Needs immediate attention and containment

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वार्षिक प्रतिवेदन
Annual Report

Directorate of Weed Science Research
Jabalpur

वार्षिक प्रतिवेदन
ANNUAL REPORT

2009-10

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DIRECTORATE OF WEED SCIENCE RESEARCH

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JABAPUR 482 004 (M.P.) INDIA

Directorate of Weed Science Research
Jabalpur (M.P.)

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Cover page :

Once an ornament…
…now a problem

The water hyacinth was originally "introduced" to India about 1896 - allegedly by a *British Raj Memsahib* from South America. She was enchanted with the purple flower and the deep green leaves and thought they'd be pretty in her new garden in Kolkata. From Bengal it then spread to almost all over the country. One hundred years later, this plant has choked waterways and sucked the life-giving oxygen needed for small aquatic beings. Presently it is the most serious aquatic weed infesting over 2,00,000 hectares of water surface in India .

FROM DIRECTOR'S DESK

Being the nodal institution Directorate of Weed Science Research (DWSR) continues to provide leadership in the country in research, training and coordination activities in the field of weed science. Success and achievements made in weed science research in recent past is becoming more and more visible in the farmers field with every passing day. Use of modern weed control methods is spreading across the farming community due to its several advantages over the traditional manual weeding technique that is laborious, time consuming and uneconomic. DWSR is consistently putting its efforts to further refine, improve and spread the modern weed management technologies.

Certain new issues like infiltration of invasive alien weeds, weedy rice and weed management *vis-à-vis* apprehended global warming are becoming growing concern for the future Indian agricultural scenario. DWSR took it seriously to deal the issue of alien invasive weeds that infiltrated to our country with the recently imported wheat.

Appropriate knowledge of weed management in cropped and non-cropped situation is the need of the day. Making people aware about losses due to weed in every situation is required. Significant finding in the areas of elevated CO_2, identification of improved traits, weed dynamics in crops and cropping system, allelopathic studies, enhancing herbicide use efficiency, organic weed management, non-chemical and biological weed controls, weed utilization and transfer of technologies have got significant attention during the period under report.

The period under report witnessed a number of important events, apart from our regular research activities. Dr. Mangala Rai, the then Secretary, DARE and DG, ICAR visited DWSR, accompanied by Dr. A.K. Singh, DDG (NRM). Directorate's foundation Day was glorified in the presence of Dr. K. Kasturirangan, eminent Space Scientist and Member (Science) Planning Commission, and his team of advisors, Dr. V.V. Sadamate, Sh Ajit K. Verma, Dr. (Mrs.) Indrani Chandrashekharan and Dr. (Mrs.) Vandana Dwivedi. We conducted the XIX Biennial Workshop of Coordinating Centers at IGKV, Raipur. Several Trainings and Review meetings of National Invasive Weed Surveillance (NIWS) on detection of quarantine weeds introduced with the recently imported wheat. The Directorate organized a nation wide campaign on *Parthenium* awareness as a regular activity during August 2009. National consultation programmes were organized at our Directorate in the presence of the dignitaries like Dr. A.K. Singh, DDG (NRM) and Dr. C.D. Mayee, Chairman, ASRB. The Directorate brought out few books of National importance and a record number of 30 Extension pocket bulletins and success stories both in Hindi and English. We tried to make our research more purposeful.

I sincerely thank Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR; Dr. Mangala Rai, Ex-Secretary, DARE and DG, ICAR and Dr. A.K. Singh, Deputy Director General (NRM), ICAR for their unstinted guidance in various activities of the Directorate. Thanks are also due to Dr. A.K. Gogoi, the then ADG (Agronomy, NRM) for his keen interest in Weed Science and development of this Directorate. The valuable suggestions by the members of the Research Advisory Committee and all other eminent weed scientists are gratefully acknowledged. I also thank the Scientists of the Directorate for giving their valuable inputs. I appreciate Dr. K.K. Barman, Dr. V.P.Singh, Dr. M.S. Raghuvanshi and Mr. O.N. Tiwari for their painstaking efforts in preparing this document.

Jay G. Varshney
Director

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Research Fields

EXECUTIVE SUMMARY

The Directorate has achieved its targets during 2009-10 in research and transfer of technology. The major research areas were cultural methods of weed management, use of herbicides, phytoremediation, climatic change vis-à-vis crop weed competition, herbicide residues and biological control of weeds through insects and plant pathogens. The directorate has continued its excellent track record of popularizing the bio-control method of *Parthenium* using Mexican beetle (*Zygogramma bicolorata)* through out the country. The Directorate has also taken up several on-farm trials and field demonstrations on proven weed management technologies, awareness campaigns, trainings, and kisan mela to enrich knowledge base of farmers and other end users. The major research achievements are summarized below.

Weed biology and eco-physiology

- Under elevated CO_2 condition, green gram as well as *Euphorbia geniculata* and *Commelina diffusa* showed enhanced growth. Rate of photosynthesis, transpiration, and water use efficiency was also found higher.

- Increase in heavy metal concentration in *Arundo donax* and *Alternanthera philoxeroides* was found at higher rate with regard to corresponding increase in levels of added metals in soil. The highest concentration of Mn and Zn were observed in *Alternanthera philoxeroides* at 1000 ppm of added heavy metals. *Arundo donax* can be utilized for large scale phytoremediation of heavy metals in contaminated sites due to its higher biomass production, metal uptake ability and tolerance to higher metal concentration.

Weed management techniques

- Inclusion of pea as a short duration cover crop after kharif season significantly reduced the weed infestation in wheat of both soybean-wheat and rice-wheat cropping systems.

- Mulching either with paddy starw or black polythene resulted in reduced weed biomass and higher yield of okra.

- Growing smother crops such as cowpea-pea-cowpea and greengram-pea-greengram as intercrops was effective in suppressing weed growth and increased growth of newly planted mango and citrus plants. Metribuzin (0.5 kg/ha PE) provided good control of weeds for a longer period, but its continuous use caused shifting in weed flora from broadleaved to grasses and also an adverse effect on soil microflora.
- Application of fluchloralin followed by fenoxaprop provided good weed control in Ashwagandha.

Herbicide as a tool in weed management

- Under long-term herbicide trial, continuous use of clodinafop followed by 2,4-D significantly decreased the population of *Phalaris* and *Avena ludoviciana* and gave highest grain yield of wheat. Continuous use of herbicides (anilofos and butachlor during *kharif* ; sulfosulfuron, clodinafop and isoproturon in wheat) showed a more reduction in the population of total fungi and actinomycetes in soil.

- New molecules of herbicides such as carfentazuron, pinoxulum, metsulfuron, fenoxaprop were tested in transplanted rice, direct seeded rice, soybean and wheat.
- In wheat, premix combination of carfentrazone-ethyl 20% + sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant at 45g/ha +625 ml/ha or metsulfuron+ carfentrazon at 22.5 g/ha with non ionic surfactant significantly increased the yield of wheat by 62% over weedy check.
- In rice, application of fenoxaprop with 6.9% EC and peoxsulum at 22.5 g/ha significantly controlled weeds and increased yield over weedy check.
- Intercropping of leafy vegetables like radish, spinach, *Amranthus* and fenugreek suppressed weeds in winter maize.
- Residues of glyphosate were detected in soil of cowpea (0.21 µg/g) and moong (0.175 µg/g) under orchard area. Similarly, residues of metribuzin was detected in soil of newly planted mango and citrus orchards during *kharif*, summer and *rabi* season.
- In long-term herbicides trial of rice-wheat cropping system, half-life of anilofos and butachlor was 15.16 and 14.06 days, respectively. While in soybean-wheat cropping system, half-life of imazethapyr was 18.85 days.
- Studies on bioaccumulation herbicide residues on non-target organism revealed the accumulation of 0.074, 0.0014 and 0.0230 µg/g residues of oxyfluorfen, butachlor and anilofos in fishes collected at 90 days in *kharif* season. While in *rabi* season, 0.020, 0.0067, 0.0138 µg/g residues of sulfosulfuron, clodinafop and metsulfuron were detected in fish collected at 90 days after herbicide application.
- Application of clodinafop, sulfosulfuron, metsulfuron, oxyfluorfen and anilofos affected the water quality by increasing pH, EC, TS, TDS. While in case of butachlor, pH and DO decreased in pond.
- Method of extraction of cuticular wax from rice, wheat, *Phalaris* and *Echinocloa* was standardized for investigating the role of leaf surface in the phototransformation of herbicides. Among different solvents, chloroform and dichloromethane proved to be better extractants in terms of higher yield and lower co-extractives. Process of coating the thin film of cutin with 2,4-D was also standardized.
- Cutin extracted from rice leave showed the ability to retard the rate of photolysis of 2,4-D under UV light.
- Results of experiments conducted in micro-plots in containment facility showed that weed control efficiency of pretilachlor increased at higher temperature.
- No adverse effect of the herbicides fenoxaprop, imazethapyr and quizalofop was noticed on soybean nodulation. This indicated that the given herbicides are safe from the view point of symbiotic nitrogen fixation in soybean.
- Nodulation was adversely affected by pendimathalin and fliuchloralin during initial stage of chickpea growth. But no adverse effect of clodinafop and quizalofop on nodulation was recorded, indicating that these post applied herbicides are safe in terms of symbiotic nitrogen fixation in chickpea.

Bio-pesticides and biocontrol of weeds

- Allelochemical fractions solubilized by 13 organic solvents covering a spectrum of polarity were obtained. The methanol soluble fraction was lethal to coontail (*Ceratophyllum* sp) at 50 ppm. While alleochemical fractions of ragweed parthenium crude was lethal at 10 ppm.
- Fractions of constituents of mugwort leaf was lethal to little canary grass seed germination and seedling growth at 100 ppm but was not at all toxic to wheat.
- The pathogenic fungi like *Fusarium* sp, *Phytophthora* sp, *Alternaria*, *Pythium* and *Curvularia* sp were isolated from the samples of *Eichhornia crassipes* and *E. cornea. Alternaria* sp and *Curvularia* sp were further acclimatized with the water hyacinth extract amended media at higher concentration to study their efficiency to to control *Eichhornia*.
- Houstorial attachments of *Cuscuta compestris* on chickpea were reduced when treated with PGPR microbes viz. *Pseudomonas flurrescens* and *Trichoderma viride*.
- Integration of herbicides with weevil *Neochetina* spp. provided satisfactory control of water hyacinth in ponds.

Transfer of technology

- Forty field demonstrations during *kharif* season in rice, maize and soybean crops; and 47 demonstrations during *rabi* season in wheat, chickpea and mustard were conducted on proven weed management technologies. Field visits as well as kisan mela-cum-kisan goshthi were also organized.

Network Research

Studies on the issues relating to weed survey-surveillance, herbicidal resistance, weed management, herbicide residues, transfer of technology and weed utilization were conducted under network research through DWSR Centres. Spreading of certain weeds in new areas, viz. *Sagitteria triflora* in Sivasagar district of Assam, *Phalaris* in many districts of Gujarat, *Solanum carolinense* in upper Nilgiri terrains, weedy rice in major rice growing areas of Kerala, Parthenium in cropped areas of Himanchal Pradesh, was recorded and is becoming a major concern. Besides higher yields, System of Rice Intensification (SRI) also showed lesser weed problem at Bhubaneswar, Sriniketan and Coimbatore. A cheap and easy technique for controlling the parasitic weed *Helicanthus elastica* of mango was developed and the experimental result obtained so far is promising. The recommended weed control technologies for rice, groundnut, potato, maize and onion, demonstrated in farmers' fields by the different DWSR Centres gave better economic output.

A view of DWSR administrative building

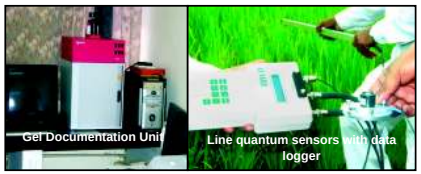
1. INTRODUCTION

Considering the importance of managing the problems caused by weeds in crop fields as well as in non-cropped areas, in the VII Five Year Plan, a decision was taken to set up a nodal centre to carry out basic, strategic and applied research in Weed Science. Consequently, National Research Centre for Weed Science (NRCWS) came into existence in April, 1989, which was then further upgraded to Directorate of Weed Science Research (DWSR) in January, 2009, with the following mandates:

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

The DWSR is the only one of its kind in the entire world where all the aspects of weed management is taken care of in a holistic manner using multidisciplinary approach. The Directorate, since its inception as NRCWS has significantly contributed in identifying major weeds in different crops and cropping systems; identifying weed competitive crop cultivars and weed smothering intercrops; developing national database on weeds; evaluating new herbicides and making herbicide recommendations; monitoring of herbicide residues in food chain and environment; improving non-chemical and biological methods of weed control; managing parasitic, perennial and other invasive weeds; and transferring improved weed management technologies to the end users.

Laboratories


Gel Documentation Unit

Line quantum sensors with data logger

The Directorate has well-equipped laboratories with modern scientific instruments like GC, HPLC, IRGA, AAS, universal research microscope with photographic attachment, stereo zoom research microscope, nitrogen auto analyzer, leaf area meter, UV-visible double beam spectrophotometer, high speed refrigerated centrifuge, HPLC grade water purification assembly, multi-probe soil moisture meter, chlorophyll meter, Line quantum sensor with data logger, Gel documentation unit, etc.

The Directorate has a big containment facility and two controlled environmental chambers to facilitate research under controlled conditions. Free Air CO_2 Enrichment (FACE) facility as well as three open top chambers are there for studies on crop-weed competition under elevated CO_2 conditions. The research outcome of these facilities provides information about the possible impact of anticipating global warming on weed menace in crops.

Component of FACE facility

The Directorate has a well-developed agricultural engineering workshop with facilities for fabrication, designing and development of weed control tools and implements. It has a pneumatic boat for survey and surveillance of aquatic flora and fauna. Quarantine insectory is there to carry out the research using bioagents.

ARIS Cell and Library

The ARIS cell is well equipped with computers, VSAT and LAN facilities, color xerox-cum-printer and A-0 plotter. Specialized software like ARCInfo for GIS analysis, ERDAS Imagine for satellite image analysis and the routinely used software for data analysis are available. All the scientists are provided with internet facility. At present the library is having a total collection of 1961 books pertaining to weed science. It has modern facilities such as CAB-PEST and CAB-SAC CD-ROMs and Current Contents on Diskette (CCOD) on biological sciences. As on date, the library subscribes to 67 Indian and 19 foreign journals. DWSR library is also a member of Consortium for e-Resources in Agriculture (CeRA) under NAIP (ICAR). All the scientists have on-line access to more than 2000 e-journals in various fields of science.

Total Library Software system has also recently been installed for facilitating the library automation and information retrieval. Reprographic and documentation facilities have been created for the preparation of documents and reports.

Networking and collaboration

DWSR carry out various network programmes through its centres at 22 SAU's located at different agro-climatic zones of the country. Besides that, there are 9 additional centres in other SAUs who voluntarily participate in the network programme and carry out the research activities as finalized in the Annual Group Meeting and Biennial Workshop of DWSR Coordinating centres. This Directorate also collaborates with several other educational and research institutions like Jawaharlal Nehru Krishi Vishva Vidyalaya (JNKVV), Jabalpur, enabling better collaboration in the area of research, teaching and extension. It has also been recognized as a post-graduate research centre for the students of Rani Durgawati Vishwa Vidyalaya. In addition, it is open to several educational institutions all over the country for their research and training activities. It has active collaboration with several ICAR Institutes and other research organizations like Delhi University, DBT, DST, DPPQS, etc. Besides, a healthy interaction exists with herbicide industry, NGOs and others.

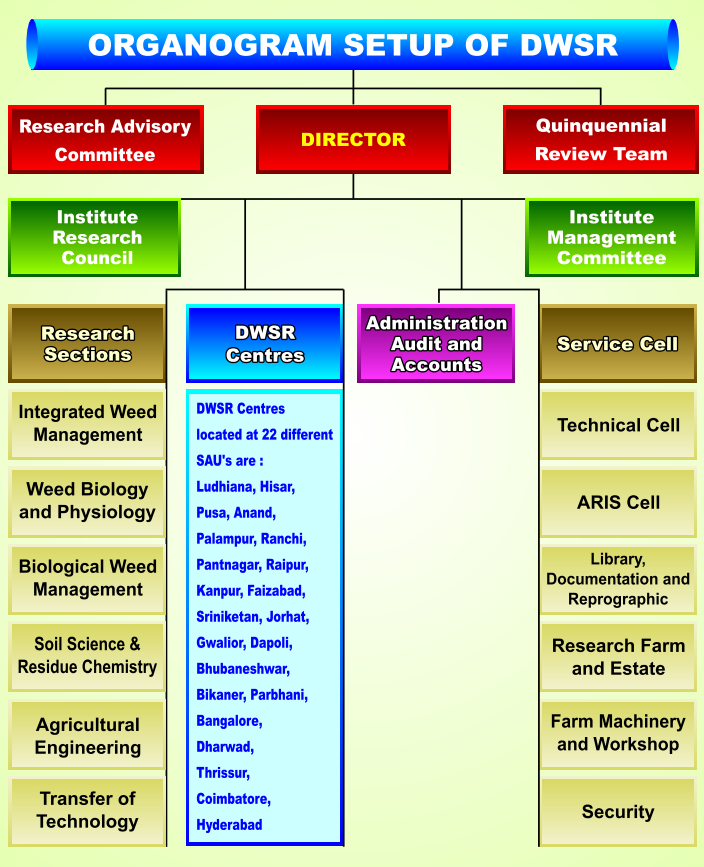
A National Invasive Weed Surveillance (NIWS) programme sponsored by DAC, Ministry of Agriculture, Govt. of India, has been launched to contain the weeds of quarantine nature that has been recently introduced in our country along with imported wheat. The programme runs in all 267 districts in the states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Gujarat, Madhya Pradesh, Chhtaisgarh and Maharashtra.

Farm and glass house/ net house facilities

The Directorate possesses 61.5 ha land, out of which 43.5 ha area is available for agricultural activities. The remaining area is occupied by building premises and other infrastructures. The farm is well developed with farm roads and drainage systems, threshing floor, farm store and Godown.

Organizational set-up

Research programmes of the Directorate are being carried out in 6 sections under the administrative control of the Director. The administrative office, accounts section, technical services, research sections and various advisory committees of the institute support the overall administration. The Institute Management Committee (IMC) and Research Advisory Committee (RAC) assist in identifying priority research areas.



Staff and finance

DWSR has sanctioned cadre strength of 27 scientists, 24 technical, 11 administrative and 23 supporting staff. Presently this Directorate has 16 scientists including one post of RMP, 24 technical, 11 administrative and 21 supporting staff. The budget utilization of the Directorate for the year 2009-10 was Rs. 299.95 lakhs in Plan and Rs. 479.48 lakhs under Non-Plan heads besides the plan expenditure of Rs. 519.14 lakhs for the DWSR Coordinating Centres. The Directorate also generates resources through the sale of farm produce and testing of new herbicide formulations provided by the pesticide industries.

Budget and expenditure for the year of 2009-10

(Rs in lakhs)

Head	Plan		Non Plan	
	B.E.	Expenditure	B.E.	Expenditure
Establishment Charges	34.73	34.72	342.47	342.35
O.T.A.	-		-	-
T.A	2.62	2.62	1.48	1.47
Other charges	249.89	249.86	130.54	130.42
Matching Grant	-		-	-
Works				
Approved Works	3.85	3.84	-	-
Maintenance of office building	-		1.94	1.88
Maintenance of residential quarter	-		2.39	2.42
Minor work	-		0.95	0.94
Other	0.98	0.98	-	-
Information Technology	5.00	5.00	-	-
HRD	2.93	2.93	-	-
TOTAL	**300.00**	**299.95**	**479.77**	**479.48**
DWSR Centres	**470.00**	**469.89**	-	-
NEH Region	50.00	49.25	-	-
Pension	-	-	3.08	3.08
Personal Loans & advances	-	-	4.32	4.32

Resource Generation

The Directorate also generated Rs. 34.13 lakhs additional resources through revenue returns, sale of farm produces, consultancy, contractual research, training, against the target fixed for Rs. 34.00 lakhs during 2009-10.

2. RESEARCH ACHIEVEMENTS

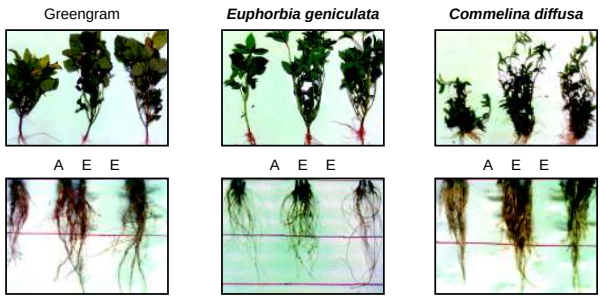
1. WEED BIOLOGY AND ECO-PHYSIOLOGY

1.2 : Crop Weed Interaction

1.2.2 : Effect of elevated CO_2 on mungbean and associated weeds-*Euphorbia geniculata* and *Commelina diffusa*

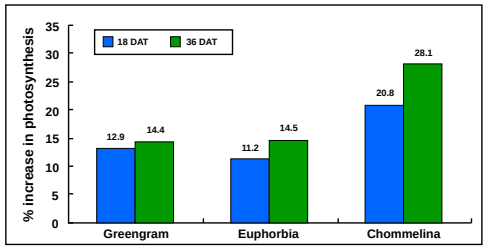
Bhumesh Kumar

An experiment was conducted to study the response of elevated CO_2 on growth and development, physiological and biochemical aspects in mungbean (K-851) and two weed species (*Euphorbia geniculata* and *Commelina diffusa*) using FACE (Free air CO_2 enrichment) system. One ring was maintained at ambient CO_2 (380 ± 5 ppm) while two rings were maintained



Shoot and root growth of mungbean and weeds at ambient (A) and elevated (E) CO_2 levels

Greengram as well as both weed species showed enhanced growth at elevated CO_2 which includes better shoot and root growth and nodule development in greengram. Rate of photosynthesis, transpiration, and water use efficiency was found to be higher at elevated CO_2. Increase in photosynthesis was highest in *Commelina difusa* followed by *Euphorbia geniculata* while it was lowest in green gram.



Relative increase in rate of photosynthesis of mungbean and weeds at elevated CO_2

Observations in respect to accumulation of reactive oxygen in species showed that greengram accumulated more H_2O_2 and superoxide as compared to that at ambient CO_2. In addition, all the three species showed considerable differences in protein profiles due to CO_2 elevation as resolved by 10% SDS PAGE. Seed yield of mungbean was found to be increased by approximately 10% as compared to that at ambient CO_2.

1.2.3: Germination, dormancy and ageing of weed seeds

D.K. Pandey

Seed coat hardness of ivy leaf morning glory (*Ipomoea hederacea* (L.) Jacq.) with reference to scarification, seed ageing and germination

The scarification was carried out using sulfuric acid. The seeds were poured into the acid for stipulated time and stirred at intervals. On expiry of the stipulated time, the seeds were washed with an excess of water. Then the seeds were tested for germination. Freshly harvested seeds were mostly dormant and a few (about 5-10%) were able to germinate. The scarification for 80-160 minutes resulted in germination of almost all seeds. After about one year through 9 years the seeds showed good germination without scarification. The scarification for 20-60 minutes, however, improved germination in the seeds aged for 4-9 years. The degree of scarification required for overcoming the hard coat mediated dormancy varied irrespective of ageing of the seeds. There did not appear any significant loss of viability of the seeds during ageing for up to 9 years. The capability of the seeds to withstand scarification for so long is interesting and implicates possible role of the hard coat in preserving the seeds especially against mechanical, chemical and biological stresses.

The results showed that (i) the seeds of ivy leaf morning glory can be tested by subjecting for germination as such and after scarification for 10-20 minutes for reliable assessment of viability, (ii). the fresh seeds immediately after maturation are unlikely to cause heavy infestation of the weed due to hard coat imposed dormancy, (iii) the seeds aged for a year or more had very high potential of infestation due cessation of the coat imposed dormancy, iii. the seeds trapped in microclimatic or ecological niches might pose potential threats of infestation for over 9 years, and (iv). the seeds appear to have relatively low rate of seed ageing and predisposed loss of viability. These findings may have relevance to testing of the seeds for diverse purposes, weed infestation and its management strategies.

Germination of seeds immersed in a liquid preservative at ambient temperature

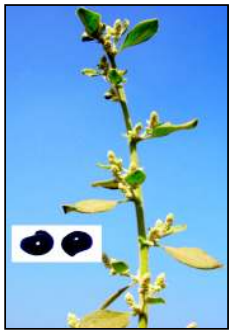
Viability of seeds of crops like wheat (var. HUW 234); rice (var. Ratna), finger millet (var. Hagari-1), green gram (var. Local collection), pea (var. RPA 9.5.2) kept for testing in 1989 was lost completely in 3-4 years at ambient temperature. The seeds similarly stored at ambient temperature immersed in the liquid preservative showed fairly good germination after 20 years. This was 25% in wheat, 97% in rice, 86% in finger millet, 94% in greengram and 89% in pea. Similarly the weed seeds like those of ragweed *Parthenium*, *Phalaris minor*, *Rumex dentatus, Echinochloa crusgalli* and *Cassia sericea* stored at ambient temperature in 1992 lost viability completely in 3-6 years. The seeds immersed in the liquid preservative showed viability even after 17 years. This was 92% in ragweed parthenium, 32% in *Phalaris minor*, 98% in *Rumex dentatus*, 72% in *Echinochloa crusgalli*, and 99% in *Cassia sericea*.

1.2.4: Identification characters of important weeds seeds

V.S.G.R. Naidu

Positive identification of pests, including weeds, is the first step in a sound integrated pest management program. Knowledge of plant morphological features, such as leaf and stem shape, flower type and color, and the presence of hairs make identification relatively easy. However, identifying a weed by the features of its seed is a daunting task because of the relatively small size of seed, the change in surface characteristics caused by various processes and color variation within the same species. Efforts have been made to describe the characters of seeds of important weeds. Some of the weed seed characters along with the seed and plant images are given below:

Achenes 4 mm long, slender, obconical, glabrous, tipped by short bristly deciduous, yellow papus forming a cup over achene.



Seeds less than 0.5 mm, bean - shaped, black and shining

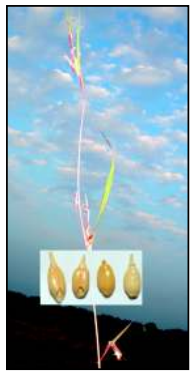
Seeds minute, (less than 0.5 mm), Light to dark brown, surface with obliquely tranverse tubercled idges.

Capsule globose, 0.3 - 0.4 cm long, glabrous; Seeds usually 4, pale brown to black, ovoid - 1.7 mm long,

Seeds trigonous, 2 - 4 mm, pale brown, shallowly pitted.

Pods jointed, muriculate with hooked, retrosely hairy bristles. Seeds 3 - 5 mm long, kidney shaped, yellowish brown with dark brown spots

Fruit is a pseudocarp, 0.6 - 1.2 cm long, globose - broadly ovoid, white to slightly bluish white, hard and polished



Seed (caryopsis) is 5 - 7 mm long, yellowish brown, resembles wheat grain.

Seeds 2-4 mm, brown, ovoid - trigonous, minutely tuberculate.

Fruit (drupe), compressed, pea sized, purplish black. 4 - 8 mm long, 4 - 5 mm broad. Endocarp annular or ribbed with a prominent dorsal crest, perforated.

1.3 : Phytoremediation of contaminated soil and waste water using weeds

1.3.1: Identification of weedy plants for phytoremediation of heavy metal contaminated sites

P. J. Khankhane , Jay G. Varshney and VSGR Naidu

Lead and manganese accumulation by weedy plants grown in contaminated sites of Jabalpur

The continuous vehicle pressure on road results in deposition of heavy metals on the road and nearby site. During precipitation, the metals along with dust are swept off the roadway which enter the soil and are channeled with runoff water into a storm drain. Lead can cause several unwanted effects such as disruption of biosynthesis of haemoglobin and anemia, rise in blood pressure, kidney damage etc. Very few plants respond to lead in a contaminated soil, however growing weedy plants in such soil have testimony to indicate their metal tolerance ability. Therefore, an investigation was carried out to study the ability of weedy plants for metal accumulation.

The soil reaction (pH), electrical conductivity and organic carbon content in the soil were in the range of 7.29 to 7.77, 0.39 to 0.76 dS/m and 0.39 -1.39 per cent respectively. The mean DTPA extractable concentrations of lead (3.92 mg/kg) and manganese (25.3 mg/kg) in soil were below the critical level of phyto-toxicity. Among the sites, the highest lead and manganese concentrations at Nagpur bypass were 7.37 and 40.4 mg/kg whereas concentrations observed at Mandla sites were 1.77 and 13.2 mg/kg, respectively. The variations in the metal concentrations were due to heavy vehicle pressure on the Nagpur highway. The major weed species observed at the contaminated sites were *Calotropis procera, Argimone asteracantha, Sphaerantha indicus, Vetivera zizinoides, Ipomea carnia, Hyptis suaveolens, Chicorium*

intybus, Lantena camera, Parthenium hysterophorus, Xanthium strumonium and Arundo donax. As far as metal accumulation by weedy plants is concerned, *Vetivera zizinoides* removed higher concentration of lead followed by *Arundo donax, Calotropis procera* and *Parthenium hysterophorus.* In case of manganese *Ipomea carnia,* followed by *Parthenium hysterophorus, Argimone asteracatha)*, and *Sida rhombifolia* extracted manganese in the decreasing order. To judge the hyper accumulating ability of plants for the selection phytoremediation, the ratio of metal concentration between soil and plant is an important criterion. If this ratio is greater than one the plant is considered as an accumulator plant. The heavy metal ratio between soil and weedy plants. In this respect, among the weeds the highest accumulation ratio for lead was observed in *Vetiveria zizinoides* (17.6) followed by *Arundo donax* (12.5), *Calotropis procera* (5.4), *Sphaerantha indicus* (2.7) and *Argimone asteracantha* (2.4). The highest manganese accumulation ratio was observed in *Vetiveria zizinoides* (6.4) followed by *Arundo donax* (6.0), *Ipomea carnia* (5.4), *Sphaerantha indicus(4.7) Hyptis suaveolense* (3.7). Thus, depending on metal accumulation and biomass producing ability, locally available weed species like *Arundo donax* and *Vetivera zizinoides* can be used for phytoiremediation of heavy metals such as lead and manganese in contaminated sites.

Table 1. Heavy metal accumulation ratio between soil and weed species

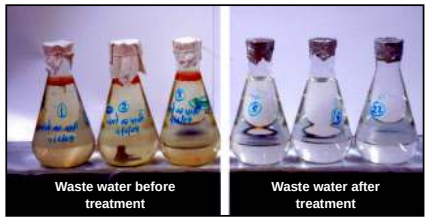
Weed species	Heavy metal ratio	
	Lead	Manganese
Calotropis procera	5.4	3.0
Argemone asteracantha	2.4	5.3
Sphaerantha indicus	2.7	4.7
Vetiveria ziznoides	17.6	6.4
Ipomea carnia	1.02	5.4
Hyptis suaveolense	1.6	3.7
Cichorium intybus	0.8	2.7
Lantana camera	1.3	2.9
Parthenium hysterophorus	1.4	3.2
Xanthium strumonium	0.5	2.6
Arundo donax	12.5	6.0

Phytoremediation of pollutants from waste water using *Arundo donax*

The entry of pollutants such as various heavy metals into land and water bodies occurs due to unscientific disposal of industrial effluents and discharge from human habitation. During dry period, the use of waste water has become the common practice for irrigating crops in the peri-urban areas of India. In Jabalpur, around 143 lakh litre of waste water is discharged daily through various open drains and the farmers in the area have been utilizing such water for irrigating crops including wheat, gram and vegetables. Earlier studies carried out at DWSR found that the metal accumulation in soils irrigated with waste water was higher as compared with the tube well water. In this respect phytoremediation are very promising and are applicable to prevent, control and remediate the contaminated sites for water quality up-gradation using weedy plants. An investigation was therefore carried out to study the performance of sub-surface wetland model using fast growing weed *Arundo donax* for the treatment of drain water. A sub-surface rectangular wetland model made up of stainless steel of size 4'x 2'x 1' (Length, width and depth) was developed for the treatment of waste water. The three zones were maintained in the model including inlet, middle zone as a treatment bed and outlet zone.


Photo showing treatment of waste water in a model of constructed wetland

It was observed that the reed plant *(A)* could grow with a well spread entangling root system in a gravel medium (without soil) and no clogging was occurred as a result of which the water was easily discharged through the outlet of the filter bed. After treatment the reed plant reduced the concentrations of nitrate, phosphate, nickel and copper to the extent of 70, 42.8, 55.8 and 40.6 per cent respectively as compared to the untreated waste water. *Arundo donax* with a well spread entangling root system performed as a filter bed and withheld the suspended particles which reduced the color of the waste water. Having ability to grow successfully in a gravel medium and phytoextracting potential for pollutants, *Aundo donax* can be utilized for treatment of drain water in field scale phytoremediation system for irrigation purposes.


Waste water before treatment

Waste water after treatment

Table 2. Performance of *Arundo donax* in a sub-surface wetland model

Parameter	Average concentration		% reduction of pollutants
	Drain water (before treatment)	Drain water (after treatment)	
pH	7.91	7.85	NA
EC (d Sm^{-1})	0.65	0.62	NA
Nitrates (mg/L)	50.0	15.0	70.0
Phosphates (mg/L)	3.50	2.0	42.8
Nickel (ug/L)	340	150	55.8
Copper (ug/L)	320	190	40.6

NA:Not applicable

2. WEED MANAGEMENT TECHNIQUES

2.1 Mechanical Weed Management

2.1.1 Evaluation of manually operated weeding tools suitable for uprooting of soil embedded weeds

H.S. Bisen

The investigation on performance evaluation of manually operated weeding tools suitable for uprooting of soil embedded weeds was carried out in field experiment in *kharif* 2009 on soybean and in *rabi* 2009-10 on chickpea. The three different types of improved mechanical weeding tools, namely, three tined hand cultivator (pull type/sweep blade), multi weeder (push type/ shoved blade) and notched disc rotary weeder (rotary and push type) were evaluated in soybean. Single tine hand hoe (pull type) crescent hand hoe (pull type), twin wheel hoe (push type) and notched disc rotary weeder (rotary and push type) has been evaluated in chickpea.

Mechanical weeder used in crops

Mechanical weeder used in Chickpea

In soybean, the higher weed control efficiencies has been achieved in notched disc rotary weeder (77%) compared to multi-weeder (72%) and three tine hand cultivator (70%) based on weed count data. In case of multi-weeder and three tined hand cultivator cut lengths of roots of weeds were respectively 6.5-8.5 cm and 5.4-8.6 cm compared to 1.4-2.6 cm in case of toothed disc rotary weeder. The weed control efficiency based on weed count and yield were found significant.

Table 3. Weed control efficiency of mechanical weeding tools in soybean

Treatment	Weed control efficiency (%)		Yield (kg/ha)
	Weed count	Dry wt	
Three tined hand cultivator (Sweep-pull type)	70.9	59.9	1495
Multi Weeder (Shovel -push type)	72.2	60.0	1620
Rotary notched disc weeder (Rotary + Push type)	77.0	58.8	1189
P.O. herbicide	70.5	57.4	1346
Manual Weeding	95.5	87.5	2101
Weedy check	00.0	00.0	1004
LSD (P = 0.05)	3.2	0.8	420

*Moisture content of soil was between 16.2-16.8 %

Table 4. Uproot / cut length of roots of weeds by different mechanical weeding tools in soybean

Name of weed	Root length uprooted / cut (cm)		
	Three tine cultivator (pull)	Multi weeder (Push)	Toothed disc Rotary Weeder (Rotary+ Push)
Commelina communis	8.1	7.7	2.2
Phyllanthus niruri	6.2	6.5	1.5
Alternanthera sessilis	5.8	8.4	2.6
Solanum Nigrum	6.9	8.0	2.2
Eichinochloa colona	6.5	7.2	7.6
Mollugo pentaphylla	5.5	6.8	1.4
Cyperus iria	6.5	9.3	1.6
Euphorbia genticulata	7.5	9.3	1.4
Cyperus rotundus	5.4	8.5	2.6
Dinbra retroflexa	6.9	8.2	1.6
Setaria glauca	8.6	8.7	1.5
Commelina bengalensis	8.2	8.9	1.9
Elusine indica	6.5	8.0	1.5

In chickpea, the weeding efficiency of twin wheel hoe was highest 78.82% followed by notched disc rotary weeder (77-80 %), crescent hand hoe (73 -78 %) and single tine hand hoe (74-75 %). The depth of operation of twin wheel hoe, notched disc rotary weeder and single tine hoe is deeper i.e. 3-6 cm, 3-6 cm, and 4-6 cm respectively compared to 3-5 cm in crescent hand hoe. The chickpea yield varied from 16 to 17.9 q/ha in plots where the improved mechanical weeders have been used compared to 23.9 q/ha in weed free plots and 11.3 q/ha in weedy plots.

Table 5. Weed control efficiency of mechanical weeding tools in chickpea

Treatment s	Weed control Efficiency (%)		Yield (kg/ha)
	Weed count	Dry wt	
Crescent hand hoe	73.3	78.4	1609
Twin wheel hoe	78.8	81.4	1781
Toothed disc rota ry weeder	77.9	80.4	1793
Single tine hand cultivator	74.6	75.4	1667
Manual Weeding	85.0	95.8	2391
Weedy check	0.0	0.0	1133
LSD (P = 0.05)	15.0	16.3	265

*Moisture content of soil was 14.5 -15.6%

Table 6. Performance of improved mechanical weeder in chickpea

Treatment	Depth of weeder operation (cm)	Field capacity		Cost of operation (Rs/ha)	Energy spent (Joule-sec)
		hrs/ha	ha/day (8 hrs)		
Three tined hand cultivator (Sweep -pull type)	3-5	86.4	0.1	864	6443
Multi Weeder (Shovel -push type)	3-6	69.4	0.1	694	5175
Rotary notched disc weeder (Rotary + Push type)	3-6	77.2	0.1	772	5749
P.O. herbicide	4-6	70.9	0.1	710	5287
Manual weeding	--	354.9	<0.1	3549	2647
Weedy check	--	0	0	0	0

Studies on different shapes of rotary blades used in tines of rotary power weeder

The self-propelled rotary power weeder is becoming necessary to carryout the timely weeding which is difficult in with manually operated tools in large area and where labrous are not available. The development of rotary power weeder has been carried out using small petrol engine. The transmission of engine power to rotary blades is through gear drive mounted on shaft with the help of bearings and bearing mountings on main frame of the unit. The unit has been tested for its functions. In preliminary trials, the developed power weeder is found working satisfactory.

Development of rotary power

2.3 : Integrated Weed Management

2.3.2: Weed management in newly planted mango and citrus orchard

V. P. Singh, C. Sarathambal, M. S. Raghuvanshi and Jay G. Varshney

The diverse situation in different agro-ecological zones of the country encourages the growth of broad-spectrum weeds especially nurseries which face a serious weed threat with annuals (mono and dicot weeds). The critical weed competition generally occurs between 3 to 5 years, causing 34-72 per cent loss due to unchecked weeds to citrus. Competition from weeds is damaging to citrus trees when they are young because of its initial slow growth and increases their susceptibility to insect and disease damage. Weeds must be managed intelligently in order to achieve the highest productivity from orchard crops.

For identifying and evaluating the economically viable integrated weed management strategies through application of both new and existing knowledge and technology, treatment consisted of Intercropping of cowpea-pea-cowpea; Intercropping of moong-pea-moong; the combination of both the intercropping with fluchloralin/ pendimethalin/ fluchloralin in each season; metribuzin 0.5 kg/ha; glyphosate 2.0 kg/ha; two mechanical weeding in each season and weedy check. The experimental fields of mango and citrus orchards were mainly infested with *Dinebra* sp, *Malachra capitata, Medicago hispida*, *Chenopodium album, Paspaladium sp., Alternanthera sessilis* and *Physalis minima* in *rabi* season. While in *kharif* season, the dominant weeds were *Echinochloa colona, Cyperus iria, Physalis minima, Cynodon dactylon, Dinebra* sp. etc.

Results revealed that adoption of cropping system like cowpea-pea-cowpea and greengram-pea-greengram as intercropping combined with herbicide application significantly reduced the weed population and weed dry matter in mango and citrus orchards. In citrus, the height increased under intercropping with a cropping system of green gram-pea- green gram, while application of metribuzin in each season gave higher per cant increase in girth as well as height of citrus plant. In case of mango, similar trend was observed with regard to control of weeds and dry matter production. Highest per cent increase in height of mango plant was recorded with metribuzin 0.5 kg/ha. While, highest increase in girth of plant was registered with glyphosate application at 2.0 kg/ha in each season. Intercropping of pea with and without pendimethalin 1.25 kg/ha and application of metribuzin 0.5 kg/ha alone performed better over other herbicidal treatments including weedy check during *rabi* season. Data revealed that the bonus yield of cowpea and green gram ranged between 2-4.7 q/ha/year in these orchards has been obtained. While in case of pea, it ranged around 10-20 q/ha/year through out the cropping system. It is very clear from the results that growing intercrops like cowpea and greengram during *kharif* and summer seasons and pea during *rabi* season with and without herbicide application could be utilized as a integrated weed management (IWM) package for effective weed control, reducing of soil weed seed bank and to get additional income during non-fruiting period of orchard crops.

Orchard infested with weeds

Orchard with cowpea

Orchard with pea

Table 7: Effect of Integrated weed management on weed growth in newly planted mango orchard (2009-10)

Treatment s	Total weed count (/m^2) At 60 DAS		Weed dry wt (g/m^2) At 60 DAS		Bonus yield (kg/ha)	
	Kharif-09	*Rabi*-09-10	*Kharif*-09	*Rabi*-09-10	*Kharif*-09	*Rabi*-09-10
T1- Intercropping of cowpea-pea-cowpea	8.0	12.3	10.3	7.6	101.6	1877
T-2 Intercropping of green gram-pea- green gram	4.7	10.7	9.9	7.9	433.1	1811
T1+ Fluchloralin/ pendimethalin/fluchloralin	6.2	9.7	9.5	5.9	183.7	2293
T2+ Fluchloralin/ pendimet halin/fluchloralin	4.8	8.7	6.7	6.1	471.9	1812
Metribuzin 0.5 kg/ha in each season	10.6	15.5	11.3	8.4	-	-
Glyphosate 2.0 kg/ha in each season	4.1	5.5	3.7	3.5	-	-
2 Mechanical weeding in each season	16.9	0.7	6.1	0.7	-	-
Weedy check	14.8	19.8	14.5	14.9	-	-
LSD (P = 0.05)	3.4	2.5	3.4	1.8	146	561

Transformed values using square root transformation

Table 8. Effect of Integrated weed management on plant growth in newly planted mango orchard (2009-10)

Treatment	Height (cm) summer'09	Girth (cm) summer'09	Height (cm) *Rabi*'09-10	Girth (cm) *Rabi*'09-10
T1- Intercropping of cowpea - pea-cowpea	181	10.3	225	18.3
T-2 Intercropping of green gram-pea- green gram	124	7.5	174	13.3
T1+ Fluchloralin/ pendimethalin/fluchloralin	146	9.6	203	23.3
T2+ Fluchloralin/ pendimethalin/fluchloralin	185	12.7	241	20.7
Metribuzin 0.5 kg/ha in each season	214	12.5	259	22.0
Glyphosate 2.0 kg/ha in each season	176	14.3	238	24.6
2 Mechanical weeding in each season	207	13.1	251	22.3
Weedy check	156	7.4	202	13.7
LSD (P = 0.05)	56	3.4	69	7.0

*Arc sign transformed values.

Table 9. Effect of Integrated weed management on weed growth in newly planted citrus orchard (2009-10)

Treatment	Total weed count (m^2) At 60DAS		Weed dry wt (g/m^2) At 60DAS		Bonus yield (kg/ha)	
	Kharif-09	*Rabi*-09-10	*Kharif*-09	*Rabi*-09-10	*Kharif*-09	*Rabi*-09-10
T_1- Intercropping of cowpea - pea-cowpea	6.7	10.8	9.4	10.9	160	504
T_2 Intercropping of green gram -pea-green gram	5.9	6.9	5.4	7.6	352	801
T_1+ Fluchloralin/ pendimethalin/fluchloralin	4.3	2.9	6.3	2.7	241	1066
T_2+ Fluchloralin/ pendimethalin/fluchloralin	5.1	4.1	6.3	3.8	370	1076
Metribuzin 0.5 kg/ha in each season	11.9	10.4	14.4	7.9	-	-
Glyphosate 2.0 kg/ha in each season	7.3	1.6	6.6	0.9	-	-
2 Mechanical weeding in each season	10.7	0.7	8.1	0.7	-	-
Weedy check	9.7	16.4	16.1	15.4	-	-
LSD (P = 0.05)	4.0	2.9	3.4	4.1	71	359

*Transformed values using square root transformation

Table 10. Effect of Integrated weed management on plant growth in newly planted citrus orchard (2009-10)

Treatment	Height (cm) summer'09	Girth (cm) summer'09	Height (cm) *Rabi*'09-10	Girth (cm) *Rabi*'09-10
T_1- Intercropping of cowpea - pea-cowpea	119	6.4	134	8.3
T-2 Intercropping of green gram-pea- green gram	126	6.7	147	10.9
T_1+ Fluchloralin/ pendimethalin/fluchloralin	153	8.0	154	11.3
T_2+ Fluchloralin/ pendimethalin/fluchloralin	135	7.7	158	11.6
Metribuzin 0.5 kg/ha in each season	143	8.9	158	12.9
Glyphosate 2.0 kg/ha in each season	122	10.0	141	13.2
2 Mechanical weeding in each season	127	7.0	125	9.8
Weedy check	144	8.1	156	11.2
LSD (P = 0.05)	55	2.7	76	4.4

*Arc sign transformed values

Soil microbial population were assessed in 30 days interval up to harvesting stage in mango. Among the treatments ($21.7x10^6$cfu/g) intercropping of greengram recorded higher bacterial population , this was followed by intercropping of cowpea ($19.5x10^6$cfu/g) within 60 days after spraying. In treatments receiving herbicide, metribuzin ($8.3x10^6$ cfu/g) recorded lower population. Results revealed that the highest fungi population were recorded in intercropping of greengram ($13.5x10^3$ cfu/g). Similarly higher actinomycetes population were observed in intercropping of greengram (7.1 $x10^3$cfu/g) followed by intercropping of cowpea ($6.5x10^3$cfu/g).

Similarly in citrus field, highest bacterial population were observed in intercropping of greengram treatment ($21.3x10^6$cfu/g).This was followed by intercropping of cowpea ($18.4x10^6$ cfu/g). Results revealed that the highest fungi ($12.3x10^3$ cfu/g) and actinomycetes ($7.3x10^3$ cfu/g) population was recorded in intercropping of greengram treatment.

The same experiment was carried out with different intercrops during *rabi* 2010, and the result were same pattern.

Table11. Assessment of soil microbial population in newly planted mango and citrus orchard in *kharif* (2009)

Treatments	Soil microbial population (CFU/g soil) at 90 days after spraying					
	Bacteria X10^6		Fungi X10^3		Actinomycetes X10^3	
	Mango	Citrus	Mango	Citrus	Mango	Citrus
T1- Intercropping of cowpea fb pea fb cowpea	19.5	18.4	12.4	11.9	7.1	7.3
T2- Intercropping of greengram fb pea fb greengram	21.7	21.3	13.5	12.3	6.5	6.9
T3- T1+Pendimethalin 1.0 kg/ha/ Fluchloralin 1.0kg/ha in each season	13.9	12.4	11.8	10.8	5.5	6.1
T4- T2+ Pendimethalin 1.0 kg/ha/ Fluchloralin 1.0kg/ha in each season	14.1	13.4	13.1	12.9	4.9	5.9
T5- Metribuzin 0.5 kg/ha in each season	8.3	11.1	10.5	11.3	4.5	4.7
T6- Glyphosate 2.0kg/ha once in a season	11.6	10.9	9.4	9.8	4.8	4.9
T7-2 mechanical weeding (Tractor) once in a season	15.8	13.8	11.5	8.9	5.3	5.6
T8- Weedy check DAS-Days after spraying	14.5	14.6	10.8	10.5	5.1	5.3
LSD (P = 0.05)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Table 12. Assessment of soil microbial population in newly planted mango and citrus orchard in *rabi* (2010)

Treatments	Soil microbial population (CFU/g soil) at 90 days after spraying					
	Bacteria X10^6		Fungi X10^3		Actinomycetes X10^3	
	Mango	Citrus	Mango	Citrus	Mango	Citrus
T1- Intercropping of cowpea fb pea fb cowpea	18.1	17.3	7.2	14.8	8.2	7.5
T2- Intercropping of greengram fb pea fb greengram	17.5	18.2	8.4	12.3	7.3	8.4
T3- T1+Pendimethalin 1.0 kg/ha/ Fluchloralin 1.0kg/ha in each season	15.8	9.7	10.3	8.4	6.9	8.2
T4- T2+ Pendimethalin 1.0 kg/ha/ Fluchloralin 1.0kg/ha in each season	16.9	10.1	14.4	9.2	7.2	8.3
T5- Metribuzin 0.5 kg/ha in each season	9.2	6.4	9.2	6.2	5.4	6.2
T6- Glyphosate 2.0kg/ha once in a season	11.3	4.8	8.4	6.8	4.9	6.3
T7-2 mechanical weeding (Tractor) once in a season	14.3	8.4	8.4	7.8	5.7	5.9
T8- Weedy check	12.6	9.1	9.2	11.4	6.9	5.7
LSD (P=0.05)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

DAS-Days after spraying

2.3.3: Organic weed management in rice wheat and soybeanwheat cropping systems

R. P. Dubey, P.J. Khankhane and C. Sarthambal

Field experiments were under taken with the objective to evaluate the effect of organic, inorganic and integrated weed management practices on weeds and productivity of rice wheat and soybean - wheat cropping systems.

2.3.3.1: Effect of intercropping, stale bed, narrow spacing and cover crop under organic, inorganic and integrated system of soil fertility and weed control on weeds and yield of direct seeded rice-wheat cropping system

Rice

The major weed flora observed in the experimental field was *Echinochloa colona, Cyperus iria, Alternanthera sessilis, Phyllanthus niruri, Physalis minima, Caesulia axilaris* etc. The lowest weed population and dry biomass at 60 DAS in direct seeded rice crop was recorded under integrated and organic weed management systems compared to inorganic treatments. Among cropping systems, weed biomass was lower in stale bed-rice and rice+ sesbania intercropping. The grain yield of rice was highest (1855 kg/ha) under integrated weed management in rice + sesbania + 2,4-D treatment.

Table 13. Interaction effect of treatments on (A) weed dry biomass (g/m^2) and (B) grain yield (kg/ha) of direct seeded rice crop

Treatments	Rice 20 cm		Rice + *Sesbania* + 2,4-D 0.5 kg/ha		Stale bed-rice(15 cm)		Green gram - rice (15 cm)		Mean	
	A	B	A	B	A	B	A	B	A	B
FYM 16 t/ha + 2 hand weeding	7.7 (59.8)	1040	7.9 (61.9)	1142	8.1 (65.1)	1110	7.5 (55.7)	940	7.8 (60.3)	1060
Recommended NPK + Herbicide	15.7 (239.7)	750	11.7 (136.4)	1125	11.3 (127.2)	760	13.7 (187	790	13.1 (171.1)	860
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	8.1 (65.1)	1250	8.3 (68.4)	1855	5.8 (33.1)	1730	7.4 (54.3)	1390	7.4 (54.3)	1550
Mean	10.5 (109.8)	1010	9.3 (85.9)	1370	8.4 (70.1)	1190	9.5 (89.8)	1040	-	-

LSD (P=0.05) Weed biomass 1.4 & NS; Grain yield 70 & 80; Interactions Weed biomass NS; Grain yield -140 & 140.

Wheat

The major weed flora observed in the experimental field was *Medicago denticulata, Cichorium intybus, Phalaris minor, Vicia sativa* and others. The inorganic treatment was significantly inferior to organic and integrated systems on controlling weeds. Among the cropping systems stale seed bed along with reduced row spacing of wheat resulted in better

Table 14. Effect of treatments on weed density and biomass at 60 DAS, and yield of wheat, berseem (intercrop) and pea (cover crop)

Treatments Main Plot (Fertility and weed control)	Weed density (no./m^2)	Total dry biomass (g/m^2)	Seed yield (kg/ha)
FYM 24 t/ha + 2 hand weeding	4.4 (18.9)	2.9 (7.9)	2510
Recommended NPK + Herbicide	5.2 (26.5)	4.1 (16.3)	3460
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	4.6 (20.7)	3.0 (8.5)	3610
LSD (P=0.05)	0.2	0.9	210
Sub Plot (Cropping system)			
Wheat 22.5 cm	5.4 (28.9)	3.7 (13.2)	3430
Wheat (30 cm) + berseem	4.9 (23.5)	3.6 (12.5)	3920 (12820*)
Stale bed– wheat (15 cm)	4.0 (15.5)	2.5 (5.8)	3730
Pea- wheat (15 cm)	4.7 (21.6)	3.5 (11.8)	1690 (2450#)
LSD (P=0.05)	0.2	0.5	170

Weed data are sq root transformed, original values are in parenthesis
* Fodder yield of berseem, # green pod yield of pea in kg/ha

weed control. The wheat seed yield was highest (3610 kg/ha) with integrated system. Wheat intercropped with berseem yielded highest (3920 kg/ha) as compared to other treatments.

Soil microbial population bacteria, fungi and actinomycetes were reduced under inorganic system where as it was similar under organic and integrated system.

2.3.3.2: Effect of stale bed, narrow spacing, intercropping and cover crop under organic, inorganic and integrated system of soil fertility and weed control on weeds and yield of soybean- wheat cropping system

Soybean

The major weed flora observed in the experimental field was *Cyperus iria, Echinochloa colona, Dinebra sp., Alternanthera sessilis,* and *Commelina benghalensis, Phyllanthus niruri, Physalis minima, Caesulia auxillaris* among others. The lowest weed dry biomass at 60 DAS in soybean crop was recorded under organic and integrated system and with stale seed bed and reduced spacing of 30 cm. However, the seed yield of soybean was comparable under all the three systems i.e. organic (1990), inorganic (1810) and integrated (1960 kg/ha). Soybean grown under pea-wheat-green gram-soybean rotation at 30 cm recorded higher yield of 2170 kg/ha.

Table 15. Effect of treatments on weed density and biomass at 60 DAS and yield of soybean.

Treatments	**Weed density (no./m^2)**	**Total dry biomass (g/m^2)**	**Seed yield (kg/ha)**
Main Plot (Fertility and weed control)			
FYM 6 t/ha+2 Hand weeding	5.3 (27.6)	6.1 (36.7)	1990
Recommended NPK + Herbicide	4.6 (20.7)	8.0 (63.5)	1810
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	4.7 (21.6)	7.0 (48.5)	1960
LSD (P=0.05)	0.3	NS	NS
Sub Plot (Cropping system)			
Soybean 45 cm	5.3 (27.6)	9.8 (95.5)	1970
Stale bed- soybean (30 cm)	4.3 (18.0)	3.2 (9.7)	1630
Green gram - soybean (30 cm)	4.9 (23.5)	8.1 (65.1)	2170
LSD (P=0.05)	0.3	1.8	110

Weed data are sq root transformed, original values are in parenthesis

Wheat

The major weed flora observed in the experimental field was *Medicago denticulata, Cichorium intybus, Phalaris minor, Physalis minima, Vicia sativa* and others. Wheat intercropped with berseem significantly reduced the weed dry biomass at 60 DAT. The wheat yield was highest (5100 kg/ha) with berseem intercropping. Wheat yield was 3210 kg/ha under organic treatment compared to 4390 kg/ha under inorganic treatment.

Soil microbial population bacteria, fungi and actinomycetes were reduced under inorganic system where as it was not affected under organic and integrated systems.

Table 16. Effect of treatments on weed density, biomass at 60 DAS, yield of wheat, berseem (intercrop) and pea (cover crop)

Treatments	Weed density (no./m^2)	Total dry biomass (g/m^2)	Seed yield (kg/ha)
Main Plot (Fertility and weed control)			
FYM 6 t/ha+2 Hand weeding	5.1 (25.5)	2.5 (5.8)	3210
Recommended NPK + Herbicide	5.6 (30.9)	3.2 (9.7)	4390
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	4.4 (18.9)	2.7 (6.8)	4280
LSD (P=0.05)	0.5	0.3	180
Sub Plot (Cropping system)			
Wheat 22.5 cm	5.7 (31.9)	3.0 (8.5)	4460
Stale bed-Wheat(30 cm) + berseem	4.4 (18.9)	2.5 (5.8)	5100 (14000*)
Pea-wheat (15 cm)	5.0 (24.5)	2.9 (7.9)	2320 (3470#)
LSD (P=0.05)	0.3	0.2	220

Weed data are sq root transformed, original values are in parenthesis
* Fodder yield of berseem, # green pod yield of pea in kg/ha

2.3.4: Organic weed management in vegetable cropping systems

R. P. Dubey, P.J. Khankhane and C. Sarthambal

Field experiments were taken up with the objective to compare the effect of organic, inorganic and integrated weed management practices on weeds and productivity of okra-cauliflower and chilli-tomato cropping systems.

2.3.4.1: Effect of mulch and intercrop under organic, inorganic and integrated system of soil fertility and weed control on weeds and yield of okra-cauliflower cropping system

Okra

The major weed flora observed were *Echinochloa colona, Cyperus iria, Alternanthera sessilis, Physalis minima* and others. Mulching the okra crop either with paddy straw or black polythene resulted in reduced weed biomass and higher yield (11710 and 11620 kg/ha respectively) of okra. The inorganic system of nutrient and weed management was most effective in producing higher pod yield (12000 kg/ha) of okra.

Table 17. Effect of treatments on weed density and biomass at 60 DAS and yield of okra

Treatments	Weed density((No./m^2)	Weed biomass (g/m^2)	Pod yield (kg/ha)
Main Plot			
FYM + 2 hand weeding	9.2 (84.1)	5.9 (34.3)	7770
Recommended NPK + Herbicide	9.2 (84.1)	6.2 (37.9)	12000
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	7.8 (60.3)	4.9 (23.5)	9280
LSD (P=0.05)	0.5	0.6	800
Sub Plot			
Okra (sole)	9.7 (93.6)	7.6 (57.3)	8110
Okra + amaranth	10.2 (103.5)	6.1 (36.7)	7300 (2400*)
Okra + straw mulch	8.5 (71.7)	5.6 (30.8)	11710
Okra + black polythene	6.4 (40.5)	3.5 (11.8)	11620
LSD (P=0.05)	0.5	0.3	1080

Weed data sq root transformed, original values are in parenthesis
*Intercrop yield

Cauliflower

The major weed flora observed in the experimental field was *Medicago denticulata, Chenopodium album, Vicia sativa, Physalis minima*. and others. Among the weed management treatments the integrated treatment of herbicide + hand weeding in combination with black polythene mulch significantly reduced the weed dry biomass at 60 DAT. Cauliflower yield was highest in integrated weed management (15290 kg/ha) and black polythene mulch (19360 kg/ha). Soil microbial population bacteria, fungi and actinomycetes were reduced under inorganic system where as it was higher under integrated system.

Table 18. Effect of treatments on weed density, biomass at 60 DAS, yield of cauliflower and soil moisture

Treatments	Weed density (No./m^2)	Weed biomass(g/m^2)	Soil moisture 75 DAS (%)	Cauliflower yield (kg/ha)
Main Plot				
FYM + 2 hand weeding	5.1 (25.5)	2.3 (4.8)	24.2	9240
Recommended NPK + Herbicide	5.8 (33.1)	3.9 (14.7)	23.0	14770
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	3.4 (11.1)	2.0 (3.5)	22.6	15290
LSD (P=0.05)	0.7	1.1	NS	1730
Sub Plot				
Cauliflower (sole)	7.2 (51.3)	4.9 (23.5)	18.9	10040
Cauliflower + radish	5.1 (25.5)	2.8 (7.3)	21.9	7440 (21800*)
Cauliflower + straw mulch	3.9 (14.7)	2.0 (3.5)	26.8	15560
Cauliflower + black polythene	2.8 (7.3)	1.3 (1.2)	25.3	19360
LSD (P=0.05)	0.5	1.0	2.2	980

Weed data sq root transformed, original values are in parenthesis
*Intercrop yield

2.3.4.2: Effect of mulch and intercrop under organic, inorganic and integrated system of soil fertility and weed control on weeds and yield of chilli-tomato cropping system

Tomato

The major weed flora observed in the experimental field was *Medicago denticulata, , Chenopodium album, Physalis minima Paspaladium sp.* and others. Among the weed management treatments the treatment of two hand weedings and application of FYM and black polythene mulch significantly reduced the weed dry biomass at 60 DAT. The tomato yield was highest under integrated weed management and black polythene mulch. The soil moisture at 75 DAS was higher in straw and black polythene mulch. Actinomycetes and bacteria population was lower under inorganic treatment.

Table 19. Effect of treatments on weed density and biomass at 60 DAS, yield of tomato and soil moisture

Treatments	Weed density (No./m^2)	Weed biomass (g/m^2)	Soil moisture (%)	Tomato yield (kg/ha)
Main Plot				
FYM + 2 hand weeding	4.7 (21.6)	2.3 (4.8)	25.4	31950
Recommended NPK + Herbicide	6.2 (37.9)	5.1 (25.5)	20.8	28790
50% FYM + 50% NPK+ herbicide fb 1 hand weeding	4.1 (16.3)	2.8 (7.3)	20.9	46760
LSD (P=0.05)	0.2	0.2	3.7	7240
Sub Plot				
Tomato (sole)	5.9 (34.3)	4.1 (16.3)	19.7	35880
Tomato + radish	5.5 (29.7)	3.7 (13.2)	21.1	21590 (13510*)
Tomato + straw mulch	4.7 (21.6)	3.3 (10.4)	25.1	32850
Tomato + black polythene	3.9 (14.7)	2.5 (5.8)	23.8	53000
LSD (P=0.05)	0.4	0.2	2.5	3030

Weed data sq root transformed, original values are in parenthesis
*Intercrop yield

2.3.5: Weed management in medicinal plants

2.3.5.1: Weed management in gurmar

Anil Dixit, R.P.Dubey and Jay G. Varshney

The field experiment was conducted with nine weed control treatments in randomized block design replicated thrice. Being perennial shrub, both seasons major weeds flora observed in the experimental field was *Medicago denticulate*, *Chenopodium album, Commelina benghalensis*, *Echinochloa colona* and others. Application of black polythene mulch significantly reduced the weed density and weed biomass to the lowest level as compared with the other treatments which was closely followed by hoeing at 15 days interval. The highest leaf yield (718kg/ha) of gurmar recorded with the application of black polythene.

Table 20. Effect of treatments on growth and yield of gurmar medicinal plant

Treatments	Total weed density (No/m^2)	Weed biomass (g/m^2)	Plant height (cm)	Number of branches	Leaf Yield (Kg/ha)
Intercropping with gram	10.3	58	93.4	6.3	284
Straw mulch	7.4	31	111.8	6.1	310
Black polythene	2.9	15	166.5	11.2	718
Pendimethalin	9.8	62	122.7	6.0	213
Fluchloralin	10.1	57	120.4	7.8	205
Fenoxaprop	7.9	66	112.4	7.3	217
Hoeing 15 days interval	3.8	17	174.7	11.1	677
Manual Weeding (2)	4.5	25	174.1	12.6	536
Weedy check	13.7	140	55.2	4.2	64
LSD (P=0.05)	2.1	16	47	2.9	137

Weed count values are subjected to square root transformation

3. HERBICIDE AS A TOOL IN WEED MANAGEMENT

3.1 Long term effects of herbicides in different cropping systems

3.1.1 Influence of continuous use of herbicides in soybean-wheat cropping system

3.1.1.1 Influence of continuous use of herbicides on weed seed bank, weed dynamics and productivity in soybean-wheat cropping system

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A field study was conducted to study the long term impact of continuous use of herbicides on weed seed bank, weed dynamics and productivity of crops in soybean-wheat cropping system. Treatments comprised of fenoxaprop 100 g/ha PO, imazethapyr 100 g/ha and 1 hand weeding at 30 DAS along with weedy check in soybean as a main plot treatments and which were superimposed by isoproturon 1.0 kg/ha, sulfosulfuron 25 g/ha and clodinafop 60 g/ha followed by 2,4-D 0.5 kg/ha and 1 hand weeding at 30 days after sowing (DAS) along with weedy check in wheat as a subplot treatments) were laid out in a split-plot design with 3 replications. *Echinochloa colona*, *Paspaladium* sp. and *Dinebra* sp among grasses, *Commelina communis*, *Phyllanthus simplex*, *Euphorbia geniculata*, *Corchorus* tricularis and *Physalis minima* among broadleaf weeds and *Cyperus iria* among sedges were dominant weed flora in soybean. Application of fenoxaprop 100 g/ha reduced the population of *E. colona* and *Paspaladium* sp. whereas, lowest infestation of *P. simplex*, *E. geniculata* and *C. iria* was recorded with continuous application of imazathepyr 100 g/ha. Manual weeding at 30 DAS was found most effective in reducing the population of *C. communis* and *E. geniculata* but failed to reduce the population of *P. simplex* and *Dinebra* sp. Continuous use of fenoxaprop at 100 g/ha caused weed flora shift from grasses (*E. colona* and *Dinebra* sp) to broad leaf weeds, whereas problem of grasses particularly *Paspaladium* sp. were substantially increased in imazethapyr treated plots. Treatment of preceding wheat crop did not influence the distribution of *all the weed speices* in succeeding soybean crop. However, higher density of *E. colona and E. geniculata* were recorded with preceded treatments of sulfosulfuron. Among weed control measures, significantly lower weed density and weed biomass production was noticed with imazethapyr at 100g/ha only which was at par with one hand weding. Crop growth viz. leaf area, number and dry weight of nodules, dry biomass of root and shoot of soybean and yield attributes viz pods and seed weight per plant and seed yield of soybean was significantly influenced with different weed control measures. Among herbicides continuous application of imazethapyr at 100 g/ha produced higher crop growth, yield attributes and seed yield over fenoxaprop at 100 g/ha and weedy check. However, highest yield attributes and seed yield of soybean were recorded with one hand weeding.

In wheat, *Avena ludoviciana, Medicago hispida, Cichorium intybus, Physalis minima* and *Euphorbia geniculata* were dominant weed flora. Preceding treatments applied in soybean significantly influenced the population of *Avena ludoviciana, E geniculata* and total weed density. Significantly higher density of *Avena ludoviciana, E. geniculata* and total weeds was recorded where fenoxaprop at 100 g/ha was applied continuously as preceding treatment. However, significantly lower density of *E. geniculata* was recorded with preceded imezethapyr 100 kg/ha. All weed control treatments applied in wheat significantly reduced the population of all weed species as well as total weed density and weed biomass over weedy check. Continuous use of clodinafop at 60 g/ha *fb* 2, 4-D at 0.5 kg/ha decreased the density of *A. ludoviciana* significantly where as it had higher population of *E. geniculata* over rest of the treatments. Continuous application of sulfosulfuron 25 g/ha failed to reduce the density of *Cichorium intybus.* Manual weeding at 25 DAS reduced the population of all weed species except *A. ludoviciana*. Application of clodinafop at 60 g/ha *fb* 2, 4-D at 0.5 kg/ha was at par with continuous use of sulfosulfuron 25 g/ha had lowest weed density and its dry matter production and gave highest grain yield of wheat over rest of the treatments.

Table 21. Weed dynamics in soybean as influenced by continuous use of herbicides under long term herbicide trial (*Kharif*, 2009)

Treatments	Density (no./m)									
	E. colona	*C. communis*	*C iria*	*Phyllanthus simplex*	*Euphorbia geniculata*	*Dinebra sp*	*P minima*	*Corcorus*	*Ipomea*	*Paspaladium*
Herbicides (Rainy season)										
Fenoxaprop 100 g/ha	0.9	2.9	1.3	1.5	8.7	0.7	1.8	2.0	1.5	1.0
Imazathepyr 100 g/ha	1.7	3.1	0.9	1.4	3.8	0.7	0.7	0.7	0.7	4.0
Manual weeding (1)	2.9	1.1	1.3	6.2	1.2	2.4	0.9	0.8	0.7	1.9
Weedy check	3.3	2.4	0.7	1.0	8.3	0.7	0.9	1.0	1.4	3.8
LSD (P=0.05)	1.1	1.6	1.1	1.6	2.6	0.7	1.5	1.0	0.6	3.4
Herbicides (winter season)										
Clodinafop 60 g/ha fb 2,4- D o.5 kg/ha	1.8	2.4	0.7	2.5	5.5	1.2	1.4	1.2	1.1	2.2
Sulfosulfuron 25 g/ha	2.1	2.2	1.3	2.3	6.4	1.1	0.8	1.3	1.3	2.0
Isoproturon 1.0 kg/ha	1.7	2.5	0.9	2.5	5.4	0.8	0.8	1.0	1.2	3.0
Manual weeding (1)	2.2	2.5	1.5	3.2	4.8	1.4	1.1	1.1	1.0	3.2
Weedy check	3.2	2.3	0.9	2.2	5.6	1.0	1.1	1.0	0.8	2.9
LSD (P=0.05)	1.0	0.7	0.6	1.1	1.4	0.9	0.5	0.3	0.5	2.2

Table 22. Weed growth and crop growth of soybean as influenced by continuous use of herbicides (*Kharif*, 2009)

Treatments	Weed density (no./m^2)	Weed biomass (g/ha)	Plant population /m^2 at 40DAS	Leaf area (cm^2/plant) at 50DAS	Nodules/ plant at 50DAS	Nodule dry weight (g) at 50DAS
Herbicides (Rainy season)						
Fenoxaprop 100 g/ha	10.6	14.1	8.9	510.8	18.7	0.1
Imazathepyr 100 g/ha	7.6	6.9	10.8	664.9	30.4	0.1
Manual weeding (1)	8.2	5.7	10.6	805.9	36.1	0.1
Weedy check	11.4	42.2	8.8	551.3	18.1	0.0
LSD (P=0.05)	1.9	46.3	2.9	256.6	12.7	0.1
Herbicides (winter season)						
Clodinafop 60 g/ha fb 2,4- D 0.5 kg/ha	9.0	10.0	9.9	641.6	25.5	0.1
Sulfosulfuron 25 g/ha	9.6	11.7	9.6	583.8	24.1	0.1
Isoproturon 1.0 kg/ha	9.3	11.6	9.8	572.7	25.0	0.1
Manual weeding (1)	9.7	10.3	9.8	671.9	25.2	0.1
Weedy check	9.6	42.6	9.7	696.1	29.3	0.1
LSD (P=0.05)	1.9	39.6	0.7	164.9	7.6	< 0.1

Table 23. Crop growth, yield attributes and seed yield of soybean as influenced by continuous use of herbicides (*kharif*, 2009)

Treatments	Root dry weight (g/plant) at 50 DAS	Plant dry weight (g/plant) at 50DAS	Pods/ plant	Seed weight /plant (g)	100-seed weight (g)	Seed yield (kg/ha)
Herbicides (Rainy season)						
Fenoxaprop 100 g/ha	0.4	4.2	34	4.2	7.0	227
Imazathepyr 100 g/ha	0.6	5.1	68	9.1	7.7	1339
Manual weeding (1)	0.8	6.6	64	8.2	7.0	1559
Weedy check	0.6	3.9	37	4.2	7.1	179
LSD (P=0.05)	0.4	2.5	15	2.9	0.8	311
Herbicides (winter season)						
Clodinafop 60 g/ha fb 2,4- D o.5 kg/ha	0.7	4.9	52	7.0	7.4	904
Sulfosulfuron 25 g/ha	0.5	4.3	49	6.4	7.0	815
Isoproturon 1.0 kg/ha	0.5	4.9	51	6.7	7.4	723
Manual weeding (1)	0.5	5.0	49	6.5	7.3	848
Weedy check	0.6	5.5	53	5.7	7.1	790
LSD (P=0.05)	0.3	1.1	14	1.7	0.6	190

Table24. Weed dynamics in wheat as influenced by continuous use of herbicides in a long term herbicide trial under soybean-wheat system. (Winter, 2009-10)

Treatments	**Density (no./m^2)**						Weed dry weight (g/m^2)
	A. ludoviciana	*M. hispida*	*C. intybus*	*P. minima*	*E. geniculata*	Total weed	
Herbicides (Rainy season)							
Fenoxaprop 100 g/ha	6.7	0.7	2.5	1.5	7.6	12.1	7.6
Imazathepyr 100 g/ha	6.0	0.9	2.3	1.6	3.0	8.9	6.0
Manual weeding (1)	5.7	0.8	2.7	1.6	3.8	9.0	5.9
Weedy check	5.8	0.7	2.4	0.9	7.8	11.5	7.2
LSD (P=0.05)	1.0	0.2	1.0	1.1	0.6	0.8	1.0
Herbicides (winter season)							
Clodinafop 60 g/ha fb 2,4_ D 0.5 kg/ha	1.5	0.9	0.8	3.6	8.0	9.4	5.5
Sulfosulfuron 25 g/ha	1.9	0.8	7.6	0.8	6.9	10.9	6.1
Isoproturon 1.0 kg/ha	10.0	0.7	0.7	0.7	4.2	11.6	7.4
Manual weeding (1)	5.3	0.7	1.7	1.0	3.1	7.0	4.2
Weedy check	11.4	0.9	1.8	0.8	5.4	13.1	10.1
LSD (P=0.05)	1.3	< 0.1	0.8	1.0	1.0	1.0	1.4

Table 25. Yield attributes and yield of wheat as influenced by continuous use of herbicides in a long term herbicide trial under soybean-wheat system. (Winter, 2009-10)

Treatments	Root dry weight (g/plant)	Spike Length (cm)	Grains/ spike	Grain weight/ spike (g)	100 seed wt (g)	Seed yield (kg/ha)
Herbicides (Rainy season)						
Fenoxaprop 100 g/ha	0.4	11.7	62.3	2.6	4.1	3766
Imazathepyr 100 g/ha	0.5	11.0	44.9	2.5	4.0	4184
Manual weeding (1)	0.5	11.5	40.6	2.5	3.9	4167
Weedy check	0.3	10.9	60.6	2.5	4.1	42.37
LSD (P=0.05)	< 0.1	0.5	40.4	0.2	0.3	401
Herbicides (winter season) Clodinafop 60 g/ha fb	0.7	11.4	54.1	2.6	4.2	4834
2,4- D o.5 kg/ha Sulfosulfuron 25 g/ha	0.4	11.8	55.3	2.6	4.0	5008
Isoproturon 1.0 kg/ha	0.3	11.1	54.2	2.6	4.0	4350
Manual weeding (1)	0.4	11.3	53.9	2.6	4.2	4540
Weedy check	0.3	10.6	42.8	2.0	3.9	1712
LSD (P=0.05)	< 0.1	0.6	4.8	0.2	0.2	547

Soil samples were collected at 0, 15, 30, 60, 90 and at 120 days after spraying. Grains and straw samples were collected at harvest. Samples were processed and analyzed for residues by HPLC using already standardized and published methods of residue lab. Persistence of fenoxaprop and imazethapyr were evaluated in soil and soybean crop produce at harvest. Sulfosulfuron, isoproturon, and clodinafop persistence was evaluated in soil, straw and grains of wheat at harvest. In soil 0.387 µg/g to, 0.0019 µg/g residues were detected after 0 to 90 days after application of herbicide. However, in soybean grains and straw 0.0031 and 0.002 µg/g of fenoxaprop residues were detected at harvest. In soil 0.264, to 0.056, µg/g imazethapyr residues were detected after 0, 15, 30, 60, and 90 days. After 120 days, residues were found <0.01 µg/g. However, in soybean straw and grains 0.0105 and 0.034 µg/g residues were detected at harvest. Half-life of imazethapyr was found 18.85 days. At 90 days, 0.0056 µg/g sulfosulfuron residues were detected. After 120 days residues were found <0.001 µg/g.

Among herbicide applied treatments the highest population of total bacteria ($2.85x10^6$cfu/g) were observed in imazethapyr treatment at the time of harvest. Similarly maximum fungi population were observed in fenoxaprop ($2.90x10^3$ cfu /g). The maximum actinomycetes population were noticed in imazethapyr treatment ($1.86x10^3$ cfu /g).

In wheat the highest population of bacteria ($2.90x10^6$ cfu/g) were found in the isoproturon treatment followed by sulfosulfuron treatment ($2.89x10^6$cfu/g). Results revealed that the highest fungi population were recorded in sulfosulfuron treatment ($2.84x10^3$ cfu/g). It was observed that the higher population of actinomycetes were observed in clodinafop ($2.05x10^3$cfu/ g) followed by isoproturon ($1.98x10^3$cfu/g).

In general treatments such as hand weeding and weedy check showed higher activity as compared with herbicide receiving treatments. This study clearly indicated that herbicide application had effect on the soil microbial population.

Table 26. Effect of continuous use of herbicides on soil micro flora in soybean wheat cropping system

Treatments	Soil microbial population (CFU/g soil)					
	Bacteria $X10^6$		Fungi $X10^3$		Actinomycetes $X10^3$	
	BHA	Harvest	BHA	Harvest	BHA	Harvest
Kharif season						
Fenoxoprop 100g/ha	2.8	2.5	2.6	2.9	2.2	1.85
Imazethapyr 100g/ha	2.9	2.6	2.6	2.7	2.2	1.86
Manual weeding (1)	3.0	3.3	2.7	2.9	2.3	2.47
Weedy check	3.0	3.2	2.8	3.0	2.3	2.36
LSD (P=0.05)	< 0.1	< 0.1	0.6	0.6	< 0.1	0.055
Rabi season						
Clodinafop 60g/ha	2.8	2.8	2.8	2.8	2.1	2.1
Sulfosulfuron 25g/ha	2.9	2.9	2.7	2.8	2.2	2.0
Isoproturon 1.0kg/ha	2.9	2.9	2.7	2.8	2.2	2.0
Manual weeding (1)	3.0	3.2	2.8	3.0	2.3	2.4
Weedy check	3.0	3.2	2.9	3.0	2.3	2.4
LSD (P=0.05)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

BHA-Before herbicide application

3.1.1.2 Influence of continuous use of herbicides on weed seed bank, weed dynamics and productivity in rice-wheat cropping system

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Regular monitoring of weed flora in long-term herbicide trial will enable to find out the change in weed flora succession and development of resistant biotypes, if any, due to the continuous use of herbicides. There is also every possibility of accumulation of applied herbicides in the food system and soil - water system as well as on soil microfloral status of the region. Considering these, a long-term herbicide trial consisting of butachlor 1.5 kg/ha, anilophos 0.4 kg/ha, 1 hand weeding along with weedy check in rice as a main- plot treatments and superimposed by isoproturon 1.0 kg/ha, sulfosulfuron 25 g/ha and clodinafop 60 g/ha followed by 2,4-D 0.5 kg/ha, 1 hand weeding at 25 days after sowing (DAS) along with weedy check in wheat as a sub-plot treatments were laid out in a split-plot design with three replications in rice wheat cropping system. The experimental field was infested mainly with *Echinochloa colona*, *Ammania baccifera*, *Commelina communis, Caesulia axillaries* and *Alternanthera sessilis* in rice, while in wheat, *Avena ludoviciana, Phalaris minor*, *Medicago hispida*, and *Chenopodium album* were dominant.

In rice, different weed control measures reduced the density of individual weed species viz. *Commelina communis* as compared to weedy check. Among herbicides, lesser population of *E. colona*, *C. communis* and *A. baccifera* was recorded with anilophos 0.4 kg/ha and its continuous use significantly reduced the total weed density, however none of the treatments had significant influence on the weed biomass production (Table 9). Different weed control treatments did not influence the crop growth, yield attributes and grain yield of rice (Table 10). Application of herbicides in preceding wheat had neither adverse effect on weeds nor on the growth of succeeding rice crop growth.

In wheat, continuous use of clodinafop-propargyl at 60 g/ha followed by 2, 4-D at 0.5 kg/ha significantly decreased the population of *P. minor* and *A. luidoviciana* over weedy check. However continuous use of sulfosulfuron 25 g/ha was most effective in reducing the population of *M. hispida* which was comparable with isoproturon 1.0 kg/ha. The preceding treatments applied in rice did not influence the density of any weed species significantly (Table 11). Clodinafop-propargyl at 60 g/ha followed by 2,4-D at 0.5 kg/ha was at par with sulfosulfuron 25 g/ha and showed the lowest weed population and weed dry matter and produced significantly higher number of effective tillers and grains per spike. Among herbicides, lowest effective tillers, grains per spike, 100 grain weight and grain yield of wheat was recorded with continuous application of isoproturon 1.0 kg/ha.

Table 27. Effect of continuous use of herbicides in a long term trial on weed dynamics under rice-wheat system (Rainy, 2009)

Treatments	Density (no. /m^2)							
	E. colona	*C. communis*	*Ammania beccifera*	*Alternant hera sessilis*	*Commelina communis*	*Caesulia axillaris*	Total weed	Weed biomass (g/ha)
Herbicides (Rainy season)								
Butachlor 1.5 kg/ha	2.3	4.5	5.0	1.1	1.5	1.4	7.9	4.4
Anilofos 0.4 kg/ha	1.6	2.6	2.6	1.8	2.4	1.7	5.6	4.2
Manual weeding (1)	1.6	6.9	5.7	0.9	1.1	1.3	9.6	4.0
Weedy check	2.1	7.2	4.8	0.8	2.1	1.4	8.9	4.6
LSD (P=0.05)	1.0	1.9	3.5	0.7	1.1	0.8	2.0	2.1
Herbicides (winter season)								
Clodinafop 60 g/ha fb 2,4- D 0.05 kg/ha	1.9	5.4	4.0	2.0	2.0	1.1	7.9	4.6
Sulfosulfuron 25 g/ha	1.9	5.0	3.9	1.6	1.6	1.7	7.5	4.2
Isoproturon 1.0 kg/ha	1.8	5.0	4.4	1.0	2.1	1.5	8.1	4.6
Manual weeding (1)	1.8	5.2	5.0	1.2	1.7	1.5	8.2	4.0
Weedy check	2.0	4.7	5.3	1.1	1.5	1.3	8.4	4.1
LSD (P=0.05)	0.5	2.2	1.7	0.4	0.8	0.6	2.4	1.7

Table 28. Effect of continuous use of herbicides on yield and yield components under rice-wheat system (Rainy, 2009)

Treatments	Root volume cc/plant	Root dry weight g/plant	No. of panicle per running (m)	Grains / panicle	Grain weight/panicle (g)	100 grain weight (g)	Grain yield (kg/ha)
Herbicides (Rainy season)							
Butachlor 1.5 kg/ha	4.3	0.5	56	207.5	6.1	3.0	6130
Anilofos 0.4 kg/ha	4.4	0.5	57	204.4	5.9	3.0	6113
Manual weeding (1)	3.3	0.7	58	205.5	5.8	2.9	6239
Weedy check	4.7	0.6	57	212.6	6.0	2.9	6088
LSD (P=0.05)	1.0	0.2	3	17.0	0.6	0.2	1641
Herbicides (winter sea son)							
Clodinafop 60 g/ha fb 2,4- D o.5 kg/ha	4.1	0.5	57	207.7	6.0	2.9	6436
Sulfosulfuron 25 g/ha	3.6	0.5	59	209.8	6.0	3.0	6368
Isoproturon 1.0 kg/ha	4.5	0.5	57	201.7	5.8	3.0	5634
Manual weeding (1)	4.2	0.5	58	212.9	6.0	3.0	6254
Weedy check	4.6	0.6	56	205.6	6.0	3.0	6020
LSD (P=0.05)	1.0	< 0.1	7	29.2	0.8	0.2	1335

Table 29. Effect of continuous use of herbicides on weed dynamics under rice-wheat system. (Winter, 2009-10)

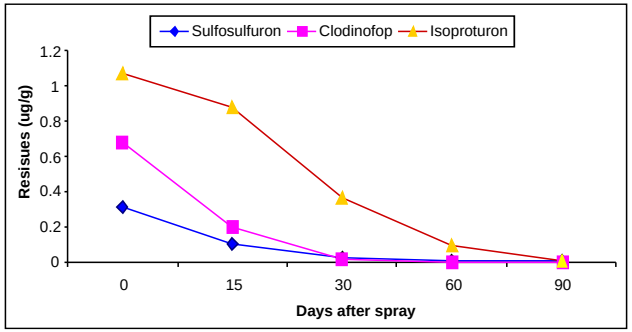
Treatments	Density (no/m^2) at 60 DAS					Weed biomass (g/m^2)
	A ludoviciana	*P. minor*	*M. hispida*	*C. album*	Total weed	
Herbicides (Rainy season)						
Butachlor 1.5 kg/ha	5.0	2.6	2.5	0.9	6.9	4.3
Anilofos 0.4 kg/ha	6.5	1.4	1.9	0.9	7.1	5.4
Manual weeding (1)	5.6	2.4	2.4	0.8	7.1	4.5
Weedy check	4.1	2.5	2.5	0.8	5.9	4.4
LSD (P=0.05)	2.5	2.1	0.4	0.3	1.4	1.6
Herbicides (winter season)						
Clodinafop 60 g/ha fb 2,4- D 0.5 kg/ha	2.0	1.0	2.7	0.8	3.6	2.0
Sulfosulfuron 25 g/ha	3.2	1.4	1.6	0.88	4.2	2.4
Isoproturon 1.0 kg/ha	8.7	2.2	2.1	0.8	9.6	7.4
Manual weeding (1)	3.2	2.4	2.5	1.1	5.1	3.3
Weedy check	9.5	4.1	3.0	0.9	11.5	8.0
LSD (P=0.05)	1.7	1.4	0.8	0.2	1.3	1.0

Table 30. Effect of continuous use of herbicides in a long term trial under rice-wheat system. (Winter, 2009-10)

Treatments	Effective tillers/ R meter	Spike Length (cm)	Grains /spike	Grain weight/spike (g)	100 seed wt (g)	Seed yield (kg/ha)
Herbicides (Rainy season)						
Butachlor 1.5 kg/ha	62.8	11.0	60.1	2.4	4.0	4131
Anilofos 0.4 kg/ha	58.4	10.5	60.1	2.3	4.0	3538
Manual weeding	57.7	10.4	61.0	2.5	4.1	3748
Weedy check	65.1	10.7	61.0	2.5	4.2	3933
LSD (P=0.5)	11.4	0.4	5.0	0.3	0.3	818
Herbicides (winter season)						
Clodinafop 60 g/ha fb 2,4- D 0.5 kg/ha	81.0	10.9	64.0	2.4	4.0	5037
Sulfosulfuron 25 g/ha	72.7	10.8	60.7	2.5	4.3	4790
Isoproturon 1.0 kg/ha	46.8	10.6	60.9	2.4	4.0	2984
Manual weeding	66.8	10.9	59.2	2.3	4.1	4162
Weedy check	37.8	10.1	57.7	2.4	4.1	2215
LSD (P=0.5)	8.2	0.5	4.8	0.2	0.2	718

With intensive cropping system and repeated application of herbicides in crop, there is potential danger of persistence of herbicide residue in soil and bio-accumulation in the crop produce. Therefore, this work was conducted to see fate and persistence of herbicides applied continuously in rice-wheat cropping system. Soil samples were collected at 0, 15, 30, 60, 90 and at 120 days after spraying. Grains and straw samples were collected at harvest. Samples were processed and analyzed to see persistence and residues of applied herbicides by HPLC using already standardized and published methods.

Persistence of anilofos and butachlor were evaluated in soil and rice crop produce at harvest. Sulfosulfuron, isoproturon, and clodinafop persistence was evaluated in soil and straw and grains of wheat at harvest. In soil 0.535, 0.354, 0.376, 0.279, µg/g residues were detected at 0, 15, 30, 60 days, respectively. At 90 days residues were 0.027, µg/g found below detectable limit in soil. Residues were persisted upto harvest. In soil 0.761, 0.135, 0.0129, 0.0061, 0.044, 0.0039 µg/g residues were detected after 0, 15, 30, 60 and 90 days. Trace amount of residues were detected in paddy grains and straw at harvest. Half-life of butachlor and anilofos were found 14.06 and 15.16 days. Sulfosulfuron, isoproturon, and clodinafop residues were persisted upto 90 days in soil.



Dissipation of sulfosulfuron, clodinafop and metsulfuron residues in soil of wheat field in rice-wheat cropping system

Soil microbial populations were assessed at 15 days interval up to harvesting stage *following serial dilution and plating method*. In the present study it was observed that the application of herbicide under field condition initially (15 days after spraying) reduces soil micro flora. How ever the activity improved gradually. Among the herbicide applied treatments, maximum bacterial population was observed in the butachlor treatment ($2.40x10^6$ cfu /g) followed by anilophos treatment ($2.35x10^6$ cfu /g) at harvesting stage.

Maximum fungi population were observed in butachlor treatment ($1.31x10^3$ cfu /g), this was followed by anilophos treatment ($1.23x10^3$ cfu /g) at harvesting stage. Actinomycetes population maintained stable after the application of herbicide. Among the two herbicides sprayed, application of butachlor had less adverse effect when compared to the application of anilophos on soil microorganisms. In wheat (rabi) at harvesting stage, maximum population of total

bacteria and actinomycetes were observed in isoproturon treatment ($2.52x10^6$,$1.95 x10^3$ cfu /g). Higher number of fungi population were recorded in clodinafop treatment ($1.70 x10^3$ cfu /g). In general treatments such as hand weeding and weedy check showed higher activity as compared with herbicide received treatments.

Table 31. Effect of continuous use of herbicides on soil micro flora in rice wheat cropping system

Treatments	Soil microbial population (CFU/g soil)					
	Bacteria $X10^6$		Fungi $X10^3$		Actinomycetes X10	
	BHA	Harvest	BHA	Harvest	BHA	Harvest
Kharif season						
Butachlor 1.5 kg/ha	2.7	2.4	1.38	1.3	2.2	2.1
Anilophos 0.4 kg/ha	2.6	2.4	1.37	1.2	2.2	1.9
Manual weeding (1)	2.8	3.0	1.79	2.0	2.1	2.2
Weedy check	2.9	3.1	1.82	2.0	2.0	2.2
LSD (P=0.05)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Rabi season						
Clodinafop 60 g/ha	2.6	2.5	1.7	1.7	1.9	1.8
Sulfosulfuron 25 g/ha	2.5	2.5	1.8	1.7	1.9	1.9
Isoproturon 1.0 g/ha	2.6	2.5	1.7	1.7	1.9	2.0
Manual weeding (1)	2.7	2.8	2.0	2.2	2.0	2.1
Weedy check	2.7	2.8	2.0	2.2	2.1	2.1
LSD (P=0.05)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

BHA-Before herbicide application

3.1.3.1: Impact of herbicides on N-Fixation by the legume-rhizobium symbiosis

K.K. Barman and Jay G. Varshney

3.1.3.1.1: Effect of fenoxaprop, imazethapyr and quizalofop on soybean nodulation

A field experiment was conducted during *kharif* 2009 to study the effect of fenoxaprop 100 g/ha, imazethapyr 100 g/ha and quizalofop 50 g/ha application (21 DAS) on nodulation in soybean (cultivar JS-97-52) following RBD with 4 replications. Observations were recorded at 40 and 60 DAS on nodule count, nodule dry matter, root volume, and seed yield. The results revealed that both nodule count as well as nodule dry matter were lowest in the weedy plots and highest in the hand weeded plots. Compared to the hand weeding, both these parameters were significantly lower in the fenoxaprop and imazethapyr treated plots at 40 DAS. Lowest root volume as recorded in the weedy treatment could be the reason behind lowest values of nodulation parameters among the given treatments. However, in spite of statistically similar root volume, significantly lower nodule number and nodule dry matter in the fenoxaprop and imazethapyr treatments than the hand weeding treatment at 40 DAS indicate that these two herbicides were toxic to the nodulation process in soybean. However, at 60 DAS all the herbicides treatments were statistically similar to hand weeding treatment in terms of nodulation indicating that the initial toxic effect of fenoxaprop and imazethapyr disappeared at later stage of soybean growth. This indicated that in general the given herbicides are safe in terms of symbiotic nitrogen fixation in soybean, but quijalofop could be considered as the safest. None of the tested herbicide showed any adverse effect in terms of soybean seed yield.

Table 32. Effect of fenoxaprop, imazethapyr and quizalofop on root volume, nodule count and nodule dry matter production in soybean

Treatment	Nodule Count (No./Plant)		Nodule dry wt. (g/plant)		Root volume (ml/plant)	
	40 DAS	60 DAS	40 DAS	60 DAS	40 DAS	60 DAS
Weedy check	11.8	21.4	0.04	0.14	1.9	2.8
Manual weeding	30.1	35.0	0.12	0.27	2.8	3.9
Quizalofop	34.6	29.8	0.12	0.24	2.9	3.9
Fenoxaprop	20.2	27.3	0.08	0.23	2.6	3.3
Imazethapyr	21.5	29.0	0.05	0.25	2.5	3.5
LSD (P = 0.05)	8.6	11.0	0.03	0.07	0.5	0.9

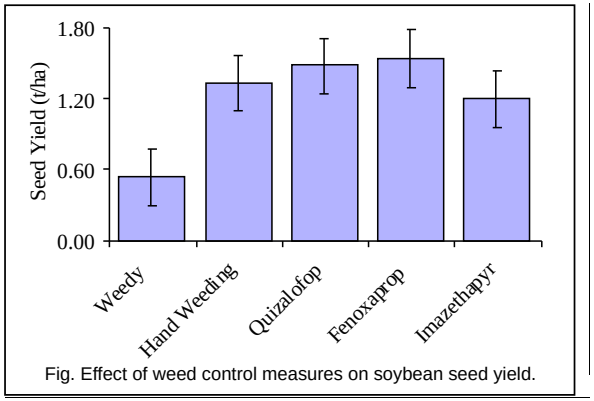


Fig. Effect of weed control measures on soybean seed yield.

3.1.3.1.2: Effect of herbicides on nodulation and yield of chickpea

A field experiment was conducted during winter season of 2009-10 to study the effect of fluchloralin 1 kg (PPI), pendimethalin 1 kg (PE), clodinafop 60 g (21 DAS) and quizalofop 50g/ha (21 DAS) application on nodulation in chickpea (cultivar JG-16) following RBD with 4 replications. Observations were recorded on nodule count and nodule dry matter, weed dry matter and seed yield. Among the tested herbicides, fluchloralin and pendimethalin treatments showed significantly lower nodule count and nodule dry matter at 40 and 60 DAS compared to the hand weeding treatment. However the toxic effect thus observed disappeared by 90 DAS. Highest weed dry matter was recorded in the weedy treatment that is in absence of any weed control measures. Among the herbicides, pendimethalin was the most successful in controlling weeds and it was statistically similar to the hand weeding treatment that showed lowest weed dry matter production. Highest seed yield was recorded in the hand weeded plots and it was significantly higher than the weedy treatment. Herbicide treatments were however similar to

both weedy as well as hand weeding treatments in terms of seed yield of chickpea. It was concluded that, although pendimethalin was as good as hand weeding treatment in terms of weed control measure and seed yield production, it was not safe to chickpea in terms symbiotic nitrogen fixation as it adversely affected nodulation during peak growing stage of chickpea that is at 60 DAS.

Table 33. Effect of pendimethalin, fluchloralin, clodinafop and quizalofop on nodule count and nodule dry matter production in chickpea

Treatments	Nodule count/plant			Nodule DM, g/plant		
	40 DAS	60 DAS	90 DAS	40 DAS	60 DAS	90 DAS
Weedy	14.4	21.4	22.7	0.02	0.05	0.06
Manual weeding (1)	23.1	29.3	30.4	0.03	0.05	0.07
Pendimethalin	15.7	19.4	26.2	0.02	0.03	0.07
Fluchloralin	15.7	18.6	25.4	0.01	0.03	0.07
Clodinafop	19.1	21.7	27.6	0.02	0.05	0.06
Quizalofop	19.7	25.3	30.8	0.03	0.05	0.06
LSD = (P = 0.05)	5.2	7.7	6.2	< 0.01	0.02	NS

Table 34. Effect of pendimethalin, fluchloralin, clodinafop and quizalofop on weed infestation and seed yield production in chickpea

Treatment	Weed DM (65 DAS, g/m ^{2})	Seed yield (Kg/ha)
Weedy check	10.4	1960
Manual weeding	5.2	2405
Pendimethalin	5.9	2212
Fluchloralin	7.8	2267
Clodinafop	8.1	2218
Quizalofop	8.8	2172
LSD (P=0.05)	2.5	310

3.1.3.1.3: Effect of herbicides on nodulation and yield of field pea

A field experiment was conducted during winter months of 2009-10 to study the effect of fluchloralin 1 kg (PPI), pendimethalin 1 kg (PE), clodinafop 60 g (21 DAS) and quizalofop 50g/ha (21 DAS) application on nodulation in field pea (cultivar JP-885) following RBD with 4 replications. Observations were recorded on nodule count, weed dry matter and seed yield. The lowest weed dry matter was recorded in hand weeding treatment and it was similar to pendimethalin, fluchloralin and quizalofop treatments. Fluchloralin, however, showed toxic effect to field pea in terms of nodule count and resulted in significantly lower nodule count than the hand weeding treatment. None of the weed control measure showed any adverse or beneficial effect over the weedy treatment in terms of seed yield. However, the seed yield in the pendimethalin treated plots was significantly lower than that as recorded in the hand weeded plots.

Table 35. Effect of pendimethalin, fluchloralin, clodinafop and quizalofop on weed infestation, nodulation and seed yield production in chickpea.

Treatments	Weed DM (65 DAS, g/m ^{2})	Nodule count/plant	Seed yield (kg/ha)
Weedy check	10.0	29.1	2091
Manual weedly (1)	3.9	35.1	2274
Pendimethalin	5.4	29.5	1796
Fluchloralin	4.3	25.5	1949
Clodinafop	7.0	29.9	2092
Quizalofop	4.8	30.3	2133
LSD (P=0.05)	1.5	9.3	350

3.1.5: Evaluation of herbicides persistence in water and their effect on non-target organism

Shobha Sondhia and Jay G Varshney

With the increasing use of herbicides for weed control, the applied herbicide may find its way into streams and underground water sources by run off and leaching mechanism. A side effect of usage of some herbicides may results in unfortunate consequences to non-target organisms. The most obvious effects of herbicides on fish and other wildlife are direct effects of acute poisoning. Herbicides can enter water sources through drift, runoff, soil erosion, leaching, and occasionally, accidental or deliberate release. Thus herbicides persistence in water and their effect on non-target organisms was evaluated under paddy based cropping system.

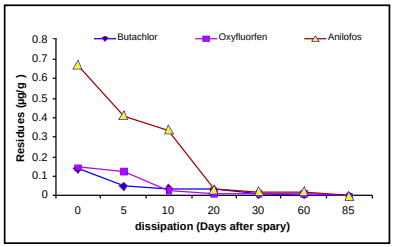
Oxyfluorfen, anilofos and butachlor were applied to the paddy crop and sulfosulfuron, clodinafop and metsulfuron were applied to wheat plots at recommended doses. Herbicide residues were determined in water, soil and fishes at different time interval. Samples were processed and analyzed for residues by HPLC.

Persistence of herbicides in water, crop, fishes and their effect on non-target organism were evaluated. Oxyfluorfen, anilofos and butachlor was applied at 0.250, 0.400 and 1.5 kg/ha in kharif 2009 to the paddy crop whereas 25, 4, 60 g/ha of sulfosulfuron, metsulfuron and

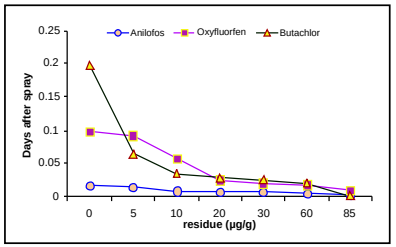
clodinafop respectively was applied in wheat in rabi 200-10. Herbicide residues in soil, paddy, wheat and water at 0, 15, 30, 60, 90, 120 days were evaluated for persistence of oxyfluorfen, anilofos and butachlor in *kharif* 2009 and sulfosulfuron, metsulfuron and clodinafop in rabi 2009-10. Fishes were also sampled after 0, 10, 20, 30, 60, 90, 120 days and after each runoff in Kharif and after 10, 20, 30, 60, 90, 120 days in rabi season after spray of herbicides and each irrigation of crop filed to see bioaccumulation and persistence of herbicides which reached to the adjoining pond through runoff and analyzed. Effect of herbicides on water quality was also evaluated in the respective days.

An amount of 0.074, 0.0014, and 0.0230 µg/g residues of oxyfluorfen, butachlor and anilofos were detected from fishes collected at 90 days in *kharif* season. Herbicides were persisted upto 90 days in the fishes. In *rabi* season 0.020, 0.0067, 0.0014 µg/g residues of respectively sulfosulfuron, clodinafop and metsulfuron were detected at 60 days in fishes.

In the soil samples 0.140, 0.667, 0.0142 µg/g residues of butachlor, anilofos and oxyfluorfen were detected after spray which dissipated with passage of time and after 90 days 0.0079, 0.0252, 0.0116 µg/g residue of butachlor, anilofos and oxyfluorfen were detected in soil.



Dissipation of herbicides in soil of rice field



Dissipation in pond water in *kharif* 2009

After first rain, 0.0161 µg/ml butachlor residues were found in the pond water which dissipated to 0.0070 µg/ml after 90 days of herbicide application. Herbicide dissipated slowly in water as compared to soil. Traces of sulfosulfuron, metsulfuron and clodinafop were detected from water in *rabi* 2009-10. TS, TDS, pH EC, was increased and there was little variation on DO after application of clodinafop, sulfosulfuron, metsulfuron, oxyfluorfen and anilofos. However, pH and DO decreased in butachlor contained ponds pond.

Herbicides residues in grains and straw persisted up to harvest stage of both paddy and wheat. At harvest 0.0033 and 0.077 µg/g residues of butachlor and oxyfluorfen were detected in paddy straw.

Table 36. Effect of sulfosulfuron on quality of pond water

Date	Temp°C	pH	EC	TDS	DO	BOD
11.12.09	20.8	7.5	0.30	320	8.1	1.5
21.12.09	19.1	7.0	0.33	327	8.3	1.6
31.12.09	21.5	6.8	0.31	310	8.0	1.8
11.1.10	20.8	6.3	0.32	340	8.4	1.9
11.2.10	20.6	7.4	0.31	350	8.5	1.7
11.3.10	21.7	7.7	0.33	339	8.6	1.5
11.4.10	25.3	8.2	0.38	410	7.7	1.4

Table 37. Effect of Clodinafop on quality of pond water

Date	Temp°C	pH	EC	TDS	DO	BOD
11.12.09	19.8	7.6	0.33	170	8.5	1.2
21.12.09	20.1	7.2	0.36	178	8.2	1.9
31.12.09	18.5	6.8	0.34	179	8.4	1.8
11.1.10	19.8	6.3	0.32	189	8.6	1.9
11.2.10	20.6	7.4	0.31	198	8.9	1.7
11.3.10	21.7	7.7	0.33	210	7.9	2.7
11.4.10	24.5	7.3	0.37	235	8.2	1.8

Table 38. Effect of Metsulfuron on quality of pond water

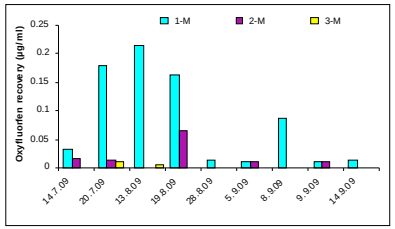
Date	Temp°C	pH	EC	TDS	DO	BOD
11.12.09	22.8	7.7	0.33	329	8.0	2.5
21.12.09	19.8	7.9	0.30	320	8.1	1.6
31.12.09	22.5	6.9	0.32	330	7.0	2.8
11.1.10	21.8	6.0	0.33	348	7.4	1.9
11.2.10	22.6	6.4	0.34	350	7.5	2.7
11.3.10	20.7	6.7	0.38	339	7.6	1.5
11.4.10	26.2	7.2	0.42	432	8.1	1.2

3.1.6: Evaluation of risk of ground water contamination by the continuous use of herbicides

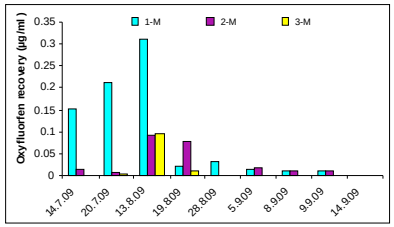
Shobha Sondhia and Jay G Varshney

Herbicide leaching through soil is particularly important due to environmental and agronomic problems. Leaching is considered as main cause of ground contamination by herbicides. As most of the herbicides are highly soluble in water and thus poses the risk of ground water under saturated moisture regime. Thus this experiment was conducted to see the mobility and leaching potential of herbicides under natural rainfall conditions in lysemeter made of cements of 1, 2, and 3 meters.

Oxyfluorfen was sprayed at 200 and 400g/ha dose to the lysimeter (Columns) of 1.0, 2.0 and 3.0 meters height under field condition and allowed to receive natural rainfall. Soil samples upto 0-25, 25-50, 50-75, 75-100, 100-125, 125-150, 150-175, 175-200, 200-225, 225-250, 250-275 cm depth and leachates were collected and analyzed by standardized HPLC method to see the movement of oxyfluorfen in soil and to predict possible risk of ground water contamination through herbicides. Residues of oxyfluorfen were detected from the 1.0, 2.0 and 3.0 meters height columns. Recovery of oxyfluorfen residues were higher in the leachates coming after 1 m column as compared to 2 and 3 meter column. Similarly residues were higher in surface soil in 1 m column as compared to 2 and 3 meter column.



Recovery of oxyfluorfen from 1, 2 and 3 metre lysemetres from T1 (200 g/ha)



Recovery of oxyfluorfen from 1, 2 and 3 metre lysemetres from T1 (400 g/ha)

3.2. Weed Management through herbicides

3.2.1: Enhancing herbicide use efficiency in wheat and direct seeded rice

3.2.1.1: Optimization of post emergence herbicides in wheat

Anil Dixit and Jay G. Varshney

The field experiment was carried out with ten treatments in randomized block design replicated thrice. The different doses of post emergence herbicides were evaluated to find out the effective dose of these herbicides for controlling wide range of weed flora in wheat. The experimental field was infested mainly with *A. ludoviciana, Medicago denticulata, Lathyrus aphaca, Physalis minima* and *Phalaris minor.* Results revealed that the density of all weed species and their dry matter production as well as yield of wheat crop were influenced due to application of all these herbicides at different doses. Isoproturon at 1000 g/ha failed to provide significant reduction in weed number and their biomass. On the other hand the dose of 1500 g/ha of isoproturon could control the weeds and found effective. The application of clodinafop at 60 g/ha could not control *Phalaris minor* though this herbicide was effective for controlling *Avena ludoviciana* at this dose but at higher dose of 75 g/ha *Phalaris minor* was controlled fully. Pinoxaden at 50 g/ha was quite effective for controlling grassy weeds in wheat and registered the higher yield of wheat crop which was at par with the application of sulfosulfuron.

Table 39. Effect of herbicide treatments on weed density, weed biomass and yield of wheat

Treatments	Dose rate (g a.i/ha)	Weed Count (No./m^2)	Weed dry Weight (g/m^2)	Yield (kg/ha)
Isoproturon	1000	6.4	25	2557
Isoproturon	1500	5.3	22	3385
Clodinafop	60	5.4	26	3547
Clodinafop	75	5.1	19	3741
Sulfosulfuron	25	5.6	21	3800
Sulfosulfuron	35	5.8	18	3922
Pinoxaden	50	5.1	13	3960
Pinoxaden	75	4.8	9	4024
Manual weeding (2)		-	4	4129
Weedy check		9.1	62	1323
LSD (P=0.05)		1.1	7	214

3.2.1.2 : Weed suppression through leafy vegetables in maize

Anil Dixit and Jay G. Varshney

Using a smother crop is thought to suppress weed density and to add other beneficial effects in sustainable agriculture systems. Weed suppression ought to be considered an essential component of integrated weed management. However, very little is known about the effects of leafy vegetables plants on weed suppression. The study comprised of four leafy vegetables viz. spinach, reddish, fenugreek and amaranthus as intercrop in maize crop. A field experiment was designed to determine the effect of the vegetable crop spinach, reddish, fenugreek and *Amaranthus* on the weeds *Medicago denticulate, Chenopodium album* and *Avena ludoviciana* in the inter rows area of winter maize crop. The weed species were suppressed differently by each vegetable crop *i.e*. leafy vegetables like spinach and *Amaranthus* reduced the weed infestation in between rows of winter maize and obtained the higher maize equivalent yield. Smother crops using vegetables crop when well established in an area, provide additional weed control to the cropping system and are effective and valuable tools in integrated weed management.

3.2.1.3 : Integrated weed management in potato

Anil Dixit

Potato, owing to its slow growth coupled with wider spacing and high fertilization, attracts weed infestation particularly at its initial stage of growth and compete with the crop resulting in 40-65% reduction of the tuber yield or even more depending upon the nature of infestation. The experiment was conducted to find out the performance of herbicides for the control of weeds in

potato. The treatments comprised metribuzin at 500g/ha, imazethapyr 100g/ha, ready mix of quizalofop or fenoxaprop+chlorimuron and glyphosate at lower dose of 500g/ha. In addition to herbicidal application 4 vegetables like fenugreek, Amaranthus, spinach and reddish were also included as intercrop. Among all the treatments, pre-emrgence application of metribuzin 500g/ha was found most effective in controlling *Chenopodium album, Medicago denticulate, Cichorium intybus* and *Physalis minima.*Application of imazthapyr on potato caused some phytotoxicity which later on recovered. Further application of chlorimuron+fenoxaprop or quizalofop did not cause any significant differences in respect to weed control and tuber yield . None of the treatments could surpass the results of metribuzin which was the only chemical effected an excellent control of weeds in potato.

Table 40. Effect of vegetable intercropping on weed density, weed biomass and yield of maize

Treatments	Weed Count (No./m^2)	Weed dry Weight (g/m^2)	Maize Equivalent (kg/ha)	Grain yield (kg/ha)	Vegetable yield (kg/ha)
Sole maize (Weedy)	8.5	131	3009	3034	-
Maize+Reddish(1:2)	7.5	87	2015	2413	30609
Maize+Reddish(1:3)	7.2	93	2625	2125	36811
Maize+ spinach (1:2)	6.5	86	21519	2529	22303
Maize+spinach (1:3)	5.7	51	29808	2108	32909
Maize+ fenugreek (1:2)	7.9	96	6703	2614	4611
Maize+fenugreek (1:3)	7.3	74	6815	2419	4319
Maize+Red Chaulai (Amaranthus sp.) 1:2	6.7	88	8800	2309	7625
--do------ 1:3	5.8	59	12030	2025	10430
Maize (2Hoeing)	5.4	56	3800	3613	-
Maize sole (2 HW)	6.1	48	4409	3309	-
LSD (P=0.05)	2.2	24	1900	1402	-

Table 41. Effect of Integrated weed management in potato

Treatments	Dose rate (g a.i/ha)	Time of application	Weed density (No./m2)	Weed biomass (g/m2)	Tuber yield (kg/ha)
Metribuzin	500	PE	3.9	47	20710
Imazethapyr	100	20DAS	9.9	150	7505
Chlorimuron+quizalofop	(6+50)	20DAS	9.3	151	8110
Fenoxaprop +chlorimuron	(100+6)	20DAS	9.6	144	8009
Glyphosate	500	20DAS	8.6	189	6925
Earthing up	-	30DAS	8.0	162	7333
Intercropping Fenugreek	-	-	7.6	138	8120
Intercropping Amaranthus	-	-	8.8	157	7709
Intercropping spinach	-	-	8.5	122	8325
Intercropping reddish	-	-	8.8	142	7713
Manual weeding (2)	-	-	4.5	65	21300
Weedy check	-	-	10.1	255	5655
LSD (P=0.05)	-	-	2.0	31	2700

3.2.1.4 : Weed management in summer vegetables

Anil Dixit

The field experiment was conducted with 12 treatments in randomized block design replicated thrice on summer vegetables.The major weed flora observed in the experimental field was *Medicago denticulate*, *Physalis minima, Dinebra* and others. The weed control treatments reduced the biomass of weeds significantly than weedy check. Among the herbicides, application of metribuzin at 500 g/ha or oxyfluorfen at 200 g/ha as a pre-emergence or post-emergence application of quizalofop coupled with one hand weeding reduced the total weed population and weed biomass significantly, than weedy check and other herbicidal application. However, alone application of either quizalofop or oxyfluorfen failed to provide any significant reduction in dry weight of weeds. This may be due to the fact that quizalofop controls only grassy weeds in summer cucurbits.

Table 42. Effect of treatments on summer cucurbits

Treatments	Dose (g/ha)	Bottle guard			Pumpkin		
		Weed density	Weed Biomass	Yield (kg/ha)	Weed density	Weed Biomass	Yield (kg/ha)
Butachlor	1000	6.0	126	16505	7.1	219	8600
Metribuzin	500	4.1	51	26510	5.5	100	25420
Quizalofop	50	5.1	107	20630	6.3	187	10415
Imazethapyr	100	4.8	78	19409	6.8	128	19119
Oxyfluorfen	200	4.4	64	26003	5.2	71	21023
Butachlor +1HW	1000	3.2	31	23313	5.3	34	18029
Metribuzin +1HW	500	2.8	28	28720	4.0	31	29530
Quizalofop +1 HW	50	2.5	25	27425	4.6	34	19824
Imazeth +1HW	100	2.7	30	26130	4.6	36	23519
Oxy+1HW	200	2.6	21	25929	4.3	26	30309
Manual weeding (2)		3.0	25	24613	4.6	33	29812
Weedy		7.3	182	14100	8.5	236	7302
LSD(P=0.05)		1.0	31	8601	1.3	26	3901

3.2.2.1: Bioefficacy of premix combination of carfentrazon-ethyl + sulfosulfuron against weeds in wheat

Anil Dixit and Jay G. Varshney

A field study was conducted including, treatments such as premix combination of carfentrazone-ethyl 20% + sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant at 36,45 and 56 g/ha with and with out surfactant along with premix combination of total and atlantice with 2 HW and weedy check were also included. The treatments were replicated thrice in randomized block design. All the herbicides were applied as a post-emergence herbicide at 33 DAS (days after sowing). The herbicides were applied in 500 liters of water per hectare using high volume knap sack sprayer with flat fan nozzle. The data noted for weed population was by quadrates (0.5 m X 0.5 m) method randomly at 45 DAS. The weed biomass was also recorded at 45 days after sowing (DAS). Grain yield of wheat was taken from plot of 22.5 m^2 and converted per hectare. The data on weed population is subjected to square root transformation.

Yield reduction due to weeds was recorded to the tune of 42 %. Grain yield differed significantly due to application of different treatments over weedy check. The grain yield obtained under carfentrazone-ethyl 20% + sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant at 45g/ha

+625 ml/ha was superior over other treatments of premix combinations at 36 and 45 g/ha and significantly increased the yield of wheat by 62% over weedy check due to lower weed competition.

Table 43. Effect of premix combination of carfentrazone + sulfosulfuron on weeds in wheat

Treatments	Dose rate (g a.i/ha)	Weed Count (No./m^2)	Weed dry Weight (g/m^2)	Yield (kg/ha)
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)	45 (20+25)	5.2 (26.6)	8	3329
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG(45% Premix) + Leader Surfactant	36 (16+ 20) +625	5.2 (26.9)	11	3324
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant	36 (16+ 20)+750	4.2 (16.9)	6	3423
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant	45 (20+25)+625	3.6 (13.1)	4	3657
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant	45 (20+25)+750	3.7 (13.1)	5	3635
Carfentrazone -ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant	54 (24+ 30)+625	3.1 (9.2)	5	3883
Carfentraz one-ethyl 20% + Sulfosulfuron 25%WDG (45% Premix)+ Leader Surfactant	54 (24+ 30)+750	2.4 (5.3)	3	3967
Carfentrazone ethyl 40%DF	20	5.5 (29.6)	7	3564
Sulfosulfuron 75%WDG (Leader) + Leader surfactant	25	5.9 (34.6)	14	3258
Total (Sulfosulfuron 75% + Metsu lfuron 5%WG) (normal recommended practice i.e., with surfactant provided with Total)	32	5.4 (28.4)	8	3844
Atlantis (Mesosulfuron -methyl 3% + Iodosulfuron-methyl-sodium 0.6%WG) (normal recommended practice i.e., with surfactant provided with Atlantis)	12 + 2.24	4.6 (17.6)	6	3851
Manual weeding (2)		2.9 (7.7)	5	3874
Untreated control		9.8 (95.5)	47	2257
LSD(P=0.05)		1.3	4	329

3.2.2.2: Effect of premix combination of MSM+ Carfentrazon in wheat

Anil Dixit and Jay G. Varshney

The field experiment was conducted with 13 treatments in randomized block design replicated trice. The premix combinations of metsulfuron methyl and carfentrazon ethyl were evaluated at four doses *i.e*. 17.5, 22.5, 25 and 30 g/ha with non ionic surfactant and with out surfactant. Application of metsulfuron methyl + carfentrazon ethyl with 0.2% non ionic surfactant reduced the weed density and weed biomass significantly to lower level as compared to the other combinations of their doses with and with out surfactant. Uncontrolled weeds on an average caused 31 % reduction in the wheat yield when compared with 2 hand weeding. Grain yield differed significantly due to application of different treatments over weedy check. Application of premix combination of metsulfuron+ carfentrazon at 22.5 g/ha with non ionic surfactant yielded more as compared to a lower level of this combination and at par with the dose of 25 and 30 g/ha.

Table 44. Effect of premix combination of MSM+ Carfentrazon in wheat

Treatments	Dose rate (g/ha)	Weed Count (No./m^2)	Weed dry Weight (g/m^2)	Yield (kg/ha)
MSM 10% + Carfentrazon 40% +0.2% NIS	17.5	4.4(19.2)	2	4025
MSM 10% + Carfentrazon 40% +0.2% NIS	22.5	4.3(18.1)	1	4374
MSM 10% + Carfentrazon 40% +0.2% NIS	25	4.3(17.7)	0	4411
MSM 10% + Carfentrazon 40% +0.2% NIS	30	3.3(10.4)	0	4414
MSM 10% + Carfentrazon 40%	17.5	5.1(25.2)	2	4073
MSM 10% + Carfentrazon 40%	22.5	4.7(21.6)	1	4235
MSM 10% + Carfentrazon 40%	25	4.5(19.7)	0	3967
MSM 10% + Carfentrazon 40%	30	3.8(13.8)	0	4122
MSM20%WDG + 0.2% NIS	25	5(19.3)	2	3965
Carfentrazon 40%	32	4.1(16.4)	2	4019
2,4-D	750	4.3(18.3)	5	3942
Manual weeding (2)		-	2	4427
Weedy check		9.5(89.1)	34	3087
LSD(P=0.05)		1.1	3	289

3.2.2.3: Bioefficacy and phytotoxicity of fenoxaprop-phethyl in direct seeded rice

Anil Dixit and Jay G. Varshney

Direct seeded rice is infested with heterogeneous group of weeds under rainfed shallow lowland, which reduces yield up to 40-80%. The problem of grassy weeds in direct seedec rice is more as compared to broad leaved weeds. The experimental filed infested with *Echinochloa colona* (40%), *Cyperus iria* (53%), *Ammania baccifera, Caesulia auxillaris and Phyllanthus niruri.* The weed population in the weedy check was significantly higher than the all other herbicide treated plots. The dry matter content recorded in cyhalofop treated plots was significantly higher than the plots treated with fenoxaprop-p-ethyl 6.9 % EC at various dosage levels. The yield obtained from all treatments with fenoxaprop-p-ethyl 6.9% EC was superior to weedy check as well as in the treatment with cyhalofop-butyl. The yield was lower than hand weeding since fenoxaprop being a graminicide has mainly controlled grasses as expected.

Table 45. Effect of treatments of Rice star (Fenoxaprop 6.9% EC) in DSR rice on weed count and weed dry weight at 60DAS and yield of rice.

Treatments	**Rate of application (g/ha)**	**Weed count (No./m^2)**	**Weed dry weight (g/m^2)**	**Yield (kg/ha)**
Rice star 6.9%EC	47.44	8.6	83	1192
Rice star6.9%EC	51.75	7.8	43	1218
Rice star6.9%EC	56.06	7.3	47	1445
Rice star6.9%EC	60.38	7.3	39	1755
Cyhalofop 10 EC(Clincher)	62.50	8.4	112	1422
Manual weeding (2)	-	0.7	-	2799
Weedy check		12.1	240	177
LSD (P=0.05)		1.2	29	275

Weed count values are subjected to square root transformation

3.2.2.4: Evaluation of penoxsulum in direct seeded rice

Anil Dixit and Jay G. Varshney

A number of herbicides like butachlor, pretilachlor, anilofos etc. have been recommended as pre-emergence for the control of early flushes of weeds in rice. These herbicides thogh efficient but may not control all the weeds. Therefore, new herbicides are continuously needed for solving emerging new weed problems. The treatments comprised of penoxsulum at three doses i.e. 20, 22.5 and 25 g/ha was compared with pyrazosulfuron at 25g/ha and pretilachlor 600g/ha as pre-emergence along with manud weedly and weedy check. The experimental field was infested with *Cyperus iria, Caesulia auxillaris, Echinochloa colona, Alternanthera sessilis* and *Dinebra retroflexa.* The application of penoxsulum at all the doses reduced the weed density and weed biomass to a significantly lower level when compared with weedy check. Penoxsulum at 22.5 g/ha applied at 20 DAS reduced the weed density and biomass to a lower level compared with all other treatments, which was at par with peoxsulum at 25 g/ha and pyrazosulfuron 25 g/ha. Application of peoxsulum at 22.5 g/ha also obtained the highest yield among the herbicidal treatments and was on par with pyrazosulfuron.

Table 46. Effect of treatments of penoxsulum in DSR rice on weed count and weed dry weight at 60DAS and yield .

Treatments	Rate of application (g/ha)	Weed count (No./m^2)	Weed dry weight (g/m^2)	Yield (kg/ha)
Penoxsulum	20	9.6	151	966
Penoxsulum	22.5	8.0	119	1066
Penoxsulum	25	7.2	118	1200
Pyrazosulfuron	25	8.5	124	1047
Pretilachlor	600	8.1	160	815
Weed free (2hw)	-	0.7	-	2660
Weedy		15.4	309	177
LSD (P=0.05)		1.2	31	258

Weed count values are subjected to square root transformation

3.2.4 : Impact of soil physical environment on pre-emergence herbicides

3.2.4.1 : Effect of temperature on efficacy of pretilachlor

A micro plot experiment was conducted in containment facility to study the effect of aerial temperature on the efficacy of pretilachlor. The containment temperatures were maintained at 28, 33 and 38°C during day time. Night temperature was maintained at 20°C uniformly irrespective of the day temperature. One g of *Echinocloa colona* seed was broadcasted in the the microplot of $2m^2$ size and mixed well with the soil. Pretilachlor was applied at 0, 0.75, 1.0 and 1.25 kg/ha after 3 days of sowing of *E. colona*. Count of *E. colona* population was recorded at 20 DAS. It was observed that in absence of pretilachlor application the germination of *E. colona* increased sharply as temperature increased from 28°C to 38°C. The germination also increased with temperature in herbicide treated plots but at a much slower rate as compared to control plots. In general, weed control efficiency of pretilachlor increased with increase in temperature from 28°C to 38°C. However, the temperature effect was significant at its lower dose of 0.75 kg/ha. Similarly, weed control efficiency increased as the pretilachlor dose was increased from 0.75 to 1.25 kg/ha at 28 and 33°C temperatures. However, the effect of pretilachlor dose was not significant at 38°C in terms of weed control efficiency.

Table 47. Weed control efficiency (%) of pretilachlor at different aerial temperatures.

Pretilachlor	28°C	33°C	38°C	Mean
0.75	58.5	69.2	76	67.9
1.00	80	86.7	83.7	83.5
1.25	77.5	87.5	86.0	83.7
Mean	72.0	81.2	81.9	
LSD (P=0.05)	Temp: 8.6;	H: 7.1;	Temp X H : 12.2 & 12.6	

3.2.6: Establishment of techniques and protocol for the investigation on the role of leaf surface in the phototransformation of herbicides

PP Choudhuray

The photochemical reaction on the leaf surface may result in the reduction of the bioefficacy of herbicides. There is no standard method available to study the effect of leaf surface on the photolysis of herbicides. To establish a standard technique the photolytic study is being carried out on epicuticular waxes of leaf of different weeds and crop plants.

The process of extraction of epicuticular waxes from rice, wheat, *Echinocloa colona* and *Phalaris minor* and *Avena luduiviciana* has been standardized. Chloroform and dichloromethane were found to be the most suitable solvents for the extrtaction of epicuticular wax.

The rate kinetic studies on the photolysis of 2,4-D and isoproturon on the extracted wax were carried out under UV light. Rate kinetic studies on different soil surfaces were also carried out in order to compare the pattern of degradation of these two herbicides on different surfaces. The samples of 2,4-D were analyzed by GLC method. The cutin of rice slowed down the degradation process of 2,4-D by quenching the photolysis and consequently it substantially increased the half-life as compare to standard glass surface. Similar increase in half-life was noticed in black-cotton and alluvial soils. However, no such effect was found in case of Echinocloa cutin and red soil.

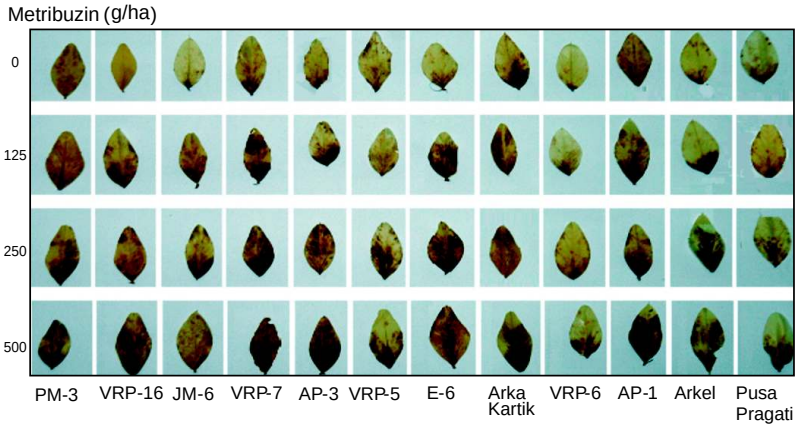
Table 48. Photolysis of 2,4-D under UV light Rate kinetic study

Surface	Rate kinetic equation	Half-life (minute)
Glass	Y= 1.90 – 0.71 X	25
Rice cutin	Y= 1.97 – 0.003 X	106
Echinocloa	Y= 1.98 – 0.01 X	30
Red soil	Y= 2.04 – 0.44 X	40
Black cotton Soil	Y= 2.01 – 0.18 X	100
Alluvial soil	Y= 2.00 – 0.11 X	164

3.2.8- Studies on metribuzin toxicity in pulses

Bhumesh Kumar

A study was conducted in field with 12 varieties of pea and 2 varieties of chickpea. Metribuzin at 0, 125, 250 and 500 g/ha was applied at 24 DAS. Observations on toxicity syndrome in the crops were recorded after 24 and 168 h of metribuzin application. Metribuzin proved extremely toxic to chickpea and plants could not survive even at the lowest dose (125 g/ha). Different varieties of pea used in this study showed wide difference in toxicity to metribuzin. Differential behavior of varieties in terms of accumulation of ROS (H_2O_2) was observed at 168 h indicating that ROS accumulation could be a good indicator for screening of varieties for metribuzin toxicity.



Effect of metribuzin on H_2O_2 accumulation in different varieties of pea

Exploratory trial on effect of controlled release formulation of butachlor on weed infestation in rice

KK Barman and Jay G Varshney

The controlled release formulations of butachlor were prepared using neem cake, mustard cake, bark dust, POP and starch as the carrier matrices. The prepared formulations were tested in field condition under direct seeded rice (JR-201) during 2009 *Kharif*. Butachlor was applied at 2 kg/ha dose through the prepared formulations as well as through its commercially available EC formulation for comparison. One treatment with no herbicide application was kept as control. Species wise weed counts and total weed dry matter were recorded at 40 DAS using a 0.5mX0.5m quadrate. The field was mainly infested with *Echinochloa colona*. As compared to control (weedy), all the herbicide treatments significantly decreased *E. colona* and total weed count, as well as total weed dry matter at 40 DAS. There was no significant difference among the herbicide treatments in terms of *E. colona* as well as total weed population. However, significant variation was there among the herbicide treatments in terms of total weed dry matter. The total weed dry matter was lowest in the starch encapsulated butachlor treatment and it was statistically similar to the treatments consisting of butachlor application through neem cake, mustard cake and bark dust. Total weed dry matter at 40 DAS in the butachlor EC treatment was significantly lower as compared to control, but significantly higher as compared to starch encapsulated butachlor treatment. Total *E. colona* dry matter was collected from the whole plots at 90 DAS. The result thus indicated that the persistence and efficacy of butachlor was increased in soil when applied through starch encapsulated formulation than when applied through EC formulation.

Table 49. Effect of controlled release formulations of butachlor on weed count and weed dry matter production in rice.

Treatments	Weed count (No./m^2)		Weed dry matter (g/m^2)	
	E. colona (40 DAS)	Total (40 DAS)	Total (40 DAS)	*E. colona* (90 DAS)
Weedy check	9.1	9.9	0.9	19.6
Butachlor EC 50%	6.9	7.4	0.8	15.7
Starch encapsulation 5%	6.9	7.0	0.8	12.9
Neem cake 2%	6.8	7.3	0.8	14.5
Mustard cake 2%	6.6	7.4	0.8	13.7
Bark dust (Kasai) 2%	6.5	7.0	0.8	14.7
POP 2% a.i.	6.5	6.8	0.8	16.8
LSD (P=0.05)	1.9	1.9	< 0.1	2.4

4. BIO-PESTICIDES AND BIOCONTROL OF WEEDS

4.1 : Survey, identification and impact evaluation of new and existing insect/plant pathogen bio-agents for biological control of important weeds in India

4.1.1: Activity enhancement of *Neochetina* species after inoculative release for early biological control of water hyacinth

Sushilkumar

Neochetina is effective but it takes long time depending upon the water hyacinth infestation and stage in a water body. Attempt was made to enhance the activity of bioagent through various other methods like augmentation of population at the time of low population structure or spraying of leaf, petiole extract.

Neochetina spp. bioagent used for augmentation

In one treatment, only augmentation of *Neochetina* adult after two, four, six and 12 month at 5 pair/sq metre after initial release of 10 pair/sqm was done. In another treatment, augmentation + spray of extract of newly folded leaves of water hyacinth was done. In control, only initial release of weevils was carried out. The experiment was done in four treatments. After initial inoculation observations of population and damage was taken at monthly interval.

Destructive population sampling of grubs and adults from 10 plants from each tank every month after three months of initial release revealed population increase. Population of grub and adults during different months in augmented tanks. After augmentation of weevils, there were increase in feeding scars on leaves and petioles indicating enhancement in population. In tanks where augmentation of weevils was done, increase damage and subsequently early collapse of water hyacinth was noticed.

Increase in population of weevils was corresponding to augmentation after 3 & 6 months of initial release. Flower production reduced in all the treatments after initial release of weevils. In augmented tanks after six months, flower production was nil.

Flower production stopped after inoculation of weevils.

4.1.2 : Evaluation of bioagents for biological control of problem weeds

4.1.2.1 : Mass rearing and supply of *Z. bicolorata* to different ACRIP centres, KVKs,NGOs, municipalities etc and its monitoring at released sites for its establishment and spread and impact

Sushilkumar

Zygogramma bicolorata were mass reared at Jabalpur during early June and supplied to centres where beetles have not established so far. In 2009-10, about 0.40 lakh beetles were distributed to various DWSRC, KVKs, farmers, NGOs etc. So far, DWSR has distributed 5.80 lakh beetles free of cost to KVKs, AICRP-WC, NGOs, municipalities, farmers, defense organizations etc.

There are good sign of establishment of this bio-agent at released sites in east and west U.P., lower Uttranchal, H.P., M.P., A.P., Punjab, Delhi, Haryana, Maharastra, Orissa, Bihar, Jharkhand and in some pockets in Rajasthan. It could not establish in Gwalior in spite of release since 2001 and in Jorhat (north-east) inspite of release since 2003. About 50 thousands beetles were augmented at 15 different sites in and around Jabalpur. This will help to increase the beetle population after monsoon

Activity-1: Release and monitoring of *Zygogramma bicolorata* in Nagpur region

Under a consultancy project given by Maharashtra Agricultural Department, Nagpur region, about 21 lakh beetles were released at various regions under sub-divisional Agricultural offices. The beetles were released at Saoner, Ramtek, Umrer, Nagpur and Katol regions. After release, monitoring was done in the month of September and October 2009. There was recovery of *Z. bicolorata* in the form of eggs and larvae indicating the process of establishment in the area.

Activity - 2 : Technology developed to keep young beetles at low temperature for longer duration

Freshly emerged '0' to '7' day beetles were collected from field and were kept at low temperature for observing survival and egg laying potential. Leaf bouquet was changed once in 10 days only. Beetles could be kept for 9 months. There was 48 % survival of beetles from initial collection. On Initiation of rearing at normal room temperature, survived female laid 600 to 1455 eggs/ female.

4.1.2.3 : Biology, host specificity and damage potential of bio-agents on *Trianthema portulacastrum*

The host specificity of *Hymenia recurvalis was rechecked. D*evelopmental studies were carried out on different hosts. It was confirmed that insect has oligophgous nature having narrow host range. Out of 26 weed species, it was having preference for three species only and among agricultural crops, it completed its life cycle on two important crops like jowar and totmato. It was concluded that although it has good damage potential in T. *portulacastrum* but it can not be recommended as bioagent for biological control of ore-purslane.

Moth and larva of *Hymenia recurvalis*

Table 50. Feeding preference of *H. recurvalis* on some weeds and crop plants.

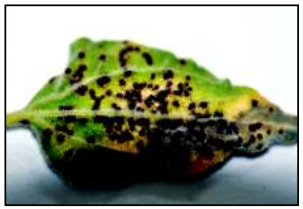
COMMON NAME	BOTANICAL NAME	FEEDING PREFERENCE
Alligator weed	*Alternanthera philoxeroides*	+++
Horse -purslane	*Trianthema po rtulacastrum*	+++
Jowar	*Sorghum*	+++
Tomato	*Lycopersicum esculentum* Mill.	+++
Amaranth (chaulai)	*Amaranthus* spp	+++

4.1.4 : Biological control of *Lagascea mollis* using rust fungi

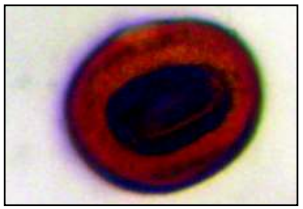
C. Kannan

4.1.4.1 : Studies on the rust disease of *Lagascea mollis*

The rust fungi on *Lagascea* mollis has been identified as *Puccinia noccae* Arthur 1905. (IMI number-398189). This is the first report of *P. noccae* occurring on *L. mollis* in India. *P. noccae* was first identified in central Mexico on *Lagasca* (Noccae).



Rust infection in *L. mollis* caused by *P. noccae*



Uredospore of *P. noccae*

4.2 : Herbicidal properties of plant constituents

4.2.1: Bio-herbicidal potential of allelochemicals from Lantana, neem and tropical soda apple

D.K. Pandey

4.2.1.1: Bio-herbicidal potential of allelochemicals from tropical soda apple (*Solanum viarum* Dunal) fruit pulp on aquatic weeds

The tropical soda apple fruits were harvested from the stands of the weed from around Jabalpur, washed, seeds removed and the fruit pulp dried in the shade, ground to about 80 mesh and stored in airtight containers until used. The fruit pulp powder was suspended in water at 1% (w/v) with intermittent stirring at ambient temperature 20-26°C for 24 hours. Subsequently, the solution was removed and spread over thin surface and dried at the ambient temperature. This was designated as allelochemical crude.

The allelochemical crude was suspended in water in triplicate at 0.01, 0.025, 0.05, 0.1, 0.25, 0.50, 0.75 and 1.0% (w/v). Water alone served as the control. Preweighed floating weeds viz., water hyacinth (*Eichhornia crassipes* Mart Solmns.), pistia (*Pistia stratiotes* L.), spirodella (*Spirodella polyrhiza* L.), lemna (*Lemna pausicostata* Hegelm.) and azolla (*Azolla nilotica* Decne) and submerged weeds viz., hydrilla (*Hydrilla verticillata* L. f. Royle), ceratophylum (*Ceratophyllum demersum* L.), potamogeton (*Potamogeton crispus* L.) and green musk chara (*Chara zeylanica* Willd.) were loaded into the suspensions and incubated outdoors. Evapotranspiratory loss of water was replenished twice daily. The toxicity symptoms were monitored and biomass was recorded 5, 10 and 15 days after initiation of the treatments.

The results revealed that the allelochemical crude was inhibitory to water hyacinth at 0.5-0.75% and lethal at 1%. The allelochemical crude inhibited pistia at 0.25-1.0% and was not killed even at the highest concentration. The spirodella was inhibited at 0.5-1% and not killed up to 1%. The azolla was killed at and above 0.5%. The submerged weeds hydrilla, ceratophylum, potamogeton and green musk chara were killed at and above 0.5%. The allelochemical crude appears to be much more phytotoxic to the submerged weeds than to floating weeds. The toxicity symptoms on floating weeds were dull green appearance, progressive desiccation and necrosis from the margins starting from old leaves or fronds, and flaccid roots leading to death and decay of the plants in 5-15 days. The toxicity symptoms in submerged weeds were dull green appearance, loss of turgidity, bleaching and fragmentation followed by death and decay of the treated plants.

The allelochemical crude showed bioherbicidal potential to aquatic weeds, more so to the submerged weeds. The present investigation strongly supports necessity of further investigations on isolation of the active constituents and evaluation for use as a natural herbicide for aquatic ecosystems and / or taking a lead for development of new safer herbicides for the aquatic ecosystems.

Out of the 13 fractions obtained with different solvents over a range of polarity, methanol fraction was lethal to water lettuce and coontail, while it did not inhibit germination and early seedling growth of rice, wheat, little seed canary grass and *Echinochloa colona*.

Table 51. Effect of tropical soda apple *(Solanum viarum Dunal)* seed allelochemical constituents solubilized by methanol on water lettuce *(Pistia stratiotes L.)*

Concentration (ppm)	Change in biomass (%) over initial value		
	5 DAT	10 DAT	15 DAT
Control (water)	3.4 ± 1.9	7.7 ± 5.7	15.5 ± 6.0
Control with 0.25 % ethanol	16.6 ± 3.8	22.3 ± 6.6	25.2 ± 7.9
10	3.8 ± 5.7	-2.3 ± 14.4	2.1 ± 7.4
25	-43.0 ± 3.5	-54.2 ± 3.6	-76.17 ± 2.5
50	-2.0 ± 3.5	0 ± 0	0 ± 0
75	-0.7 ± 1.3	0 ± 0	0 ± 0
100	1.9 ± 3.3	0 ± 0	0 ± 0

The values are means of 3 replications±SD. Hundred % loss of biomass signified death of the treated plants.

Table 52. Effect of tropical soda apple (*Solanum viarum* Dunal) seed allelochemical constituents solubilized by methanol on coontail (*Ceratophyllum demersum L.*)

Concentration (ppm)	Change in biomass (%) over initial value		
	5 DAT	10 DAT	15 DAT
Control (water)	10.8 ± 5.8	16.0 ± 4.5	20.7 ± 6.5
Control with 0.25 % ethanol	7.9 ± 5.7	13.2 ± 8.5	19.6 ± 12.0
10	4.9 ± 3.2	14.7 ± 3.7	-15.2 ± 2.3
25	-11.1 ± 2.0	-9.9 ± 3.9	-8.2 ± 1.2
50	-10.0 ± 7.2	0.8 ± 1.5	0 ± 0
75	-6.1 ± 5.3	0 ± 0	0 ± 0
100	-1.4 ± 2.5	-2.2 ± 3.9	0 ± 0

The values are means of 3 replications ± SD. Hundred % loss of biomass signified death of the treated plants.

The alkaloid fraction of tropical soda apple seed allelochemicals isolated by the scheme of Harborne (1998) was lethal to coontail at 25 ppm.

4.2.1.2: Bioherbicidal potential of ethyl acetate fraction of neem leaf allelochemical crude

The ethyl acetate fraction of neem leaf allelochemical crude was lethal at 50 ppm to coontail and water lettuce. The coontail plants had dull green appearance, flaccid texture, fragmentation and death and decay following exposure to the lethal level. The water lettuce had dull green appearance, desiccation of above water plant parts, flaccid roots and death and decay following exposure to the lethal level.

4.2.1.3 : Bioherbicidal potential of methanol soluble allelochemical fraction obtained from allelochemical crude of lantana seed

The methanol soluble fraction was lethal to the submerged weed coontail at 100 ppm.

4.2.1.4: Bioherbicidal potential of mugwort leaf constituents

One of the fractions of constituents of the mugwort leaf was lethal to little seed canary grass seed germination and seedling growth at 100 ppm but was not at all toxic to wheat. This is being further investigated. The selective compound is being isolated. Preliminary investigations revealed that the active constituents appears to be phenolics in nature, as terpenoid and alkaloid fractions did not show bioherbicidal activity individually at 100 ppm, while phenolics fraction was lethal to coontail and was inhibitory to little seed canary grass seed germination at 75-100 ppm. The phenolics fractions had two components. These are being isolated for further studies.

4.2.4: Biological management of *Eichhornia crassipes* (Water hyacinth) using potential aquatic fungal pathogens

C. Kannan and P.P. Choudhuray

Fusarium sp was isolated from water hyacinth and tested for its pathogenicity. The pathogen was able to infect the host and completely kill the plant within a period of 10 days. The underwater parts like roots stem and bulbs were completely rotten by the pathogen infection.

***Fusarium* sp infection in water hyacinth**

4.2.5: Activation of systemic resistance in chickpea and onion against *Cuscuta campestris*

C. Kannan and Bhumesh Kumar

Two PGPR microbes *viz., Pseudomonas fluorescens* and *Trichoderma viride* were isolated from the native rhizosphere of chickpea. The effect of the microbes in inducing systemic resistance against *Cuscuta* demonstrated under controlled conditions. Accordingly the microbes were applied as seed treatment and foliar application at 20 days and 45 days of sowing. The results showed that the microbe treated plants had the ability to suppress the haustorial infection from the parasite. The number of haustorial attachments was significantly less in the microbe treated plants leading to the increased life of the host plants.

***Cuscuta* infection in chickpea showing the haustorial attachments**

4.2.3: Isolation and identification of root exudates of linseed and marigold and their growth inhibitory effect on few weeds

Shobha Sondhia and Jay G. Varshney

Experiments were conducted to isolate and identify root exudates from marigold and linseed plants. Root exudates of **linseed** were collected at every 4-5 days interval upto four months. Leachates were filtered and concentrated to approximately 500 ml. Concentrated extract was then separated and purified as already standardized method. With methanol, it gave precipitates in viscous form, which then filtered under vacuum, concentrated and purified.

4.2.3.1: Extraction, isolation and identification of marigold and linseed phyto-chemicals

Allelochemicals were isolated through solvent portioning method involving organic solvent of increasing polarity of various solvent. Finally, pure allelochemicals were isolated from linseed and marigold in methanol, which were evaporated, and allelochemicals were obtained in viscous powder form. Three compounds were isolated from methanol fraction of marigold and resolved on TLC as three distinct spots were identified on silical gel G coated plates of 0.2 mm thickness. Two compounds were isolated from methanol fraction of linseed and resolved on TLC as two distinct spots at Rf of 0.64 and 0.35. Identification of various components of marigold and linseed by TLC.

Table 53. Identification of various component of marigold and linseed by TLC

Crystals dissolved in Solvent	Marigold (Rf)	Linseed (Rf)
Methanol	0.36	0.64
	0.42	0.35
	0.82	
Aqueous	0.80	0.82

Pure aqueous leachates after separation and cleanup yielded one compound which was resolved as single spot in TLC at Rf of 0.82. These isolated compounds were further purified and identified by HPLC using PDA detector at 205 nm. In ethyl acetate, fraction two peaks were identified at RT of 2.6 and 4.5. Pure compounds obtained from different fractions were further identified as single peak by HPLC using RF detector. Distinct peaks were observed at RT of 10.92 (14.8 %) from aqueous fraction, RT of 7.6 (41.5%) from PE fraction, RT of 18.13 (45.3 %) from chloroform fraction, RT of 19.23 (21.9 %) from n-hexane fraction and RT of 13.89(14.8 %) from methanol fraction of linseed. Identification of various compounds of marigold and linseed by HPLC using RF detector.

Table 54. Identification of various compounds of linseed by HPLC

Different fractions	Linseed		Magigold	
	% Purity	RT	% Purity	RT
Aqueous	14.8	10.9	26.0	14.0
PE	41.5	7.6	20.6	27.2
Chloroform	45.3	18.3	27.3	18.3
n-Hexane	21.9	19.2	52.6	17.9
Methanol	14.8	13.9	53.5	20.2

5. WEED UTILIZATION

5.1 : Soil Physical and Chemical amelioration

5.2.1 : Vermi-composting of *Echinochloa*, *Parthenium* and water hyacinth

5.2.1.1: Preparation of vermi-compost from various weed species and evaluation of their nutrient status and seed viability

Sushilkumar and P.J. Khankhane

A lot of weed biomass uprooted from various crops in agricultural farms is thrown away which may be efficiently utilized in vermi-compost making. These weed species may be assessed for making vermicompost alone or in combinations with other agriculture waste like straw of various crops like wheat, paddy, soybean, maize etc. from commercially available earthworm species. Likewise, nutrient composition and effect of vermicompost on yield of crops/orchards may vary weed species to species. Information is not available on viability of weed seeds in the vermicomost.

Weed biomass of *Parthenium* and *Echinochloa colona during Kharif and Medicago hispida during rabi was collected from farm area.* Weed biomass was mixed with cow dung in 25 : 75 ratio. On half decomposed material, earthworm's species *Eisenia fetida* was released at the rate of 6 kg in 70:30 ratios of earthworms and compost in an area of 3x7 feet surface area. Earthworm population was found established in all the treatments. There was increase in population of earthworm in all the treatments but more in cow dung followed by *Parthenium hysterophorus,* wheat straw *and Echinocloa colona*. Good quality vermicompost was also obtained from these treatments.

Table 55. Mean of earthworm population/15cm2 area after two months of initial inoculation of 9.45/15 cm^2

Type of material	No. of Cocoons	No. of Juvenile	No. of adults
Cow dung	63. 7	99. 7	29.3
Echinochloa colona	17.0	24.0	8.3
Parthenium hysterophorus	73.0	91.0	19.3
Wheat straw	27.0	28.0	29.0

*Cocoons sample from upper 5 cm layer **Earth worm sample from 30 cm deep

View of vermicompost unit, preparation of vermi-compost beds and Initial inoculation of earthworms in pits

6. TRANSFER OF TECHNOLOGY

6.1 : Demonstration, training, awareness of proven technologies

6.1.1: Evaluation of improved weed control technologies on farmers' fields

P.K. Singh

Technology Transfer is equally important as that of technology development for sustenance of agriculture. The yield of crops is low and the wide gap in adoption of weed management technologies by the growers is one of the major constraints. Keeping in view the importance of weed management DWSR is regularly carrying out various extension activities throughout the year with a view to popularize and show the performance and profitability of proven weed management technologies among farming community in order to make them aware and adopt these for enhanced crop productivity.

Demonstrations

Several demonstrations of proven weed management technologies were laid out at farmers field during *Kharif* 2009 and *Rabi* season 2009 - 10.

Table 56. Number of field demonstrations in cropped and non-cropped situations

Season/Crop	Number
Kharif 2009	
Rice (Direct seeded rice)	25
Soybean	10
Maize	05
Rabi 2009-10	
Wheat	22
Mustard	05
Chickpea	10
Zero tillage	10

Rice

Echinachloa colona (Sawa) was a major weed problem of rice. Pre-emergence herbicides viz., butachlor / Anilophos are in use for its control but not very effective. Fenoxaprop followed by Chlorimuron + Metsulfuron was used at larger scale for demonstrations on farmers' fields. The dominant weed flora were *Echinochloa colona, Commelina, Cyperus spp., Corchorus sp., Eclipta, Alternanthra Ceasulia axillaries* and other broadleaved and grassy weeds. Results revealed that fenoxaprop 60 g/h at 30 DAS effectively controlled *Echinachloa colona* in comparison to other herbicide. Application of chlorimuron + metsulfuron (4 g/ha) one week after fenoxaprop resulted in broad-spectrum weed control and higher grain yield. Maximum benefit was recorded in Fenoxaprop-p-butyl at 60 g/ha + fallowed by clorimuron ethyl and metsulfuron methyl at 4.0 g/ha (PO). It may be concluded that in the *Echinachloa colona* dominated areas fenoxaprop alone may be used. When there is problem of broad leaf weed along with *Echinachloa colona*, chlorimuron + metsulfuron may be applied one week after fenoxaprop. The farmers are fully satisfied with the performance of the herbicides.

Table 57. Field demonstration on weed management technology in Rice

No. of Demo	Treatments	WCE (%)	Grain yield (kg/ha)		% Increase in yield over farmer practice	Cost of treatment (Rs./ha)	Economic Benefit (Rs./ha)
			FP	Treated			
7	Fenoxaprop-p-butyl @60 g/ha (PO)	45	2935	3765	28	1000	7285
7	Pretalachlor @ 750 g/ha (PE)	50	3208	3884	21	600	6097
11	Fenoxaprop-p-butyl @60 g/ha (PO) + fallowed Clorimuron ethyl and metsulfuron methyl @ 4.0 g/ha (PO)	57	3011	3971	32	1325	7795

FP Farmer practice (Hand weeding once at 35 DAS)

It was further studied in Mahagawa and Tagar villages of Jabalpur district to assess the impact of the use of herbicides on yield and attitude of rice growers towards integrated weed management in the area, during *Kharif* 2009. The study has observed that most of the farmers followed a cropping system of rice followed by wheat. Weed control in rice is a highly cumbersome operation as it, Involves more labour (both man and woman) and capital intensive. The cost of chemical weed management was Rs. 800-1500/ hectare while the hand weeding method required Rs. 2500/ha. It has reiterated the need for chemical method of weed control. The difference in income realization between the adopters and non-adopters of IWM was also studied and the results of the study revealed that adopters of integrated weed management has obtained an increased crop yield of 7.5 8 q/ha and Rs. 7500-8000/ha as difference in income that the non-adopters. It clearly indicated the importance of IWM in controlling the weeds of rice. Among the various sources of technical information, the private input dealers were the primary sources. The major factor that come in the way of farmers adopting the IWM was the technical reason (55%) which was followed by expenditure (25%) to be incurred for the purchase of modern inputs. Results revealed that adoption of integrated weed management practices has increased the yield of rice and thereby increasing the farm income of farmers cultivating rice. This was proved by the simple economic analysis which has revealed a positive change in the income level of the farmers due to the adoption of chemical means of controlling the weeds.

Soybean

Ten field demonstrations were conducted in soybean. The fields were infested with mixed weed flora viz., *Echinochloa colona, Commelina communis, Dinebra retroflexa, Digera arvenisis, Cyperus spp., Parthenium hysterophorus.* Clorimuron ethyl+ fenoxaprop-p-butyl, imazethapyr were applied at 20 DAS. Results revealed that application of clorimuron ethyl + fenoxaprop-p-butyl gave broad spectrum weed control and higher benefit.

Table 58. Field demonstration on weed management technology in soybean crop

No of Demo	Treatments	Weed Count / m²		WCE %	Grain yield kg/ha		Increase in yield over FP (%)	Cost of Treat (Rs. /ha)	Benefit due to treatment (Rs./ha)
		FP	Treated		FP	Treated			
5	Clorimuron ethyl @ 10 g/ha + Fenoxaprop-p-butyl @ 100 g/ha (PO)	115	58	68	1148	1667	45	1650	7636
5	Imazethapyr @ 100 g/ha (PO)	112	71	57	1135	1574	38	1600	6248

FP Farmer practice (Hand weeding once at 25 DAS)

Maize

Five field demonstrations on weed management technology in Maize crop were conducted. The fields were infested with mixed weed flora *Echinochloa colona,Commelina communis, Alternenthara sessilis, Dinebra retrotlexa Cyperus spp, Euphorbia geneculata.* Treatments consisted of atrazine 1 kg/ha, atrazine + 1 HW at 45 DAS and one hoeing at 30 DAS. Results revealed that application of atrazine + 1 H.W. was more effective than others and gave the maximum benefit of Rs. 8000/-ha.

Table 59. Field demonstration on weed management technology in Maize

No of Demo	Treatments	Weed Count / m²		WCE%	Grain yield kg/ha		Increase in yield over FP (%)	Cost of Treat. (Rs. /ha)	Benefit due to treatment (Rs./ha)
		FP	Treated		FP	Treated			
2	Atrazine @ 1.0 kg/ha PE	120	80	33	3100	3600	17	772	6000
2	Atrazine @ 1.0 kg/ha (PE) + 1 H. W. at 45 DAS	115	25	76	3050	4150	39	2300	8000
1	Hoeing at 30 DAS	125	90	32	2900	3200	08	800	4200

FP Farmer practice (Hand weeding once at 25-30 DAS)

Wheat

Twenty two field demonstrations on weed management technology in wheat crop were laid out on farmers' fields in five (5) locations of Jabalpur. The major weeds of the area were *Lathyrus sativa, Vicia sativa, Melilotus alba, Chenopodium album, Avena sp.* (Wild oat), *Medicago hispida, Phalaris minor.* Treatments consisted of sulfosulfuron at 25 g/ha (PO), clodinofop at 60 g/ha + Metsulfuron 4 g/ha (PO), 2,4-D + IPU at 750+750 g/ha, 2,4-D alone 750 g/ha. Herbicides were applied according to the nature of weed flora of the location. All the treatments effectively controlled the weeds (WCE over 50%) and increased the yield of wheat (33-48%) as compared to FP. Mixture of 2,4-D + IPU effectively controlled mixed weed flora except *Wild oat*. Whereas Clodinafop + Metsulfuron effectively controlled mixed weed flora including Wild oat and *P. minor.* Maximum benefit due to treatment was obtained from Clodinofop + Metsulfuron followed by 2,4-D + IPU

Impact of herbicides on weed infestation in wheat

Table 60. Field demonstration on chemical weed control in wheat

No. of Demo	Treatments	WCE (%)	Grain yield (kg/ha)		Increase in yield over FP (%)	Cost of treatment (Rs./ha)	Economic Benefit (Rs./ha)
			FP	Treated			
6	Sulfosulfuron 25 g/ha (PO)	55	2771	3682	33	2488	7100
8	Clodinofop 60 g/ha + metsulfuron methyl 4 g/ha (PO)	62	2468	3671	48	3205	9427
8	2,4-D + IPU 500+500 g/ha (PO)	69	2380	3250	37	1000	8500

FP Farmer practice (No weeding operation)

Chickpea

Ten field demonstrations on weed management technology in chickpea were conducted. Demonstration site was infested mainly with *Avena sp.* (wild oat), *Phalaris minor*, *Chenopodium album, Medicago hispida, Lathyrus sativa. Treatments consisted of* pendimethalin 1000 g/ha (PE) and mechanical weeding (hoeing) at 30 DAS. In chickpea pendimethalin effectively controlled weeds and gave higher benefit. The maximum benefit was recorded Rs. 6685/- ha with pendimethalin.

Impact of pendimethalin on weed in chickpea

Table 61. Demonstration of weed management technology in chickpea

No of Demo	Treatments	WCE %	Grain yield kg/ha		Increase in yield over FP (%)	Cost of Treat (Rs /ha)	Economic Benefit due to treatment (Rs./ha)
			FP	Treated			
05	Pendimethalin 1000 g/ha (PE)	60	2233	2805	26	1325	6685
05	One hoeing at 30 DAS	52	2253	2692	21	1000	5678

FP Farmer practice (No weeding operation)

Mustard

Total five field demonstrations were laid out in two location of Jabalpur district. Weed Flora consisted of *Chenopodium album, Medicago hispida, Vicia sativa, Parthenium hysterophorus, Cyperus Spp. and treatments of p*endemethalin at 1000 g/ha (PE) and hoeing (one) at 30 DAS. Similarly in mustard, pendimethalin was found more effective then others and gave the maximum benefit of Rs. 6193/- per hectare.

Table 62. Field demonstration on weed management technology in mustard

No. of Demo	Treatments	WCE (%)	Grain yield (kg/ha)		Increase in yield over FP (%)	Cost of Treat (Rs. /ha)	Benefit due to treatment (Rs./ha)
			FP	Treated			
3	Pendimethalin at 1000 g/ha (PE)	57	1425	1910	34	1325	6193
2	Hoeing at 30 DAS	51	1418	1850	23	1000	5580

FP Farmer practice (No weeding operation)

7. EXTERNALLY FUNDED PROJECTS

7.1 National Invasive Weed Surveillance (NIWS)

Jay G. Varshney and V.S.G.R. Naidu

- NIWS project is being operated by this Directorate sponsored by DPPQS for three years for early detection of the five invasive weed species, namely, *Cenchrus tribuloides*, *Solanum carolinense*, *Viola arvensis*, *Cynoglossum officinale* and *Ambrosia trifida* intercepted in wheat imported from various countries during 2006-07 for Public Distribution System. This project is being run in 10 states, viz. Andhra Pradesh, Chattisgarh, Gujarat, Karnataka, Kerala, Orissa, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal, where the weed seed contaminated wheat was distributed. The NIWS programme is being reviewed and monitored every quarter by the National Co-ordinator Dr. Jay G. Varshney.

The programme is being implemented in 10 states

Sl. No.	States	No. of Districts
1.	Tamil Nadu	30
2.	Andhra Pradesh	23
3.	Kerala	14
4.	Karnataka	27
5.	West Bengal	18
6.	Maharashtra	34
7.	Gujarat	25
8.	Orissa	30
9.	Madhya Pradesh	48
10.	Chattisgarh	18
	Total	267

- After proper monitoring, survey and surveillance, amongst five quarantine weeds, *Solanum carolinens* has been detected at Vishwa Bharti, Sriniketan; UAS, Bangalore; TNAU, Coimbatore; TNAU, Madurai, ANGRAU, Hyderabad; ANGRAU, Tirupati; and KAU, Thrissur under non cropped areas. The identity of the species has been confirmed by the Botanical survey of India (BSI) and certificates have been issued by the BSI to this effect.


Solanum carolinense


Viola arvensis


Cenchrus tribuloides


Ambrosia trifida


Cynoglossum officinale

Invasive weeds intercepted in imported wheat

7.2 : Compost production from weed biomass for socio-economic development of rural people

Vinita Parmar and Shobha Sondhia

Weed biomass is one of the easily available sources of organic matter and plant nutrients. Weed composting is one of the recycling technologies, which will improve the quality of the products. The aim of the present study was to find out the possibility of utilization of agricultural wastes for composting. Open pit technique was chosen for composting. Treatment consisted of Parthenium weed +cow dung, mixed weed +cow dung, *Echinochloa colona* +cow dung. After 5.5 months, nutrient values were determined from the compost and compared. It was found that NPK values were maximum in compost obtained from mixed weed other than *Parthenium hysterophorus* and *Echinocloa colona* weed compost.

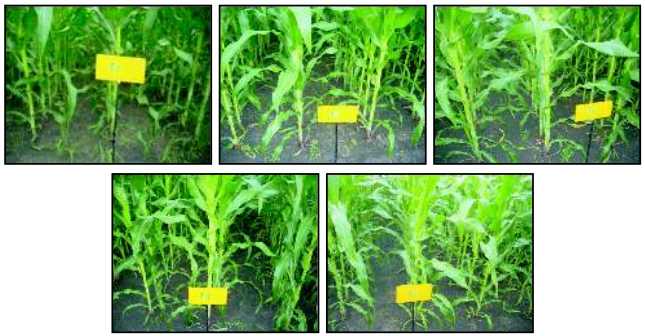
7.3 : Bio-safety Research Trial Level -1 for Transgenic Staked Corn Hybrids

Anil Dixit, MS Raghuvanshi and Jay G. Varshney

The experiment was conducted at DWSR to study the bio-efficacy and residual study of glyphosate in transgenic corn (MON 89034X NK 603). Two transgenic corn hybrid Hishell and 900M Gold, resistant to Glyphosate as well as to stem borer (*Chilo partelus*) and cob borer (*Helicoverpa* sp), were tested and compared with its non-transgenic counterpart Proagro-4640 and HQPM-1. Observations were recorded on weeds, insect, growth parameter and yield attributes.

The results are as under:

- Major weeds present in experimental field were *Echinochloa colona, Cyperus iria, Corchorus sp., Phyllanthus niruri, Dinebra sp., Physalis minima, Commelina benghalensis, Alternanthera sessilis* etc. and major insects recorded were Coccinalid, Spider, Syrphids, Pollinator, Aphids etc.
- There was significant weed control (100%) in Hishell and 900M Gold transgenic hybrids receiving K salt of Glyphosate.



Effect of K-salt of glyphosate on weeds in transgenic corn (100% weed control)

- There was no natural infestation of borers in transgenic and conventional hybrids. Hence *Chilo partelus* and *Helicoverpa* sp was introduced artificially in all the treatments with a view to assess the resistance against stem borer incidence. Hishell and 900M Gold showed resistance to *Chilo partelus* and *Helicoverpa* sp. Where as in all other conventional entries stem and cob borer infestations was observed.

Transgenic healthy cob showing no symptoms and Infestation of *Helicoverpa* on National check

- Hishell and 900 M Gold transgenic hybrids performed better with regard to grain yield ranging between 6-8 t/ha which was approximately three times higher than the average yield of maize crop per hectare i.e. 2.30 t/ha.

3 TRANSFER OF TECHNOLOGY

Campaign on *parthenium* eradication

One-day Parthenium Awareness campaign during *Parthenium* Awareness Day was organized by the Directorate on 11 August 2009 in Tagar village. This programme was enthusiastically attended by several farmers, school children etc.

As a part of ongoing *Parthenium* eradication campaign, all the staff members of the Directorate made '*Shramdan'* at M.P. Housing Board Colony, Maharajpur, Jabalpur on 08-08-2009, to make people aware of the problems caused by this dangerous weed. Residents of the colony also actively participated who were told about the ill effects of this weed on human health, animals and the environment.

Activities of Parthenium awareness week

Farmers' visit at the Directorate

DWSR imparted knowledge on weed management to agriculture officials/farmers who visited this centre time to time through lectures and video films under training programme. Directorate also participated several times in different training programme on weed management organised by FTC/State Agril. Dept. and other organization. During the programmes agriculture officials/farmers were briefed about the importance of weed management practices. Scientist of the centre explained the chemical and biological control of weeds in crop and non- crop situations, use of mechanical tools and implements for weed control in field crop etc.

Farmers' visit at the Directorate

Organization of Kisan Mela-cum-Krishak Goshthi

Directorate of Weed Science Research organized a Foundation Day and Kisan Mela-cum-Krishak Goshthi-2010 on 23.01.2010. The function was inaugurated by Hon'ble Planning Commission Member (Science) Dr. K Kasturirangan and Hon'ble Cabinet Minister for Agriculture, Govt of Madhya Pradesh Dr. Ram Krishna Kusmaria. About 5,000 farmers of Jabalpur and adjoining villages were benefited with the latest developments in weed science and other 54 stall of different aspects of agriculture including pesticide companies. During the occasion, Hon'ble Chief Guest released the publications on Success Stories on Weed management technologies adopted on Farmers' fields and a Book on Herbicides.

Glimpses of Kisan Mela

Kisan Goshthies

Kisan Sangosthi and Farmers Day on Weed Management including *Parthenium* awareness was organized by Gwalior centre at different villages of Gwalior Division involving KVK Centre's i.e. Gwalior, Morena, Datia, Shivpuri, Aron (Guna), Ashoknagar.

Visit of Scientists on Farmers' fields and their interaction with farmers

Scientists of the Directorate visited the weed free village i.e. Tagar Village of Panagar Block. They also interacted with the farmers for their weed problems in cropped areas

4 EDUCATION AND TRAINING

Advance training on analysis of herbicide residues in soil, water and food chain

Directorate offered a Short-term training course on *Advance Instrumentation for the analysis of herbicide residues in soil, water and food chain* to young scientists from different organizations from 16-22 November, 2009. It covered the theoretical aspects of herbicide residues, their analysis, toxicological importance and remediation. The training programme was coordinated by Dr. Shobha Sondhia, Sr. Scientist.

National training on weed management in field crops

An eight days *National training on Weed management in field crops* was conducted from 4-11 January, 2010 at the Directorate. Trainees from the various State Agricultural Universities and Krishi Vigyan Kendras of states such as Andhra Pradesh, Jammu & Kashmir, Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra participated in the programme. The objective of the training was to disseminate the information on ill effects of weeds in realizing the optimum yield potential of any crop and management of weeds for improved productivity, controlling health hazards, clean environment and contribute to the National prosperity. The training programme was coordinated by Dr. Anil Dixit, Pr. Scientist (Agronomy).

Training on *Parthenium* management

The Directorate organized a one-day special training programme on *Parthenium* management on 12.08.2009for farmers as well as for children. A quiz competition on *Parthenium* was conducted at the Directorate for children of different schools in Jabalpur.

Director addressing the participants

5 AWARDS AND RECOGNITION

Awards and Recognition

- Dr. Jay G. Varshney, Director, DWSR, Jabalpur has been nominated as a Member of the Policy Planning Committee on Science and Technology, Govt. of Chattisgarh, Raipur.
- Dr. Jay G. Varshney, Director, DWSR, Jabalpur received Shree PP Singhal Memorial Award from Society of Plant Protection Sciences of PI Industries Ltd. For the year 2009-10.
- Dr. Jay G. Varshney, Director, DWSR, Jabalpur was awarded 'Gold Medal' by Indian Society of Weed Science in its Biennial Conference held at Raipur during 25-26 Feb. 2010.
- Dr. Jay G. Varshney and Dr Shobha Sondhia were awarded 'Best Book Award' (in English) for 'HERBICIDES' jointly with by Indian Society of Weed Science in its Biennial Conference held at Raipur during 25-26 Feb. 2010.
- Dr. V.P. Singh, Pr. Scientist, DWSR, Jabalpur was awarded 'ISWS Fellowship' by Indian Society of Weed Science in its Biennial Conference held at Raipur during 25-26 Feb. 2010.
- Dr Shobha Sondhia, Sr. Scientist, DWSR, Jabalpur was awarded 'ISWS Fellowship' by Indian Society of Weed Science in its Biennial Conference held at Raipur during 25-26 Feb. 2010.
- Dr. Anil Dixit, Pr. Scientist was awarded Best Resource Person in Farmer's Training Centre (FTC) of Farmer's Welfare and Agriculture Development, Jabalpur
- NRCWS, Jabalpur has been upgraded to the status of Directorate of Weed Science Research (DWSR) w.e.f. January, 2009.
- Dr.Jay G. Varshney was nominated as member, Core group of Expert, National Integrated Bio-security System, Govt.of India
- Dr.Jay G.Varshney has been nominated as a statutory member in "Review Committee on Genetic Manipulation", Deptt. of Biotechnology, Govt. of India for a term of 3 years.
- Dr. Jay G. Varshney and Dr. R.L. Arya were awarded 'Best Book Award' (in Hindi) for 'Kharpatwar niyantran' by Indian Society of Weed Science in its Biennial conference held at Raipur during 25-26 Feb. 2010.
- Dr. Jay G. Varshney, Director, DWSR, Jabalpur was reelected as President of Indian Society of Weed Science unanimously for 2009-12

Award of promotions

The assessments of technical employees were carried out by the Directorate during the year under report. Under category-II, Sh. R.N. Prasad Bharti and Sh R.K. were promoted from T-3 to T-4 on 13.07.2009 and 29.07.2009, respectively.

While under Category-III, Dr. M.S. Raghuvanshi (T-6) and Sh R.S. Upadhyay (T-6) were promoted to the post of T-7-8 on 13.07.2009.

6 DIRECTORATE OF WEED SCIENCE RESEARCH COORDINATING CENTRES

DWSR has 22 coordinating and 9 volunteer centres located at different state agricultural universities for carrying out network research and generating location specific technologies on weed management in different crops, cropping systems and non-crop situations. The salient research achievements made under the network programme during 2009-10 is presented below:

Weed survey and surveillance

Survey and surveillance of weeds under cropped and non-cropped situations was continued at all the cooperating centres following revised protocols.

- In wheat crop at Ludhiana, *Phalaris minor* was the most predominant grassy weed with IVI values from 57.6 to 116.8%. Clodinafop and sulfosulfuron were the most common herbicides adopted for weed control. Intensity of *Poa annua* increased as it was not controlled by these herbicides. *C. album, R. dentatus*, *Medicago denticulata* and *A. arvensis* dominant broad leaf weeds; *M. neglecta* and *C. sativa* were found around field boundaries. Farmers did not spray any herbicide to wheat sown following berseem or potato as it was free of weeds.
- *Rabi* crops of Panna and Katni districts were mainly infested with *Convolvulus arvensis, Chenopodium album, Anagallis arvensis, Vicia spp., Cynodon dactylon, Cyperus rotundus, Melilotus indica, Chrozophora parviflora, Lathyrus aphaca* and *Spergula arvensis.* Major weed flora of *Kharif* crops in Bhopal and *Hoshangabad districts* were infested with *Echinochloa crusgalli, Commelina benghalensis, Celosia argentea, Cyperus rotundus, Alternanthera sessilis* and *Parthenium hysterophorus.*
- Weed survey in different cropped areas of Una district of Himachal Pradesh was done during *Kharif 2009*. The major weeds in maize were *Echinochloa colona, Eleusine indica, Digitaria sanguinalis, Dactyloctenium aegyptium, Sorghum halepense, Commelina benghalensis, Ageratum conyzoides*, *Commelina forskalii, Cynodon dactylon, Brachiaria ramosa* and *Cyperus rotundus.*
- *Sagitteria triflora* has extended its distribution to aquatic situations of Sivasagar district.
- Anand centre monitored and recorded the biotypes of weedy and wild rice in paddy fields at different locations of middle Gujarat, namely, Tarapur, Petlad, Matar, Khambhat, Sojitra, Bareja, Nadiad, Anand, Vadodara, Dabhoi and Karjan. Infestation of *Phalaris minor* in wheat, first recorded in Ahmedabad district in the year 1996, has increased in the state. It has now also been reported from Banasankantha, Sabarakantha, Mahesana, Patan, Gandhinagar, Ahmedabad, Kheda, Anand, Pandhamahal and Dahod districts.
- Ethnobotany of *Cystisus scoparius*, *Solanum carolinense*, *Rubus* sp. and *Ulex europaeus* revealed that these weeds are alien invasive species under different ecosystems of Tamil Nadu. Invasion of *Solanum carolinense* is mainly in non-cropped situations and the other three species were observed in terrains of upper Nilgiri district.
- Sugarcane crop at Faizabad was heavily infested with climber, eg. *Ipomoea* species. Whereas, infestation of weedy rice, *Fimbristyllis miliaceae*, *Cyperus iria*, *Scirpus tuberosus* and *Ammania baccifera* is increasing in rice every year.
- Survey in Burdwan district during *rabi* 2008-09 in vegetables revealed that the dominant species were *Gnaphalium, Anagallis, Chenopodium, Cyperus* and *Croton*. Weed infestation in onion was comparatively more, while it was lower in potato due to higher number of ploughing, well preparation of land and earthing up.
- Some winter season weed flora like *Melilotus indica, Coronopus didymus, Spergula arvensis* were replaced by summer season weeds like *Setaria glauca, Dactyloctenium aegipticum, Panicum* sp., *Eleusine* sp. etc. at Ranchi.
- Weed survey was carried out in East and South-eastern Coastal Plain zones of Orissa. The grasses like *Cynodon dactylon*, *Echinochloa colona*, *Panicum repens*, broad leaf weeds like *Celosia argentea*, *Ludwigia parviflora,* and sedges like *Cyperus rotundus* were dominant weed flora of direct seeded upland rice.
- *Mustard crop* was heavily infested with *Chenopodium album in the districts of Hisar,* Bhiwani, Sirsa and Fatehbad.
- At Raipur, the dominant weeds of the cropped area (mainly rice) were *Echinochloa colona, Ageratum conyzoids, Cyperus rotundus followed by Cynodon dactylon and Abutilon indicum.*
- Infestation of weedy rice and the Chinese Sprangletop are spreading in Kerala. Large areas in all the three major rice zones, namely, Kut tanad (in Alleppey, Kottaym Dist.), Kole lands (in Thrissur and Malappuram Dist.) and Palakkad (Palakkad Dist.) are severely infested with weedy rice (*Oryza rufipogan)*. With the morphological similarity to rice and lack of any selective herbicide, weedy rice has become a major problem to the rice farmers. A total of eighteen species of mistletoes were identified in the state. *Tolypanthus lagenifer* was found only in Kannur and Kasargod districts of the state. *D. neelgherrensis, D. memecylifolius* were collected from the high ranges of Idukki district.
- Severe infestation of *Striga* was noticed in some sugarcane fields in Bagalkot, Mudhol and Jamakhandi blocks (taluks) of Bagalkot district of Karnataka. The *Cuscuta* incidence was noticed in onion and chilli crops in Gadag block (Gadag district) and Kundagol block of Dharwad district. The *Orobanche* problem in tomato and brinjal fields has been observed in new areas Viz., Chikabagewadi, Hirebagewadi and Aralikatti villages of Belgaum district. Earlier its incidence was restricted only to traditional tobacco growing areas of Nippani block of Belgaum district.
- Infestation of dicotyledonous weed *Solanum nigrum* and *Malwa parviflora was more* in wheat fields planted by zero till method and only carfentrazone was found effective against this weed in areas of Bhiwani, Sirsa, Fatehbad, Hisar and Rohtak.
- In Una district of Himachal Pradesh, increasing dominance of *Brachiaria ramose, Eragrostis tenella*, *Sorghum halepense, Ageratum conyzoides* and *Commelina benghalensis* was observed in upland *kharif* crops since last survey. *Parthenium hysterophorus* also started invading the upland *Kharif* crops. More than 60 per cent of the farmers are using herbicides to control weeds in maize and rice. But some of the farmers were not using herbicides at proper time, dose and method of application.
- *Mikania micrantha*, previously confined to the road side plantations, was observed in the interior areas of Jagatsinghpur, Kendrapara, Cuttack, Puri, Khurda and Nayagarh districts *of Orissa*. *Alternanthera philoxeroides* is becoming a problem in low lying swampy areas of Coastal districts. Large scale invasion of *Celosia argentea* was reported in groundnut crop grown in *kharif* season under rainfed upland situation of Dhenkanal and Anugul districts.

- *Alternanthra triandra* in cropped fields especially in direct seeded rice which occupies around 70% area in Chhatisgarh state has emerged as a new havoc. The road sides, bunds etc. are also getting heavily infested with this weed especially in Raipur district. The control of this weed after 4-5 leaf stage get difficult with prevalent herbicides like chlorimurom+metsulfuron (Almix), however, 2,4-D is still an effective solution for this weed. Another weed invading the non-cropped area is *Malwa pusila.* The intensity of this weed is multiplying day by day. However, the good side of its invasion is that it is replacing *Parthenium hysterophorus.* If the multiplication continues, undoubtedly it is going to invade cropped area within a short period.
- Loranthus infestation observed on mango, sapota, silver oke, paltaforum bottle brush, custard apple and *Khijari* trees at Anand.
- Sriniketan centre reported that *Dendropthoe* has infestated mango, kurchi (*Holarhena sp.*), jackfruit, *Accasia, Butea,* Teak, etc in the different part of Birbhum district. *Dendrophthoe was also noticed on mahua, mango, peepal and acacia trees* at Kanpur, Mango and Neem under mid and low hill conditions of Kangra district of HP.

Studies on herbicidal resistance in different weed flora

- Pantnagar centre reported that *Phalaris minor* plants from the locations S2 (Bhattpuri, Bajpur area) S6 (Fatehpur) S7 (Gadarpur area) and S10 Bachchipur (Haldwani-Halduchaur) area exhibited various degrees of resistance to isoproturon even at 2.0 kg ai/ha. However, plants from rest of the locations were effectively controlled by isoproturon at the recommended dose. *P. minor seeds collected from parts of Udham Singh Nagar District and Haldwani areas of Nainital district, exhibited about 6.0 to 15.0 per cent resistance to isoproturon at the recommended dose.*
- At Ludhiana, the long term study on management of isoproturon resistant populations of *P. minor* revealed that during tenth year no mortality was observed with isoproturon, fenoxaprop-*p*-ethyl and clodinafop. This year mortality with sulfosulfuron was also low as reflected by per cent decline in population and weed dry matter of *P. minor*. Out of two newly recommended herbicides, pinoxaden was more effective than meso + iodosulfuron and induced complete mortality. The RGR value was lowest for pinoxaden and highest for isoproturon. Another study on development of cross/multiple resistance in *P. minor* revealed higher GR_{50} value for clodinafop and sulfosulfuron than recommended doses indicating development of resistance against these herbicides also. The GR50 values for pinoxaden and meso+iodosulfuron were lower than their recommended doses indicating that these herbicides are effective against *P. minor*. Another field study confirmed development of resistance in *P. minor* against clodinafop and also indicated that resistance is increasing at a very fast rate.
- Studies done at Hisar showed that Chanarthal (kurukshetra) and Barhi (Ambala) biotypes of *P. minor* have developed resistance to clodinafop and fenoxaprop. Application of sulfosulfuron+metsulfuron (RM) at 32 g/ha, meso+iodosulfuron at 15 g/ha and pinoxaden at 50 g/ha can be used presently to control these biotype of *P. minor* in wheat crop. In another pot-culture studies with *P. minor* biotypes (Teek, Geong, Teontha, Budanpur, Solu Majra, Chandlana, Manjura, Sambhli, Majra Rodan, Shahpur, Chirao biotypes) from farmers' fields indicated that clodinafop and fenoxaprop were not satisfactory against most of the biotypes except 'Sambhli' biotype. Sulfosulfuron was better than clodinafop and fenoxaprop against most of the biotypes and performed well against Teontha, Sambhli and Chandlana biotypes. Pinoxaden provided >80% control of most of the biotypes except 70% control of Budanpur and Shahpur biotypes. All herbicides were good against Uchani and Sambhli biotypes indicating to be sensitive biotypes. However clodinafop was slightly weak against Uchani biotypes (65%).
- No resistance has been noticed in *Echinochloa glabrescens* under Red and Lateritic Zone at Sriniketan centre where butachlor has been used during last four years.
- At Coimbatore, from the controlled condition experiments, it has been observed that there was no resistant developed by *Echinochloa colona* against post emergence application of Azimsulfuron at 30, 35 and 40 g/ha. There was no regeneration of *Echinochloa* seeds at all the doses up to 60 DAT. The percentage control and drying were higher with 35 and 40 g/ha than 30 g/ha and the drying percentage was higher at 14 and 21 DAT. This showed that *Echinochloa* has not developed resistance to the post-emergence herbicide Azimsulfuron.

Propagation potential of perennial weeds - *Cyperus rotundus*

- At Ludhiana, a field study revealed that glyphosate had good suppressing potential against *Cyperus* shoots and addition of 2% jaggery to glyphosate increased shoot mortality and decreased the tuber population at 0-10 cm depth. However, tubers at 10-20 and 20-30 cm were not affected due to herbicide treatment.

Effect of CO_2 fertigation on weed species and herbicide efficacy

- At Thrissur, weeds kept inside the CO_2 chambers had higher growth indicating that weed growth was likely to be higher with increased CO_2 and humidity levels.

Study on biology of *Echinochloa spp.*

- Altogether 46 numbers of *Echinochloa* specimens (Herbaria) have been collected by Jorhat centre from northeast and south India. Collected specimens have been studied in respect of their morphology, habit and habitat. Different herbaria of the country viz. Kanjilal Herbarium, Shillong, Central National Herbarium, Howrah; Herbarium of Forest Research Institute, Dehra Dun, Herbarium of the Botany Department, Guwahati University, etc., have been consulted for collection of information on *Echinochloa* diversity and identification of specimens.

Weed management in crops and cropping system

- Direct seeded rice sown after onset of monsoon resulted in comparatively less weed density and weed biomass than when sown prior to onset of monsoon at Ranchi, Faizabad, Sriniketan, Pantnagar and Coimbatore. Amongst the weed control treatments, application of butachlor at 1.5 kg/ha along with one hand weeding was found significantly better in realizing highest grain yield at Coimbatore and Faizabad.
- System of Rice Intensification (SRI) and Transplanted method of rice establishment was significantly efficient in reducing the weed density and obtaining higher grain yield of rice at Bhubaneswar, Sriniketan and Coimbatore.
- Application of pendimethalin and isoproturon each at 1.0 kg/ha significantly reduced the weed density, weed dry matter as well as cane yield of sugarcane ratoon crop at Faizabad and Kanpur. Significant increase in yield of sugarcane ratoon crop was also recorded when intercropped with potato (Faizabad centre) and blackgram (Kanpur centre).
- Application of carfentrazone 25 g fb pinoxaden 40 g/ha in wheat significantly reduced weed density and resulted in higher yields at Kanpur, Gwalior, Hisar, Faizabad and Palampur.

- Compared to conventional tillage, zero tillage in *Kharif* rice resulted in higher weed biomass in rice-wheat cropping system at Raipur. Whereas, both the tillage systems performed equally well in both the crops at Kanpur and Ranchi centres with regard to weed intensity and grain yield.
- In rice-rice system at Bhubneswar, conventional tillage (CT) CT was effective in reducing weed density as compared to zero tillage (ZT)-CT and CT-ZT.
- At Coimbatore, continuous ZT encouraged higher growth of grass weeds and increased soil compaction and resulted in lower yield attributes and economics. Whereas weed density was comparatively lower in CT which enhanced the yield attributes and resulted in higher yield and economics of maize - sunflower cropping system.
- Continuous application of butachlor + 2,4-DEE herbicide mixtures in both kharif and rabi seasons, or rotational application of butachlor + 2,4-DEE during *kharif* and pretilachlor + 2,4-DEE during *rabi* in rice-rice system at Coimbatore did not show build up of these herbicides in the post harvest soil, grain and straw.
- The treatments of rotational use of clodinafop 60 g/ha *fb* 2,4-D 1.0 kg/ha at Palampur centre and continuous use of clodinafop at Hisar centre showed significantly lower population and dry matter of *Phalaris minor* and other weeds in wheat.
- In rice-mustard cropping system at Sriniketan, repeated use of butachlor or rotational use of pretilachlor /butachlor in *kharif* rice resulted in disappearance of *Hydrolea zeylanica*.

Weed management in non-crop situation

- At Coimbatore, significant control of grasses, sedges and broadleaved weeds was achieved with application of glyposate 1.25 kg/ha + Richwet 0.50%. However, re-growth or regeneration of most of the weed species was observed due to continuous rainfall. Surfactant Richwet increased contact angle of Glyposate on *Cyperus rotundus, Trianthema portulacastrum* and *Oxalis latifolia*. Surface tension as measured for the herbicide along with different concentrations of surfactants was in the order of Richwet >Alwet gold > Salfix > Surfactant >Indtron.

Long term herbicide trial

- In rice-chickpea cropping system at Pantnagar and Faizabad, lowest weed density and highest grain yield was obtained with the application of pendimethalin 0.75 kg/ha fb one hand weeding at 30 days after sowing in chickpea. In addition, application of anilophos 0.5 kg/ha as pre-emergence in rice during *kharif* season encouraged the yield of chickpea significantly during *rabi* season over rest of the treatments. In rice, butachlor 1.5 kg/ha + 1 HW or anolophos 0.5 kg/ha + 1 HW treatments were similar to two hand weeding at 20 and 40 days in terms of weed control measure.
- In rice-wheat cropping system, application of butachlor and pretilachlor to rice, isoproturon + adjuvant to wheat significantly lowered weed density and weed dry weight compared to weedy check. The total count for *Azotobacter, Azospirillum* and PSB decreased in herbicide treated soils after harvest of rice and wheat.
- I*n field pea/chickpea* at Ludhiana*, i*ntegration of pendimethalin 0.75 kg with one hoeing gave season long control of weeds and the recorded seed yield was at par to two hoeings. Microbial population in soil showed a downward trend in herbicidal treatments.

Management of parasitic/ invasive/ problematic/ aquatic weeds

- At Bhubaneswar, summer deep ploughing was effective in reducing the density of *Cuscuta* in niger. Stale seed bed + pendimethalin 0.5 kg/ha PE recorded significantly the lowest *Cuscuta* density compared to pendimethalin 1.0 kg/ha PE as sand mix and farmers' Practice of two hand weeding.
- At Hisar, post emergence application (25 & 55 DAS) of glyphosate at 25 g/ha + $(NH_4)_2SO_4$ (1% sol) helped to minimize the *Orobanche* population in mustard.
- A field trial on management of *Orobanche* in brinjal crop was initiated in Padanpur village of Khurda district (Orissa), during November, 2009. The emergence of the *Orobanche* shoot takes around 49 days and there were on an average 5.2 shoots per brinjal plant. The shoot of *Orobanche* goes up to a height of 14.3 cm and the shoot dries in 38 days. The parasite produces around 4500 seeds / floret and there were 40 florets per shoot.
- At Coimbatore, application of imazethapyr 30 g/ha on 55 DAT reduced *Orobanche* shoot density, and increased yield of tobacco leaf as well as cost benefit ratio. Plant hole application of neem cake 200 kg/ha on 30 DAT was also effective for control of *Orobanche cernua* and increased tobacco leaf yield.
- Pre-emergence application of atrazine 1.0 kg/ha on 3rd DAP combined with post-emergence spraying of 2,4-D Na salt 1.0 kg/ha + urea 1% + soap solution 1% on 70 - 75 DAP was effective for control of *Striga asiatica* and increased productivity and profitability in sugarcane cultivation at Coimbatore.
- At Thrissur, a mango tree with its trunk completely infected by *Helicanthus elastica* was sprayed with ethrel 4000 ppm and this resulted in almost complete defoliation of the parasite. However within a period of 2 months re-growth was observed in some of the branches. Hence 2,4-D (5%) padding was done in a few nodal points on the root and till date (9 months) no re-growth was observed. The mango plant became healthy and shows no toxicity symptoms of 2,4-D.

Management of aquatic weeds (*Eichhornia crassipes*)

- Study on control of *E. crassipes* at Jorhat revealed that application of paraquat showed faster drying of the plants. Lowest weed dry weight at 7 days after spray was recorded with paraquat 8 ml/l and highest in untreated control. Weed plants were completely killed by 15 days after spray in all the herbicide treated tanks while the dry weight in control tank was increased to 71.2 g/m^2. Regrowth of weeds up to 120 days of spray was not observed in treated tanks. Paraquat was also found effective by Sriniketan, Hisar, Thrissur centres.
- At Faizabad, application of metsulfuron methyl at 0.05 or 0.08 g/l showed complete control of water hyacinth on 21 DAHS but moderate control from 40 to 70 DAHS.
- Paraquat , glyphosate , 2,4 -D and Metsulfuron methyl were effective in controlling *Eichhornia crassipes* at Thrissur. No difference in pH of treated water samples was observed, but dissolved oxygen increased from 20 DAS onwards.
- Application of paraquat 8 g, 2,4-D amine 2.5 g/l water provided 96% control of *Eichhornia crassipes* in natural water bodies at Hisar. 2,4-D Na and 2,4-D Ester were less effective than 2,4-D amine in this regard.

- At Coimbatore, glyphosate 10 ml/l alone or in combination with Carfentrazone 4 mg/l had completely controlled water hyacinth without regeneration. There was no mortality of fishes with all the tested herbicides.

Herbicide residues, persistence, leaching behaviour and toxicity

Studies on herbicide residue in food chain, soil and ground water

- At Gwalior reported that isoproturon 1.0 kg/ha and fenoxaprop 60 and 90 g/ha applied to wheat persisted in soil up to 30 DAA. Doubling their doses enhanced the persistence up to 45 DAA. Sulfosulfuron at 25 and 50 g/ha persisted upto 60 DAA. In soybean, Quizalofop ethyl 100 and 200 g/ha persisted in soil up to 30 and 45 days respectively. Chlorimuron ethyl 9 and 18 g/ha persisted up to 45 and 60 days, respectively. No herbicide residues were detected after harvest of crops as per bioassay method using maize as test crop.
- Butachlor and pretilachlor residues were detected up to 45 days in rice soils of Bhubaneswar. But the residues were below detectable limit in post harvest soil, grain and straw. While, butachlor and pretilachlor residues in surface soil were below detectable limit (0.01 ppm) at 30 days after spray in upland direct seeded rice at Jorhat for both recommended and twice the recommended doses
- There is no residue of clodinafop and atrazine at harvest of maize under both zero and conventional tillage systems at Ludhiana.
- Prelilachlor 0.5 kg/ha persisted up to 30 days, Almix 6 g/ha and oxadiargyl 0.1 kg/ha persisted upto 45 days, while Almix 12 g, pretilachlor 1.0 kg and oxadiargyl 0.2 kg/ha persisted up to 60 days in transplanted rice soil of Faizabad.

Studies on herbicide persistence in water

- Paraquat residue was below detectable limit (0.05 ppm) in water after 14 days spray to aquatic system at Jorhat and Anand centres.
- No residue of anilophos butachlor, isoproturon, 2,4-D and sulfosulfuron and clodinafop was noticed in ground water of Ludhiana, Jalandhar, Ferozepur, Moga, Amritsar and Faridkot districts of Punjab.
- Only 1-2 per cent of the applied 2,4-D was recovered in the water at 20 days after its application to the aquatic system at Coimbatore. Half life for the applied 2,4-D was less than 10 days irrespective of the presence of water hyacinth.

Characterization of leaching behaviour of herbicide in soil

- 2,4-D leached up to 30-40 cm in Gwalior soil as per bioassay technique using greengram as test crop.
- High mobility of metsulfuron methyl was observed in Pantnagar soil.
- At Jorhat, butachlor residue was detected up to 20 and 25 cm depth of soil column at recommended and twice recommended dose, respectively. Similar observation was recorded for pretilachlor.
- Alachlor residue was detected upto 60 cm depth of leaching column when applied at 2 and 4 kg/ha at Coimbatore. Increased dose enriched the soil with the herbicide molecule besides transporting considerable quantity to lower depth.
- At Palampur, most of the applied sulfosulfuron and metsulfuron remained only within 25 and 20 cm but the movement of herbicide was up to 50 and 45 cm, respectively.

Transfer of Technology

- *Zygogramma bicolorata* appreciably established their population at Raipur, Pantnagar, Sriniketan, Coimbatore, Palampur and Anand centres and damaged the growth of *Parthenium hysterophorus*. However, at Ranchi and Hisar the beetle could not establish properly.

Yield loss estimation

- Reports received from different centres indicated that the extent of yield loss due to weed varied from location to location. In general there was 10-60% loss in wheat yield and 8.5-55% loss in rice yield due to weed infestation.

On Farm trial (OFT)

- Recommended and proven chemical weed control technologies for rice were demonstrated on farmers fields at Bhubaneswar, Coimbatore, Sriniketan and Faizabad. Demonstrated technologies effectively controlled weeds, and gave more yield and economic return over farmers practice. Similarly, better economic return of the recommended weed control technologies in wheat was reported by Hisar and Faizabad centres. The recommended weed control technologies for groundnut, potato, maize and onion were also demonstraded in farmers fields by the different centres.

Weed Utilization

- At Jorhat, vermin-compost from *Ipomoea carnea* was prepared and was superior in terms of total N, P, K contents.

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Release of books/ bulletins

DDG (NRM) releasing books on Weed Atlas Vol-I and II, Hand book on herbicide recommendations, herbicide use in field crops

Hon'ble Member Planning Commission Dr. K. Kasturirangan and Cabinet Minister of Agriculture, Govt of MP releasing books on Herbicides

Hon'ble Member Planning Commission Dr. K. Kasturirangan and Cabinet Minister of Agriculture, Govt of MP releasing books on Success Stories

Hon'ble Deputy Director General (NRM) Dr. A.K. Singh releasing Extension pocket bulletins.

8. APPROVED RESEARCH PROJECTS

Code	Theme	Code	Programme	Code	Projects	PI
1	Weed biology and eco physiology	1.2	Crop-weed interaction	1.2.2	To study the effect of elevated CO_2 on weeds and competitive interaction between crops and weeds	Dr. Bhumesh Kumar
				1.2.3	Germination, dormancy and ageing of weed seeds	Dr. DK Pandey
				1.2.4	Collection, multiplication and characterization of weed seeds	Dr. VSGR Naidu
		1.3	Phytoremediation of contaminated soil and waste water using weeds	1.3.1	Identification of weedy plants for phytoremediation of heavy metal contaminated water	Dr. PJ Khankhane
				1.3.2	Evaluation of efficacy of weedy plants in constructed wetland for phytoremediation of drain water	Dr. PJ Khankhane

Code	Theme	Code	Programme	Code	Projects	PI
2	Development and evaluation of integrated weed management techniques /practices	2.1	Mechanical weed management	2.1.1	Evaluation of manually operated weeding tools suitable for uprooting of soil embedded weeds in soybean and chickpea	Er. HS Bisen
		2.2	Management of parasitic and problem weeds	-	-	-
		2.3	Integrated weed management	2.3.2	Weed management in citrus and mango orchards	Dr. VP Singh
				2.3.3	Development of organic weed management in rice-wheat and soybean-wheat cropping system	Dr. RP Dubey
				2.3.4	Development of organic weed management in okra-cauliflower-cowpea and chili-tomato-cowpea cropping systems	Dr. RP Dubey
				3.3.5	Weed management in medicinal plants	Dr. Anil Dixit

Code	Theme	Code	Programme	Code	Projects	PI
3	Herbicide as a tool in weed management	3.1	Long-term effects of herbicides in different cropping systems	3.1.1	Influence of continuous use of herbicides in soybean-wheat cropping system	Dr. VP Singh
				3.1.2	Influence of continuous use of herbicides on weed dynamics and soil health in rice-wheat cropping system	Dr. VP Singh
				3.1.3.1	Impact of herbicides on N-Fixation by the legume-rhizobium symbiosis	Dr. KK Barman
				3.1.4	Herbicide residues in soil and food chain	Dr. Shobha Sondhia
				3.1.5	Evaluation of herbicide toxicity on non-targeted organism under paddy cum fish culture	Dr. Shobha Sondhia
				3.1.6	Evaluation of risk of ground water contamination by the continuous use of herbicides	Dr. Shobha Sondhia

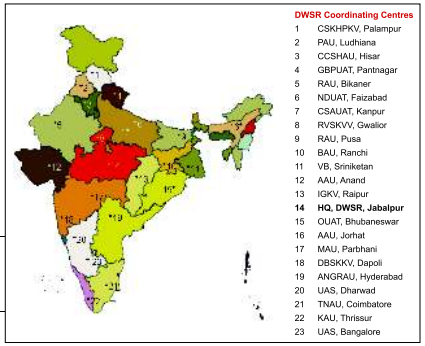
Code	Theme	Code	Programme	Code	Projects	PI
		3.2	Efficient weed management through herbicide use	3.2.1	Enhancing herbicide use efficiency in wheat, onion and direct seeded rice	Dr. Anil Dixit
				3.2.2	Preliminary screening of new molecules	Dr. Anil Dixit
				3.2.3	Role of adjuvants on bio-efficacy of recommended herbicides in soybean and wheat	Dr. VP Singh
				2.2.4	Impact of soil physical environment on pre-emergence herbicides	Dr. KK Barman
				2.2.5	Studies on herbicides soil moisture interaction	Dr. VP Singh
				2.2.6	Establishment of techniques and protocol for the investigation on the role of leaf surface in the phototransformation of herbicides	Dr. PP Choudhary
					Investigation on	
				2.2.7	phototransformation of sulfosulfuron and propaquizafop in aqueous phase and on soil surface	Dr. PP Choudhary
				2.2.8	Studies on metirbuzin phytotoxicity in pulses	Dr. Bhumesh Kumar

Code	Theme	Code	Programme	Code	Projects	PI
4	Bio-pesticides and biocontrol of weeds	4.1	Survey, identification and impact evaluation of new and existing insect/ plant pathogen bio-agents for biological control of important weeds in India	4.1.1	Evaluation of *Neochetina* sp and glyphosate on water quality and fish mortality and integrated management of water hyacinth	Dr. Sushilkumar
				4.1.2	Evaluation of bioagents for biological control of problem weeds	Dr. Sushilkumar
				4.1.3	Biological management of *E. crassipes* using potential aquatic fungal pathogens	Dr. C. Kannan
				4.1.4	Biology, host specificity and damage potential of bioagent on Trianthema portulacastrum	Dr. Sushikumar
				4.1.5	Induction of systemic resistance against *Cuscuta* sp in Chickpea	Dr. C. Kannan
		4.2	Herbicidal properties of plant constituents	4.2.1	Bio-herbicidal potential of allelochemicals fromLantana, neem and tropical soda apple	
				4.2.2	Isolation and identification of root exudates of linseed and marigold and their growth inhibitory effect on weeds	Dr. Shobha Sondhia

Code	Theme	Code	Programme	Code	Projects	PI
5	Weed Utilization	5.1	Vermicomposting	5.1.1	Preparation of vermi-compost from various weed species and evaluation of their nutrient status and seed viability	$ushilkumar
6	Transfer of technology	6.1	Demonstration, training, awareness of proven technologies	6.1.1	Evaluation of improved weed control technologies on farmers' fields	Dr PK Singh

9. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNALLY FUNDED PROJECTS

DWSR, a nodal agency for research and training in the field of Weed Science and a repository of information in Weed Science in the country, offers research and training to the research scholars and provides expertise and consultancy to the staff and students of SAUs, ICAR Institutes, NGOs, herbicide industries, etc.



Besides coordinating with 22 numbers of DWSR Centres and a large number of volunteer centres being operated at different agro-climatic zones of the country, DWSR also collaborates with several other educational and research institutions. MoU was signed with Jawaharlal Nehru Krishi Vishva Vidyalaya (JNKVV), Jabalpur, enabling better collaboration in the area of research, teaching and extension. This Directorate has also been recognized by Rani Durgavati Vishva Vidyalaya (RDVV), Jabalpur, as a post-graduate research centre for their students. In addition, the Directorate is open to several educational institutions all over the country for their research and training activities. The overall programme of DWSR and its coordinating centres are regularly monitored by the Director, DWSR. This directorate made linkages with agencies like CIAE, SAUs, PDBC, DBT, DST and several herbicide industries for data generation and sharing, joint research, HRD, technology dissemination and impact analysis.

Externally-funded projects

Project Title	Funding Agency	Duration		Budget (Rs. in lakhs)
National Invasive Weed Surveillanc e Programme	DPPQS	2008	2011	729.00
Compost production from weed biomass for the socio economic development of rural people	DST	2008	2011	5.55
Precision farming technologies based on microprocessor and decision support systems for enhancing input application efficiency in production agriculture	NAIP	2008	2011	50.57
Bio safety research trial level 1 on transgenic corn	MIL	2009	2010	6.50

10 QRT, RAC, IMC, IRC AND OTHER MEETINGS

Institute Management Committee

IMC Meetings were convened under the Chairmanship of Dr Jay G Varshney, Director on 15.04.2009 and 15.09.2009. The other members were Dr SS Tomar, DRS, JNKVV; Dr Anand Swarop, Head, SSAC, IARI; Dr VV Singh, Head, AMD, CIAE; Dr Rabindra Dawkar, Bayer Crop Science; Er HS Bisen, DWSR; Dr Anil Dixit, DWSR; Dr PK Singh, DWSR; Sh AK Shrivastava, AF&AO, DWSR and Member Secretary Sh SL Harinkhare, AAO, DWSR.

Institute Research Committee

A meeting of Institute Review Committee was convened on 19-20 June 2009 under the Chairmanship of the Director. The IRC reviewed the research work done by the scientists in 2008-09 and gave suitable suggestions to further improve the quality of scientific information being generated in the ongoing research projects. All the scientists of the Directorate attended the meeting.

Research Advisory Committee

A meeting of Research Advisory Committee (RAC) was convened under the Chairmanship of Dr DP Singh, Former VC, JNKVV at the Directorate on 25-26 June 2009. The other members were Dr Jay G Varshney, Dr DV Singh, Dr DN Singh, Dr Madhuban Gopal, Dr OP Singh, Sh Kunwar Narendra Singh and Member Secretary Dr KK Barman along with scientists of the Directorate.

Institute Bio-safety Committee (IBSC)

A meeting of Institute Bio-safety Committee was held under the Chairmanship of Dr Jay G Varshney, Director, DWSR on 04 July 2009 for undertaking a trial on Bio-safety Research Level-1 on staked corn. The other members were DBT Nominee Dr SS Tomar, DRS, JNKVV; Dr SK Gulati, MD; Dr Sharad Tiwari, Associate Professor, Biotechnology, JNKVV; Dr VSGR Naidu, DWSR; Dr MS Raghuvanshi and Member Secretary Dr. Anil Dixit, DWSR.

11. PARTICIPATION IN SEMINARS, SYMPOSIA, etc.

Participants	Conference / Symposium	Venue & Date
Dr (s) Jay G Varshney KK Barman, PK Singh VP Singh, RP Dubey Sushilkumar, Anil Dixit PJ Khankhane, Shobha Sondhia, VSGR Naidu C Kannan, PP Choudhury Sarathumbal, MS Raghuvanshi Sandeep Dhagat	National symposium on weed threat to environment, biodiversity and agri. productivity organized by ISWS	TNAU, Coimbatore, 2-3 August 2009
Dr (s) Jay G Varshney Anil Dixit, VP Singh RP Dubey, Sushilkumar Shobha Sondhia, VSGR Naidu, PP Choudhary ON Tiwari, Pankaj Shukla	XIX Biennial workshop of coordinating centres	IGKV, Raipur, 23-24 February 2010
Dr (s) Jay G Varshney VP Singh, DK Pandey PK Singh, KK Barman RP Dubey, Sushilkumar PJ Khankhane, Shobha Sondhia, VSGR Naidu C. Kannan, Bhumesh Kumar, PP Choudhury, C Sarathambal, MS Raghuvanshi, Pavan K Kauraw	Biennial conference on Recent advances in Weed Science Research-2010 organized by ISWS	IGKV, Raipur, 25-26 February 2010
Dr (s) Jay G Varshney, HS Bisen, VP Singh, DK Pandey, PK Singh, Anil Dixit, KK Barman, Sushilkumar, PJ Khankhane, Shobha Sondhia, VSGR Naidu, C Kannan, Bhumesh Kumar, PP Choudhury, C Sarathambal, MS Raghuvanshi	National Consultation on Weed Utilization	DWSR, Jabalpur, 20-21 October 2009
Dr PJ Khankhane	Platinum Jublee Symposium on Soil Science meeting the challenges to food security and environmental quality	IARI, New Delhi, 22-25 December 2009
Dr PJ Khankhane	FESCO 2009	Agra, 16-18 September 2009
Dr (s) Jay G Varshney, VP Singh, DK Pandey PK Singh, KK Barman RP Dubey, Sushilkumar PJ Khankhane, Shobha Sondhia, VSGR Naidu C. Kannan, Bhumesh Kumar, PP Choudhury, C Sarathambal	National Consultation on Biological Weed Control	DWSR, Jabalpur, 17-18 March 2010
DK Pandey	National Symposium on Recent Developments in the Management of Plant Genetic Resources	National Bureau of Plant Genetic Resources, ICAR, New Delhi, 17-18 December 2009
Dr(s) Jay G Varshney, VP Singh, Anil Dixit, RP Dubey, VSGR Naidu	ICAR-Zonal Technology Management and Business Planning and Development Meeting-cum-Workshop	CICR, Nagpur, 5-6 March 2010
Dr Anil Dixit	Zonal Workshop on IPR and technology management	CICR, Nagpur, 5-6 March, 2010
Dr Anil Dixit	National Food Security Mission on Pulse programme of Govt. of MP	KVK, Ujjain, 11-12 September 2009

12 WORKSHOPS, SEMINARS, TRAINING PROGRAMMES ORGANISED

XIX Biennial Workshop of DWSR Coordinating Centres

The XIX Biennial Conference of DWSR Coordinating Centres was organized at IGKV, Raipur, Chhattisgarh, on February 23-24, 2010. Sh. P Joy Oomen, Chief Secretary, Govt of Chhattisgarh inaugurated the workshop. Dr MP Pandey, Vice Chancellor, IGKV, Raipur, chaired the inaugural session. The workshop was spread over three technical sessions and the salient research findings and recommendations of each technical session were discussed in plenary session. Scientists from DWSR head quarters and Coordinating Centres attended the workshop.

Biennial Conference of Indian Society of Weed Science

The Biennial Conference of Indian Society of Weed Science (ISWS) was held at IGKV, Raipur, Chhattisgarh, on February 25-26, 2010. The theme of the conference was Recent Advances in Weed Science Research-2010. The Conference was inaugurated by Sh Chandra Shekhar Sahu, Hob'ble Minister of Agriculture, Veterinary, Fishery and Labour of the state of Chhattisgarh. Dr. MP Pandey, Vice Chancellor, IGKV, Raipur, was the chairman of the function. Dr Jay G Varshney, Director, DWSR and President, ISWS emphasized on the control of invasive weeds. There were four technical sessions and a plenary session in the conference. A Scientists - Extension Officers - Farmers Interface was also organized. There were 16 oral presentations including 13 lead papers and 162 poster presentations. An even number of 274 delegates took the part in the conference.

National Consultation of Weed Utilization

A National Level Consultation programme was organized by the Directorate on October 20-21, 2009. The theme of the consultation was “Utilization of weed plants for useful purposes.” Dr AK Singh, DDG (NRM), ICAR, New Delhi, inaugurated the programme and explained the utility of this programme by citing some examples on the use of weeds. There were four technical sessions with 16 invited and 20 contributory presentations. Dr Gautam Kalloo, Vice Chancellor, JNKVV, Jabalpur, chaired the plenary session with the Co-Chairman Dr. Jay G Varshney, Director, DWSR. A series of recommendations were evolved from this consultation.

Interface Meeting

An Interface Meeting between the Planning Commission and ICAR institutes of Central Zone was held at DWSR on 23 January, 2010. Dr K Kasturirangan, Member (Science), Planning Commission led his team of Advisors. Directors and Heads of different ICAR institutes in Central Zone took part in the meeting. The issues relating to possibilities of increasing pulse production in India were discussed in the meeting.

National Consultation on Biological control of weeds

National Consultation on Biological control of weeds was convened on 17-18 March 2010 at DWSR, Jabalpur. Chief Guest of the function was Dr. CD Mayee, Chairman, ASRB. This National Consultation programme was organized at this nodal centre for weed research in India with the view for encouraging the interactions among the scientists and subject matter specialists in the field of biological control of weeds. The programme was attended by 30 renowned entomologists and plant pathologists having vast experience in the field of biological control of weeds.

13. IMPORTANT EVENTS ORGANIZED

World environment day

World environment day was celebrated on 5 June 2009 with full grandeur at DWSR, Jabalpur. Dr Kalyan Singh, Head, Agronomy, BHU, was the chief guest of the function. Dr CP Singh, PS, Seeds, ICAR, New Delhi, also graced the occasion. Tree plantations in and around the campus of DWSR was undertaken to stress the importance of trees in saving the environment. The chairman delivered a lecture on the issues relating to environmental pollution.

Annual Review Meet of NIWS

Annual Review meet of National Invasive Weed Surveillance was organized at TNAU, Coiumbatore on 1st August 2009. All the Area Coordinators, SSIs and SIs of NIWS Programme participated in the meet. During the meet, the work of all the centres was reviewed by the National Coordinator Dr. Jay G. Varshney, Director, DWSR.

Parthenium awareness week

The Directorate observed the *Parthenium* Awareness week from 7-13, August 2009 nationa-wide. The campaign was inaugurated at CSKHPKV, Palampur on 6 August 2009. During the period, DWSR also conducted the eradication programmes along with the release of Mexican beetle on *Parthenium* for making the colony residence aware of *Parthenium* menace and its ill effects. Posters and pamphlets on *Parthenium* were distributed in the city as well as in nearby villages and a quiz programme was also organized for school children of the city.

District level Bio-safety committee meeting

District Bio-technological Committee (DLC), Jabalpur with its Chairman Sh Hari Ranjan Rao, District Collector along with committee members visited the Directorate on 28.08.2009 to monitor the performance of IBSC BRL-1 trial on staked corn being carried out.

Press conference on IBSC trial on GM transgenic staked corn

In view of growing debate in local newspapers on the institute biosafety committee (IBSC) field trial conducted by the directorate on GM transgenic staked corn, DWSR, arranged a Press Conference on 10 September 2009 for on-going IBSC trial to explain the working with respect to the genetically modified crops. About 28 reporters from various news agencies participated in the press conference and raised several important issues relating the GM trial.

Hindi Rajbhasha Pakhwada

The Hindi Rajbhasha Pakhwada was organized at the Directorate from 14-30 September 2009 and the function was inaugurated by the Director of the Directorate. During the period, various Hindi based competitions were organized and the winners were honored.

Laying of the foundation stones of second research wing and staff welfare facility

Secretary, DARE and Director General, ICAR Dr Mangala Rai marked the laying of the foundation stones of second wing for facilitating the research and staff welfare facility on 20 October 2009. On the occasion, Dr. A.K. Singh, Dy. Director General (NRM), Dr. Jay G. Varshney, Director and staff of the DWSR were also present.

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bld vfrfDr fun'kky; e J"B fgUnh e dk; dju gr ,o fgUnh dk dk;y;hu mi;kx c<ku e vge Hkkfedk fuHkku oky vuHkkx gr ÁkR lkgu ;kstuk d vrxr pfyr 'khYM ,o di j[k x; FkA mDr ijLdkjk d p;u gr dk;ky; d pkj mPpkf/kdkfj;k dh lfefr dk xBu fd;k x;k Fkk] lfefr d fu.k;kulkj ijLdkj pfyr 'khYM f"k vfHk;kf=dh ,o dk;'kkyk vuHkkx dk ÁFke LFkku] i{k= vuHkkx f}rh; LFkku] Ø; ,o Hk.Mkj vuHkkx dk rrh; LFkku inu fd;k x;kA fgUnh ikR lkgu ;kstuk d vUrxr o"k Hkj e fun'kky; d vf/kdkfj;k@depkfj;k dk 20]000@& l vf/kd fgUnh 'kCn fy[ku gr uxn iFke ijLdkj d #Ik e 800@& #i;] f}rh; ijLdkj d #Ik e 600@& #i; ,o rrh; ijLdkj d #Ik e 400@& #i; inku fd; x;A bld vfrfjDr 20]000 'kCnk d dk; gr fu.kk;d lfefr d lnL;k dk Hkh lEeku fd;k x;kA

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fun'kky; e ij o"k e jkt Hkk"kk dk;kZo;u lfefr dh pkj =ekfld cBdk dk fnukd 06@07@2009] fnukd 03@09@2009 fnukd 10@09@2009 ,o 07@01@2010 fnukd 12@04@2010 dk fu;fer vk;kstu fd;k x;kA cBdk e jkt Hkk"kk okf"kd dk;Øe e fu/kkfjr y{;k dk ikIr dju rFkk jkt Hkk"kk foHkkx ,o Hkkjrh; f"k vul/kku ifj"kn l ikIr fun'kk@vkn'kk d vuikyu ij ppk dh xb vkj bu cBdk e fy, x, fu.k;k dk ykx dju d fy, dk;okgh dh xbA ftle fun'kky; d vf/kdkfj;k@depkfj;k dk /;ku fgUnh dh ixfr l lcf/kr ckrk ij vkdf"kr fd;k x;k vkj fiNyh frekgh cBdk ij fn; x; vk'okluk dk ijk dju d fy, vkxg fd;k x;kA

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15 DISTINGUISHED VISITORS

Dr. Kaliyan Singh, Head, Agronomy, BHU, Varanasi	05.06.2009
Dr. T.P Trivedi, project Director, DIPA, ICAR, New Delhi	20.06.2009
Dr. D.P. Singh, Former Vice Chancellor (JNKVV) & Chairman, RAC, DWSR	26.06.2009
Dr. S.N. Shukla, Assistant Director General (Crops), ICAR, Krishi Bhawan, New Delhi	26.06.2009
Sh Hari Ranjan Rao, Collector, Jabalpur	28.08.2009
Dr. BS Bisht, Vice Chancellor, GBPUA&T, Pantnagar	06.10.2009
Dr. Mangala Rai, Secretary, DARE & Director General, ICAR, New Delhi	20.10.2009
Dr. A.K. Singh, Deputy Director General (NRM), ICAR, New Delhi	20.10.2009
Dr. Gautam Kalloo, Vice Chancellor, JNKVV, Jabalpur	21.10.2009
Dr. K. Kasturirangan, Member Planning Commission (Science), Govt of India, New Delhi	22.01.2010
Dr. A.K. Verma, Advisor, Planning Commission, Govt of India, New Delhi	22.01.2010
Dr. S.D. Sadamate, Advisor, Planning Commission, Govt of India, New Delhi	22.01.2010
Dr. R.K. Kusmaria, Cabinet Minister for Agriculture, Govt of Madhya Pradesh	23.01.2010
Dr. C.D. Mayee, Chairman, ASRB, New Delhi	18.03.2010





Distinguished visitors at the Directorate

16 PERSONALIA

Dr. Jay G. Varshney — Director

Scientific

Er. H.S. Bisen	Pr. Scientist (Agril. Engg.)
Dr. P.K. Singh	Pr. Scientist (Agril. Extension)
Dr. V.P. Singh	Pr. Scientist (Agronomy)
Dr. Sushilkumar	Pr. Scientist (Entomology)
Dr. Anil Dixit	Pr. Scientist (Agronomy)
Dr. D.K. Pandey	Sr. Scientist (Plant Physiology)
Dr. K.K. Barman	Sr. Scientist (Soil Science)
Dr. R.P. Dubey	Sr. Scientist (Agronomy)
Dr. P.J. Khankhane	Sr. Scientist (Soil Science)
Dr. Shobha Sondhia	Sr. Scientist (Organic Chem.)
Dr. V.S.G.R. Naidu	Sr. Scientist (Economic Botany)
Dr. C. Kannan	Sr. Scientist (Plant Pathology)
Dr. P.P. Chowdhaury	Sr. Scientist (Resi. Chem.)
Dr. Bhumesh Kumar	Sr. Scientist (Plant Physiology)
Dr. C. Sarathambal	Scientist (Microbiology)

Administration, Finance and Accounts

Sh S.L. Harinkhare	AAO
Sh. A.K. Shrivastava	AFAO
Smt Nidhi Sharma	Sr. Steno
Sh. A.K. Bhowal	Jr Steno
Sh. M.K. Gupta	Jr Steno
Sh. J.P. Kori	Assistant
Sh R. Hadge	Assistant
Sh. T. Lakhera	Assistant
Sh. B.P. Uriya	Jr. Clerk
Sh. Francis Xavier	Jr. Clerk

Supporting

Sh. Veer Singh	Messenger (SSG-II)
Sh. A.K. Tiwari	Messenger (SSG-I)
Sh. Shiv K. Patel	Messenger (SSG-I)
Sh. S.L. Koshta	Lab. Attendant (SSG-I)
Sh. J.P. Dahiya	Lab. Attendant (SSG-I)
Sh. Madan Sharma	Lab. Attendant (SSG-I)
Sh. J. Vishwakarma	Lab. Attendant (SSG-I)
Sh. Raju Prasad	Farm Mazdoor (SSG-II)
Sh. Jagoli Prasad	Farm Mazdoor (SSG-II)
Sh. Jagat Singh	Farm Mazdoor (SSG-II)
Sh. C.L. Yadav	Farm Mazdoor (SSG-II)
Sh. Anil Sharma	Farm Mazdoor (SSG-I)
Sh. Ram Kumar	Farm Mazdoor (SSG-I)

Technical

Dr. M.S. Raghuwanshi	T-7-8 (Sr. Technical Officer)
Sh. R.S. Upadhyay	T-7-8 (Farm Manager)
Sh Mukesh Bhatt	T-6 (Artist-cum-Photographer)
Sh. S. Dhagat	T-6 (Technical Officer)
Sh B. Mishra	T-5 (photographer)
Sh V.K.S. Meshram	T-5 (Artist)
Sh G.R. Dongre	T-5 (Draftsman)
Sh O.N. Tiwari	T-5 (Tech. Asstt)
Sh M.P. Tiwari	T-5 (Mechanic)
Sh Pankaj Shukla	T-4 (Tech. Asstt)
Sh. R.N. Bharti	T-4 (Librarian)
Sh S.K. Parey	T-4 (Tech. Asstt)
Sh J.N. Sen	T-4 (Tech. Asstt)
Sh. K.K. Tiwari	T-4 (Field Asstt)
Sh. R.K. Meena	T-4 (Field Asstt)
Sh. M.K. Meena	T-4 (Field Asstt)
Sh. S. K. Tiwari	T-3 (Field Asstt)
Sh. S.K. Bose	T-3 (Field Asstt)
Sh. G. Vishwakarma	T-3 (Field Asstt)
Sh. Ajay Pal Singh	T-3 (Field Asstt)
Sh. Premlal	T-II (Driver)
Sh. D.K. Sahu	T-II (Driver)
Sh. B. Prasad	T-II (Driver)
Sh. Sebasten	T-I (Driver)

Supporting

Sh. Naresh Singh	Farm Mazdoor (SSG-I)
Sh. Gajjulal	Farm Mazdoor (SSG-I)
Sh. S.C. Rajak	Farm Mazdoor (SSG-I)
Sh. Rajesh	Security Gaurd (SSG-I)
Sh. Gangaram	Security Gaurd (SSG-I)
Sh. Santosh Kumar	Security Gaurd (SSG-I)
Sh. Santlal	Security Gaurd (SSG-I)
Sh. Mahendra Patel	Security Gaurd (SSG-I)

Our new colleagues

Dr. Bhumesh Kumar, previously worked at International Centre for Genetic Engineering and Biotechnology, New Delhi, joined as Senior Scientist, Plant Physiology, on 30.06.2009 at this directorate

Ms. Sarathambal. C. joined as Scientist, Agricultural Microbiology, on 20.06.2009 at this Directorate through ARS