Information Bulletin No 20

Technologies on Weed Management




All India Coordinated Research Project on Weed Management
ICAR-Directorate of Weed Research
Jabalpur (M.P.)
(ISO 9001:2008 Certified)


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Cover page

Front:

A. Control of *Echinochloa glabrescens* by bispyribac-Na 25 g/ha in transplanted rice
B. Control of *Phalaris minor* by clodinafop 0.06 kg + metsulfuron 0.005 kg/ha in wheat
C. Weeding by cycle-hoe in soybean
D. Management of *Striga asiatica* by atrazine 1.0 kg/ha (PE) *fb* HW at 45 DAP *fb* earthing up 60 DAP *fb* 1.25 kg 2,4-D Na salt at 90 DAP *fb* trash mulching 5 t/ha at 120 DAP
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Map showing coordinating centres of AICRP-Weed Management

Preface

Weeds are a major biotic constraint limiting agricultural production. The problem is not only location-specific but also highly dynamic. The efforts for managing weeds are going on since time immemorial but the infestations are getting aggravated. This is due to very hardy nature of the weeds, which enable them to adapt to diverse environments. Further, the so-called modern cultivation practices, which involve extensive tillage and use of external inputs like seeds, irrigation water, organic manures, synthetic fertilizers and other agro-chemicals, are also leading to increased weed infestation. The threats posed by herbicide-resistance development in weeds, globalization and introduction of alien invasive weeds, and climate change favouring intense crop-weed competition are also a major concern. Despite the development of effective weed management technologies and their adoption on large areas throughout the country, there is a need for continuous monitoring and refinement of strategies in order to lessen the adverse effect on agricultural productivity, environment and biodiversity.

The launching of the All India Coordinated Research Programme on Weed Control in 1978 (now renamed as AICRP on Weed Management since 2014) was a major step forward by the Indian Council of Agricultural Research to develop location-specific weed management technologies and their demonstration on the farmers' fields. This network programme with initially six centres gradually expanded to 23 centres at present in all the major State Agricultural Universities throughout the length and breadth of the country. Over the years, integrated weed management technologies have been developed by all centres to solve location-specific problems, and their adoption has led to significant gains in crop productivity. In fact, weed management technologies are the most demanding in the present context in view of the large-scale labour scarcity for manual weeding and increased cost of cultivation.

All centres of AICRP-WM have brought out various documents highlighting the research achievements, technologies developed and success stories in their respective state/ region. Recommendations on weed management have been included in the 'Package of Practices' brought out by the Agricultural Universities and State Department of Agriculture. In order to share and disseminate the most innovative technologies on weed management, it was proposed in 2012 to bring out a compilation on the most important technologies developed at each centre based on several years of research. It was decided to give major emphasis on the most emerging problems of the region and present the write-up on each technology in a systematic manner under the heads: significance of the problem, technology developed, applicability, economic benefits, impact and precautions in adoption of the technology. It was desired that the details are presented in an effective manner along with suitable data and photographs for easy understanding by the stakeholders including the farming community.

I am happy to note that more than three years of continuous efforts have led to collection of valuable information from different centres of the project. The editors have presented the information in a logical sequence, i.e. crop and theme-wise for each centre. I am sure that 83 technologies on weed management included in this document will be beneficial to all our stakeholders including the scientists, field functionaries and farmers for solving the weed related problems and reducing loss in crop productivity. Comments as well as suggestions for further improvement will be highly appreciated.

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Dated: 05 December, 2015

Contents

1.0 Weed management in rice

1.1 Rice nursery

1.1.1 VB, Sriniketan

Weed management in rice nursery and main field

Significance: Farmers from different areas in West Bengal express their concern on the problem caused by weeds particularly where rice-rice system is followed. Many farmers are compelled to discard nursery beds owing to severe infestation of *Echinochloa* sp. Effective herbicides are needed to manage weeds in nursery and the main field also.

Technology: Apply herbicide bispyribac-Na 25 g/ha as early post-emergence (15 DAS) both in nursery and the main field to control most of the grassy and some broadleaved weeds.

Heavy infestation of *Echinochloa glabrescens* in the main field

Bispyribac-Na 25 g/ha as early post-emergence in transplanted rice

Applicability: This technology is applicable to wide range of agro-ecological situations both in *boro* and *aman* rice.

Economic benefits: On an average 725 kg additional rice yield and net returns of ` 9200/ha are obtained.

Impact: Due to adoption of improved weed management technology, the weeds are being managed satisfactorily and rice productivity has been improved. The farmers are also satisfied to have a weed-free nursery bed.

Precautions: Application of herbicide in proper dose, method and stage of crop growth should be ensured.

1.2 Transplanted rice

1.2.1 AAU, Jorhat

Weed management in summer (*boro*) rice

Significance: *Boro* (summer) rice is an important crop in Assam and the productivity is comparatively higher than in other seasons. In recent years, the crop is gaining importance in view of the development of shallow tube-well irrigation facility and recurrent flood devastation causing severe damage to *Sali* rice crop. Hence, there is the utmost necessity to develop efficient weed management technology for *boro* rice farmers.

Technology: Apply butachlor 1.0 kg/ha or pretilachlor 0.75 kg/ha as pre-emergence (0-3 DAT) followed by paddy weeder at 30 DAT for weed control in *boro* rice.

Weed management in *boro* rice

Treatment	Weed dry weight at 60 DAT (g/m^2)		Grain yield (t/ha)		Benefit : cost ratio	
	On-station	*On-farm	On-station	*On-farm	On-station	*On-farm
Farmer's practice (butachlor 0.75 kg/ha)	6.0	5.1	1.5#	3.19	0.75#	1.48
Butachlor 1.0 kg/ha PE *fb* paddy weeder 40 DAT	4.7	3.0	2.8	3.91	1.27	1.78
Pretilachlor 0.75 kg/ha PE *fb* paddy weeder 40 DAT	2.9	2.9	2.9	3.68	1.32	1.68

*On-farm data are mean of seven locations over 2 years (2006 and 2007)

Applicability: Areas having accessibility to shallow tube well and partly to the lift irrigation water during summer season. Unlike winter rice, weed management practices varying from mechanical to chemical methods are widely followed.

Economic benefits: Pre-emergence application of butachlor 1.0 kg/ha or pretilachlor 0.75 kg/ha, and working with rotary paddy weeder at 40 DAT has given higher yield and economic returns than the farmers' practice.

Impact: The *boro* rice crop has become very popular in the areas with developed irrigation facilities. The technology is well adopted by almost all the farmers in those areas.

Precautions: The herbicide should be applied at the right dose and right time to get the desired result.

1.2.2 CCSHAU, Hisar

Weed management in transplanted rice

Significance: Weeds in transplanted rice are responsible for 10-70% loss in grain yield. Grassy weeds start to germinate from the day of transplanting and after 15-20 days, broadleaved weeds and sedges start to infest the crop causing huge loss in grain yields.

Technology: For controlling complex weed flora in transplanted rice, apply butachlor 1.5 kg/ha, anilofos 400 g/ha, oxadiargyl 50 g/ha or pretilachlor 1.0 kg/ha at 3 days after transplanting (DAT), and for the control of broadleaved weeds, sedges and semi-aquatic weeds, ready mix formulation of metsulfuron + chlorimuron 4 g/ha + 0.2% surfactant or ethoxysulfuron 18.75 g/ha or 2, 4-D ester/amine at 500 g/ha at 20-25 DAT using 500 litres of spray volume.

Pretilachlor 1.0 kg/ha at 3 DAT

Applicability: Rice growing farmers in Haryana.

Economic benefits: These herbicides provide 95% control of weeds with no crop suppression. Pretilachlor is the preferential choice of 71% farmers. Use of these herbicides in rice crop brought out net saving of ` 666.4 crores in a year due to 20% yield gain.

Impact: During *kharif* 2010, rice crop was transplanted on 10.54 lakh ha area, out of which 9.03 lakh ha (85.7%) was treated with herbicides. Rice growing farmers in Haryana have adopted this technology on large scale.

Precautions: Herbicide should be applied at recommended stage, dose and with proper water quantity.

1.2.3 GBPUAT, Pantnagar

Use of herbicides in transplanted rice

Significance: In Uttarakhand, rice, wheat, sugarcane, soybean, maize and potato are the dominant crops. In plains, most of the area is under transplanted rice. The major weeds in rice are: *Echinochloa colona, E. crus-galli, Leptochloa chinensis, Panicum repens* among the grasses, *Alternanthera sessilis*, *Caesulia axillaris*, *Ammania baccifera* and *Commelina difusa* among the broadleaved, and *Cyperus iria*, *C. difformis* and *Fimbristylis milliacea* among the sedges. Yield loss due to weeds range from 30-35% in transplanted rice. Herbicides are in demand for weed control in transplanted rice.

Technology: Apply butachlor 1.5 kg/ha or anilofos 400 g/ha or pretilachlor 0.75 kg/ha followed by chlorimuron-ethyl + metsulfuron-methyl 4 g/ha or oxadiargyl 100 g/ha as pre-emergence after transplanting or bispyribac-Na 20 g/ha as post-emergence (15-20 DAT). Depending upon weed infestation and species composition, 2, 4-D 500 g/ha or chlorimuron-ethyl + metsulfuron-methyl 4 g/ha as post-emergence (25-30 DAS) should be applied to control sedges and broadleaved weeds or two manual weeding should be done at 25 and 45 DAT.

Bispyribac-Na 20 g/ha at 15-20 DAT

Pretilachlor 750 g/ha *fb* HW at 20 DAT

Applicability: This technology can be used in transplanted rice following ZT wheat during *rabi* and ZT cowpea during summer season in Uttarakhand.

Economic benefits: Highest B: C ratio was obtained with application of anilofos 400 g/ha as pre-emergence *fb* chlorimuron-ethyl + metsulfuron-methyl 4 g/ha as post-emergence, whereas lowest was obtained with farmer's practice.

Impact: The application of pretilachlor *fb* chlorimuron-ethyl + metsulfuron-methyl, produced the highest grain yield (5.16 t/ha) and weed control efficiency which was followed by application of bispyribac-Na (5.01 t/ha) as compared to farmer's practice (4.82 t/ha).

Precautions: Herbicide should be applied at recommended stage, dose and with proper water quantity.

1.2.4 OUAT, Bhubaneswar

Weed management in transplanted rice

Significance: Rice is not only the staple food but plays a pivotal role in the economy of the state. The productivity of the wet season rice is low as weeds pose serious menace in limiting the production. The weed flora in transplanted condition consists of all groups of weeds causing yield reduction. The effective control of weeds at initial stages will help in increasing the rice yield. Though use of herbicides is gaining popularity among the farmers due to scarcity of labour at peak period of crop growth, the choice of suitable low-volume herbicide is a major problem in many cases. Therefore, application of low volume selective post-emergence rice herbicides will play an important role in managing the weeds.

Technology: Apply bispyribac-Na 20 g/ha + (chlorimuron + metsulfuron) 4 g/ha post-emergence at 25 DAT (3-4 leaf stage) to obtain higher weed control and rice yields.

Bispyribac-Na 20 g/ha + (chlorimuron + metsulfuron) 4 g/ha at 25 DAT

Weedy check at 60 DAT

Effect of herbicide at 60 DAT

Applicability: All transplanted rice growing areas of the state.

Economic benefits: Highest net returns of ` 21478/ha and B:C ratio 2.85 were obtained from post-emergence application of bispyribac - Na + (chlorimuron + metsulfuron), followed by bispyribac-Na + ethoxysulfuron (` 20713/ha ; 2.85).

Impact: Highly beneficial under conditions of unavailability of labour in peak period of crop growth and easier application in controlling diverse weed population.

Precautions: The low volume herbicides should be applied after preparation of proper stock solution with due calibration.

1.2.5 TNAU, Coimbatore

Weed management in transplanted rice

Significance: Weeds are the most severe and widespread constraint in rice production and responsible for heavy yield losses to the extent of complete crop loss under extreme conditions. In transplanted rice, the most serious weeds include grassy weeds viz. *Echinochloa crus-galli*, *Panicum repens* and the dominant sedge *Cyperus difformis*. Among the broadleaved weeds *Eclipta alba*, *Ammania baccifera* and *Marsilea quadrifoliata* are the dominant species. These weeds are well adapted to the aquatic environment, capable of rapid growth, multiplication and very competitive with rice crop. The similarity of some weeds to rice such as *Echinochloa* sp. at early stages of growth makes it very difficult for farmers to distinguish them at the time of hand weeding. Weed control in transplanted rice by cultural methods is expensive. Use of herbicide is labour and time saving technology to control weeds in transplanted rice and it resolves the problem of weed control during peak period of labour crisis. As compared to mechanical and cultural methods of weed control, herbicide use is more effective in controlling weeds and reduces the losses in yield. The loss in grain yield due to unchecked weed growth throughout the crop growth period was estimated to be 62.6% in transplanted rice. Reduction of grain yield due to weed infestation ranges from 17.0 to 86.7% depending upon weed species and infestation level.

Technology: Apply butachlor 1.0 kg/ha on 3rd day after transplanting (DAT) followed by finger type double row rotary weeder weeding on 45 DAT.

Butachlor 1.0 kg/ha + rotary weeder weeding

Applicability: This recommendation is suitable for 3.3 lakh ha of transplanted rice area under Tamil Nadu.

Economic benefits: With the area of adoption and the yield increase, the increased production will be 5.86 lakh tonnes and an income increase of nearly ` 642 crores at current prices.

Impact: Nearly, 69% of the farmers are adopting the technology. The difference in yield was 465 kg/ha, which was 16.5% more than the farmer's practice.

Precautions: Do not drain the water immediately after the application of herbicide and also avoid trampling in to the field.

1.2.6 UAS, Bengaluru

Post-emergence herbicide in transplanted rice

Significance: In transplanted rice a broad spectrum post-emergence herbicide which can be applied at 2-4 leaf stage of weeds is very much in demand from the farmers facing labour constraints during peak period of manual weeding, since paddy is transplanted at a time in large area in command areas after the release of canal water.

Technology: Apply bispyribac-Na 20 g/ha at 2-4 leaf stage of weeds followed by one hand weeding at 45 DAT.

Bispyribac-Na 20 g/ha application at 20 DAT

Applicability: This technology of new herbicide has been recommended for Zones 7 and 10 of Karnataka.

Economic benefits: Post-emergence application of bispyribac-Na 20 g/ha at 2-4 leaf stage of weeds *fb* one hand weeding at 45 DAT gave higher grain yield, net returns and B : C ratio (5.08 t/ha, ` 28497/ha and 1.88) compared with two hand weedings (4.75 t/ha, ` 22989/ha and 1.67).

Impact: Adoption of this technology by farmers was very quick since bispyribac-Na is broad-spectrum herbicide controlling grasses and broadleaved weeds effectively in addition to saving in weeding cost (`1657/ha) compared to manual weeding during peak period of labour demand.

Precautions: Post-emergence herbicide should be applied at the recommended dosage at 2-4 leaf stage of weeds.

1.2.7 VB, Sriniketan

Weed management in wet season transplanted rice

Significance: Rice is the main crop of West Bengal. Severe infestation of grassy as well as sedges occurs in different rice ecosystems depending on the intensity and distribution of rainfall in rainy season. Timely weed management through manual weeding becomes difficult owing to non-availability of labour in peak period of demand. Recently, even under usual conditions availability of labour is a big concern because of their engagement in MGNREGS.

Technology: Apply pretilachlor 0.75 kg/ha pre-emergence *fb* hand weeding for weed control in transplanted rice in wet season.

Pretilachlor 0.75 kg/ha *fb* hand weeding

Applicability: Applicable in wide range of agro-ecological situations under transplanted rice.

Economic benefits: Following this technology, an additional yield and net returns of about 500 kg/ha and ? ` 6200/ha, respectively was obtained.

Impact: The farmers are satisfied by adopting this technology of weed management. Earlier the major weed management practice followed by the farmers was hand weeding. In most of the cases, the major share of cost of cultivation was for manual weeding. But the cost of new technology is much less than that of earlier existing practices. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Sufficient water depth should be maintained immediately after application of herbicides for their effectiveness. Application of herbicide with proper dose, method and at recommended stage of crop growth should be ensured.

1.3 Direct-seeded rice

1.3.1 PJTSAU, Hyderabad

Weed management in aerobic rice

Significance: Aerobic rice cultivation is highly suitable for the tail-end areas of the canal and tank commands which usually witness late release coupled with inadequate supply of water required for transplanting of rice.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence, or herbicide combinations of cyhalofop-p-butyl 75 g/ha + (metsulfuron-methyl + chlorimuron-ethyl) 4 g/ha post-emergence (25 DAS) for effective and economic weed management in aerobic rice.

Cyhalofop-butyl + (chlorimuron-ethyl + metsulfuron- methyl) at 25 DAS

Applicability: This technology can successfully be adopted by the farmers in the tail-end areas of the canal and tank commands.

Economic benefits: 35-40 labour days can be saved by adopting the herbicide usage (pre and post- emergence) and crop can be saved from weed competition up to 35-40 DAS.

Impact: The farmers growing aerobic rice have started using these herbicides.

Precautions: Herbicides should be applied at recommended stage, dose and with proper water quantity.

1.3.2 BAU, Ranchi

Weed control in direct-seeded rice

Significance: The total area under rice cultivation in Jharkhand accounts for nearly 16 lakh ha, out of which nearly 40% is under direct-seeded upland condition. Farmers usually broadcast seeds of rice few days before onset of monsoon. As the monsoon rain starts, rice seeds start germinating but at the same time annual weed seeds also start germinating giving severe competition to rice crop. This results in 60 to 70 % loss in the yield of rice. Sometimes the loss is so heavy that farmers do not get the price of seeds that was sown. Effective weed control in direct-seeded rice is very much required.

Technology: Apply butachlor 1.5 kg/ha pre-emergence followed by mechanical weeding by wheel hoe at 30 days after sowing for higher productivity and profitability.

Weedy check

Butachlor 1.5 kg/ha *fb* mechanical weeding

Applicability: For weed control in direct-seeded upland rice in Jharkhand state.

Economic benefits: Farmers practice of weed control i.e. manual weeding at 25 and 45 days after sowing costs nearly ` 5000 to 6000 /ha, while application of butachlor 1.5 kg/ha costs nearly ` 500/ha without reduction in crop yield. Thus, there is net saving of ` 4500 to 5,500/ ha.

Impact: Due to escalating cost of labour and their non-availability in Jharkhand, as well as massive extension programme by AICRP on Weed Management, Ranchi centre, now farmers are opting for chemical methods of weed control.

Precautions: Farmers found butachlor safe for application in rice and are using frequently in their field not only in rice but also in other crops. There is fear that by repeated use of this herbicide in the same field, some resistant weeds may emerge. Hence, farmers have been advised to rotate the herbicide with pretilachlor, pendimethalin and other pre-emergence herbicides.

1.3.3 GBPUAT, Pantnagar

Use of herbicides in direct-seeded rice

Significance: In Uttarakhand, rice, wheat, sugarcane, soybean, maize and potato are the dominant crops. Rice is grown either as transplanted or direct-seeded. Direct-seeded rice (DSR) occupies around 34.5% area in the hill zone of the state. The major weeds in direct-seeded rice are *Cynotis axillaris*, *Digitaria sanguinalis, Dactyloctenium aegyptium, Celosia argentea, Cucumis* spp. and *Physalis minima*. The loss in yield caused due to weeds ranged between 90-100%.

Technology: Apply pendimethalin 1.0 kg/ha (0-3 DAS) or anilofos 400 g/ha (7-10 DAS) or oxadiargyl 100 g/ha as pre-emergence. For control of weeds at later stage, apply bispyribac-Na 20 g/ha (20-25 DAS) or metsulfuron-methyl 4 g/ha (25-30 DAS) or hand weeding or mechanical weeding should be done, if needed (at 20-25, 40-45 and 60-65 DAS).

Herbicide applied zero-tilled direct-seeded rice crop

Treatment	Dose (g/ha)	WCE at 60 DAS (%)	B:C ratio
Bispyribac-Na	25	75.9	0.69
Pendimethalin *fb* bispyribac-Na	1000 *fb* 25	97.5	2.85
Oxadiargyl *fb* bispyribac-Na	25 *fb* 100	96.9	2.72
Pyrazosulfuron *fb* bispyribac-Na	20 *fb* 25	76.8	0.85
Pendimethalin *fb* bispyribac+HW	1000 *fb* 25+45 DAS	98.6	1.91
Pendimethalin *fb* HW	1000	89.8	1.95
Bispyribac-Na (chlorimuron+metsulfuron)	20+4	53.5	0.59
Mechanical weeding (3)	Cono-weeder	33.9	0.72
Hand Weeding (3)	20,40 & 60 DAS	95.1	0.93
Weedy check	-	-	-

Applicability: Pendimethalin can be used in DSR (CT & ZT)-based cropping systems.

Economic benefits: Application of pendimethalin *fb* bispyribac-Na (1000 *fb* 25 g/ha) + one hand weeding at 45 DAS gave the highest weed control efficiency. Pendimethalin *fb* bispyribac-Na (1000 *fb* 25 g/ha) and oxadiargyl *fb* bispyribac-Na (1000 *fb* 25 g) also gave satisfactory weed control. Pendimethalin *fb* bispyribac-Na 1000 *fb* 25 g/ha provided highest B:C ratio (2.85) followed by oxadiargyl *fb* bispyribac- Na 100+25 g/ha (2.72).

Impact: Farmers are convinced with the technology and adopting it.

Precautions: Herbicide should be applied at recommended stage, dose and with proper water quantity.

1.3.4 IGKV, Raipur

Weed management in traditional *biasi* method of rice cultivation

Significance: *Biasi* (*Beushening*) method of rice cultivation is very popular and widely adopted practice of direct-seeded rice in Chhattisgarh. Farmers prepare the field and broadcast the seed at the onset of monsoon and allow the crop and weeds to grow up to *biasi* operation which is generally carried out at 30-35 DAS, when there is sufficient impounded water in the field. So there is initial crop-weed competition for 30-35 days, and it may increase during the ill distribution of rainfall. Crop-weed competition at initial growth period of crop may result in to great loss in grain yield of rice. Application of pre-emergence herbicides could reduce the initial crop-weed competition and use of post-emergence herbicides could reduce the crop-weed competition under delayed *biasi* or no *biasi* situation.

Technology: Weed management by herbicides (pyrazosulfuron 25 g/ha pre-emergence, fenoxaprop 60 g/ha, chlorimuron + metsulfuron 4 g/ha and bispyribac-Na 20 g/ha) in traditional *biasi* method of rice cultivation.

Existing method of *Beushening* (*Biasi*)

Effect of pre-emergence herbicide on weeds in DSR

Applicability: The applicability of this technology is in mid-land and low-land conditions of rice cultivation.

Economic benefits: An average saving of ` 3000-3500/ha has been observed at farmer's fields where this technology has been adopted.

Impact: The release of this technology by AICRP-WM Raipur centre coupled with its demonstration by KVKs, Department of Agriculture, NGOs, herbicide industry, input dealers and many other agencies have substantially popularized the use of herbicides in direct-broadcast rice cultivation. The most popular herbicides in use in this system of rice cultivation are pyrazosulfuron, fenoxaprop, chlorimuron + metsulfuron. The increase in consumption of the above herbicides in the state in last five years is nearly 75, 95, and 90%, respectively. Bispyribac-Na has also gained similar kind of growth. The increase shown itself explains about the impact of technology released by the project.

Precautions:

- Timely operations like sowing, weeding.
- Application of recommended herbicide, doses, proper nozzle and at right stage of weed.
- Use of standard herbicide and non-expired material.
- Precautions during herbicide spraying.

1.3.5 NDUAT, Faizabad

Integrated weed management in direct-seeded rice

Significance: Rice is one of the very important crops of *kharif* season grown in more than 70% of cultivated area in eastern U.P., mainly by the transplanting method. However, under the changing scenario, now farmers are keen to shift towards the direct-seeded rice especially under wet conditions. Because of the severe weed infestation, harnessing of better productivity of the DSR is a problem and profitability is declining.

Technology: Intercrop rice with *dhaincha* and apply pendimethalin 1.0 kg/ha pre-emergence *fb* use of 2, 4-D 0.5 kg/ha post-emergence at 40 DAS.

***Dhaincha* + pendimethalin 1.0 kg/ha (PE) *fb* 2, 4-D 0.5 kg/ha (POE) at 40 DAS.**

Applicability: Farmers growing direct-seeded rice in eastern U.P.

Economic benefits: Yield increase due to the technology was recorded up to 54% higher over weedy check, higher net return of (` 28700) and B: C ratio (2.92) was recorded.

Impact: After dissemination of the technology through FLDs and field visits, farmers were convinced to use this technology. About 16 % of rice area in the eastern U.P. is under DSR (wet) and farmers have started to follow this technology to control the weeds effectively. By using this technology, in addition to weed control through smothering effect, organic matter is also being added into soil.

Precautions: 2, 4-D at 0.5 kg/ha must be applied not later than 40 DAS to kill *dhaincha*.

1.3.6 OUAT, Bhubaneswar

Weed management in direct-seeded rice

Significance: Direct-seeded rice (DSR) is gaining popularity in the state of Odisha as it eliminates many farm operations like nursery raising, puddling and transplanting, thereby reducing the cost of production. Heavy weed infestation is the major bottleneck in the production of the direct-seeded rice. The losses may range in between 50-100%, depending on the severity of the weed problems. Farmers use some pre-emergence herbicide to control the weeds. But it is difficult to raise weed-free DSR with the application of only one herbicide. Therefore, an effective combination of one pre and post-emergence herbicide application is warranted for weed control in these situations.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence *fb* bispyribac-Na 25 g/ha at 20 DAS.

Pendimethalin 1.0 kg *fb* bispyribac-Na 25 g/ha

Weedy condition

Applicability: All direct-seeded rice growing area of the Odisha state.

Economic benefits: Highly beneficial under non-availability of labour during peak period of crop growth and helping in eliminating the weeds which are morphologically similar to rice.

Impact: Highest net return and B:C ratio of ` 18900/ha and 1.78 were obtained from application of pendimethalin 1.0 kg *fb* bispyribac-Na 25 g/ha.

Precautions: The pre-emergence herbicide should be applied within 2 days of sowing of crop or 24-48 hrs after cessation of rain and the post-emergence herbicide at 20 DAS.

1.4 System of Rice Intensification (SRI)

1.4.1 PJTSAU, Hyderabad

Weed management in SRI/ drum-seeded rice

Significance: System of rice intensification (SRI)/drum-seeded rice (DSR) holds promise for the rice growing regions of the Andhra Pradesh and Telangana states, especially in middle and tail-end reaches of the canal commands, tank command areas and small-irrigation projects in view of the significant savings in water and higher yields. However, weed management is a crucial factor for achieving desired results, as the soil will be maintained at saturated state during most of the crop growth period which provides relatively more favorable conditions for the weeds to be established compared to conventional transplanted rice. Hence, identification of cost-effective, efficient weed management strategies is very essential for popularizing this technology.

Technology: Apply pyrazosulfuron-ethyl 25 g/ha as pre-emergence (3-5 DAT) *fb* mechanical weeding/ hand weeding at 35-40 DAT for effective weed control in SRI.

Weedy check

Pyrazosulfuron 25 g/ha at 5 DAS

Weed management in drum-seeded rice

Weedy check

Pyrazosulfuron 25 g/ha at 5 DAS

Weed management in SRI

Applicability: This technology is suitable for SRI, drum-seeded rice grown in Andhra Pradesh and Telangana states.

Economic benefits: This technology helps in establishment of the crop in weed-free condition and also saves 25-30 labour days/ha. Economic value of this saving could be ` 6250-7500/ha.

Impact: The area under drum-seeded rice has increased to more than 1.0 lakh ha in both the states and this recommendation is widely adopted by the farmers in view of the weed control efficacy and cost-effectiveness.

Precautions: Herbicide dose and time of application should be done as per the recommendation.

1.4.2 VB, Sriniketan

Integrated weed management in rice under SRI

Significance: Rice is grown normally as transplanted crop in West Bengal. Transplanting is done in the month of July which necessitates raising of nursery bed one month earlier. The alternative method of rice establishment i.e. SRI (System of Rice Intensification) is gaining popularity and spreading in different rice growing areas. This system offers several advantages like earlier transplanting, earlier crop maturity by 7-10 days and often higher yield and profit with less water. One of the important requirements of SRI is assurance of root aeration. Only the use of herbicide may not be sufficient both for root aeration and weed control point of view. Again only mechanical weeding may encourage some weeds which propagate vegetatively. In this perspective integrated use of pyrazosulfuron-ethyl and cono-weeder was found promising for effective weed control under SRI.

Technology: Integrated use of pyrazosulfuron-ethyl at 25 g/ha (PE) *fb* mechanical weeding (cono-weeder) in rice under SRI.

Integrated use of pyrazosulfuron-ethyl at 25 g /ha *fb* cono-weeder under SRI

Applicability: Technology is applicable under SRI where assured water supply and controlled water management is possible.

Economic benefits: By adopting this technology farmers get on an average 790 kg/ha extra rice grain yield with a net benefit of ` 10,530/ha.

Impact: The technology is time and cost effective and sustainable in management of natural resource point of view. Timely weed management by this technology checks the loss of water and nutrient removed by the weeds, and thus increases water and fertilizer use efficiency. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Maintenance of proper depth of water is essential at the time of application of herbicide and cono-weeder. Application of herbicide with proper dose, methods and at right stage of crop growth should be ensured.

1.5 Specific weed problems in rice

1.5.1 KAU, Thrissur

Control of *Echinochloa* spp.

Significance: *Echinochloa* (commonly known as barnyard grass, jungle rice etc.) is the most serious grass weed in rice fields of Kerala. Different species of *Echinochloa* are seen in Kerala, adapted to different agro-climatic conditions. *E. colona* is typical of upland and semi-dry rice, whereas *E. crus-galli* and *E. glabrescense* are seen in low land rice. *E. stagnina* is predominant in the back water regions where tidal action results in intrusion of saline water from the sea. As these weeds mimic rice seedlings, it is not easy to control them by manual weeding. Moreover, there is acute shortage of labourers, and the labour charges are very high preventing large scale hand weeding. Therefore, herbicidal control seems to the viable option.

Technology: Post-emergence application of the following herbicides should be done for effective control of *Echinochloa* spp.

Herbicide	a.i. (g/ha)	Commercial product (dose/ha)	Time of application
Cyhalofop-butyl	80-100	800 - 1000 ml	15 – 20 DAS
Fenoxaprop-p-ethyl	60.38	875 ml	20 – 25 DAS
Bispyribac-Na	25	250 ml	15 – 20 DAS
Azimsulfuron	35	70 g	15 – 20 DAS
Penoxsulam	25	100 ml	15 – 20 DAS

Cyhalofop applied plot *vs* unsprayed control

Applicability: The technology is applicable to all methods of rice culture (Dry-seeded, wet-seeded and transplanted). No serious phytotoxicity is noticed on rice seedlings.

Economic benefits: Farmer can save about `10000 – 15000, on the expenses for weed control. In addition, the increase in grain yield of rice will be worth ` 30000 – 50000/ha.

Impact: For effective control of *Echinochloa* spp. at affordable cost and without any adverse effect on rice, almost 70 - 75% of the rice farmers have adopted this technology.

Precautions:

1. Apply the herbicide at correct stage and correct dose.
2. Cyhalofop and fenoxaprop are effective against grass weeds only. For controlling sedges and broadleaved weeds follow up application of a suitable herbicide is needed.

1.5.2 KAU, Thrissur

Control of *Leptochloa chinensis*

Significance: *Leptochloa chinensis* (Chinese sprangletop) has become a major problem weed in rice during the recent years. Till a decade back, it was a problem only in the soils of alkaline pH, but during the last few years it is seen invading the rice fields of acid soils, which constitute the major portion of rice area in Kerala. The weed mimics the rice crop during early stages, hence it was found difficult to manage by hand weeding.

Technology: Post-emergence application of the following herbicides should be done for effective control of *Leptochloa chinensis*.

Herbicide	a.i. (g/ha)	Commercial product (dose/ha)	Time of application	Remarks
Cyhalofop-butyl	100	1000 ml	15 – 20 DAS	Very effective
Fenoxaprop-p-ethyl	60.38	875 ml	20 – 25 DAS	Very effective
Azimsulfuron	35	70 g	15 – 20 DAS	70 - 80%
Penoxsulam	25	100 ml	15 – 20 DAS	Partial control

No weed control by bispyribac-Na

Total weed control by Cyhalofop *fb* Almix

Applicability: The technology is very effective for selective control of *Leptochloa chinensis* in rice fields.

Economic benefits: Compared to manual weed control (approximate cost: ` 35000/ha), this technology is very cost effective (cost ` 5000/ha). Moreover, manual weed control is difficult to practice on time, due to shortage and high wages for labourers.

Impact: The farmers have successfully adopted the technology and are expressing satisfaction.

Precautions: The herbicides, cyhalofop and fenoxaprop are effective against grass weeds only, including *Leptochloa chinensis.* For a field with mixed flora of weeds, a follow-up application with a herbicide effective against sedges and broadleaved weeds is essential to get control of all weeds. On the contrary, azimsulfuron and penoxsulam are effective against sedges and broadleaved weeds also, although they do not give 100% control of *Leptochloa chinensis.* Therefore, in areas where *Leptochloa* is not the main problem, these broad spectrum herbicides should be preferred.

1.5.3 KAU, Thrissur

Control of weedy rice

Significance: Weedy rice (*Oryza sativa f. spontanea)* refers to the weedy population of annual *Oryza* species that competes with cultivated rice and reduces its yield and quality. Because of the morphological and biochemical similarity to cultivated rice, it is very difficult to manage the weed by hand weeding or by using herbicides. In field with severe infestation of weedy rice, yield reduction by 50 – 100 % is noticed; and many farmers had to abandon the crop without harvesting.

Technology: Stale-seedbed technology has been found effective to reduce the problems of weedy rice. The steps in the technology are given below.

a. Flood the field for one week after harvest of the crop
b. Drain the water and allow soil seed bank to germinate for 15 – 20 days
c. Destroy the germinated seedlings by dry ploughing
d. Flood the field after one week for wet ploughing
e. Drain the field to germinate soil seed bank and destroy them after ten days by application of glyphosate 0.8 kg/ha
f. Flood the field after 8 – 10 days after application of lime 100 – 150 kg/acre to prevent build up of acidity during next crop season

Flooding after harvest (1 week)

Germination from soil seed bank (15-20 days)

Dry ploughing (10-15 days)

Wet ploughing

Germination from soil seed bank

Flooding till sowing (10-15 days)

Applicability: The technology is applicable in both lowland and upland rice, if there is a gap of about one month between the two crops of rice. If the gap is more, the operation can be repeated to get better results.

Economic benefits: Even though farmer has to spend some amount for the stale-seedbed preparation, he can get rid of the severe problems of weedy rice which threatens to stop rice cultivation.

Impact: Many farmers who were finding it difficult to continue rice cultivation, due to the severe incidence of weedy rice have adopted the technology and got benefitted. Understanding the benefits of the technology, some farmers with very severe incidence of the weed have skipped rice in one season and adopted repeated stale- seedbed preparation to get rid of the problem.

Precautions: Don't go for deep ploughing after preparing stale- seedbed, as it is likely to bring the buried seeds of the weedy rice from the lower layers of the soil surface.

1.5.4 VB, Sriniketan

Control of *Marsilea quadrifolia*

Significance: In West Bengal, tractor and power tiller have been used extensively since last one decade. As a result of which the problem of vegetatively propagated weeds like *Marsilea, Cardenthera, Jussia* etc. is increasing. Hand weeding further aggravates the problem of these weeds. *Marsilea quadrifolia* is a big menace in low to medium land rice-rice system where power tiller/tractor is used intensively. Using power tiller/tractor, the stems are broken into many fragments which individually appear as separate plant. Farmers are not able to tackle these weeds through manual weeding. This necessitates the use of improved technology through herbicide metsulfuron-methyl + chlorimuron-ethyl 4 g/ha which was successful in managing such problematic weeds.

Technology: Apply metsulfuron-methyl + chlorimuron-ethyl 4 g/ha at 20 DAT for control of *Marsilea quadrifolia* in rice.

***Marsilea* infested plot**

Metsulfuron-methyl + chlorimuron-ethyl 4 g/ha

Applicability: Technology is very effective and applicable for management of *Marsilea quadrifolia* and other broadleaved weeds under low to medium land situations and other vegetatively propagated weeds in transplanted rice which are difficult to control manually.

Economic benefits: An additional grain yield of 625 kg/ha and net return of ₹ 8800/ha is gained by the farmers by using the technology.

Impact: The new technology of weed management has been adopted by the farmers to manage the weed problem particularly *Marsilea* and other low land weeds propagated vegetatively. About 8.2% area under rice cultivation is covered by this technology with an additional net return of about ₹ 134 million per year. Farmers have regained confidence in cultivation of rice by satisfactory control of these weeds under rice-rice cropping system.

Precautions: Application of herbicide with proper dose, methods and at appropriate stage of crop growth should be ensured.

2.0 Weed management in wheat

2.1 CCSHAU, Hisar

Management of herbicide resistance in *Phalaris minor* against isoproturon

Significance: Isoproturon, a phenyl-urea, relatively inexpensive herbicide was recommended to control *P. minor* in 1977, which continued to provide effective control of the weed up to 1990, its consumption also increased to 1200 MT. After 1990-91, lot of complaints about poor or no efficacy of isoproturon against *P. minor* continued to pour from different parts of Haryana, especially Karnal, Kurukshetra, and Ambala, Kaithal, Panipat and Jind areas where rice-wheat is the predominant crop rotation and isoproturon was being used continuously more than 10-12 years. Initially resistant populations were mostly found on farms practicing rice-wheat rotation for more than 8 years. Subsequently, resistant population of *P. minor* infested other rotations such as cotton-wheat and clusterbean-wheat in the dry central regions of Haryana as well. Recommendation of isoproturon was withdrawn for use in resistance affected areas. New herbicides viz. clodinafop-propargyl, sulfosulfuron and fenoxaprop were recommended to control resistant population of *P. minor* after thorough testing at various locations. These herbicides showed excellent efficacy against resistant biotypes. During 1996-97, after the use of these herbicides, wheat yields again shot up.

Technology: Apply new post- emergence herbicides clodinafop-propargyl 60 g/ha, sulfosulfuron 25 g/ha, fenoxaprop 120 g/ha, mesosulfuron + iodosulfuron 14.4 g/ha, sulfosulfuron + metsulfuron 32 g/ha at 30-35 DAS in wheat to control isoproturon resistant *P. minor*.

***P. minor* being removed from wheat fields**

***P. minor* controlled by herbicides**

Applicability: Wheat growing area where resistance to isoproturon in *P. minor* has been established.

Economic benefits: Wheat yield increase of 1-2 t/ha.

Impact: During 2009-10, area under wheat crop in the state was 25.18 lakh ha out of which 69.8% area was treated by clodinafop, sulfosulfuron, sulfosulfuron + metsulfuron (RM), mesosulfuron + iodosulfuron (RM) herbicides. Based on herbicide consumption data of 2010, net gains from use of wheat herbicides in Haryana state was found to be □2233.6 crores by taking into account a loss of 2.03 million tonnes of wheat due to weeds.

Precautions: Over- lapping of herbicide spray should be avoided.

2.2 CCSHAU, Hisar

Cross resistance in *Phalaris minor* against alternate herbicides

Significance: From the year 2003, complaints of poor efficacy of fenoxaprop and regeneration in case of sulfosulfuron treatment were reported from farmers' fields. Clodinafop use increased at the cost of sulfosulfuron and fenoxaprop. Due to no crop suppression and ease of application, clodinafop ultimately became choice of most of the farmers. Having bitter experience of poor efficacy of clodinafop achieved from 2008-2010, farmers started to use 1.5-2.0 times higher dose of this herbicide but with poor control. For confirmation and quantification of the cross resistance, pot bioassay studies were also initiated in 2006-07 and continued till 2010-11. Results of pot experiments showed that after continuous spray of clodinafop for 5-6 years, the LD_{50} values have gone high. Variations in protein profiles amongst susceptible biotypes were observed. So, it was concluded that *P. minor* has developed resistance against clodinafop-propargyl herbicide in Kaithal, Karnal, Jind, Kurukshetra, Panipat and parts of Fatehbad, Ambala and Yamuna Nagar districts of the state.

Technology: Apply post-emergence herbicides viz. sulfosulfuron + metsulfuron (RM) 32 g/ha, mesosulfuron + iodosulfuron 14.4 g/ha or pinoxaden 50 g/ha at 30-35 DAS by using 375 litres of water /ha.

3 sprays of clodinafop but with 10% control of *P. minor*

Applicability: Farmers of Kaithal, Karnal, Kurukshetra, Tohana, Jind and Ambala facing problem of clodinafop resistance have adopted use of these herbicides on large scale.

Economic benefits: These herbicides provide 80-95% control of clodinafop resistant biotypes of *P. minor* with no increase in cost.

Impact: Productivity of wheat in this region has increased to 5.22 t/ha from 4.05 t/ha.

Precautions: Sorghum and maize should not be planted as succeeding crop immediately after wheat harvest.

2.3 CCSHAU, Hisar

Control of broadleaved weeds in wheat

Significance: In southern Haryana, wheat is grown after pearlmillet and clusterbean. Broadleaved weeds *Asphodelus tenuifolius, Chenopodium murale, Rumex spinosus* and *C. album* are responsible for 10-50% yield reduction. All these weeds except *C. album* are not controlled by use of the earlier recommended herbicide 2, 4-D.

Technology: Apply metsulfuron-methyl 4 g/ha at 30-35 DAS to obtain excellent control of broadleaved weeds especially *Rumex dentatus* and *Asphodelus tenuifolius* in wheat. Carfentrazone 20 g/ha also provides excellent control of all broadleaved weeds including *Malva parviflora* and *Convolvulus arvensis* in wheat crop.

Control of *Asphodelus tenuifolius* by metsulfuron

Applicability: Wheat growing farmers of Loharu, Bhiwani, Mahendergarh, Sirsa, Hisar, Rewari and Gurgaon are using metsulfuron-methyl on a large scale.

Economic benefits: These herbicides provide 90-100% control of weeds with no crop suppression and residual carry-over effect. Yield increase is 10-60% due to use of this technology.

Impact: In south-western Haryana, 70% farmers apply herbicide to control weeds in wheat. An estimated 700 tonnes of metsulfuron-methyl worth ₹ 76.0 lakhs is being used in Haryana.

Precautions: Herbicide should be applied at recommended stage, dose and with proper water quantity.

2.4 PAU, Ludhiana

Management of isoproturon resistance in *Phalaris minor* in wheat

Significance: In view of herbicide resistance development in *Phalaris minor* in wheat growing areas of Punjab, there is need to find out new herbicides for its control.

Technology: Apply alternate herbicides: clodinafop 60 g, sulfosulfuron 25 g, fenoxaprop 100 g/ha as post-emergence and trifluralin 1200 g/ha as pre-emergence. Adopt combination of cultural practices: Early sowing, narrow row spacing, stale-seedbed, zero-till seeding, and crop rotations.

P. minor infested field

Clodinafop 0.06 kg + metsulfuron 0.005 kg/ha

Trifluralin 1.2 kg/ha *fb* 2,4-D 0.5 kg/ha

Applicability: The technology is applicable under all situations in all the cropping systems, soil types and all the agro-climatic regions.

Economic benefits: As the area under herbicide use in Punjab is 80% and taking a minimum of 10% increase in grain yield with herbicide use, the total benefit to the farmers at the prevailing rates comes out to be ₹ 6660/ha and ₹ 15850 million for whole of Punjab.

Impact: *P. minor* is a major weed of wheat crop and the alternate herbicides are applied on 80% of infested fields. The use of herbicides increases the wheat grain yield by 20%. The technology has reverted back the wheat yields to the original levels and improved the economic benefits to the farmers.

Precautions: Avoid continuous use of same herbicide to prevent the evolution of cross resistance. Adopt integrated approaches for better and long term control of *P. minor*.

2.5 GBPUAT, Pantnagar

Use of herbicides in wheat

Significance: In Uttarakhand, rice, wheat, sugarcane, soybean, maize and potato are the dominant crops. The dominant weed species in wheat crop are *Phalaris minor, Coronopus didymus, Fumaria parviflora*, *Melilotus* spp. *Polygonum plebejum*, *Rumex acestocella*, *Medicago denticulata, Stelaria media* etc. The losses caused due to weeds in wheat crop range between 30-47%.

Technology: If grassy weeds are dominating, spray clodinafop 60 g/ha or fenoxaprop-p-ethyl 100 g/ha or pinoxaden 50 g/ha at 25-30 DAS. In case of a mix population of weeds, apply isoproturon 1.0 kg/ha or sulfosulfuron 25 g/ha or mesosulfuron + iodosulfuron 14.4 g/ha or a follow up application of 2, 4-D 0.5 kg/ha or metsulfuron-methyl 4 g/ha. Recently ready mix combinations of two herbicides are used in place of one herbicide and their efficacy is found better.

Herbicide treated wheat crop

Applicability: Almost all the herbicides may be applied in wheat under rice-wheat, soybean-wheat and maize-wheat cropping systems.

Economic benefits:

Herbicides	Dose (g/ha)	B:C ratio
Sulfosulfuron 75% + metsulfuron-methyl 5%	32	1.38
Clodinafop - propargyl 15% + metsulfuron - methyl 1%	60	1.57
Farmer's practice (Clodinafop - propargyl)	60	1.27
Weedy check	-	0.45

The highest B:C ratio was obtained with the post-emergence application of ready mix combination of clodinafop-propargyl 15% + metsulfuron-methyl 60 g/ha *fb* sulfosulfuron + metsulfuron- methyl 32 g/ha, and clodinafop alone 60 g/ha.

Impact: The highest weed control efficiency was recorded with ready mix combination of herbicides. Farmers are finding it easier to apply ready mix combinations for weed control.

Precautions: Herbicide should be applied at recommended stage dose and with proper water quantity.

2.6 RVSKVV, Gwalior

Weed management in wheat

Significance: Wheat is an important *rabi* crop of Madhya Pradesh. Weeds cause yield reduction up to 50% or sometimes more depending upon the density and type of weed flora. In M.P. wheat fields are infested with wide range of grassy and non-grassy weeds i.e. *Phalaris minor, Avena fatua, Chenopodium album, Convolvulus arvensis, Vicia sativa* etc. Crop weed competition period is between 30 to 45 DAS. Manual weeding (hand weeding) is effective and common method to control weeds but scarcity and high wages of labour particularly during peak period make this operation difficult and uneconomic. Different post-emergence herbicides are used to control weed species in wheat crop. The application of herbicide or its mixture may be useful for the control of broad spectrum weed flora in wheat crop.

Technology: Apply 2, 4-D 0.5 kg/ha + isoproturon 0.75 kg/ha or sulfosulfuron 25 g/ha for control of broad and narrow-leaved weeds. Clodinafop 60 g/ha is also effective to control *Phalaris minor* and other narrow-leaved weeds.

Isoproturon 0.75 kg/ha + 2,4-D 0.05 kg/ha

Weedy situation

Applicability: All wheat growing area of Madhya Pradesh.

Economic benefits: Chemical weed management practice is highly beneficial in area of labour scarcity as well as in heavy soils in comparison to traditional weed management practices.

Precautions: Apply herbicides at recommended stage, dose and with proper quantity of water.

2.7 SKRAU, Bikaner

Weed management in wheat

Significance: In Rajasthan, comparatively more broadleaved weeds infest the wheat crop. In recent years *Rumex dentatus* affected wheat crop the most, throughout the state. Application of 2, 4-D controls most of the broadleaved weeds effectively but hardy weeds like *Rumex dentatus* are not controlled effectively, hence, some new herbicide is needed to control these difficult to control weeds.

Technology: Apply metsulfuron-methyl 4.0 g/ha post-emergence to control hardy broadleaved weeds in wheat crop.

Weedy check

Herbicidal weed control

Economic benefits: The increase in wheat grain yield with the herbicide over weedy check was 1309 kg/ha and net returns of ₹15517/ha with B: C ratio 3.1 was recorded.

Applicability: All wheat growing regions in Rajasthan.

Impact: Farmers in wheat growing areas of Rajasthan have started to adopt this herbicide as a replacement of 2, 4-D to control weeds especially the hardy broadleaved weeds.

Precautions: Herbicide should be applied at recommended stage, dose and with proper water quantity.

3.0 Weed management in maize

3.1 AAU, Anand

Weed Management in maize

Significance: Competition of maize with annual and perennial grass and broadleaved weeds is responsible for severe yield reduction in maize. The losses due to weeds vary with type of weeds, weed control methods, and time of weed control. Therefore, efficient management of weeds is essential for obtaining optimum economic returns. To keep weeds below economic threshold level, the most frequent used practice is manual weeding and use of sole herbicide. Information regarding comparison of mechanical, cultural and use of herbicide in maize is lacking.

Technology: Apply tank mixture of pendimethalin 0.25 kg/ha + atrazine 0.50 kg/ha as pre-emergence or application of atrazine 1.0 kg/ha as pre-emergence. Twice interculturing and hand weeding (20 and 40 DAS) is also equally effective for weed management in *kharif* maize crop.

Weedy condition

Pendimethalin 0.25 kg + atrazine 0.50 kg/ha as pre-emergence

Applicability: All maize growing areas of Gujarat.

Economic benefits: Highly beneficial during paucity of labourers as well as in black soils compared to traditional weed management practices.

Impact: The application of pendimethalin 0.25 kg/ha with atrazine 0.50 kg/ha gave the highest additional profit (₹14526 /ha) followed by application of atrazine 1.0 kg/ha (₹13410 /ha).

Precautions: The herbicide should be applied within 2-3 days of sowing the crop.

3.2 BAU, Ranchi

Weed management in maize

Significance: Maize is grown in an area of 2.6 lakh hectare in Jharkhand with the productivity of 1603 kg/ha. Weeds are the major problem in maize cultivation. Herbicides could be the best alternative to manual weeding.

Technology: Apply atrazine 1.0 kg/ha pre-emergence or fluchloralin 1.25 kg/ha as pre-plant incorporation.

Weedy plot

Atrazine 1.0 kg/ha pre-emergence

Applicability: All maize growing areas in Jharkhand, but not where maize is intercropped with legumes.

Economic benefits: Maize requires two weedings at 20 and 40 days after sowing with 30 to 40 labourers in each weeding. Manual weed control in maize is costly affair as cost on manual weeding comes to ₹ 12000 to 16,000/ha. Problem becomes grave when labourers are not available at peak period of weeding as this period coincides with transplanting of paddy as well as sowing/ interculture operation of other upland crops. Application of herbicides reduces the weeding cost without reduction in crop yield.

Impact: For the last 4 to 5 years, farmers of Jharkhand are becoming aware about use of herbicides in maize crop. Herbicide atrazine for maize crop is very popular among the farmers.

Precautions: Herbicide should be applied at recommended stage and dose with proper water quantity.

3.3 PAU, Ludhiana

Weed management in *kharif* maize

Significance: Maize is a popular crop in Punjab which is severely affected by weeds for which effective weed management technology is required by farmers.

Technology: Apply atrazine 1.0 kg/ha pre-emergence as blanket application or 0.33 kg/ha as band application at 10 DAS for effective control of annual grasses and broadleaf weeds in *kharif* maize. Alternatively, grow one or two rows of cowpea for fodder in between two maize rows and harvest it at 35-45 DAS. It gives effective control of all types of weeds.

Atrazine at 1.0 kg/ha

Applicability: The technology is applicable under all the environments including all soil types, cropping systems and agro-climatic regions.

Economic benefits: Taking a minimum of 15% increase in yield with herbicide use, the total benefits to the farmers at the prevailing rates comes out to be ₹ 3645/ha and ₹ 202 million for the whole of Punjab.

Impact: In Punjab state, the atrazine herbicide is used on 40% of total area under maize. The use of herbicide increases the maize grain yield, on an average by 15%. The use of intercrop as a weed control tool is also adopted by some farmers.

Precautions: Apply 25% higher dose of atrazine in heavy textured soils. Use flat fan or flood-jet nozzle for spray of herbicides. Always apply the herbicides on moist soil.

3.4 TNAU, Coimbatore

Weed management in irrigated maize

Significance: Maize is a crop having higher yield potential among cereals and cultivated over a wide range of agro-climatic zones, and hence it is popularly called as "*Queen of Cereals*". In Tamil Nadu, maize is a non-traditional crop, cultivated over an area of 0.18 million ha, with a production of 0.29 million tonnes and an average productivity of 1.55 t/ha. The predominant weed flora of the maize field was *Trianthema portulacastrum*, *Cleome gynandra*, *Boerhavia diffusa, Digera arvensis* and *Cyanotis axillaris*. Among the grassy weeds, *Cynodon dactylon* and *Dactyloctenium aegyptium* were dominant. *Cyperus rotundus* was the only sedge observed. Weeds cause considerable yield loss due to competition for resources with maize crop. Season long competition reduced the grain yield of maize to as much as 70%. Weed management in maize is carried out by manual, mechanical and chemical methods, among which chemical method along with mechanical weeders is the most economical and effective tool to suppress weeds in order to get healthy crop stand and good yield in irrigated maize.

Technology: Apply atrazine 0.5 kg/ha pre-emergence or oxyfluorfen 0.2 kg /ha on 3 DAS *fb* twin wheel- hoe weeding at 45 DAS for effective control of weeds in maize.

Atrazine 0.5 kg/ha at 3 DAS

Applicability: The technology is suitable for maize growers of Tamil Nadu.

Economic benefits: The technology would result in a total production gain of 0.45 lakhs tonnes of maize grain and additional income of ₹ 43.97 crores at the state level.

Impact: Adoption of this technology was seen at 73.5%. At this level of adoption, the area coverage under maize will be 1.93 lakh ha. An increase in the yield by 317 kg/ha was seen from the studies conducted at TNAU.

Precautions: Adequate soil moisture is required at the time of pre-emergence herbicide application and trampling into the field should be avoided.

3.5 UAS, Bengaluru

Weed management in maize by pre-emergence herbicides

Significance: Maize being a wide spaced crop suffers from severe weed competition in the initial stages of its establishment and it leads to poor growth and development, if timely weed management is not undertaken. Farmers usually employ manual labour for two hand weedings or two intercultural operations to manage weeds. But if rains persist for longer period they will not be in a position to take up timely weed management. Under such conditions use of pre-emergence herbicides will help in managing the initial flush of weeds and one hand weeding at 30 DAS will help in reducing the critical period of crop weed competition. The labour meant for hand weeding can be used for other enterprises profitably and human drudgery particularly women labour can be avoided.

Technology: Apply herbicides *viz.,* pendimethalin 0.75 kg/ha, and oxyfluorfen 100 g/ha as pre-emergence for weed management in maize.

Unweeded

Pendimethalin 0.75 kg/ha at 3 DAS

Applicability: This herbicide technology has been recommended for all agro-climatic conditions of southern Karnataka (Zones 4, 5, 6, 7 and 9).

Economic benefits: The saving in weeding cost will lower the cost of cultivation by ₹ 550 to 750/ha, based on trials in farmers' fields during 1998 -2000.

Impact: The new technology lowers the weed competition from the beginning and saves loss of nutrients to an extent of 20-50%. This technology relieves pressure on human labour for weeding, cheaper, timely weed control from the beginning, saves loss of nutrients resulting in yield improvement.

Precautions: Herbicides are to be applied as spray by using knapsack sprayer with WFN Nozzle 78 using 500 liters of water/ha within 3 days after sowing. For effectiveness of herbicides, adequate soil moisture and fewer clods should be ensured.

3.6 PJTSAU, Hyderabad

Weed management in zero- till maize in rice fallows

Significance: Zero-till maize in rice-fallows is a very important cropping system practiced in more than 2.81 lakh ha in Andhra Pradesh and Telangana states with an average productivity of 8.1 t/ha. Weed management in zero-tillage assumes importance in view of the sprouting of the harvested rice stubbles, germination of the rice seed fallen during harvesting, and other weed competition due to absence of tillage at the time of sowing.

Technology: Apply atrazine 1.0 kg/ha + paraquat 600 g/ha as pre-emergence for effective weed control in zero-till maize in rice fallows.

Atrazine alone as pre-emergence

Paraquat + atrazine as pre-emergence

Applicability: This system is being adopted in almost all the zero-till maize growing areas in both the states.

Economic benefits: This technology saves 20 labour days/ha/season. Saving in the cost of labour could be ₹ 5000-6000/crop.

Impact: This technology has been widely accepted and practiced by most of the zero-till maize farmers of the state and has resulted in very high productivity of more than 8.0 t/ha.

Precautions: This herbicide combination should be applied as pre-emergence only within 48 hours after sowing.

4.0 Weed management in pulse crops

4.1 AAU, Anand

Weed management in clusterbean

Significance: Clusterbean is now considered as one of the good remunerative crops owing to its diversified usage. Due to ever increasing demand, the area under clusterbean cultivation has increased. Slow growth at initial stages of the crop favours recurrent flushes of weeds, which compete with crop for essentials of growth and cause heavy reduction in its seed yield. Due to continuous rain in *kharif* season, removal of weeds manually or mechanically is sometimes difficult.

Technology: Apply pendimethalin or fluchloralin or trifluralin or butachlor 0.5 kg/ha as pre-emergence with interculture at 30 DAS for efficient weed management.

Weedy check

Trifluralin 0.5 kg/ha *fb* interculture at 30 DAS

Butachlor 0.5 kg/ha *fb* interculture at 30 DAS

Applicability: All clusterbean growing area of Gujarat.

Economic benefits: The technology is highly economical in comparison to traditional weed management practices. Application of butachlor 0.5 kg/ha applied as pre-emergence showed highest ICBR (1:9.88).

Impact: Due to economical weed management, farmers have now adopted the use of recommended herbicides.

Precautions: The herbicide should be applied within 2-3 days of sowing the crop.

4.2 AAU, Jorhat

Weed management in lentil

Significance: Lentil is a promising *rabi* season pulse crop of Assam. Weed infestation is one of the major factors for low yield of this crop. Further, unavailability of hired labourers at reasonable wages also escalates the cost of production. Therefore, development of cost effective weed management practices is of prime importance.

Technology: Apply oxyfluorfen 150 g/ha *fb* hand weeding at 20 days after sowing. Alternately hand weeding twice at 20 and 30 days after sowing is also recommended.

Oxyfluorfen 150 g/ha *fb* hand weeding

Applicability: The technology is applicable for lentil grown in the light soils of river bank areas in Central Brahmaputra valley, Lower Brahmaputra valley and North Bank Plain Zone of Assam.

Economic benefits: Application of pre-emergence herbicide significantly reduces the cost and dependence on manual labour with higher economic returns from this crop.

Treatments	On station		On-farm	
	Yield (t/ha)	B:C ratio	Yield (t/ha)	B:C ratio
Oxyfluorfen 150 g/ha *fb* HW 20 DAS	0.85	2.29	0.83	2.26
Hand weeding at 20 and 30 DAS	0.71	1.97	0.76	2.11

Impact: The farmers under demonstration area were fully impressed by the technology. However, making the herbicide available in small quantity containers shall help in full adoption of this technology.

Precautions: The herbicide is to be applied at optimum dose and time. The sprayer used in herbicide spraying should be cleaned thoroughly before and after use.

4.3 RVSKVV, Gwalior

Weed management in blackgram

Significance: Blackgram is an important pulse crop in India. It is generally grown in *kharif* season, resulting in high weed population and weed growth. Being a short duration and initially slow growing, the crop is heavily infested with weeds, which compete with crop resulting in yield reduction to the tune of 30-50%. Weeds could be controlled by hand weeding effectively but hand weeding is laborious, time consuming, costly and tedious under these conditions. Use of herbicides offers an alternative for effective control of weeds.

Technology: Apply pendimethalin + imazethapyr (pre mix) 0.9 kg/ha as pre- emergence or imazethapyr 100 g/ha as early post or imazethapyr + imazamox 50 g/ha as early post for effective control of weeds in most of the pulse crops.

Imazethapyr + pendimethalin (pre-mix) 900 g/ha as PE

Weedy situation

Applicability: All pulse growing area of Madhya Pradesh

Economic benefits: Chemical weed control practices are more beneficial in labour scarcity area and heavy soils.

Impact: The pulse growing farmers are impressed with this technology.

Precautions: Herbicide should be applied at recommended stage and dose.

5.0 Weed management in oilseed crops

5.1 AAU, Anand

Weed management in soybean

Significance: Soybean is an important cash crop grown in the *kharif* season. This crop is newly introduced in middle Gujarat. Among different constraints, weed menace is one of the serious bottlenecks for increasing the yield of soybean. This crop is initially slow growing, short stature and incapable of offering competition to the weeds. Yield reduction depends upon type of weed flora, intensity of weeds and nature of weed infestation under a prevailing agro-climatic condition. Crop-weed competition period for *kharif* soybean is between 15 to 45 days. Manual weeding, interculturing or application of recommended pre-emergence herbicide is difficult in rainy season for efficient weed management. This warrants the use of post-emergence herbicide for weed management. Quizalofop-ethyl is a selective post-emergence herbicide. It is used for controlling annual grassy weeds.

Technology: Apply fluchloralin 1.0 kg/ha or pendimethalin 750 g/ha pre-emergence *fb* hand weeding at 30 DAS or quizalofop 50 g/ha (post- emergence) *fb* hand weeding at 30 DAS or interculture and hand weeding at 20 and 40 days after sowing for efficient weed management in soybean.

Pre-emergence application of fluchloralin 1.0 kg/ha *fb* HW at 30 DAS

Pre-emergence application of pendimethalin 0.75 kg/ha *fb* HW at 30 DAS

Applicability: All soybean growing area of Gujarat.

Economic benefits: Highly beneficial in paucity of laborer as well as in black soils, in comparison to traditional weed management practices. The benefit:cost ratio (ICBR) by the application of quizalofop *fb* hand weeding was 1: 8.86, fluchloralin 1.0 kg/ha *fb* hand weeding 1: 8.58, pendimethalin 750 g/ha *fb* hand weeding 1: 7.70.

Impact: Farmers have adopted the herbicide technology on a large scale.

Precautions: Application of post-emergence herbicide at proper weed stage (4-6 leaf stage) is very essential otherwise the performance would be poor.

5.2 BAU, Ranchi

Weed management in soybean

Significance: In Jharkhand, soybean is grown as rainy season crop which is infested severely by the weeds. The infestation of weeds get aggravated as farmers are not able to perform weeding due to costly labour, non-availability of labour at peak time of requirement, while irregular rains prevent farmers to perform manual weeding.

Technology: Apply fluchloralin 0.75 kg/ha as pre-plant incorporation or metolachlor 0.75 kg/ha pre-emergence or oxyfluorfen 0.2 kg/ha as post-emergence for effective control of weeds in soybean.

Comparison of herbicide applied and weedy plot

Applicability: Soybean growing areas of Jharkhand.

Economic benefits: Application of herbicide in soybean has been economical as compared to manual weeding.

Impact: The cultivation of soybean is gaining popularity among farmers, as such use of fluchloralin is also picking up. Although, this herbicide is not marketed in Ranchi, yet farmers are getting it from neighbouring states like Bihar, Odisha and Uttar Pradesh.

Precautions: Herbicide should be applied at proper stage, dose and with proper water quantity.

5.3 RVSKVV, Gwalior

Weed management in soybean

Significance: Soybean is an important rainy season crop grown in most parts of Madhya Pradesh. The various grassy and broadleaved weeds emerge simultaneously with the crop and compete for essential nutrients, moisture, sunlight and space causing substantial loss in seed yield (35-60%) depending on the type of weeds and its density. Due to intermittent rainfall during rainy season and scanty labour, manual weeding at right time is difficult, time consuming and expensive, so the farmers readily adopt pre and post-emergence application of herbicides for controlling weeds in soybean crop.

Technology: Apply imazethapyr 100 g/ha as early post-emergence 12 DAS or chlorimuron 9 g/ha + fenoxaprop 90 g/ha as post-emergence 20 DAS for effective control of the weeds in soybean.

Imazethapyr 100 g/ha

Weedy check

Applicability: All soybean growing area of Madhya Pradesh.

Economic benefits: Chemical or integrated weed management practices are highly beneficial as compared to manual weeding due to scarcity and high wages of labour.

Impact: The technology is easy to accept and farmers are adopting this technology.

Precautions: Herbicide should be applied at proper stage, dose and with proper water quantity.

5.4 VNMKV, Parbhani

Use of cycle-hoe for weed control in soybean

Significance: Labour for weeding is not available easily and if available, cost is high. To reduce the cost of cultivation of crops, it is essential to use modern interculture implements.

Technology: Perform interculture operation using cycle-hoe at 20 and 40 DAS to control the weeds and to increase growth and yield of soybean.

Weeding by cycle-hoe in soybean

Applicability: Technology is very much applicable particularly for the small holding farmers having no bullocks.

Economic benefits: As interculturing with cycle-hoe helps to reduce the cost on bullocks, fodder and fuel, there is no requirement of any recurring expenditure. The cycle-hoe once purchased will work for more than 10 years with no any additional expenditure on its maintenance. The cost of interculture is reduced by 60% as compared to all other methods.

Impact: Cycle-hoe is becoming popular among the small land holding soybean growers and state Government has offered 50% subsidy for purchase of cycle-hoe through *Panchyat samiti*.

Precautions: Cycle-hoe should be operated at right stage i.e. 20 and 40 DAS for effective weed control.

5.5 VNMKV, Parbhani

Integrated weed management in soybean

Significance: Soybean is becoming a major crop of the Maharashtra state by replacing area under sorghum. The crop is short durational and benefits by adoption of technology. Integrated weed management strategy is required for harnessing the optimum yield potential of the crop.

Technology: Apply pendimethalin 0.75 kg/ha pre-emergence + hand weeding and hoeing at 6 weeks after sowing.

Pendimethalin 0.75 kg/ha pre-emergence *fb* hand weeding

Applicability: The farmers are accepting this technology easily to avoid weed growth at early post-emergence period.

Economic benefits: The crop is becoming popular and area is increasing day by day. Use of this technology gives 20% increase in seed yield.

Impact: The technology is easy to accept and farmers particularly from dry land areas are adopting this technology.

Precautions: As crop is short in duration and needs the weed control at proper stage, any delay will lead to drastic reduction in yields. The inter culture at later stage is difficult. Technology is very effective but needs proper application with optimum soil moisture.

5.6 AAU, Anand

Weed management in *kharif* groundnut

Significance: Groundnut can be successfully grown under both rainfed and irrigated conditions. Agro climatic conditions of middle Gujarat are quite favourable for the cultivation of groundnut in *kharif* and summer seasons. Groundnut is the major oilseed crop accounting for about 34% of the oilseed production in the country. But the current average yield of groundnut in Gujarat is very low as compared to that in many other regions of India. Among different constraints, weed menace is one of the serious bottlenecks for increasing the yield of groundnut. This crop is initially slow growing, short stature and incapable of offering competition to the weeds. Manual weeding and pre-emergence application of pendimethalin and fluchloralin are recommended for weed management. Quizalofop-ethyl and fenoxaprop-p-ethyl are selective post-emergence herbicides.

Technology: Apply pre-emergence pendimethalin 0.75 kg/ha followed by hand weeding (HW) at 40 DAS or post-emergence application of quizalofop-ethyl or fenoxaprop-p-ethyl 100 g/ha at 15 DAS followed by hand weeding at 40 DAS for efficient weed management in groundnut.

Pendimethalin 750 g/ha *fb* HW at 40 DAS

Quizalofop-ethyl 100 g/ha *fb* HW at 40 DAS

Applicability: All groundnut growing area of Gujarat.

Economic benefits: Highly beneficial in paucity of labourers as well as in black soils, compared to traditional weed management practices.

Impact: The technology is easy to accept and farmers are adopting this technology.

Precautions: Application of post-emergence herbicide/s at proper weed growth stage (4-6 leaf stage) is very essential otherwise the performance would be poor.

5.7 OUAT, Bhubaneswar

Weed management in *kharif* groundnut

Significance: The area under *kharif* groundnut in Odisha is 86.8 thousand ha and most of it is confined in the coastal regions. The productivity of the crop is meager 1000 kg/ha. Weed infestation severely reduces the yield depending upon the type of weed flora, intensity of weeds under a prevailing agro-climatic condition. Manual weeding or intercultural operations are difficult in rainy season. This situation promotes the use of herbicide for weed management. Oxyfluorfen is a selective pre-emergence broad spectrum herbicide used to check the initial germination of all types of weeds.

Technology: Apply oxyfluorfen 0.05 kg/ha pre-emergence at 0-3 DAS with sufficient moisture in the field for efficient weed management in groundnut.

Oxyfluorfen 0.05 kg/ha applied plot at 0-3 DAS

Applicability: All groundnut growing area of Odisha.

Economic benefits: Highly beneficial in comparison to traditional weed management practices. The average benefits in terms of monetary return are ₹ 38500- 42750/ha.

Impact: The technology is easy to accept and farmers are adopting this technology.

Precautions: Application of herbicide/s at proper moisture condition of the soil, and at proper dose should be taken care of and the water requirement for spraying should be 500 l/ha using a flat fan nozzle.

5.8 SKRAU, Bikaner

Integrated weed management in groundnut

Significance: Groundnut production in Rajasthan gained momentum particularly in north-western part of the state. Due to increase in the facilities of irrigation, weed problem is also increasing. Groundnut is of short stature and slow growing crop in initial stage and therefore does not offer competition to faster growing weeds in early stage of growth. So weed management is essential for optimum production of the crop. For this, integration of herbicidal or mechanical methods could be an option.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence + one hand weeding at 30 DAS for effective weed control in groundnut.

Weedy check

Herbicidal weed control

Applicability: Groundnut growing area of Rajasthan.

Economic benefits: Net returns of ₹ 12633/ha and B:C ratio 1.57 could be obtained by this technology.

Impact: Farmers of groundnut growing area like Bikaner, Hanumangarh, Jaipur and Dausa districts have now started using this technology.

Precautions: Mechanical weeding should be done before pegging in groundnut crop. Sufficient moisture should be maintained in the field at the time of herbicide application.

5.9 TNAU, Coimbatore

Weed management in irrigated groundnut

Significance: One of the major constraints in groundnut production is weed menace. Groundnut germinates and grows slowly, takes more time to cover the ground surface. These factors favour the weeds to grow vigorously and compete with the crop leading to considerable yield reduction. The loss in pod yield due to unchecked weed growth throughout the crop growth period was estimated to be 65-70% in groundnut. Since, groundnut is a short statured initially slow growing crop, needs weed free condition throughout the crop growth period. Manual weeding requires more time and labour. Once peg formation has begun, manual methods should not be continued as they damage the pegs and roots, and reduce crop yield. Thus, herbicides offer the most effective means of control of weeds emerged during late season. Chemical weed management can be made cheaper and safer than mechanical methods.

Technology: Apply pendimethalin 0.75 kg/ha pre-emergence at 3 DAS + hand weeding and earthing up + lay by application of pendimethalin 0.75 kg/ha on 40 DAS.

Pendimethalin 0.75 kg/ha

Applicability: Total irrigated area of groundnut is 55.25 lakh hectares. Out of this area, the recommendation is suitable for 10.32% of irrigated groundnut growing farmers under Tamil Nadu.

Economic benefits: The technology in the adopted area of groundnut would increase the total production by 0.42 lakh tonnes of groundnut and an additional income of ₹113.84 crores.

Impact: At this level of adoption, an area of 5.32 lakh ha would be covered. The increase in productivity by the adopters was estimated to be 767 kg/ha.

Precautions: Adequate moisture is needed at the time of pre-emergence herbicide application and also avoid excess moisture in the case of pendimethalin application. Do not trample into the field.

5.10 UAS, Bengaluru

Post-emergence herbicides in groundnut

Significance: Groundnut is a major rainfed crop in Karnataka and suffers from severe weed competition resulting in yield loss to the tune of 25 to 40%. Although recommendation of alachlor 0.75 kg/ha as pre-emergence herbicide is given, but sometimes due to unfavorable weather conditions or lack of soil moisture, farmers are not in a position to use the pre-emergence herbicides. So under such conditions there is a need for suitable post-emergence herbicide in groundnut.

Technology: Apply imazethapyr 125 g/ha at 2-3 leaf stage of weeds followed by one hand weeding at 45 DAS.

Imazethapyr 125 g/ha at 2-3 leaf stage of weeds

Imazethapyr 125 g/ha at 2-3 leaf stage of weeds *fb* one hand weeding at 45 DAS

Applicability: This technology of new herbicide has been recommended for dry region of central and eastern dry zones of Karnataka (Zones 4 and 5).

Economic benefits: The use of post-emergence herbicide imazethapyr 125 g/ha at 2-3 leaf stage of weeds followed by one hand weeding at 45 DAS has given almost comparable weed control with that of farmer's practice of two hand weedings at 20 and 40 DAS with considerable saving in weeding cost to the tune of ₹ 2000 to 3000/ha.

Impact: Farmers have adopted this new technology of weed management in groundnut and it has minimized their dependence on manual labour during peak period of labour requirement.

Precautions: Post-emergence herbicide should be applied at the recommended dosage and at correct time during bright sunny conditions.

5.11 RVSKVV, Gwalior

Weed management in mustard

Significance: Mustard is a major oilseed crop of northern Madhya Pradesh. Weed infestation is one of the major causes of low productivity. Yield losses due to crop-weed competition in mustard have been estimated to the tune of 23-70% depending upon the type, intensity and duration of weed competition in mustard field. Manual weeding at 3-4 weeks after sowing is most common practice to control weeds, but due to increasing wages and scarcity of labour it is not possible. Control of weeds in mustard by application of pre or post-emergence herbicide may be economical.

Technology: Apply pendimethalin 1.0 kg/ha or isoproturon 0.75 kg/ha or oxadiargyl 90 g/ha pre-emergence and quizalofop-ethyl 50 g/ha as post-emergence 20 DAS for effective control of all types of weeds in mustard.

Pendimethalin 1.0 kg/ha

Weedy check

Isoproturon 0.75 kg/ha

Applicability: All mustard growing area of Madhya Pradesh.

Economic benefits: Compared to traditional manual weedings, this technology of herbicide use is highly economical.

Impact: Weed management through herbicide has covered more area in short time.

Precautions: Herbicide should be applied at proper stage, dose and using proper water quantity.

5.12 VB, Sriniketan

Weed management in rapeseed-mustard

Significance: Rapeseed-mustard is the most important oilseed crop in West Bengal. Among the rapeseed-mustard group yellow sarson is most widely cultivated by the farmers. Weed infestation is one of the constraints for cultivation of this crop. In rapeseed-mustard, weeds become serious especially after first irrigation. Manual weeding is not effective because farmers generally sow this crop as broadcast. Twenty to thirty per cent yield loss occurred due to infestation of weeds. Pendimethalin at 0.75 kg/ha was found effective when used as pre-emergence.

Technology: Apply pendimethalin 0.75 kg/ha as pre-emergence for control of weeds in rapeseed-mustard.

Unweeded control

Pendimethalin 1.0 kg/ha

Applicability: Applicable in wide range of agro-ecological situations and in all the groups of rapeseed-mustard.

Economic benefits: By adopting this technology the farmers get a minimum of 145 kg/ha extra seed yield with an additional net return of ₹5,275/ha.

Impact: The farmers of West Bengal are adopting this weed management technology. About 4.4% area under rapeseed-mustard cultivation is covered by this single technology. The cost of technology is much less than the earlier practice, and economic returns of the farmers has increased. Timely weed management by this technology checks the losses of water and nutrient removed by the weeds and thus increases water and fertilizer use efficiency. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Application of herbicide with proper dose, methods and at appropriate stage of crop growth should be ensured. Irrigation immediately after application of herbicide must be avoided.

5.13 UAS, Dharwad

Weed management in sunflower

Significance: Sunflower is an important oilseed/commercial crop cultivated throughout Karnataka state. Initial period of 35-40 days is considered to be the critical period of crop-weed competition. Later, sunflower crop suppresses the weeds because of its leaf canopy with broad leaves. But in the first 30 days it requires one or two inter cultivations and one hand weeding in the rows. However, this is not possible due to non-availability and costly labour. Hence, there is need of pre-emergence herbicides which keep the sunflower fields free of weeds in initial 30-40 days of the crop growth.

Technology: Apply butachlor 1.5 kg/ha pre-emergence to control weeds in sunflower.

Butachlor 1.5 kg/ha treated sunflower

Applicability: The technology is easily applicable to sunflower fields in Karnataka.

Economic benefits: The cost of chemical weed control by butachlor is ₹1150/ha. While in conventional method, it works out to be ₹ 3200 (1 hoeing ₹ 700 + 1 hand weeding ₹ 2500). Thus, there can be a saving of ₹ 2050 per ha when herbicide is used.

Impact: Herbicides were not being used by farmers. But in recent years, the efforts made by AICRP-WM Dharwad centre through on-farm trials and front-line demonstrations have yielded good results and the farmers have now started adopting this technology.

Precautions: The technology can be very safely adopted by the farmers. No special precautions are required.

6.0 Weed management in vegetables crops

6.1 AAU, Jorhat

Weed management in potato

Significance: Potato has a slow initial growth and grown with high amount of nutrients. Therefore, weed growth in the period up to earthing up is very critical from the weed management point of view.

Technology: Apply prometryn 1.5 kg/ha followed by interculture with grubber at 40 DAP.

Weedy check

Prometryn 1.5 kg/ha

Applicability: Potato is cultivated throughout the state covering an area of about 70,000 hectares and the usual practice of weed management is hand weeding *fb* earthing up at 20-25 days after planting and during stolon formation. This technology is applicable in potato growing area as an alternative to manual methods of weed control.

Economic benefits: Application of prometryn 1.5 kg/ha reduces the cost of production and increases tuber yield, resulting in higher economic returns than farmers' practice or working with grubber at 20 and 40 DAP.

Treatment	Weed dry weight at 25 DAP (g/m^2)		Tuber yield (t/ha)		Benefit: cost ratio	
	On station	*On-farm	On station	*On-farm	On station	*On-farm
Farmer's practice (hand weeding twice with earthing up)	5.90	7.2	13.9	18.4	1.08	2.06
Prometryn 1.5 kg/ha *fb* grubber at 40 DAP	2.48	3.8	16.3	24.9	1.57	2.20
Grubber at 20 and 40 DAP	4.40	5.2	14.3	20.5	1.29	1.94

Impact: The technology has been demonstrated to the farmers through frontline demonstrations and on-farm trials. Farmers are ready to adopt the technology, but availability of the commercial product of the herbicide shall help in adoption of the technology.

Precautions: The herbicide is to be applied at optimum dose and time. The sprayer used in spraying should be cleaned thoroughly before and after use.

6.2 VB, Sriniketan

Weed management in potato

Significance: Potato is one of the most important crops in West Bengal. Potato starts to emerge from 15-20 DAP. It is comparatively wide spaced crop, requiring high dose of fertilizer and frequent irrigation. As a result, potato is severely infested with weeds from very early growth stage. Though, earthing up is essential, it cannot control weeds appearing within the crop row. Repeated earthing up also involves higher cost and engagement of labour for longer period of time. Under this situation integrated use of metribuzin along with one earthing up was found effective for weed management in potato.

Technology: Apply metribuzin at 0.4 kg/ha as pre-emergence *fb* earthing up 20-25 DAP.

Metribuzin at 0.4 kg/ha along with earthing up in potato

Applicability: Technology is applicable in all the potato growing areas.

Economic benefits: This technology produces 3390 kg/ha additional tuber yield with a net additional benefit of ₹ 22,840/ha.

Impact: The farmers adopted the technology of weed management with great satisfaction. In potato belt, about 30% area is covered by this technology. This technology is time and cost effective. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Continuous application of the same herbicide year after year in same field should be avoided at it leads to appearance of weeds tolerant to specific herbicides and shift in weed flora. Application of herbicide with proper dose, methods and at suitable stage of crop growth should be ensured.

6.3 AAU, Jorhat

Weed management in brinjal

Significance: Brinjal is one of the most popular and profitable vegetable crops of Assam. However, irrespective of different types, season and situations, the crop faces serious competition from weeds. Hence, timely weed control options are required.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence at 0-3 DAP, followed by hand weeding at 35 DAP.

Pendimethalin 1.0 kg/ha reduces weeding cost in brinjal

Applicability: High market demand throughout the year tempts the commercial vegetable growers to take up large scale cultivation of the brinjal crop. Most of the farmers go for early October planting in an attempt to capture the high priced market, and the crop suffers competition from weeds during first month.

Economic benefits: Application of pendimethalin 1.0 kg/ha *fb* garden hoeing 35 DAP reduces labour requirement and cost and gives higher economic returns than the farmers' practice.

Impact: The farmers of the brinjal growing areas are already convinced about the impact of the technology through various demonstrations and on-farm trials conducted. However, adoption could be ensured by introduction of small packs of herbicides in the market.

Precautions: The herbicide is to be applied at optimum dose and time. The sprayer used in spraying should be cleaned thoroughly before and after use.

6.4 RVSKVV, Gwalior

Weed management in onion

Significance: Onion is one of the most important commercial vegetable crops grown all over the Madhya Pradesh. It is slow growing, shallow rooted, having narrow upright leaves and non branching habit. Due to this type of growth habit, onion crop cannot compete well with weeds. Yield loss due to weed infestation in onion is to the tune of 40 to 80%. The conventional methods of weed control are laborious, expensive and insufficient. Moreover, weeding during critical growth stages is very difficult due to increased cost of human labour and its poor availability. On the other hand, use of herbicides alone does not prove effective for weed control due to their limited spectrum of weed kill.

Technology: Apply oxadiargyl 90 g/ha as pre-emergence *fb* one hand weeding at 45 DAS or oxyfluorfen 250 g/ha as pre-emergence *fb* one hand weeding at 45 DAS for effective weed control in onion.

Oxadiargyl 90 g/ha *fb* 1 hand weeding

Unweeded plot

Applicability: All onion growing area of Madhya Pradesh.

Economic benefits: Chemical method of weed control is more beneficial and economically viable than traditional method of weed control in onion crop.

Precautions: Application of herbicides at proper stage, doses and proper quantity of water for spraying are essential to obtain good weed control.

6.5 UAS, Bengaluru

Post-emergence herbicides in onion

Significance: Onion is one of the popular commercial crops of Karnataka. Severe weed menace is one of the bottlenecks for successful cultivation of this crop. Although there is a recommendation of oxyfluorfen 117 g/ha as pre-emergence application in onion, few grassy weeds emerge at later stage and needs efficient management for successful and profitable cultivation of onion crop.

Technology: Apply quizalofop-p-ethyl 37.5 g/ha or fenoxaprop-p-ethyl 67.5 g/ha at 2-3 leaf stage of weeds followed by one hand weeding at 45 DAP.

Quizalofop-p-ethyl 37.5 g/ha as post-emergence *fb* one hand weeding at 45 DAT

Applicability: This technology of new herbicide has been recommended for dry region of central and eastern dry zones of Karnataka (Zones 4 and 5).

Economic benefits: The application of post-emergence herbicides i.e. quizalofop-p-ethyl 37.5 g/ha or fenoxaprop- p-ethyl 67.5 g/ha at 2-3 leaf stage of weeds followed by one hand weeding at 45 DAP in onion results in similar yield as that obtained under three hand weeding practice (20, 40 and 60 DAS/DAT) with considerable saving in weeding cost to the tune of ₹ 4000 to 4500/ha.

Impact: Farmers have adopted this new technology of weed management in onion and it has minimized their dependence on manual labour during peak period of labour requirement. Under present conditions of labour scarcity, use of post-emergence herbicides reduces the labour requirement for hand weeding. Depletion of soil fertility status due to severe weed infestation is also avoided.

Precautions: Post-emergence herbicide should be applied at the recommended dosage and at correct time of application during bright sunny conditions.

6.6 UAS, Dharwad

Weed management in onion

Significance: Onion is an important commercial crop in North Karnataka. It is a very poor competitor against weeds. It takes comparatively more time for its germination. Weeds emerge much before the complete germination in onion. Because of erect leaves and poor canopy development in onion, weeds profusely grow and compete heavily with the crop. Many a times, the onion seeds are broadcast sown. Hence, farmers heavily invest on manual weeding (nearly 3-4 times) during the crop growth period. Even in case of transplanted onion also, farmers are facing difficulty in managing the weeds.

Technology: Apply butachlor 1.5 kg/ha pre-emergence followed by oxyfluorfen 0.25 kg/ha at 40 days (transplanted onion).

Butachlor 1.5 kg/ha *fb* oxyfluorfen 0.25 kg/ha at 40 days

Applicability: The technology is easily applicable to field conditions.

Economic benefits: The cost of weed control through herbicides works out to be ₹ 3,550/ha as against ₹ 8,000-10,000/ha in conventional method (3-4 manual weedings). There will be net saving of about ₹ 5,000- 6,000 /ha through chemical weed control. Added advantage with this method is timely weed control in onion which facilitates better bulb development, increased yields and higher net returns. Yield increase of about 12-15% was noticed in FLDs.

Impact: Herbicides were not in use, but in recent years, the efforts made by AICRP-WM Dharwad centre through on-farm trials and front-line demonstrations have yielded good results and the farmers have now started adopting this technology.

Precautions: The technology can be very safely adopted by the farmers. No special precautions are required.

6.7 VB, Sriniketan

Weed management in onion

Significance: Onion is one of the important vegetable crops in West Bengal, and mainly grown in medium to upland situation in late *rabi*. High dose of fertilizer and frequent irrigation facilitate weed seed germination and emergence which may sometimes result in complete crop failure. Due to severe weed infestation, the farmers of West Bengal were frustrated and compelled to stop onion cultivation. Manual weed management in onion requires repeated spading or hand pulling which involves huge cost and also longer period of engagement of labour. Weed infestation not only reduces the productivity but also size and shape of onion bulb. Oxyfluorfen 0.2 kg/ha as pre-emergence was found quite effective in controlling all categories of weeds in onion.

Technology: Apply oxyfluorfen 0.2 kg /ha as pre-emergence in onion.

Weed management in onion

Applicability: Applicable in all the onion growing areas for controlling broad spectrum weeds.

Economic benefits: The technology produces about 1602 kg/ha additional bulb yield with an additional net returns of ₹ 14, 816/ha.

Impact: Recently, the farmers of West Bengal are using the modern weed management technology with great satisfaction. About 6.2% area of onion is under adoption of technology. The technology is time saving, low cost and effective. Timely weed management practices by this technology checks the losses of water and nutrient removed by the weeds and thus increases water and fertilizer use efficiency. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Application of herbicide with proper dose, methods and at recommended time should be ensured. Herbicide dose higher than recommended may cause phyto-toxicity in onion.

6.8 RVSKVV, Gwalior

Weed management in coriander

Significance: Coriander is one of the most widely used seed-spice crop throughout the India. Madhya Pradesh is the largest producer of the crop in India. It occupies prime place amongst the seed spices grown in Northern India. Amongst the different biotic constraints heavy weed growth is a recognized major bottleneck in realizing the full yield potential. Since germination and initial growth of coriander is very slow, weeds smother this delicate crop at every stage of growth by depleting water, nutrients, space, solar radiation as well as exibiting allelopathic effects, resulting in yield loss to the extent of 20-50%. Conventionally weeds are controlled manually by hand weeding, which is cumbersome, time consuming and labour intensive.

Technology: Apply pendimethalin 1.0 kg/ha or isoproturon 0.75 kg/ha as pre-emergence to control weeds in coriander.

Pendimethalin 1.0 kg/ha

Isoproturon 0.75 kg/ha

Applicability: Advised to apply in all coriander growing area of Madhya Pradesh.

Economic benefits: Chemical weed management practices are more economical than traditional manual weeding.

Precautions: Apply herbicides at proper stage, dose, and quantity of water for spraying.

6.9 VNMKV, Parbhani

Integrated weed management in turmeric

Significance: Turmeric is an important cash crop grown in western Maharashtra but now the area under this crop is increasing in Marathwada since last few years and farmers are benefited due to higher prices in market. Weed infestation leads to reduced productivity of turmeric. Effective weed management is required in this long duration crop.

Technology: Apply atrazine 0.75 kg/ha or oxyfluorfen 0.15 kg/ha as pre-emergence *fb* hand weeding at 9 and 12 WAP.

Atrazine 0.75 kg/ha or oxyfluorfen 0.15 kg/ha *fb* hand weeding at 9 and 12 WAP

Applicability: Applicable to all turmeric growing area of the Maharashtra state.

Economic benefits: The crop is grown on large area in state. The technology adoption results in 20 % increase in yields and 15% reduction in cost of cultivation by saving expenditure on labour.

Impact: The technology is very much popular and more than 45% farmers are using this technology as there is acute shortage of labour during the growing period every year.

Precautions: For adoption of technology the use of herbicide at higher or excess does should be avoided, also the spraying should be done with proper sprayer and at proper time.

7.0 Weed management in commercial crops

7.1 GBPUAT, Pantnagar

Use of herbicides in sugarcane

Significance: Sugarcane is one of the important crops in Uttarakhand region. Due to its long duration, it is severely infested by weeds which require effective control. Major weeds of sugarcane crop are *Cyperus rotundus, Ageratum conyzoides, Ipomoea* spp., *Cynodon dactylon, Sorghum halepense, Celosia argentea, Solanum nigrum, Brachiaria ramosa, E. colona* and *Dactyloctenium aegyptium*. The losses caused due to weeds in sugarcane are up to 40-60%.

Technology: After emergence of sugarcane, irrigate the crop at 40-45 days stage, and give one hoeing to destroy emerged weeds followed by application of atrazine at 2.0 kg/ha or metribuzin at 1.0 kg/ha within 3-4 DAP before emergence of weeds. Apply 2, 4-D at 500 g/ha to control *Ipomoea* spp. To control broadleaved weeds, apply chlorimuron-ethyl + metsulfuron-methyl 8 g/ha at 2-4 leaf stage of weeds. For control of mix population of weeds, apply hexazinon + diuron 1.2 kg/ha as pre (0-3 DAP) or early post-emergence at 15-20 DAP.

Hand weeded sugarcane crop

Applicability: This technology is applicable in rice-toria-sugarcane-ratoon-wheat cropping system.

Economic benefits: The highest net profit (₹ 165160/ha) could be obtained with 3 hand hoeings, metribuzin 0.88 kg/ha *fb* one hoeing at 45 DAP *fb* 2, 4-D (Na-salt) 0.75 kg/ha (₹ 161386/ha), atrazine 1.5 kg/ha at 3 DAP *fb* 2, 4-D (Na salt) 0.75 kg/ha (₹ 154624/ha), and atrazine 1.5 kg/ha PE (₹ 128574/ha).

Impact: The sugarcane farmers of Uttrakhand region are readily adopting this technology as an alternative to manual hoeing.

Precautions: The herbicide should be applied at recommended dosage and stages of crop growth.

7.2 NDUAT, Faizabad

Weed management in autumn-planted sugarcane

Significance: Sugarcane in one of the important cash crops being grown on a sizeable area in eastern U.P. In light of the shrinking holding size, farmers are now switching over to autumn planted cane along with intercrops in the additive series. But weed problem is being experienced severely which is declining the productivity and profitability of the system.

Technology: Grow sugarcane at 90 cm apart and in between two rows of sugarcane, grow two rows of potato at 45 cm. For weed management, apply pendimethalin 1.0 kg/ha as pre-emergence or undertake manual weeding.

Integrated weed management in sugarcane

Applicability: For sugercane farmers in the districts like Kushinagar, Deoria, and Maharajganj of U.P.

Economic benefits: About 59% increase in the cane yield equivalent over sole crop has been recorded.

Impact: Under paucity of manual labour and shrinking of holding size especially in the eastern U.P., intercropping of potato in autumn planted sugarcane is becoming popular among the farmers. The weed management through herbicides has also become inevitable.

Precautions: Timely planting of sugarcane in the month of October and potato in the first fortnight of November at proper spacing must be done.

7.3 OUAT, Bhubaneswar

Weed management in sugarcane

Significance: Sugarcane is grown in the state as a cash crop and plays pivotal role in agriculture as well as industrial economy. Its initial slow growth, wider row spacing, long duration nature promotes severe weed problems. Uncontrolled weeds may cause 12-72% cane yield reduction depending on the intensity and nature of weeds present. Farmers of the state though practice mechanical methods for controlling weeds but due to its higher cost involvement and unavailability of labor at proper time make it difficult to adopt. Therefore, there is need to develop effective method of weed control which will help in reducing the weed population at initial stages of the crop growth.

Technology: Apply atrazine 2.0 kg/ha pre-emergence at 0-3 days after planting.

Atrazine 2.0 kg/ha

Weedy check

Applicability: All sugarcane growing areas of Odisha.

Economic benefits: Highly beneficial in comparison to traditional weed management practices. The average savings for weeding operation is ₹ 2500-2800 /ha in comparison to traditional manual weeding.

Impact: Highest B:C ratio of 3.54 was obtained with the application of the herbicide in comparison to farmer's practice (2.21).

Precautions: Application of herbicide/s at proper moisture condition of the soil, and at proper dose should be taken care of, and the water requirement for spraying should be 500 l/ha using flat-fan nozzle.

7.4 PAU, Ludhiana

Weed management in spring sugarcane

Significance: Sugarcane is an important cash crop in Punjab. However, due to its long duration it is heavily infested by weeds. An effective weed management strategy is required for the use of farmers.

Technology: Apply atrazine 2 kg/ha as pre-emergence by dissolving in 500 litres of water for effective control of annuals in spring sugarcane. Metribuzin 1.4 kg/ha or diuron at 1.6 kg/ha applied as pre-emergence by dissolving in 500 lires of water gives effective control of atrazine-tolerant *Brachiaria reptans* and other annual weeds. 2,4-D sodium salt 1.6 kg/ha and 2,4,D amine salt 0.58 kg/ha gives effective control of climbing weed *Ipomoea* sp. and other broadleaf weeds in sugarcane when these weeds are in 3- 5 leaf stages.

Atrazine 2.0 kg/ha

Diuron 1.6 kg/ha

Metribuzin 1.4 kg/ha

Unsprayed

Applicability: The technology is applicable under all the environments including all soil types, cropping systems and agro-climatic regions.

Economic benefits: Taking a minimum of 15% increase in yield with herbicide use, the total benefits to the farmers at the prevailing rates comes out to be ₹ 18900/ha and ₹ 567 millions for whole of Punjab.

Impact: In Punjab state, the herbicides in spring sugarcane are used on 50% of total area. The use of herbicides, pre followed by post-emergence, increases the sugarcane yield, on an average by 15-20%.

Precautions: Use flat fan or flood-jet nozzle for spray of herbicides. Always apply the herbicides in moist soil. Adopt herbicide rotation. The herbicides use may be integrated with inter-culture for control of late emerging weeds.

7.5 AAU, Anand

Weed management in *Bt* Cotton

Significance: Gujarat state ranks first in cotton production and productivity, contributing nearly 35 % of the national production, from 24% area in the country. Effective weed management is one of many critical components of successful cotton production. Cotton requires better weed control than either corn or soybean. Weeds also interfere with harvesting of cotton and they can reduce the lint quality. Cotton is long duration and widely spaced crop, loss of yield in India due to weeds range from 50-85%. Manual weeding and pre-emergence application of pendimethalin is recommended for weed management.

Technology: Carry out interculturing and hand weeding at 15, 30 and 45 days after sowing (DAS) when labour is available, but in paucity of labour, apply pendimethalin 900 g/ha pre-emergence *fb* interculture + hand weeding at 30 and 60 DAS or apply fenoxaprop-p-ethyl or quizalofop-ethyl 50 g/ha post-emergence (15-20 DAS) *fb* interculture + hand weeding at 30 DAS for efficient weed management in *Bt* cotton.

Fenoxaprop 50 g/ha POE *fb* IC+HW at 30 DAS

Quizalofop 50 g/ha POE *fb* IC+HW at 30 DAS

Applicability: All cotton growing area of Gujarat.

Economic benefits: Highly beneficial under paucity of labour compared to traditional weed management practices.

Precautions: Application of herbicide/s at proper weed growth stage (4-6 leaf stage) is very essential otherwise the performance will be poor.

7.6 PJTSAU, Hyderabad

Weed management in cotton

Significance: Cotton is the most important commercial crop grown in Andhra Pradesh and Telangana in 22.69 lakh ha with a production of 76.0 lakh bales. In both the states, cotton is predominantly grown as rainfed in deep black soils to red sandy loams. Farmers use rigorous inter-cultivation practices for weed management in cotton. Of late, dwindling farm animal availability and cost escalation in labour hiring are forcing the farmers to search for chemical/ integrated weed management strategies.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence *fb* application of pyrithiobac-sodium 50-75 g/ha in combination with quizalofop-p-ethyl 40 g/ha or propaquizafop 62.5 g/ha at 20-25 DAS *fb* mechanical weeding / inter-cultivation at 50-55 DAS for effective weed management in cotton.

Unweeded

Herbicide treated plot

Applicability: This technology is suitable for farmers growing cotton in red and black soils under rainfed conditions in both the states.

Economic benefits: Establishment of the cotton crop in weed-free condition and maintenance of the crop with a significantly low weed pressure up to 40-45 DAS will reduce the cost of cultivation by ₹ 6250-7500 /ha.

Impact: This technology is being adopted by 65-70 % of cotton growing farmers of the state, especially in the areas where labourers are scarcely available.

Precautions: Post-emergence application of pyrithiobac-sodium + quizalofop may result in reddening of cotton plants (especially under moisture stress conditions). Top dressing with urea and irrigation will aid in quick recovery of the crop.

7.7 PAU, Ludhiana

Control of mixed weed flora in cotton

Significance: In Punjab cotton is an important cash crop. The crop is severely affected by complex weed flora. Cotton with minimal weed competition during the initial phase would yield better. Therefore, effective weed control strategy is required for the use of farmers.

Technology: Apply pendimethalin 0.75 kg/ha pre-emergence by dissolving in 500 to 625 litres of water within 24 hours of sowing for effective control of annuals in American and in *Desi* cotton. Pendimethalin 0.75 kg/ha can be applied after first irrigation in American cotton. Paraquat 0.3 kg/ha or glyphosate 1.0 kg/ha can be applied 6-8 WAS as a directed spray for effective control of weeds in between the rows of American cotton.

Herbicide use in cotton

Applicability: The technology is applicable under all the environments including all soil types, cropping systems and agro-climatic regions.

Economic benefits: Taking a minimum of 15% increase in yield with herbicide use, the total benefits to the farmers at the prevailing rates comes out to be ₹ 7400/ha and ₹ 945 millions for whole of Punjab.

Impact: In Punjab state, the pre-emergence herbicides are used on small scale, however, the post-emergence herbicides as directed spray are used by large number (25%) of farmers. The use of herbicides, pre followed by post-emergence (directed), increases the cotton yield, on an average by 15-20%.

Precautions: Use flat fan or flood-jet nozzle for spray of herbicides. Always apply the herbicides in moist soil. Adopt herbicide rotation. The herbicides need to be integrated with interculture for control of late emerging weeds.

7.8 TNAU, Coimbatore

Weed management in cotton

Significance: In Tamil Nadu, around 0.5 million bales cotton are produced while sowing is done in 0.13 million hectares. Cotton, being a long duration, widely spaced and relatively slow growing crop during early growth stages is subjected to severe weed menace. Manual weeding is not always practical being expensive and time consuming. Availability of labour for timely weeding operation may be inadequate owing to peak season of labour demand. Weed infestation in cotton has been reported to offer severe competition in early stages and causing yield reduction to an extent of 40 to 85%. Thus, there is need for selection of pre-emergence herbicide to control weeds during initial crop period.

Technology: Apply pendimethalin 38.7% 2.0 kg/ha pre-emergence or early post-emergence (EPOE) trifloxsulfuron 10 g/ha on 15 DAS *fb* hand weeding on 45 DAS.

Herbicide use in cotton

Applicability: This herbicide recommendation is suitable for 80,000 hectares of cotton fields under Tamil Nadu.

Impact: IWM technology was followed by 71.2% of the sample farmers, which increased the productivity by 15.2%. With this adoption level, an area of 0.79 lakh ha will be covered.

Economic benefits: With the projected area of adoption, an increased production to the tune of 0.20 lakh tonnes could be obtained. The resultant increased income would be ₹ 8.26 crores.

Precautions: Adequate moisture is needed at the time of pre-emergence herbicide application. Post-emergence herbicide application need bright sunshine hours and rain free period up to 48 hours.

7.9 VNMKV, Parbhani

Integrated weed management in cotton

Significance: The cotton crop is the dominant crop in the region and Maharashtra state. Cotton as a long duration crop needs better weed control during early crop growth stage up to 90 DAS.

Technology: Apply pendimethalin 1.0 kg/ha (PE) or diuron 0.50 kg /ha (PE) or fluchloralin 0.50 (PPI) *fb* hand weeding and hoeing at 6 weeks after sowing.

IWM in cotton

Applicability: This technology is useful to cotton growers in Maharashtra state.

Economic benefits: The adoption of technology resulted in saving the labour cost and increased yield by 15%.

Impact: The technology is easy to accept and farmers are adopting the technology. More than 40% farmers in the state have now adopted this technology.

Precautions: The herbicide needs to be applied at proper time and at correct dose.

7.10 VB, Sriniketan

Weed management in jute

Significance: Jute is the second most important crop after rice in West Bengal. It is mainly sown in the pre-*kharif* season. During the jute growing season temperature and humidity remain high with frequent rainfall as a result of which the crop is heavily infested with all categories of weeds. About 80–90% yield loss due to weeds has been reported from various jute growing areas. Farmers from jute growing districts expressed their concern mainly regarding the infestation of grassy weeds like *Digitaria, Echinochloa* and *Cynodon* in jute. Hand weeding is quite effective but recently due to non-availability of labour in peak period of demand, timely and effective weed management is not possible in jute. Under this situation, application of quizalofop-p-ethyl has been found quite effective for controlling grassy weeds in jute.

Technology: Apply quizalofop-p-ethyl at 50 g/ha as post-emergence for grassy weed management in jute.

Weedy check

Quizalofop-p-ethyl 50 g/ha

Applicability: Applicable in all the jute growing areas where grassy weeds predominate.

Economic benefits: This technology produces 1.77 bale/ha extra fiber yield with an additional net return of ₹ 8,515/ha.

Impact: The farmers in jute belt adopted the technology to get rid of the problem of grassy weeds in jute. About 17% area under jute cultivation is covered by this technology. By adoption of improved weed management practices a change has occurred in the net economic returns of the farmers. Higher income from this technology and increased opportunity to be engaged in other sectors for additional earnings, have improved the socio-economic condition of the farmers.

Precautions: Continuous use of the same herbicide should be avoided to check the shift of weeds from grasses towards broadleaved. Technology should not be applied where broadleaved weeds predominate. Sufficient moisture in the soil should be ensured for better result. Application of herbicide with proper dose, methods and appropriate stage of crop growth should be ensured.

8.0 Weed management in ornamental crops

8.1 AAU, Jorhat

Weed management in marigold

Significance: Marigold is an important commercial flower crop in some pockets of the state and its demand is growing gradually. Weeds are one of the serious constraints of production of this crop. Effective weed management is required for obtaining higher profits.

Technology: Apply butachlor 1.0 kg/ha as pre-emergence at 0-3 DAP, followed by working with grubber at 35 DAP. Alternatively, garden hoeing at 20 and 40 DAP is recommended.

Butachlor 1.0 kg/ha *fb* garden hoe at 35 DAP

Applicability: The commercial cultivation of marigold is limited mainly in few pockets of Kamrup district around Guwahati. Considering the uniform and growing demand for the flower throughout the state, the acreage of the crop is expected to increase in near future.

Economic benefits: Because of planting with a relatively wider spacing, the weed management involves additional labour cost at initial stage. Application of butachlor 1.0 kg/ha *fb* Grubber 35 DAP enables reduction in cost of cultivation with higher benefit cost ratio.

Treatment	Weed dry weight at 30 DAP (g/m)		Fresh flower yield (t/ha)		Benefit: cost ratio	
	On station	*On-farm	On station	*On-farm	On station	*On-farm
Farmer's practice (Garden hoeing at 20 & 40 DAP)	8.07	10.6	14.0	23.9	1.60	3.29
Butachlor 1.0 kg/ha *fb* Grubber 35 DAP	6.69	7.2	11.0	24.3	2.26	3.54
Weedy	9.38	-	8.0#	-	1.00#	-

Impact: The technology is already adopted by at least 30 % of the marigold growers.

Precautions: The herbicide is to be applied at optimum dose and time. The sprayer used in spraying should be cleaned thoroughly before and after use.

9.0 Management of parasitic weeds

9.1 AAU, Anand

Management of *Cuscuta* in lucerne

Significance: Lucerne is one of the most important forage crops during winter season for dairy industry in India and extensively grown in the Gujarat state under irrigation conditions. In case of seed crop lucerne, *Cuscuta* seeds may be mixed with lucerne seed at the time of harvest. This mixture cannot be separated easily due to similar colour and size of both. Due to this, in many areas lucerne fields are found heavily infested with this weed. The parasitic weed dodder emerges (few days late 7 to 10 DAS) along with the germinating lucerne seedlings and parasitizes them soon by attaching themselves to the host. Manual weeding is not effective. Thus, herbicides which can control the dodder seed germination or kill at early stage of infestation, would greatly aid lucerne cultivation.

Technology: Apply pendimethalin 0.5 kg/ha 10 days after sowing. (dissolving in 500 liters of water/ha) for effective control of *Cuscuta* in lucerne.

Lucerne crop infested by *Cuscuta*

Pendimethalin 0.5 kg/ha at 10 DAS

Applicability: In all lucerne growing area of Gujarat state.

Economics benefits: Application of pendimethalin 0.5 kg/ha at 10 DAS resulted in net profit of ₹ 26,143 /ha, and B:C ratio 2.18.

Impact: Highly beneficial to control *Cuscuta* and to obtain higher profit. Pendimethalin residues were not detected in lucerne plant, hence, use of this herbicide is safe.

Precautions: Pre-emergence application of pendimethalin caused toxicity in lucerne crop. Herbicide application at 10 DAS is safe and controls monocot and dicot weeds as well as parasitic weed *Cuscuta*.

9.2 PJTSAU, Hyderabad

Management of *Cuscuta* in lucerne

Significance: Lucerne is a very important leguminous fodder crop grown by the dairy farmers in the peri-urban areas of the state. *Cuscuta* is perennial problem for these farmers. This parasitic weed drastically reduces the fodder yield of lucerne which has direct impact on the milk yield and dairy economics. Hence, identification of effective *Cuscuta* management strategy is highly essential.

Technology: Apply pendimethalin 1.0 kg/ha pre-emergence or imazethapyr 75 g/ha post-emergence for effective control of *Cuscuta*.

Weedy check

Imazethapyr 75 g/ha

Applicability: Most of the dairy farmers especially in peri-urban areas are adopting this technology, as lucerne is one of the component crops for year round supply of fodder to milch cattle.

Economic benefits: This technology saves fodder yield loss up to 80% depending on severity of infestation.

Impact: Farmers were unaware of the usage of the herbicides in fodder crops and this has reached the different fodder growing areas of the state through extension programs organized by the DAATCS and KVKs in the state. The residues of the herbicides were found to be below detectable limit in harvested fodder.

Precautions: Recommended herbicide doses should be applied.

9.3 SKRAU, Bikaner

Management of *Cuscuta* in lucerne

Significance: Lucerne is an important fodder crop grown in both good and poor quality water in Rajasthan. It is severely infested with annual, perennial and parasitic weeds like *Cuscuta*, as its initial growth is very slow, early control of weeds especially with the use of pre-emergence herbicides could benefit the crop early in the season. Parasitic weed *Cuscuta* infests the lucerne and reduces the fodder and seed yield drastically.

Technology: Adopt deep summer ploughing, and apply pendimethalin 1.0 kg/ha as sand mix as pre-emergence or imazethapyr at 75 g/ha as post-emergence spray.

Pendimethalin 1.0 kg/ha sand mix

Farmer's practice

Applicability: All lucerne growing area of Rajasthan.

Economic benefits: Application of pendimethalin 1.0 kg/ha as sand mix and imazethapyr 75 g/ha (post-emergence) recorded higher net returns of ₹ 54600 and ₹ 55095 and B: C ratio 4.19 and 4.36, respectively.

Impact: Increase in green fodder yield with these treatments over farmer's practice were 27.4 to 27.2 %. Farmers are adopting this technology on a large scale in Rajasthan.

Precautions: Recommended herbicide doses should be applied.

9.4 DBSKKV, Dapoli

Management of *Cuscuta* in *Lablab purpureus*

Significance: *Kharif* rice followed by *rabi Lablab purpureus* (*kadawa wal*) is the predominant cropping system of Konkan region. In recent past the problem of infestation of *Cuscuta reflexa,* a complete parasitic weed on zero-tilled dibbled *Lablab purpureus* and other pulses *viz*., cowpea, horsegram, blackgram, redgram has been observed in Chiplun, Khed and Mandangad tahsils of Ratnagiri district and Roha, Mangaon, Mahad, Uran and Karjat tahsil of Raigad district.The cultivation of *rabi* pulses has been threatened in this area and some of the farmers have abandoned growing of pulses during *rabi* season looking to the complete loss of production due to this parasitic weed.

Technology: Adopt summer ploughing and apply pendimethalin 1.0 kg/ha as pre-emergence with sand mix for effective *Cuscuta* control and to obtain higher yield and net returns.

Pendimethalin 1.0 kg/ha

Applicability: Area under *Lablab* cultivation in Konkan region.

Economic benefits: Higher net returns of ₹ 3922/ha was obtained with summer ploughing than crop sown without ploughing. Summer ploughing along with application of pendimethalin 1.0 kg/ha PE recorded higher net returns (₹ 12744/ha) and B:C ratio 1.50.

Impact: Farmers are adopting the technology in Maharashtra.

Precautions: Recommended herbicide doses should be applied.

9.5 KAU, Thrissur

Control of *Loranthus*

Significance: Most of the tree crops of Kerala are infested with parasitic weeds from Loranthaceae and Viscaceae families. The weed infestation affects the growth and vigour of the tree crops resulting in yield decline and gradual death of the tree. Studies were conducted for controlling this parasitic weed and the results are encouraging.

Technology: Spraying Ethrel (ethephone 39% SL) 25 ml/l will result in complete defoliation of the parasite within 48 hours. In case, re-growth is observed after 3-4 months of application, padding with 2,4-D (1g in 20 ml water soaked in sponge) in a few nodal points on the root of the parasite after scraping away the bark of the branch of the parasite will completely eliminate the parasite.

Spraying of ethrel

Dried after the application

Applicability: In the plains and high ranges of Kerala on tree crops including mango, cashew, sapota, apple, pomegranate and nutmeg.

Economic benefits: No damage has been reported by ethrel application to any of the trees sprayed. Moreover, in a few cases early fruiting was observed.

Precautions: Indiscriminate spraying of ethrel (including aerial spraying) is not recommended.

9.6 CCSHAU, Hisar

Control of *Orobanche* in mustard

Significance: In southern Haryana, mustard is grown on light textured loamy sand, poor fertility soils under restricted irrigation facilities. Mustard crop in Bhiwani, Loharu, Rewari, Mewat, Jhajjar, and some parts of Hisar is severally infested with root parasitic weed *Orobanche aegyptiaca* responsible for 10-70% yield reduction.

Technology: Apply glyphosate 41% SL 25 and 50 g/ha post-emergence at 30 and 55-60 DAS, respectively by using 375 litres of water/ha.

Heavy infestation of *Orobanche* in mustard

Wilting due to *Orobanche* infeastation

Applicability: Mustard growing areas of Haryana, Rajasthan and Madhya Pradesh.

Economic benefits: On-farm trials since last 2 years showed that this herbicide provided 60-85% control of *Orobanche* with no crop suppression, and yield increase of 5-15%.

Impact: To popularize this technology, large scale demonstrations on farmers' fields are being conducted since last two years and farmers are accepting and eager to use but with hesitation/or fear of phytotoxicity in mustard.

Precautions: Crop should not be under stress at the time of spray hence, irrigate the field 2-3 days before or after glyphosate application. Over dosing of herbicide may cause leaf chlorosis, stunting of crop growth and even leaf burning.

9.7 TNAU, Coimbatore

Management of *Striga* in sugarcane

Significance: Sugarcane being a widely planted long duration crop with slow initial growth habit, the weed problem is more acute at its early growth stages. Yield loss due to the presence of weeds were estimated at 12 to 83 %. The parasitic weed *Striga asiatica* is the most dominant one in sugarcane ecosystem. Globally, *Striga* has a greater impact on human welfare than any other parasitic angiosperms because their hosts are subsistence crops in areas marginal for agriculture. In general, low soil fertility, nitrogen deficiency, well-drained soils and water stress accentuate the severity of *Striga* damage to the hosts. Especially in western zone of Tamil Nadu more than 50% sugarcane is cultivated in red gravel soils and infestation of *S. asiatica* is also more in this type of soils. The effect of these parasitic weeds has been so devastating that the crop yield loss of 10 to 100% has been recorded, leading to complete crop failure and sometimes abandoning the land. There are approximately 50 species of *Striga*, all of which are parasitic on other plants, not only robbing them of nutrition but also causing various debilitating effects.

Technology: Apply atrazine 1.0 kg/ha 3 days after planting (DAP) *fb* hand weeding on 45 DAP *fb* earthing up on 60 DAP combined with 2,4-D Na salt 5 g/l (0.5%) + urea 20 g/l (2%) on 90 DAP *fb* mulching with cane trash 5 t/ha after final inter cultivation on 120 DAP.

Infestation of *Striga asiatica* in sugarcane

Atrazine 1.0 kg/ha (PE) *fb* HW at 45 DAP *fb* earthing up 60 DAP *fb* 1.25 kg 2,4-D Na salt at 90 DAP *fb* trash mulching 5 t/ha at 120 DAP

Applicability: This herbicide recommendation is suitable for 1.98 lakh ha of sugarcane area under Tamil Nadu.

Economic benefits: The area covered would be 1.92 lakh ha, while the enhanced income based on the increased productivity would be ₹ 397.48 crores with an increase in production of 27.41 lakh tonnes in the state.

Impact: Adoption percentage of this technology was observed to be 64%. The increased yield was seen at 14% over the non-adopters.

Precautions: Adequate moisture is needed at the time of pre-emergence herbicide application and also trampling should be avoided. Post-emergence herbicide application needs bright sunshine hours and rain free period up to 48 hours.

10.0 Management of aquatic weeds

10.1 AAU, Jorhat

Management of *Ipomoea* sp.

Significance: The major natural water bodies of the state are infested by *Ipomoea* sp., the intensity varying from place to place. In some cases, the thick and profuse growth of the plants interfere the natural flow of water of the stream. This results in siltation, shallow stream bed and ultimately overflowing of water to the banks to cause flash flood, and in extreme situation change in the direction of the stream. Farmers of the affected areas usually cut the stems to clear the waterways, which gives temporary relief with regeneration of the plants in the next season.

Technology: Spraying of glyphosate 1.5 kg/ha + 2, 4-D (amine salt) 0.75 kg/ ha as tank mix with a spray volume of 500-600 l/ha at active growing stage.

Spraying of glyphosate + 2,4-D controls *Ipomoea carnea* in water canals , facilitating successful cultivation of rice in a large area

Glyphosate 1.5 kg/ha + 2,4-D 0.75 kg/ha for effective control of *Ipomoea carnea*

Applicability: The technology is highly applicable in the entire state since the weed has created serious problem everywhere particularly it is hampering the cultivation of rice which is the major crop of the state.

Economic benefits: The economic benefit of this technology is far reaching as it is helping in timely planting of the *kharif* rice, as well as it is being used as cheap raw material for good quality vermicomposting.

Impact: The technology has been widely demonstrated by Jorhat Centre to government and non-government organisations and relevant trainings imparted to the stakeholders. The technology received ample appreciation in the form of adoption in a community approach.

Precautions: The herbicide is to be applied at optimum dose and time. The herbicide application is effective when the weed is at active vegetative stage.

10.2 KAU, Thrissur

Herbicides for aquatic weed control

Significance: The two main rice bowls, Kuttanad and Kole lands, which account for half of the total rice production of the state are located in the low lying areas and are severely infested with weeds like *Salvinia*, *Eichhornia, Limnocharis* etc. These weeds are to be removed before land preparation for the rice crop. Traditional removal of weeds (manual/mechanical) from these vast areas became practically very difficult and the chemical methods were found promising.

Technology: Recommendations for chemical control of aquatic weeds

Name of the weed	Promising herbicides
Ipomoea carnea	Glyphosate 15- 20 ml/l water
Limnocharis flava	2, 4-D -1.0 kg/ha or chlorimuron + metsulfuron 4 g/ha
Typha sp.	Glyphosate 20 ml/l
Scirpus grossus	2, 4-D 1.0 kg/ha
Eichhornia crassipes	2, 4-D (1.0 kg/ha), glyphosate (15-20 ml/l) and metsulfuron -methyl (5 g/ha)
Salvinia molesta	Paraquat (0.8 kg/ha), 2, 4-D (1.0 kg/ha), glyphosate (1.0 kg/ha)

Spraying herbicides for controlling weeds in *Kole* lands

Dried weeds two weeks after herbicide spraying

Applicability: The above technology is applicable for weed control before land preparation in water logged paddy fields. The same herbicides can be recommended for weed control in large tanks, ponds etc. where the water is not used for drinking purpose.

Economic benefits: Practicing chemical method of weed control resulted in a saving of ₹ 4000-6000/ha to the farmer, compared to the manual removal of the weeds.

Impact: The state government is encouraging the cultivation of abandoned paddy fields by giving subsidy of ₹ 5000/ha. Now, rice is being grown in many of these areas by adopting chemical weed control.

Precautions: Histopathological studies in fish showed some alterations in the fish tissues viz., liver and muscles due to application of herbicides like paraquat, glyphosate and 2,4-D. Therefore, application of herbicides for aquatic weed control can be practiced only when these aquatic bodies are free from fish and other aquatic fauna and the water is not used for drinking purpose.

10.3 NDUAT, Faizabad

Management of water hyacinth

Significance: Eastern U.P. is having a large number of ponds and reservoirs as well as low land areas which are severely infested with water hyacinth. Water hyacinth poses various types of problems for the farmers having ponds. Manual control is very costly.

Technology: Apply glyphosate 5-10 ml/l of water on fresh foliage to obtain complete control of water hyacinth.

Pond with water hyacinth

Pond after application of glyphosate

Applicability: This technology is applicable for water bodies infested with water hyacinth.

Economic benefits: Control of the water hyacinth by using glyphosate 5-10 ml/l of water was found quite effective and safe for water, and fish. The cleaned ponds could be utilized for human and other economic activities.

Impact: Farmers having ponds are willing to adopt the technology. No regeneration of weed is seen from 21-120 days after herbicide spraying. There was no mortality of released fish fingerlings with the application of glyphosate.

Precautions: Herbicides should only be applied when there is complete mat of foliage of newly developed leaves of water hyacinth on the water surface.

11.0 Weed utilization

11.1 AAU, Jorhat

Weed utilization for compost production using earthworms

Significance: Composting is an age old practice for recycling of plant nutrients through utilization of bio-waste and farm refuse of plant and animal origin. The technology is successfully standardized and employed for large quantities of urban waste in big towns and cities. The technology aims to benefit small and marginal farming community, promises adoption only if compost quality is better, composting period is shorter than the usual practice with a reasonably lower initial cost involvement. The wide abundance and huge biomass of weeds in non-cropped situation offers their use as raw materials for composting. Among the methods available, compost prepared through use of earthworms befits the requirements for its adoption by small farm units with only drawback of slightly high initial cost.

Technology: A detailed method of composting a mixture of bio-waste, mainly weed biomass, and cow dung is developed and recommended. The features of the technology include construction of appropriate concrete tank, collection, preparation of bio-waste/cow dung, efficient species of earthworms through screening, the method of composting including requisite precaution and care, and application of the compost in selected crops.

Weed biomass utilization for vermicomposting is a successful technology

Applicability: This technology can be adopted by all organic farmers, entrepreneurs for utilizing weed biomass in the states and country as well.

Economic benefits: The technology is already adopted by the farmers, tea gardens and rural youth helping in organic cultivation. This has also contributed to livelihood promotion of the farmers. Many large scale vermicompost units on commercial scale have been set up in the state.

Impact: A large number of farm units have taken up the method for utilization of farm resources. Unemployed youths are provided the technical support to set up small to medium commercial composting units with financial support through government schemes and financial institutions.

Precautions: Adequate training and skill development of the entrepreneurs is essential for successful preparation of the vermicompost.

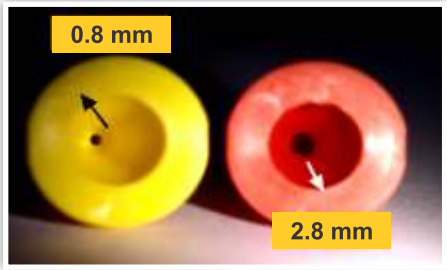
12.0 Herbicide spray techniques

12.1 UAS, Bengaluru

Use of narrow orifice nozzle for post-emergence herbicides

Significance: Narrow orifice flood-jet nozzle produces finer drop deposit on entire foliage than single same volume coarse drop, reduces runoff loss on all types of weed foliage. Flood jet nozzle does not produce drift. Low discharge rate (0.8 l/min.) than wide orifice nozzle (2.8 l/min) gives equal opportunity to individual herbicide molecule to load to epi-cuticle owing to more contact area, spread over entire foliage.

Technology: Use narrow orifice nozzle (Aspee WFN 24 or WFN 40) for improved fine droplet deposition while using post-emergence herbicides.



Narrow and wide orifice nozzles

Applicability: Released for the use of farmers of Southern Karnataka (Zones 4, 5, 6, 7, 9 and 10)

Economic benefits: Drastically saves 30 % spray volume per hectare. Suits the walking speed of spray applicator. Reduced spray volume and thus less pollution to the environment.

Impact: Effect of nozzle on ED_{50} of glyphosate (g/ha) on weed control

Nozzle types	*Cyperus rotundus*	*Digitaria marginata*
Aspee WFN 24 (Zeneca AN 0.6)	173 (4.88)	96 (4.39)
Aspee WFN 70 (Zeneca AN 2.4)	205 (5.02)	406 (5.33)

Precautions: This is recommended for use of non-selective herbicides like glyphosate on the control of weeds in non-crop areas and plantation crops.

13.0 Weed seed and seedling identification

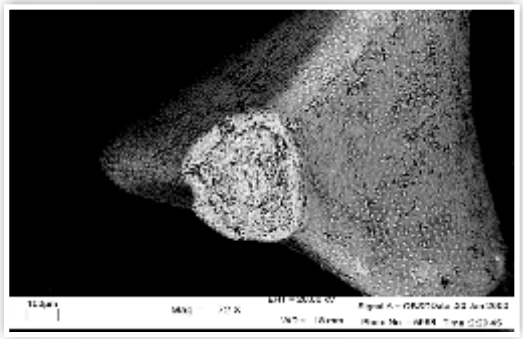
13.1AAU, Jorhat

Weed seed identification technique

Significance: Identification of weed seeds to their species rank is a challenging task. However, recognition of these minute creatures to their lowest possible taxonomic rank enables in checking spread of objectionable weed species across the geographical zones, in studying soil seed bank for predicting weed population, in adopting appropriate management strategy of many soil borne weeds as well as in undertaking strategic practices in handling and using weed contaminated crop seeds.

Technology: Weed seed identification KEYs for nearly 150 weed species have been developed based on some easily understandable morphological features. Help of at least a simple stereoscopic microscope, however, is required for characterization of these seeds, as most of the weed seeds are very small in size.

Seeds of *Cyperus compressus* in a stereoscopic microscopic field



A scanning electron microscopic view of a seed of *Cyperus compressus*

Applicability: Recognition of viable seeds present in soil helps in predicting the weed problem. Similarly, immigration and emigration of objectionable weed species across the geographical regions and the plant quarantine activities are highly dependent on correct identification techniques of weed seeds to the rank of species.

Economic benefits: As almost all alien invasive weeds have created havoc and great economic loss in the countries, successful prohibition of further spread of such weed species certainly will be a matter of great help in checking the loss. Similarly, early prevention of problem weeds at seed state or at least after germination identification will give great relief to the farmers in saving their crop management expenditure.

Impact: The techniques have been tested for several situations and incidences in identifying weeds seeds by researchers, crop management officials, as well as for plant quarantine stations, etc.

Precautions: A careful observation, use of high magnification glasses / stereoscopic microscope and understanding of some of the important botanical terminologies relevant to seed morphology are very important.

13.2 AAU, Jorhat

Weed seedling identification technique

Significance: Effective management of weed invasion should follow three main steps from prevention, early detection to control or eradication. For early detection, identification of weed species at seedling stage, more particularly just after emergence, is very important, also for adoption of effective and eco-friendly management practices.

Technology: The newly emerged seedlings were morphologically characterized just at the stage of development of the primary leaves. Weed seedlings were observed from the top in the field condition. Visual photograph of the critical organs were taken in digital camera. The snap were transferred to the PC for detail interpretation of the characters. Characters studied were: Phyllotaxy; Number of young leaves arises from the axis; Lamina shape and length-width ratio; Lamina apex, base and margins; Lamina colour; Lamina surface (hairy / glabrous, etc.); Lamina texture (membranous / succulent/ fleshy, etc.); Venation (Reticulate / Parallel) and number of primary basal nerves. The KEY for identification of the species has been developed by compiling all these information and variations.

Seedlings of *Borreria articularis* at different growth stages

Clear top view of the seedlings is the primary input for the KEY for identification

Applicability: This taxonomic method is of utmost importance to identify the weed seedlings in the field condition. Its direct applicability is in weed management activities and also in predicting the weed species in the crop fields.

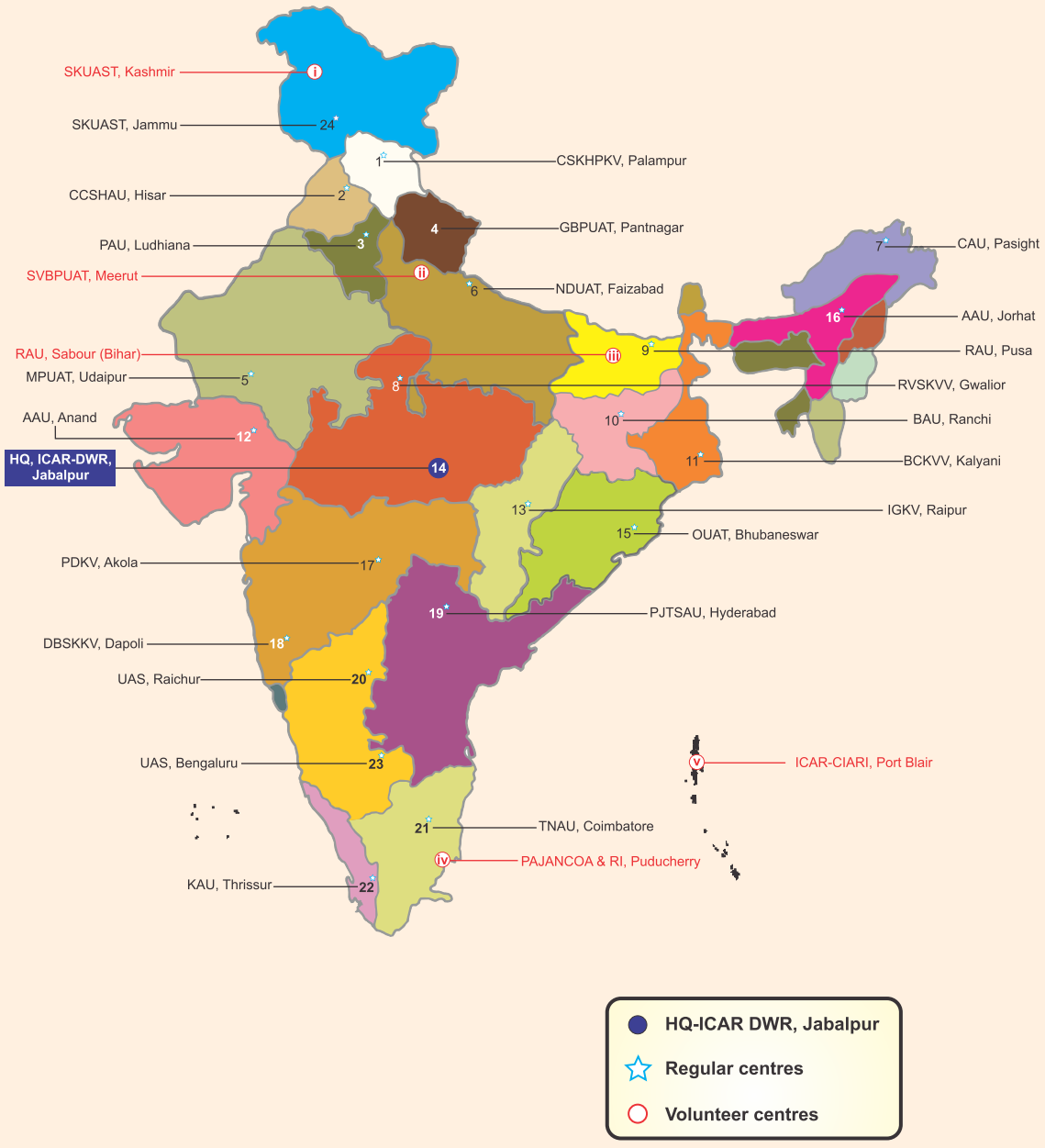
Economic benefits: Early detection of weed species helps in minimizing the cost of weed management.

Impact: The technique is restricted nearly to 30 most common broadleaved and a few narrow-leaved weeds of Assam. The "KEY for identification" has been tested in different fields and conditions and necessary refinement is done for these species.

Precautions: Weed seedlings are to be observed and snaps are to be taken from the top preferably with digital camera. Then the images are to be transferred to a PC. Morphological characters are to be recorded from the images.

Publications in local languages

Location of AICRP-WM Coordinating Centres



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