986.

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

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

In the VIII Plan, 4 new centres, viz. Rajasthan Agricultural University, Bikaner; (Raj.) Indira Gandhi Krishi Vishva Vidyalaya, Raipur (C.G.); Konkan Krishi Vidhya Peeth, Dapoli (Maharashtra) and University of Agricultural Sciences, Dharwad (Karnataka) were initiated with total outlay of Rs 16.41 lakhs. Seventy five percent of the total budget required by each centre was provided by the ICAR and the remaining 25% was met from the state department of agriculture as a state share. There was however 100% funding by the ICAR to Visva Bharati, Sriniketan. During IX Plan (1997-2002), X Plan (2002-2007) and XI plan (2007-2012) the total expenditure incurred under AICRP-WC was ` 823.79, 1696.57 and 3548.78 lakhs, respectively.

During XII Plan (2012-17), four AICRP on Weed Control centres, viz. University of Agricultural Sciences, Dharwad (Karnataka); Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.); Swami Keshwanand Rajasthan Agricultural University, Bikaner (Rajasthan), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani and Visva-Bharati, Sriniketan were closed and new centers at Maharana Pratap University of Agriculture and Technology, Udaipur (Raj.); University of Agricultural Sciencies, Raichur (Karnataka); Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra); Bidhan Chandra Krishi Viswavidyalaya, Kalyani (W.B.); Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu and Central Agricultural University, Pasighat (Arunachal Pradesh) by redeployment of existing manpower were opened.

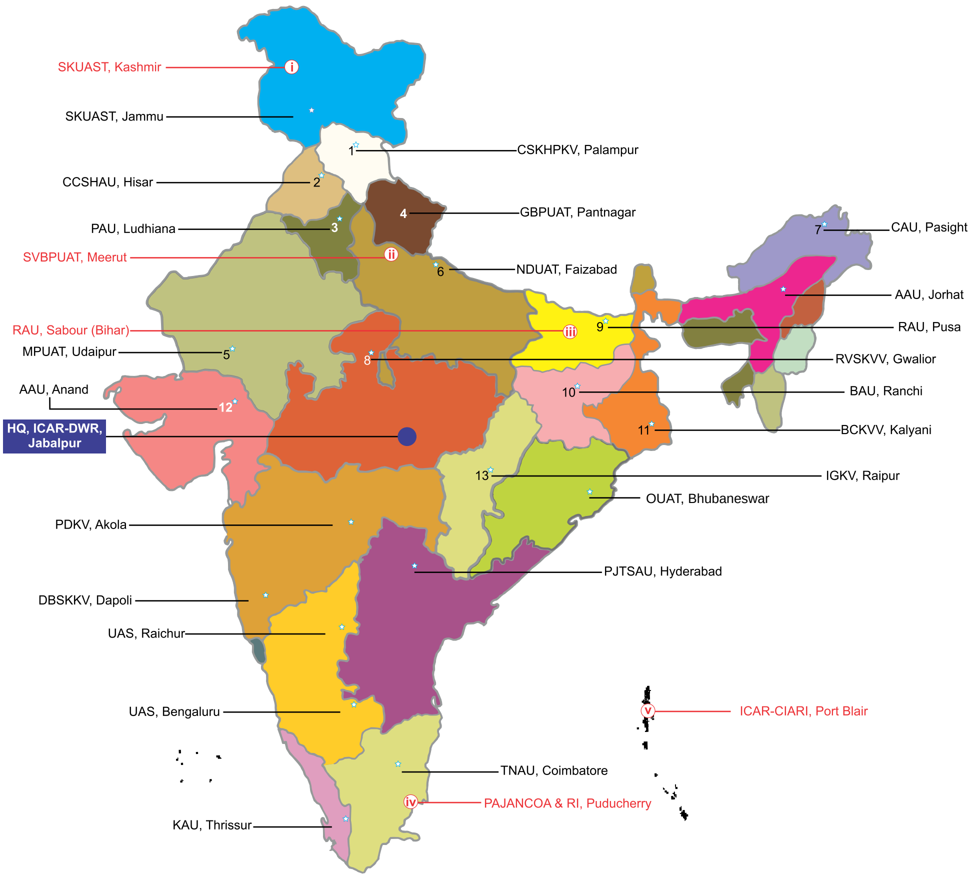
The coordinating unit of the project was located initially at Central Rice Research Institute, Cuttack, and shifted to National Research Centre (NRC) for Weed Science in 1989. Later in 2009, NRC for Weed Science was upgraded to Directorate of Weed Science Research. During XII Plan (2012-17), it has renamed as "ICAR-Directorate of Weed Research" and "AICRP on Weed Control" was renamed as "AICRP on Weed Management".

1.2 Mandate

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

1.3 Objectives

- To survey and surveillance of weed flora, mapping their distribution, ecology and habitat
- To evaluate new herbicides and working out the residual effect on non-targeted organisms
- To work out effective and economic weed management modules for field and horticultural crops and in different aquatic situations
- To study biology and control of problem weeds including aquatic and parasitic weeds
- To study long-term residual and cumulative effects, if any, of herbicides
- To standardize techniques for herbicide residues in soil, water and food chain
- To carry out basic research at different centres having adequate laboratory facilities for rendering support to adaptive research
- To test available tools/ implements for weed management under various agro-ecosystems
- To transfer weed management technologies on farmers' fields through OFTs and FLDs their impact assessment and training.



AICRP-Weed Management	
Regular Centre	
1	CSKHPKV, Palampur
2	CCSHAU, Hisar
3	GBPUAT, Pantnagar
4	PAU, Ludhiana
5	NDUAT, Faizabad
6	MPUAT, Udaipur
7	CAU, Pasighat
8	RVSKVV, Gwalior
9	RAU, Pusa
10	BAU, Ranchi
11	BCKV, Kalyani
12	AAU, Anand
13	IGKVV, Raipur
14	OUAT, Bhubaneswar
15	AAU, Jorhat
16	PDKV, Akola
17	DBSKKV, Dapoli
18	PJTSAU, Hyderabad
19	UAS, Raichur
20	TNAU, Coimbatore
21	KAU, Thrissur
22	UAS, Bengaluru
23	SKUAST, Jammu
Volunteer Centres	
i	SKUAST, Kashmir
ii	SVBPAUT, Meerut
iii	RAU, Sabour (Bihar)
iv	Pajncoa & RI Punducherry
v	ICAR-CARI, Port Blair

2. STAFF POSITION AND EXPENDITURE

AICRP on Weed Management is presently under operation in 23 State Agricultural Universities in 21 different states of the country. These centres represent 18 agro-ecological regions. Altogether, 63 scientists of different disciplines (Agronomy, Plant Physiology, Taxonomy, Residue Chemistry and Microbiology) are working in inter-disciplinary mode. Besides 23 main centres, 5 volunteer centres are also in operation. The details of staff position and funds allocated in the financial year 2016-17 are given below:

Staff position at different coordinating centres during 2016-17

Centre	Scientific		Technical (Including Driver)		Administrative		Supporting	
	Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled	Sanctioned	Filled
PAU, Ludhiana	4	4	3	3	1	-	2	1
UAS, Bengaluru	4	2	3	3	1	1	2	2
RVSKVV, Gwalior	3	3	2	2	1	-	2	2
GBPUAT, Pantnagar	4	4	1	1	1	1	2	2
CSKHPKV, Palampur	4	4	3	3	1	-	2	2
AAU, Jorhat	4	4	3	3	1	1	1	1
AAU, Anand	4	4	3	3	-	-	2	1
TNAU, Coimbatore	4	4	3	3	1	1	2	2
NDUAT, Faizabad	4	3	2	2	1	-	2	2
BAU, Ranchi	3	2	2	2	1	1	1	1
KAU, Thrissur	4	4	2	2	1	1	1	1
OUAT, Bhubaneshwar	3	3	3	3	1	-	1	1
PJTSAU, Hyderabad	3	3	1	1	1	1	1	1
CCSHAU, Hisar	4	2	2	1	1	-	2	-
RAU, Pusa	3	2	1	1	1	1	1	1
DBSKKV, Dapoli	2	2	1	1	1	1	1	1
IGKVV, Raipur	3	3	1	1	1	1	1	1
PDKV, Akola	2	2	1	1	1	-	1	1
CAU, Pasighat	2	1	1	-	1	-	1	-
UAS, Raichur	2	2	1	1	1	1	1	1
MPUAT, Udaipur	2	2	1	-	1	-	1	-
SKUAST, Jammu	2	2	1	-	1	-	1	-
BCKV, Kalyani	2	1	1	-	1	-	1	-
Total	72	63	42	37	22	11	32	24

Funds released to different coordinating centres during the financial year 2016-17

(` in lakhs)

Sl.	Centre name	Pay & allowances	TA	Recurring	Total ICAR Share
1	PAU, Ludhiana	34.24	0.88	3.00	38.12
2	UAS, Bengaluru	36.24	0.50	1.69	38.43
3	RVSKVV, Gwalior	18.24	0.66	2.25	21.15
4	GBPUAT, Pantnagar	38.11	0.88	3.00	41.99
5	CSKHPKV, Palampur	38.24	0.88	4.50	43.62
6	AAU, Jorhat	55.24	0.88	3.00	59.12
7	AAU, Anand	20.24	0.88	4.00	25.12
8	TNAU, Coimbatore	38.80	1.04	3.00	42.84
9	NDUAT, Faizabad	36.24	0.50	1.69	38.43
10	BAU, Ranchi	19.50	0.44	1.50	21.44
11	KAU, Thrissur	32.24	1.26	3.00	36.50
12	OUAT, Bhubaneshwar	19.24	0.66	2.25	22.15
13	PJTSAU, Hyderabad	27.24	0.66	2.25	30.15
14	CCSHAU, Hisar	23.24	0.50	1.69	25.43
15	RAU, Pusa	26.24	0.44	1.50	28.18
16	DrBSKKV, Dapoli	12.75	0.44	1.50	14.69
17	IGKV, Raipur	18.24	0.66	2.25	21.15
18	PDKV, Akola	12.75	0.44	1.50	14.69
19	BCKV, Kalyani*	--	0.22	1.00	1.22
20	CAU, Pasighat*	---	0.30	1.00	1.30
21	UAS, Raichur	8.75	0.44	1.50	10.69
22	MPUAT, Udaipur	22.46	0.44	1.50	24.40
23	SKUAST, Jammu	11.76	0.44	1.50	13.70
	Total	**550.00**	**14.44**	**50.07**	**614.51**
24	PC, Unit, Jabalpur	0.00	1.83	13.62	15.45
	Total (ICAR Share)	**550.00**	**16.27**	**63.69**	**629.96**

*Not filled up post position.

3. RESEARCH ACHIEVEMENTS

WP 1 Development of sustainable weed management practices in diversified cropping systems

WP 1.1 Weed management in conservation agriculture systems

WP 1.1.1 Weed management in rice-green gram-rice cropping system under conservation agriculture

Cooperating centers:

Bangaluru, Dapoli, Hisar, Jorhat, Ludhiana, Thrissur, Faizabad, Pantnagar, Bhubaneshwar, Raipur and Pusa.

Treatment structure of weed management in rice-green gram-rice cropping system under conservation agriculture was as below:

A. Tillage and residue management (main plot)

Treatment	*Kharif* (Rice)	*Rabi* (Green gram)	Summer
T1	CT (Transplanted)	CT	-
T2	CT (Transplanted)	ZT	ZT
T3	CT (Direct -seeded)	CT	ZT
T4	ZT (Direct -seeded)	ZT	ZT
T5	ZT(Direct -seeded) + R	ZT + R	ZT

CT- Conventional tillage (3-4 harrowings / cultivations followed by planking

ZT-No tillage, opening a slice for placing seed / fertilizer leaving inter-row areas undisturbed:

R - Crop residues - all residues produced to be retained in situ on soil surface

UAS, Bengaluru

Major dominant weed flora observed in the experimental plots was *C. difformis*, *C iria* (sedge), *Echinochloa colona* (grass) and *Alternanthera sessilis*, *Spilanthes acmella* and *Monochoria vaginallis* (broad leaf weeds), indicated their dominance at 60 DAP/S. On 60 DAP/S, use of pre-emergence herbicide-pyrazosulfuron-ethyl at 25 g/ha - 3 DAS/P alone or followed by passing cono weeder (45 DAS/P) reduced the weeds' density and dry weight as compared to unweeded control (Table 1.1.1.1). Weeds' density and weed dry weight did not differ much between conventional tillage as well as zero tillage at 60 DAP/S.

Table 1.1.1.1 Effect of CRP practices in weed density and dry weight in greengram-rice cropping system

Treatments	Weeds density (No./m²)				Weed dry weight (g/m²)
	Sedge#	Grasses#	BLW#	Total #	Total #
A. Tillage and residue management (main plot)					
T1	1.2 (16.7)	1.1 (11.1)	1.3 (18.7)	1.6 (46.6)	1.4 (29.6)
T2	1.2 (17.2)	1.1 (11.2)	1.2 (18.7)	1.6 (47.1)	1.4 (30.1)
T3	1.3 (21.3)	1.1 (13.0)	1.3 (21.6)	1.3 (55.9)	1.5 (37.8)
T4	1.2 (20.3)	1.1 (14.8)	1.4 (22.4)	1.7 (57.6)	1.5 (40.8)
T5	1.3 (22.3)	1.2 (17.6)	1.4 (24.1)	1.8 (64.0)	1.6 (46.8)
SEm ±	0.04	0.08	0.06	0.05	0.05
LSD (P=0.05)	0.15	0.30	0.20	0.20	0.20

B. Weed management (sub-plot)					
W1	3.8 (18.8)	3.3(11.5)	3.9 (20.7)	5.1 (51.0)	4.3 (27.4)
W2	3.4 (12.2)	2.9 (8.7)	3.5 (13.8)	4.6 (34.7)	3.4 (12.9)
W3	4.3 (27.7)	3.9 (20.3)	4.4 (28.3)	5.7 (76.8)	5.6 (70.8)
SEm ±	0.05	0.04	0.04	0.03	0.02
LSD (P=0.05)	0.15	0.10	0.10	0.08	0.08
T1W1	1.2(17.7)	1.0(9.0)	1.3(19.0)	1.6(45.6)	1.3(22.4)
T1W2	1.1(10.0)	0.9(7.0)	1.0(11.0)	1.4(28.0)	1.0(8.7)
T1W3	1.4(22.7)	1.3(17.3)	1.4(26.0)	1.8(66.0)	1.8(57.7)
T2W1	1.3(18.7)	1.0(9.3)	1.3(20.0)	1.7(48.0)	1.4(24.4)
T2W2	1.1(11.0)	0.8(6.3)	1.1(12.3)	1.4(29.6)	1.0(9.7)
T2W3	1.4(22.0)	1.3(18.0)	1.4(23.7)	1.8(63.7)	1.7(56.5)
T3W1	1.3(21.3)	1.1(11.3)	1.3(21.0)	1.7(53.6)	1.4(28.6)
T3W2	1.1(12.7)	0.9(8.3)	1.2(14.7)	1.6(35.6)	1.1(12.6)
T3W3	1.5(30.0)	1.3(19.3)	1.5(29.0)	1.9(78.3)	1.8(72.2)
T4W1	1.2(16.7)	1.1(12.7)	1.3(20.7)	1.7(50.0)	1.5(28.5)
T4W2	1.2(13.3)	0.9(10.0)	1.2(15.3)	1.6(38.67)	1.2(15.2)
T4W3	1.4(31.0)	1.3(21.7)	1.5(31.3)	1.9(84.00)	1.9(78.8)
T5W1	1.3(19.7)	1.2(15.3)	1.4(22.7)	1.7(57.7)	1.5(33.7)
T5W2	1.2(14.3)	1.1(12.0)	1.2(16.0)	1.6(42.3)	1.3(18.1)
T5W3	1.5(33.0)	1.4(25.3)	1.5(33.7)	1.9(92.0)	1.9(88.7)
SEm ±	0.1	0.1	0.09	0.05	0.05
LSD (P=0.05)	0.3	0.2	0.29	0.17	0.16

Data analyzed using transformation, + = square root of (X + 1), # = Log (X+2) values within the parentheses are original values; BLW = Broad leaf weeds

DBSKKV, Dapoli

Effect of tillage and residue management did not influence weed density of monocots at harvest and BLWs at all the stages of observation (P=0.05). However, weed density of monocots at 30 and 60 DAS/DAT was significantly reduced in treatment T_1 (CT: transplanted rice) and T_2 (CT: transplanted rice) as compared to rest of the treatments. Application of oxadiargyl at 0.1 kg/ha + 1 HW at 40 DAS/DAT recorded significantly least weed density of monocots and BLWs over oxadiargyl alone and weedy check during all the stages of observations. The interaction effect between tillage and weed control measures was found to be non significant during both the years of experimentation.

CCSHAU, Hisar

In rice-wheat system, *Phalaris minor* was the dominant weed in wheat. Grain yield of wheat after ZT/CT-DSR (5.36-5.42 t/ha) were higher than after conventional PTR (5.12-5.16 t/ha). Emergence of *Phalaris minor* was low under ZT wheat with residues (7.3-9.3/m^2) as compared to ZT/CT wheat without residues (14.7-29.3/m^2). During *Kharif* 2016, grain yield of rice under DSR was lower (2.16-2.18 t/ha) than CT-Transplanted (2.4-2.6 t/ha) due to incidence of brown spot disease in DSR during this season.

AAU, Jorhat

The lowest weed density and dry weight were observed in integrated weed management (Pretilachlor 0.75 kg/ha + mechanical weeding) which was closely followed by recommended herbicide (Pretilachlor 0.75 kg/ha). One hand weeding was least effective in controlling the weeds. Plant height and number of tillers as well as yield attributes were significantly increased by transplanting under conservation tillage as compared to direct seeding under conservation tillage. Integrated weed management resulted in significantly higher grains and straw yield over recommended herbicide as well as one hand weeding (Table 1.1.1.2).

Table 1.1.1.2 Weed density and dry weight as affected by treatments in rice.

Treatment	Weed density (No./m²)			Weed dry weight (g/m²)		
	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest
A. Tillage and residue management						
CT(Transplanted)	4.9	6.7	6.9	3.3	4.72	5.3
CT(Transplanted)	5.0	6.6	6.9	3.6	4.7	5.2
CT(Direct- seeded)	4.9	6.5	6.9	3.4	4.7	5.2
CT(Direct- seeded)	4.9	6.6	6.8	3.5	4.8	5.2
CT(Direct- seeded) + R	5.0	6.6	6.8	3.4	4.9	5.1
LSD (P=0.05)	NS	NS	NS	0.1	0.1	0.1
B. Weed management						
Recommended herbicide (pretilachlor 0.75kg / ha)	4.9	6.6	6.8	3.4	4.8	5.3
Integrated weed management (pretilachlor 0.75kg / ha + mechanical weeding)	4.5	6.3	6.5	3.2	4.2	4.6
One hand weeding	5.5	7.0	7.3	3.8	5.4	5.8
LSD (P=0.05)	0.2	0.1	0.7	0.9	0.1	0.9

PAU, Ludhiana

In wheat, weed flora included *Phalaris minor* major grasses, *Rumex dentatus, Coronopus didymus, Anagallis arvensis* and *Medicago denticulata* among broadleaf weeds and *Cyperus rotundus* among sedges. Among tillage and residue management, ZT-wheat with and without residue retention recorded lower density of *P. minor* compared to CT-wheat, and broadleaf weeds density were significantly more under ZT crop at 30 DAS but weed biomass was not affected by tillage and residue management. Among weed control, recommended herbicides and IWM recorded significantly lower population and biomass of grass and broadleaf weeds compared to unweeded control. At 60 DAS, weed population of *P. minor, M. denticulata* and *C. didymus* was not affected under different tillage and residue management.

P. minor, P. annua, R. dentatus and *A. arvensis* were the major weeds in soil weed seed bank during *Rabi* 2015-16. Interaction effects of tillage, residues and weed management on weed seed bank were non-significant. Tillage and residue management treatments exhibited non-significant effect on weed seed bank of *A. arvensis.* Among weed control, IWM and herbicides recorded significantly higher wheat grain yield and economic returns compared to unweeded control, and IWM recorded significantly higher wheat grain yield and economics returns than recommended herbicides.

In puddled transplanted rice (PTR), *Echinochloa colona* and *E. crus-galli* were major weeds. In direct-seeded rice (DSR), weed flora included *E. colona, Dactyloctenium aegyptium, Acrachne racemosa, Digitaria ciliaris, Digera arvensis, Phyllanthus niruri, C. iria, C. compressus* and *E. crus-gall.* Among tillage and residue management, PTR recorded significantly lower weed population and biomass compared to DSR at 60 DAS and at harvest (Tables 1.1.1.2). At harvest, weed biomass in PTR treatments was the lowest and significantly lower than CT-DSR. Among DSR, weed population and biomass in CT-DSR was the lowest and seconded by ZT-DSR+R; however, ZT-DSR recorded significantly higher density and weeds biomass. Among weed control, IWM recorded significantly lower population and dry matter of grass, broadleaved and sedges weeds as compared to recommended herbicides and unweeded control.

E. crus-galli, E. colona, D. aegyptium and *Trianthema portulacastrum* were major weeds in weed seed bank during *Kharif* 2016 and interaction effects of tillage, residue and weed management treatments were significant. IWM recorded higher gross returns than recommended herbicide treatment, but due to more cost involved in hand pulling, net returns and B:C were low compared to recommended herbcide. The interaction effect revealed that PTR and CT-DSR recorded similar grain yield under herbicide and IWM treatments (Table 1.1.1.3). Pendimethalin, bispyribac-sodium and fenoxaprop-p-ethyl residues in soil and rice grain under different tillage and IWM treatments were below detectable limit (<0.01 µg / g) at the time of harvest in both the seasons. Among tillage and residue management systems, CT-CT and ZT-DSR+R *fb* ZT wheat+R *fb* ZT green manure system found to be the most energy efficient production system in wheat; in rice, CT (PTR)-CT (wheat) were more productive than DSR based systems.

Table 1.1.1.3 Effect of tillage, residue and weed management on yield attributes, yield and economies of wheat and economics of different treatments (2015-16)

Treatment	Effective tillers (No./m²)	Spike length (cm)	Wheat grain yield (t/ha)	Biological yield (t/ha)	Variable cost (` /ha)	Gross returns (` / ha)	Net returns (` / ha)	B:C
A. Tillage and residue management								
TRM1	353	11.9	4.9	12.8	39,111	75,518	36,407	1.9
TRM2	336	11.9	4.8	12.8	34,298	74,359	40,061	2.2
TRM3	397	12.4	4.1	13.6	39,111	63,074	23,963	1.6
TRM4	406	12.0	5.2	15.2	34,298	79,193	44,895	2.3
TRM5	399	12.2	4.5	10.4	34,298	68,396	34,098	1.9
SEm ±	17	0.1	0.05	0.3	-	-	-	-
LSD (P=0.05)	NS	NS	0.2	0.9	-	-	-	-
B. Weed management								
W1	406	12.2	5.3	13.	32,665	81,313	48,648	2.5
W2	384	12.2	5.4	13.4	44,403	82,228	37,826	1.8
W3	345	11.8	3.5	12.1	31,603	52,780	21,178	1.7
SEm ±	8	0.1	0.03	0.2	-	-	-	-
LSD (P=0.05)	30	0.3	0.08	0.7	-	-	-	-
Interaction LSD (P=0.05)	NS	NS	NS	NS	-	-	-	-

MSP of wheat: ` 15,250 / t

KAU, Thrissur

A long-term trial on weed management in rice- green gram / sesame- green manure cropping system under conservation agriculture was started in 2016. The major weed in the experimental area was *Echinochloa glabrescens*. Other weeds present in very small numbers included the grasses *Isachne miliacea* and *Digitaria ciliaris*, broad leaf weeds *Ludwigia parviflora*, *Eclipta alba*, *Sphaeranthus indicus* and *Commelina diffusa*, and sedges *Fimbristylis miliacea* and *Cyperus iria*. Integrated weed management resulted in significantly lower count of *E. glabrescens*. At 60 DAS integrated weed management was significantly superior in controlling weed growth. This was followed by herbicidal control, which was significantly superior to unweeded control.

Effects of treatments on number of panicles per hill and percentage of filled grains per panicle were significant. In both cases, integrated weed management gave highest values of panicles per hill i.e., 5.1 and percentage of filled grains per panicle, i.e., 86.5%. However, application of herbicides gave values on par. Unweeded control was significantly inferior with 3.6 panicles per hill and 75.6% filled grains per panicle. Grain yield of rice was found to be the highest in integrated weed management (3.9 t / ha) followed by herbicidal application (3.3 t / ha). Unweeded management resulted in significantly lower grain yield (1.3 t / ha). Integrated weed management and application of herbicides produced 8.6 t / ha straw yields while unweeded control resulted in significantly lower straw yield (4.1 t / ha).

NDUAT, Faizabad

Dominant weed species in the experimental plot were *Phalaris minor*, *Medicago denticulata*, *Rumex acetosella*, *Analgallis arvensis*, *C. album*, *Vicia sativa*. Among the establishment methods of wheat after rice significantly lower population of weeds were recorded in the plots where wheat was sown with zero till ferti seed drill after conventional or zero till rice at 30 and 60 DAS followed by the treatments TPR(CT)- wheat (CT) (Table 1.1.1.4). Density of *P. minor* was significantly lower in the treatments where wheat was sown as zero till than conventional till system. Integrated weed management practice was found superior over the alone application of herbicide towards the density of weeds at 30 and 60 DAS. Significantly lower dry weight of weeds was recorded in the zero till residue-wheat (ZT) + crop residue – *Sesbania* (ZT) and rest of the treatments revealed similar level of dry matter accumulation of weeds. While among the weed management treatments, integrated weed management practices recorded the lowest weed dry matter.

Table 1.1.1.4 Effect of tillage, residue and weed management on periodic weed biomass and nutriant depletion in wheat (2015-16)

Treatment	Weed biomass (g/m²)*				Nutrient depletion at harvest (kg/ha)		
	At 30 DAS	At 60 DAS		At harvest			
		Grass	Broadleaves		N	P	K
Tillage and residue management							
TRM1	2.1 (4)	3.4 (23)	1.7 (3)	4.7 (48)	12.6	1.7	19.0
TRM2	2.5 (5)	3.0 (14)	2.0 (5)	7.2 (79)	20.9	2.8	31.6
TRM3	1.9 (3)	4.6 (48)	2.0 (5)	4.6 (47)	14.8	1.6	18.8
TRM4	2.5 (6)	3.4 (23)	1.5 (2)	5.6 (47)	14.9	1.7	18.9
TRM5	2.1 (4)	3.0 (16)	1.5 (2)	4.7 (46)	14.4	1.6	18.3
SEm ±	0.1	0.4	0.1	0.4	-	-	-
LSD (P=0.05)	NS	NS	0.2	1.2	-	-	-
Weed management							
W1	2.2 (4)	1.2 91)	1.0 (0)	2.9 (12)	3.5	0.4	5.0
W2	2.0 (3)	1.0 (0)	1.0 (0)	1.2 (0)	0.1	0.0	0.2
W3	2.6 (6)	8.3 (74)	3.2 (10)	12.0 (147)	42.9	5.1	58.8
SEm ±	0.1	0.1	0.1	0.4	-	-	-
LSD (P=0.05)	0.3	0.2	0.3	1.7	-	-	-
Interaction LSD	NS	NS	S	NS	-	-	-

*Data subjected to square root transformation. Figures in parenthesis are means of original values.

Total weed dry matter accumulation at 60 DAS was found significantly lower in DSR followed by wheat conventional and retention of *Sesbania* followed by transplanted rice –zero till wheat along with *Sesbania*, however, weed control treatments revealed no significant effect on total dry matter of weeds at 60 DAS. No significant effect was recorded on plant height of wheat at 30 DAS. Among all the establishment methods of rice wheat cropping system, significantly higher grain yield of wheat (4.5 t/ha) was recorded with TPR (CT)- wheat (CT) as compared to other establishment methods. Integration of weed management practices eg. application of herbicides supplemented with one hand weeding significantly increased number of spike/m^2, grain yield (5.0 t/ha) and straw yield of wheat (6.0 t/ha) than other weed management practices.

During *Kharif* 2016, no significant effect of the treatments was observed on plant height and 1000-grain weight of rice. Among all the establishment methods of rice-wheat system, highest number of panicle (231.6/m^2), grain yield (4.86 t/ha) and straw yield (6.2 t/ha) was recorded under TPR (CT)- wheat (CT) system of rice establishment over other methods of rice. Integration of weed management practices (herbicide + one hand weeding) data showed significant increase in number of panicle/m^2 (246.8/m^2), grain yield (5.6 t/ha) and straw yield (7.06 t/ha) of rice. Highest net return (` 64,206) and BCR (2.50) was recorded in plots where rice was grown in the system of TPR (CT)- wheat (CT-ZT) along with IWM practices.

GBPUAT, Pantnagar

Dominant weed species in the experimental plot of wheat under unweeded situation were recorded as *P. minor* (29.0%), *M. denticulata* (52.6%), *P. plebeium* (0.8%), *C. didymus* (0.6%), *M. alba* (3.8%), *C. album* (5.6%), *V. sativa* (3.5%), *R. acetosella* (2.5%) and *C. rotundus* (1.7%) at 60 DAS. Higher *P. minor* population was observed in conventional system while significantly least was obtained in zero-till wheat without residue retention. *M. denticulata* was dominant weed among BLWs recording higher population under zero-till condition along with retention of rice residue. Higher population of *C. album* was recorded under conventional system of wheat either with incorporation of *Sesbania* or not while significantly least were obtained in all the establishment methods of wheat as zero-till system.

IWM practices (rec. herbicide *fb* one hand weeding) totally controlled density of all broad leaved weeds, except *M. denticulata, P. plebenium* and *R. acetosella*, whereas, recommended herbicide (clodinafop + metsulfuron) completely reduced *C. didymus* and *M. alba.* Significantly highest dry matter accumulation of grassy weeds was obtained under conventional till system of wheat without inclusion of *Sesbania* and minimum under zero-till wheat with inclusion of *Sesbania* without rice residue retention. Wheat in respect to grain yield under different establishment methods was recorded highest (3.8 t/ha) in DSR (CT)-wheat (CT)-*Sesbania* (ZT) as brown manuring which was at par with other establishment methods except zero-till wheat with as well as without rice residue retention while among weed management practices highest spike/m^2, grain/spike, grain yield (4.0 t/ha) and straw yield (5.8 t/ha) was obtained with IWM practices (rec. herbicide *fb* one hand weeding) being at par with recommended herbicide (clodinafop + metsulfuron) except for spike/m^2 and significantly superior to unweeded check.

Among different establishment methods, the highest net return and benefit cost ratio of ` 64,973 and 1.9, respectively, was recorded in the plots where wheat was sown in the TPR (CT)-wheat (ZT)-*Sesbania* (ZT) incorporated as green manure system while within weed management practices, IWM (recommended herbicide *fb* one hand weeding) practice recorded the highest net return (` 62,929) and benefit cost ratio (1.9). Interaction between the establishment method and weed control treatments was significantly affected yield of rice (Table 1.1.1.5). TPR (CT)-wheat (ZT)-*Sesbania* (ZT) recorded maximum grain yield of rice with integration of IWM practices which was comparable with rest of the establishment system in combination with other weed management practices except DSR (ZT)-wheat (ZT)-*Sesbania* (ZT) along with weed management practices. It was also found at par with unweeded treatment in combination with TPR (CT)-wheat (ZT)-*Sesbania* (ZT) only.

Table 1.1.1.5 Interaction effect of establishment methods and weed management on grain yield of rice in rice-wheat cropping system

Treatment	TPR (CT) -wheat (CT)	TPR (CT) -wheat (ZT) -*Sesbania* (ZT)	DSR (CT) -wheat (CT) -*Sesbania* (ZT)	DSR (ZT) -wheat (ZT) -*Sesbania* (ZT)	DSR (ZT) +R-wheat (ZT)+R-*Sesbania* (ZT)	Mean
Rec. herb. (Bispyribac- Na 25g/ha)	4.8	5.0	4.4	3.4	4.6	4.5
IWM (Rec. herbicide *fb* HW)	4.8	5.6	4.6	3.5	5.3	4.7
Unweeded	4.2	5.5	0.0	0.0	0.2	2.0
Mean	4.6	5.4	3.0	2.3	3.4	
LSD (P=0.05)	1.2					

HW: Hand weeding

Among different establishment system, highest net return and benefit cost ratio of ` 73,363 and 1.9, respectively, were recorded in the plots where rice was planted in the TPR (CT)-Wheat (ZT)-*Sesbania* (ZT) green manuring system. However, within weed management practices, IWM (recommended herbicide *fb* one hand weeding) practice recorded the highest net return (` 69,717), with benefit cost ratio (1.8) which was equally obtained with the application of recommended herbicide (Bispyribac-Na 20g/ha) alone (Table 1.1.1.6).

Table 1.1.1.6 Effect of establishment methods and weed management on economics of rice in rice-wheat cropping system

Treatment	Cost of cultivation (` /ha)	Gross return (` /ha)	Net return (` /ha)	B:C ratio
Establishment system tillage and residue management				
TPR (CT)-wheat (CT)	39,533	1,04,126	64,593	1.6
TPR (CT)-wheat (ZT)- *Sesbania* (ZT)	40,733	1,19,867	73,363	1.9
DSR (CT)-wheat (CT)- *Sesbania* (ZT)	35,733	70,313	34,580	0.9
DSR (ZT)-wheat (ZT)- *Sesbania* (ZT)	34,188	58,127	23,938	0.6
DSR (ZT)+R-wheat (ZT)+R- *Sesbania* (ZT)	34,188	77,819	43,631	1.2
Weed management				
Rec.herb. (Bispyribac-Na 20 g/ha)	36,792	1,04,319	67,527	1.8
IWM (Rec. herbicide *fb* one hand weeding)	39,492	1,09,209	69,717	1.8
Unweeded	34,342	44,624	10,282	0.2

MSP rice 1470/q and straw 400/q. General cost of CT 37000/ha, Direct 32000/ha and ZT 29500/ha.

OUAT, Bhubaneswar

Weed management in conservation agriculture systems under rice-maize-cowpea was undertaken. The floristic composition in *Kharif* was dominated by *E. crus-galli, E. colona, P. scorbiculatum, C. dactylon, M. quadrifolia, A. sessilis, L. parviflora* among broadleaved weed, *C. difformis, C. iria, C. rotundus* and *F. miliacea* among sedges. The CT method of tillage recorded significantly the lowest weed density at 60 DAP over CT (direct-seeded) methods. The average weed dry weight (44.4 g/m ^{2}) was found to be 35 % more than the weed dry weight (33 g/ m^2) in the CT (direct- seeded plots).

Recommended practice (butachlor 1.5 kg/ha) significantly lowered the weed densities (40.8/m^2) over the unweeded control check (113.4/m^2) at 60 DAP and the decrease was in the tune of 57%. Imposition of mechanical weeding with herbicide (butachlor 1.5 kg/ha) reduced the weed population significantly (64%) over control which was at par with recommended herbicides (Table 1.1.1.7). There was no significant difference in grain yield, gross and net return among different tillage system at the first season. However, practice of CT (direct seeded) system resulted 3.0 t/ha grain yield which was at par with the CT (Transplanted) method. However, the highest B: C ratio (1.7) was obtained in the CT (direct-seeded) method in comparison with CT (transplanted) method. Among the weed management practices, the highest grain yield (3.4 t/ha) was recorded in IWM which was at par with the application of recommended herbicides (3.3 t/ha) and proved better (49%) than unweeded control. Among weed management practices, the highest B:C ratio (1.94) was obtained with recommended herbicides and lowest B:C ratio was includes with control (1.0).

Table 1.1.1.7 Effect of tillage and weed management practices on weed growth in rice at 60 DAP under conservation agriculture

Treatments	Total weed density (no./m^2)	Total weed dry weight (g/m^2)	Yield (t/ha)	Gross return (`/ha)	Net return (`/ha)
Tillage and residue management					
CT (Transplanted)-CT	79.4	32.4	3.1	44,520	9,520
CT (Transplanted)-ZT-ZT	81.3	33.6	3.2	48,213	10,231
CT (Direct -seeded)-CT-ZT	98.7	41.4	3.0	42,152	11,245
ZT (Direct -seeded)-ZT-ZT	108.4	47.3	2.9	41,213	10,895
ZT(Direct –seeded) + R-ZT+R-ZT	102.6	44.6	3.0	42,411	11,895
LSD (P=0.05)	8.4	6.9	NS	NS	NS
Weed management					
Recommended herbicides	48.4	25.8	3.3	51,621	12,354
IWM (herbicide *fb* mechanical weeding what was interrupted	40.8	27.1	3.4	53,412	11,987
Unweeded	113.4	38.5	2.3	34,213	7,542
LSD (P=0.05)	21.1	9.4	0.1	-	-

IGKV, Raipur

Weed dry matter was significantly low under CT-(transplanted) treatment than CT/ZT-direct seeded treatments at all the stages in rice. Similarly, weed dry matter was significantly low under recommended *i.e.* pyrazosulfuron (20 g/ha) *fb* pinoxsulam (22.5 g/ha) POE treatment than unweeded check but was at par with integrated weed management treatment. Seed yield under CT (transplanted) rice was remarkably higher over ZT-direct-seeded rice. Significantly higher seed yield was recorded under recommended practice than unweeded check but it was comparable with integrated weed management. The net income and B: C ratio was higher under CT (transplanted) followed by CT (DSR). However, the lowest net return and B: C ratio was optaind under ZT (DSR) – R. Among the weed management practices higher net return and B:C ratio was found in integrated weed management followed by recommended herbicide. It was found that CT had higher efficiency (33.2%) over ZT, transplanting (35.8%) followed by direct seeding, chemical weed control over unweeded and integrated weed control proved to be 4.8 times more efficient over unweeded, respectively.

No remarkable change was observed in soil pH at the end of the crops cycle. However, significantly lower EC of soil was observed in plots where weed management treatments applied under transplanted conditions. The organic carbon content was found significantly higher under all the treatments put under DSR over transplanted conditions (Table 1.1.1.8). Among different weed management methods maximum soil dehydrogenase enzyme activity and microbial biomass carbon was measured in unweeded plots, which was found at par with integrated weed management practice.

Table 1.1.1.8 Changes in physico-chemical properties of soil as influenced by different tillage and weed management practices

Treatment	Physico-chemical property					
	At sowing of wheat			After harvest of rice		
	pH	EC	OC	pH	EC	OC
Main plot (Tillage methods)						
CT (Transplanted) -CT – CT Tillage	6.79	0.18	0.45	6.71	0.16	0.47
CT (Transplanted) -CT – ZT Tillage	6.77	0.18	0.48	6.62	0.17	0.50
CT (DSR) –CT-ZT Tillage	6.78	0.18	0.47	6.61	0.17	0.51
ZT (DSR)- ZT+ R - ZT	6.79	0.19	0.49	6.63	0.20	0.53
ZT (DSR) + R – ZT + R - ZT	6.78	0.19	0.51	6.68	0.20	0.56
LSD (P=0.05)	NS	NS	0.05	NS	0.02	0.05
Sub-plot (Weed management methods)						
Recommended Herbicide	6.77	0.18	0.47	6.68	0.17	0.50
Integrated weed management	6.78	0.18	0.45	6.62	0.17	0.47
Unweeded	6.79	0.19	0.52	6.65	0.18	0.56
LSD (P=0.05)	NS	NS	0.04	NS	NS	0.04

pH: Soil reaction, EC: Electrical conductivity in dS/m OC : Organic carbon (%)

RAU, Pusa

In rice, the lowest weed count (8.7, 10.4 and 7.4 /m^2) and weed dry weight (14.8, 20.1 and 12.1 g/m^2) were recorded at 30 and 60 DAS and at harvest, respectively under CT (Transplanted)-ZT-ZT which were statistically at par with CT (Transplanted)-CT- and significantly superior over rest of the treatments under tillage and residue management. However, the highest grain yield of rice (4.7 t/ha) was recorded under CT (Transplanted) – CT- which was statistically at par with CT (Transplanted)-ZT-ZT (4.6 t/ha). In wheat, the lowest weed count (6.4 and 23.6/m^2) and weed dry weight (10.6 and 12.8 g/m^2) were recorded at 30 and 60 DAS, respectively under CT (Transplanted)-CT; however, at harvest the lowest weed count (5.9/m^2) and weed dry weight (5.4 g/m^2) were recorded under CT (Transplanted)-ZT-ZT under tillage and residue management. However, the highest grain yield of wheat (4.7 t/ha) was recorded under CT (Transplanted)–CT-which was significantly superior than rest of the treatments. The lowest grain yield of wheat (4.2 t/ha) was recorded under treatment T_4 i.e. ZT (Direct-seeded) – ZT- ZT.

In greengram, the lowest weed count (6.3, 33.3 and 7.6 / m^2) and weed dry weight (9.6, 18.9 and 10.7 g / m^2) were recorded at 30 and 60 DAS and at harvest, respectively under CT (Transplanted)-ZT-ZT under tillage and residue management. However, the highest grain yield of greengram (1.3 t / ha) was recorded under CT (Direct-seeded) – CT-ZT which was significantly superior over rest of the treatments. The lowest grain yield of greengram (0.97 t / ha) was recorded under ZT (Direct-seeded) – ZT- ZT. The highest gross return (` 2,20,322 / ha), net return (` 1,52,109 / ha) and B:C ratio (3.24) were recorded under CT (Transplanted)-ZT-ZT under tillage and residue management. Under weed management practices the highest gross return (` 2,26,149 / ha) was recorded by integrated weed management (herbicide + hand weeding). However, the highest net return (` 1,54,015 / ha) and B:C ratio (3.5) were recorded under recommended herbicides.

WP 1.1.2 Weed management in maize based cropping systems

Field experiments were carried out at centers, Coimbatore, Ranchi and Udaipur to develop information on weed population dynamics in maize based cropping systems,

TNAU, Coimbatore

In maize – sunflower cropping system of conservation agriculture significantly higher grain yield and economics were recorded in zero tillage in ZT-ZT+R system and in PE pendimethalin at 1.0 kg / ha + HW on 45 DAS in sunflower crop (Table 1.1.2.1). Whereas, in maize, CT-CT system and in PE atrazine at 0.5 kg / ha + HW on 45 DAS recorded higher productivity as well as high income in maize crop. The total bacteria, fungi, actinobacteria, phosphobacteria and soil enzymes viz., alkaline phosphatase and dehydrogenase were decreased up to 5 days after application of herbicides. After 15 days, the population and enzymes activities were increased double the time compared with control in both sunflower and maize crop. Soil organic carbon and nutrients status at the harvest of both the crops were not influenced significantly by the conservation agricultural practices.

Table 1.1.2.1. Effect of tillage and weed control methods on weed infestation and yield in sunflower

Treatment	Sunflower (*Rabi 2015*)			Yield (t/ha)	Net return (`/ha)	B:C ratio
	Total weed density (No./m^2)	Total weed dry weight (g/ m^2)	WCE (%)			
Tillage methods						
T_1 (CT-CT)	7.7 (60.2)	5.6 (32.2)	46.9	1.6	14,533	1.8
T_2 (CT-ZT)	6.4 (41.3)	4.0 (16.5)	68.9	2.0	18,839	1.9
T_3 (ZT+R - ZT)	7.0 (49.3)	4.8 (22.7)	65.1	1.7	16,346	1.9
T_4 (ZT – ZT+R)	5.4 (29.8)	3.7 (13.8)	75.3	2.2	22,918	2.1
T_5 (ZT+R – ZT+R)	5.5 (31.2)	4.1 (14.8)	-	1.6	14,096	1.7
SEd $\pm$	0.2	0.1	-	0.1	-	
LSD (P = 0.05)	0.5	0.3	-	0.2	-	
Weed management methods						
W_1 Recommended herbicides	6.58 (44.1)	4.35 (16.8)	71.9	1.8	11,580	1.4
W_2 Integrated weed management	4.91(24.1)	3.8 (12.5)	79.2	1.9	17,150	1.7
W_3 (Unweeded check)	7.99 (65.6)	7.74 (57.9)	-	0.9	1,010	1.0
SEd $\pm$	0.4	0.22	-	88	-	
LSD (P = 0.05)	0.8	0.4	-	176	-	

Figures in parenthesis are means of original values, Data subjected to square root transformation

BAU, Ranchi

At Ranchi, CT-CT tillage sequences adopted in *Kharif* and *Rabi* recorded reduced weed density of grassy, broad leaf and total weed density at 30 and 60 DAS during 2015-16. However, it was similar to ZT-ZT+R and produced significantly reduced dry matter of grassy and broad leaf compared to ZT+R-ZT+R during 2015-16. CT-CT recorded reduced total weed dry matter similar to CT-ZT, ZT-ZT, ZT-ZT+R at 30 DAS during 2015-16 and also at 60 DAS when data were pooled. IWM performed in maize and wheat recorded reduced grassy, broad leaf and total weed density during 2014-15 and 2015-16 and also when data of two years pooled and it was similar to *R H - RH* except 2015-16. IWM-IWM similar to RH-RH recorded reduced weed dry matter compared to weedy check in both the seasons during both the years and also when data were pooled. However, it was similar to RH-RH at 30 and 60 DAS except during 2015-16. Conventional tillage sequences performed in *Kharif* and *Rabi* produced higher effective tillers/m^2 similar to CT-ZT and number of grains per spike thus it recorded higher wheat grain yield (3.9 t/ha) similar to CT-ZT. Among weed control methods, IWM – IWM performed in *Kharif* and *Rabi* recorded higher effective tillers/m^2, spike length (cm), grains /spike and 1000 seed weight (g) resulted in higher wheat grain and straw yield. CT-ZT recorded maximum B:C ratio similar to CT-CT during 2015-16 and under pooled of two years (2.3 and 2.4, respectively).

ZT-ZT+R tillage performed in *Kharif* and *Rabi* recorded increased pH (5.63) from the start of experiment (5.5). While ZT+R-ZT+R recoded higher organic carbon (5.1 g/kg soil), CO_2 evolution (6.9 µg/hr/g soil), and dehydrogenase activity (6.8 ppmTPF/hr). Among different weed control methods, IWM –IWM performed in *Kharif* and *Rabi* seasons recorded higher CO_2 (6.2 µg/hr/g soil) evolution and dehydrogenase (6.35 ppmTPF/*hr*) compared to their initial values (5.6 µg/hr/g soil and 6.1 ppm TPF/hr).

In maize, IWM – IWM recorded reduced density of narrow, broad leaved weeds and sedges at 30 DAS and 60 DAS in both the crops. ZT-ZT tillage sequence recorded significantly reduced dry matter of narrow and broad leaved weed at 30 DAS during 2016 and also sedges at 60 DAS. However, it was similar to ZT+R-ZT+R during 2015 and 2016 and also under pooled data except in case of narrow leaf at 30 DAS and 60 DAS during 2016 and 2015, respectively. ZT-ZT tillage sequence also recorded reduced total weed dry matter at 30 and 60 DAS during both the years and also under pooled data except at 30 DAS during 2015 when ZT+R-ZT+R recorded reduced total weed dry matter compared to rest of the tillage sequences. CT-CT tillage sequence similar to CT-ZT and ZT-ZT tillage sequences recorded maximum grain/cob during 2015, 2016. IWM-IWM approach of weed control methods recorded significantly higher yield attributes like grain/cob and 100 grain weight thereby produced significantly higher maize grain yield. ZT-ZT tillage sequence recorded significantly higher net return and B: C ratio during 2016 (` 53,444/-ha and 3.6, respectively).

MPUAT, Udaipur

Dominant weed species in the experimental plot were *Echinochloa colona* (33.7%), *Dinebra retroflexa* (30.2%), *Commelina benghalensis* (11.6%), *Digera arvenris* (9.6%), *Trianthema partulacastfram* (8.8%) and *Corchorus olitorious* (6.1%) at 30 DAS. Among tillage and residue management treatments, none of the treatment recorded significant effect on weed density and dry matter of different weeds. Since this was the first year of the experiment, therefore, effect of tillage and residue management was not observed on weed density and weed dry matter. While compared with weedy cheek, both weed control treatments resulted in significant decrease in density and dry matter of grassy and broad leaf of weeds. Minimum number of grassy and broadleaf weeds and dry weight were observed at 30 DAS and 60 DAS by application of atrazine (0.5 kg/ha) pre-emergence followed by hand weeding at 30-35 DAS treatment. The interaction effect between tillage and residue management and weed control was non significant on weed control and weed dry matter at different crop growth stages. Application of atrazine (0.5 kg/ha) as PE with hand weeding (IWM) resulted in significant enhancement of plant height (4.7%) and dry matter accumulation (12.9%) over weedy check at harvest of the crop. Yield attributes like cob weight and 1000 grain weight increased with IWM but their magnitude of increase was statistically non significant.

Yield attributes *viz.*, cob length, width, weight and 1000 grain weight and crop yield i.e. grain and stover failed to record significant response with tillage and residue management practices. Among weed management treatments maximum values of yield attributes, cob length (31.1 cm), cob width (3.1cm) and cob weight (112 g) were recorded with integrated weed management weed management (atrazine 0.5kg /ha with hand weeding). Grain and stover yield of maize also not recorded significant response with tillage and residue management practices. Minimum grain (2.8 t/ha) and stover (4.2 t/ha) yield were recorded with weedy check which was inferior to atrazine 0.5 kg/ha PE *fb* tembotrione 125 g/ha PoE and integrated weed management with chemical i.e. atrazine 0.5 kg/ha PE and hand weeding at 30 DAS. Amongst different weed management practices, highest grain yield (4.1 t/ha) and stover yield (6.4 t/ha) were obtained by controlling weeds through IWM. The maximum net return (` 55,984/ha) and B: C ratio (2.2) were realized by pre-emergence application of atrazine 0.5 kg/ha *fb* hand weeding at 30 DAS.

CSKHPKV, Palampur

During *Rabi* 2015-16, *Phalaris minor*, *Avena fatua, Lolium temulentum*, *Vicia sativa*, *Coronopus didymus* and *Anagallis arvensis* were the dominant weeds in wheat. Tillage treatments brought about significant variation in the count of all the weeds associated with wheat crop. CT-ZT (conventional tillage in maize *fb* zero tillage in wheat) remained at par with ZT-ZT resulted in significantly lower count of *Lolium temulentum* and *Avena ludoviciana*. CT-ZT had significantly lower count of *Vicia sativa* over other treatments. ZT-ZT-R, CT-CT, CT-ZT and ZT-ZT had significantly lower count of *Phalaris minor* over ZT+R-ZT+R. ZT-ZT and ZTR-ZTR had more count of *Coronopus didymus* than other treatments. ZTR-ZTR remaining at par with CT-ZT had significantly lower count of *Anagallis arvensis*.

Recommended herbicide application gave significantly lower count of *Lolium* and *Avena*. IWM resulted in significantly lower count of *Coronopus*. Dry weight of weeds had almost similar trend as weed count. Tillage and weed management treatments brought about significant variation in total weed count and total weed dry weight. CT-ZT had significantly lower total count and dry weight of weeds as compared to other tillage treatments. In maize, tillage treatments brought about significant variation in the count and dry weight of weeds. ZTR-ZTR, ZT-ZTR, ZT-ZT and CT-ZT remaining at par gave significantly lower count of *Digitaria sanguinalis*, *Cyperus* sp, *Commelina benghalensis* and *Ageratum conyzoides*. ZT-ZT and ZTR-ZTR remaining at par with ZT-ZTR had significantly lower count of *Cynodon dactylon* over CT-CT and CT-ZT (Table1.1.1.2.2). Tillage treatments brought about significant variation in the maize cob yield. ZTR-ZTR remaining at par with CT-CT resulted in significantly higher maize cob yield over other treatments. Similarly weed control treatments had significant variation in the cob yield of maize followed by herbicidal treatment.

Table 1.1.1.2.2 Effect of tillage and weed management on species wise weed count (No/m^2) at 90 DAS in maize

Treatment/Tillage	*Digitaria*	*Commelina*	*Cynodon*	*Cyperus*	*Ageratum*	Plant height (cm)	Maize cob yield (t/ha)
Tillage and residues management							
CT-CT	3.7(13.3)	9.0(80.4)	3.5(12.0)	4.1(16.4)	17.9(320)	86.0	5.84
CT-ZT	1.8(3.6)	3.9(16.0)	3.0(9.8)	1.7(3.1)	11.0(132)	89.2	5.06
ZT-ZT	2.1(4.9)	5.3(32.4)	1.6(2.7)	1.8(3.6)	9.6(92)	92.9	4.38
ZT-ZT+R	1.0(0.0)	5.0(28.4)	2.3(5.8)	2.5(6.7)	10.2(104)	92.1	4.31
ZT+R-ZT+R	1.0(0.0)	3.9(15.6)	1.9(3.6)	2.2(6.7)	10.7(140)	84.2	6.09
SEm ±	0.4	0.5	0.3	0.3	0.5	3.2	0.43
LSD (P=0.05)	1.3	1.5	1.1	1.0	1.5	NS	NS
Weed management							
Recommended herbicide	2.2(5.6)	6.4(45.6)	3.0(9.9)	2.5(7.2)	11.1(138)	87.2	5.19
IWM (herbicide+ mechanical+intercrop)	2.0(4.8)	5.3(33.1)	2.0(4.3)	1.8(4.0)	10.8(129)	89.3	5.98
Hand weeding	1.6(2.7)	4.5(25.1)	2.4(6.1)	3.0(10.7)	13.9(206)	90.1	4.23
SEm ±	0.1	0.2	0.1	0.2	0.3	1.3	0.23
LSD (P=0.05)	0.4	0.7	0.6	0.6	1.3	NS	0.90

WP 1.1.3 Pearlmillet based cropping system

Cooperating Centers: RVSKVV, Gwalior and AAU Anand

RVSKVV, Gwalior

Main weeds of the experimental field were *Cyperus rotundus*, *Phalaris minor*, *Chenopodium album*, *Spergula arvensis*, *Anagallis arvensis* and *Convolvulus arvensis* in both the years. Different tillage practices could not reach the level of significance in respect to population and dry weight of weeds except *Cyperus rotundus* and *Phalaris minor* on both the crop stages (30 and 60 DAS) and *Spergula arvensis* at 30 DAS. Dry weight of weeds at 30 DAS and weed biomass at harvest was significantly affected by tillage practices and lowest values were recorded in conventional tillage CT – CT and CT-ZT-ZT. Highest weed control efficiency (86.7%) was recorded in CT – CT followed by ZT+R – ZT – R-ZT and lowest (80.8%) in ZT-ZT-ZT.

All the weed management practices significantly influenced the density and dry weight of weeds at 30 and 60 DAS except *Cyperus rotundus* in 2014-15 at 60 DAS and *Convolvulus arvensis* at 30 and 60 DAS in 2015-16. Highest weed dry weight was recorded in weedy check while lowest was found in oxyfluorfen 0.23 kg/ha PE + 1 HW at 25-30 DAS. The weed control efficiency was maximum under integrated weed management practices (87.3%) followed by recommended herbicide pendimethalin 1.0 kg/ha PE (79.3%) at 60 DAS of crop.

Weed control treatments significantly increased the number of siliqua/plant, length of siliqua and number of seeds/siliqua under oxyfluorfen 0.23 kg/ha PE + 1 HW 25-30 DAS followed by pendimethalin 1.0 kg/ha as PE application as compared to weedy check. Maximum net return was obtained in CT-CT followed by ZT-ZT+R-ZT. However B:C ratio was heighest ZT-ZT+R-ZT and lowest (2.6) in CT-CT tillage practice. Similarly higher net return of ` 37,248 was obtained in integrated weed management method (oxyfluorfen + 1 HW) followed by pendimethalin 1.0 kg/ha PE (` 35,975) while higher B:C ratio was obtained in pendimethalin followed by oxyfluorfen + 1 HW (Table 1.1.3.1).

Table 1.1.3.1 Effect of different weed management and conservation tillage practices on yield and economics in mustard under pearlmillet-mustard-green gram based cropping system

Treatment		Seed yield (t/ha)	Stover yield (t/ha)	Gross return (`/ha)	Net return (`/ha)	B:C Ratio
Tillage and residues management						
T_1	Conventional Tillage (CT-CT)	1.3	3.4	53,583	38,790	3.6
T_2	Zero Tillage (CT-ZT-ZT)	1.1	3.5	47,305	34,612	3.7
T_3	Zero tillage ((ZT-ZT-ZT))	1.0	3.2	43,706	31,013	3.4
T_4	Zero tillage + Crop residue (ZT-ZT+R-ZT)	1.2	3.4	48,373	35,680	3.8
T_5	Zero tillage + Crop residue (ZT+R-ZT+R-ZT)	1.1	3.6	47,658	34,965	3.7
SEm (±)		0.03	0.2	-	-	-
LSD (P=0.05)		0.1	NS	-	-	-
Weed management						
W_1	Pendimethalin PE	1.2	3.3	49,568	35,975	3.6
W_2	Oxyfluorfen PE + 1 HW	1.2	3.7	52,241	37,248	3.4
W_3	Weedy check	1.0	3.2	42,542	30,249	3.4
SEm (±)		0.01	0.09	-	-	-
LSD (P=0.05)		0.03	0.3	-	-	-

Rate of mustard Rs. 40/ kg; Straw Rs. 0.5 / kg

AAU Anand

Major monocot weeds observed in the experimental fields were, *Eragrostis major, Eleusine indica, Digitaria sanguinalis, Cyperus rotundus, Cynodon dactylon* and *Echinochloa colona.* The dicot weeds were *Euphorbia hirta, Spergula arvensis, Mollugo nudicaulis, Boerhavia diffusa, Amaranthus spinosus, Tridex procumbens* and *Phyllanthus niruri* in pearlmillet. Among weed management practices, grain and straw yield were significantly the highest with atrazine 0.50 kg/ha as PE *fb* IC at 30 DAS. Same trend was also recorded in weed dry weight at harvest. Grain and straw yield as well as weed dry biomass recorded at harvest were significantly influenced by interactive effect of tillage and weed management practices in Pearl millet. Grain yield was significantly higher in zero tillage with incorporation of residues with integration of atrazine 0.50 kg/ha *fb* IC at 30 DAS while, straw yield was significantly higher recorded in conventional tillage (T_1) with integration of atrazine 0.50 kg/ha *fb* IC at 30 DAS. Weed biomass recorded at harvest was significantly lowest with pre-emergence application of atrazine 0.50 kg/ha *fb* IC at 30 DAS with conventional tillage (T_2).

Among weed management practices, monocot and dicot weeds as well as weed dry biomass of monocot were significantly lowest in pre-emergence application of atrazine 0.50 kg/ha *fb* IC at 30 DAS. Same trend was noticed at 60 DAS. In interactive effect, zero tillage (T_2) with atrazine 0.50 kg/ha *fb* IC (W_2) showed significantly lower monocot weed counts and dicot weed count recorded at

30 DAS. In the soil statistically no significant effect of different tillage and weed management practices was found on microbial properties of soil. However, among different tillage practices, zero tillage + residue treatment showed maximum increase in all microbial properties in comparison to initial properties, numerically. Moreover, there was not any adverse effect recorded of different weed management practices on microbial properties of soil.

In mustard, major monocot weeds were *Cynodon dactylon, Cyperus rotundus, Eleusine indica* and *Cyperus iria.* The dicot weeds were, *Chenopodium album, Chenopodium murale, Amaranthus viridis, Oldenlandia umbellata, Portulaca quadrifida* and *Digera arvensis.* Seed and straw yield were also not significantly influenced by tillage practices while weed management showed significant effect. Seed and straw yield of mustard were significantly the highest recorded in integrated approach among weed management practices (Table 1.1.3.2).

Monocot weed dry biomass was significantly lower under conventional tillage at 30 DAS while dicot was significant lower with zero tillage at 30 DAS while other weed parameters were non significantly influenced by tillage practices. Dicot weed counts, total weed counts and dry weed weight of monocot were significantly influenced by interactive effect of tillage and weed management practices at 30 DAS. Highest fungal count in soil was recorded in unweeded check (31.4 x 10^4 CFU / g soil), while lowest was recorded in pendimethalin 0.5 kg / ha (28.6 x 10^4 CFU / g soil) among different treatments. In comparison to initial, there was an increase in soil microbial activities.

Table 1.1.3.2 Growth and yield attributes as influenced by tillage and weed management practices in pearlmillet-mustard cropping system

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Weed dry weight at harvest (g/m²)	WCE (%)
Tillage practices in pearlmillet (T)				
T_1 : CT - CT -	1479	6099	6.9 (48.4)	-
T_2 : CT – ZT - ZT	1427	6222	6.9 (48.8)	-
T_3 : ZT – ZT - ZT	1486	6136	7.1 (51.7)	-
T_4 : ZT - ZR+R - ZT	1459	6235	7.1 (51.7)	-
T_5 : ZT+R - ZT+R - ZT	1448	6309	7.1 (51.5)	-
S. Em. ±	28.8	58.4	0.08	
LSD (P=0.05)	NS	NS	NS	
WM practices in pearl millet (W)				
W_1 : Pendi 0.50 kg / ha PE	1590	6089	6.9 (46.3)	40
W_2 : Pendi 0.50 kg / ha PE *fb* IC 30 DAS	1707	6763	5.3 (27.5)	65
W_3 :Unweeded	1083	5748	8.8(77.4)	-
S. Em. ±	19.9	50.1	0.04	
LSD (P=0.05)	58.7	147.9	0.1	
Interaction T x W	NS	NS	NS	

WP 1.2 Weed management in organic farming systems

TNAU, Coimbatore

WP 1.2.3 (i) Non chemical weed management in organically grown okra + leaf coriander - maize + cowpea cropping system

Treatment

1. Hand weeding twice on 20 and 45 DAS
2. Power weeder weeding on 20 DAS followed by hand weeding on 45 DAS
3. Twin wheel hoe weeder weeding on 20 DAS followed by hand weeding on 45 DAS
4. Hand weeding on 20 DAS + crop residue mulching 5 t / ha
5. Power weeder weeding on 20 DAS + crop residue mulching 5 t / ha
6. Twin wheel hoe weeder weeding on 20 DAS + crop residue mulching 5 t / ha
7. Crop residue mulching 5 t / ha
8. Recommended herbicides
9. Unweeded control

The predominant broad leaved weeds were *Trianthema portulacastrum, Digera muricata Amaranthus* *viridis, Amaranthus polygamus, Portulaca oleracea, Desmodium triflorum, Parthenium hysterophorus* and *Boerhaavia erecta.* Among the grass weeds, *Cynodon dactylon, Chloris barbata, Dactylactenium aegyptium, Echnicoloa colona, Setaria verticillata* and *Dinebra retroflexa* were the dominant ones. *Cyperus rotundus* was the only sedge weed present in the experimental field of okra. Among different non chemical methods in okra, significantly lower total weed density and dry weight (3.3/m^2 and 1.2 g/m^2) were recorded in crop residue mulch 5 t/ha. Crop residue treatments recorded comparatively less weed density and dry weight at 45 DAS than recommended herbicide treatment (PE pendimethalin 1.0 kg/ha).

Table1.2.1 Effect of non chemical weed management practices on weed density, WCE and growth parameters of okra (45 DAS) in 2016

Treatment	*Khairf* (2016)					
	Weed density (No./m^2)			Total weed density (No./m^2)	Total weed dry weight (g/m^2)	WCE (%)
	Grasses	Sedges	BLW			
Hand weeding twice on 20 and 45 DAS	3.5 (12.3)	1.1 (1.3)	5.2 (27.3)	6.4 (40.9)	6.0 (36.4)	61.4
Power weeder weeding on 20 DAS followed by hand weeding on 45 DAS	2.9 (8.4)	1.3 (1.7)	4.6 (21.0)	5.6 (31.1)	5.3 (28.6)	63.9
Twin wheel hoe weeder weeding on 20 DAS followed by hand weeding on 45 DAS	2.9 (8.8)	1.4 (1.9)	4.6 (21.9)	5.7 (32.6)	4.7 (21.7)	57.9
Hand weeding on 20 DAS + Crop residue mulching 5 t/ha	1.1 (1.2)	0.7 (0.6)	1.7 (2.8)	2.1 (4.6)	1.4 (1.9)	85.7
Power weeder weeding on 20 DAS + crop residue mulching 5 t/ha	1.8 (1.4)	1.0 (1.1)	1.6 (2.7)	2.3 (5.2)	1.5 (2.3)	86.3
Twin wheel hoe weeder weeding on 20 DAS + Crop residue mulching 5 t/ha	1.2 (1.5)	0.8 (0.7)	1.4 (2.1)	2.1 (4.4)	1.5 (2.2)	84.3
Crop residue mulching 5 t/ha	1.5 (1.1)	0.9 (0.9)	1.4 (1.3)	1.8 (3.3)	1.1 (1.2)	91.2
Recommended herbicides (PE pendimethalin 1.0 kg/ha)	1.9 (3.8)	1.2 (1.3)	2.9 (8.3)	3.7 (13.4)	3.1 (9.2)	82.3
Unweeded control	6.2 (38.7)	2.2 (4.8)	7.5 (56.3)	9.9 (99.8)	7.9 (62.2)	-
SEm±	0.1	0.1	0.2	0.4	0.2	-
LSD (P=0.05)	0.2	0.2	0.4	0.9	0.5	-

Figures in parenthesis are means of original values; Data subjected to square root transformation

At 45 DAS, higher weed control efficiency of 91.2% was recorded in crop residue mulching 5 t/ha. All other crop residue mulched plots recorded higher weed control efficiency than recommended herbicide plot at 45 DAS (Table 1.2.1). Among different non chemical weed management methods, crop residue mulching 5 t/ha recorded significantly higher fruit yield of 29.8 t/ha. Higher net return (` 5.3 lakh/ha) and B: C ratio (5.8) was recorded in crop residue mulching 5 t/ha. Among non chemical weed management practices, comparatively higher net return were recorded with crop residue treatments. The recommended herbicide treatment was recorded lower net return and B: C ratio of ` 4.4 lakh/ha and 4.8, respectively.

WP 1.2.3 (ii) Non chemical weed management in organically grown beetroot - maize

Treatment

1. Hand weeding twice on 20 and 45 DAS
2. Power weeder weeding on 20 DAS followed by hand weeding on 45 DAS
3. Twin wheel hoe weeder weeding on 20 DAS followed by hand weeding on 45 DAS
4. Hand weeding on 20 DAS + crop residue mulching 5 t/ha
5. Power weeder weeding on 20 DAS + crop residue mulching 5 t/ha
6. Twin wheel hoe weeder weeding on 20 DAS + crop residue mulching 5 t/ha
7. Crop residue mulching 5 t/ha
8. Recommended herbicides
9. Unweeded control

The predominant broad leaved weeds were *Trianthema portulacastrum, Digera muricata, Amaranthus viridis* and *Boerhaavia erecta*. Among the grass weeds, *Cynodon dactylon, Dinebra retroflexa* and *Brachiaria reptans* were the dominant ones. *Cyperus rotundus* was the only sedge weed present in the experimental field of beet root. Among different non-chemical methods, significantly lower total weed density and dry weight (2.3/m^2 and 1.2 g/m^2) were recorded in crop residue mulching 5 t/ha. Crop residue treatments recorded comparatively less weed density and dry weight than recommended herbicide treatment (PE pendimethalin 1.0 kg/ha) at 45 DAS in beet root.

At 45 DAS, in the beet root field, higher weed control efficiency of 93.4% was recorded in crop residue mulching 5 t/ha. All other crop residue mulched plots recorded higher weed control efficiency than recommended herbicide plot at 45 DAS. Beetroot tuber yield was significantly higher in crop residue mulched plots. Higher net return (` 1,96,544/ha) and B: C ratio of 7.3 was recorded in crop residue mulching 5 t/ha. The recommended herbicide treatment was recorded lower net return and B:C ratio (` 1,51,371/ha and 3.9).

DBSKKV, Dapoli

WP 1.2.4 Management of complex weed flora in organically cultivated rice-groundnut cropping system.

Main plot treatments : Green manuring

M_1 Green manuring (*Sesbania rostrata*):

manuring (*Sesbania rostrata*):

M_2 Without green manuring :

Sub plot treatments : Weed control measures

	Rice (*Kharif*) :	Groundnut (*Rabi*)
T_1 :	Mulching with *G. maculata* (5 t/ha) 20 DAT:	Mulching with black polythene (7 micron)
T_2 :	Mulching with G. *maculata* (5 t/ha) 20 DAT *fb* 1 HW 40 DAT:	Mulching with silver polythene (7 micron)
T_3 :	Mulching with *G. maculata* (5 t/ha) 20 DAT *fb* 1 hoeing with cono weeder 40 DAT	Mulching with paddy straw (5 t/ha) 20 DAS *fb* 1 HW 40 DAS
T_4 :	Weed free check (2 HW at 20 and 40 DAS)	Weed free check (2 HW at 20 and 40 DAS)
T_5 :	Oxadiargyl PE 0.1 kg/ha *fb* 2-4 D POE 1.00 kg/ha 25 DAT	Pendimethalin PE 1.0 kg/ha *fb* imazethapyr POE 100 g/ha 25 DAT
T_6 :	Weedy check (1 hoeing 20 DAS/DAT)	Weedy check (1 hoeing 20 DAS/DAT)

Green manuring with *Sesbania rostrata* and without green manuring did not influence weed density of monocots and BLWs at all stages of observations in rice during *Kharif* 2016. However, weed density of monocots and BLWs was reduced in treatment M_1 (Green manuring) than M_2 (Without green manuring). The different weed control measures influenced significantly the weed density of monocots and BLWs at all the stages of observations except BLWs at 30 DAS. However application of oxadiargyl PE 0.1 kg/ha *fb* 2-4 D POE 1.0 kg/ha 25 DAT recorded significantly least weed growth of monocots as well as BLWs as compared to weedy check and which was remained at par with T_2 and T_3 during all the stages of observations. All the weed control measures significantly reduced weed growth of monocots and BLWs as compared to weedy check at 30, 60 DAT at harvest. Treatment T_4 recorded significantly maximum number of tillers, height, grain and straw yield as compared to rest of the treatments except treatment T_2 and T_3 in respect to height. Application of green manuring did not influence weed density and weed growth but significantly influence the yield attributes and yield.

WP 1.2.5 Weed management in turmeric based organic cropping system

NDUAT, Faizabad

Treatments

Weed management treatments (Main- plot)

- Rice straw mulch 5 t/ha.
- Rice straw mulch 10 t/ha.
- Manual weeding at 30, 60, 90 and 120 DAP
- Recommended herbicide metribuzin 700 g/ha as PE followed by two HW at 45 and 75 DAP
- Weedy check

Organic sources (Sub plot)

Kharif & *Rabi* (Turmeric)
1 FYM 20 t/ha
2 50% of total N by pressmud + 50% by vermicompost

Summer (Greengram)
Only rhizobium inoculation will be done

Note: FYM: 0.5, 0.25, 0.5 (%) NPK, vermi-compost: 2.5, 1.5, 1.5(%) NPK, press mud; 1.07, 2.62, 1.75 (%) NPK, RDF 120 kg N, 80 kg P_2O_5 and 80 kg K_2O/ha

The weed flora of the experimental field consisted of *Echinochloa* species, *Dactyloctenium aegyptium* and *Elusine indica* among grasses, *Ludwigia crustacea, Commelina benghalensis, Ammania beccifera, Ageratum conyzoides* and *Solanum nigrum* among broad leaf weeds and *Cyperus rotundus* and *Fimbristyllis* sp. among sedges. *Commelina benghalensis, Ludwigia crustacea,* sedges and *Echinochloa* spp. were observed up to 120 days stage of crop growth. However, *Ageratum conyzoides* and *Solanum nigrum* did not appear in early stages but recorded beyond 120th day stage remained upto harvest of this crop. The total weed density increased upto 120th stage and declined at later but later on BLWs made their dominancy. Beyond 120 days stage of crop, presence of *Rabi* weeds, *Phalaris minor, Melilotus alba, Chenopodium album* was also found. At 60 and 120 DAP, minimum density of weeds was recorded (2.8) where straw mulch (10 t/ha) + FYM 20 t/ha was applied followed by straw mulch 10 t/ha + 50% N (pressmud) + 50% N (VC) treatment. The straw mulch provided effective control of weeds. Herbicide showed no phytotoxicity on the crop.

CCSHAU, Hisar

WP 1.2.7 Non-chemical weed management in turmeric and its residual carry over effect on succeeding greengram

Treatments

Turmeric			Greengram
Treatment	Quantity (t/ha)	Application time	Only seed inoculation with Rhizobium culture
Straw mulch	6	JAS*	
Straw mulch	8	JAS	
Straw mulch	10	JAS	
Straw mulch	12	JAS	
Straw mulch *fb* 1 hand weeding	6	JAS *fb* 50 DAS	
Straw mulch *fb* 1 hand weeding	8	JAS *fb* 50 DAS	
Straw mulch *fb* 1 hand weeding	10	JAS *fb* 50 DAS	
Straw mulch *fb* 1 hand weeding	12	JAS *fb* 50 DAS	
Hoeing (2)		25 and 50 DAS	
Hoeing (3)		25, 50 and 75 DAS	
Pendimethalin *fb* mulching	1000/10	JAS	
Weed free		-	
Weedy check			

*JAS: Just after sowing

Weed flora of the experimental field consisted of *Dactyloctenium aegyptium, Brachiaria reptans, Digitaria reptans, Eragrostis tenella* among grasses; *Trianthema portulacastrum* among broadleaf weeds (BLW); and *Cyperus rotundus* among sedges. Pendimethalin followed by straw mulch were found most effective against all type of weeds particularly against broadleaf weeds and sedges followed by hoeing at 25, 50 and 75 DAS. Wheat straw alone used as mulch irrespective of dose was not found effective to minimize weed emergence but its integration with one hand weeding at 50 DAS helped to control grassy and broadleaf weeds effectively as is evident from density and dry weight of weeds at 60 DAS and density of grassy and BLW's in these treatments was at par with two / three hoeing employed at 25, 50 and 75 DAS. Because of decomposition of straw, weeds emerged in mulching treatments as density of weeds in these treatments integrate with one HW was almost equal to mulching alone at all application rates. None of the treatment was found effective against sedges. In all pre-emergence use of pendimethalin at 1000 g/ha followed 10 tonnes of mulching was found to be best herbicide treatment as evident from density and dry weight of weeds at 60 and 90 DAS which was at par with two or three hoeing treatment and significantly less than all mulching treatments. Plant height and numbers of tillers/plant were maximum in weed free and pendimethalin treated plots.

SKUAST, Jammu

WP 1.2.9 Weed management options in high value basmati rice-potato-french bean cropping system under organic farming

Treatment	Basmati rice-potato-french bean
1.	Rice bran (2.5 t/ha) 10 DBT/DBS*
2.	Rice bran (2.5 t/ha) 10 DBT/DBS + 1 HW 30 DAT
3.	Mustard seed meal (2.5 t/ha) 10 DBT/DBS
4.	Mustard seed meal (2.5 t/ha) 10 DBT/DBS + 1 HW at 30 DAT
5.	Rice husk extract 5 DBT/DBS
6.	Mustard plant extract 5 DBT/DBS
7.	Rice husk extract 5 DBT/DBS+ 1 HW at 30 DAT
8.	Mustard plant extract 5 DBT/DBS+ 1 HW at 30 DAT
9.	Recommended herbicide (for rice, potato and french bean)
10.	Weed free
11.	Weedy check

*DBT/DBS= Days before transplanting/sowing

The experimental field was dominated by *Echinochloa* spp. and *Cynodon dactylon* amongst grassy weeds; *Alternanthera philoxeroides* and *Caesulia axillaris* amongst broad-leaved weeds and *Cyperus* spp. Beside these major weeds *Ammannia baccifera* and *Commelina benghalensis* were also recorded. Different weed management treatments had significant effect on weed density and weed biomass at 30 and 60 DAT and at harvest. Significantly lowest density of *Cyperus* spp. was recorded in mustard seed meal 2.5 t/ha treatment than all other treatments.

At 60 and harvest, rice bran 2.5 t/ha + 1 hand weeding, mustard seed meal 2.5 t/ha + 1 hand weeding, rice husk extract + 1 hand weeding and mustard plant extract + 1 hand weeding were recorded significantly lower total weed density and biomass as compared to weedy check and other weed management treatments. Among the organic weed management treatments, higher growth parameters were recorded with mustard seed meal applied treatments followed by rice bran applied treatments. The highest number of panicles/m^2, grain yield and straw yield were recorded with mustard seed meal 2.5 t/ha + one hand weeding at 30 DAT which was significantly higher than rice bran 2.5 t/ha, rice husk extract, mustard plant extract and weedy check and statistically at par with all other treatments. The highest number of grains/panicles was recorded with mustard seed meal 2.5 t/ha + one hand weeding at 30 DAT which was significantly higher than rice husk extract, mustard plant extract and weedy check and statistically at par with all other treatments. Highest B.C ratio was recorded in with butachlor 1.5 kg/ha followed by mustard plant extract + one hand weeding.

PAU, Ludhiana

WP 1.2.11 Weed management in organic based basmati rice-durum wheat cropping system

Treatment	Basmati rice (puddle transplanted)	Durum wheat
T1	GM 50 kg/ha + unweeded	Unweeded
T2	GM 50 kg/ha + weed free	Weed free
T3	GM 50kg /ha + 25 % higher plant density + one hand pulling	50% higher plant density + one hoeing
T4	DT + GM 50 kg/ha + 25% higher plant density + one hand pulling	50% higher plant density+ straw mulch (6t/ha)
T5	GM 75 kg/ha + 25% high plant density + one hand pulling	DT + 50% higher plant density + one hoeing
T6	DT + GM 75 kg /ha + 25% higher plant density + one hand pulling	DT+ 50% higher plant density + straw mulch (6 t/ha)
T7	GM 100 kg/ha + 25% higher plant density + one hand pulling	ZT with residues + 50% higher plant density
T8	DT + GM 100 kg /ha + 25% higher plant density + one hand pulling	ZT with residues +50% higher plant density + seed coating with natural HydroGel
T9	DT + GM 100 kg/ha + normal plant density + one hand pulling	Bed planting + 25% higher plant density + one hoeing
T10	Conventional agriculture (weedfree for both rice and wheat)	
GM = Green manuring (with *Sesbania aculeata*) DT= Deep tillage; ZT-Zero tillage		

In Basmati rice, soil weed seed bank consisted mainly of *Trianthema portulacastrum* and *Dactyloctenium aegyptium* in *Kharif* 2016. All deep tillage treatments recorded significantly higher seed bank of *T. portulacastrum* and *D. aegyptium* as compared to normal tillage (Table 1.2.11.1). Tillage and *Sesbania aculeata* check seed rate did not exihibit any significant effect on weed growth and on biomass of *Sesbania aculeata*. In basmati rice, weeds were not observed at any growth stage of crop indicating that the two week ponding was sufficient to take care of the weeds in this crop. There was non-significant effects of different weed control treatments (tillage, green manure, seed rate, planting density, manual hand pulling) on weeds, growth, and grain yield of rice.

Table 1.2.11.1 Effect of tillage on soil weed seed bank (*Rabi* 2015-16)

Treatments	*T. portulacastrum*		*D. aegyptium*	
	Before tillage	After tillage	Before tillage	After tillage
T1	1.0 (0)	1.0 (0)	1.0 (0)	6.6 (42.4)
T2	1.0 (0)	1.0 (0)	1.0 (0)	6.6 (42.4)
T3	6.5 (42.4)	11.3 (127)	11.3 (127)	11.3 (127)
T4	6.5 (42.5)	13.0 (170)	9.3 (84.8)	15.6 (255)
T5	1.0 (0)	1.0 (0)	12.9 (170)	11.3 (127)
T6	6.5 (42.4)	12.9 (170)	6.45 (42.4)	12.9 (170)
T7	1.0 (0)	1.0 (0)	6.55 (42.4)	6.6 (42.4)
T8	6.6 (42.4)	12.9 (170)	9.01 (83.2)	14.1 (212)
T9	6.6 (42.4)	11.3 (127)	9.1 (84.8)	11.3 (127)
T10	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
SEm±	0.4	0.7	0.8	1.2
LSD (P=0.05)	1.1	2.1	2.4	3.6

Data subject to square root transformation; Figure in parentheses are means of original values.

WP 1.2.12 Weed management in organic crop production system (maize - garlic) under mid hill conditions of Himachal Pradesh

CSKHPKV, Palampur

Treatment details

Treatment	*Kharif*	*Rabi*
	Maize (green cob)	Gralic
T_1	One hoeing followed by earthing up at knee high stage	Hoeing (twice) at 15 DAS & 45 DAS
T_2	Stale seed bed + hoeing + earthing up	Stale seed bed + hoeing + HW
T_3	Raised stale seed bed + hoeing + earthing up	Raised stale seed bed + hoeing + HW
T_4	Mulch (*Lantana*) 5t/ha	Mulch (*Lantana*) 5t/ha
T_5	Stale seed bed + mulch 5t/ha	Stale seed bed + mulch 5t/ha
T_6	Raised stale seed bed + mulch 5t/ha	Raised stale seed bed + mulch 5t/ha
T_7	Intercropping (soybean) + hoeing	Intercropping (Coriander) + hoeing
T_8	*Maize/soybean + hoeing + earthing up	*Garlic/pea + hoeing+ HW
T_9	Mulch + manual weeding *fb* autumn crop of coriander	Mulch + manual weeding *fb* summer crop of green manure
T_{10}	Chemical check	Chemical check

*In *Kharif*, maize/ soybean and in *Rabi* garlic/peas alternate crop

Intercropping of soybean with maize (T_7) resulted in significantly lower count of grassy weeds than most of the other weed control treatments. Sedges were found to be sensitive to intercropping competition and were completely eliminated under T_7. The other treatments were more or less similar to chemical check. Plant height varied significantly and T_6, T_5 and T_3 had higher height over other treatments. Any treatments could not significantly affect number of cobs/plant but the cob weight varied significantly. Intercropping treatment (T_7) resulted in higher cob weight significantly more than chemical check but it was comparable to most other treatments. The other treatments were more or less similar to chemical check in influencing the maize green cob yield. T_7 (intercropping of soybean) increased maize green cob yield by 114.2% over the chemical check (Table 1.2.12.1). Phosphate solublising microorganism (PSM) was significantly highest in maize/soybean+hoeing+earthingup (31.3 x 10^3) and lowest numerical population was observed in stale seed bed+hoeing+ earthingup (22.9 x 10^3). The microbial biomass, acid phosphatase, dehydrogenase, alkaline phosphotase enzyme activity of soil microbes at the time of harvest was highest in Mulch (*Lantana*) 5 t/ha application (19.6 µg p-nitro phenol/g of soil/h) and the lowest in recommended herbicide maize/soybean + hoeing + earthingup.

Table 1.2.12.1 Effect of treatments on counts (no./0.32 m^2) of weeds and yield attributes and yield of maize

Treatment	Grasses	Sedges	Broad-leaved	Total	Plant height (cm)	Cobs/ plant (no.)	Cob weight (g/cob)	Cob yield (t/ha)
T1	3.6(37.7)	2.4(5.3)	4.2(17.0)	6.1(37.7)	173.3	0.8	187.5	4.5
T2	4.0(45.0)	3.9(15.3)	3.6(12.7)	6.7(45.0)	170.3	0.7	204.2	4.2
T3	3.6(36.3)	2.5(7.3)	3.6(13.0)	6.0(36.3)	190.0	0.7	162.5	3.4
T4	4.8(31.0)	1.4(2.0)	2.0(5.0)	5.6(31.0)	169.7	0.8	179.2	4.2
T5	5.6(53.7)	2.0(3.7)	4.2(18.3)	7.3(53.7)	192.7	0.8	170.8	4.1
T6	5.3(41.7)	1.3(1.3)	3.4(11.7)	6.4(41.7)	192.7	1.0	233.3	6.8
T7	2.5(10.0)	0.7(0.0)	1.8(3.3)	3.1(10.0)	176.7	1.0	291.7	8.5
T8	3.4(31.7)	2.3(5.3)	3.3(11.0)	5.6(31.7)	174.3	0.8	250.0	6.0
T9	4.8(37.0)	2.0(3.7)	3.0(10.7)	6.1(37.0)	187.3	0.8	237.5	5.4
T10	3.7(32.7)	2.2(4.7)	3.8(14.0)	5.8(32.7)	173.7	0.8	162.5	3.9
SEm ±	0.6	0.4	0.6	0.5	5.6	0.12	25.9	0.7
LSD (P=0.05)	1.7	1.2	NS	1.5	16.7	NS	77.1	2.0

Data transformed to square root transformation; Figures in parentheses are the means of original values.

AAU, Anand

The major monocot weeds observed in the experimental fields were *Eleusine indica, Dactyloctenium aegyptium, Digitaria sanguinalis, Commelina benghalensis* and *Cyperus iria.* The major dicot weeds were *Chenopodium album, Melilotus alba, Digera arvensis, Chenopodium murale, Boerhavia diffusa, Oldenlandia umbellata* and *Phylanthus niruri*. Lowest weed density of monocot and total weeds and weed dry biomass of monocot, dicot and total weeds were recorded in paddy straw mulch 5.0 t/ha treatment at 75 DAP. Significantly the lowest weed density of monocot and total weeds were recorded in combination of paddy straw mulch with application of oxyfluorfen 0.223 kg/ha PE. Weed dry biomass of monocot weeds were recorded significantly lower in the application of oxyfluorfen 0.223 kg/ha PE but remained at par with manual weeding at 20 and 40 DAP. Weed dry biomass of dicot and total weeds were recorded significantly lower with application of pendimethalin 1.00 kg/ha PE. Interaction effect of mulching and weed management practices was found significant and significantly higher bulb yield of garlic was obtained in pendimethalin with paddy straw mulch, but it was remained at par with the combination of mulching with PE application of oxyfluorfen. NPK uptake by weeds was recorded minimum in paddy straw mulch. While in weed management practices minimum uptake of NP and K was recorded in twice hand weeding at 20 and 40 DAP. The highest B:C ratio was obtained with mulching (3.9), pendimethalin (4.3), interaction of paddy straw mulch with pendimethalin (5.5) and application of oxyfluorfen with paddy straw mulch (5.5).

GBPUAT, Pantnagar

Dominant weed species in the experimental plot were *P. minor* (56.2%), *A. ludoviciana* (1.4%), *P. monspeliensis* (6.0%) among grassy weeds, *M. denticulata* (4.6%), *M. alba* (2.6%), *C. didymus* (10.8%), *P. plebeium* (7.7%), *C. album* (5.2%), *A. arvensis* (1.2%), *R. acetocella* (0.9%), *F. parviflora* (1.3%) among BLWs and *C. rotundus* (2.1%) as sedge at 75 DAS. Density of *P. minor* as well as *P. monspeliensis* was minimum with pendimethalin applied as pre emergence at 1.0 kg/ha while density of *A. ludoviciana* was found minimum with pre-emergence application of oxyflurofen at 0.223 kg/ha and both herbicides was comparable to each other towards the density of grasses. Mulching could not show the significant effect on grassy weeds, however, all herbicidal treatments were significantly superior over the weedy check. Among herbicidal treatments, application of oxyflurofen at 0.223 kg/ha recorded minimum dry biomass of all weed categories as well as total dry biomass of weeds except dry biomass of BLWs which was recorded with application of pendimethalin at 1 kg/ha (PE).

Highest and significantly higher yield (4.2 t/ha) and yield attributing characters like number of bulb (30.7/m^2), diameter of bulb (8.6 cm) and number of cloves/bulb (18.4) were achieved with the application of mulch material (5 t/ha). Interaction effect showed that hand weeding without mulch was significantly superior to both of the herbicides while within herbicidal application, use of oxyflurofen at 0.233 kg/ha recorded highest bulb yield which was comparable with pendimethalin applied at 1.0 kg/ha. However, with straw mulch maximum bulb yield was recorded with twice hand weeding (25 & 45 DAP) which was at par with both of the herbicidal application. Within main plot treatments straw mulch obtained maximum net return (` 2,80,250) and B:C ratio (4.6) and within sub plot treatments the same was achieved with twice hand weeding at 25 and 45 DAP followed by the application of oxyflurofen at 0.233 kg/ha (PE).

NDUAT, Faizabad

Application of mulch at 10 t/ha reduced weed density, dry weight, and maximum weed control effeciency (75.1%) was recorded with 10 t/ha mulch followed by 5 t/ha mulch treatment. Among all the weed control treatments application of oxyflurofen (0.223 kg/ha) recorded higher growth and yield of garlic than weedy check but was at par with pendimethalin 1.0 kg/ha. Maximum B:C ratio (2.1) was recorded under the paddy straw mulch 10.0 t/ha + pendimethalin 1.0 kg/ha PE followed by paddy straw mulch 10.0 t/ha + oxyfluorfen 0.223 kg/ha PE (` 2.1), respectively. No herbicidal phytotoxicity symptoms were recorded on garlic crop.

PAU, Ludhiana

Rumex dentatus, Coronopus didymus, Oenothera laciniata, Medicago denticulata among broadleaf weeds and *Phalaris minor* among grasses were major weeds. Uniform spreading of paddy straw mulch at 5 t/ha significantly reduced density of *M. denticulata* and *O. laciniata*, and total weed weed biomass compared to without mulch at 75 DAP. Straw mulch at 7.5 t/ha further reduced density of these two weeds and total weed biomass significantly compared to 5 t mulch/ha. The WCE at 5 and 7.5 t mulch/ha was 19 and 23%, respectively. Similar results were recorded for nutrient depletion by weeds at harvest. *R. dentatus* and *C. didymus* were not affected significantly by mulch application. Among weed control, pendimethalin 1.0 kg, oxyfluorfen 0.223 kg/ha and 2 hand hoeings significanlty reduced population of all weeds and weed biomass compared to weedy check, resulted in 53-97% WCE under these three treatments. The interaction effect of mulch and weed control treatments revealed that the application of herbicides and hand hoeings significantly reduced the weed biomass under all the mulch levels (Table 1.2.12.2).

Paddy straw mulch and herbicides did not influence emergence of garlic and growth of garlic plants. Among weed control treatments, pendimethalin, oxyfluorfen and two hand hoeings significantly improved the garlic yield, yield attributes and economic returns than weedy check. Garlic clove yield under herbicides and hand hoeing treatments were comparable, however, the economic return under herbicides treatments were higher compared to hand hoeing owing to higher cost of manual labor. The study concluded that integrated use of paddy straw much and herbicides could be adopted for sustainable weed management in garlic.

Table 1.2.12.2 Effect of straw mulch and weed control on growth and yields and economics of garlic (2015-16)

Treatment	Plant weight at harvest (g/plant)	Leaf weight (g/plant)	Corm weight (g/plant)	Cloves/ corm (No.)	Garlic yield (t/ha)	Economics			
						Variable cost (`/ha)	Gross returns (`/ha)	Net returns (`/ha)	B:C
Paddy straw mulch									
Without PSM	19.1	5.8	9.8	18.1	5.2	1,63,740	2,64,200	1,00,460	1.6
PSM 5 t/ha	20.8	8.2	12.0	20.4	7.0	1,70,240	3,53,250	1,83,010	2.0
PSM 7.5 t/ha	28.4	8.3	16.3	23.4	10.5	1,73,490	5,28,800	3,55,310	3.0
SEm±	1.0	0.3	0.8	1.5	0.3	-	-	-	-
LSD (P=0.05)	3.9	1.4	3.0	NS	1.1	-	-	-	-
Weed control									
Pendimethalin 1.0 kg /ha	25.9	9.5	14.4	22.9	10.2	1,68,859	5,12,100	3,43,241	3.0
Oxyflurofen 0.223 kg /ha	26.3	7.9	14.8	21.1	10.0	1,69,449	5,00,850	3,31,401	2.9
Two hoeings at 4 and 6 WAP	24.5	7.7	12.7	22.0	8.8	1,70,959	4,40,050	2,69,091	2.5
Weedy check	14.3	4.6	8.8	16.3	1.5	1,67,359	75,300	-92,059	0.4
SEm±	1.0	0.7	0.6	1.3	0.3	-	-	-	-
LSD (P=0.05)	2.9	2.1	1.7	3.9	0.8	-	-	-	-
Interaction	S	NS	S	NS	S	-	-	-	-

Market price for garlic: ` 50,000/t

WP 1.2.13 Weed management options in rice-wheat cropping system under organic mode of cultivation

GBPUAT, Pantnagar

Under organic mode, lowest dry biomass of *E. colona* was recorded with soil solarized transplanted rice supplemented with one hand weeding (40 DAT) which was comparable to conventional direct-seeded rice either seeding done on FIRB under stale bed along with one mechanical and one hand weeding or direct-seeding as conventional, transplanted as well as transplanted rice where summer ploughing followed by stale seed bed along with one mechanical and hand weeding was done at 20 and 40 DAT, respectively. All organic weed management in conventional practice under transplanted rice as well as direct-seeding in soil solarized bed *fb* one hand weeding had complete control over the dry biomass of *E. indica* and *D. aegyptium*. *A. baccifera* dry biomass was recorded least under direct-seeding either where *Sesbania* was intercropped (green manuring) or FIRB in stale bed *fb* one mechanical and one hand weeding or one hoeing and one hand weeding. *M. stricta* dry biomass was also recorded least under organic mode except direct -seeded FIRB supplemented with one hoeing and one hand weeding as well as solarized bed plots along with one hand weeding and conventional transplanted rice. No *C. rotundus* was recorded under direct-seeding with *Sesbania* incorporated plot as well as soil solarization *fb* one hand weeding.

Minimum total density as well as dry biomass of weeds were recorded in conventional transplanted rice. Maximum number of grains / panicle was recorded with direct-seeding either stale seed bed with FIRB along with one hoeing *fb* one hand weeding or direct-seeding on soil solarized beds *fb* one hand weeding. Grain yield was not significantly influenced by the treatments. Numerically highest grain and straw yield of rice was achieved under transplanted where stale seed bed technique was followed along with one mechanical weeding *fb* one hand weeding. Stale seed bed technique under direct-seeded rice with *Sesbania* incorporated with one mechanical and one hand weeding and summer ploughing+ stale seed bed under transplanting attained equal yield next to conventional practice of transplanted rice.

WP 1.2.15 Weed management in organically grown direct seeded aromatic rice- sweet corn cropping system

IGKV, Raipur

Treatment details [(Nutrient management (Main plot)]

Kharif (Rice)	*Rabi* (Sweet corn)
50% N (FYM) + 50% N (vermicompost) + *Azospirilium* + PSB	50% N (FYM) + 50% N (vermicompost)
50% N (FYM) + 50% N (poultry manure) + *Azospirilium* + PSB	50% N (FYM) + 50% N (vermicompost)
50% N (FYM) + 25% N (vermicompost) + 25% N (poultry manure) + *Azospirilium* + PSB	50% N (FYM) + 50% N (vermicompost)

In *Kharif* diluted cow urine 500 litre / ha was applied as foliar spray twice

Weed management (sub-plot), *Kharif*

1. Hand weeding twice (at 20 & 40 DAS)
2. Motorized weeder (at 20 & 40 DAS)
3. Recommended herbicides (oxadiargyl 80 g / ha PE *fb* bispyribac -Na 25 g / ha PoE)

Weed management (sub-plot), *Rabi*

1. Straw mulch (5 t / ha)
2. Plastic mulch
3. Recommended herbicides (atrazine 1.5 kg / ha PE)
4. Control (weedy check)

Weed flora of the experimental site was dominated with *Echinochloa colona* in grasses, *Alternanthera triandra* in broadleaf and *Cyperus iria* in sedges. Other weeds present on the field were *Ischamum rugosum*, *Cynotis axillaris* and *Fimbristylis miliacea* etc. No significant difference in weed dry weight was recorded at all the observational stages due to various organic nutrient management sources. Significantly higher dry weight of weeds was recorded under untreated control over rest of the weed management options. No significantly difference in grain yield of scented rice (Dubraj) was found under different nutrient management practices. However, in weed management practices maximum grain yield was found under application of oxadiargyl (80 g / ha) *fb* bispyribac-Na (25 g / ha) which was significantly superior to rest of the treatments. Incase of other than chemical method of weed management, hand weeding twice and motorized weeder twice were equally effective and recorded comparable yield. Highest net return and B:C ratio was found under 50% N (FYM) + 50% (PM) + *Azospirillum* + PSB. Where as under weed management practices, motorized weeder twice gave maximum net return and B: C ratio.

Organic carbon content was increased in soil due to incorporation of different organic manures and biofertilizers but non significant variation in organic carbon content was observed in soil due to different organic treatments put in main plots. The organic manures and biofertilizers improved the microbiological and biochemical properties of soil as evidenced by higher dehydrogenises activity (DHA), microbial biomass carbon content (MBC) and basal soil respiration rate (BSR) of soil but different organic treatments found at par. Maximum DHA, MBC and BSR was found in soil due to nutrient management of 50% N by FYM + 50% N by poultry manure and application of PSB and *Azospirillum*, followed by 50% N by FYM + 25% N by vermicompost + 25% N by poultry manure and application of PSB and *Azospirillum*.

BAU, Ranchi

WM 1.2.16 Weed management in organic vegetable production in okra-onion cropping system

Treatment	Okra	Onion
T1	Plastic mulch	Plastic mulch
T2	Available weeds mulch	Available weeds mulch
T3	Straw mulch	Straw mulch
T4	Cover crops (cowpea)	Cover crops (Berseem / coriander)
T5	Mechanical weeding (Dutch hoe)	Mechanical weeding (Dutch hoe)
T6	Hand weeding (20, 40 and 60 DAS)	Hand weeding (20, 40 and 60 DAP)
T7	Oxyfluorfen 0.25 kg / ha PE	Oxyfluorfen 0.25 kg / ha PE
T8	Pendimethalin 1.0 kg / ha PE	Pendimethalin 1.0 kg / ha PE
T9	Weedy	Weedy

Weed mulches of locally available sources was applied in crops during *Kharif* and *Rabi* at 10 t / ha.

The experimental field was infested with narrow leaved weeds like *Echinochloa colona*, *Echinochloa crusgalli*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, *Cynodon dactylon*, *Eleusine indica*, *Commelina benghalensis*, *Commelina nudiflora*, among broad leaved weeds, *Stellaria media*, *Ageratum conyzoides*, *Celosia argentea*, *Phyllanthus niruri* and among sedges *Cyperus rotundus*.

Plastic mulch recorded significantly reduced narrow, broadleaved and sedges weed as well as weed dry matter throughout growing period. However, at 30 DAS, it was similar to cover crop and pendimethalin 1 kg / ha PE in case of broad leaf. While in case of sedges it was similar to straw mulch and cover crop. Application of plastic mulch in okra recorded significantly higher fresh okra yield (20.7 t / ha) and net return (` 2,50,543 / ha) and B:C ratio as compared to straw mulch, cover crops (cowpea), oxyfluorfen 0.25 kg / ha PE, pendimethalin 1.0 kg / ha PE, mechanical weeding (Dutch hoe), hand weeding (20, 40 and 60 DAS) and weedy check. However, B:C ratio was also similar to straw mulch. Different weed control methods did not influence microbial population change in pH, EC, OC g / kg soil, CO_2 µg / g soil / h, dehydrogenase (µgTPF / h / g soil) and *azatobacter* cfu (X 10^3) population. However, SMBC was found to increase significantly compared to rest of the treatments. Application of plastic mulch similar to mulching by available weeds in okra recorded significantly higher fresh okra yield (20.7 t / ha) and net return (` 2,50,543 / ha) and B: C ratio (1.53).

KAU, Thrissur

WP 1.2.17(i) Organic farming methods to manage weeds in pineapple

Treatments

1. Coir pith mulching
2. Paper mulching
3. Cowpea intercropping

4. Coconut frond mulching
5. Plastic mulching
6. Diuron 3 kg / ha
7. Hand weeding
8. Unweeded control

Weed flora in the experimental plot consisted mainly of broad leaf weeds. The grasses observed were *Panicum repens, Brachiaria miliformis, Digitaria* sp., and *Pennisetum pedicellatum* in very low numbers. The main broad leaf weed was *Borreria latifolia*. Others weeds were *Ageratum conyzoides, Ludwigia parviflora, Cleome burmanii, Lindernia crustacea, Phyllanthus amarus, Cyanotis axillaris, Mitracarpus verticillatus, Emilia sonchifolia, Scoparia dulcis* and *Synedrella nodiflora*. At 30 days after application, paper mulching and plastic mulching recorded least values for weed count and were on par with application of Diuron (Table 1.2.4). The next best treatments were mulching with coir pith and coconut fronds. Intercropping with cowpea recorded higher weed count, probably due to low foliage development.

Table 1.2.4 Effects of treatments on total weed density

Treatments		Total weed density (no./m^2)		
		30 DAT	60 DAT	90 DAT
T_1	Coir pith mulching	5.6^{e**}(32)*	10.8^c(117.3)	6.5^b(42.7)*
T_2	Paper mulching	0.2^f(0)	3.4^d(12.0)	3.4^c(12.0)
T_3	Cowpea intercropping	15.9^c(256)	19.2^a(381.3)	7.0^{ab}(53.3)
T_4	Coconut leaf mulching	6.8^d(46.7)	9.9^c(96)	7.6^{ab}(58.7)
T_5	Plastic mulching	0.2^f(0)	0.2^e(0)	0.2^d(0)
T_6	Diuron 3 kg / ha	0.2^f(0)	0.2^e(0)	0.2^d(0)
T_7	Hand weeding	19.8^b(384.0)	12.1^b(153.3)	7.4^{ab}(57.3)
T_8	Unweeded control	21.2^a(453.3)	20.21^a(409.3)	8.1^a(68.0)
LSD (P=0.05)		0.8	1.0	1.3

*Original values are given in parentheses

**Values followed by same alphabet do not differ significantly in DMRT

Plastic mulching and diuron application did not allow to weed growth at 60 and 90 days after treatment application. Some weed growth was noticed in plot that was mulched with paper. Coir pith mulching, coconut frond mulching and cowpea intercropping were also ineffective in controlling weed growth and progressively higher values of weed dry matter production were recorded at 60 and 90 DAT. Hand weeding at monthly intervals could bring down weed dry matter production to a great extent, while unweeded control recorded highest values of weed dry matter, i.e., 494 and 1123 g / m^2 at 60 and 90 DAT, respectively.

WP 1.2.17 (ii) Effect of different mulches on weed management and productivity in brinjal

Treatments

1. Pendimethalin 1.0 kg / ha
2. Dried leaves mulch
3. Polythene mulch
4. Coir pith mulch
5. Unweeded control
6. Hand weeding
7. Spade weeding

Mulching with dried leaves resulted in significantly taller plants when compared to hand and spade weeding, but were on par with application of pendimethalin, polythene and coir pith mulching. Harvesting of brinjal fruits began 60 days after planting and continued up to 100th day. Mulching with polythene recorded higher fruit number followed by hand weeding. Yield in polythene mulching was the best treatment (13.4 t / ha) followed by spade weeding and hand weeding and all the three treatments were on par. Unweeded control recorded the lowest yield (3.9 t/ha). The highest B:C ratio was recorded by chemical weed control, followed by polythene mulching. In unweeded control and coir pith mulch treatment, the ratios were less than one.

MPUAT, Udaipur

WP 1.2.18 Organic weed management in fennel /sweet corn

Treatments details

1. Summer ploughing + 1 hand weeding at 20 DAS
2. Summer ploughing + straw mulch (10 t/ha) at 20 DAS + 1 hand weeding at 40 DAS
3. Summer ploughing + plastic mulch at sowing
4. Stale seed bed preparation + 1 hand weeding at 20 DAS
5. Stale seed bed preparation straw mulch (10 t/ha) at 20 DAS+1 hand weeding at 40 DAS
6. Stale seed bed preparation + plastic mulch at sowing
7. Soil solarization + 1 hand weeding
8. Soil solarization + straw mulch (10 t/ha) at 20 DAS + 1 hand weeding at 40 DAS
9. Soil solarization + plastic mulch at sowing
10. *Sesbania* as smothering crop in between rows and used same *Sesbania* as mulch after 30 days with tillage + 1 HW at 40 DAS
11. Pendimethalin 1.0 kg /atrazine 500 g *fb* straw mulching (10 t/ha) at 20 DAS
12. Weedy check

The major broadleaf weeds in the experimental fields were *Digera arvensis, Trianthema partulacasfrum* and *Commelina benghalensis.* The grassy weeds were *Echinochloa colona* and *Dinebra retroflexa.* Weed density recorded at harvest was significantly influenced by organic weed management practices. Weed density of monocot and dicot weeds were recorded significantly lower in plastic mulch either with summer ploughing, sowing after stale seed bed preparation or soil solarization. *Sesbania* as smothering crop with hand weeding or pre-emergence application of herbicide with straw mulch (10 t/ha). Treatment of soil solarization with plastic mulch proved most effective and recorded 69.7 and 70.1% reduction in total weed dry matter at 60 DAS and at harvest, respectively in comparison to weedy check at 60 DAS (15.7 g/m^2) and at harvest (19.3 g/m^2). Maximum cob weight (28.8 g) was recorded with treatment in which maize crop field prepared with summer ploughing followed by plastic mulching, however it was found at par with other treatments of plastic mulch. Maximum seed yield (3.1 t/ha) and stover yield (6.1 t/ha) of sweet corn were recorded with crop sown with treatment of stale seed bed with plastic mulch, which was at par with plastic mulch with soil solarization and summer ploughing. All the organic weed management treatments proved statistically superior over weedy check. The highest net return (` 46,674/ha) and B: C of (1.5) was obtained with summer ploughing with plastic mulch.

WP 1.3 Herbicidal control of weeds in crops and cropping systems

WP 1.3.1 Weed management in rice and rice-based cropping systems

UAS, Bengaluru

WP 1.3.1.1 (i) Herbicides combinations for control of complex weed flora in transplanted rice

Major weed flora observed in the experimental plots were; *Cyperus difformis, Cyperus iria* (among sedges), *Panicum triferon, Paspalum distichum* and *Echinochloa colona* (among grasses), *Alternanthera sessilis, Monochoria vaginallis, Marselia quadrifolia, Ludwigia parviflora* (among broad leaf weeds), were higher than other weed species indicated their dominance from the beginning of the crop cycle. At 60 DAP all the herbicide treatments reduced the weed density and dry weight as compared to weedy check. However, application of bensulfuron-methyl + pretilachlor (60 + 600 g/ha) as PE *fb* triafamone+ ethoxysulfuron (60 g/ha) at 30 DAT and oxadiargyl (100 g/ha) as PE *fb* triafamone + ethoxysulfuron (60/ha) at 30 DAT have significantly reduced the weed density and dry weight followed by application of bensulfuron-methyl + pretilachlor (60 + 600 g/ha) as PE *fb* bispyribac-Na (25 g/ha) at 30 DAT and oxadiargyl (100 g/ha) as PE *fb* bispyribac-Na (25 g/ha) at 30 DAT, indicated necessity of combination of herbicides to manage complex weed flora in transplanted rice (Table 1.3.1).

Table 1.3.1 Effect of herbicide mixtures on weeds' density and dry weight in transplanted rice during *Kharif* 2016

Treatments	Weeds' dry weight (g/m²)			
	Sedges+	Grasses +	Broad leaf#	Total #
Bensulfuron methyl + pretilachlor *fb* passing of cono weeder	2.9(7.5)	2.0(3.4)	1.0(8.23)	1.3(19.1)
Oxadiargyl *fb* passing of cono weeder	2.9(8.6)	2.2(4.2)	1.1(10.5)	1.3(23.3)
Bispyribac-Na *fb* passing of cono weeder	3.7(13.2)	2.5(5.8)	1.2(12.9)	1.5(32.0)
Triafamone+ ethoxysulfuron *fb* passing of cono weeder	3.3(10.3)	2.4(5.2)	1.09(11.5)	1.4(27.4)
Bensulfuron-methyl + pretilachlor *fb* bispyribac-Na	2.1(3.5)	1.6(1.6)	0.9(5.8)	1.1(11.2)
Oxadiargyl *fb* bispyribac-Na	2.1(4.2)	1.6(1.7)	0.8(5.6)	1.1(12.4)
Bensulfuron-methyl + pretilachlor *fb* triafamone+ ethoxysulfuron	2.0(3.9)	1.8(2.4)	0.8(4.8)	1.0(10.3)
Oxadiargyl *fb* triafamone + ethoxysulfuron	2.0(3.0)	1.8(2.6)	0.8(5.1)	1.1(10.8)
Hand weeding at 25 and 45 DAS	1.6(1.9)	1.6(1.6)	0.7(2.7)	0.91(6.2)
Weedy check	5.1(25.1)	4.1(16.6)	1.5(30.7)	1.8(72.5)
SEm ±	0.3	0.3	0.07	0.05
LSD (P = 0.05)	0.9	0.9	0.2	0.1

Data within the parentheses are original values; Transformed values: # = log (x+2), + = square root of (x+1)

CCSHAU, Hisar

Combination of different herbicides for control of complex weed flora in transplanted rice was evaluated. Weed flora of the field was dominated by *Echinochloa crus-galli* along with broadleaf weed *Ammannia baccifera* and sedges like *Cyperus difformis.* All the herbicidal treatments except pyrazosulfuron *fb* chlorimuron+metsulfuron provided effective control of *Echinochloa crus-galli* in transplanted rice. Addition of ethoxysulfuron and chlorimuron+ metsulfuron as tank-mix with bispyribac-Na and in sequence with pretilachlor improved the control of broad-leaved weeds and sedges. Similarly ready-mix treatments of pretilachlor + pyrazosulfuron (615 g/ha) and triafamone + ethoxysulfuron (60 g/ha) also provided effective control of grassy as well as broadleaf weeds and sedges. There was no phytotoxicity of different herbicidal treatments on the crop.

Plant height and panicle length were not influenced by different treatments. All the herbicidal treatments except pyrazosulfuron *fb* chlorimuron+ metsulfuron produced effective tillers and grain yields similar to weed free check. Similarly, all herbicidal treatments except pyrazosulfuron *fb* chlorimuron + metsulfuron resulted in higher B:C ratio than other treatments. Pyrazosulfuron *fb* chlorimuron + metsulfuron treatment was inferior among all herbicidal treatments regarding B:C ratio.

PJNCARI, Karikal

The dominant weed flora observed in the study was *Echinochloa crus-galli*, *Leptochloa chinensis*, *Eclipta prostrata*, *Marselia quadrifolia*, *Cyperus difformis* and *Cyperus iria*. Application of triafamone+ ethoxysulfuron significantly reduced weed density (16.0 no./m^2) and dry weight (8.1 g/m^2) and resulted in higher rice grain yield (5.05 t/ha). Excellent control of the grasses, sedges and broadleaved weeds was noticed in this treatment during 2015-16. It was followed by pre-emergence application of either pretilachlor or pyrazosulfuron *fb* (chlorimuron + metsulfuron) in terms of weed control and rice grain yield. Post-emergence application of bispyribac-sodium was found ineffective in controlling broadleaved weeds, and hence resulted in higher weed density. Unweeded control accounted for 39.2% yield loss in coastal ecosystem of Karaikal. Application of triafamone+ ethoxysulfuron was better in terms of B: C ratio (2.5), followed by pre-emergence application of pretilachlor *fb* chlorimuron+metsulfuron (2.4) and pyrazosulfuron *fb* chlorimuron+metsulfuron (2.4), respectively.

WM 1.3.1.1 (ii) Herbicides combinations for control of complex weed flora in dry direct- seeded rice

UAS, Bengaluru

Major weed flora observed in the experimental plots was *Cyperus rotundus* (sedge), *Cynodon dactylon, Chloris barbata, Digitaria marginata, Echinolchloa colona* (among grasses). Whereas, among broadleaf weeds, major weeds were *Commelina benghalensis, Acanthospermum hispida, Lagascea mollis Euphorbia geniculata, Borreria hispida, Tridax procumbens* and *Ageratum conyzoides.* Among the weed species, densities of *C. rotundus, D. marginata, A. conyzoides* and *C. benghalensis, C. dactylon* and *L. mollis* were more than other weed species. Effective control of weeds was noticed at 60 DAS with application of bensulfuron-methyl + pretilachlor (60 + 600 g/ha) as PE *fb* bispyribac-sodium (25 g/ha) at 25 DAS followed by bensulfuron-methyl + pretilachlor (60 + 600 g/ha) as PE *fb* triafamone + ethoxysulfurn (60 g/ha at 25 DAS) as evident from the reduced weed density and dry weight. All these herbicide mixtures were superior to unwedded control in reducing the weeds' density and dry weight. None of the herbicides caused phytotoxicity to rice in terms of yellowing, curling, epinasty, hyponasty and wilting symptoms.

PJNCARI, Karikal

Dominant weed flora in the field was *Echinochloa colona, Echinochloa crus-galli, Leptochloa chinensis, Bergia capensis, Ludwigia purpurea, Eclipta prostrata, Marselia quadrifoliata, Sphaeranthus indicus, Cyperus difformis, Cyperus iria* and *Fimbristylis miliacea.* Effective control of weed density and dry wright was observed with PE application of pendimethalin 1.0 kg/ha *fb* bispyribac (POE) 25 g/ha either alone or with a manual weeding on 40 DAS (1.7 no./m^2 and 0.2 g/m^2 respectively). It was followed by manual weeding thrice at 20, 40 & 60 DAS or application of pyrazosulfuron *fb* bispyribac application. Post-emergence application of bispyribac-sodium alone (25 g/ha) was found ineffective in controlling *Leptochloa chinensis*, and resulted in poor weed control efficieny (50.1%). Application of pendimethalin (1.0 kg/ha) *fb* bispyribac (POE) (25 g/ha) integrated with a manual weeding at 40 DAS was better in terms of B: C ratio (1.47) followed by pre-emergence application of pendimethalin (1.0 kg/ha) integrated with a manual weeding (1.39).

WP 1.3.1.2 Long-term herbicide trial in transplanted lowland rice-rice cropping system

TNAU, Coimbatore

During *Rabi*, 2015, relative density of grasses and broad leaved weeds were dominant in all the treatments at 60 DAT. Among the grasses, *Echinochloa crus-galli* and *Ludwigia parviflora* were dominant species in broad leaved weeds. Significantly lower total weed density (9.3) was recorded with PE pyrazosulfuron-ethyl *fb* hand weeding. In *Rabi*, 2015, hand weeding recorded significantly higher total weed dry weight than chemical treatments. PE pyrazosulfuron ethyl *fb* hand weeding recorded lesser total weed dry weight at 60 DAT which was comparable with PE bensulfuron methyl + pretilachlor *fb* hand weeding.

Higher grain yield of 5.7 t/ha was recorded with PE bensulfuron-methyl + pretilachlor *fb* hand weeding. Significantly lower grain yield was recorded with unweeded check. Higher net return of ` 19,648 and benefit cost ratio (3.0) was recorded with PE bensulfuron-methyl + pretilachlor *fb* hand weeding. At 60 DAT, significantly lower total weed density (6.1), higher grain yield of 6.7 t/ha, higher net return (` 2,80,89) and benefit cost ratio (2.9) were recorded with PE pyrazosulfuron-ethyl *fb* hand weeding.

In general, all applied herbicides affected the soil microflora except actinobacteria and soil enzymes upto 5 days during *Rabi*, 2015-16 and *Kharif* 2016. The maximum number of population was recorded with PE pyrazosulfuron-ethyl *fb* POE bispyribac-sodium. The soil enzymes viz., alkaline phosphatase (265.5 µg p-nitrophenol/g/soil/h), dehydrogenase (133.5 µg TPF/g/soil/24h) and urease (42.1 µg NH_3 released/g/soil/h) were increased in the PE pyrazosulfuron-ethyl *fb* hand weeding in *Kharif* 2016.

WP 1.3.1.3 Weed management studies in aerobic rice-wheat cropping system

NDUAT, Faizabad

The major weed species recorded in weedy plot were *Echinochloa colona, Echinochloa crus-galli, Panicum maximum* among grassy while *Caesulia axillaris* and *Eclipta alba* in BLWs and *Fimbristylis miliacea* and *Cyperus difformis* in sedges. Pyrzosulfuron was found significantly superior with pendimethalin followed by bispyribac–Na. However, WCE was obtained same as total weed density. Yield attributes, plant height (95.1 cm), panicle (328/m^2), grains per panicle (140) and grain yield (4030 kg/ha) were significantly higher over weedy check.

A combination of two herbicides or along with hand weeding (HW) recorded significantly lower values of weed dry weight and higher values of WCE. A combination of pendimethlin *fb* bispyribac-Na being at par with pendimethalin *fb* bispyribac-Na *fb* MW recorded significantly less weed dry weight (25.8 g/m^2) and highest value of WCE (75.7%) followed by pendimethalin. Pendimethalin followed by bispyribac-Na followed by hand weeding (45 DAS) recorded highest gross return (` 58,928/ha, however, net return (` 34,747/ha) were recorded highest under pendimethalin followed by bispyribac-Na.

AAU, Jorhat

WP 1.3.1.5 (i) Integrated weed management in upland direct-seeded rice

Ageratum houstonianum, Borreria articularis, Melochia corchorifolia, Mimosa pudica, Mollugo pentaphylla and *Polygonum glabrum* were the common broadleaved weeds. Among the sedges, *Cyperus flavidus, C. iria, C. rotundus, Fimbristylis bisumbellata, F. littoralis* and *Scleria terrestris* and among the grasses *Cynodon dactylon, Digitaria setigera, Eleusine indica* and *Panicum repens* were the dominant flora.

Weed management treatments brought about significant variation in respect of weed density and dry weight at all stages. Application of pretilachlor (0.75 kg/ha) followed by one hand weeding significantly reduced density and dry weight of weeds as compared to mechanical weeding and weedy check. A significant increase in the number of filled grains with corresponding decrease in the number of false grain due to consortium culture followed by *Trichoderma* and ABT microbial culture was found. The trend was reflected on the grain and straw yield of rice and the highest values were given by this treatment. It was significantly better than rest of the treatments. Data on weed density showed a significant variation among the microbial cultures only at harvest. The lowest value was recorded with consortium followed by *Trichoderma*. Weed dry weight was significantly affected by treatments with microbial cultures at 60 DAS and harvest. The lowest values were recorded with consortium followed by *Trichoderma* and ABT microbial culture (Table 1.3.1.5.1).

Table 1.3.1.5.1 Yield attributes, grain and straw yield of rice as affected by treatments

Treatment	No of filled grain/panicle	No. of false grain/panicle	Grain yield (t/ha)
Microbial seed treatment			
Trichoderma	68.8	26.6	1.3
ABT microbial culture	68.5	27.6	1.3
Consortium	72.3	24.2	1.3
Hydration	64.8	27.4	1.2
LSD (P=0.05)	2.1	NS	0.03
Weed management practice			
Pretilachlor 0.75 kg/ha *fb* one hand weeding	95.2	13.5	1.7
Mechanical weeding twice 15 and 45 DAS	88.5	14.4	1.7
Weedy	22.1	51.5	0.5
LSD (P=0.05)	1.8	2.31	0.03

WP 1.3.1.5 (ii) Long-term herbicidal trial in rice-rice cropping sequence

Weed flora was composed of mostly broadleaved species, sedges and grasses mostly. Almost all the species prevailed in the field up to almost 100 days after transplanting. At harvest state, only perennial species were recorded. Pyrazosulfuron (25 g/ha) + 2,4-D (0.5 kg/ha) (100% nutrient through fertilizers) and pyrazosulfuron (25 g/ha) + 2,4-D (0.5 kg/ha) rotated with pretilachlor 0.750 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source) maintained the lowest weed density throughout the crop season. Similarly, these two treatments also resulted in lowest weed dry weight at all stages. Yield attributes, *viz.* effective tillers, panicle number, panicle length and filled grains per panicle were highest in pyrazosulfuron (25 g/ha) + 2,4-D (0.5 kg/ha) rotated with pretilachlor 0.750 kg/ha (75% nutrient through fertilizers + 25% nutrient through organic source). This trend was also reflected on the grain yield of the crop. Available nutrients (N – 285.4 kg/ha, P_2O_5 - 22.4 kg/ha, K_2O - 96 kg/ha) in soil was found in the treatment receiving rotation of pre-emergence herbicide and addition of organic manure along with chemical fertilizer. Water holding capacity and porosity were higher in plots receiving conjoint application of organic and inorganic manure. There was no significant increase in mean weight diameter.

Application of herbicide resulted in inhibition of azotobacter and phosphate solubilising bacterial population up to 14th day. Addition of organic manure along with chemical fertiliser resulted in lesser inhibition. Application of herbicide resulted in inhibition of acid phosphatase activity and highest inhibition was found at 14 day after application of the herbicide. Similar trend was observed in case of respiration and microbial biomass carbon. The urease activity did not show any characteristic trend like the other enzymes. However treatments receiving organic manure along with chemical fertilisers resulted in higher urease activity than those where only chemical fertilisers are applied. Substitution of N-fertilizer from organic sources gave more dehydrogenase activity than application of inorganics alone.

WP 1.3.3.1 Weed management in maize based cropping system

CSKHPKV, Palampur

The weed flora of the experimental field was composed of *Avena ludoviciana, Phalaris minor, Lolium temulentum, Anagallis arvensis* and *Coronopus didymus.* Combinations of herbicides had better efficacy in controlling *Phalaris minor* than sole application of herbicides and were comparable to hand weeding twice. Weed control treatments brought about significant variation in yield attributes and yield of wheat. Post-emergence application of clodinafop (60 g/ha) + metsulfuron (4 g/ha) remaining at par with post-emergence application of penoxaden + metsulfuron (4g/ha) and pre-emergence pendimethalin (1.0 kg/ha) *fb* post-emergence metsulfuron (2 g/ha) gave significantly higher grain and straw yield of wheat. These three better treatments gave 107.7, 97.9 and 99% higher grain yield of wheat over weedy check and 28.6, 22.5 and 23.1% over farmers practice of hand weeding twice. Weeds in weedy check reduced wheat seed yield by 51.9%

RAU, Pusa

The dominant weed species observed in the experimental field were: *Avena fatua, Cynodon dactylon, Phalaris minor, Cyperus rotundus, Anagallis arvensis, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Eclipta alba, Fumaria parviflora, Lathyrus aphaca, Launia pinnatifida, Melilotus alba, Physalis minima, Rumex dentatus* and *Vicia hirsuta.* The lowest weed count (11/m^2), weed dry weight (5.72 g/m^2) and grain yield of wheat (4.76 t/ha) were recorded by two hand weedings which was significantly superior over rest of the treatments. Among different herbicides combinations, the lowest weed count (18.5/m^2), weed dry weight (8.94 g/m^2) and highest grain yield of wheat (4.54 t/ha) were recorded by sulfosulfuron + metsulfuron which was statistically at par with pendimethalin *fb* sulfosulfuron, pinoxaden+ metsulfuron. The highest net return (` 51,136/ha) and B:C ratio (3.24) were recorded by sulfosulfuron + metsulfuron. The highest B:C ratio (3.24) was recorded by sulfosulfuron + metsulfuron which was statistically at par with mesosulfuron + iodosulfuron (3.06) and clodinafop + metsulfuron (3.15).

AAU, Anand

Major monocot weeds observed in the experimental field were *Phalaris minor, Avena fatua, Asphodelus tenuifolius, Setaria tomentosa, Dactyloctenium aegyptium* and *Cyperus iria.* The dicot weeds were *Chenopodium murale, Chenopodium album, Melilotus alba, Amaranthus viridis, Oldenlandia umbellata* and *Digera arvensis.* Dicot weeds (87.1%) were predominant compared to monocot weeds (12.9) in pooled. Post-emergence application of sulfosulfuron (25 g/ha PoE) and mesosulfuron + iodosulfuron (0.014kg/ha) showed slightly phytotoxicity on crop (vein clearing and wilting of wheat) at 7 days after application during both the years of experimentation, while other herbicides were found safer for wheat crop at tested dose.

Total weeds were recorded the lowest in both the years in hand weeding carried out at 30 & 60 DAS and pendimethalin (0.75 kg/ha PE) *fb* sulfosulfuron (0.018 kg/ha PoE) in 2016. Weed density and weed dry biomass of dicot weeds were recorded the lowest in pendimethalin (1.0 kg/ha PE) *fb* sulfosulfuron (0.018 kg/ha PoE) and pendimethalin (1.0 kg/ha) + metribuzin (0.175 kg/ha PE), but remained at par with all the treatments except clodinafop (0.06 kg/ha PoE) and weedy check. Grain (4.4 t/ha) and straw (7.1 t/ha) yield of wheat were significantly higher under premixed broad spectrum post-emergence application of clodinafop + metsulfuron-methyl which was at par with hand weedings carried out at 30

& 60 DAS. Maximum net return (` 46,459/ha) was recorded under clodinafop + metsulfuron-methyl followed by sulfosulfuron + metsulfuron-methyl, pinoxaden + metsulfuron (Tank mix). Nutritient depletion by the weeds in unweeded control treatment to the tune of 50.7 kg N, 6.3 kg P and 75.6 kg K was recorded at harvest.

BAU, Ranchi

Two hand weedings performed in wheat crop at 30 and 60 DAS significantly reduced weed density of broadleaved, grassy, sedges and total weeds during 2015-16. Among different herbicides, pendimethalin + metribuzin (1.0 kg/ha+0.175 kg/ha) pre-emergence reduced density of grassy, broad leaf and sedges weeds at 30 and 60 DAS during 2015-16. Metribuzin (0.021 kg/ha) pre-emergence reduced density of all categories of weeds.).

Two hand weedings performed in wheat at 30 and 60 DAS similar to pendimethalin (0.75 kg/ha) pre-emergence, pendimethalin + metribuzin (1.0+ 0.175 kg/ha) pre-emergence, pendimethalin (1.0 kg/ha) PE *fb* sulfosulfuron (0.018 kg/ha) post-emergence, and mesosulfuron + iodosulfuron (0.012 + 14.4 g/ha) at 5 WAS during 2015-16 recorded significantly higher grain (3.5 and 3.9 t/ha) and straw (5.0 and 5.6 t/ha) yield. This resulted in higher net return (` 46,890 and ` 39,632/ha) and B:C ratio. On the basis of two years experiment it can be concluded that pendimethalin (1.0 kg/ha pre-emergence) *fb* sulfosulfuron (0.018 kg/ha post-emergence) resulted significantly higher net return (` 32,019/ha) and B:C ratio (1.3).

MPUAT, Udaipur

The experimental area was infested with *Phalaris minor* among the grassy weed, whereas, *Chenopodium album, Chenopodium murale, Medicago denticulata* and *Coronopus didymus* among broadleaved weeds. At 60 DAS minimum density of broadleaf weeds were noticed under sulfosulfuron + metsulfuron (5.3/m^2) followed by mesosulfuron + iodosulfuron (7.0/m^2), clodinafop + metsulfuron (8.6/m^2), pendimethalin *fb* sulfosulfuron (11.6/m^2), pinoxaden + metsulfuron (13.0/m^2) and pendimethalin + metribuzin (17.0/m^2) in the order of significance. The least number of grassy weeds were observed under sulfosulfuron + metsulfuron (4.6/m^2). Both the hand weeding treatments were significantly inferior to herbicidal treatments.

Though the hand weeding treatment accounted for significant reduction in weed density, their effects were significantly inferior to all the herbicidal treatments. Alike broadleaf and grassy weeds, minimum density was registered by sulfosulfuron + metsulfuron (7.3/m^2), mesosulfuron + iodosulfuron (10.7/m^2), clodinafop + metsulfuron (15.0/m^2), pinoxaden + metsulfuron (19.0/m^2) and pendimethalin *fb* sulfosulfuron (21.0/m^2). At 45 DAS, the greatest weed control efficiency (79.3%) was acquired by sulfosulfuron + metsulfuron mixture followed by pendimethalin *fb* sulfosulfuron (77.9%), pendimethalin + metribuzin (77.1%), mesosulfuron + iodosulfuron (76.7%) over weedy check. The minimum nutrient uptake was recorded by weed through sulfosulfuron + metsulfuron with an account of 0.20 kg N/ha, 0.16 kg P_2O_5/ha and 0.42 kg K_2O/ha followed by mesosulfuron + iodosulfuron and clodinofop + metsulfuron, respectively. Highest yield (6.0 t/ha) was obtained by controlling weeds through sulfosulfuron + metsulfuron followed by mesosulfuron + iodosulfuron (5.8 t/ha). The maximum net return (` 85,556) and B C ratio (2.02) were obtained by applying sulfosulfuron + metsulfuron, which was 116.9% higher over weedy check.

At 40 DAS, metribuzin applied at PE gave setback to wheat crop by causing moderate but more persistent injury to wheat plants putting the plants under doubtful recovery zone. Pendimethalin and sulfosulfuron alone, however, resulted in injury more pronounced but not persistent injury at 40 DAS. At this stage clodinafop, pendimethalin *fb* sulfosulfuron and pendimethalin + metribuzin caused slight injury and discolouration of wheat plants. With the progression of time, the phytotoxicity caused by these herbicides was reversed.

NDUAT, Faizabad

Experimental field was infested with natural population of grassy, broadleaved and sedges. The dominant weeds were *viz.*, *Phalaris minor, Chenopodium album, Melilotus alba, Anagallis arvensis, Vicia sativa, Fumaria parviflora* and *Rumex dentatus.* Application of pendimethalin 1.0 kg + metribuzin 0.175 kg/ha at PE followed by pendimethalin *fb* sulfosulfuron (1.0 and 0.018 kg/ha, PRE & POE respectively), sulfosulfuron + metsulfuron (32 g/ha, 5 WAS), pinoxaden + metsulfuron (Premix) (64 g/ha, 5 WAS), mesosulfuron + iodosulfuron (14.4 g/ha, 5 WAS) and clodinafop + metsulfuron (Premix) (64 g/ha, 5 WAS) controlled all types of weed very effectively as compared to single herbicide molecule application. Among the different weed control measures, maximum WCE was recorded (95.3%) under hand weeding treatment followed by pendimethalin (1.0 kg/ha) + metribuzin (0.175 kg/ha) (81.1%). No herbicide combination caused the phytotoxicity on the wheat crop.

Among the herbicides treatments, maximum grain and straw yield was recorded (4.3 and 6.3 t/ha) with pendimethalin + metribuzin application which was at par with pendimethalin *fb* sulfosulfuron. It is very much oblivious that a combination of two herbicides (pendimethalin + metribuzin pre-emergence) controlled the wide spectrum of weeds very effectively and consequently having the higher weed control efficiency, grain and straw yield. There was no phytotoxicity of any of the herbicidal treatments on the crop. Pendimethalin + metribuzin treatment recorded maximum B:C (2.1) than other weed control measures.

PAU, Ludhiana

Phalaris minor, *Medicago denticulata*, *Rumex dentatus* and *Chenopodium album* were major weeds. Pre-emergence application of pendimethalin (0.75 and 1.0 kg/ha), metribuzin (0.175 and 0.21 kg/ha) and tank-mix of metribuzin (0.175 kg/ha) with pendimethalin (0.75 and 1.0 kg/ha) provided 73-81% control of *P. minor* at 30 DAS . Pendimethalin when used alone or in tank-mix provided 98-100% control of *R. dentatus* and *C. album*. *M. denticulata* was not controlled by pendimethalin (27-33%) and metribuzin (58-63%) used alone, and their tank-mix resulted in 77-85% control. At 60 DAS, tank-mix of pendimethalin+ metribuzin gave 60-67% weed control. Tank-mix of pinoxaden + metsulfuron, pre-mix of sulfosulfuron + metsulfuron, mesosulfuron + iodosulfuron, clodinafop + metsulfuron provided effective control of broadleaf weeds and significantly reduced the weed biomass and nutrient depletion by weeds, as compared to unweeded control. All the weed control treatments except clodinafop (60 g/ha) recorded significantly higher wheat grain yield and yield attributes than unweeded control. Sequential application of pendimethalin *fb* sulfosulfuron recorded the highest WCE (93-96%), wheat grain yield and was at par with all other herbicidal treatments except clodinafop (60 g/ha). No crop phyto-toxicity was observed during this season (Table 1.3.3.1).

The study concluded that sequential/tank-mix application of pre- and or post-emergnece grass and broadleaf killers could be adopted for broad-spectrum control of weeds in wheat.

Table 1.3.2.1 Wheat grain yield, yield attributes and economics under different weed control treatments (2015-16)

Treatments	Dose (kg/ha)	Effective tillers (no./m^2)	Grain yield (t/ha)	Economics			
				Variable cost (`/ha)	Gross returns (`/ha)	Net returns (`/ha)	B:C Ratio
Pendimethalin	0.75	341	4.1	33,734	63,349	29,615	1.8
Pendimethalin	1.0	350	4.2	35,028	64,965	29,937	1.8
Sulfosulfuron	0.025	348	4.2	34,478	64,462	29,984	1.8
Metribuzin	0.175	348	4.2	34,353	64,416	30,063	1.8
Metribuzin	0.21	348	4.2	34,453	65,102	30,649	1.8
Clodinafop - propangyl	0.06	301	3.1	34,678	47,519	12,841	1.3
Pendmethalin + metribuzin	0.75+0.175	367	4.3	35,234	67,039	31,805	1.9
Pendmethalin + metribuzin	1.0+0.175	358	4.3	34,528	67,024	32,496	1.9
Pendmethalin *fb* sulfosulfuron	0.75 *fb* 0.018	372	4.6	34,918	70,669	35,751	2.0

Pendmethalin *fb* sulfosulfuron	1.0 *fb* 0.018	370	4.6	35,213	70,730	35,517	2.0
Sulfosulfuron+metsulfuron	0.03+0.002	368	4.4	34,853	67,756	32,903	1.9
Pinoxaden + metsulfuron	0.06+0.004	363	4.5	34,889	69,449	34,560	1.9
Mesosulfuron + iodosulfuron	0.012+0.0024	356	4.4	35,078	68,564	33,486	1.9
Clodinafop + metsulfuron	0.06+0.004	311	4.1	35,103	63,364	28,261	1.8
2 HW	-	372	4.6	46,653	70,638	23,985	1.5
Unweeded control	-	259	2.6	33,853	40,733	6,880	1.2
SEm±	-	17.4	0.2	-	-	-	-
LSD (P=0.05)	-	3.1	0.5	-	-	-	-

Minimum suppling price of wheat: ` 15250/t

WP 1.3.3.2 Evaluation of different herbicide mixtures for post-emergence weed control in maize and residual effect on succeeding mustard under raifed conditions

SKUAST, Jammu

The experimental field was dominated by weed's such as *Cyperus* spp., *Digitaria sangunalis, Echinochloa colona, Cynodon dactylon, Acrache racemosa, Eragrostis Ienella, Eleusine* spp. *Amaranthus viridis, Solanum nigrum, Commelina benghalensis, Physalis minima* and *Phyllanthus niruri* weeds.

In maize, lowest weed density and biomass was recorded with tembotrione (100 g/ha+ halosulfuron 67.5 g/ha) which was significantly lower than all other herbicidal treatment at 30 DAS. At 60 DAS, tembotrione (100 g/ha) + atrazine (500 g/ha) recorded lowest weed density which was statistically at par with atrazine (1000 g/ha) *fb* tembotrione (100 g/ha). The highest number of grains/cob, grain and straw yields were recorded with tembotrione (100 g/ha) + atrazine (500 g/ha) which was statistically at par with tembotrione (100 g/ha) + halosulfuron (67.5 g/ha), atrazine (1000 g/ha) *fb* tembotrione (100 g/ha) and atrazine (1000 g/ha) *fb* metribuzin 250 g/ha. Highest net returns and B:C ratio were recorded with tembotrione + atrazine followed by atrazine tembotrione and atrazine *fb* metribuzin (Table 1.3.3.2.1).

Table 1.3.3.2.1 Effect of different herbicides mixtures on weed biomass (g/m^2) at 60 DAS in maize

Treatment	Grasses	Broadleaf	Sedges	Grain yield (t/ha)	Net return (`/ha)	B:C ratio
Tembotrione 100 g/ha at 15-20 DAS	4.2 (17.4)	3.9 (14.3)	2.5 (5.0)	2.9	33,120	2.6
Halosulfuron 67.5 g/ha at 15-20	5.4 (28.3)	4.2 (16.9)	1.8 (2.6)	2.7	25,522	2.1
Atrazine 1000 g/ha at 0-3 DAS	4.4 (19.0)	4.1 (15.8)	4.1 (15.4)	2.8	33,237	2.7
Atrazine 500 g/ha at 15-20 DAS	5.3 (28.0)	5.1 (24.9)	5.0 (24.2)	2.1	19,633	2.0
Tembotrione 100 g/ha+atrazine 500 g/ha at 15-20 DAS	2.1 (3.7)	1.8 (2.2)	1.8 (2.2)	3.5	43,705	3.1
Tembotrione 100 g/ha+ halosulfuron 67.5 g/ha at 15-20 DAS	2.9 (7.9)	2.5 (5.5)	1.4 (1.1)	3.5	38,746	2.5
Halosulfuron 67.5 g/ha+ atrazine 500 g/ha at 15-20 DAS	5.2 (26.1)	2.9 (7.5)	1.5 (1.4)	2.8	27,918	2.2
Atrazine1000 g/ha 0-3 DAS *fb* 2,4-D 500 g/ha at 15-20 DAS	4.5 (19.9)	2.2 (4.2)	3.3 (10.4)	2.9	33,306	2.7
Atrazine 1000 g/ha *fb* metribuzin 250 g/ha	3.1 (9.2)	2.7 (6.5)	2.9 (7.6)	3.4	40,960	3.0
Atrazine 1000 *fb* tembotrione 100 g/ha	2.9 (7.9)	3.11 (8.7)	2.2 (4.1)	3.5	43,038	3.0
Weed free	1.0 (0.0)	1.00 (0.0)	1.0 (0.0)	3.6	38,084	2.3
Weedy check	6.3 (39.8)	6.32(39.0)	5.6 (30.5)	1.9	16,223	1.8
SEm ±	0.08	0.10	0.06	1.5	-	-
L.S.D (P=0.05)	0.2	0.3	0.2	0.4	-	-

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

WP 1.3.3.3 Weed management in maize (sweet/ baby corn)- french bean cropping system

CAU, Pasighat

Weed management in sweet corn (*Kharif* 2016)

Treatments

T1 : Maize + soybean (IC) (1:1)

T2 : Maize + blackgram (IC) (1:1)

T3 : Maize + greengram (IC) (1:1)

T4 : Banana pseudostem mulch

T5 : Grass mulch

T6 : Paddy straw mulch

T7 : Hand weeding (25 and 50 DAS)

T8 : Weedy check

Major weeds species in the experimental field were *Cynodon dactylon, Echinochloa colona, Spilanthes acmella, Cyperus iria, Amaranthus* spp., *Solanum nigrum, Ageratum conyzoides, Physalis minima, Commelina benghalensis*, etc. Two hand weedings at 25 and 50 significantly reduced weed population. Intercropping of soybean and black gram at 1:1 with sweet corn also found effective for controlling all kind of weeds. Dry weight of grassy weeds and sedges were higher followed by broad leaved weeds at 60 DAS. Cultivation of sweet corn with intercrop of soybean and black gram showed a reduction in weed dry weight and increased WCE. Hand weeding twice at 25 and 50 DAS resulted in significantly higher number of cobs/plant, cob length and number of rows/cob which was at par with remaining all weed control treatments. Intercropping of soybean with corn (1:1) recorded significantly higher number of cobs (0.64 lakh/ha) than un-weeded control followed by hand weeding twice at 25 and 50 DAS. Higher B:C ratio (3.4) was recorded with maize + soybean intercropping treatments which was very close to all other weed control treatments except maize + blackgram intercropping (2.8) and mulching with banana pseudo-stem (2.8).

WP 1.3.4 Weed management in okra-vegetable pea cropping system

CAU, Pasighat

Treatments

T1 : Plastic mulch

T2 : Grass mulch

T3 : Hand weeding (twice)

T4 : Weed free

T5 : Hoeing (twice)

T6 : Pendimethalin 1.5 kg/ha (PE) *fb* 1 HW (30 DAS)

T7 : Weedy check

Weed flora in the experimental plots was *Eleusina indica, Digitaria sanguinalis, Cynodon dactylon* (among grasses). Whereas, among broad leaf weeds, major weeds were *Ludwigia parviflora, Eryngium foetidum, Spilanthes acmella, Corchorus* species, *Physalis minima.* Keeping the plots weed free upto 60 DAS significantly reduced weed population. Treatments of plastic mulch, application of pendimethalin (1.5 kg/ha) supplemented with hand weeding at 30 DAS with use of grass mulch significantly reduced weed dry matter and increased weed control efficiency (WCE). The lowest WCE (36.3%) and highest (56.9%) recorded with hand weeding (twice) treatment and plastic mulch treatment, respectively.

Plastic mulched plots recorded significantly higher fresh fruit yield (7.2 t/ha) than weedy check followed by application of pendimethalin supplemented with one hand weeding at 30 DAS. Remaining other weed control treatments were found significantly superior over weedy check. Higher net return of ` 23,000 was recorded with application of pendimethalin + hand weeding at 30 DAS followed by plastic mulch treatments. Higher B:C ratio of 1.5 was recorded with pendimethalin *fb* hand weeding at 30 DAS treatments which was very close to all other weed control treatments except hoeing twice.

WP 1.3.5 Weed management in greengram

RVSKVV, Gwalior

WP 1.3.5.1 Integrated weed management of problematic weeds in greengram

The major weed flora of experimental site was *Echinochloa crus-galli, Setaria glauca,* and *Eragrostis* spp. seen as grasses and *Commelina benghalensis, Digera arvensis, Celosia argentea* and *Phyllanthus niruri* were emerged as major broad-leaf weeds (BLWs). The only sedge, *Cyperus rotundus* was most dominating among all the weeds. Lowest significant total weed population and dry weight was recorded in 2 HW followed by imazethapyr + imazamox (RM) (80 g/ha PoE), pendimethalin + imazethapyr (RM) (1000 g/ha PE) and pendimethalin + imazethapyr (RM) (750 g/ha PE). The highest weed control efficiency (86.9%) was recorded with two hand weedings at 20 and 40 DAS followed by imazethapyr + imazamox (71.%) and pendimethalin + imazethapyr (52.2%), respectively. Maximum seed yield (972 kg/ha) and highest B:C ratio (3.2) was recorded under imazethapyr+ imazamox followed by two hand weedings at 20 and 40 DAS (898 kg/ha). The minimum net return (` 8,332/ha) and B:C ratio (1.5) was recorded under weedy check.

WP 1.3.5.2 Herbicidal weed management in greengram

CCSHAU, Hisar

Weed flora of the field consisted of *Digera arvensis*, *Trianthema portulacastrum* and *Cyperus rotundus*. Other weeds present in experimental field were *D. aegyptium* and *E. crus-galli*. Post-emergence application of aciflourfen + clodinafop (RM) at all applied rates proved very effective against *D. arvensis* and *T. portulacastrum* but its efficacy against *C. rotundus* was poor. Pyroxasulfone alone at 127.5 and 150 g/ha and its combination with pendimethalin proved very effective against all weeds but caused poor germination of greengram. Imazethapyr and its combination with imazamox were very effective against *D. arvensis* but their efficacy against *T. portulacastrum* was very poor. Although post emergence application of both these herbicides caused suppression in *Trianthema* growth but pre-emergence treatment of pendimethalin in combination with imazethapyr (1000 g/ha) were very effective to minimize *Trianthema* population as evident from density of weeds at 25 and 50 DAS.

At 25 DAS, WCE was maximum (94.6%) with aciflourfen + clodinafop (RM) at 370 g/ha followed by its lower dose (94.2%), 92.2% with pyroxasulfone at 127.5 g/ha and 89.5% with pre-emergence use of pendimethalin + imazethapyr (RM) at 1000 g/ha. Imazethapyr alone or in combination with quizalofop caused 17.4-20.3% toxicity where as imazethapyr +imazamox caused 11% toxicity at 30 DAS but the plants recovered at 45 DAS without any yield penalty. At 50 DAS, maximum WCE (91-92.4%) was recorded with post-emergence use of aciflourfen + clodinafop (RM) at all rates followed by pyroxasulfone (86-89%) and pendimethalin +imazethapyr (RM) at 1000 g/ha (84%). Maximum plant height and dry matter accumulation/plant were recorded under weed free treatment which was at par with aciflourfen + clodinafop at all rates and imazethapyr + pendimethalin (RM) but significantly higher than all pyroxasulfone treatments. Similarlily maximum number of pods/plant and number of seeds /pod were highest in weed free and two hoeing treatments which were statistically at par with all premix treatments. Presence of weeds throughout the season caused 74.5% reduction in seed yield of green gram. Seed yield was maximum (1.1 t/ha) with use of aciflourfen + clodinafop at (370 g/ha) which was significantly at par with its lower dose (305 g/ha) and weed free check but significantly higher than all other treatments. Minimum seed yield (60-100 kg/ha) was recorded with use of pyroxasulfone which was even significantly less than weedy check treatment.

AAU, Anand

Grassy weeds were predominated (74.6%) followed by broad-leaved (25.4%) in the experimental field of greengram. *Eleusine indica* and *Digera arvensis* were found more dominant weed species among the grassy and broad-leaved weeds, respectively. Significantly the lowest total weeds were recorded in the hoeing at 20 & 40 DAS but remained at par with imazethapyr + pendimethalin (1000 g/ha PE) and imazethapyr + imazamox (80 and 70 g/ha PoE). Phytotoxicity of imazethapyr and imazethapyr + imazamox (RM) was found up to two weeks but after words crop fully recovered from the ill effect of herbicides.

Significantly the higher seed (1.4 t/ha) and haulm yield (2.4 t/ha) of greengram were recorded in hoeing at 20 & 40 DAS and application of imazethapyr + pendimethalin, respectively. Highest WCE (93%) was recorded in hoeing at 20 & 40 DAS practices.

Application of imazethapyr, imazethapyr + pendimethalin, imazethapyr + imazamox, imazethapyr and imazethapyr was found equally effective to manage weeds with higher B:C ratio without any phytotoxic effect on succeeding mustard crop. Plant stand, plant height, plant dry biomass, seed and stalk yield of mustard were not influenced significantly by the herbicides applied in preceding greengram crop indicated that there was no any carry over/residual phytotoxic effects on succeeding mustard crop.

WP 1.3.5.4 (i) Studies on time of chemical weed management in blackgram

UAS, Raichur

Field experiment were conducted at two locations at Richur and Bidar district. The predominant grassy weeds associated with blackgram were *Cynodon dactylon, Digitaria longiflora, Digitaria marginata, Dinebra retroflexa, Panicum javanicum* and among sedges *Cyperus rotundus* was the predominat weed. *Abutilon indicum, Cassia tora, Celosia argentea, Euphorbia geniculata, Euphorbia hirta, Portulaca oleracea, Phyllanthus niruri, Lagascea mollis, Merremia gangetica, Mimosa pudica, Trianthema protulacastrum, Tribulus terrestris* and *Tridax procumbens* were the broadleaved weeds. At 40 DAS, significantly the lowest total weed density (3.1 and 3.4 / m^2) and dry weed biomass (2.3 and 2.5 g/ m^2) were noticed with the one intercultivation and one hand weeding at 20 and 40 DAS, respectively. The next best treatment was ready mix combination of imazethapyr + imazamox (75 g/ha) applied at 3-4 leaf stage of weed, which recorded a total weed density (5.1 and 5.6 /m^2, respectively) and dry weed biomass (3.7 and 4.1 g/m^2).

One intercultivation and one hand weeding at 20 and 40 DAS recorded significantly the highest weed control efficiency (91.4 and 90.4%). Application of ready mix combination imazethapyr + imazamox at 3-4 leaf stage of weed noticed second best weed control efficiency (77.3 and 73.6 %). Among the different herbicides, imazethapyr (75 g/ha) applied at 0-3 DAS observed significantly the lowest weed control efficiency (51.1 and 47.9 %, respectively) next only to weedy check. Significantly higher seed yield (0.9 and 1.0 t/ha, respectively) and stover yield (2.0 and 2.1 t/ha) was recorded with one intercultivation and one hand weeding at 20 & 40 DAS and was found at par with the application of ready mix combination imazethapyr + imazamox which recorded seed yield (0.8 and 0.9 t/ha) and stover yield (1.9 and 1.8 t/ha). Benefit: cost ratio was significantly higher with application of ready mix combination imazethapyr + imazamox. The lowest benefit: cost ratio was noticed with the weedy check (1.3 and 1.5) over both the locations.

GBPUAT, Pantnagar

Among the herbicidal treatments (either applied alone or in combination) application of pendimethalin (1000 g/ha) in black gram achieved highest plant height, plant population / m^2(at harvest), number of pods/plant and 1000 seeds weight while highest plant population PoE (at 15 DAS) and seeds/pod was obtained with PoE application of imazethapyr (70 g/ha). Ready mix application of imazethapyr+ imazamox as pre-emergence (70 g/ha) recorded highest seed yield of blackgram which was comparable to its same dose applied as post-emergence and pendimethalin applied as pre-emergence at 70 g / ha (Table 1.3.5.4.1).

Application of imazethapyr (70 & 80 g/ha) either applied as pre or post-emergence as well as ready mix application of imazethapyr applied in preceeding blackgram crop showed severe phytotoxic effect on succeeding mustard crop in respect to germination, plant growth and caused reduction in seed yield. While ready mix application of imazethapyr+ imazamox at both doses (70 & 80 g/ha) either applied pre or post-emergence could not show any phytotoxic effect on succeeding crop mustard and also yielded comparable seed yield over the twice hoeing (20 & 40 DAS).

Table 1.3.5.4.1 Effect of weed management treatments on plant height, plant population, yield and yield attributes in succeeding mustard crop

Treatments	Dose (g/ha)	Plant height (cm)	Plants (no./m²)		No of pods/ plant	Seeds/ pod	1000 seed weight (g)	Seed yield (t/ha)
			15 DAS	Harvest				
Imazethapyr (PE)	70	142.2	15.5	14.0	121.4	9.6	4.2	0.6
Imazethapyr (PE)	80	101.2	11.0	10.3	74.3	8.4	3.6	0.2
Imazethapyr (PoE)	70	162.7	24.3	15.3	147.9	12.7	4.1	0.9
Imazethapyr (PoE)	80	156.8	22.7	15.0	140.8	10.3	3.8	0.7
Imazethapyr +imazamox (RM) (PE)	70	158.9	19.7	17.0	197.6	11.0	4.3	1.3
Imazethapyr+imazamox (RM) (PE)	80	149.1	17.7	16.3	168.9	10.7	4.0	0.9
Imazethapyr+imazamox (RM) (PoE)	70	172.7	23.3	20.7	231.4	12.5	4.3	1.2
Imazethapyr+imazamox (RM) (PoE)	80	170.3	22.3	19.7	228.3	11.5	4.0	1.1
Pendimethalin (PE)	1000	180.7	24.0	22.7	235.8	12.0	4.3	1.2
Imazethapyr+pendimethalin (RM) (PE)	1000	152.7	23.0	14.7	195.4	10.7	3.8	0.9
Hoeing (twice)	20 & 40 DAS	183.0	27.0	22.3	240.8	12.9	4.2	1.4
Weedy	-	168.0	25.3	22.7	219.9	11.3	4.3	1.3
SEm–		2.7	1.0	0.48	6.3	0.29	0.1	0.04
LSD (P=0.05)	-	7.9	3.0	1.4	18.4	0.86	0.3	0.1

PE- pre-emergence, PoE- post-emergence, RM- ready-mix, DAS- days after sowing

WP 1.3.5.4 (ii) Weed management with application of imazethapyr and its ready mix combination with imazamox against weeds in green gram

UAS, Raichur

Major weed flora in the experimental plots was *Cynodon dactylon, Panicum* spp., *Dactyloctenium aegyptium, Digitaria marginata, Erogrostis gangetica, Echinochloa colona, Phyllanthus niruri, Tribulus terrestris, Abutilon indicum, Parthenium hysterophorus, Mimosa pudica, Digeria arvensis, Cyperus rotundus,* etc. At 40 DAS, plots treated with herbicide combinations, such as imazethapyr + imazamox (RM) (75 g/ha) at 3-4 leaf stage of weed, imazethapyr + pendimethalin (RM) (1000 g/ha) as pre- emergence, imazethapyr (75 g/ha) as pre-emergence recorded lower weed density and dry weight as compared to unweeded control. Significantly lower weed density and dry weight was recorded in treatment with one intercultivation at 15 DAS and one hand weeding (HW) at 30 DAS.

Higher weed control efficiency was recorded in imazethapyr + imazamox (RM) followed by imazethapyr + imazamox and imazethapyr + pendimethalin (77.9%). Among the different herbicides evaluated, imazethapyr + imazamox recorded significantly higher seed yield (10.05 t/ha) and haulm yield (2.1 t/ha) followed by imazethapyr + pendimethalin (1.0 t/ha). Herbicide or herbicide mixtures were cheaper than intercultivation and hand weeding. Imazethapyr + imazamox recorded higher gross return, net returns and B:C ratio (` 78,463/ha, ` 54,403/ha and 3.3) followed by imazethapyr + pendimethalin (` 76,926/ha, ` 52,156/ha and 3.1) and imazethapyr (` 73,055/ha, ` 49,382/ha and 3.1). The lowest B:C ratio (1.7) was observed in weedy check plots.

WP 1.3.5.5 Evaluation of pre and post-emergence herbicides against complex weed flora in green gram (*Kharif*)

MPUAT, Udaipur

The experimental plot was infested with grassy, broad leaf weeds and sedges. Prominent weed species were *Echinochloa colona* (29.8%), *Commelina benghalensis* (5.8%), *Trianthama portulacastrum* (11.3%), *Digera arvensis* (6.2%), *Parthenium hysterophorus* (17.0%) and *Cyperus rotundus* (29.8%). Among various weed control treatments, ready mix application of acifluorfen + clodinafop (370 g/ha) as post-emergence at 3-4 leaf stage followed by two hand weedings at 20 and 40 DAS than followed by pre-emergence application of pyroxasulfone (127.5 g + pendimethalin 1000 g/ha) were found more effective in reducing the density and weed dry matter of weeds at 25 DAS and harvest as compared to other herbicidal treatments. Post-emergence application of ready mix combination of acifluorfen + clodinafop recorded the maximum seed yield (0.9 t/ha) and it was statistically at par with pyroxasulfone and imazethapyr alone and tank mix applications of pyroxasulfone + pendimethalin. The lowest yield was recorded in weedy check. Pre-emergence application of pendimethalin *fb* quizalofop recorded lowest seed yield (0.7 t/ha), however, results of which was significantly higher over weey check. The highest net returns (` 50,140/ha) and B:C ratio (2.7) were realized with post-emergence application of ready mix combination of acifluorfen + clodinafop applied at 370 g/ha.

WP 1.3.6 Weed management in groundnut

WP 1.3.6.1 Effect of different herbicides on weeds and yield of groundnut

UAS, Raichur

Major weed flora observed in the experimental plots were *Alternanthera sessilis, Ocimun canum, Dinebra retroflexa, Parthenium hysterophorus, Cynodon dactylon, Phyllanthus niruri, Amaranthus viridis, Echinochloa colona* and *Sida acuta.* At 60 DAS, significantly lowest weed density and weed dry weight were noticed with hand weeding done thrice at 15, 30 and 45 DAS. Among the herbicide treatments, pendimethalin at (1000 g/ha as PE) followed by imazethapyr (75 g/ha) at 2-5 leaf stage, imazethapyr + imazamox (RM) at (75 g/ha) at 10-15 DAS, imazethapyr + pendimethalin (RM) (1000 g/ha) as pre-emergence recorded lower weed density and dry weight of weeds as compared to application of pendimethalin (1000 g/ha) as pre-emergence, pendimethalin (750 g/ha) as pre-emergence and imazethapyr (75 g/ha) as pre emergence. Higher weed control efficiency was recorded in hand weeding thrice at 15, 30 and 45 DAS and pendimethalin as pre-emergence followed by imazethapyr at 75 g/ha.

Hand weeding thrice at 15, 30 and 45 DAS had given significantly higher pod (2.3 t/ha) and haulm yield (2.4 t/ha) followed by the plots treated with pendimethalin (750 g/ha) as pre-emergence followed by imazethapyr (75 g/ha) at 2-5 leaf stage, pendimethalin (1000 g/ha) as pre-emergence followed by imazethapyr (75 g/ha) at 2-5 leaf stage and imazethapyr + imazamox (RM) (75 g/ha) at 10-15 DAS. Unweeded control gave the lowest pod yield (0.6 t/ha) and haulm yield (0.7 t/ha) due to severe competition from all types of weeds. Herbicides or herbicide mixtures were cheaper than hand weeding. Application of pendimethalin as pre-emergence followed by imazethapyr recorded higher gross returns, net returns and BC ratio (` 1,01,238/ha, ` 65,189/ha and 2.8, respectively). The lowest B:C ratio (0.8) was observed in weedy check plots.

WP 1.3.7 Weed management in soybean

WP 1.3.7.1 Integrated weed management in soybean

RAU, Pusa

Weed flora found in the experimental field were *Digitaria sanguinalis, Cynodon dactylon, Sorghum halepense, Dicanthium annualatum* and *Eleusine indica,* grasses:, *Cyperus rotundus, Cyperus difformis,* and *Fimbristylis miliacea* sedges:, *Eclipta alba, Phyllanthus niruri, Physalis minima, Leucas aspera, Digera arvensis* and *Croton sparsiflorus* broadleaved weeds.

Hand weeding twice at 20 and 40 DAS resulted in higher weed control efficiency (62.5%) and lowest weed population (5.62/m^2) and dry weight of weeds (5.42 g/m^2) which were significantly superior over rest of the treatments and closely *fb* pendimethalin (1.0 kg/ha as PE) *fb* quizalofop- ethyl (50 g/ha) as PoE at 20-25 DAS (6.4/m^2 and 6.2/m^2). Hand weeding twice at 20 and 40 DAS proved significantly superior in respect of all crop growth parameters and yield attributes but was at par with pendimethalin *fb* quizalofop-p-ethyl. The highest yield was obtained under weed free situation (1.87 t/ha) and was statistically at par with pendimethalin as PE *fb* quizalofop-p-ethyl as PoE at 20-25 DAS (1.6 t/ha). Highest stover yield was also associated with weed free treatment. Pendimethalin as PE + quizalofop- ethyl as PoE at 20-25 DAS also recorded highest B:C ratio (2.3) among the treatments which was found statistically at par with imazethapyr (100 g/ha + fenoxaprop (100 g/ha) as PoE at 20-25 DAS (2.3).

WP 1.3.7.2 Effect of different herbicide combination on weeds and yield of soybean

UAS, Raichur

The field experiments were conducted at Raichur and Bidar districts. Predominant grassy weeds associated with soybean were *Cynodon dactylon, Digitaria longiflora, Digitaria marginata, Dinebra retroflexa, Panicum javanicum, Eleusine indica,* and among sedges *Cyperus* rotundus was the predominant weed. *Phyllanthus niruri, Leucas aspera, Parthenium hysterophorus, Euphorbia hirta, Ocimun canum, Sida acuta, Amaranthus viridis* and *Tridax procumbens* were the broadleaved weeds.

At 40 DAS, lowest total weed density (3.5 and 3.2 / m^2) and dry weed biomass (2.5 and 2.3 g / m^2) were noticed with one intercultivation and one hand weeding at 20 and 40 DAS and it was found on par with application of ready mix combination of imazethapyr + pendimethalin (RM) 1000 g / ha at 0-3 DAS with total weed density (3.6 and 3.3 no. / m^2) and dry biomass (2.6 and 2.4 g / m^2). Significantly higher weed control efficiency (89.9 and 92.0 %) was observed with one intercultivation and one hand weeding and was found on par with application of ready mix combination of imazethapyr + pendimethalin (89.2 and 90.8%).

Significantly higher grain (1.8 and 1.9 t / ha) and stover yield (1.7 and 1.8 t / ha) were recorded with one intercultivation and two hand weedings at 20 and 40 DAS and it was on par with imazethapyr + pendimethalin (1.8 and 1.9 t / ha) grain yield and (1.6 and 1.8 t / ha) stover yield. Weed index (46.67 and 45.92%) was significantly higher with weedy check compared to rest of the treatments. Significantly higher benefit cost B:C ratio (1.7 and 1.8) was noticed with imazethapyr + pendimethalin (RM) and it was found on par with imazethapyr + imazamox (1.7 and 1.8), pendimethlain (1.6 and 1.7) and one intercultivation and one hand weeding at 20 and 40 DAS (1.6 and 1.6).

WP 1.3.9 Weed management in turmeric

WP 1.3.9.1 Integrated weed management in turmeric

PDKV, Akola

Major weed flora during *Kharif* in turmeric was *Xanthium strumarium, Celosia argentea, Tridax procumbens, Phyllanthus niruri, Euphorbia hirta, Abutilon indicum, Abelmoschus moschatus, Boerhaavia diffusa, Calotropis gigantea, Ageratum conyzoides, Bidens pilosa, Cynodon dactylon, Cyperus rotundus, Amaranthus viridis, Dinebra arabica, Panicum* spp. *Commelina benghalensis, Dinebra retroflexa,* etc. Both broad and narrow leaved weeds were observed but dominance of broadleaved weeds was observed in entire field.

Weed control treatments significantly reduced weed population and biomass when compared with unweeded control. At 60 DAS, hand weeding (25, 45 & 75 DAP) recorded significantly lower weed count and dry matter accumulation followed by glyphosate *fb* 2 HW (45 & 75 DAP), pendimethalin 1.0 kg / ha (0-5 DAP) *fb* straw mulch 10 t / ha (10 DAP) *fb* one HW (75 DAP) and metribuzin 0.7 kg / ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP). Similar trend of result was noticed in weed count and dry matter accumulation at 90 DAS. At 60 DAS the highest weed control efficiency was recorded under post emergence application of glyphosate *fb 2* HW (45 & 75 DAP) followed by metribuzin (0.7 kg / ha) (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP). Maximum rhizome yield was observed in weed free treatment (20.8 t / ha) while among the IWM treatments, application of pendimethalin 1.0 kg / ha (0-5 DAP) *fb* straw mulch 10 t / ha (10 DAP) *fb* one HW (75 DAP) recorded higher rhizome yield (20.7 t / ha) which was closely followed by metribuzin 0.7 kg / ha (0-5 DAP) *fb* straw mulch (10 DAP) *fb* HW (75 DAP). The maximum B:C ratio was found in pendimethalin 1.0 kg / ha (0-5 DAP) *fb* straw mulch 10 t / ha (10 DAP) *fb* one HW (75 DAP).

WP 1.3.9.2 Integrated weed management with pre and post-emergence herbicides in turmeric

CSKHPKV, Palampur

The major weeds of the experimental field were *Echinochloa colona, Digitaria sanguinalis, Panicum dichotomiflorum, Commelina benghalensis, Cyperus iria, Ageratum conyzoides, Polygonum* sp., *Physallis minima, Bidens pilosa* and *Aeschynomene indica.* All the weed control treatments except atrazine 750 g / ha significantly reduced population of *Echinochloa colona* and other grassy weeds over weedy check. Metribuzin *fb* straw mulch *fb* hoeing, pendimethalin *fb* hoeing, pendimethalin *fb* fenoxaprop + metsulfuron-methyl, pendimethalin *fb* straw mulch *fb* hoeing and atrazine *fb* straw mulch *fb* hoeing were as good as weed free in reducing the population of *Echinochloa colona* and other grassy weeds up to mid November.

Metribuzin (700 g / ha) *fb* fenoxaprop (67 g / ha) + metsulfuron-methyl (4 g / ha), pendimethalin *fb* fenoxaprop (67 g / ha) + metsulfuron-methyl (4 g / ha) and atrazine *fb* fenoxaprop (67 g / ha) + metsulfuron-methyl (4 g / ha) showed phytotoxicity on turmeric. Canopy formation could not take place and lately in these treatments as well as in others, *Ageratum* appeared in large number. Mulch proved to be extremely important practice as the treatments constituting the straw mulch *viz.*, pendimethalin / metribuzin / atrazine *fb* mulch *fb* hoeing resulted in significantly higher fresh rhizome yield over other treatments. Weeds in unweeded check reduced the cured rhizome yield by 47.9% over the best treatment *i.e.* metribuzin / pendimethalin *fb* straw mulch *fb* hoeing. The treatments metribuzin / pendimethalin / atrazine *fb* hoeing were superior to hand weeding thrice in influencing the fresh and cured rhizome yield (Table1.3.9.2.1).

Table1.3.9.2.1 Effect of weed management treatments on weed and turmeric rhizome yield

Treatment	Total weed density (no./m²)	Total weed dry biomass (g/m²)	WCE (%)	Fresh rhizome yield (t/ha)	Cured rhizome yield (t/ha)
Metribuzin 0.7 kg / ha *fb 2* hand weedings	4.4 (20.3)	4.4 (19.0)	95.2	15.4	9.5
Metribuzin 0.7 kg / ha *fb* fenoxaprop + metsulfuron (67 + 4 g / ha)	19.4 (377.3)	17.6 (308.3)	23.2	1.7	1.2
Metribuzin 0.7 kg / ha *fb* straw mulch 10 t / ha *fb* HW	4.2 (17.0)	3.9 (16.7)	95.8	18.2	12.6
Pendimethalin 1.0 kg / ha *fb* 2 HW	6.3 (39.3)	5.4 (29.0)	92.7	13.3	9.0
Pendimethalin 1.0 kg / ha *fb* fenoxaprop + metsulfuron (67 + 4 g / ha)	20.5 (419.7)	17.7 (314.3)	21.7	2.0	1.3
Pendimethalin 1.0 kg / ha *fb* straw mulch 10 t / ha *fb* HW	5.3 (27.3)	5.6 (33.3)	91.7	18.2	12.3
Atrazine 0.75 kg / ha *fb* two HW	5.9 (35.0)	4.3 (18.3)	95.4	17.0	10.9
Atrazine 0.75 kg / ha *fb* fenoxaprop + metsulfuron (67 + 4 g / ha)	7.9 (59.7)	17.4 (301.7)	24.9	1.6	0.9
Atrazine 0.75 kg / ha *fb* straw mulch 10 t / ha *fb* HW	5.1 (28.3)	4.4 (20.0)	95.0	22.2	14.4
Oxyfluorfen 0.30 kg / ha *fb* two HW	7.5 (58.3)	5.2 (26.7)	93.3	10.9	7.3
Oxadiargyl 0.25 kg / ha *fb* two HW	6.8 (49.3)	5.6 (31.7)	92.1	15.4	10.1
Glyphosate 5.0 ml / l *fb 2* HW	8.5 (86.0)	5.4 (31.7)	92.1	12.5	6.6
Glyphosate 7.5 ml / l *fb 2* HW	5.1 (29.0)	4.4 (20.0)	95.0	11.3	6.2
Hand weeding (3)	4.8 (27.0)	4.1 (16.7)	95.8	15.8	9.8
Un-weeded check	11.1 (122.0)	20.1 (401.7)	*0.0*	12.1	7.5
SEm ±	1.0	0.6	-	1.7	1.1
LSD (P=0.05)	2.8	1.8	-	5.0	3.2

Values given in parentheses are the means of original values; Data transformed to square root transformation ($\sqrt{x+1}$)

GBPUAT, Pantnagar

All the weed management practices had significant effect on the weed density at 75 DAP. Minimum total density and dry matter accumulation of grassy weeds was attained by the application of metribuzin (0.7 kg / ha) followed by pendimethalin (1.0 kg / ha) applied as pre-emergence along with straw mulch (10 t / ha) then supplementation of 1 HW at 75 DAP and these are significantly superior over rest of the treatments. Density and dry matter accumulation of BLWs were totally controlled by pre-emergence application of metribuzin as well as pendimethalin *fb* straw mulch at 10 t / ha supplemented with one hand weeding at 75 DAP which was comparable with pre-emergence application of atrazine at (0.75 kg / ha) *fb* straw mulch at (10 t / ha) along with one hand weeding at 75 DAP. However, the lowest density and dry biomass of sedges was achieved by the application of glyphosate at (7.5 ml / l) of water supplemented with twice hand weeding (45 & 75 DAP). Among all the integrated approaches, the lowest total dry biomass of weeds and highest weed control efficiency was obtained with application of metribuzin at (0.7 kg / ha) + straw mulch (10 t / ha *fb* hand weeding at 75 DAP followed by atrazine (0.75 kg / ha) + straw mulch (10 t / ha) then the supplementation of one hand weeding at 75 DAP.

All the treatments had significant effect on turmeric yield. Application of atrazine applied as PE + straw mulch (10 t / ha) supplemented with 1 HW at 75 DAP attained highest turmeric yield (21.8 t / ha) which was significantly superior to all other combination except PE application of metribuzin + straw mulch at 10 t / ha supplemented with 1 HW at 75 DAP and pendimethalin applied as PE along with straw mulch at 10.0 t / ha supplemented with 1 HW at 75 DAP. Highest gross return (` 4, 56,133 / ha), net return (` 3, 62,776.00 / ha) and B:C ratio 3.9 were obtained with application of atrazine + straw mulch along with 1 HW followed by metribuzin + straw mulch supplemented with 1 HW at 75 DAP.

WP 1.3.10.1 Integrated weed management in ginger (*Kharif* 2016)

CAU, Pasighat

The experimental field was infested with *Physalis minima, Cynodon dactylon, Digitaria sanguinalis, Panicum* sp., *Echinochloa* spp., *Eleusine indica, Cyperus* spp., *Commelina benghalensis, Murdania kiosak, Solanum khasiana, Ageratum conyzoides, Spilanthes acmella, Sida acuta,* etc. Keeping the plots weed free upto 60 DAP significantly reduced weed population. Application of oxyfluorfen supplemented with hand weeding at 30 days after planting (DAP) *fb* mulching also found effective treatment for controlling weeds.

Application of oxyfluorfen supplemented with hand weeding at 30 DAP *fb* mulching showed reduction in weed dry weight and increased WCE (72.9%). Hand weeding twice at 30 and 60 DAP resulted in significantly higher rhizome length, rhizome width which was at par with application of oxyfluorfen supplemented with one hand weeding at 30 DAP *fb* mulching. Hand weeding twice at 30 and 60 DAP recorded significantly higher fresh rhizome yield (9.8 t / ha) than un-weeded control followed by application of oxyfluorfen supplemented with one hand weeding at 30 DAP *fb* mulching and application of pendimethalin supplemented with one hand weeding at 30 DAP *fb* mulching. Remaining other weed control treatments were found statistically at par with each other. Higher B:C ratio of 2.0 was recorded with hand weeded plots which was very close to all other weed control treatments except pendimethalin alone *fb* mulching.

WP 1.4 Improving input-use efficiency through weed management

WP 1.4.2 Effect of irrigation methods and weed management on weed flora dynamics in direct- seeded rice and wheat

SKUAST, Jammu

The experimental field was dominated by *Echinochloa* spp., *Cynodon dactylon, Digitaria sanguinalis* and *Setaria glauca* amongst grassy weeds; *Caesulia axillaris, Phyllanthus niruri, Physalis minima* and *Euphorbia* spp. amongst broadleaved weeds and *Cyperus* spp. Besides, these major weeds *Commelina benghalensis, Cucumis* spp. and *Dactyloctenium aegyptium* were recorded as other weeds.

Different irrigation treatments had non-significant effect on weed density and weed biomass at 30 and 60 DAT and at harvest. However, lower weed density and weed biomass were recorded in flood irrigation as compared to sprinkler and sprinkler with variable speed device (VSD). The density of *Caesulia axillaris* was higher in flooding irrigation as compared to sprinkler and sprinkler with VSD. However, density of *Echinochloa* spp., *Cynodon dactylon, Digitaria sanguinalis, Setaria glauca, Phyllanthus niruri, Physalis minima, Euphorbia* spp. and *Cyperus* spp. were higher in sprinkler with VSD irrigation method as compared to flooding irrigation.

The lowest total density of grassy and broadleaved weeds, higher number of panicles / m^2, number of grains / panicle, grain and straw yield were recorded in pendimethalin *fb* bispyribac-sodium + ethoxysulfuron-ethyl which was statistically at par with pendimethalin *fb* penoxsulam + cyhalofop-butyl and significantly lower than all other herbicidal treatments at 60 DAS and harvest (Table 1.4.2.1 and 1.4.2.2). Under conventional transplanted rice, the highest B:C ratio was recorded with herbicidal treatment as compared to integrated weed management treatment and weedy check. Under direct-seeded rice, the highest B:C ratio was recorded with integrated weed management treatment as compared to herbicidal treatment and weedy check. Amongst all the tillage and weed management combinations, highest net returns and B:C ratio was recorded in direct- seeded rice and integrated weed management treatment combination.

Table 1.4.2 .1 Effect of irrigation methods and weed management practices weed biomass (g / m^2) in rice

Treatments	Weed biomass (g/m^2) at 60 DAS				Weed biomass (g/m^2) at harvest			
	Grassy	BLWs	Sedges	Total	Grassy	BLWs	Sedges	Total
Irrigation method								
Flooding	4.8 (27.3)	2.4 (6.8)	3.0 (10.8)	6.1 (44.9)	5.1 (30.9)	3.00 (11.3)	3.5 (15.6)	6.7 (57.8)
Sprinkler	4.9 (28.7)	2.5 (7.1)	3.1 (11.2)	6.2 (47.0)	5.2 (32.2)	3.1 (11.9)	3.6 (16.5)	6.9 (60.6)
Sprinkle with VSD*	4.9 (29.2)	2.5 (7.4)	3.1 (11.3)	6.2 (47.9)	5.4 (33.6)	3.0 (12.0)	3.7 (17.4)	7.1 (63.0)
SEm ±	0.05	0.05	0.02	0.05	0.08	0.08	0.05	0.09
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed management								
Pendimethalin 1000 g / ha *fb* bispyribac-sodium 25 g / ha	4.0 (15.2)	2.2 (4.1)	2.5 (5.0)	5.0 (24.4)	4.0 (15.4)	2.6 (5.9)	2.7 (6.6)	5.4 (27.9)
Pendimethalin 1000 g / ha *fb* bispyribac-sodium 25 g / ha+ ethoxysulfuron- ethyl 18 g / ha	3.5 (11.7)	1.0 (0.0)	1.7 (1.9)	3.83 (13.7)	3.7 (12.8)	1.0 (0.0)	1.8 (2.4)	4.2 (15.2)
Pendimethalin 1000 g / ha *fb* fenoxaprop 60 g / ha+ ethoxysulfuron 18 g / ha	4.1 (15.9)	2.9 (7.8)	3.1 (8.8)	5.8 (32.5)	4.6 (20.7)	3.7 (13.2)	3.8 (12.6)	6.9 (46.5)
Pendimethalin 1000 g / ha *fb* penoxsulam + cyhalofop-butyl 135 g / ha	3.5 (11.6)	1.4 (0.9)	1.98 (3.0)	4.1 (15.5)	3.7 (12.7)	1.6 (1.6)	2.4 (4.7)	4.5 (19.1)
Weedy check	9.4 (87.6)	4.8 (22.6)	6.1 (36.7)	12.2 (147.0)	10.0 (99.6)	6.2 (37.9)	7.56 (56.3)	13.9 (193.8)
SEm ±	0.07	0.04	0.06	0.06	0.08	0.08	0.06	0.08
LSD (P=0.05)	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

Data was subjected to square root transformation $\sqrt{x+1}$. Original values are in parenthesis,
*VSD=Variable speed device which work on the basis of soil infiltration rate

Table 1.4.2.2 Effect of irrigation methods and weed management practices on yield attributes, yield of rice and Water use efficiency

Treatments	Panicles/ m^2	Grains/ panicles	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	WUE (kg/ha/ mm)
Irrigation method (I)						
Flooding	229	63	21.2	2.4	5.1	2.4
Sprinkler	224	62	20.9	2.3	5.1	2.6
Sprinkle with VSD*	217	59	20.7	2.3	4.9	2.7
SEm ±	5	2	0.1	0.5	0.8	-
LSD (p=0.05)	NS	NS	NS	NS	NS	-
Weed management (W)						
Pendimethalin 1000 g/ha(PRE) *fb* bispyribac-sodium 25 g/ha	233	59	21.2	2.4	5.4	2.8
Pendimethalin 1000 g/ha(PRE) *fb* bispyribac-sodium 25 g/ha+ ethoxysulfuron- ethyl 18 g/ha	257	69	21.9	2.8	6.1	3.1
Pendimethalin 1000 g/ha(PRE) *fb* fenoxaprop 60 g/ha + ethoxysulfuron 18 g/ha	238	60	21.2	2.5	5.5	2.8
Pendimethalin 1000 g/ha(PRE) *fb* penoxsulam + cyhalofop-butyl 135 g/ha	250	67	21.6	2.6	5.8	2.9
Weedy check	138	51	18.7	1.2	2.5	1.3
SEm ±	7	2	0.2	0.6	1.4	-
LSD (P=0.05)	20	5	0.6	0.1	0.4	-
Interaction (I x W)	NS	NS	NS	NS	NS	-

WP 1.4.3 Weed and nutrient management under upland direct-seeded rice

AAU, Jorhat

The major weeds recorded were *Cynodon dactylon, Digitaria setigera, Eleusine indica* and *Panicum repens* amongst grasses, *Cyperus flavidus, C. iria, C. rotundus, Fimbristylis bisumbellata, F. littoralis* and *Scleria terestris* amongst sedges and the broadleaved weed species, *Ageratum houstonianum, Borreria articularis, Melochia corshorifolia, Mimosa pudica, Mollugo pentaphylla* etc. All the treatments other than recommended dose of fertilizer (40:20:20 N: P_2O_5: K_2O kg/ha), without weed management and no fertilizer, no weed management, recorded almost similar weed density and dry weight at different stages of crop growth. Highest values of plant growth in terms of number of tillers and plant height, yield attributes in terms of number of panicle, panicle length and number of filled grains were recorded in the treatment of 75 % RD fertilizer + vermicompost (2 t/ha) mixture 3 splits (before sowing, 30 and 60 DAS) + pretilachlor (750 g/ha) mixed with the first split followed by HW at 30 DAS. This treatment finally resulted in highest grain (2.1 t/ha) and straw yield (4.2 t/ha) which was closely followed by the treatment of RD fertilizer + pretilachlor as sand mixture before sowing followed by HW at 30 DAS, urea top-dressed with vermicompost (600 kg/ha) mixture at tillering and PI stage.

WP 1.4.3(i) Effect of weed management and water regimes on direct-seeded rice

RAU, Pusa

Weed flora in the experimental field was comprised of grasses*: Echinochloa crus-galli, E. colona, Digitaria sanguinalis, Dactyloctenium aegyptium, Cynodon dactylon;* sedges: *Cyperus rotundus, Cyperus difformis, Cyperus iria* and *Fimbristylis miliacea,* and broadleaved weeds*: Caesulia axillaris, Lippia nodiflora, Amaranthus spinosus, Amaranthus viridis, Eclipta alba, Phyllanthus niruri* and *Monochoria vaginalis.* The lowest weed population (12.4/m^2) and weed dry weight (19.4

g / m^2) were recorded in 3 days after disappearance of water (DAD) which were significantly superior over rest of the treatments in main plots. Among the different herbicide treatments, the lowest weed population (10.8 / m^2) and weed dry weight (17.2 g / m^2) were recorded in pendimethalin (1.0 kg / ha, PE) *fb* bispyribac-sodium (25 g / ha) at 20 DAS which were significantly superior over rest of the treatments in sub plots. The highest weed control effiency (71.4%) was recorded by weed free treatment which was closely followed by pendimethalin *fb* bispyribac-sodium at 20 DAS (62.3%) and pendimethalin *fb* chlorimuron + metsulfuron (4 g / ha) at 20 DAS (54.8%).

The highest grain yield of rice (3.6 t / ha) was recorded by weed free treatment which was statistically at par with pendimethalin *fb* bispyribac-sodium at 20 DAS (3.4 t / ha) and significantly superior over rest of the treatments in sub plots. Water use efficiency (WUE) was not influenced by moisture regimes. However, maximum WUE was recorded 5 DAD (48.6 kg / ha / cm) followed by 3 DAD (46.5 kg / ha / cm) and 7 DAD (44.6 kg / ha / cm). The highest WUE (52.4 kg / ha-cm) was recorded by weed free which was closely followed by pendimethalin *fb* bispyribac-sodium (49.6 kg / ha / cm). The maximum value of water productivity was recorded with pendimethalin *fb* bispyribac-sodium (3.98 ` / m$^3$) which was statistically at par with pendimethalin *fb* chlorimuron + metsulfuron at 20 DAS (3.9 ` / m^3) and chlorimuron+metsulfuron at 20 DAS (3.5 ` / m^3). The highest B: C ratio (1.9) was also recorded by 3 DAD water regime treatments which was significantly superior over rest of the treatments in main plots. In sub plots, the highest B: C ratio (1.9) was recorded by pendimethalin (PE) *fb* chlorimuron + metsulfuron which was statistically at par with pendimethalin *fb* bispyribac-sodium (1.8) and chlorimuron+ metsulfuron (1.8) in sub plot treatments.

WP 1.4.3 (ii) Effect of weed management and nitrogen on weed dynamics and yield of rice under aerobic condition

The major weed flora observed was *Echinocloa crus-galli, E. colona, Digitaria sanguinalis, Dactyloctenium aegyptium*, *Cynodon dactylon* as grasses; *Cyperus rotundus, Cyperus difformis, Cyperus iria* and *Fimbristylis miliacea* among sedges; *Caesulia auxillaris, Lippia nodiflora, Amaranthus spinosus, Amaranthus viridis, Eclipta alba, Phyllanthus niruri* and *Monochoria vaginalis* as broadleaved weeds. The lowest weed population (11.1 / m^2) and weed dry weight (24.9 g / m^2) were recorded in 160 kg N / ha which were significantly superior over rest of the treatments in main plots and the lowest weed population (7.9 / m^2) and weed dry weight (18.2 g / m^2) were recorded in weed free treatment (3 hand weedings at 20, 40 and 60 DAS) which were significantly superior over rest of the treatments in sub plots. Among the different herbicide treatments, the lowest weed population (8.9 / m^2) and weed dry weight (21.2 g / m^2) were recorded in pendimethalin + (pyrazosulfuron 25 g / ha + bispyribac-sodium 25 g / ha as (tank mix at 20 DAS) tank mix of pyrazosulfrron + bipyribac (25 + 25 g / ha at 20 DAS).

Highest grain yield of rice (3.6 t / ha) was recorded by the treatment 160 kg N / ha which was statistically at par with 140 kg N / ha (3.4 t / ha) in main plots and the highest grain yield of rice (3.9 t / ha) was recorded by weed free treatment which was significantly superior over rest of the treatments except pendimethalin + pyrazosulfuron + bispyribac-sodium (tank mix) (20 DAS) treatment (3.7 t / ha). The highest weed control efficiency (70.8%) was recorded under the weed free treatment which was closely followed by pendimethalin (PE) + pyrazosulfuron 25 g + bispyribac-sodium (tank mix) (20 DAS) (66.1%). There were not any phytotoxic effects on rice crop. Highest B: C ratio (2.1) was also recorded by 160 kg N / ha treatment which was statistically at par with 140 kg N / ha (2) in main plots. In sub plots, the highest B: C ratio (2.27) was recorded by pyrazosulfuron + bispyribac-sodium which was statistically at par with bispyribac-sodium (2.2) and pendimethalin + pyrazosulfuron + bispyribac-sodium (2.2) in sub plot treatments.

WP 1.4.3 (iii) Integrated nutrient and weed management on growth, yield and quality of aromatic rice

The major weed flora comprised of *Echinochloa crus-galli, E. colona, Digitaria sanguinalis, Dactyloctenium aegyptium*, *Cynodon dactylon* as grasses, *Cyperus rotundus, Cyperus difformis, Cyperus iria* and

Fimbristylis milliaceae among sedges, *Caesulia axillaris, Lippia nodiflora, Amaranthus spinosus, Amaranthus viridis, Eclipta alba, Phyllanthus niruri* and *Monochoria vaginalis* as broadleaved weeds.

The lowest weed population (13.6/m^2) and weed dry weight (26.1 g/m^2) were recorded in 50% RDN through inorganic source + 50% RDN through vermicompost which were significantly superior over rest of the treatments in main plots and the lowest weed population (10.9/m^2) and weed dry weight (20.2 g/m^2) were recorded in pretilaclor weed free treatment (2 HW at 20 & 40 DAT) which were significantly superior over rest of the treatments in sub plots. Among the different herbicide treatments, the lowest weed population (15.1/m^2) and weed dry weight (28.3 g/m^2) were recorded in 750 g/ha (P.E.) + 1 HW at 20 DAT which were significantly superior over rest of the treatments in sub plots. The highest weed control efficiency (66.2%) was recorded under the weed free treatment which was closely followed by pretilachlor 750 g/ha (P.E.) + 1 HW at 20 DAT (52.6%).The highest grain yield of rice (4.9 t/ha) was recorded by 50% RDN through inorganic source + 50% RDN through vermicompost which was statistically at par with 75% RDN through inorganic source + 25% RDN through vermicompost (4.7 t/ha) in main plots. There were no phytotoxic effects on rice crop. The highest B: C ratio (2.7) was recorded by the treatment 100% RDN through inorganic source which was significantly superior over rest of the treatments in main plots. In sub plots, the highest B: C ratio (2.4) was recorded by pretilachlor + bispyribac-sodium 25 g/ha at 20 DAT which was significantly superior over rest of the treatments in sub plot treatments.

WP 1.5 Station trials on weed management

WP-1.5.1(ii) Integrated weed management in soybean

PDKV, Akola

The major weed flora during *Kharif* were *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Ischaemum pilosum, Acalypha indica, Cardiospermum halicacabum, Ipomoea reniformis, Corchorus acutangulus, Phyllanthus niruri etc.* Significantly lowest weed count and weed dry matter was recorded in pendimethalin (1.0 kg/ha PE) at 20 DAS. At 40 DAS, imazethapyr (100 g/ha + quizalofop-ethyl 50 g/ha PoE) at 15 DAS (*Tank mix*) recorded lowest weed count and weed dry matter but found at par with imazethapyr (100 g/ha PoE), imazethapyr + imazamox (*premix*) (70 g/ha) at 15 DAS. At 60 DAS imazethapyr (100 g/ha) + quizalofop-ethyl (50 g/ha) (Tank mix) recorded lowest weed count and weed dry matter but found at par with quizalofop-ethyl (50 g/ha) + chlorimuron-ethyl (10 g/ha PoE) 15 DAS (*Tank mix*). Highest grain yield was recorded (2.4 t/ha) in weed free treatment which was closely followed by tank mix of imazethapyr + quizalofop- ethyl (2.4 t/ha) but both these treatment were statistically at par with each other and found significantly superior over rest of the treatments. Maximum gross monetary returns (` 80,619/ha) was registered with weed free treatment while imazethapyr + quizalofop-ethyl 50 g/ha at 15 DAS produced máximum net returns (` 79,400/ha) and benefit cost ratio (2.7).

WP- 1.5.1(iii) Integrated weed management in cotton

The major weed flora observed during *Kharif* in cotton crop were *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Ischaemum pilosum, Digitaria sanguinalis, Dinebra retroflexa, Digera arvensis, Euphorbia geniculata, Amaranthus viridis, Acalypha indica, Ipomoea reniformis, Phyllanthus niruri, Ageratum conyzoides* etc. At 30 DAS, 3 HW at 20, 40 and 60 DAS recorded lowest weed count and weed dry matter but statistically found at par with pendimethalin PE (1.0 kg/ha) *fb* 2 HW at 20 & 50 DAS. The highest weed control efficiency was recorded under 3 HW at 20, 40, & 60 DAS at all the growth stages. Further, lowest weed index was noticed in pyrithiobac-sodium (0.062 kg/ha) + quizalofop-ethyl (0.050 kg/ha) at 20 DAS (*Tank mix*) *fb* directed spray of glyphosate (2.00 kg/ha) 60 DAS. Highest seed cotton yield (2.4 t/ha) was registered with 3 HW at 20, 40 and 60 DAS which was at par with pyrithiobac-sodium + quizalofop-ethyl (*Tank mix*) *fb* HW at 50 DAS. Similar trend of result was noticed in stalk yield (t/ha).

WP-1.5.1 (iv) Efficacy of pre and post emergence herbicides in maize

The major weed flora in maize crop during *Kharif* were composed of *Xanthium strumarium, Celosia argentea, Portulaca oleracea, Lagascea mollis, Euphorbia geniculata, Euphorbia hirta, Phyllanthus niruri, Cyperus* *rotundus, Commelina benghalensis, Ischaemum pilosum, Poa annua,* etc. At 15 and 30 DAS, weed free treatment recorded significantly lower weed count and dry matter followed by atrazine 1.0 kg / ha PE and atrazine 0.50 kg + pendimethalin 0.50 kg / ha PE at 15 and 30 DAS. Later on the treatment atrazine 0.50 kg / ha *fb* 2,4-D sodium salt 0.5 kg PoE 30 DAS followed by atrazine (1.0 kg / ha PE) and atrazine (0.50 kg) + pendimethalin (0.50 kg / ha) PE showed superiority in minimizing the weed count upto harvest. Grain weight per cob was found maximum in weed free treatment followed by atrazine (0.50 kg / ha) *fb* 2,4-D sodium salt (0.5 kg PoE) 30 DAS and atrazine (1 kg / ha PE). Maximum B:C ratio was found in atrazine *fb* 2,4-D (3.2) than weed free treatment (2.9).

WP-1.5.1(v) Efficacy of post emergence herbicides in groundnut (*Arachishypogaea*)

Major weed flora during *Kharif* in groundnut were composed of *Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Ischaemum pilosum, Digitaria sanguinalis, Digera arvensis, Euphorbia geniculata, Alysicarpus monilifer, Alternanathera triandra, Portulaca oleracea, Amaranthis viridis, Acalypha indica* etc. At 20 DAS, weed count and dry matter were significantly lowest in pendimethalin (1.0 kg / ha PE). At 40 DAS, propaquizafop (0.10 kg / ha 20 DAS) recorded lowest weed count and weed dry matter but found at par with imazethapyr+ imazamox (0.10 kg / ha) at 20 DAS. At 40 DAS and at harvest maximum WCE was recorded with propaquizafop at 20 DAS followed by imazethapyr + imazamox at 20 DAS. Weed free check gave highest pod yield (2.6 t / ha) followed by post emergence application of propaquizafop 0.10 kg / ha PoE 20 DAS (2.5 t / ha with B: C ratio as 3.7) and imazethapyr+ imazamox (2.4 t / ha with B: C ratio as 3.5).

WP 1.5.2 Management of complex weed flora in garlic (*Allium sativum* L.)

AAU, Anand

Experimental field was dominated with *Eleusine indica, Dactyloctenium aegyptium, Digitaria sanguinalis, Commelina benghalensis, Chenopodium murale, Boerhaavia diffusa, Oldenlandia umbellata, Phyllantheus niruri* etc. Lowest weed density and dry biomass of monocot, dicot and total weeds was recorded significantly in straw mulch 5.0 t / ha. Significantly the lowest weed density of monocot, dicot and total weeds were recorded in oxyfluorfen (0.223 kg / ha PE). Significantly lowest weed dry biomass of monocot and total weeds were recorded at 75 DAP in hand weedings at 20 and 40 DAP without paddy straw mulch. At harvest, significantly the lowest weed density of monocot, dicot and total weeds were recorded in combination of paddy straw mulch with oxyfluorfen (0.223 kg / ha PE). While dry biomass of dicot and total weeds were recorded significantly lower in combination of paddy straw mulch 5.0 t / ha with pendimethalin (1.0 kg / ha PE) and HW at 20 & 40 DAP without paddy straw mulch, respectively. Bulb yield of garlic was significantly influenced by mulching treatment and significantly the highest bulb yield of garlic (8 t / ha) was recorded in paddy straw mulch and in PE application of pendimethalin (8.6 t / ha) separately but highest in combination with PE application of pendimethalin (1.0 kg / ha) with paddy straw mulch, but it was remained at par with the combination of mulching with PE application of oxyfluorfen. Highest B:C ratio was obtained with mulching (3.9), pendimethalin (4.4), paddy straw mulch 5 t / ha with pendimethalin (5.6) and application of oxyfluorfen with paddy straw mulch (5.5).

WP 1.5.3 (i) Studies on time of application of imazethapyr and its ready mix combination with imazamox (Odyssey) against weeds in blackgram

SKUAST, Jammu

Experimental field were dominated by *Cyperus* spp., *Cynodon dactylon, Digitaria sangunalis, Solanum nigrum, Physalis minima, Phyllanthus niruri, Setaria glauca* and *Equisetum* spp. were recorded as major weeds in the experimental field. The lowest weed density and weed biomass were recorded with pre-emergence application of imazethapyr + pendimethalin (RM) (1000 g / ha) which was statistically at par with PoE applications of imazethapyr (80 g / ha) and imazethapyr + imazamox (80 g / ha). The highest number of pods / plant, grain and straw yields were recorded with imazethapyr + pendimethalin (RM) which was statistically at par with the all the post-emergence applications of herbicides. Highest net returns and B.C ratio were recorded in with imazethapyr + pendimethalin followed by imazethapyr (Table 1.5.3.1).

Table 1.5.3.1 Effect of different weed management practices on weed and crop in summer blackgram

Treatments	Weed density (no./ m²) at 30 DAS	Weed density (no./m²) at 60 DAS	Weed biomass (g/m²) at 30 DAS	Weed biomass (g/m²) at 60 DAS	100-grain weight (g)	Grain yield (t/ha)	Stover yield (t/ha)
Imazethapyr 70 g (Pre-emergence)	8.0 (63.6)	9.1 (83.0)	4.2 (16.6)	4.9 (23.3)	2.9	0.5	1.6
Imazethapyr 80 g (Pre-emergence)	7.5 (56.3)	8.7 (76.0)	3.9 (14.7)	4.8 (22.4)	2.9	0.6	1.7
Imazethapyr 70 g (3-4 leaf stage)	7.1 (49.0)	6.6 (43.7)	3.4 (10.5)	4.2 (16.5)	3.1	0.6	2.1
Imazethapyr 80 g (3-4 leaf stage)	6.6 (43.3)	6.3 (38.7)	3.2 (9.4)	4.1 (15.6)	3.2	0.6	2.1
Imazethapyr + imazamox (RM) 70 g (Pre-emergence)	7.7 (59.3)	8.8 (77.3)	4.0 (15.3)	4.9(22.8)	2.9	0.6	1.6
Imazethapyr + imazamox (RM) 80 g (Pre-emergence)	7.5 (55.3)	8.6 (73.0)	3.8 (13.7)	4.7 (21.7)	2.9	0.6	1.8
Imazethapyr + imazamox (RM) 70 g (3-4 leaf stage)	6.8 (45.7)	6.5 (41.0)	3.29 (9.8)	4.1 (15.9)	3.1	0.7	2.1
Imazethapyr + imazamox (RM) 80 g (3-4 leaf stage)	6.6 (43.0)	6.4 (40.0)	3.2 (9.20)	3.9 (14.6)	3.2	0.7	2.1
Pendimethalin 1000 g (Pre-emergence)	8.0 (64.0)	9.3 (85.7)	4.3 (17.5)	4.9 (23.9)	2.9	0.6	1.4
Imazethapyr + pendimethalin (RM) 1000 g (Pre-emergence)	6.1 (36.3)	5.8 (33.3)	3.0 (8.3)	3.8 (13.9)	3.3	0.7	2.1
Hoeing (2) 15 & 30 DAS	5.4 (28.0)	5.9 (35.0)	2.7 (6.2)	3. 4 (10.3)	3.4	0.8	2.2
Weedy check	10.9 (118.0)	11.9 (141.7)	5.5 (29.5)	6.6 (42.9)	2.4	0.3	1.2
Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	3.5	0.9	2.4
SEm (±)	0.2	0.2	0.06	0.1	0.1	0.03	0.09
LSD (P=0.05)	0.5	0.6	0.2	0.3	0.4	0.1	0.2

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

WP 1.5.7 (ii) Critical period of crop-weed competition in aerobic rice

GBPUAT, Pantnagar

Relative weed density in the experimental field was found highest of sedges with 65.3% followed by grassy weeds and broad leaf weeds, i.e., 29.5 and 5.2%, respectively at 60 DAS. Grain and straw yield reduced significantly with increased weed competition period, i.e., yield continued to minimize as the duration of weed competition increased over 45 DAS. When aerobic rice field kept weed free only upto 15 DAS then yield reduction was 51.8% over the weed free plots followed by 32.1% in weed free plot upto 30 DAS. As weed free situation was extended upto 45 to 75 DAS the grain yield increased drastically and was statistically at par with season long weed free period. The highest grain yield (5.6 t/ha) was achieved with the plot which was kept weed free followed by weedy plot upto 15 DAS. No significant differences in the grain yield were observed when the experimental area was kept weed free until 45 to 75 DAS and weedy plot until 15 DAS. Thus, critical period of crop weed competition in the above study revealed that upto 15-30 DAS weed control is essential to avoid considerable reduction in the crop yield.

1.5.7. (iia) Weed management in direct (dry) seeded in rice-brahmi intercropping system

Major weed flora in DSR was *Cyperus rotundus*, *Echinochloa colona*, *Echinochloa cruss-galli*, *Alternanthera sessillis*, *Caesulia axillaris* and *Cyperus iria*. Intercropping of direct (dry) seeded rice and brahmi in the ratio 2:1 was found to be more effective in reducing the density as well as dry matter accumulation of weeds as compared to planting of DSR and brahmi in the ratio of 1:1. Amongst both ratios (1:1 and 2:1) of DSR and brahmi, application of pendimethalin at (1.0 kg/ha) applied as pre emergence *fb* cyhalofop-butyl at (0.1 kg/ha) as post-emergence supplemented with 1 HW at 45 DAS/P was found superior than other weed control treatments in respect to reducing the weed density as well as dry matter accumulation of weeds. However, sole planting of brahmi gave minimum weed dry matter accumulation of weeds among all the treatments might be due to more competitive and creating more coverage on ground surface which affect the germination of weed plants.

Highest grain (5.3 t/ha) and straw yield (9.8 t/ha) and land equivalent yield (1.5 and 1.4) of rice in 1:1 and 2:1 ratio was recorded with the application of pendimethalin applied as pre at (1.0 kg/ha) *fb* cyhalofop-butyl as post-emergence at (0.1 kg/ha) along with 1 HW at 45 DAS in sole crop DSR. Brahmi herbage yield was found maximum in sole brahmi (7.4 t/ha) with thrice HW (30, 45 and 60 DAS) with land equivalent yield of 1.0. Highest net returns and benefit cost ratio was found in the treatment of sole brahmi (` 7,17,000/ha) which was followed by sole crop of DSR (` 64,860/ha) in which pendimethalin was applied as pre at (1.0 kg/ha) *fb* cyhalofop-butyl as post emergence (0.1 kg/ha) along with 1 HW at 45 DAS. Among the two row ratios, maximum net returns and benefit cost ratio was found in 1:1 ratio in which pendimethalin *fb* cyhalofop-butyl along with 1 HW at 45 DAS (` 5,95,323/ha).

1.5.12 Preliminary study on herbigation in direct seeded rice

PAJANCOA&RI Karaikal, Puducherry

The predominant weeds of the experimental field were *Echinochloa colona, Eragrostis* spp., *Ludwigia parviflora, Eclipta prostrata* and *Cyperus iria*. Manual weeding twice at 20 and 40 DAS recorded significantly lower weed density (42.7 no./m^2), weed dry weight (23.1 g/m^2) and higher rice yield (2.42 t/ha). It was found to be on par with the pyrazosulfuron application by herbigation integrated with a manual weeding at 40 DAS (1.97 t/ha). Weed control efficiency (WCE) of oxadiargyl and pendimethalin by herbigation was found to be inferior to the application of pyrazosulfuron either alone or in integration with a manual weeding at 40 DAS. The yield loss ranged from 22.6 to 65.4% among the application of pre-em application of pyrazosulfuron, oxadiargyl and pendimethalin alone and 18.6 to 62.1% in integration with a manual weeding at 40 DAS.

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

WP 2.1 Monitoring of appearance of new weed species

To monitor the appearance of new weed species in particular region, surveillance was made at places of high risks (i.e. nearby area of public distribution systems, procurement centres, FCI godowns, garbage area or any other hot spot). Centre-wise report is given below:

AAU, Anand

New weed *Celosia argentea* was found in different *Kharif* fields' crops like maize, pigeonpea, soybean and pulses in many parts of Gujarat.

AAU, Jorhat

Sacciolepis indica: This weed is native of South-east Asia, but has not been recorded as serious weed in the crop fields ealrlier. During survey in 2016, this weed confirmed its expansion from non-crop areas to transplanted rice ecosystems, particularly in the summer season. The plant was also recorded in the coffee plantation at AAU, Jorhat campus. Morphologically *S. indica* differed from the most common weed *Sacciolepis interrupta* in having annual habit, thin and firm, non-floating, smaller spikelets (<3mm long). While, *S. interrupta* is a perennial rhizomatous grass, with spreading and semierect stems with hollow internodes, often floating, and spikelets are 3 to 5 mm in length.

Ludwigia peruviana: This invasive weed of semi-aquatic and aquatic habitat has already spreaded in Dhansiri river catchment area and eastern catchment of Kapili River in Karvi Anglong and Nagaon district of Assam. Its satellite patches had been discovered in Guwahati (Kamrup district) and Saran beel of Morigaon district. During 2016, the expansion of these patches has been noticed. Almost all the swampy plant species have been replaced by this weed at Guwahati and successfully colonized in its monocultural patch at Ulubari area. Similarly, at Morigaon, the weed has expanded its occurrence to the shore areas of the wetland "Saran beel" and occupied the drains and shaded areas, nearly up to 1 km distiance from the place of its first appearance in the beel.

CCSHAU, Hisar

Weed surveillance studies conducted in *Kharif* crops revealed that no new weed has appeared in any crop. Wild / weedy rice was not observed in any of the rice growing districts. Infestation of *Striga* was not observed in any part of state. Increase in intensity of new weed *Lolium* spp. was observed in wheat and barseem crops in Karnal, Kaithal, Ambala, Yamuna Nagar, Kurukshetra, Rania (Sirsa) and Tohana (Fatehbad) districts. *Coronopus didymus*, *Polypogon monspliensis* and *Poa annua* were becoming major weeds of berseem crop. Tomato and brinjal crops in Nuh, Punhana and Ferozepur Jhirka areas of Mewat and Dadri tehsil of Bhiwani district were severely infested with *Orobanche* spp. caused 30-70% decrease in fruit yield of both crops. Even taramira, radish, turnip, gobhi sarson and cabbage were found infested with *Orobanche* but Karan rye field had no infestation of *Orobanche*. In Sirsa, Fatehbad and Hisar districts, *Ipomoea* spp. has started infesting cotton crop and the infestation is increasing every year causing economic losses to the cotton growers. None of herbicide was effective against this weed.

DBSKKV, Dapoli

Baseliine survey was done in Raigad, Thane and Palghar districts in *Kharif* 2016. Survey was made in different crops and non-cropped areas and detailed information were documented. Dominant weed species in non-cropped areas and crop like rice and plantation crops *viz.* banana, coconut, sapota and mango have been covered. In addition, major weed species in nursheries were also documented.

GBPUAT, Pantnagar

Weed surveillance and monitoring was undertaken by the centre during *Kharif* and *Rabi* 2016. Different areas and hotspots such as seed plants, seed production centre, procurement centres and rice mills and seed companies. No new weed species was noticed in these areas.

IGKV, Raipur

Weed surveillance study revealed that *Alternanthra triandra* is now appeared in crop fields especially in DSR which covers major part of Chhattisgarh. It also found at road sides and bunds especially in Raipur district and adjoining plains of Chhattisgarh. Control of this weed after 4-5 leaf stage was difficult with prevalent herbicides like chlorimurom + metsulfuron, however, 2,4-D is still an effective solution for this weed. Other weeds invaded the non-cropped area were *Malwa pusila, Cenchrus ciliaris* in Chhattisgarh plains and *Chromolaena odorata* entering from southern parts of Chhattisgarh and knocking the door steps of C.G. Plains. The intensity of these weed is multiplying at a rapid pace. However, the good side of these invasions was that it was replacing *Parthenium hysterophorus.*

KAU, Thrissur

In Nelliyampathy of Palakkad district and in the Wayanad Wild Life Sanctuary (WWS), wild growth of invasive alien plant *Hypoestes phyllostachya* was noted. The plant was having quick growth and had the ability to eliminate ground vegetation. After the spread of the plant, appearance of spotted deer, which was commonly seen grazing on grass lands near the forest area, has reported to be very rare. It is suspected that the species came to the forest area from households in the nearby area where the plant was grown as an ornamental plant.

MPUAT, Udaipur

Weed carried out to monitor appearance of new weed species in hot spots like FCI godown, railway yards and krishi upaj mandies, PDS shops of Udaipur city and rural areas of different tehsils were surveyed twice in a season and baseline information were documented. No new weed flora was observed in these areas.

OUAT, Bhubaneswar

The weed surveillance exercise was carried out in two major agro-climatic zones *viz.*, - East and South Eastern Coastal Plain and Mid-Central Table Land during 2016. East and South Eastern Coastal Plain, infestation of few weed species like *Mikania micrantha, Parthenium hysterophorus, Eichhornia crassipes* and *Alternanthera philoxerroides* was on increase and became a serious problem in some areas. Sporadic incidence of *Orobanche* was observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda district along river Mahanadi. In Mid- Central Table Land Zone, *Celosia argentea, Echinochloa colona* and *Digitaria sanguinalis* were found to be major weeds.

PAU, Ludhiana

A new weed *Nicotiana plumbaginifolia* was observed in wheat fields in district Ludhiana.

PDKV, Akola

During survey work weed species *viz., Cassia tora, Celosia argentea* and *Alteranthera trianda* were found more prominently along roadside in Western & Central Vidarbha zone which needs effective weed management technology. Due to monocropping, heavy infestation of *Cuscuta reflexa* in some pocket of Western and Central Vidarbha zone (Akola, Buldana, Amravati Dist Yeotmal & Wardha Dist) was observed. It was also observed in some pocket on farmers field particular on soybean and pigeonpea crops. Escape of missing was observed in the research farm as a result of pre-emergence application of pendimethalin. This weed has infested pulse crop, *viz.*, soybean, pigeonpea, greengram and some weeds also. Infestation can be managed by crop rotation.

TNAU, Coimbatore

There was no new weed species noticed in three districts of study areas.

UAS, Bengaluru

Cassytha filiformis was found as a new weed in some areas. Further observations are being made for occurrence of new weed and marking of the geographical locations.

SKUAST, Jammu

Malvastrum coromandelianum and *Croton* spp. were indentified from non-cropped areas of Jammu region. However, no new weed species found in *Kharif* 2016 at high risks places (i.e nearby area of public distribution system, procurement centres, FCI, godowns, garbage area and other spots as compared to bench mark survey of *Kahrif* 2015.

BAU, Sabour

No new weed species was observed during survey in Bhagalpur and Banka districts.

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

Weed shift have been documented in long-term trials specific to cropping system allotted to a particular centre. Centre-wise report is given below:

AAU, Anand

In many districts of Gujarat, weed flora shifted towards monocot weeds in wheat crop fields due to continuous use of 2,4-D or metsulfuron-methyl to manage dicot weeds. Which provide opportunities to flourish monocot weeds and that did not control by said herbicides. Awareness campaign / training programme were organized to manage complex weed flora in wheat by using pre-mixed herbicides. Escape incidence of monocot weed *Commelina benghalensis* and dicot weed *Digera arvensis* after application of recommended herbicides in different crops were observed at farmers' fields and research farms. Escape of dicot weed *digera arvensis* was observed in the research farm as a result of pre-emergence application of pendimethalin.

AAU, Jorhat

A study was conducted in different developmental blocks of Jorhat distict of upper Brahmaputra Valley Agroclimatic zone in the winter season and several crop-land and non-cropland ecosystems of Bagsha, Bongaigaon and Dhubri districts of the lower Brahmaputra Valley Agroclimatic zone of Assam during *Kharif* of 2016. A distinct shift of weeds has been noticed in the East Jorhat DB. In the *Rabi* vegetable fields dominancy of *Oxalis debilis-Ageratum* complex was recorded in 2004-05, which was changed to *Stellaria media-Panicum repens* complex in 2010-11. However, in 2015-16, the sedge dominant situation was recorded (Figure 2.2.1)

Figure 2.2.1 Weed flora shift in *Rabi* vegetable fields of East Jorhat Developmental Block

The Kaliapani developmental block recorded weed flora shift from *Polygonum glabrum* IVI = 66.24), *Alternanthera philoxeroides* (IVI = 49.15) and *Ergrostis unioloides* (IVI = 25.03) of 2010-11 to *Cynodon dactylon-Cyperus rotundus-Amaranthus spinosus* dominant state in 2015-16.

In Bagsha and Dhubri districts, *Khaif* rice fields were surveyed between 20 to 30 DAT both in Bagsha and Dhubri districts. Broadleaved weeds have dominated the field at the early state of crop growth. Because of the influence of monsoon flood, *Eichhornia crassipes* appeared as the most dominant weed, pushing the most common obligate weeds of transplanted rice ecosystems *viz. Monochoria vaginalis* and sedges to the second and third positions, respectively in both the districts. Study also revealed presence of *Eichhornia crassipes* in both the districts and *Alternanthera philoxeroides* in Bagsha district due to the inundation crop fields by flood water; the runoff water current carried both the weeds from non-crop areas to those rice fields.

A distinct shift of weed flora was noticed in the jute fields of Bongaigaon district. In this district, prevalence of *Eragrostis unioloides*, *Spilanthes paniculata* and *Amaranthus spinosus* was prominent in 2001-02, which was changed to *Eichhornia crassipes-Hygroryza aristata* dominant status in 2016. Another important observation recorded during the study was the alarming increase of the troublesome weed *Celosia argentia* density in the entire district, which might create severe problem in near future. Comparing to about 2278 ha of land in Bongaigaon district, nearly 13075 ha of land was under jute cultivation in Dhubri district. Species diversitity of weed flora in the jute fields at Dhubri was higher than that of Bongaigaon district, the ratio of broadleaves, grasses and sedges was 7:6:2 and the ratio of their cumulative IV indices (dominance spectrum) was 182.5:95.1:22.4. Amongst the weed species, the most dominant three were *Eichhornia crassipes*, *Colocasia antiquorum* and *Paspalidium distans*.

Mesta (*Hibiscus sabdariffa*) is commonly cultivated in waterlogging areas throughout Dhubri district. The plants survived half merged in most of the places during monsoon season. The watery conditions destroyed the early emerged weeds, however, helped in prevalence of aquatic species. During the study, density and dominance of *Eichhornia crassipes* was recorded as the highest. The aquatic fern *Ceratopteris thalictroides*, broadleaved monocot *Colocasia antiquorum* and the perennial grass *Sacciolepis interrupta* were the next dominant weeds. Cococasia (Taro) is cultivated widely in marshland situations throughout the NE Region, hence, weed flora of this crop usually were of semi-aqutic nature. Species diversity of the weed flora in Dhubri distict was 11 numbers of BLWs, 3 sedges and 2 grassy species; their cummulatice IV indices were 220.9, 42.3 amd 36.2, respectively. *Curcuma angustifolia* was the most dominat weed and it was followed by *Ludwigia linfolia*, *Paspalum distichum* and *Centella asiatica.*

Unlike cropland weed flora, monoculture patches of different weed species have been recorded at different roadside locations. *Diplazium esculentum* was the most common, highly populated and dominat species, followed by *Senna tora, Hyptis suaveolens, Clerodendrum viscosum* and *Chromolaena odorata.* The non-cropland marshy areas in Bagsha district was occupied by nine numbers of common weeds during monsoon period of 2016 comprising of 5 grass and 4 broadleaved species. Amongst these weeds, *Eichhornia crassipes* and *Saccharum spontaneum* were the most dominant weeds.

As many as 26 species of macrophytes, comprising of 16 broadleaved species, 4 sedges and 6 grasses have been recorded as weed flora of aquatic situations in Dhubri district. *Eichhornia crassipes* possessed the highest IV index amongst all the species. However, suspended macrophyte *Ceratophyllum demersum* and submerged broadleved species *Vallisneria spiralis* were the highest populated weeds and possessed 27.3 and 21.7% relative density. It was also observed that the flood water was the main carrier agent for spreading of several problematic invasive weeds in the Brahmaputra Valley, including *Eichhornia crassipes*, *Ipomoea carnea*, *Paspalum distichum*, *Saccharum spontaneum* etc.

KAU, Thrissur

A permanent herbicide trial was started in 2001. This was continued upto 2014. Treatments included, hand weeding, continuous application of butachlor or pretilachlor or butachlor alternated with pretilachlor with or without FYM, and 2, 4-D application in all the treatments except hand weeding. During *Kharif* 2001, when the experiment was started, weeds of *Echinochloa* sp. were practically nil. Rainfall during first two months of the crop was high during the year (1120 mm). In 2002, with comparatively low rainfall during initial two months (770 mm), *Echinochloa* population was $34.6/m^2$. The following years witnessed a build up of the species *Echinochloa glabrescens* due to continuous application of butachlor/ pretilachlor which were ineffective to control *Echinochloa*. The year, 2008 was a dry year and the *Echinochloa* population rose to $178/m^2$. Then cyhalofop-butyl spraying was resorted during both the seasons and the number of *Echinochloa* could be brought down to $4.87/m^2$ during 2016. However, a shift in weed flora was not observed.

IGKV, Raipur

In *Kharif* direct seeded rice 2016, dominance of *Celosia argntea* was still noticed after the completion of the sixth year of long-term herbicide trial, which suppressed the *Alternanthera triandra* under normal weather condition.

PAU, Ludhiana

A long term field experiment to study the effect of continuous and rotational use of herbicides on shifts in weed flora and productivity of rice-wheat system was started in *Kharif* 1993. This long term experiment was concluded in *Rabi* 2015-16. In wheat, *Phalaris minor* and *R. dentatus* were the major weed species observed in wheat crop during the year 2004. In 2016, 8 weed species viz. *P. minor, R. dentatus, M. denticulata, A. ludoviciana, C. album, Fumaria parviflora, Coronopus didymus, P. annua* and *Anagallis arvensis* were recorded. In rice, *E. crus-galli, C. iria, I. rugosum* and *C. axillaris* were major weeds in 2004. In 2015, *Ammania baccifera, Alternanthera* sp. and *Cyperus compressus* also recorded.

Weed management in rice-wheat based conservation agriculture systems:

A long-term field experiment to study the effect of tillage and residue management practices on shifts in weed flora and productivity of rice-wheat system was started in *Rabi* 2012-13. In wheat, *Rabi* 2012-13, *P. minor, R. dentatus, M. denticulata, A. arvensis, C. album, C. didymus, Malva parviflora* and *F. parviflora* were major weeds. During *Rabi* 2015-16, *M. denticulata, C. album, M. parviflora* and *F. parviflora* were not observed but infestation of *Cyperus rotundus* was recorded. In *Kharif* 2013, major weeds observed in rice were *E. colona, E. crus-galli, D. aegyptium, C. iria, D. arvensis* and *C. compressus* but *Digiataria ciliaris, Eleusine indica, Euphorbia microphylla, Commelina benghalensis, Phyllanthus niruri, Acrachne racemosa* and *Eragrostis* spp. were also recorded in the field. During *kharif* 2016, *C. iria, Acrachne racemosa, E. indica* and *C. benghalensis* were not observed but two new weeds - *Cyperus rotundus* and *Alternanthera philoxeroides* were recorded.

PDKV, Akola

Duing this year, *Parthenium* was replaced by *Cassia tora* along the roadsides in Vidarbha region. *Alternanthera trianda* (Reshimkata) wide spread in non-crop area and on farmers field. A fast spread on grazing land after rainy season has been evident which create problem to grazing animals. In Wetern and Central Vidarbha zone in soybean based cropping system, continuous use of imazethapyr led to problem of resistance in *Commelina benghalensis* against imazethapyr.

OUAT, Bhubaneswar

Earlier, *Eichhornia crassipes* was confined to locations like ponds and ditches etc., but now it can be widely seen in low land rice fields of coastal districts of Cuttack, Puri, Ganjam and Balasore. A shift from

Alternanthera sessilis to *Alternanthera philoxerroides* was recorded in several low-lying rice areas of Jagatsinghpur, Kendrapara, Puri , Khurda and Jajpur. Sporadic incidence of *Orobanche* was observed in brinjal and tomato crops under the potential vegetable tracts of Cuttack and Khurda districts along river Mahanadi. Infetstation of *Cuscuta chinenesis* a parasitic weed was observed in niger crop of Semiliguda district. Heavy infestation of *Heliotropium* spp. was observed in the greengram and blackgram fields in coastal districts of cuutack, Puri, Jagatsingpur. Heavy infestation of *Mikania spp.* in banana has been observed in all the coastal districts.

RVSKVV, Gwalior

Sonchus aspera and *Vicia sativa* emered as a new weed in wheat field of farmers at Guna district while *Fumaria parviflora* and *Melilotus* spp. which were the major weeds in 2001-02 were not recorded in 2015-16. In coriander, *Melilotus* spp. and *C. rotundus* were present in 2001-02 but were not found in 2016. *Vicia sativa* and *Sonchus aspera* were emerged as new weeds in 2015-16. In pea crop, some weeds (i.e. *A. arvensis*, *C. album*, *L. asplenifolia* and *C. dactylon*) were recorded in 2001-02 but not in 2015-16. *Convolvulus arvensis* which was minimal in 2001-02 has became a prominent weed in 2015-16. *Saccharum spontaneum* emerged as new major weed in 2015-16 at Guna pea fields.

In wheat crop, *S. aspera* appeared as most prominent new weed in 2015-16. *Euphorbia geniculata, Melilotus spp.* and *C. rotundus* were listed as major weeds in 2003- 04 were not recorded in wheat field in 2015-16. *Vicia sativa* and *C. arvensis* were minor weeds in 2003- 04, but became major weeds in 2016. In Chickpea, *Launea asplenifolia*, *C. arvensis* and *S. spontaneum* which were minor weeds in 2003-04, have emerged as major weeds in 2015-16. *Anagallis arvensis* and *C. album* were prominent weeds in 2003- 04 were not recorded in 2015-16. In coriander, *V. sativa, S. asper* and *C. arvensis* emerged as major weeds in 2015-16. *Anagallis arvensis, E. geniculata* and *C. rotundus* which were prominent weeds of coriander fields in 2003-04 were not recorded in 2015-16. In lentil, *Sonchus asper* was observed as major weed in 2015-16. *Convolvulus arvensis*, the minor weed in 2003-04 in lentil crop shifted to major one in 2015-16, however, *E. geniculata* and *L. asplenifolia* shifted from major to minor weeds in 2015-16.

TNAU, Coimbatore

Monitoring of weed flora was done in the ongoing permanent herbicide trials with rice- rice cropping system. *Echinochloa crus-galli* and *Ludwigia parviflora* were dominant species in broad leaved weeds, *Cyperus iria* and *Cyperus nudans* under sedges present in the field in both *Rabi* 2015 and *Kharif* 2016 in 3rd cycle in the long term rice- rice system. So far, not much shift has been noticed in weed flora.

RAU, Pusa

Initially dominant weed species were *E. colona*, *D. aegyptium*, *C. dactylon*, C. *rotundus*, *E. indica*, and *A. viridis* during *Kharif* in transplanted rice crop but with the passage of time *Caesulia auxillaris* and *Cleome viscosa* have emerged as the dominant weeds. Similarly, during *Rabi*, initially dominant weeds were *R. dentatus*, *C. album*, *C. rotundus*, *C. dactylon*, *M. alba*, *M. indica*, *C. sativa*, and *A. fatua* but a shift was observed in weed flora as *P. minima*, *P. minor*, *S. nigrum*, *Launea pinnatifida* and *C. arvense* became dominant weeds.

SKUAST, Jammu

In conservation agriculture experiment *Alternanthera philoxeroides* and *Caesulia axillaris* were significantly higher in transplanted rice as compared to direct seeded rice. However, density of *P. niruri* and *P. minima* were significantly higher in direct seeded rice as compared to transplanted rice.

MPUAT, Udaipur

This centre is estblished very recently and has no long-trem trial in place. A benchmark survey (GPS based) was carried out in 23 villages of 10 tehsils of Udaipur district. During surveys, major crops and dominant crop-wise weed flora, weed management practices was documented for future reference.

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

After development of resistance in *P. minor* against isoproturon, some alternate herbicides were recommended. It has also been reported that some biotypes of *P. minor* had developed resistance against alternate herbicides. Therefore this experiment was started to study the efficacy of combination of herbicides against resistant biotypes (cross resistant) of *P. minor*.

CCSHAU, Hisar

Based on the observations recorded from farmers interviews and experiments being conducted at farmers fields, greenhouse bioassay studies, it appeared that *P. minor* has developed resistance against clodinafop-propargyl in Kaithal, Kurukshetra, Karnal, Jind, Panipat and parts of Sonipat, Fatehbad, Ambala and Sirsa districts of Haryana. To control resistance problem against clodinafop at farmers fields, use of mesosulfuron +iodosulfuron (RM) 14.4 g/ha, sulfosulfuron+ metsulfuron (RM) at 32 g/ha and pinoxaden at 70 g/ha performed well exhibiting 85% control of *P. minor* resulted in good yields. In some rice-wheat cropping areas, farmers have started using double the recommended dose of clodinafop or sequential application / tank mix of clodinafop and sulfosulfuron and metribuzin for the control of *P. minor*; even these mixtures were not work well. The problem was worse in areas under continuous use of a particular herbicide. Seeds from *P. minor* plants, escaped after the application of higher doses/tank mixes of these herbicides, were collected and were being screened for monitoring the evolution of resistance against the recommended herbicides.

The pot-culture studies with 20 biotypes of *P. minor* from farmers' fields in different parts of Haryana indicated decrease in efficacy of one or two herbicides. Clodinafop and sulfosulfuron at X dose were effective (≥80% control) against 9 biotypes, and mesosulfuron + iodosulfuron and pinoxaden against 17 biotypes. Efficacy of mesosulfuron + iodosulfuron and pinoxaden against majority of the biotypes from farmers' fields indicated their suitability in management of herbicide resistance in *P. minor*. Clodinafop and sulfosulfuron were not effective (≤20% control) against five and one biotypes, respectively. Sequential application of pendimethalin (1.5 kg/ha PRE) followed by tank mix pinoxaden+ metsulfuron (64 g /ha) or mesosulfuron+ iodosulfuron 14.4g/ha POE provided excellent control of *P. minor* as well as broadleaf weeds. Although, in the absence of pendimethalin PRE, pinoxaden+metsulfuron (64 g /ha POE), mesosulfuron+iodosulfuron (14.4 g/ha POE) and sequential application of sulfosulfuron (25 g /ha) followed by pinoxaden (60 g/ha) were effective against *P. minor* but some yield reductions were noted. Alone PRE application of pendimethalin+ metribuzin was effective against *P. minor* at higher dose of pendimethalin but due to the toxicity of metribuzin on wheat significant reductions in yield was recorded.

PAU, Ludhiana

After development of resistance in *P. minor* against isoproturon, alternate herbicides namely clodinafop, sulfosulfuron and fenoxaprop were recommended. To monitor the response of *P. minor* to these herbicides, seeds of ten *P. minor* populations escaped after the application of different herbicides at farmers' field were collected during *Rabi* 2014-15 and were sown in rows during *Rabi* 2015-16. Six herbicides viz. isoproturon, clodinafop, sulfosulfuron, fenoxaprop-p-ethyl, pinoxaden and mesosulfuron+ iodosulfuron were sprayed at their recommended doses, across the rows at 30 days after sowing. Dry matter of five plants was recorded at 30 days after spray (DAS) for assessing the efficacy of different herbicides. Populations differed significantly in their response to herbicides with respect to mortality and dry matter accumulation at 30 DAS. Isoproturon failed to control any of the biotytpes. Clodinafop and fenoxaprop-p-ethyl exhibited satisfactory control of only three biotypes. Pinoxaden caused > 70 % mortality of all populations except two populations indicating the development of cross resistance in *P. minor* to pinoxaden. Sulfosulfuron and mesosulfuron+iodosulfuron provided satisfactory control of all biotypes. Dry matter accumulation was minimum in mesosulfuron+ iodosulfuron treatment and this herbicide caused >80 % mortality of all *P. minor* populations. However, pinoxaden, sulfosulfuron and mesosulfuron+ iodosulfuron recorded about 70% mortality of *P. minor* populations (Table 2.3.1).

Table 2.3.1 Percent mortality and dry matter of *P. minor* populations under different herbicides

Herbicides dose (g/ha)	% Mortality (20 DAS)	Dry matter (mg/plant) (30 DAS)
Unsprayed control	0	38.7 (1500)
Isoproturon (1250)	0	30.2 (914)
Clodinafop (400)	43.7	30.6 (1080)
Fenoxaprop–p-ethyl (1000)	43.7	27.1 (744)
Pinoxaden (400)	66.7	17.6 (324)
Sulfosulfuron (33.75)	81.3	17.7 (314)
Mesosulfuron+ iodosulfuron (400)	89.0	11.1 (123)
SEm±	1.2	0.8
LSD (P=0.05)	3.3	2.3
P. minor populations		
P_1	39.0	25.2 (708)
P_2	37.1	25.3 (712)
P_3	41.9	24.9 (707)
P_4	56.2	22.5 (579)
P_5	57.1	22.9 (605)
P_6	43.3	24.4 (681)
P_7	41.0	24.7 (692)
P_8	44.3	25.3 (716)
P_9	59.5	23.7 (639)
P_{10}	43.8	28.3 (1101)
SEm±	1.4	1.0
LSD (P=0.05)	3.9	2.8

Data subjected to square root transformation; Parentheses are means of original values

Chlorophyll fluorescence studies:

Fv/Fm values of *P. minor* population (P_1) which was resistant to isoproturon, clodinafop, fenoxaprop-p-ethyl and pinoxaden but not to sulfosulfuron and mesosulfuron + iodosulfuron were recorded. The observations on chlorophyll fluorescence were taken at 24 hr, 5 days and 15 days after spray. Only sulfosulfuron and mesosulfuron + iodosulfuron treatments caused significant reduction in Fv/Fm ratio as compared to unsprayed control at 5 and 15 DAS. Isoproturon, clodinafop, fenoxaprop-p-ethyl and pinoxaden failed to cause any decrease in Fv/Fm ratio at any stage indicating the development of resistance in *P. minor* against these herbicides (Table 2.3.2).

Table 2.3.2 Chlorophyll fluorescence (Fv/Fm ratio) of *P. minor* under different herbicide treatments

Herbicides dose (g/ha)	24 hr after spray	5 days after spray	15 days after spray
Unsprayed control	0.748	0.739	0.743
Isoproturon (1250)	0.750	0.728	0.736
Clodinafop (400)	0.742	0.728	0.736
Fenoxaprop–p-ethyl (1000)	0.740	0.731	0.731
Pinoxaden (400)	0.748	0.737	0.725
Sulfosulfuron (33.75)	0.744	0.703	0.646
Mesosulfuron+ iodosulfuron (400)	0.741	0.689	0.620
SEm±	0.004	0.003	0.004
LSD (P=0.05)	NS	0.01	0.03

Phalaris minor (Resistance to isoproturon and inheritance of resistance to alternate herbicides).

Seeds of one isoproturon resistant *P. minor* biotype were exposed to six herbicides at graded doses in pots. Herbicides were applied at 35 DAS and weed dry matter was recorded on 30 days after spray to calculate GR_{50} values. Isoproturon, fenoxaprop, clodinafop and pinoxaden recroded higher GR_{50} values than their recommended doses (Table 2.3.3). The calculated GR_{50} values for the sulfosulfuron and mesosulfuron plus iodosulfuron were lower than their recommended doses. The results indicated that this biotype has developed multiple-resistance including isoproturon, clodinafop, fenoxaprop and pinoxaden.

Table 2.3.3 GR_{50} values of isorproturon resistant *P. minor* biotype to different herbicides

Herbicides	**Recommended dose (g/ha)**	**GR_{50}**
Isoproturon	1250	2233
Clodinafop	400	669
Fenoxaprop	1000	1710
Pinoxaden	400	582
Sulfosulfuron	33.75	25.1
Mesosulfuron+iodosulfuron	400	201

GR_{50}-Dose required for 50% retardation of growth in terms of biomass

WP 2.4 Threshold study of important weed species

AAU, Jorhat

This experiment was started with the objective to study the loss of yield and quality of crop under the influence of different density of selected weed species. In transplanted *Kharif* rice (var. Ranjit) the threshold level of *Echinochloa crusgalli* was found as 70 / m^2 while the tested densities of the weeds were 0, 10, 20, 30, 40, 50, 60, 70, 80, 90,100, 110, 120 and 130 in 2015. Based on this finding, *Echinochloa* densities 0, 10, 20, 30, 40, 45, 50, 55, 60, 65, 70, 75 and 80 were taken into account for further refinement of the threshold level in 2016. Rice variety *Ranjit* was transplanted on 19th July, 2016 in well puddle soil at the ICR Farm of AAU, Jorhat by strictly following the recommended package of practices except the weed management. Weed seeds were sown just after transplantation of the crop and all these 13 treatments were tested with 3 replications in randomized block design. Desired population density of these weed species were maintained up to 80 DAT by manual uprooting of all other weeds. The crop was harvested on 25.11.2016.

Rice var. *Ranjit* had average stature of around 96 cm at their vegetative stage. Total number of tiller of rice per square meter area did not differer significantly because of competition with the weed; but the panicle / m^2 was the highest under competition with *Echinochloa* density 20 / m^2 (344.6), which was at par up to the weed density from 0 to 55 / m^2. The grain yield of the crop varied from 4.15 to 5.79 t / ha and straw yield from 8.5 to 11.8 t / ha (Table 2.4.1). Rice yield under *Echinochloa* density from 0 to 60 / m^2 did not possessed significant difference with the highest yield, beyond which the yield reduced drastically. Significant yield reduction started at the weed density 65 / m^2, and therefore, this density of *E. crus-galli* can be considered as the threshold limit in transplanted *Kharif* rice (var. Ranjit).

Table 2.4.1 Crop height, tiller number, panicle number and crop yield of transplanted *Kharif* rice under competition with different densities of *Echinochloa crus-galli*

Echinochloa density	Crop height (cm)	Panicle no./m^2	Grain yield (t/ha)	Straw yield (kg/ha)
0	103.0	344.3	5.8	11.9
10	100.0	341.7	5.7	11.8
20	95.3	344.7	5.9	11.7
30	94.7	340.3	5.6	11.3.
40	95.0	338.7	5.5	11.2
45	97.3	343.3	5.6	11.4
50	93.3	343.0	5.6	11.3
55	94.7	343.3	5.5	11.2
60	98.0	335.7	5.5	11.2
65	96.0	309.0	5.3	10.7
70	98.3	302.3	5.4	11.0
75	96.0	272.0	4.9	10.1
80	93.0	268.7	4.1	8.5
LSD (P=0.05)	NS	6.3	0.3	0.6
GM	96.5	325.5	5.4	11.0

Table 2.4.2 Phenological stages of rice and *Ischaemum rugosum*

Phenological stage of rice	Days after transplanting (DAT)
Panicle initiation	66
50 % panicle emergence	74
100 % panicle emergence	80
Physiological maturity	108
Harvest maturity	115
Phenological stage of *I. rugosum*	
Emergence of seedlings	40
Flowering initiation	78
Completion of flowering	90
Maturity	120

Table 2.4.3 Effect of *I. rugosum* density (no./m^2) on yield and yield attributes of rice

Density of *I. rugosum* (no./m²)	Plant height (cm)	Effective tillers (no./m²)	Biological yield (t/ha)	Grain yield (t/ha)
0	67.7	242	13.5	7.3
1	68.7	242	13.6	7.3
2	67.7	240	13.6	7.3
4	68.3	238	13.3	7.2
6	68.2	236	13.5	7.2
8	69.3	243	13.7	7.3
10	68.4	246	13.4	7.2
SEm±	0.9	3.6	0.3	0.2
LSD (P=0.05)	NS	NS	NS	NS

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

WP 3.1 Biology of important weeds

Co-operating centres: Hisar, Ludhiana, Thrissur, Coimbatore and Hyderabad

Biology of *Ischaemum rugosum*, *Melochia corchorifolia* and *Alternanthera* spp., *Ammania baccifera* and *Cleome viscosa* was determined at Ludhiana, Thrissur and Coimbatore, respectively. Two different species of *Alternanthera* viz., *Alternanthera bettzickiana* and *Alternanthera brasiliana*, commonly found in the garden lands of Kerala, were studied. Seeds collected in the month of April- May were sown in plastic containers of size 16 m^2, kept in the net house and irrigated at an interval of 3 days. Observations on number of days taken from germination to flowering and fruit maturity were noted. It was observed that *A. bettzickiana* had low germination percent (50%) and took 50 and 60 days to reach up to flowering and maturity stage, respectively while germination percentage was 70% in *A. brasiliana* and it took 90 and 60 days to reach up to flowering and maturity stage, respectively.

Seeds of *A. brasiliana* were found to be bigger in size and the seed weight was also higher as compared to *A. brasiliana*. Average number of flowers and seeds per plant was higher for *A. bettzickiana* (875) as compared to *A. brasiliana* which had only half number of seeds (483). Growth rate was faster for *A. bettzickiana* as compared to *A. brasiliana*. Relative growth rate of the weeds at 10 days interval was estimated on the basis of dry weight. Data indicated initial slower growth of *A. bettzickiana* for 20 to 30 days as compared to *A. brasiliana* but from 30-50 days the growth rate was reversed.

Comparison of phenophases 50 days after germination

Melochia corchorifolia, is a major problem in the sesame cultivating areas of Kayamkulam in Kerala. The plant is an annual, germinating from seeds. Eighty percent germination was observed when the seeds were sown on the soil surface and 68% at a depth of 5 cm. The percent germination was only 8 when the seeds were sown at a depth of 10 cm. No seeds germinated when sowing depth was increased to 15 cm. Phenological studies revealed that the plant took 7 days from germination to 4 to 5 leaf stage, at this stage the seedlings can be identified in the field. To complete the vegetative growth it took 53 days. The period from vegetative stage to flowering extended to 30 days. From flowering to seed locule formation it took 6 to 8 days. Seed maturation occurs after 20-25 days.

Only 1 to 2% of the freshly harvested seed germinated in the month of June while the germination during other months was negligible. However when the seeds were dipped in hot water for 7 to 10 seconds; 70 to 90 of the seeds germinated, indicated that the seeds have seed coat dormancy or dormancy due to inhibitory substances which has to be further confirmed. However the vigour of the seedlings was higher with 7 seconds treatment of hot water.

Studies done on germination ecology of *Ischaemum rugosum* at Ludhiana revealed that germination of this weed was independent of light. Highest germination was recorded in the temperature regime of 30/20°C; however, seeds were able to germinate under wide temperature range of 15/5 to 35/25°C. The weed did not germinate at 40/30°C. Germination of *I. rugosum* was sensitive to moisture stress with complete inhibition at water potential equal to or more than -0.8 MPa (Table 3.1.1). At -0.4 MPa, germination was reduced by about 33.4% points with germination speed reduced to half and seedling vigor reduced by more than half as compared to their respective controls.

Table 3.1.1 Effect of moisture stress on germination ecology of *Ischaemum rugosum*

Osmotic potential (MPa)	Germination (%)	Germination speed	Seedling vigor index
Control	96.7	12.9	964
-0.1	86.7	11.0	682
-0.2	76.7	8.1	562
-0.4	63.3	6.1	395
-0.6	57.8	4.5	272
-0.8	0	0	0
SEm±	1.4	0.24	18.4
LSD (P=0.05)	5.0	0.87	66.8

Highest (80.5%) seed emergence of *I. rugosum* was recorded at 0-1 cm depth. When placed at 4 cm depth, the emergence was reduced by about 50% compared to surface placed seeds. Emergence was more than 20% when placed at 6 cm depth and no emergence was recorded when seeds were buried at ≥ 8 cm.

Biology of *Ammannia baccifera* and *Cleome viscosa,* under cropped situation was studied at Coimbatore. *Ammannia baccifera* emerged from 0 to 7.5 cm depth of soil and the emergence was higher in the top 2.5 cm of the soil. Flowering started 55-85 days after emergence, and seeds matured on 10-17 days after flowering. Seed production was around 7200 - 8100 seeds/plant. *Ammannia baccifera* complete life cycle with quick multiplication rate in 90-120 days period.

Cleome viscosa emerged mostly from the top 2.0 cm of the soil profile, with few emerging seeds located deeper than one 2.5 cm. More deeply buried seeds remain dormant. The days to emergence from the soil ranged between 4 to 10 days. *Cleome viscosa* completed its life cycle within 90-110 days and produced 170-230 seeds per pod.

WP 3.2 Management of problematic weeds

3.2.1 (a) *Orobanche*

Crop : Mustard/Tomato/Brinjal/Tobacco

Cooperating centers: Anand, Faizabad, Hisar Pusa, Udaipur

Mustard: Bioefficacy of different treatments were evaluated at Hisar against *Orbanche* in mustard. Soil application of neem cake at sowing *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* soil drenching of metalaxyl 0.2% at 25 DAS, neem cake *fb* metalaxyl 0.2% at 25 DAS did not prove effective in minimizing population of *Orobanche aegyptiaca* at 90 and 120 DAS. Presence of *Orobanche* throughout crop season caused 29.6% reduction in seed yield of mustard as compared to use of glyphosate 25 g/ha at 25 DAS and 50 g/ha at 55 DAS (RP). Glyphosate at recommended as well as 125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS provided 86-89 % control of *Orobanche* with 1.7-2.2 stalks/m^2 as against 117/m^2 in untreated check up to 120 DAS. Addition of $(NH_4)_2SO_4$ was found slightly effective for control of *Orobanche* over RP.

Tomato: In tomato, excellent control of Egyptian broomrape was obtained with post or pre plus post treatments of sulfosulfuron and ethoxysulfuron when compared with non-treated controls. During 2015-16, *Orobanche* stalks to the tune of 0.67-4.0 panicles/m^2 appeared in various herbicide treatments which was significantly less than untreated control. Weed control efficiency (WCE) in various herbicide treatments calculated on the basis of fresh weight of broomrape spikes varied from 85.2-89.2%. Treatment of ethoxysulfuron 25 g/ha was more phytotoxic than post and tomato exhibited severe growth reduction. Minor developmental delay in tomato was observed with ethoxysulfuron applied pre or 30 DAS at 25 g/ha. Residues of sulfosulfuron and ethoxysulfuron at any dose and time of application did not cause adverse effect on succeeding sorghum crop as evident from number of plants/meter row length, plant height and sorghum yield at 45 DAS (Table 3.2.1). It was observed that none of the samples of soil and tomato were having residues of any of the applied herbicides above detection limit of 0.01 µg / ml (in case of sulfosulfuron, ethoxysulfuron) and 0.001 µg / ml (in case of pendimethalin and metribuzin).

Table 3.2.1 Effect of different weed control measures on *broom rape (Orobanche)* and fruit yield of tomato

Treatment	Broom rape control (%)		Broom rape spike length (cm)	Plant height (cm)	Crop phytotoxicity (%) harvest	No. of fruits/ plant	Fruit yield (t/ha)	B:C
	120 DAP	Harvest						
Neem cake 200 kg / ha at sowing *fb* pendimethalin 1.0 kg / ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2 % at 20 DAT	18 .4 (10)	12.9 (5.0)	14.7	40.5	0 (0)	16.7	11.20	4.6
Neem cake 200 kg / ha at sowing *fb* metribuzin 0.5 kg / ha pre-em, 3 DAP *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAT	15.9 (8)	0 (0)	15.2	39.8	0 (0)	16.0	9.10	3.8
Neem cake 200 kg / ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAT	0(0)	0 (0)	14.8	38.0	0(0)	16.3	10.31	4.4
Ethoxysulfuron 25 g / ha (PRE) and 50 g / ha at 45 DAT	63.5 (80)	53.7 (65)	6.3	35.9	23.6 (15.7)	20.6	13.5	5.4
Ethoxysulfuron 25 g / ha (PRE) *fb* 50 g / ha as 30 and 60 DAT	67.4 (85)	65.2 (82.3)	8.3	36.2	30.6 (25.7)	19.0	13.8	5.2
Ethoxysulfuron 25 g / ha at 30 and 60 DAT	59.6 (75)	56.8 (70)	7.6	42.8	0(0)	26.4	16.8	7.0
Ethoxysulfuron 25 g / ha at 45 DAT *fb* 50 g / ha 90 DAT	69.5 (88)	67.4 (85)	8.2	41.9	0(0)	27.9	19.2	7.9
Ethoxysulfuron 25 g / ha at 60 & 90 DAT	74.8 (90)	59.8 (75)	8.0	41.7	0(0)	29.2	19.9	8.2
Sulfosulfuron 50 g / ha at 60 and 90 DAT	75 (90)	71.9 (90)	7.8	42.9	0(0)	28.7	20.5	8.8
Sulfosulfuron 25 g / ha at 60 and 90 DAT	65.4 (82.7)	60.1 (75)	6.8	42.5	0(0)	27.0	19.7	8.2
Weedy check	0(0)	0	15.9	37.5	0(0)	13.3	8.6	3.8
S Em ±	3.6	1.2	-	0.4	0.7	2.1	2.1	-
LSD (P=0.05)	10.7	3.6	1.	1.2	2.0	0.7	0.7	-

*Original figures in parenthesis related to broom rape density were subjected to square root transformation ($\sqrt{X+1}$) before statistical analysis. Values on broom rape control were subjected to arc /sin transformation before statistical analysis. Broom rape did not emerge above ground up to 90 DAP so no data is generated

Brinjal: Application of neem cake during sowing in combination with pendimethalin or metribuzin followed by soil drenching by metalaxyl MZ 0.2 % at 20 DAT did not cause any inhibition in broom rape (*Orobanche*) emergence as evident from density of *Orobanche* at 90, 120 DAP and harvest. Metribuzin applied at 3 DAP proved highly toxic to brinjal and resulted in complete mortality. Although excellent control of *Orobanche* was obtained with post or pre plus post treatments of sulfosulfuron and ethoxysulfuron when compared with non treated controls but found phytotoxic to brinjal crop. Maximum B: C ratio (11.1) was obtained with post emergence use of sulfosulfuron (25 g / ha) at 60 and 90 DAT and minimum (6.7 & 6.8) with use of ethoxysulfuron (25 g / ha) (pre) & 50 g / ha) at 45 DAT and ethoxysulfuron (25 g/ha) at 30 and 60 DAT, respectively (Table 3.2.2).

Table 3.2.2 Effect of different weed control measures on *broom rape (Orobanche)* visual control, plant height, toxicity and fruit yield of brinjal

Treatment	Visual broom rape control (%)		Plant height (cm) 120 DAP	No. of fruits/ plant	Fruit yield (t/ha)	B:C
	120 DAP	Harvest				
Neem cake 200 kg / ha at sowing *fb* pendimethalin 1.0 kg / ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2 % at 20 DAT	0(0)	0	110.6	14.0	24.2	7.9
Neem cake 200 kg / ha at sowing *fb* metribuzin 0.5 kg / ha pre-em, 3 DAP *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAT	0(0)	0	0.0	0.0	0.0	0.0
Neem cake 200 kg / ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAT	0(0)	0	112.7	13.0	24.8	8.4
Ethoxysulfuron 25 g / ha (PRE) and 50 g / ha at 45 DAT	64.7(85.0)	82	55.4	14.0	20.6	6.7
Ethoxysulfuron 25 g / ha (PRE) *fb* 50 g / ha as 30 and 60 DAT	90(100.0)	95	52.4	13.3	21.7	7.3
Ethoxysulfuron 25 g / ha at 30 and 60 DAT	68.4(86.3)	80	59.5	12.0	19.8	6.8
Ethoxysulfuron 25 g / ha at 45 DAT *fb* 50 g / ha 90 DAT	79.5(95)	90	53.2	12.7	22.6	7.7
Ethoxysulfuron 25 g / ha at 60 & 90 DAT	66.8(84.3)	85	68.2	16.7	25.7	8.8
Sulfosulfuron 50 g / ha at 60 and 90 DAT	75(90)	90	72.9	18.7	24.8	7.9
Sulfosulfuron 25 g / ha at 60 and 90 DAT	63.5(80)	85	106.4	22.0	32.0	11.1
Weedy check	0(0)	0	111.1	14.3	24.9	8.6
S Em ±	3.2	-	1.7	0.6	0.4	-
LSD(P=0.05)	9.6	-	5.2	1.9	1.3	-

Tobacco: In background of recommendations made to control *Orobanchae* in tobacco from other centers of AICRP-WM, an On Farm Trial (OFT) was conducted at Faizabad. Emergence of *Orobanche* shoots as well as dry weight was affected adversely due to neem cake 200 kg / ha treatment only up to 45 DAP stage. As the stage advanced, *Orobanche* shoots growth was not declined to the reasonable level while other treatments imazethapyr at (30 g / ha) and glyphosate (2 g/L) applied at 20 DAP substantially declined number of shoots and shoot dry weight at 90 DAP stage. The neem cake treatment found even more effective over imazethapyr and glyphosate. About 90.2% increase in tobacco leaf yield was recorded due to use of 200 kg / ha neem cake as compared to control treatment consequently higher leaf yield per plant (265.9 g) was also achieved than other treatments.

The use of neem cake treatment proved economically followed by imazethapyr (30 g / ha), soil drenching of metalaxyl MZ 0.2% at 20 DAP and glyphosate (0.2 g / L).

The yield reduction due to this weed was found up to 60 to 80% in tobacco in Bihar. Therefore, experiment conducted at RAU, Pusa revealed that 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 yield (2.4 t / ha). Imazethapyr (30 g / ha) at 40 DAP caused severe phytotoxicity on tobacco leaves.

The growth of plant was severely stunted and size of leaves was decreased leading to loss in yield of the crop. The highest net return (` 3,42,600 / ha) and B:C ratio (2.2) were recorded by neem cake 200 kg / ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAP which were significantly superior over rest of the treatments (Table 3.2.3).

Table 3.2.3 Management of *Orobanche* in tobacco in Bihar

	Herbicide	Number of *Orobanche* / tobacco plant			Tobacco yield (t/ha)	Gross return (`/ha)	Net re turn (`/ha)	B:C ratio
		60 DAP	90 DAP	At harvest				
W_1	Neem cake 200 kg / ha at sowing *fb* soil drenching of metalaxyl MZ 02.% at 20 DAP	5.1	8.1	12.0	2.4	4,78,400	3,42,600	2.2
W_2	Imazethapyr 30 g / ha at 40 DAP	10.8	13.9	16.7	1.7	3,41,000	1,90,200	1.3
W_3	Glyphosate 0.2 g / L at 20 DAP	9.1	11.9	15.1	1.9	3,77,400	2,27,100	1.5
W_4	Soil drenching of metalaxyl MZ 0.2% at 20 DAP	6.9	5.8	14.7	1.9	3,95,000	2,44,200	1.6
W_5	Weedy check	22.3	25.7	26.8	15.2	3,05,000	1,55,000	1.0
S. Em±		0.2	0.6	0.7	0.5	4,121	4,121	0.1
LSD (P=0.05)		0.6	1.8	2.1	1.5	12,365	12,365	0.2

Orobanche management was conducted in tobacco at Anand. Number of *Orobanche* shoots emerged at 60 and 90 DATP and harvest of tobacco were not influenced by the treatments. *Orobanche* shoots were emerged after 70 DATP of tobacco crop. The results revealed no positive effect of applied herbicides or combination of organic and fungicides on the emergence of *Orobanche*. Plant height recorded at harvest was affected by different post-emergence application of herbicides. The lowest plant height, leaf length and leaf breadth as well as yield (Table 3.2.4) of tobacco leaves were recorded in the application of imazethapyr (30 g / ha) at 40 DATP followed by application of glyphosate (0.2 g / L) at 20 DATP of tobacco indicated that these herbicides showed phyto-toxic effect on tobacco leaves. The visual phyto-toxicity of post-emergence application of herbicides was observed on leaves of tobacco. Tobacco leaves was severely affected by the application of imazethapyr 30 g / ha at 40 DATP. Plants were stunted and affected leaves were not recovered from the effect.

Table 3.2.4 Effect of weed management treatments on emergence of *Orobanche* shoots in tobacco at Anand (Guj.)

Treatment	*Orobanche* shoots emerged (no./m²)			Plant height at harvest (cm)	Leaf length (cm)	Leaf breath (cm)	Yield (t / ha)
	60 DATP	90 DATP	at harvest				
Neem cake 200 kg / ha *fb* soil drenching of metalaxyl MZ 0.2%	0.0	0.9	12.6	98.2	69.5	29.4	3.3
Imazethapyr 30 g / ha	0.0	0.0	0.0	38.0	48.0	17.0	2.2
Glyphosate 0.2 g / L	0.0	9.1	30.3	77.6	58.3	20.8	2.4
Soil drenching of metalaxyl MZ 0.2%	0.0	29.2	30.9	98.5	81.1	27.4	3.4
Weedy check	0.0	10.0	11.7	101	78.2	30.2	3.6

3.2.1 (c) Integrated management of parasitic weed *Cuscuta* sp. in Lucerne

Cooperating centre: TNAU

Lucerne (*Medicago sativa*), a forage crop has now became a cash crop was found infested sporadically with *Cuscuta*, especially in Coimbatore and Tirupur districts. Post-emergence directed application of paraquat at 0.80 kg/ha resulted in lower weed coverage of *Cuscuta* and weed dry weight among the herbicidal management. Higher green fodder yield and better economic returns was obtained with pre-emergence (PE) application of pendimethalin (1.0 kg/ha) + hand weeding on 25 DAS followed by PE oxyfluorfen (250 g/ha) + hand weeding on 25 DAS (Table 3.2.1.1).

Table 3.2.1.1 Integrated weed management in *Cuscuta* in Lucerne (*Medicago sativa*)

Treatment	Weed coverage (%)		Weed dry weight (g/m^2)		Green fodder yield (t/ha*)	Net return (` Laks/ha)	B:C ratio
	Other	*Cuscuta*	Other	*Cuscuta*			
Pendimethalin 1 kg/ha (PE)	39.0	19.1	32.5	16.7	41.6	1.7	3.1
Oxyflourfen 250 g/ha (PE)	33.2	17.4	28.6	14.8	43.6	1.5	3.1
Pendimethalin 1 kg/ha as PE + hand weeding at 25 DAS	19.3	12.4	22.4	7.6	55.6	3.2	4.2
Oxyflourfen 250 g/ha as PE + hand weeding at 25 DAS	16.7	11.5	21.8	9.4	53.4	3.1	4.1
Paraquat as post-emergence directed spray 0.75 kg/ha at 20 DAS	8.3	9.5	10.2	3.4	37.2	1.5	2.7
Hand weeding twice at 25 and 50 DAS	3.4	4.9	18.5	5.5	39.2	1.8	2.2

*(Total 14 harvests/year), but during study period, only 6 harvests have been accounted for green fodder yield

WS 3.2.1(c.1) Management of *Cuscuta* in niger

Cuscuta chinensis, a dreaded parasitic weed, is a serious threat in niger growing areas such as the hilly tracts of South Eastern Ghat, Eastern Ghat High Lands and Northern Plateau agro-climatic zones of Odhisa. In order to find out suitable and economic weed management practice for niger in these tracts, an experiment was taken at farmer's field as OFT in the district of Koraput, Odisha.

Among the different weed control methods, *Cuscuta* appeared as early as 12 DAS in stale seedbed *fb* pendimethalin (1.0 kg/ha) as pre-emergence and it was delayed up to 18 DAS in the treatment of pendimethalin (1.0 kg/ha) as PE (Table 3.2.1.2). Germination of *Cuscuta* was less in stale seedbed *fb* pendimethalin 1.0 kg/ha – PE (2.0 no./m^2). Among the herbicidal treatments, the treatment stale seedbed *fb* pendimethalin recorded the lowest *Cuscuta* density of 3.2/m^2 and 12.4/m^2 at 30 and 60 DAS followed by pendimethalin (4.3 and 13.1/m^2 respectively).

Table 3.2.1.2 Effect of weed management on germination, density of *Cuscuta* and yield of niger (2016)

Treatment	Germination of *Cuscuta*		Density of *Cuscuta* (m^{-2})		Yield of niger (kg/ha)	B:C ratio
	(DAS)	no/m^2	30 DAS	60 DAS		
Pendimethalin 1.0 kg/ha – pre-em	18.0	2.4	4.3	13.1	710.0	1.8
Stale seed bed *fb* pendimethalin 1.0 kg/ha– pre-em	12.0	2.0	3.2	12.4	792.0	1.7
Imazethapyr 75 g/ha as PPI	14.0	2.8	4.8	12.8	702.5	1.8

Stale seed bed *fb* pendimethalin (1.0 kg/ha PE) recorded highest grain yield of 0.7 t/ha followed by pendimethalin (1.0 kg/ha PE) (710 kg/ha). Stale seed bed *fb* pendimethalin increased the grain yield of niger by 11.5 and 12.8%, respectively over pendimethalin alone and imazethapyr 75 g/ha as PPI. Pendimethalin produced highest B:C ratio (1.8) followed by imazethapyr as PPI (1.8).

3.2.1 (d) Management of *Loranthus*

Cooperating centre: Jammu

Three treatments *viz.*, cotton padding of copper sulphate 4 g + 2, 4-D sodium salt 0.5 g on parasitic weed, directed spray of paraquat 0.5% and directed spray of glyphosate 1% were applied on parasitic weed which was infesting fruit trees (fig, walnut, peach, timbru, apricot, pomegranate, *grewia* and citrus) at farmers fruit orchards of village Narole and Trishi in district Udhampur in *Rabi* 2015-16. Cotton padding of 4 g copper sulphate + 0.5 g 2, 4-D sodium completely controlled *Dendrophthoe* spp. But it showed slightly phytotoxicity on host plant also. Directed spray of paraquat 0.5% and glyphosate 1% caused more phytotoxicity on fruit plants. Higher control of *Dendrophthoe* spp. was achieved with cotton padding of 4 g copper sulphate + 0.5 g 2, 4-D sodium with least phytotoxicity as compared other treatments.

WS 3.2.1(e) Making of *Parthenium* free campus

It was decided that each centre should make efforts to make their campus *Parthenium* free and to put a board after achieving the target. Round the year each centre except a few did some activities, like uprooting, spray of chemicals and to make people aware to clean the *Parthenium* from their vicinity. In most of the centres, more rigorous efforts are required to make the campus *Parthenium* free and to put the board. Pantnagar, Jammu, Hissar, Gwalior, Ranchi and Ludhiana centres were able to mobilize different departments of the university and involved people for uprooting of *Parthenium* from the campus. But so far none of the centers has claimed to put the board on the gate of the University. All the AICRP-WM centres motivated university staff to come forward to uproot the *Parthenium* from the campus during *Parthenium* Awareness Week observed from 16-22 August, 2016. Many school and colleges premises were also cleaned during the awareness week. With the collaborative effort of weed scientists of Ludhiana and the people of Mansuran, the village Mansuran has been declared as the first *Parthenium* free village in the state.

At TNAU, Coimbatore the infestation of *Parthenium* has been reduced drastically.

WS 3.2.3 Intensive survey on the incidence of *Cuscuta*

Cuscuta infestation in berseem fields was observed in some villages of Jalandhar, Kapurthala and Moga. *Cuscuta* problem was more severe during first cut in October and/or in March-April. Yield losses varied between 5-10%.

WP 3.3 Use of botanicals for weed management

Cooperating centers: Raichur, Ranchi

WP 3.3.1 Effect of botanicals on seed germination and seedling length of *Parthenium hysterophorus*

An experiment was conducted at Raichur to determine effect of aqueous leachates of eucalyptus, tamarind and *Prosopis juliflora* (10 and 20%) on seed germination and growth. Aqueous leachates were prepared by soaking air dried leaf in distilled water (1:10 weight/volume) for 24 hours and filtered through Whatman No. 1 filter paper. Calculated quantity of eucalyptus oil was mixed with distilled water to prepare required 0.5 and 1.0% of concentration. Fresh leaf leachates of eucalyptus and *Prosopis* were found promising in inhibiting the germination and seedling growth of *Parthenium hysterophorus* under laboratory condition (Table 3.3.1.1).

Table 3.3.1.1 Effect of aqueous extract of botanicals on seed germination of *Parthenium*

Treatment	Concentration (%)	Germination inhibition (%)	Seedling length (cm)
Eucalyptus fresh leaf leachate	10	100.0	-
Eucalyptus fresh leaf leachate	20	100.0	-
Eucalyptus oil	0.5	88.3	1.5
Eucalyptus oil	1.0	93.2	0.5
Tamarind fresh leaf leachate	10	55.2	3.0
Tamarind fresh leaf leachate	20	82.3	1.6
Prosopis juliflora leaf leachate	10	94.8	0.5
Prosopis juliflora leaf leachate	20	97.2	0.3
Control (distilled water)	-	2.9	5.7

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

Cooperating centres: All the centers

At Anand, water hyacinth density was taken by three random samples of 1 m^2 each from the site. The release of adult weevils was done on 23-09-2016. Additionally, fungal biocontrol agent *Alternaria alternate* formulation was also applied twice on 02-07-2016 and 19-11-2016. Weevils (15.7 / m^2) were released in water hyacinth infested pond. Total 350 adult of *Neochetina bruchi* were released. Data recorded on quarterly basis showed that there were no built up of the population of the weevil on the water hyacinth. Even no feeding scars were observed on the water hyacinth plant. No any dieback symptoms were recorded on the water hyacinth plants (0 scale) by the weevil. Symptoms of fungal infection was also not observed on water hyacinth.

At Jorhat, the biocontrol agent was released four times in different locations in and around Jorhat city. However, the insect became out of trace after 3-4 days of release, and hence no follow up action was taken. Bioagent was released by Hisar center in heavily infested water hyacinth area of Ottu dam (Sirsa) and Nasir village in Ambala district during August, 2015. At Thrissur, because of poor performance of *Neochetina* weevils on water hyacinth in Kerala conditions, further studies were not taken up.

At Gwalior, one pond infested with water hyacinth named Matholi was selected at Morena district. Release of adult weevils in 500 numbers procured from Jabalpur was made on 02.09.2016. Water hyacinth density of the selected pond were taken after three months where weevil released was released at 15 / m^2. Culture of *Alternaria alternate* was also sprayed on water hyacinth.

At Coimbatore, *Neochetina* beetles obtained from ICAR-DWR, Jabalpur were released on 10.09.2015 at Krishnampathy tank near Wetland farm of Coimbatore. The same tank was observed for *Neochetina* multiplication and their damage during this year. The symptoms on water hyacinth plants were negligible (Rating-1 out 85) and feeding was very less. At Bengaluru, NGOs and other public was educated on the removal/control of this weed by conducting training programmes and visiting nearby tanks / pond by releasing weevils.

Two perennial ponds were selected by Pusa at two different locations i.e. one at Biraul in Darbhanga district and other at Samastipur district. One hundred adults per square meter were released at both the sites in the first week of April 2016. After release of bio-agent on the aquatic plant, fortnightly observations were recorded to study the impact. For this purpose 10 plants from each site were randomly selected and there after selecting the 25 leaves randomly, percentage of scars per leaf was recorded and intensity of damage were categorized on scale of 0-4 (Table 3.4.1.1). To enhance the effectiveness of the bio agent again in the first week of December 2016, 100 adults per square meter were released at both the sites again. Observations were taken regularly to assess the impact. The results revealed that at both the sites leaves were affected up to 50 to 60 percent showing dieback symptoms/scars. It was also observed that complete eradication of this weed from the water bodies can not be achieved by using bioagents only. Thus to make water bodies completely free from these weeds an integrated weed management approaches will have to be undertaken.

Table 3.4.1.1 Effect of *Neochetina bruchi* on water hyacinth (*Eichhornia crassipes*)

Fortnights / months	Dieback symptoms (as per 0-4 scale) and no. of weevils per leaf			
	Pusa		Biraul	
	Dieback symptoms (0-4 scale)	No. of weevils/ leaf	Dieback symptoms (0-4 scale)	No. of weevils/ leaf
Second fort night of Sept., 2016	Negligible	0.5	Negligible	0.3
First fortnight of Oct. 2016	1	1.0	1	0.7
Second fortnight of Oct., 2016	2	1.2	2	1.0
First fortnight of Nov., 2016	3	1.5	3	1.3
Second fortnight of Nov., 2016	3	1.8	3	1.7
First fortnight of Dec., 2016	3	1.8	3	1.8
Second fortnight of Dec., 2016	3	1.8	3	1.8

At Jammu, *Neochetina* beetles obtained from ICAR-DWR, Jabalpur were released on 07.09.2016 in perennial pond at Tanda village. After 3 month release of beetles on an average 16 feeding scars / leaf were observed in water hyacinth infested pond. After 3 month of release observed that feeding of leaves was very less and caused only scars on water hyacinth leaves. Only 5-10% die back symptoms were observed to the extent of 10-15%. The clear water appearance was not observed after 3 month of beetle release. At Hyderabad, weevils population has been buildup well in Mylardev pally tank where it was released during 2015. About 8-10 weevils were recorded / clump. By December 2016, water hyacinth was killed and sank in about 30% area due to which water become visible.



Plates - Gradual control of water hyacinth through *Neochetina* spp.

3.4.2 Biological control of water hyacinth using *Alternaria alternate*

Cooperating centres: PAU, Jammu, Jorhat, Hisar

An experiment was conducted in a pond which was infested with water hyacinth at Goergaon village, Maharashtra to find out effect of *Alternanthera alternata* to control water hyacinth. Fungi *Alternanthera alternata* was sprayed on 1st June 2016. However, no damage to water hyacinth was observed by the *Alternanthera alternata.*

At Ludhiana, two perennial pond in villages Kher Jhameri and Dolon were selected for this study. Water hyacinth of this pond was infested with *Neochetina bruchi* weevil. Die back symptoms were observed to the extent of 10% but clear water appearance was not observed. These ponds were also sprayed with talc formulation of *A. alternata* isolates DWR. This talc formulation of *A. alternata* was also sprayed on water hyacinth plants established in cemented tanks at PAU Ludhiana. Like last year, clear water appearance was not observed after spray of bio-control fungus in either ponds or cemented tanks. At Jammu, The talc formulation of *Alternaria alternata* was sprayed in perennial pond infested with water hyacinth in Rattian village, district Jammu in the month of October, 2016. The growth of water hyacinth plants was hampered but clear water was not seen. At Hyderabad use of *Alternaria alternata* pathogen did not cause any symptoms of disease on the plants.

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

WP 4.1 Study on herbicide residues in the long-term conservation agriculture

Pretilachlor was used as pre-emergence herbicide in rice –mustard – greengram cropping sequence in the conservation agriculture experiment at AAU, Jorhat. This experiment was initiated during 2016 in the soils that was acidic in reaction. Surface soil samples (0–15 cm) were collected on the day of herbicide application and periodically from 1st rice crop after harvesting of winter rice and dried under shade and processed for analysis of various physico – chemical parameters and herbicide residues. Dissipation of pretilachlor in soil followed a pseudo first order equation. Pretilachlor residue ranged 3.14 – 3.92 µg / g on the day of application and observed up to the ranged of 0.001 – 0.013 µg / g on the 21st day. Pretilachlor residue level was observed at BDL from 30th day of application of at AAU, Assam (Table 4. 1.1).

Table 4.1.1 Residues of pretilachlor in soil in long term conservation agriculture experiments during 2016

Treatment	Pretilachlor residues (µg/g)					
	0 days	3 days	7 days	15 days	21 days	30 days
Transplanted	0.364	0.248	0.170	0.087	0.009	BDL
	0.352	0.255	0.168	0.013	0.006	BDL
Transplanted	0.386	0.265	0.157	0.027	0.005	BDL
	0.375	0.278	0.183	0.036	0.001	BDL
Direct seeded	0.332	0.238	0.169	0.025	0.004	BDL
	0.328	0.242	0.174	0.018	0.001	BDL
Direct seeded	0.314	0.234	0.198	0.024	0.006	BDL
	0.318	0.229	0.158	0.097	0.013	0.002
Direct seeded	0.392	0.289	0.186	0.066	0.008	BDL
	0.386	0.292	0.196	0.026	0.005	BDL

BDL- below detectable limit

At Hisar, a permanent field experiment in conservation agriculture under rice-wheat cropping system was initiated at CCSHAU, Karnal during *Kharif* 2015. The treatments were ZTDSR+(R)-ZTW+(R); ZTDSR-ZTW+(R); CTDSR-CTW; CTR (PTR)-ZTW; CTR (PTR)-CTW. Herbicides applied in different treatments were pretilachlor (1000 g / ha) at 3 DAT in T_4, T_5, and pendimethalin (1000 g / ha) fb bispyribac-sodium (25 g / ha) + pyrazosulfuron (25 g / ha) at 25 DAS in T_1, T_2 and T_3. Sampling of soil, grain and straw for residue analysis of herbicides was done at harvest of the crop. Residues of pendimethalin in soil, grain and straw were detected within range of 0.01 to 0.03 µg / g which were below MRL of 0.05 µg / g in all treatments. Residues of pretilachlor, bispyribac-sodium and pyrazosulfuron were not detected in any of the soil, grain and straw samples (Table 4.1.2).

Table 4.1.2 Residues in pendimethalin (µg / g) in rice grains, straw and soil samples taken from conservation agriculture experiment under rice-wheat cropping system

Treatments	Pendimethalin residues* (µg/g)		
	Soil	Rice grains	Straw
T_1: ZTDSR+(R)-ZTW+(R)	0.010	0.010	0.013
T_2: ZTDSR-ZTW+(R)	0.020	0.020	0.020
T_3: CTDSR-CTW	0.012	0.010	0.026
T_4: CTR (PTR)-ZTW	BDL	BDL	BDL
T_5: CTR (PTR)-CTW	BDL	BDL	BDL

**Average of three replicates*

At Pantnagar, a long-term trial to study the effect of herbicides on persistence and herbicide residues buildup in rice-wheat cropping system under different tillage conditions is in progress since 2011-12. Clodinafop-propargyl + metsulfuron-methyl (64 g / ha) in wheat and bispyribac- sodium (20 g / ha) in rice were applied continuously in every season. At the time of harvest, samples of soil, grain and straw of wheat or rice were collected from the treated plots and analyzed for the residues by HPLC with a minimum quantification limit of 0.01 g / g. Metsulfuron-methyl, clodinafop-propargyl and bispyribac-sodium residues were not detected at the time of harvest in soil, grains and straw in both tillage and residue management techniques.

At Ludhiana, persistence of pendimethalin, fenoxaprop-ethyl and bispyribac-sodium in rice and metsulfuron-methyl and sulfosulfuron in wheat under different tillage and residue management techniques was studied. The initial deposits of pendimethalin in recommended herbicide and IWM treatments in soil ranged from 0.177 to 0.392 µg / g in CT(DS)- CT(DS)- ZT, ZT (DS)- ZT + R (DS)- ZT and ZT (DS)+ R- ZT (DS)+ R- ZT treatments. Initial residues of fenoxaprop-p-ethyl ranged from 0.117 to 0.182 µg / g in ZT (DS)- ZT + R (DS)- ZT treatment and bispyribac sodium ranged from 0.209 ± 0.038 to 0.323 µg / g in CT (T)- CT (T) and CT(T)- ZT(T)- ZT treatment under recommended herbicide and IWM treatments. Results showed that residues of pendimethalin applied at 750 g / ha in CT(DS)- CT(DS)- ZT, ZT (DS)- ZT + R (DS)- ZT and ZT (DS)+ R- ZT (DS)+ R- ZT treatments, fenoxaprop-p-ethyl applied at 67 g / ha in ZT (DS)- ZT + R (DS)- ZT treatment and bispyribac-sodium applied at 25 g / ha in CT (T)- CT (T) and CT(T)- ZT(T)- ZT treatment in soil and rice grain under recommended herbicide and IWM treatments were below detectable limit (<0.01 µg / g) at the time of harvest (Table 4.1.3). Residues of sulfosulfuron and metsulfuron-methyl under different tillage and residue management techniques were below the limit of quantification of 0.01 µg / g in wheat.

Table 4.1.3 Harvest residues (µg / g) of pendimethalin, fenoxaprop-p-ethyl and bispyribac-sodium in soil and rice grain

Treatment	Herbicide	W_1		W_2	
		Soil	Rice	Soil	Rice
CT (T)- CT (T)	Bispyribac-sodium	BDL	BDL	BDL	BDL
CT(T)- ZT(T)- ZT	Bispyribac-sodium	BDL	BDL	BDL	BDL
CT(DS)_ CT(DS)_ ZT	Pendimethalin	BDL	BDL	BDL	BDL
ZT (DS)- ZT + R (DS)- ZT	Pendimethalin *fb* fenoxaprop-p-ethyl	BDL	BDL	BDL	BDL
ZT (DS)+ R- ZT (DS)+ R- ZT	Pendimethalin	BDL	BDL	BDL	BDL

BDL is < 0.01 µg / g

At Ludhiana, pendimethalin (0.75 kg/ha) and clodinafop-propargyl (0.06 kg/ha) were used continuously for 5 years and 14 years, respectively, in wheat in rice-wheat system. Pendimethalin residues in soil from a depth of 0-20 cm at 0 (5 h), 3, 7, 15, 30, 45, 60, 90 days and at harvest and wheat grain at harvest were determined by HPLC. Immediately after 5 h (0 day) of treatment, average pendimethalin residues in the soil were 0.221 µg/g. Residues decreased successively as a function of time and more than 67.8 and 92.8% of the pendimethalin residues dissipated within 30 and 90 days after application, respectively. Residues declined below the detection limit (<0.01 µg/g) in soil samples collected at harvest. Pendimethalin in soil dissipated according to the equation as: y= -0.013 x + 1.322 and half-life was found 22.9 days. Pendimethalin residues at harvest in soil, wheat grain and straw were below the limit of quantification <0.01µg/g**.** The residues of clodinafop-propargyl were found below the detectable limit (<0.05 µg/g) in soil, wheat grain and straw at harvest (Figure 4.1.1).

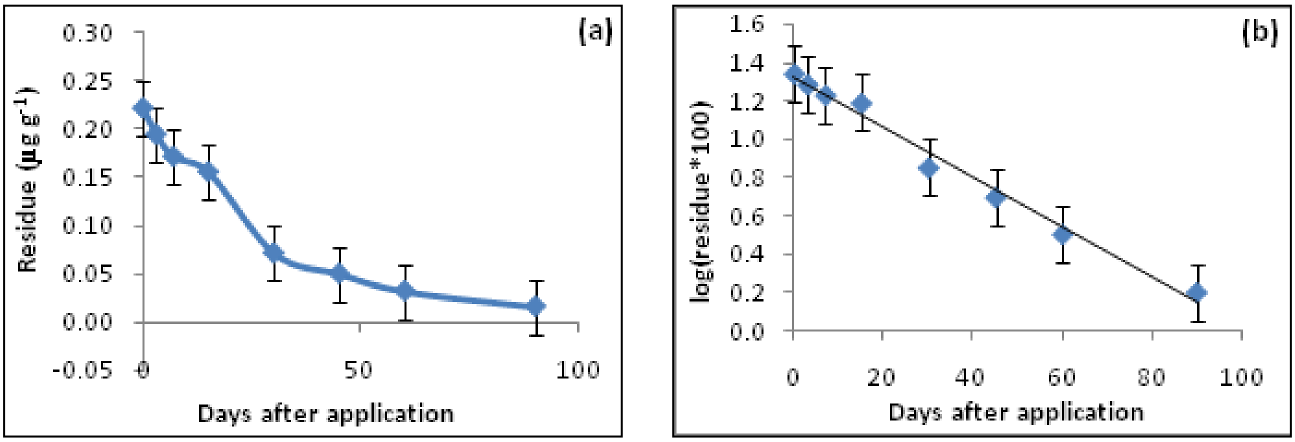


Figure 4.1.1 (a) Residues and (b) dissipation kinetics of pendimethalin in soil

At Gwalior, a field experiment was conducted during *Rabi* 2015-16 and *Kharif* 2016 in pearlmillet on persistence of herbicide in soil applied to mustard under pearlmillet - mustard cropping system. This was the second year and fourth season of the trial. Ttreatments consisted of combination of five tillage practices with three weed control practices viz. pendimethalin (1.0 kg/ha PE), oxyfluorfen (0.23 kg/ha PE) + one hand weeding 25-30 days after sowing (DAS) and weedy check. In *Kharif*, main treatment consisted of five different tillage practices and three sub treatments comprised of atrazine (500 g/ha PE) +2,4-D (500g/ha POE), atrazine (500 g/ha PE) + 1 HW at 25 DAS and weedy check applied in pearlmillet.

Soil samples (0-15 cm depth) were collected at 0, 15, 30, 45, and 60 days after application (DAA) and after harvest of mustard and pearmillet to study the persistence of herbicides in soil by maize and barley bioassay technique. Observations on plant height, fresh weight and dry weight per plant of cucumber were recorded after 21 days of sowing. A significant reduction in plant height of test plants were recorded up to 60 DAA of herbicides while fresh and dry weight were reduced up to 45 and 30 days, respectively. Fresh and dry weight of maize plant was significantly reduced up to 45 and 30 days, respectively by both the herbicides. Pendimethalin (1.0 kg/ha) and oxyfluorfen (0.23 kg/ha) reduced the plant height of maize plants up to 60 and 45 days, respectively. No significant reduction in growth of maize was recorded in soil after harvest of mustard. Different tillage practices in pearlmillet-mustard cropping system could not affect the persistence of herbicides applied to pearlmillet.

At Coimbatore, sunflower and maize were grown as test crops which received pendimethalin and atrazine, respectively, as pre-emergence herbicides to control weeds in long term conservation agriculture experiment under maize-sunflower system during *Rabi* 2015-16 and *Kharif* 2016. Residues of pendimethalin during *Rabi* 2015-16 in sunflower and atrazine during *Kharif* 2016 in maize were analyzed at different periods viz., 0, 15, 45 days after herbicide application and at harvest. Dissipation of both the molecules was found to follow first order reaction kinetics (R^2> 0.90) irrespective of tillage practices under both the weed control methods with the half life of 16.7-18.4 and 17.3–18.9 days for pendimethalin and atrazine, respectively. Irrespective of tillage practices and weed management methods, >80% of both the herbicides dissipated from the soil (Table 4.1.4). Atrazine and pendimethalin residues in soil and maize grains from different plots were below 0.01 mg/kg irrespective of the tillage management practices followed for weed control.

Table 4.1.4 Pendimethalin (mg / kg) residue in soil of sunflower (*Rabi* 2015-16) in maize–sunflower system

Treatments	W_1 (Pendimethalin 1.0 kg/ha)				W_2 (Pendimethalin 1.0 kg/ha)+ HW on 45 DAS)			
	0 day	15 day	45 day	Harvest	0 day	15 day	45 day	Harvest
T_1 (CT-CT)	0.459	0.131	0.057	BDL	0.461	0.181	0.065	BDL
T_2 (CT-ZT)	0.480	0.167	0.062	BDL	0.426	0.171	0.079	BDL
T_3 (ZT+R - ZT)	0.479	0.178	0.067	BDL	0.423	0.190	0.080	BDL
T_4 (ZT – ZT+R)	0.467	0.196	0.087	BDL	0.471	0.202	0.087	BDL
T_5 (ZT+R – ZT+R)	0.476	0.198	0.090	BDL	0.482	0.215	0.098	BDL

At Bhubaneswar, long-term experiment on weed management in conservation agriculture system under rice-maize-cowpea crop sequence was initiated in *Kharif* season, 2013 to monitor weed dynamics, crop productivity, herbicide residues, changes in physico-chemical and biological properties of soil health. The soil was sandy clay loam, acidic, low in available N, P and medium in available K. The nutrient availability in the soil was low to medium due to acidic in nature. Persistence of herbicides was almost equal in all the treatments but it was steeper in case of pretilachlor. After 30 DAA pretilachlor were found below 0.001mg / kg. Addition of organic matter decreased herbicide residues rapidly. Crop residue increased organic carbon content in the soil which decreased herbicide residues rapidly.

Effect of herbicides on microbial population was also determined. The bacterial population of the soils varied from 20.0 to 25.0 x 10^9 / g soil. Presence of crop residues increased microbial activity. The weed control measures followed in *Kharif* rice significantly changed the bacterial population in soils. Application of organic matter in the form of crop residue did help in stabilizing the bacterial population (24.2 x 10^9) and recorded an increase of 9% over the treatments without organic matter. Population of fungi varied from 69 to 84.2 x 10^5 / g in soil. Similarly, application of herbicides decreased fungal population by 6.4 to 9.5% over hand weeded treatments and addition of crop residue enhanced fungal population (79.2 x 10^5 / g soil) by 8.4%. However, variations in fungal population due to herbicide application both in *Kharif* and *Rabi* were not significant.

Application of herbicides in *Kharif* rice reduced the urease activity in the tune of 3.6 to 10.8% over hand weeded treatments. However, there was increase in activity of acid phosphatase by 4% and that of dehydrogenase by 20.3 to 28.3% through herbicidal applications along with residue (crop). In general, an increasing trend in microbial population and enzyme activities were observed since the initial year of study (2013), particularly in the treatments with crop residues incorporated in the plots, thereby indicated stabilizing effects of organic matter on soil microbes. Initially the carbon content of the soil was low but continuous application of crop residue increases gradually the organic carbon content of the concerned treatment (Table 4.1.5).

Table 4.1.5 Initial soil characteristics measured in 2013 *vis–a-vis* 2016

Soil characteristic	*Kharif* 2013	*Kharif* 2016
pH (1:2.5)	5.3	5.4
BD (g / cc)	1.43	1.60
OC (%)	0.39	0.62
Available N (kg / ha)	170.0	198.0
Available P (kg / ha)	21.0	22.0
Available K (kg / ha)	140.0	140.0

Application of herbicides did not have any significant effect on BD, pH, organic carbon and other available indices except available P and S or N. There was substantial increase in P & S levels and slight decrease in N & K levels with herbicide treatment in rice. N level also increased but there was no change in K.

At Palampur, persistence of herbicides in soil and plants under different tillage and residue management techniques was studied. Residues of clodinafop-propagryl and isoproturon applied in wheat (*Rabi* 2015-16), atrazine in maize and pendimethalin in soybean (*Kharif* 2016) were determined. Atrazine and pendimethalin residues in soil and grain under different tillage and residue management techniques were found below detectable limits of 0.05 µg / g at the time of harvest.

At Hisar, a permanent field experiment in conservation agriculture under rice-wheat cropping system was initiated in *Kharif* 2015 with set of treatments T_1: ZTDSR+(R)-ZTW+(R); T_2: ZTDSR-CTW; T_3: CTDSR-ZTW+(R); T_4: CTR (PTR)-ZTW; T_5: CTR (PTR)-CTW. The herbicides applied in different treatments were pretilachlor (1000 g / ha) at 3 DAT in T_4, T_5 and pendimethalin (1000 g / ha) *fb* bispyribac-sodium (25 g / ha) + pyrazosulfuron (25 g / ha) at 25 DAS in T_1, T_2 and T_3. Sampling of soil, grain and straw for residue analysis of herbicides was done at harvest of the crop.

Pendimethalin residues (0.066 µg / g) in rice grains were detected in T_1. In all other treatments, residues of pendimethalin were not detected in rice grains. In straw samples, residues of pendimethalin varied from 0.007 to 0.059 µg / g in DSR treatments. Pendimethalin residues were found 0.059 µg / g in T_3 were above than MRL value of 0.05 µg / g. In soil, residues of pendimethalin were found 0.040 to 0.070 µg / g in DSR treatments only. Residues of pretilachlor, bispyribac-sodium and pyrazosulfuron were not detected in any of the soil, grain and straw samples (Table 4.1.6).

Table 4.1.6 Residues in pendimethalin (µg/g) in paddy grains, straw and soil samples taken from conservation agriculture under rice-wheat cropping system

Treatments	Pendimethalin residues* (µg/g)		
	Soil	Paddy grains	Straw
T_1: ZTDSR+(R)-ZTW+(R)	0.070	0.066	0.032
T_2: ZTDSR-CTW	0.040	BDL	0.007
T_3: CTDSR-ZTW+(R)	0.045	BDL	0.059
T_4: CTR (PTR)-ZTW	BDL	BDL	BDL
T_5: CTR (PTR)-CTW	BDL	BDL	BDL

**Average of three replicates*

WP 4.2 Herbicide residues in high value crops / organic farming system (newer products and combination formulations)

At Jorhat, a field trial was conducted with chili as the test crop and metribuzin (500 and 1000 g / ha) was applied in winter as weed control measure to estimate herbicide residue in high value crops / organic farming system. Soil physico–chemical parameters and metribuzin residues in soil and chili were determined. Dissipation of metribuzin in soil followed a pseudo first order equation. Metribuzin residues ranged 0.163–0.356 ppm on the day of application of metribuzin and observed up to the range of 0.023–0.087 ppm on the 21st day of application of metribuzin. The metribuzin residue level was observed at BDL from 30th day of application of metribuzin.

Table 4.2.1 Degradation of metribuzin residues in soil

Treatment	Metribuzin residues (ppm)					
	0 days	3 days	7 days	15 days	21 days	30 days
X (500 g / ha)	0.163	0.126	0.098	0.058	0.023	BDL
2X (2x500 g / ha)	0.356	0.299	0.286	0.114	0.087	BDL

BDL- Below Detectable Limit

At Pantnagar, a long-term trial to study the effect of herbicides on persistence and herbicide residues buildup in rice-wheat cropping system under organic farming conditions in high value crops (basmati) was started in *Kharif* of 2016-17 with treatment of bispyribac-sodium at 20 g/ha in rice and clodinafop-propargyl + metsulfuron-methyl at (60 + 4 g/ha) in wheat continuously in every season. At the time of harvest samples of soil, grain and straw of wheat or rice were collected and analyzed for the residue. Bispyribac-sodium and clodinafop-propargyl + metsulfuron-methyl residues were found below MRL (0.02 mg/g) at the time of harvest in soil, rice grains and rice straw in both tillage and residue management technique.

At Coimbatore, field experiment was conducted at TNAU to estimate the harvest time residues of quizalofop-ethyl in/on onion and soil. A single post-emergence application of quizalofop-ethyl was done at 50 and 100 g/ha along with untreated control on 15 days after onion planting. Soil and plant samples were collected at harvest and analyzed by HPLC-DAD. Quizalofop-ethyl residues were not detected in the plants, a bulb of onion and soil samples. Residues were below detectable level (0.01 mg/kg) in all the harvested samples of onion plant, bulb and field-soil irrespective of doses of applications. Hence it is recommended for weed management in onion with the pre harvest interval of 62 days.

At Palampur, atrazine residues in soil were below detectable levels in soil samples collected after the harvest of maize crop field treated with atrazine at 1.5 kg/ha. At Hisar, samples of onion bulb, leaf and soil under onion crops were collected from different regions of Karnal, Ambala and Panchkula districts for the analysis of herbicide residues. It was observed that soil samples from Manka of Panchkula, two location in Khanpur of Karnal, Barouli of Panchkula and Naval of Karnal were having pendimethalin residues above 0.05 µg/g. Whereas, pendimethalin residues in onion bulbs and leaf were found below MRL.

Table 4.2.2 Residues in onion leaf, bulb and soil under onion crop collected at farmers' fields from various regions of Haryana

Name & address of farmer	Herbicide sprayed	Dose	Residues (µg/g)		
			Soil	Bulb	Leaf
Jairnail Singh, Manka, Panchkula	Pendimethalin	X	0.052	0.003	BDL
Raju, Handesra, Ambala	Pendimethalin + oxyfluorfen	X	0.028	BDL	BDL
Nazim, Batawar, Panchkula	Pendimethalin + oxyfluorfen	X	0.021	BDL	0.006
Ram Kumar, Khanpur, Karnal	Pendimethalin + oxyfluorfen	X	0.060	0.003	0.004
Harbaksh Singh, Khanpur, Karnal	Pendimethalin + oxyfluorfen	X	0.143	BDL	BDL
Inder Singh, Ramban, Karnal-Indri Road	Pendimethalin + oxyfluorfen	X	0.018	BDL	BDL
Raj Kumar, Barouli, Panchkula	Pendimethalin	X	0.264	0.004	BDL
Hari Om, Naval, Karnal	Pendimethalin + oxyfluorfen	X	0.068	BDL	BDL
Ram Kishor, Manka, Panchkula	Pendimethalin + oxyfluorfen	X	0.037	BDL	BDL

WP 4.3 Adsorption, degradation (new molecule only) and mitigation of selected persisting herbicides

WP4.3.1 Adsorption of candidate herbicides of state

At Ludhiana, a study was conducted to investigate adsorption and desorption behavior of penoxsulam in three soils of Punjab having different textures (Table 4.3.1.1). Batch adsorption experiments were conducted to determine the adsorption of penoxsulam on soil with 0.1, 0.5, 1.0, 5, 10 and 20 µg/mL concentrations. Preliminary adsorption experiments revealed that adsorption equilibrium was attained within 6 hours and beyond that the amount of penoxsulam adsorbed by soil remained almost steady (Table 4.3.1.2).

Table 4.3.1.1 Physico-chemical properties of soil samples

Parameters	Soil 1	Soil 2	Soil 3
Texture class	Sandy loam	Loam	Clay loam
pH	8.8	8.2	8.6
EC (dS/m)	0.2	0.2	0.2
Organic carbon (%)	0.2	0.4	0.6
Organic matter (%)	0.4	0.8	1.1

Adsorption of penoxsulam increased with increase in initial concentration and the order of adsorption was: clay loam > loam >sandy loam. On the basis of the measured R^2 values, penoxsulam adsorption conformity to different isotherms can be arranged as: Freundlich> Langmuir >Temkin> D-R model (Table 4.3.1.3).

Table 4.3.1.2 Amount of penoxsulam adsorbed in three soils

C_i (µg/mL)	C_s (µg/g)		
	Sandy loam	Loam	Clay loam
0.1	0.48	0.49	0.51
0.5	1.75	1.80	1.85
1	3.62	3.80	4.02
5	17.13	18.10	20.93
10	35.12	30.68	24.04
20	64.62	70.01	71.95

Table 4.3.1.3 Correlation coefficients for adsorption isotherms

Soils	R^2			Freundlich			
	D-R	Temkin	Langmuir	R^2	$\log K_{Fads}$ (µg$^{1-1/n}$ g^{-1} mL$^{1/n}$)	$1/n_{ads}$	K_D (mL/g)
Sandyloam	0.674	0.671	0.933	0.991	0.772	0.862	6.100
Loam	0.677	0.683	0.984	0.993	0.813	0.885	6.671
Clay loam	0.685	0.635	0.902	0.903	1.207	0.702	7.091

$\log K_{Fads}$ value of the Freundlich adsorption isotherm is the relative measurement of the affinity for the adsorbate with soil. The adsorption capacity of penoxsulam was found to be different for various soils because of the difference in their physico-chemical characteristics. Soil with higher OM and clay content showed higher $\log K_{Fads}$ value and soil with lowest OM and clay content showed lowest $\log K_{Fads}$ value. Higher K_D values attained for clay loam soil exhibited more retention of penoxsulam due to presence of high OM and clay content as compared to other soils having less OM and clay content. Desorption studies were carried out in triplicate for initial concentrations of 0.1, 1.0 and 10 µg/mL of penoxsulam. Desorption percentage was found to be highest in loamy sand soil followed by loam and clay loam soil. The order of desorption was as follows: loamy sand > loam > clay loam. This implies that the release of the adsorbed penoxsulam into water was difficult in clay loam soil followed by loam and loamy sand soil (Table 4.3.1.4).

At Palampur, a laboratory experiment was conducted to study the behaviour of bispyribac-sodium in silty clay loam soil. Preliminary kinetic studies revealed that maximum adsorption took place within first 24 hours. After equilibration, the amount of bispyribac-sodium left in the solution phase was determined by HPLC. Total amount of bispyribac-sodium adsorbed increased with increasing initial concentration from 2.5 to 25 µg/ ml of equilibrium solution (25 g to 250 g µg/soil). The isotherm expressed an increasing trend in the adsorbed content Cs (µg/g) with respect to increase in the equilibrium concentration of bispyribac-sodium Ce (µg/ml) in solution.

Table 4.3.1.4 Bispyribac- sodium adsorption in silty clay loam soil

Initial concentration (µg/ml)	Equilibrium concentration (µg/ml)	Amount adsorbed per gram of soil (µg/g)
2.5	0.6	19.4
5.0	0.8	40.7
10.0	2.2	78.4
15.0	4.6	100.1

At Coimbatore, quizalofop- ethyl sorption were determined in surface sandy loam soil (0-15 cm) having pH of 5.2, EC of 0.52 ds/m and very high char OC of 4.35%. The amount of quizalofop- ethyl adsorbed in soil ranged from 1.0 to 380 mg/g and adsorbed amount increased with rise in the initial concentration (C_i). After sorption experiment, desorption was studied using parallel method and found that 24 h shaking desorbs maximum quantity (of 1.0 – 9.2%) the sorbed quizalofop-ethyl from soil

(Table 4.3.1.4 and 4.3.1.5) when comparing 12, 18 and 48 hours shaking with the desorption range of 0.5-7.6, 1.9-8.4 and 1.3-9.3%, respectively. It has been found that desorption from soil was hysteretic and incomplete, often consisted of a significant resistant fraction or the added compound might undergoes chemical reactions in soil. On the basis of the measured R^2 values, the adsorption of quizalofop-ethyl in soil fitted well in Freundlich and Langmuir equations with the R^2 values of >0.99, however the Temkins model was showed inferior fit with R^2 value 0.625. Using the Fruenlich contstant (K_f), the organic carbon normalized partition was calculated and was found to be 56.4 for quizalofop-ethyl sorption in sandy loam soil. The Hysteresis index, was calculated for the adsorption– desorption isotherms according to the equation HI = (n desorption) / (n adsorption), where n desorption and n adsorption were Freundlich constants (n) obtained for desorption and adsorption isotherms, respectively. It was found that the HI was positive for the present study since it was below 1 (0.048).

Table 4.3.1.5 Adsorption and desorption of quizalofop ethy in sandy loam soil

C_i (mg/Lit)	C_{ad} (mg/g)	C_{de} (mg/g)	Desorption (%)
0.05	1.0	0.001	1.0
0.10	1.8	0.002	2.2
0.50	8.8	0.046	9.2
1.00	18.1	0.061	6.1
5.00	89.5	0.362	7.2
10.0	187.8	0.690	6.9
20.0	380.2	1.431	7.2

The study concluded that sorption and desorption of quizalofop-ethyl was influenced significantly by the organic carbon content with the organic carbon normalized partition coefficient (Kfoc) of 56.4 in the soil having OC% of 4.35 and pH of 5.2. At Hisar, adsorption of oxyfluorfen in the clay loam soil at 10, 20, 30, 40 and 50 µg was determined. Adsorption of oxyfluorfen was high but desorption was found quite low (Table 4.3.1.6).

Table 4.3.1.6 Adsorption of oxyfluorfen in clay loam type soil

Herbicide added (µg)	Residue (µg)/25 ml of 0.01M $CaCl_2$ solution	Residues/5 g of soil (µg)	C_e (Residue/ml of 0.01M $CaCl_2$ solution) (µg)	x/m (Residues/ g of soil) (µg)	$Kd = \frac{\Sigma C_e.x/m}{\Sigma C_e^2}$
10	1.8	8.2	0.07	1.6	23.6
20	4.8	15.2	0.19	3.0	15.8
30	5.0	25.0	0.20	5.0	25.0
40	8.2	31.8	0.33	6.3	19.3
50	9.5	40.5	0.38	8.1	21.2

WP 4.3.2 Degradation of candidate herbicides of state

At Assam, pretilachlor is commonly used as pre-emergence herbicide for controlling weeds in rice. Therefore, degradation of pretilachlor was conducted under laboratory conditions in pot with 30% moisture level and an application of pretilachlor at 750 and 1500 g / ha rates. Dissipation of pretilachlor in soil followed a pseudo first order equation. Pretilachlor residues ranged 0.98 – 1.56 ppm on the day of application of pretilachlor and found 0.06 – 0.31 ppm on the 21st day of application of pretilachlor. Pretilachlor residue was found to be at BDL from 30th day of application of pretilachlor.

At Pantnagar, degradation of imazethapyr at applied rate of 100 and 200 g / ha in clay loam soil (0-20 cm depth) was determined. Soil samples were collected at different time intervals after 0 (4 h), 1, 3, 5, 7, 10, 15, 30, 60, 90, 120 and 150 days after herbicide application. Dissipation of herbicide in soil treated at 100 g / ha was 2.1% on 1st day and then it gradually increased to 82.4% on 90th day after application. However, no detectable residues (<0.01 g / g) were found on 120th day of application. At 200 g / ha imazethapyr application, dissipation of herbicide in soil was 6.2% day on first day and dissipated up till 120th day after application. No detectable residue (<0.01 g / g soil) was observed on 150th day of application.

At Ludhiana, laboratory studies were conducted to investigate dissipation of penoxsulam in loamy sand soil. Penoxsulam was applied to loamy sand soil at an application rate of 22.5 and 45 g / ha under field capacity and submergence conditions and incubated at 30°C. Soil samples were collected at 0 (5 h), 3, 15, 30 and 45 days after herbicide application from treated and untreated pots. After the application of penoxsulam, residues were found to vary with the applied concentration under both moisture conditions (Table 4.3.2.1, Figure 4.3.2.1). After 45 days, residues were found 0.265 and 0.41 µg/g, respectively, under the submerged conditions at 22.5 and 45 g/ha, respectively. More than 82% of residues dissipated within 45 days after application of penoxsulam at 22.5 and 45 g/ha under field capacity and submerged conditions.

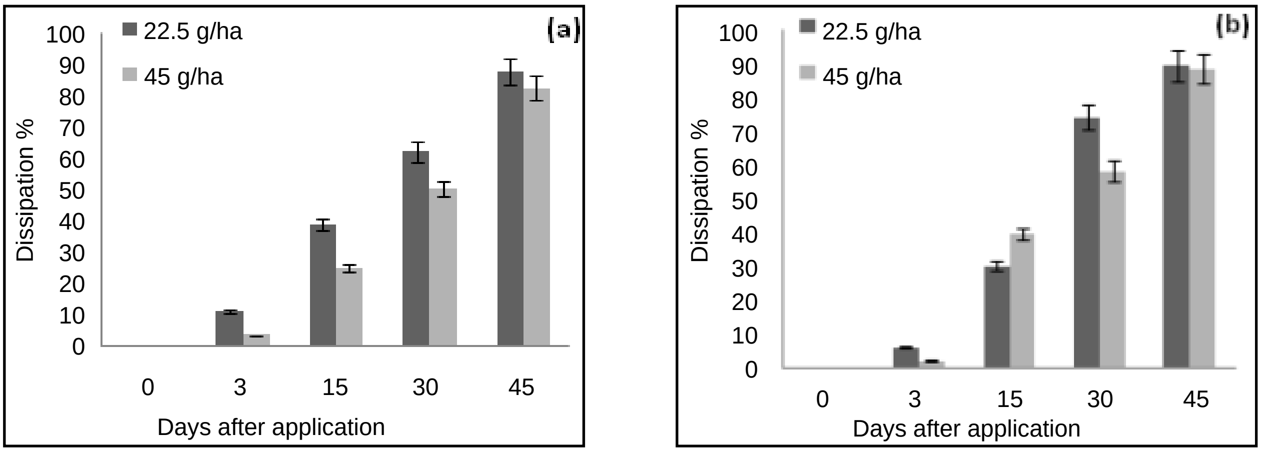


Figure 4.3.2.1 Dissipation percentage of penoxsulam in soil under (a) field capacity and (b) submergence

Table 4.3.2.1 Half-lives and other statistical parameters for penoxsulam dissipation in soil

Moisture	Dose (g/ha)	Equation	k (per day)	DT_{50} (days)	R^2
Field capacity	22.5	y= -0.019x + 2.487	0.0439	15.77	0.955
	45.0	y= -0.016x + 2.641	0.0368	18.84	0.973
Submergence	22.5	y= -0.022x + 2.464	0.0509	13.61	0.973
	45.0	y= -0.02x + 2.620	0.0459	15.07	0.931

At Palampur, degradation of bispyribac-sodium at 25 g/ha, 50 g/ha was studied in rice cropped soil. Initial concentrations after herbicide bispyribac -sodium application at 25 and 50 g/ha were 0.089 and 0.179 mg/kg, respectively. No bispyribac-sodium residues could be detected in soil at 30 and 60 days in both the treatments. At Bengaluru, degradation of bispyribac-sodium in soil of transplanted rice and residues in grains and straw were determined by HPLC. Adsorption-desorption and movement of bispyribac-sodium were conducted in four selected soils collected from different agro climatic zones of southern Karnataka namely Mandya, Kathalagere, Bramhavara and Mudigere. A field experiment in transplanted rice ecosystem was also taken up to study the bio-efficacy, persistence and degradation of the herbicide. Adsorption of bispyribac-sodium was mainly influenced by the soil organic carbon content. Adsorption of bispyribac-sodium in soils decreased in the order of Mandya > Kathalagere > Bramhavara > Mudigere, which was also the order of decreasing organic carbon content.

Leaching of bispyribac-sodium increased with increased application rate. Persistence of bispyribac-sodium followed first order exponential degradation kinetics in soils and mainly influenced by soil organic matter and soil pH. Faster degradation of bispyribac-sodium was noticed under recommended dose of bispyribac-sodium followed by double the recommended dose. Half-lives of bispyribac-sodium were found 17.3 and 23.9 days at recommended and double the recommended dose, respectively. Bispyribac-sodium residues were not found in rice grain, straw and soil at harvest.

At Coimbatore, quizalofop- ethyl degradation in soil with sandy loam in texture, pH of 5.2, EC of 0.52 ds/m and OC of 4.35% was studied in lab under controlled condition by imposing 50 and 100 g/ha doses. The soil samples were collected at periodical interval and analyzed for quizalofop-ethyl residues and dissipation pattern in soil. After application of quizalofop-ethyl, residues were found to vary with the applied concentration (Table 4.3.2.2) from 39.2 to 316.8 µg/kg soil. Quizalofop-ethyl residues in soil declined to the extent of 54.4 – 62.9% and >85% within the time period of 7 and 15 days after application, respectively. On day 30, quizalofop-ethyl residues becomes below detectable limit of 0.01 mg/kg at both the doses of application. Increase in concentration of application increased the half life of quizalofop ethyl was 4.1 and 5.6 days, respectively, at 50 and 100 g/ha applied treatments.

Table 4.3.2.2 Persistence, half- lives and statistical parameters for quizalofop dissipation in soil

Dose	Days after quizalofop application (µg/kg)					k	R^2	DT_{50} (days)
	0	3	7	10	15			
50 g /ha	191.1	100.2	70.8	35.6	<0.01	0.068	0.968	4.1
100 g/ ha	316.8	203.8	144.3	92.6	39.2	0.051	0.988	5.6

At Hisar, degradation of oxyfluorfen at 300 and 600 g/ha doses was determined in the clay loam soil. Oxyfluorfen residues reached to near detection limit (0.003 kg/ha) on 30 days of application showed 100% dissipation. The half life was observed to be 6.7 days at single dose application. At double dose, residues reached to below detectable level on 30 days. The half-life of oxyfluorfen was found to be 7.9 days followedfirst order kinetics.

WP 4.3.3 Mitigation of candidate herbicides of state

At Assam, butachlor and mitigation measure were evaluated in soil in consortia based approach. The consortium consists of four bacterial isolates that have isolated from oil fields of Assam. For mitigation, a pot culture study was conducted by incorporating microbial consortium on the pot with the treatments: control (butachlor), butachlor + consortium (½n- recommended dose), butachlor + consortium (n-recommended dose), butachlor + consortium (2n-recommended dose).

Two kg of air dried soil was put in each pot and 30 % moisture level was maintained by sprinkling water frequently to the pot. A microbial consortium of (isolated from oil fields) four bacterial isolates was prepared and applied to the pot 10 kg/ha equivalent to 0.9 µg/g of soil as recommended dose i.e., 0.45 µg/g of soil as ½ n and 1.8 µg/g of soil as 2n (1 – 2 days for establishment of bacterial colony). Butachlor was applied to each pot at 1.0 kg/ha on the next day. Soils were collected periodically from the day of application of butachlor till 30 day of application for determination of physico – chemical properties and butachlor degradation pattern under the action of microbial consortium in the soil sample. Dissipation of butachlor in soil followed a first order equation. Butachlor residues were found at BDL from 30th day of application of butachlor (Table 4. 3.3.1).

Table 4.3.3.1 Degradation of butachlor residues in soil under various mitigation measures during 2016

Days of butachlor application	Butachlor residue (ppm)		
	Butachlor 1 kg/ha (T1)	Butachlor 1 kg/ha+ consortium10 kg/ ha (T2)	Butachlor 1 kg/ha+ consortium 20 kg/ ha(T3)
0 days	0.692	0.286	0.168
3 days	0.575	0.164	0.098
7 days	0.442	0.084	0.065
15 days	0.063	0.035	0.016
21 days	0.025	BDL	BDL
30 days	BDL	BDL	BDL

At Ludhiana, effect of addition of FYM on the persistence of penoxsulam in sandy loam soil of Punjab under field capacity and submerged conditions were studied. Commercial formulation of penoxsulam was applied to soil at an application rate of 22.5 g /ha. To the soil samples, FYM was applied at application rate of 10 and 15 t/ha. The soil moisture was adjusted to field capacity and submerged conditions using distilled water. Soil samples were incubated at 30°C. The soil samples were collected from control and treated pots after 0 (5 h), 3, 15, 30 and 45 days of treatment for residue analysis. The extraction of penoxsulam from soil was done using MSPD method and residues were quantified using HPLC. After the application of penoxsulam, residues were found to vary with the applied concentration of FYM under both moisture conditions. Initial deposits of penoxsulam in soil under field capacity and submergence varied from 2.5 to 2.9 µg / g and 2.0 to 2.2 µg / g, respectively, for both application rates. Penoxsulam residues in soil declined and reached the level of 0.20 and 0.12 after 45 days at an application rate of FYM at 10 and 15 t / ha, respectively under field capacity conditions. Under the submerged conditions, after 45 days penoxsulam residues were 0.09 and 0.045 µg / g at an application rate of FYM at 10 and 15 t / ha, respectively. More than 90% of residues dissipated within 45 days after application of FYM at 10 and 15 t / ha under field capacity and submerged conditions (Figure 4.3.3.1).

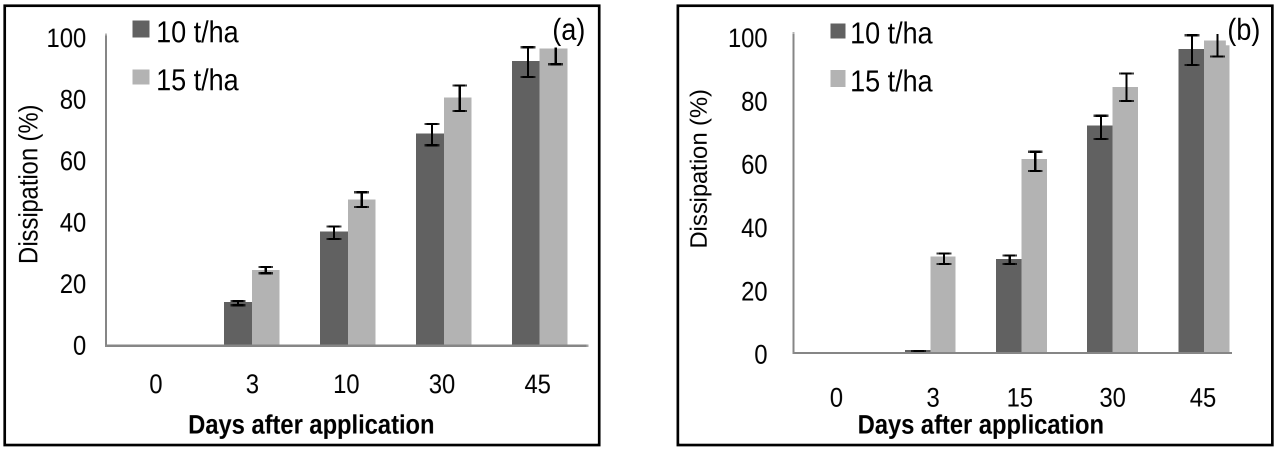


Figure 4.3.3.1 Dissipation percentage of penoxsulam in soil under (a) field capacity and (b) submergence conditions.

Penoxsulam DT_{50} ranged between 10.4 to 13.2 days in soil at 10 and 15 t / ha under field capacity conditions and 8.6 to 10.5 days under submerged conditions. Disappearance of penoxsulam was more rapid under submergence than field capacity conditions. The higher dissipation of penoxsulam was observed in soils having higher dose rate of FYM probably due to rapid microbial degradation of penoxsulam.

At Coimbatore, persistence of atrazine in sandy clay loam soil having pH 8.35, EC 01.1dS / m, OC 0.46%, available N,P,K of 260, 19.8 and 593 kg / ha

Table 4.3.3.2 Persistence of atrazine in soil as influenced by the organic sources and microbial application under pot study

Treatments	Atrazine residues (mg/kg) in soil				
	0 day	1 day	3 day	10 day	15 day
FYM 10 t / ha	0.691	0.364	0.113	0.271	0.087
Vermicompost 5 t / ha	0.843	0.325	0.056	0.071	0.051
Biochar 5 t / ha	0.362	0.350	0.164	0.129	0.038
Phosphobacteria 10 kg / ha	0.374	0.197	0.150	0.085	0.034
Trichoderma 10 kg / ha	0.418	0.300	0.269	0.129	0.072
VAM 10 kg / ha	0.375	0.092	0.054	0.045	0.039
Pseudomonas 10 kg / ha	0.544	0.360	0.223	0.084	0.041
Urea 100 kg / ha	0.895	0.354	0.159	0.055	0.041
Crop residue (maize straw) incorporation 5 t / ha	0.370	0.118	0.086	0.070	0.036
Control (no manure / bioagents)	0.879	0.484	0.121	0.103	0.067

as influenced by the organic sources and microbial application under pot study were studied. It was found that FYM 10 t /ha or vermi-compost 5/ha or biochar 5 t/ha were efficient in reducing residual concentration of atrazine in maize grown soil. This could be due to the enhanced adsorption of the compounds by these sources. Application of different microbes degraded the atrazine with the half lives ranged from 14.3 to 41.5 days and slowed degradation by microbes could be ascribed to the low quantity of application when comparing the organic sources like FYM, Vermi compost, biochar etc. Hence the influence of combined application of manures and microbes should be studied in future.

At Hisar, mitigation measures of oxyfluorfen in soil were determined. Oxyfluorfen was applied at 300 (single dose) and 600 g/ha (double dose) along with mulching with paddy straw residue at application rate of 10 t/ha. Soil sampling was done on 0, 1, 3, 7, 15, 30, 45 and 60 days after application of herbicide. The half life of oxyfluorfen was found to be 5 days which was less than the half life without straw mulching (6.67 days) at single dose application without straw mulching. At double dose, half-life of oxyfluorfen was found to be 6.3 days which was lesser than 7.8 days at double dose application without strong mulching. The dissipation followed first order kinetics.

WP 4.4 Testing of persistence of herbicides in the farmers' field (soil, water and crop produce)

At Assam, butachlor and pretilachlor residues (applied at 1.0 and 0.75 kg/ha) in summer and winter rice plants and soil (0-15 cm) were found at below detectable limit (0.05 ppm). At Hisar, soil and plants samples were collected from farmers' field at harvest from different rice-wheat growing regions of Haryana at harvest. The samples were taken from the sites where farmers are continuously using the pretilachlor from many years. Nine samples out of 20 locations were detected with sulfosulfuron and meso + iodosulfuron (RM) residues in soil which ranged 0.011 to 0.048 µg/g which was less than MRL of sulfosulfuron (0.05 µg/g). In *Kharif* 2015, 9 out of 21 samples were detected with pretilachlor residues ranged between 0.004 – 0.024 µg/g in soil. Three out of 21 samples were having pretilachlor residues in rice grain ranging from 0.005 to 0.089 µg/g and 9 out of 21 samples were having pretilachlor residue between 0.014 to 0.089 µg/g in straw. Oxadiargyl residues were not observed in soil, grains and straw samples (Table 4.4.1 and 4.4.2).

At Hisar, 5 out of 26 locations i.e. from Pipaltha of Jind, Kalwan of Jind, Ludas and one site at Gannaour were detected with sulfosulfuron and meso+iodosulfuron residues in soil ranging between 0.025 to 0.048 µg/g but the residues were less than MRL value of sulfosulfuron (0.05 µg/g). There were no residues of these herbicides in wheat grains and straw from any sample.

Five out of 30 locations i.e. from village Danoda of Jind, Urjani of Yamuna Nagar, Kharka of Guhla and two sites from village Nangla of Tohana were detected with pretilachlor residues above 0.05 µg/g of soil. There were no residues of pretilachlor or oxadiargyl in paddy grains from any of the 30 locations. Three sites i.e village Danoda of Jind, Kingan of Pehowa and Nangla of Tohana were having pretilachlor residues slightly above MRL value of 0.05 µg/g in paddy straw.

Table 4.4.1 Herbicide residues in soil, wheat grains and straw from farmers' field during *Rabi* 2015-16

S. No.	Name & address of farmer	Herbicide/s sprayed	Dose	Residue* (µg/g)		
				Soil	Grain	Straw
1.	Gurmukh Singh, Pipaltha, Jind	Atlantis (meso+iodosulfuron)	X	0.033	BDL	BDL
2.	Surender Nain, Danoda, Jind	Atlantis(meso+iodosulfuron)	X	BDL	BDL	BDL
3.	Bhim Singh, Jind	Total (sulfosulfuron +MSM) + Topik	X	0.048	BDL	BDL
4.	Ram Niwas Chahal, Uchana	Sulfosulfuron+metribuzin	X	BDL	BDL	BDL
5.	Swarn Singh, Ludas, Hisar	Leader(sulfosulfuron)+Topik+ Axil+Topic	X	0.025	BDL	BDL
6.	Nirmal Singh, Ludas	Leader (sulfosulfuron)	X	BDL	BDL	BDL
7.	Balraj Singh, Kalwan, Jind	Leader (sulfosulfuron)	X	0.045	BDL	BDL
8.	Sahib Singh, Kaithal	Sulfosulfuron + clodinafop	X	BDL	BDL	BDL
9.	Ram Gopal, Gannaour	Leader (sulfosulfuron)	X	0.035	BDL	BDL

Table 4.4.2 Residues in paddy grains, straw and soil at farmer's field during *Kharif* 2016

S. No.	Farmers name and address	Herbicide sprayed	Residues (µg/g)		
			Soil	Grain	Straw
1.	Surender, Village Danoda (Jind)	Pretilachlor	0.037	BDL	0.026
2.	Surender, Village Danoda (Jind)	Pretilachlor	0.060	BDL	0.073
3.	Raju Village Sherpur (Y. Nagar)	Pretilachlor	0.005	BDL	0.04
4.	Naresh Saini, Village Urjani (Y. Nagar)	Butachlor	BDL	BDL	BDL
5.	Sishpal, Village Zaidari (Y. Nagar)	Pretilachlor	0.06	BDL	BDL
6.	Ishwar Chand, Village Deodhar (Y. Nagar)	Pretilachlor	0.032	BDL	BDL
7.	Gyan Ghai, Village Kachwa (Karnal)	Pretilachlor	0.032	BDL	BDL
8.	Ranjeet Singh, Village Diwana (Pehowa)	Pretilachlor	0.018	BDL	0.036
9.	Lila Ram, Village Kingan (Pehowa)	Pretilachlor	0.010	BDL	0.071
10.	Inder, Village Kingan (Pehowa)	Pretilachlor	0.047	BDL	BDL
11.	Harpal Singh, Village Nangla (Tohana)	Pretilachlor	0.006	BDL	0.067
12.	Darshan, Village Patli Dabar (Sirsa)	Pretilachlor	0.015	BDL	0.023
13.	Village Titukhera (Rania)	Pretilachlor	0.012	BDL	BDL
14.	Amarjeet, Village Laharian ki Dhani (Rania)	Pretilachlor	0.027	BDL	BDL

At Pantnagar, wheat plants and clay loam soil samples at 0-15 cm treated with of 2,4-D at 0.50 kg/ha, metsulfuron-methyl (4.0 g/ha) and clodinafop-propargyl (60 g/ha) from farmer were collected at harvest for determination of residue in *Rabi*. Rice plant and soil samples treated butachlor (1.5 kg/ha), bispyribac-sodium (0.02 kg/ha) and 2,4-D (0.50 kg/ha) were collected at harvest in *Kharif*. Water samples were collected near the agricultural field, viz. pond, well, borewell, canal, river, ditches, springs, etc. within one week of herbicide spray and after one month to determine persistence in water and change in water quality. Residues of the herbicide were found below MRL limits (0.01 µg/g) in all components at the time of harvest of wheat and rice. 2,4-D and metsulfuron-methyl collected from different places and locations in *Rabi* and *Kharif* were below detectable limits of 0.009 µg/ml.

At Faizabad, a field trial was conducted during *Rabi* 2015-16 at the farmers' field. Soil samples were taken at 0, 10, 30, 45, 60, 80 and at harvest level in days at different intervals and persistence were determined by bioassay method. Visual phytotoxic effects on cucumber as influenced by herbicides applied in wheat at different intervals were recorded. Isoproturon (1000 g/ha) and 2,4-D Na salt (500g/ha) at post-emergence persisted up to 30 days in the soil of wheat while metribuzin (200 g/ha), sulfosulfuron (25 g/ha) and clodinafop (60 g/ha) at post-emergence persisted up to 45 days in soil of wheat in farmers field (Table 4.4.3).

Table 4.4.3 Visual phytotoxic effect on cucumber as influenced by herbicides applied in wheat

Sl.	Treatments	0	10	30	45	60	80	At harvest
1.	Control	0	0	0	0	0	0	0
2.	Isoproturon 1000 g/ha post-emergence	+++	++	+	0	0	0	0
3.	Metribuzin 200 g/ha post-emergence	+++	++	+	+	0	0	0
4.	Sulfosulfuron 25 g/ha post-emergence	+++	++	++	+	0	0	0
5.	Clodinafop 60 g/ha post-emergence	+++	++	++	+	0	0	0
6.	2,4-D Na Salt 500 g/ha post-emergence	+++	++	+	0	0	0	0

Note: Visual phytotoxic rating
No toxicity = 0; Slight toxicity = +
Medium toxicity = ++; Severe toxicity = +++

At Ludhiana, soil, water and crop samples were collected at harvest from farmer's fields at Moga, and Kapurthala districts of Punjab in rice/wheat cropping system for residue of pretilachlor, butachlor, anilophos, clodinafop-propargyl and pendimethalinin. Residue of butachlor, pretilachlor, anilophos, clodinafop-propargyl and pendimethalin were found below detectable limit (<0.01µg/g) in soil, water and crop produce.

At Gwalior, demonstrations were conducted on 10 farmers' field for weed control in wheat during *Rabi* 2015-16 at Morena district and in blackgram in *Kharif* 2016 at four villages of Gwalior district. The treatments consisted of post-emergence application of sulfosulfuron (25 g/ha), clodinafop + metsulfuron (premix) (64 g/ha), 2, 4-D (0.5 kg/ha) and control (no herbicide) in wheat and post-emergence application of imazethapyr + imazamox (RM) (80 g/ha), imazethapyr (80 g/ha), quizalofop-ethyl 50 g/ha in blackgram. Soil samples were collected after harvest of crop and residues of herbicides were determined by bioassay technique using maize as bioassay plant. Herbicides residues were found not significant in post harvest soil as per bioassay study using maize as test plant.

At Coimbatore, sandy clay to silty clay loam soil and crop samples were collected at harvest from five farmers' fields from Valappady block of Salem district in Tamil Nadu from maize-maize grown field. Residues of these herbicides were found below detectable limit in soil, maize grains and water samples. At Bhubaneswar, soil and plant samples (maize) from Odhisa, Kuaput, Haladia, Khorda districts were collected from farmers' field at harvest in *Kharif*, 2016, for residue analysis. Pendimethalin residues were not detected in soil and grain samples collected at harvest. At Palampur, soil and wheat grain samples were collected from the clodinafop-propagryl treated fields of eight farmers of Kangra district at the harvest of the crop and were analyzed for clodinafop-propagryl residues in soil and wheat. Residues in soil and grain were found below detectable levels (BDL> 0.03 µg/g) in all samples.

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

Transfer of technology

Technology transfer is equally important as that of technology development for sustainability 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 of weed management and their adoption levels. However, any weed management technology cannot perform equally in every agro-climatic situation. On-farm trials (OFT) aim at testing a new technology in farmer's fields under farmers' conditions and management by using farmer's own practice as control. On-farm trials should help to develop innovations consistent with farmer's circumstances, compatible with the actual farming system and corresponding to farmer's goals and preferences. Accordingly, OFTs are formulated by the AICRP-WM centres' based on weed problems and priority of the problems faced by the farmers as given below:

WP 5.1 On-farm trials/Research

At Hissar, OFTs conducted at 11 locations and revealed that Shagun, a ready mix combination of clodinafop+ metribuzin against complex weed flora in wheat, had an edge over farmer's practice as it provided 89.5% control of *P. minor* as against 79.5% by use of Vesta with yield increase of 0.4 t/ha. Shagun showed good efficacy against grassy and broad leaf weeds but with 10-20% toxicity to some of varieties viz: PBW 550, HD 2967 and HD 2891 under high moisture conditions at some locations and regeneration of *P. minor* in some cases.

At Ludhiana, eight OFRs for testing efficacy of new pre-mix herbicide metsulfuron+chlorimuron (20 g/ha) applied as post-emergence were conducted in direct seeded rice. The new herbicides recorded effective control of broadleaf and sedges and recorded rice grain yield and economic return similar to recommended azimsulfuron and was safe to rice. Similarly, eight OFRs for testing efficacy of new pre-mix herbicide sulfosulfuron+ carfentrazone-ethyl at 100 g/ha (against recommended sequential application of sulfosulfuron and carfentrazone), and eight OFRs for testing the efficacy of new pre-mix herbicide metribuzin + clodinafop at 500 g/ha (against recommended herbicide metsurfuron + iodosulfuron) as post-emergence were conducted in wheat. The new herbicides provided effective control of broadleaf and grasses weeds and recorded similar wheat grain yield and economic return compared to earlier recommended herbicides.

At Pantnagar, OFTs on rice and soybean were conducted at two locations of the districts, US Nagar (Tarai area), and Nainital (Bhabar area) during *Kharif*, 2016. In Tarai region of Uttarakhand, application of bispyribac-Na at (25 g/ha) was found more effective against weeds in rice compared to farmers practice (butachlor 1000 g/ha) and it recorded an highest (41.9%) increase in grains yield due to application of bispyribac-Na and farmers practices (32.2%). Among the different weed control treatments, highest grain yield (4.4 t/ha), gross return (` 62,040 /ha), net return (` 30,165/ha) and B:C ratio (1.9) was recorded with bispyribac-Na followed by farmer's practice. Similarly, in soybean, imazethapyr (0.1 kg/ha) at 15 DAS and alachlor (2.5 kg/ha) (PE) were used for evaluation. The highest grain yield was obtained with early post-emergence application of imazethapyr (1.7 t/ha) followed by pre-emergence application of alachlor (1.6 t/ha) and farmer practice (1.5 t/ha). During *Rabi*, four OFTs were conducted in the districts, US Nagar and Nainital. In Tarai and Bhabar regions of Uttarakhand, application of ready mix of clodinafop-propargyl + metsulfuron methyl (60+4 g) /ha in wheat crop was found more effective against weeds at farmer's field as compared to application of sulfosulfuron+ metsulfuron-methyl (30+2 g) /ha.

At Palampur, eight OFT were conducted on different weed management technologies at various locations. Results revealed that weeds reduced grain yield of paddy by 53.7%. Dose of pyrazosulfuron (20 g/ha) remained at par with pyrazosulfuron (15 g/ha) and gave significantly higher grain yield of rice over other weed control treatments. Similarly post-emergence application of clodinafop (60 g/ha) + metsulfuron (4 g/ha) remained at par with post-emergence application of penoxaden + metsulfuron (4 g/ha) and pre-emergence pendimethalin (1.0 kg/ha) *fb* post-emergence metsulfuron (2 g/ha) gave significantly higher grain and straw yield of wheat. These were found better treatments which gave 107.7, 97.9 and 99% higher grain yield of wheat over weedy check and 28.6, 22.5 and 23.1% over farmers practice (hand weeding twice). Similarly application of imazethapyr at (80 g/ha) early post was found at par with pendimethalin + imazethapyr at 800 or 900 g/ha pre-emergence resulted in significantly lower dry weight of weeds higher green pea yield. There was significant variation in the population of grasses, sedges and broad-leaved weeds due to different rice based cropping systems.

At Dapoli, four OFTs were conducted at Lanja tehsil of Ratanagiri district in rice. Tested weed management technology oxadiargyl PE gave overall effective result in term of yield and net returns with higher B:C ratio compared to other treatment and farmers' practice of weed management. In *Kharif* groundnut, four OFTs were also conducted at same locations. Application of pendimethalin at 1.0 kg/ha PE recorded higher yield with net profit of ` 55,000/ha.

At Faizabad, three OFTs were conducted in tobacco to control *Orobanche cernua*. Application of neem cake 200 kg/ha + soil drenching of metalaxyl MZ 0.2% at 20 DAP showed higher tobacco leaf yield (265.9 g/plant), followed by imazethapyr (0.03 kg/ha) at 20 DAP (240 g/plant). Whereas in rice, application of pretilachlor (750 g/ha) as PE *fb* crlorimunr + metsalfuron (4 g/ha) as PoE recorded higher grain yield (5.4 t/ha) with net profit of ` 48,000/ha.

At Pusa, ten OFTs were conducted using the chemical weed management technologies for rice crop (5 OFT) in *Kharif* and wheat (5 OFT) in *Rabi* at different farmers' field. Pretilachlor (750 g/ha) *fb* chlorimuron+ metsulfuron (crlorimunr + metsalfuron) at 4 g/ha 25 DAT in rice and clodinafop + metsulfuron (Premix) (60 +4 g) at 5 WAS in wheat were found superior in term of grain yield and B:C ratio over farmers practices.

At Akola, two OFTs were carried out in cotton using pre- emergence herbicides pendimethalin at (1.0 kg/ha) followed by post-emergence herbicide pyrithiobac-sodium (625 g/ha). Results revealed that the weed control and crop yield in all the two farmers' field was relatively better due to the improved technology as compared to their own practice (3-4 hoeing + 2 - 3 hand weeding). At Coimbatore, five OFTS on weed management in okra and five in black-gram were carried out. Application of oxyflourfen 200 g/ha (PE) + one hand weeding on 30-35 DAS showed broad spectrum weed control, higher fruit yield and economic returns in okra. Due to adoption of improved weed management technology (EPOE quizalofop- ethyl 50 g/ha and imazethapyr 50 g/ha on 15-20 DAS, on an average black gram yields increased and ranged from 16.9 to 31.1% higher over farmers practice (two hand weeding). The highest income also obtained by improved practice over farmers practice and it has been popularized among the farmers.

At Jorhat three OFTs were carried out in greengram using pendimethalin (750 g/ha) (PE). Result revealed that the weed control and grain yield in all the three farmers' field was higher due to the improved technology as compared to their own practice (2 hand weedings).

At Bhubaneswar six OFTS on weed management in transplanted rice were carried out during *Rabi* 2015-16 at Alsua village of Banki block of Cuttack district. Maximum yield of 4.2 t/ha was recorded in the plot treated with pretilachlor 1.0 lit/ha. A net saving of ` 2500 - 3500/ha was obtained in the plots treated with herbicides.

At Gwalior OFT were conducted in blackgram using imazethapyr + imazamox (RM) 80 g/ha. Results revealed 64.5% increase of grain yield of blackgram over farmer practice with B:C ratio of 2.9 over 1.8 in farmer practice. Similarly in wheat 3.7 t/ha grain yield was obtained with the application of sulfosulfuron followed by clodinafop + metsulfuron (3.3 t/ha) and 2,4-D (3.1 t/ha) which was 32.9, 19.3 and 12.2% higher over farmers practice.

At Anand OFT conducted on farmers field showed that IC *fb* HW carried out at 20 and 40 DAS was more effective for weed management as compared to post-emergence application of quizalofop-ethyl in soybean crop.

At Raipur, five OFTs were carried out at Village Chotod, district Raipur in direct line seded rice with application of pinoxsulam (20 g/ha) as post-emergence. There was 23.6% increase in grain yield due to recommended practice over farmers practice alongwith a B:C ratio of 3.71 adn 2.87, respectively.

At Jammu, two OFTs were carried out using stale seed bed with glyphosate (1.5 kg/ha), paraquat (0.8 kg/ha) and quizalofop-ethyl (0.16 kg/ha) in transplanted basmati rice for the management of weedy rice at village Rattan and Makhanpur Gujran of RS Pura block of Jammu region during *Kharif* 2015. Application of stale seed-bed with glyphosate was found to be significantly superior to all other treatments in terms of grain yield (2.9 t/ha), net returns (` 59,947/ha) and B:C ratio (1.9) of transplanted rice.

At Raichur, fourteen OFTs were conducted on weed management technology in black gram (7) and rice (7) at different locations during *Kharif* 2016. Recommended weed management technology of black gram and rice was compared with farmers practice (Two hand weedings at 20 and 40 DAS). On an average, farmers practice gave higher seed yield, economic benefit with high B: C ratio as compared to improved weed management practices in both the crops.

WP 5.2 Front Line Demonstrations

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

At Raipur, 25 FLDs were conducted on weed management in rice in two tribal villages of Kanker, District during *Kharif* 2016 with the help of KVK Kanker. Average yield of farmers practice and recommended practice was 40.6 and 49.4 q/ha, respectively. However, percent increase under recommended practice over farmers practice was 21.6%. The average benefit cost ratio was calculated to be 2.5 and 3.2 under farmers practice and recommended practice.

At Hisar, results of 116 FLDs conducted on 185 acres in Bhiwani, Hisar and Mahender Garh districts revealed that post-emergence application of glyphosate (25 g/ha) at 30 DAS followed by its use at 50 g/ha at 50-60 DAS provided effective control (79, 87 and 98%, respectively) of *Orobanche aegyptiaca* in mustard. Similarly, tembotrione (120 g/ha) was demonstrated against complex weed flora in *Kharif* maize at five locations in Panchkula district. Results showed that tembotrione provided 85-100% control of weeds, namely *Cyperus rotundus*, *Cynodon dactylon*, *Cyperus rotundus*, *Brachiaria reptans*, *Commelina benghalensis, Digitaria sanguanalis, Sorghum helepense* and *Elusine indica* which were not being controlled by use of atrazine being used by farmers. Yield data showed that economics was in favour of use of tembotrione at all locations. During *Kharif* 2016, fifteen demonstrations on bioefficacy of Eros, a ready mix combination of pretilachlor + pyrazosulfuron against complex weed flora in transplanted rice were conducted in various parts of state and compared with earlier recommended herbicide *Rifit* (pretilachlor). On an average Eros, had an edge over pretilachlor as it provided more than 91.5% control of complex weed flora as against 83% by use of pretilachlor with yield increase of 0.4 t/ha, means 7.6% increase over farmers practice of use of pretilachlor.

At Pantnager, FLDs using herbicides for managing weeds in rice, soybean and wheat were conducted at farmers' field in different location of Bhabar and Tarai area. In rice, use of bispyribac-sodium (20 g/ha) gave broad spectrum weed control and increased mean net return with higher B: C ratio over farmers practice. In soybean, application of imazethapyr (0.1 kg/ha) as post-emergence produced 12.5% higher grain yield as compared to farmers' practice. Similarly in wheat ready mix application of clodinafop-propargyl + metsulfuron at 64 g/ha at 30 DAS effectively controlled broad leaved weeds in all locations and increased grain yield, mean net return and B: C ratio compared to farmers practice.

At Ludhiana, improved spray technology (use of tractor operated multi-boom sprayer) for enhancing herbicides efficacy was demonstrated in direct seeded rice during *Kharif* 2016 at 60 locations of five districts, viz Sri Muktsar Sahib, Patiala, Bathinda, Jalandhar and Amritsar. Improved spray technology gave 6.2% higher rice grain yield, 22% higher weed control and ` 5,500/ha higher net returns than conventional spay technology. Similarly during *Rabi* 2015-16 improved spray technology (use of tractor operated multi-boom sprayer) for enhancing herbicides efficacy was carried out in wheat under FLD programme at 109 locations of 6 districts, viz Sri Muktsar Sahib, Patiala, Bathinda, Jalandhar, Moga and Amritsar. Averaged data of different locations revealed that improved spray technology gave 4.3% higher wheat grain yield, 11.2% higher weed control and ` 3,627/ha higher net returns than conventional spray technology.

At Pusa, 10 farmers were selected from Darbhanga, Madhubani, Samastipur, Muzaffarpur, Rohtas and Vaishali districts of Bihar for FLDs during *Kharif* 2016 to demonstrate performance of pretilachlor (750 g/ha) *fb* chlorimuron + metsulfuron (crlorimunr + metsalfuron) at 4 g/ha 25 DAT. Total area for this demonstration was 4 ha. Highest grain yield of rice (4.6 t/ha) was recorded with the demonstrated weed management technology which was 29% higher than the farmers practice. Similarly FLDs were conducted in 10 farmers' fields using ready-mix combination of clodinafop + metsulfuron (60+4 g/ha) at 5 WAS for managing weeds in wheat in Madhubani, Samastipur, Muzaffarpur, Vaishali and Nawada districts. Compared to the farmers practice, wheat yield was 29.3% higher with the application of readymix combination of clodinafop + metsulfuron (4.65 t/ha).

At Coimbatore, five FLDs were carried out in blackgram at different location. Due to adoption of improved weed management technology (EPOE quizalofop-ethyl (50 g/ha) and imazethapyr (50 g/ha) at (15-20 DAS), on an average, the grain yield of black gram increased by 16.9 to 31.07 % higher over farmers practice (two hand weedings). Highest income also obtained in improved practice over farmers practice (two hand weedings). Majority of the farmers were fully satisfied with the performance of improved weed management technology.

At Akola, two FLDs were carried out in soybean crop at Alanda and Ghusar villages of Akola using herbicides diclosulam (22 g/ha) PE followed by imazethyper + imazamox (100 g/ha) at 20-25 DAS for managing the weed. The higher grain yield (2 t/ha) and B: C ratio (2.6) obtained in improved practice over farmers practice (1.2 t/ha and 2.4). Farmers were fully satisfied with the performance of improved weed management technology.

At Palampur, five FLDs using herbicides for managing weeds in wheat (3) and Rajmash (2) were conducted at farmers' field in different location of Palampur and Mandi districts. In wheat, IWM gave broad spectrum weed control and increased grain yield (3.1 t/h) with higher B: C ratio (2.4) over farmers practice (grain yield 1.2 t/h with B:C ratio 1.2). Similarly in Rajmash, application of herbicides effectively controlled weeds in the farmers' fields and increased grain yield, mean net return and B: C ratio compared to farmers practice.

At Raichur, during *Kharif* 2016, ten FLDs were conducted on weed management technology in cotton (05) and rice (05) at different locations. Recommended weed management technologies of cotton and rice were compared with farmers practice. On an average, improved weed management practices gave higher seed yield, economic benefit with high B: C ratio in both the crops.

At Thrissur, demonstration of oxyfluorfen as an alternative herbicide for diuron in pineapple was carried out. Result revealed that farmers were fully convinced about its efficacy for the control of weeds at very low concentrations.

At Udaipur, eleven FLDs using improved weed management technology for managing weeds in maize (05), and wheat (06) were conducted at farmers' fields of different locality. In maize, tembotrione at 15 DAS gave very good weed control and increased grain yield (54.5%) with higher B: C ratio over farmers practice. Similarly in wheat, application of ready mix combination of sulfosulfuron (30 g / ha) + metsulfuron 2.0 g / ha at 30 DAS produced 62.5% higher grain yield as compared to farmer's practice.

At Gwalior, FLDs were conducted on weed management technology in pearlmillet during *Kharif* 2016. Average yield in the demonstration field of pearlmillet (2,4-D 0.5 kg / ha PoE) was 4.7 t / ha with B:C ratio of 2.6, while the average yield in farmer practice was 3.7 t / ha with B:C ratio of 2.2.

At Bhubaneswar, ten FLDs were carried out in transplanted rice at Munida, Satyabadi of Puri districts using bispyribac- sodium (25 g / ha) at 25 DAT for managing the weed. Higher grain yield (21 - 42%) and B:C ratio were obtained in improved practice over farmers practice.

Table 5.1 Extension activities undertaken by coordinating centres.

Centres	Training imparted	Radio talks	TV programmes	Kisan melas/Kisan day	Handouts/folders /pamphlets	Bulletins/booklet	Training participated	On-farm trials	Frontline demonstrations	Parthenium awareness programme
PAU, Ludhiana	-	1	5	-	-	-	10	24	169	Ö
UAS, Bengaluru	-	1	1	-	-	-	3	242	-	Ö
RVSKVV, Gwalior	-	-	-	-	-	1	-	14	4	Ö
GBPUAT, Pantnagar	-	2	-	-	-	1	3	27	14	Ö
CSKHPKV, Palampur	2	1	-	-	-	2	-	8	5	Ö
AAU, Jorhat	1	8	-	-	-	-	-	6	-	
AAU, Anand	15	1	3	-	-	-	7	2	2	Ö
TNAU, Coimbatore	-	-	-	-	-	-	12	5	5	-
NDUAT, Faizabad	-	3	-	1	-	1	1	4	-	Ö
BAU, Ranchi	-	5	-	-	-	-	1	-	-	Ö
KAU, Thrissur	-	-	-	-	-	-	-	3	1	Ö
OUAT, Bhubaneshwar	2	-	-	-	-	-	-	8	2	Ö
PJTSAU, Hyderabad	2	3	10	-	2	3	-	1	4	Ö
CCSHAU, Hisar	22	4	1	4	-	-	1	11	136	Ö
RAU, Pusa	-	1	5	1	-	-	-	10	20	Ö
DrBSKKV, Dapoli	-	-	-	-	-	-	2	5	2	
IGKV, Raipur	-	5	4	-	-	-	-	5	25	Ö
PDKV, Akola	-	-	2	-	6	-	3	2	2	Ö
BCKV, Kalyani	-	-	-	-	-	-	-	-	-	
CAU, Pasighat	2	-	-	-	4	-	-	-	-	Ö
UAS, Raichur	-	1	2	-	-	-	3	14	10	Ö
MPUAT, Udaipur	2	1	-	-	2	-	-	-	11	Ö
SKUAST, Jammu	-	-	-	-	-	5	2	1	-	Ö
Total	48	37	33	6	14	13	48	392	412	

4. RECOMMENDATIONS FOR PACKAGE OF PRACTICES

AAU, Anand

- Application of pendimethalin (1.0 kg/ha) as PE and mulching of paddy straw (5 t/ha) was found effective to manage weeds and produce higher garlic bulb yield.
- Application of pendimethalin (1000 g/ha) as PE and integration with hand weeding at 20 and 50 days after sowing or sequential application of pyrithiobac-sodium + quizalofop-p-ethyl (62.5 + 50 g/ha, tank mix) as PoE and glyphosate (2000 g/ha) or paraquat (600 g/ha) at 60 days after sowing were found effective to manage weeds and produce higher seed cotton yield.
- Application of pre-mixed broad spectrum herbicides clodinafop + metsulfuron-methyl (64 g/ha) or sulfosulfuron + metsulfuron-methyl (32 g/ha) or mesosulfuron + iodosulfuron (14.4 g/ha) as post-emergence application (25-30 DAS) or hand weeding at 20 and 40 days after sowing is recommended to the farmers of Middle Gujarat to manage complex weed flora in wheat in irrigated wheat.
- Application of tank-mix of pendimethalin (0.25 kg/ha) with atrazine (0.50 kg/ha) or atrazine alone (1.0 kg/ha) as pre-emergence is recommended in maize which is equally effective to IC *fb* HW carried out at 20 and 40 DAS in maize in maize-wheat cropping system. In succeeding wheat crop, pre-emergence application of pendimethalin (0.50 kg/ha) or post-emergence application of metsulfuron-methyl (4 g/ha) or hand weeding at 30 DAS is also recommended. These herbicides do not exert any adverse effect on soil microbial properties at harvest.
- Post-emergence application of imazethapyr (30 g/ha) at 40 DATP effective for control of *Orobanche* in tobacco crop , however it was found phytotoxic to tobacco crop.
- Application of pendimethalin (0.5 kg/ha) as sand mix provided 100% control of *Cuscuta* in lucerne crop but showed phytotoxicity on lucerne crop. Imazethapyr (40 g/ha) as PoE found effective to manage *Cuscuta* infestation.
- For effective weed control in greengram, application of imazethapyr or imazethapyr + imazamox (RM) (70-80g/ha) as PoE is recommended. Though it showed phytotoxicity to greengram up to two weeks of herbicide application but later on it was recovered and yielded higher seed yield without carryover/ residual effect on succeeding mustard crop.

AAU, Jorhat

- Application of oxadiargyl (90 g/ha) followed by garden hoeing at 30, 50 and 80 DAP for better weed control and fruit yield of brinjal is recommended.
- Application of metribuzin (500 g/ha) pre-emergence + garden hoe 30 and 60 DAP for better weed control and fruit yield of chilli is recommended.
- Application of metribuzin (0.75 kg/ha) at 10 DAP for better weed control and higher yield of potato is recommended.

BAU, Ranchi

- Pre-emergence application of pendimethalin (1.0 kg/ha) + metribuzin (0.175 kg/ha) within 3 days after sowing of wheat was found effective to control major weeds in wheat. It also reduces weed dry matter thereby produced higher grain and straw yield as well as higher net return (` 46,890/ha) and B:C ratio (1.63). This technology is as good as two hand weedings performed at 25 and 55 days after sowing.
- Application of atrazine (0.75 kg/ha) pre-emergence within three days after sowing *fb* straw mulch at 10 DAP days after planting *fb* hand weeding at 75 DAP can be practiced for higher growth, productivity and profitability of turmeric.
- Application of glyphosate (0.80 kg/ha) + oxyfluorfen (0.2 kg/ha) just before emergence of sprouts of ginger is effective in controlling weeds of ginger in all the growth stages and resulted in maximum ginger rhizome yield (27 t/ha), net return (` 8,72,514/ha) and B:C ratio (4.2).

- Application of imazethapyr (50 g/ha) applied at 2 days after sowing of black-gram is recommended for effective weed management. It also increased seed yield, net return and B:C ratio.
- Application of herbicide combination atrazine + pendimethalin (0.50+0.50) kg/ha as pre-emergence is recommended for effective weed management and higher yield of maize.
- Zero tillage along with crop residue in rainy and winter seasons (ZT+R-ZT+R) is recommended for higher maize grain yield as well as maize – wheat system productivity and profitability compared to CT-CT. For effective weed management, integrated weed management (IWM) with intercropping of blackgram and pre-emergence application of pendimethalin (1.0 kg/ha) + manual weeding at 30 DAS in maize and 2,4-D 0.5 kg/ha post-emergence in wheat *fb* hand weeding at 40 DAS is recommended in maize and wheat.
- Conventional tillage in rice and wheat sequences and application of butachlor (1.0 kg/ha) as pre emergence + 2,4-D (0.5 kg/ha) as post-emergence in rice and isoproturon (0.75 kg/ha) + 2, 4-D (0.5 kg/ha) as post-emergence in wheat, was the most productive and remunerative approach in direct-seeded rice-wheat system.
- Application of pyrazosulfuron (20 g/ha) 3 DAS *fb* bispyribac-sodium (25 g/ha) at 25 DAS can be practiced for better crop growth, higher productivity and profitability of direct seeded rice.

CSKHPKV, Palampur

- Spraying of mixture of isoproturon (1000 g/ha) + 2, 4-D (sodium salt) (500 g/ha) at 2-3 leaf stage of weeds or ready mix herbicide clodinafop-propargyl + metsulfuron-methyl (60 + 4 g/ha) at 2 – 3 leaf stage of weeds is recommended in the wheat field if it is infested with grassy as well as broad leaved weeds.

GBPUAT, Pantnagar

- In rice, summer ploughing of main field is recommended to destroy weeds and expose soil and wet bed method for raising rice nursery. Application of anilofos (0.4 kg/ha) or thiobencarb (1.0 kg/ha) when first leaf of rice has turned green or butachlor (1.5 kg/ha), anilofos (400 g/ha), pretilachlor (1.0 kg/ha) or thiobencarb (1.0 kg/ha) as pre-emergence after transplanting is effective for weed control.
- Application of 2,4-D (500 g/ha) or chlorimuron + metsulfuron (4 g/ha) as post-emergence to control sedges and broad leaf weeds in rice is recommended.
- For effective weed management in direct seeded rice, application of pendimethalin (1.0 kg/ha) within 0-3 DAS *fb* metsulfuron-methyl (4 g/ha) at 25-30 DAS and one hand weeding (40-45 DAS) is recommended.
- Application of alachlor (2.0 kg/ha) or metolachlor (1.0 kg/ha) as pre-emergence or fluchloralin or trifluralin (1.0 kg/ha) as pre-plant incorporation or metribuzin (350 g/ha) as pre-emergence *fb* one hand weeding at 30-35 DAS is recommended in soybean.
- In wheat, application of pendimethalin (1.0 kg/ha) as pre-emergence, clodinafop-propargyl (60 g/ha) or sulfosulfuron (25 g/ha) *fb* one hand weeding was found effective for effective weed management. Apply 2,4-D (0.5 kg/ha) at 30 days stage or metsulfuron-methyl (0.004 kg/ha) at 35-40 days stage for control of broad leaved weeds and sedges.

NDUAT, Faizabad

- In direct-seeded rice (wet), application of pendimethalin (1000 g/ha) at 0-2 DAS *fb* bispyribac-Na (25 g/ha) applied at 35 days after sowing was very much effective to control all type of weeds.
- In direct-seeded rice (dry), application of bispyribac-Na (25 g/ha) applied at 25-35 day after sowing control all type of weeds.
- In wheat, for controlling broad leaf weeds only, 2,4-D sodium salt at (625 g/ha) is recommended at 30-35 DAS along with 400-500 litres water by using flat fan or flood jet nozzle. For management of complex weed flora in wheat, application of pendimethalin (1.0 kg/ha) PE followed by metribuzin PoE (175 g/ha) followed by sulfosulfuron PoE (18 g/ha), respectively can be applied for effective weed control. This treatment recorded highest net return (` 54,668/ha) and BCR (2.08) values.

- For control of *Cyperus rotundus*, leave the infested field fallow in ensuing rainy season. Application of glyphosate (4.0 litres/ha) along with 400-500 litres of water/ha is recommended for spray on fast growing *Cyperus* plants in between mid August to mid September. This helps in killing of *Cyperus rotundus* plants in the next 10-15 days. After one month period, succeeding crops can be grown.

PAU, Ludhiana

- Post-emergence application of metsulfuron-methyl + carfentrazone-ethyl (50 g/ha) with surfactant at 35 DAS is recommended in wheat for effective control of broadleaf weeds including hardy weeds like *Solanum nigrum, Rumex spinosus, Vicia sativa* and *Convolvulus arvensis*.
- Post-emergence application of metsulfuron-methyl + chlorimuron-ethyl (4.0 g/ha) at 20 days after sowing is recommended in direct-seeded rice for effective control of sedges and broadleaf weeds.
- Application of pendimethalin (1.0 g/ha) as pre-emergence is recommended for effective control of *P. minor* in wheat.
- Pre-emergence application of pendimethalin (1.0 g/ha) for effective control of annual weeds in direct-seeded rice.
- Pre-emergence application of pretilachlor (0.6 g/ha) is recommended for effective control of grass weeds in transplanted rice.
- Pre-emergence application (0-5 days after transplanting) of pretilachlor + pyrazosulfuron (615 g/ha) is recommended for effective control of mixed weed flora in transplanted rice.

RVSKVV, Gwalior

- Application of post-emergence herbicide combinations viz sulfosulfuron + metsulfuron (30 + 2 g/ha), clodinofop + metsulfuron (60 + 4 g/ha) and mesosulfuron + iodosulfuron is recommended for control of most of weeds in wheat. It also give higher yield and profit in wheat.

TNAU, Coimbatore

- In transplanted rice, pre-emergence application of pretilachlor at (750 g/ha) *fb* POE chlorimuron + metsulfuron (4.0 g/ha) is recommended for for higher grain yield and effective control of mixed weed flora.
- System of rice intensification and pre-emergence application of pyrazosulfuron-ethyl (30 g / ha) at 3 DAT + weeding with finger type double row rotary weeder at 40 DAT is recommended for effective control of mixed weed flora. It also recorded higher grain yield in rice.

UAS, Bengaluru

- For effective control of mixed weed flora, pre-emergence application of oxadiargyl (300 g/ha) or pendimethalin (1453 ml/ha) applied at 3 DAS in sunflower is recommended for Zone-5 & 6.
- Padding of 4 g $CuSO_4$ + 0.5 g 2,4-D sodium salt is recommended for management of parasitic weed *Dendrophthoe (Loranthus)* in sapota for Zone-5.
- Pre-emergence application of pendimethlain (1940 ml/ha) applied at 0-3 DAS followed by post-emergence application of 2,4-D sodium salt 625 g/ha applied at 30 DAS in maize is recommended for Zone-7.

RAU, Pusa

- Application of pendimethalin (1.0 kg/ha) as pre-emergence + porpaquizafop (62 g/ha) at 20 DAS may be recommended for better yield and economic return in sun flower. Pendimethalin (1.0 kg/ha) as pre-emergence *fb* + quizalofop-ethyl (37.5 g/ha) at 20 DAS and pendimethalin (1.0 kg/ha) as pre-emergence *fb* + fenoxaprop-ethyl (37.5 g/ha) were found equally effective for enhancing seed yield and net return and B:C ratio.
- Neem cake 200 kg/ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAP was found effective in controlling *Orobanche* shoot and producing the highest tobacco yield (23.9 q/ha) and fetching the highest net return (` 3,42,600/ha) and B:C ratio (2.2).
- Application of bispyribac-sodium (25 g/ha) + ethoxysulfuron (18.7 g/ha) at 25 DAT or pendimethalin (750 g/ha) at 0-3 DAT *fb* bispyribac-sodium (25 g/ha) 25 DAT or either pretilachlor (750 g/ha) or pyrazosulfuron (20 g/ha) (at 0-3 DAT) *fb* chlorimuron+metsulfuron (4 g/ha) (at 25 DAT is quite effective in controlling

weeds and obtaining higher yield of transplanted rice and fetching higher net return and B:C ratio.

- Pre-emergence application of metribuzin (0.7 kg/ha) or pendimethalin (1.0 kg/ha) at 3 DAP *fb* fenoxaprop (67 g/ha) + metsulfuron (4 g/ha) at 45 DAP is effective in controlling weeds and producing good yield of turmeric rhizome with higher B:C ratio.
- Application of glyphosate (0.80 + oxyfluorfen 0.2 kg/ha) or pendimethalin (1.5 kg/ha) at 15 DAP or hand weeding or pendimethalin (1.5 kg/ha) at 3 DAP but before mulching *fb* hand weeding at 30 DAP or oxyfluorfen 0.2 kg/ha at after planting but before mulching *fb* hand weeding at 30 DAP was found effective in managing weed flora with higher B:C ratio in ginger.

SKUAST, Jammu

- Application of imazethapyr + pendimethalin (1000 g/ha) as pre-emergence or imazethapyr (70 g/ha) as post-emergence or imazethapyr + imazamox (RM) 70 g/ha as post-emergence is recommended for most effective control of weeds in summer blackgram in blackgram-rice cropping system.
- The stale seed-bed technique with glyphosate (1.5 kg/ha) or paraquat (0.8 kg/ha) is recommended for effective control of weedy rice in transplanted rice.

CAU, Pasighat

- For effective management of weeds in horticultural crops (sweet corn, okra and ginger) under high rainfall areas of Arunachal Pradesh, integrated weed management approaches like growing of soybean as inter crop with maize, use of plastic mulch for okra and ginger, and application of oxyfluorfen (0.20 kg/ha) as pre-emergence + hand weeding 30 DAP coupled with slashed grass mulching is more efficient and economically viable.

5. TRIBAL SUB-PLAN PROGRAMME

RVSKVV, Gwalior

Thirty FLDs on wheat were conducted on weed management practices during *Rabi* 2015-16. Demonstrations on wheat were conducted in 3 villages viz., Sad (Rama block), Kardawad (Petlawad Block) and Mailpada (Jhabua block), Sejwani, Mailpada, Bisoli (Jhabua block) and Mokampura Villages (Rama block). Agricultural inputs like seed, herbicides and insecticides were provided to these farmers. Average yield in the demonstration plots of wheat treated with metsulfuron-methyl (4 g / ha) PoE was found 3.9 t / ha while in farmers' field average yield was 2.7 t / ha. Yield of demonstration plot were higher by 39.9% as compared to farmers' field. Maximum yield in the demonstration plot was 4.4 t / ha while minimum was 3.2 t / ha. Average B: C ratio found in FLDs' was 2.9 as against 2.2 in farmers' practices.

CSKHPKV, Palampur

Training programmes on 'Advances in scientific management of vegetables and horticultural crops' were organized for enhancing knowledge of tribal farmers at Mountain Agricultural Research and Extension Centre, Salooni, Deol, Holi, Bharmour and Machhatar (Chanouta), Holi, Bharmour on 13-14 Feb, 2016, 27 September, 2016 and 28 September, 2016. In this programme approximately 120, 85 and 115 tribal farmers participated, respectively in each location.

AAU, Anand

In 2016-17, Dahod district was chosen to distribute weed management inputs *i.e.* ASPEE bakpak sprayer plastic pumps, hand hoe *Dharti* brand, spray nozzles XL-54 and spray nozzles FFP / 95 / 900. Forty farmers for spray pumps and 94 farmers for hand hoe were selected. Herbicide spraying nozzle was distributed to all farmers who participated in group meeting at village level. Selection and distribution of inputs was carried out in collaboration with KVK, Dahod and tribal women farmer, Training Centre, Devgadh Baria (Dahod district). Collection of land records and Election Voters Card of each beneficiary was also done.

Input distribution to tribal farmers

BAU, Ranchi

A training programme on weed management in different crops was organized for tribal farmers. During the training programme, farmers were acquainted with losses caused by weeds, different methods of weed control, different types and uses of herbicides, different weed control implements, weed control in cereals, pulses, oilseeds and vegetable crops etc. Prior to training, a pre-training evaluation of all farmers was conducted. After evaluation, it was found that the level of knowledge of farmers was very poor prior to start of training. Post training evaluation of trainees was conducted after completion of training. It was observed that the knowledge of farmers about weed control enhanced to the extent of 70 to 80%. It showed that training was successful in imparting weed control knowledge among farmers.

OUAT, Bhubaneswar

The programme has been operated in two tribal dominated villages of Sundargarh and Keonjhar districts for overall development of farmers' livelihood by supplying different farm machineries implements and agricultural inputs. About 225 farmers were directly benefited under this programme.

IGKV, Raipur

In an area of 25 acres, frontline demonstrations on weed management in rice were laid down in tribal villages Nawagaon and Khartha in district Kanker. A total of 25 farmers were benefitted by this programme. Demonstrations were conducted by AICRP-Weed Management with the help of KVK, Kanker during *Kharif* 2016. The average yield of farmers practice and recommended practice was 4.1 and 4.9 t / ha, respectively. However, percent increase under recommended practice over farmers practice was 21.6%. The average benefit cost ratio was calculated to be 2.5 and 3.2 under farmers practice and recommended practice.

6. LINKAGES AND COLLABORATION

All India Coordinated Research Project on Weed Management has effective collaboration with state agriculture universities, ICAR institutes such as IIPR, Kanpur, IISS, Bhopal, IVRI, Izatnagar, IIFSR, Modipuram, and other AICRP's such as AICRP-IFS and Network Project on Organic Farming (NIOF), IIFSR, Modipuram. Following collaborative research work was carried out during the year.

PAU, Ludhiana

Development of organic farming package for system base high value crops in maize-potato-onion cropping system was done. Different organic farming treatments recorded diverse weed flora viz grasses, sedges and broadleaf weeds in all the three crops. Total of eight weed species were observed in maize crop. The dominant weed species was *Cyperus rotundus* in all the treatments. Three broadleaf weeds like *Trinathema potulacastrum, Phyllanthus niruri,* and *Digera arvensis,* four grass weeds *Dactyloctenium aegyptium, Digitaria ciliaris, Eragrostis* spp. and *Eleusine indica* were reported this year. *Euphorbia hirta* and *Amaranthus viridis* were observed last year, but was not found in this season in maize crop. In potato crop, three weed species namely *Cyperus rotundus, Gnaphalium purpureum* and *Oenothera drummondii* were prominent along with *Medicago denticulata, Rumex dentatus, Coronopus didymus* and *Anagallis arvensis.* In onion crop, ten broadleaf weeds like *Oenothera drummondii, Coronopus didymus, Spergula arvensis, Rumex dentatus, Chenopodium album, Medicago denticulata, Veronica agrestis, Anagallis arvensis, Malva parviflora, Polygonum plebium*; one grass weed- *Poa annua* and perennial sedge – *Cyperus rotundus* were observed.

Another experiment was conducted on evaluation of bio-intensive complementary cropping systems. Weed flora in both *Rabi* and *Kharif* consisted of annual grass and broadleaf weeds and perennial sedges. In *Rabi*, twelve weed species namely *Cyperus rotundus;* broadleaf weeds namely *Oenothera laciniata, Rumex dentatus, Medicago denticulate, Coronopus didymus, Anagallis arvensis, Polygonum plebium, Veronica agrestis, Chenopodium album;* grasses namely *Poa annua, Phalaris minor, Avena fatua* were observed in different *Rabi* crops. In *Kharif*, eight weed species namely: *Cyperus rotundus*, grasses namely *Dactyloctenium aegyptium, Digitaria ciliaris, Echinochloa colona,* broadleaf weeds like *Commelina benghalensis, Euphorbia microphylla, Phyllanthus niruri, Trianthema portulacastrum* were observed. The cropping system showed differential effect on weed species in *Rabi*, for example no weeds were observed in plots where maize (furrow) + turmeric (bed)-wheat / barley sown on beds + linseed was sown in furrows. Maize-potato-spring maize cropping system had maximum *Cyperus rotundus* in *Rabi ; Poa annua* was the highest in hyola, radish and potato based systems, and *Anagallis arvensis, Coronopus didymus, Polygonum plebium* in turmeric based system. Cropping systems affected weed density and diversity in *Kharif* also. There were no weeds observed in basmati rice- radish-spring maize cropping system plots in *Kharif.* Cotton + *Sesbania* have only *Cyperus rotundus* in abundance along with two grass weeds only, no broadleaf weed was observed.

7. PUBLICATIONS

AAU, Anand

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AAU, Jorhat

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BAU, Ranchi

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CCSHAU, Hisar

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CSKHPKV, Palampur

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GBPUAT, Pantnagar

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IGKV, Raipur

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KAU, Thrissur

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NDAUT, Faizabad

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PAU, Ludhiana

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PJTSAU, Hyderabad

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TNAU, Coimbatore

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UAS, Bengaluru

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OUAT, Bhubaneswar

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RAU, Pusa

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UAS, Raichur

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SKUAST, Jammu

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RVSKVV, Gwalior

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Table 7.1 Publications by the coordinating centres

Centres	Research paper	Popular articles	Paper presented seminars/ symposia /conferences	Books	Book Chapter	Lecture delivered during training	Student guided	
							M.Sc.	Ph.D.
PAU, Ludhiana	13	10	4	-	-	13	10	4
UAS, Bengaluru	4	-	6	-	-	-	-	-
RVSKVV, Gwalior	1	-	3	-	-	-	-	-
GBPUAT, Pantnagar	8	-	7	-		8	6	5
CSKHPKV, Palampur	7	1	9	-	1	17	-	-
AAU, Jorhat	3	3	5	-	1	2	1	4
AAU, Anand	6	2	5	-	3	13	9	
TNAU, Coimbatore	11	1	20	2	4	11	3	3
NDUAT, Faizabad	2	2	-	-	-	-	5	3
BAU, Ranchi	7	-	6	-	-	-		
KAU, Thrissur	3	-	1	-	-	5	15	7
OUAT, Bhubaneshwar	3	-	-	-	1	-	1	-
PJTSAU, Hyderabad	11	4	8	-	-	13	2	5
CCSHAU, Hisar	10	5	13	-	-	-	4	4
RAU, Pusa	2	2	-	2	-	2	-	-
DrBSKKV, Dapoli	-	-	-	-	-	-	2	
IGKV, Raipur	8	1	2	-	-	2	4	2
PDKV, Akola	-	4	6	-	-	-	3	4
BCKV, Kalyani	-	-	-	-	-	-	-	-
CAU, Pasighat	-	-	1	-	-	-	-	-
UAS, Raichur	4	-	6	-	-	2	-	-
MPUAT, Udaipur	6	4	3	-	1	4	4	4
SKUAST, Jammu	5		5	1		3	1	-
Total	114	39	110	5	11	95	70	45

8. AWARDS AND RECOGNITIONS

CCSHAU, Hisar

- Dr. S.S. Punia has been conferred "Bharat Ratna Mother Teresa Gold Medal Award" by Global Economic Progress and Research Association during National Unity Conference on 24.12.2016 held at Chennai.
- Dr Dharam Bir Yadav has been conferred upon with 'Editorial Excellence Award" by the journal Legume Research during 2016.
- Best Paper Award (3rd Prize) was given for research paper on 'Nanoparticles: A Tool for Pesticide Remediation. *In:* National Conference on Trends in Nano biotechnology' by Anil Duhan, Makhan Lal, Dinesh Tomar, S.S. Punia, Ritu and Bunty Sharma (2015). *In:* National Conference on Trends in Nano biotechnology, November 29 - 30, 2016, CCS HAU Hisar.
- Best Paper Award (2^{nd} Prize) was given for research paper on 'A novel strategy for management and mitigation of herbicide resistant weeds in wheat by V.K. Sindhu, Samar Singh, S.S. Punia, Samunder Singh and Anil Duhan *In:* 4th International Agronomy Congress, Novemeber 22–26, 2016, New Delhi, India.

PAU, Ludhiana

- PAU Ludhiana was awarded the Best Centre Award for AICRP-Weed Management for 2015-16 at XXIII Annual Review Meeting held at Jalgaon, Maharashtra on 28-30 April, 2016
- Dr M.S. Bhullar , PI, AICRP-WM , PAU Ludhiana was awarded with ; Appreciation Certificate' by PAU- for outstanding research work on the development of weed management technologies for field and horticultural crops in Punjab- On the eve of PAU Kisan Mela on 22 September, 2016.
- Dr. Manpreet Singh, a student of AICRP-WM, Deptt of Agronomy under the guidance of Dr. M. S. Bhullar was awarded the prestigious 'Jawahar Lal Nehru Award' by the ICAR for the best doctoral research for 2015.

SKUAST, Jammu

- Dr. B.R. Bazaya, Sr. Scientist & PI, AICRP on Weed Management, SKUAST-Jammu has been awarded with 'Reviewer excellence award' by Agricultural Research Communication Center (ARCC), Karnal as best reviewer and outstanding contribution for many years to the Indian Journal of Agricultural Research and Legume Research-An International Journal during the year of 2016.

TNAU, Coimbatore

- Dr. A. Ramalakshmi has been awarded as Best Women Researcher Award by PEARL- A foundation for Educational Excellence

PDKV, Akola

- The AICRP-Weed Management, Akola Centre has received the First Prize in State Level Agriculture Exhibition "Agrotech-2016", a mega exhibition held at Dr. Panjabrao Deshmukh Krishi Vidyapeeth , Akola for best display of the exhibits and for dissemination of technology regarding weed management in different crops and management of parasitic weed *Cuscuta* and biological control of *Parthenium*. More than 10 lakhs farmers visited the exhibition from Maharashtra and adjoining states.
- Dr. J.P. Deshmukh, Agronomist received Best Poster Award in the National Seminar on "Rainfed agriculture in India: Perspective and Challenges" organized by Maharashtra Society of Extension Education at Dr. PDKV, Akola during 7-9 December, 2016.
- Dr. S.U. Kakade, Jr. Agronomist received "Bharat Shiksha Ratna Award" in the National Seminar organized by the Global Society for Health & Educational Growth at New Delhi on 24^{th} September, 2016.

UAS, Bengaluru

- Dr. G.N. Dhanapal, Professor of Agronomy and PI, AICRP on Weed Management, UAS, MRS, Hebbal, Bengaluru was conferred with "Fellow of the year-2016" by the National Environmental Science Academy, New Delhi on 19.11.2016 during the National Conference at Chandigarh.

9. RECOMMENDATIONS OF XXIII ANNUAL REVIEW MEETING

Recommendations of Annual Review Meeting of all India Coordinated Research Project on Weed Management held at Jain Irrigation Systems, Jalgaon (Maharashtra) during 28-30 April, 2016 are given below:

1. Studies on weed management in organic farming systems should be taken-up in high-value crops.
2. Weed management should also be undertaken in horticulture (fruits, vegetables, ornamentals) /plantation crops – based systems in the relevant centres / universities.
3. A realistic economic analysis is a must in all field trials including OFTs and FLDs. The benefits or otherwise of any weed management practice should be clearly quantified in terms of BCR and ICBR.
4. A system-based approach to weed management should be pursued. The direct, residual and cumulative effects of weed management practices / herbicides should be investigated in a system mode on a long-term basis.
5. High-value crops like turmeric should not be overloaded with herbicides. A combination of chemical along with mechanical and cultural practices should be worked out for effective weed management.
6. Conservation tillage should become a part of farming and at least 30% of soil surface should be covered with crop residues. Weeds management in conservation agriculture needs utmost attention.
7. Physiological studies on weeds in long-term experiments should be done in addition to weed density and seed bank.
8. Performance of the centres will be judged based on the reports of the monitoring teams, implementation of approved technical programme, quality of data in the Annual Report, presentation made in the AGM, research publications, OFTS / FLDs conducted, timely submission of AUC, staff position, expenditure statement and other information sought by the HQ, budget utilization, extension activities, awards / recognitions etc.
9. The economics of conservation agriculture should also be worked out.
10. Basic studies on herbicide residue on microflora, chemical properties of soil etc. should be taken up and development of prediction models would help to predict the herbicide residues.
11. Studies on effect of climate change on weed shift should be encouraged.
12. Phytoremediation studies using aquatic weed should be included in the technical program.
13. Compatibility of different agrochemical inputs should be studied.
14. There should be alternate option for *Zygogramma* for *Parthenium* control as it is not working effectively in many places.
15. Data recording, analysis and presentation needs considerable improvement. PIs should check / verify the data carefully and should be clear about the reported results.
16. Annual report must be presented as per the guidelines uniformly. Nodal officers should go through the reports critically and present their observations in the meeting.
17. A farm pond infested with aquatic weeds like water hyacinth should be selected in the city or in the village, and a success story on weed eradication should be developed and widely publicized. Similarly, *Parthenium* eradication programme must be undertaken in the campus. Such centers showing visible impact of weed control technology will be suitably recognized at the ARM and provided additional grants for infrastructure development.

18. Technology on *Orobanche* management developed at HAU centre should be demonstrated on a large scale at all other centres including Gwalior, Udaipur and others, for which additional funding support can be provided from the HQ.
19. Directorate will process the specific cases received from the centers, which are related to herbicide recommendations not included in the label claim, and submit to the DPPQS / CIRBC for consideration.
20. Centers graded as 'Average' and 'Below average' must improve their performance as per the criteria / guidelines issued earlier, failing which the QRT may recommend closure / shifting of these centers in the next plan as done during this plan.

10. STATUS OF EXPERIMENTS

Summary of experiments at different centres

Sl. No.	Coordinating Centres	Network Programmes WP 1 Development of sustainable weed management practices in diversified cropping systems	WP 2 Weed dynamics and management under the regime of climate change and herbicide resistance	WP 3 Biology and management of problem weeds in cropped and non cropped areas	WP 4 Monitoring, degradation and mitigation of herbicide residues and other pollutants in the environment	WP 5 On-farm research and demonstration of weed management technologies, their adoption and impact assessment
1.	PAU, Ludhiana	WP 1.1.1.9 WP1.2.11 WP1.3.5.3* WP1.3.8.1* WP1.5.5*	WP2.1 WP2.2 WP2.3 WP2.4	WP3.1 WP3.2.1(f)* WP3.3.1* WP3.4.1 WP3.4.2	WP4.1 WP4.2* WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1 WP5.2
2.	UAS, Bengaluru	WP 1.1.1.1 WP1.3.1.1(i) WP1.3.1.1(ii) WP1.3.10.1* WP1.5.3	WP2.1 WP2.2	WP3.2.1(b) WP3.2.1(f) WP3.4.1	WP4.1* WP4.2* WP4.3.1* WP4.3.2* WP4.4*	WP5.1 WP5.2*
3.	RVSKKV, Gwalior	WP 1.1.3.1 WP1.2.6 WP1.3.5.1	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1	WP4.1 WP4.2 * WP4.3.1* WP4.3.2* WP4.3.3	WP5.1 WP5.2
4.	GBPUAT, Pantnagar	WP 1.1.1.10 WP1.2.13 WP1.5.7(i)* WP1.5.7(ii)	WP2.1 WP2.2* WP2.3*	WP3.2.1(f) WP3.4.1	WP4.1 WP4.2 WP4.3.1 WP4.3.2 WP4.3.3 * WP4.4	WP5.1 WP5.2
5.	CSKHPKV, Palampur	WP 1.1.2.2 WP1.2.12 WP1.3.9.2 WP1.5.6*	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1*	WP4.1 WP4.2* WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1 WP5.2
6.	AAU, Jorhat	WP 1.1.1.8 WP1.2.10(i) WP1.2.10(ii) WP1.3.1.5(i) WP1.3.1.5(ii) WP1.3.10.2* WP1.4.3 WP1.5.4(i) WP1.5.4(ii)	WP2.1 WP2.2 WP2.4	WP3.2.1(e) WP3.2.1(f) WP3.4.1 WP3.4.2*	WP4.1 WP4.2 WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1 WP5.2*

7.	AAU, Anand	WP 1.1.5.1* WP1.2.1* WP1.3.3.1* WP1.5.2	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1	WP4.1* WP4.2 * WP4.3.1* WP4.3.2 * WP4.4*	WP5.1 WP5.2
8.	TNAU, Coimbatore	WP 1.1.2.1 WP1.2.3(i) WP1.2.3(ii) WP1.3.1.2	WP2.1 WP2.2	WP3.1 WP3.2.1(b) WP3.2.1(f) WP3.4.1	WP4.1 WP4.2 WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1 WP5.2
9.	NDUAT, Faizabad	WP 1.1.1.4 WP1.2.5 WP1.3.1.3 WP1.3.4.1*	WP2.1* WP2.2*	WP3.2.1(f) WP3.4.1*	WP4.1* WP4.2* WP4.3.1* WP4.3.2* WP4.3.3* WP4.4*	WP5.1 WP5.2
10.	BAU, Ranchi	WP 1.1.2.3 WP1.2.16 WP1.4.4*	WP2.1* WP2.2*	WP3.2.1(f) WP3.3* WP3.3.2* WP3.4.1*		WP5.1* WP5.2*
11.	KAU, Thrissur	WP 1.1.1.14 WP1.2.17(i) WP1.2.17(ii)	WP2.1 WP2.2	WP3.1 WP3.4.1	WP4.1* WP4.2 WP4.3.1* WP4.3.2* WP4.4*	WP5.1 WP5.2
12.	OUAT, Bhubaneshwar	WP 1.1.1.2 WP1.2.2* WP1.3.12.1*	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1*	WP4.1 WP4.2 * WP4.3.1* WP4.3.2* WP4.4	WP5.1 WP5.2
13.	PJTSAU, Hyderabad	WP 1.1.1.6 WP1.2.8 WP1.3.1.4	WP2.1 WP2.2	WP3.1 WP3.2.1(f) WP3.4.1	WP4.1 WP4.2 WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1 WP5.2
14.	CCSHAU, Hisar	WP 1.1.1.5 WP1.2.7 WP1.3.5.2 WP1.3.13.1*	WP2.1 WP2.2 WP2.3	WP3.1* WP3.2.1(a) WP3.2.1(c)* WP3.2.1(f) WP3.4.1* WP3.4.2*	WP4.1 WP4.2 WP4.3.1 WP4.3.2 WP4.3.3 WP4.4	WP5.1, WP5.2
15.	RAU, Pusa	WP 1.1.1.11, WP1.3.3.4 WP1.3.7.1, WP1.4.3(i) WP1.4.3(ii) WP1.4.3(iii) WP1.5.8	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1		WP5.1 WP5.2
16.	DBSKKV, Dapoli	WP 1.1.1.3 WP1.2.4 WP1.4.1*	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1		WP5.1 WP5.2
17.	IGKVV, Raipur	WP 1.1.1.13 WP1.2.15 WP1.5.9*	WP2.1 WP2.2	WP3.2.1(f)		WP5.1 WP5.2

18.	SKUAST, Jammu	WP 1.1.1.7 WP1.2.9 WP1.3.3.2 WP1.3.13.1 WP1.4.2 WP1.5.3(i) WP1.5.3(ii)	WP2.1 WP2.2	WP3.2.1(d) WP3.2.1(f) WP3.4.1 WP3.4.2		WP5.1
19.	MPUAT, Udaipur	WP 1.1.2.4 WP1.2.18 WP1.3.5.5 WP1.3.11.1*	WP2.1 WP2.2*	WP3.2.1(a)* WP3.2.1(f) WP3.4.1*		WP5.1* WP5.2
20.	UAS, Raichur	WP 1.1.1.12 WP1.2.14 WP1.3.5.4(i) WP1.3.5.4(ii) WP1.3.6.1 WP1.3.7.2	WP2.1 WP2.2	WP3.2.1(f) WP3.3.3 WP3.4.1		WP5.1 WP5.2
21.	PDKV, Akola	WP 1.1.4.1 WP1.3.2.1 WP1.3.9.1 WP1.5.1(i)* WP1.5.1(ii) WP1.5.1(iii) WP1.5.1(iv) WP1.5.1(v)	WP2.1 WP2.2	WP3.2.1(f) WP3.4.1*		WP5.1 WP5.2
22.	CAU, Pasighat	WP1.3.3.3 WP1.3.4.2 WP 1.3.10.2	WP2.1* WP2.2*	WP3.2.1(f)* WP3.4.1*		WP5.1* WP5.2*
23.	SKUAST-Srinagar	WP1.5.10(i)* WP1.5.10(ii) WP1.5.10(iii) WP1.5.10(iv)*	WP2.1 WP2.2*			WP5.1* WP5.2*
24.	Meerut		WP2.1* WP2.2*			
25.	PJNCA&RI, Karaikal		WP2.1* WP2.2*			
26.	BAU, Sabour		WP2.1* WP2.2*			
27.	ICAR-CIARI, Port Blair		WP2.1* WP2.2*			

*Not reported

11. NEW INITIATIVES

- Research themes were reorganized and technical program for 2016-18 has made in tune with the research programmes of the Directorate based on the emerging challenges in weed management.
- XXIII Annual Review Meeting was organized for the first time outside the ICAR/ SAU system at Jain Irrigation Systems Limited, Jalagaon to expose the participants to corporate culture.
- Network experiments related to weed management in conservation agriculture, organic farming, input-use efficiency and herbicide use in cropping systems were proposed.
- Effective system of monitoring and evaluation of research and extension work was developed through nomination of Nodal Officers for different themes and regions.
- Collaboration with other AICRPs at the university like integrated framing systems, dryland agriculture, organic farming, pesticide residues and others dealing with crops like rice, wheat, maize, soybean, sugarcane, pulses etc. was proposed.
- Compilation of the work done so far on herbicide residues, biology and management of major weeds of cropped and non-cropped lands in each state / region, long-term trials on herbicides/ tillage and technologies generated were undertaken.
- Evaluation of the centers based on score card and 'Best Centre Award' were initiated. Additional grants and incentives were given to the better performing centre and winner of the Best Centre Award.
- Greater emphasis was given on publication of the research data generated over the years and bringing out quality publications in reputed journals.
- Salient achievements and happenings of the Directorate were presented and shared with the scientists of AICRP-Weed Management during the Annual Review Meeting. It was desired that all scientists of the project should attend the meeting every year.
- An initiative to maintain '*Parthenium*-free campus' was taken with the involvement of students and other staff of the University.

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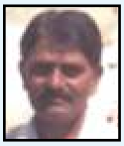

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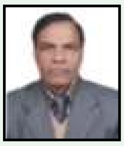

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13. STATUS OF SUBMISSION OF ANNUAL REPORT - 2016

Sl No.	Centre's name	Received	
		Before due date (31.12.2016)	After due date
Regular centres			
1.	PAU, Ludhiana	31.12.2016	-
2.	UAS, Bengaluru	23.12.2016	-
3.	RVS KVV, Gwalior	31.12.2016	-
4.	GBPUAT, Pantnagar	30.12.2016	-
5.	CSKHPKVV, Palampur	-	13.1.2017
6.	AAU, Jorhat	31.12.2016	-
7.	AAU, Anand	29.12.2016	-
8.	TNAU, Coimbatore	28.12.2016	-
9.	NDUAT, Faizabad	31.12.2016	-
10.	BAU, Ranchi	30.12.2016	-
11.	KAU, Thrissur	31.12.2016	-
12.	OUAT, Bhubaneswar	31.12.2016	-
13.	PJTSAU, Hyderabad	-	30.1.2017
14.	CCSHAU, Hisar	31.12.2016	-
15.	RAU, Pusa	-	12.1.2017
16.	DBSKKV, Dapoli	22.12.2016	-
17.	IGKVV, Raipur	-	13.1.2017
18.	SKUAST-Jammu	-	14.1.2017
19.	PDKV, Akola	-	11.1.2017
20.	CAU, Pasighat	31.12.2016	-
21.	UAS, Raichur	-	12.1.2017
22.	MPUAT, Udaipur	-	11.1.2017
Volunteer centres			
1.	SVBPUAT, Meerut	-	-
2.	SKUAST-Kashmir	-	28.1.2017
3.	PJNCA&RI, Karaikal	-	10.1.2017
4.	BAU, Sabour	-	13.1.2017
5.	ICAR-CIAS, Port Blair	-	-

AICRP-WM in the News

गाजर घास के प्रति किया जागरूक

कांग्रेस घास की रोकथाम अति आवश्यक : डा. पूनिया

KASHMIR TIMES

खरपतवार से 60 प्रतिशत तक उत्पादन प्रभावित

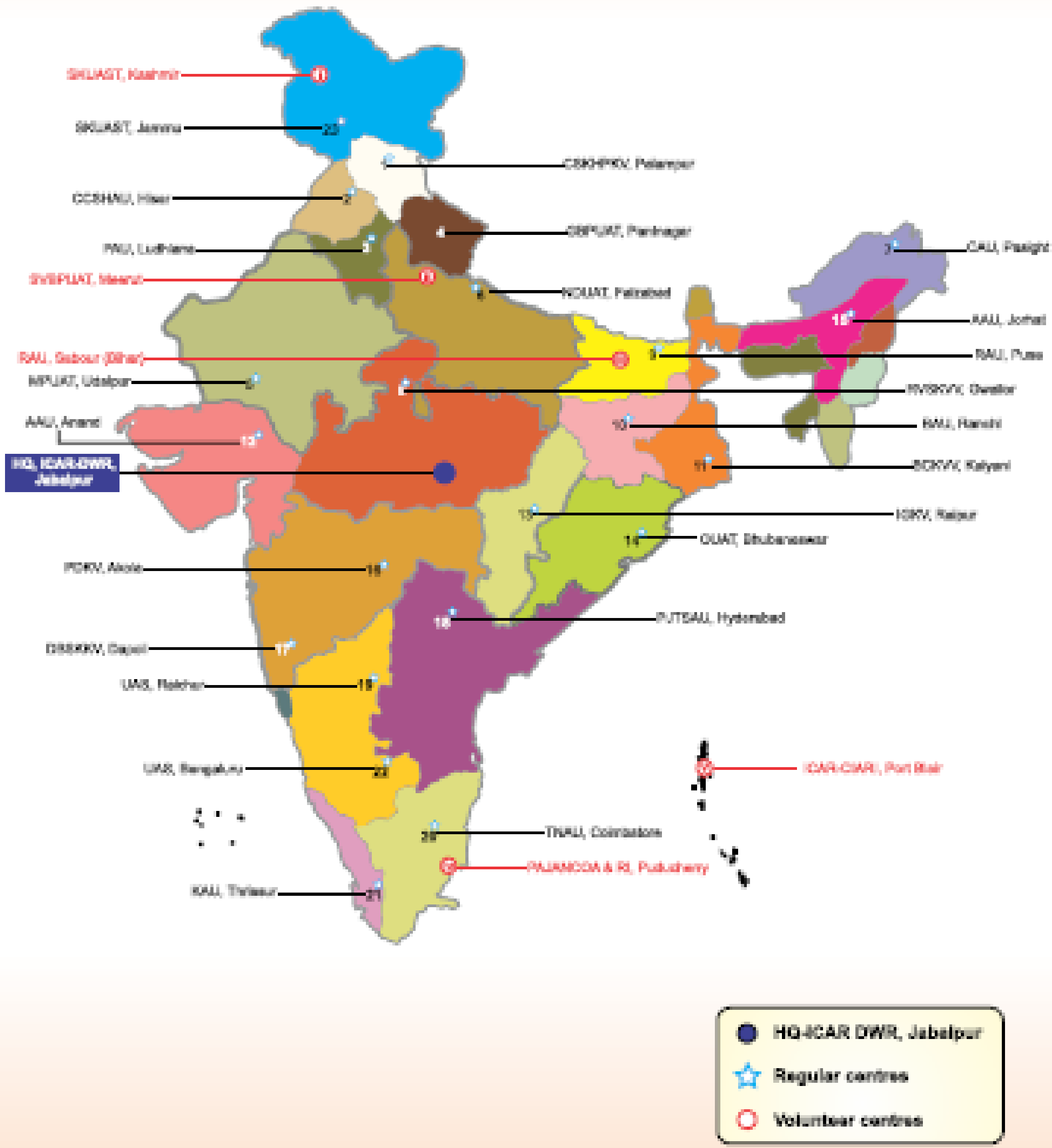
गाजरघास - ज्वलंत समस्या, लोगों में हो गाजरघास के प्रति जागरूकता

गाजर घास से हो सकते हैं कई रोग

जय राजस्थान

किसानों को खरपतवार को नियंत्रित करने के उपाय बताए

Director ICAR-Directorate of Weed Science, Jabalpur visits SKUAST-Jammu



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