Uttarakhand at a Glance

The state of Uttarakhand is situated between 28° 43' N to 31° 27' N latitude and 77° 34' E to 81° 02' E longitude. It has 0.35 m ha of net irrigated area. About 54.81 % at the geographic area is covered with forests. The state has a total population of 101.1 lakhs. The average annual rain fall is 1500 mm. The temperature ranges from 44° C during the hot summer month to -2°C during the winter. Monsoon rainfall is received during June to September. The soil in general are alluvial in nature , low to medium in available phosphorus , medium to high in available potassium and medium to high in organic matter. The plant nutrient consumption per unit of gross cropped area is 67.6 kg N/ha, 18.1 kg P_2O_5/ha and 6.6 kg K_2O/ha. The total consumption of pesticides in the state is 132 t technical grades.

Agriculture is practised in the river valleys of Uttarakhand that constitutes a small 10-15% of the total land area. Over hundreds of years, many of the slopes have been developed into field terraces, a common characteristic of mountain Agriculture throughout the World. The region's farmers have also developed advanced manure, crop rotation, and intercropping systems. Most of the lands on the slopes are un-irrigated.

Three types of agriculture can be found in the river valleys. Each type is particularly suited to the type of land. These are:

***Katil* -forest edge land**

- Hoe cultivation, with a standard rotation of 3 crops in 5 years
- Major crop(s): 1. **Millets** – 1. *Echinochloa coracana* (*mandua/kodo*),
  2. Eleusine frumentaceus (jhangora)
  2. Amaranth-1.*Amaranthuspolygamous* (*marsa/chua/chaulai*)
  2. *Amaranthus blitum*

***Upraon* - hillside land**

- Permanently terraced, but unirrigated
- Major crop(s): mandua, jhangora, chaulai

***Talaon* - valley bottom land**

- Paddy cultivation, low-lying, irrigated, double cropped
- Major crop(s): wheat, rice, sugarcane, etc.

Major crops in different ecological sub - regions of Uttarakhand

Ecological sub-region	Altitude (m)	Major Crops
Lower Dun, Tarai	300-600	Wheat, rice, sugarcane
Upper Dun, Bhabar, lower Shivaliks	600-1,200	Wheat, rice, *mandua, jhangora, chaulai*, maize
Middle Garhwal-Kumaon	1,200-1,800	Wheat, rice, Finger millet (*mandua), jhangora, "cheena*" (*Panicum miliaceum*), potato, barley, Maize
Upper Garhwal-Kumaon	1,800-2,400	Wheat, barley, potato, *chaulai, cheena*, maize, "*phaphra*" (*Fagopyum tataricum*)
Cold Zone	2,400-3,600	SUMMER- wheat, barley, potato, *phaphra*, *chaulai*, "*kauni*", "*ogal*", "*kodo*" (*Fagopyum esculentum*), "*uva*" (*Hoycleum himalayanse*)

Various pulses such as Lentil (*Lens culinaris),* Horse gram (*Dolichos biflorus*) are grown as intercrop during the two harvest seasons - early winter after the rainy season (millet) and mid summer before the hot dry season (barley-wheat). Dry and wet rice, pumpkins, beans, corn, ginger, chili,

cucumbers, leafy vegetables, and tobacco are also grown. Potatoes have become an important cash crop, growing in areas unsuitable for other plants.

Cropping Systems

Cropping system is generally dependent upon irrigation facilities, geographical location and environmental conditions. Uttarakhand is divided in two distinct zones, i.e. .plains and hills. The plain area and hill valleys are having irrigation facilities and most rice is transplanted but agriculture in sloppy hills is rainfed. The cropping pattern, thus, varies accordingly.

Cereal Based cropping systems

Rice-wheat, Rice-wheat-Sugarcane-Sugarcane ratoon, summer paddy is also becoming popular in district Udham Singh Nagar in rotation of vegetable Pea- summer rice- *kharif* rice, summer rice – *kharif* rice-wheat. Rice-wheat-Fingermillet-fallow. Rice-lentil, Rice- barley, Rice-potato, Rice-barseem. Fallow in *kharif* and then wheat in *rabi* is also common in high hills.

Maize – Wheat, Maize - Wheat – Mustard, Maize – Chickpea, Maize - Toria – Wheat, Maize – Potato, Maize - Potato – Wheat, Maize - Potato - Urd/Moong, Proso millet – wheat/barley/chick pea,Proso millet – lahi / taramira, Maize – potato – proso millet, Maize – wheat – proso millet, Maize – toria – wheat – proso millet, Maize-Potato-Okra, Paddy-Potato-French bean, Bajra-Pea-Okra, Sorghum – Pea-Cluster bean, Paddy-Pea-Bitter gourd, Maize-Carrot-Amaranth,

Vegetable based cropping systems

French bean- Potato-Okra, Okra-Potato-Onion, Cluster bean-Potato-Onion, Bottle gourd-Onion, Chilli- Soybean-Onion, Okra-Pea-French bean, Torai-Pea-*Arbi,* Early Cauliflower-Pea-Brinjal, French bean-Pea-Chilli, *Arbi*-Pea –Bottle gourd, Okra-Carrot-French bean, Early Cauliflower-Carrot—Cluster bean, French bean-Carrot-Chilli, Cauliflower-Early Carrot- Brinjal, Cluster bean-Radish-Tomato, Okra-Garlic-French bean, Torai-Garlic-French bean, French bean-Garlic-Maize, French bean-Tomato-Okra, Cauliflower-Radish-Tomato, Chilli –Tomato, Capsicum-cowpea-Okra, Capsicum-Chilli-Onion-Frenchbean, Potato-Capsicum-Okra, Onion-Capsicum-Chilli-Cowpea ,Cauliflower-Capsicum-Cluster, Cabbage-Capsicum-Cluster, Cowpea – Brinjal –Cucumber, Cauliflower-Onion-Tomato, Early Cauliflower- Carrot, Cauliflower-Radish

Duration of major Cropping System

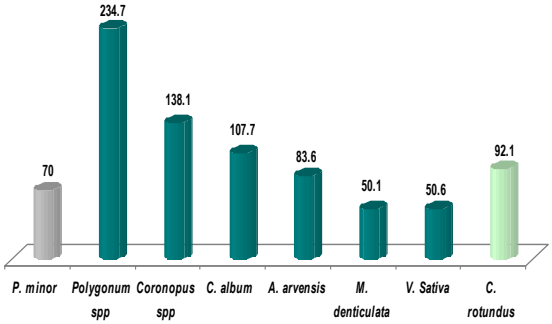
Hills	
Rotation	**Duration**
Rice-Wheat	1 year
Maize-Wheat	1 year
Rice -Lahi-Wheat	1 year
Jowar-Wheat- Moong	1 year
Maize-Potato-Wheat/Gram	1 year
Potato-Maize-Wheat-Moong	1 year
Green manure-Wheat-Maize-Potato-Sugarcane	2 years
Ragi-Barley-Paddy/Barnyard Millet/Wheat	2 years
Ragi-Toria/Rai- Rice /Barnyard Millet/Wheat	2 years
Ragi-Fallow-Rai-Pea/Wheat	2 years
Plains	
Rice-Wheat	1 years
Rice-Pea-Rice	1 years
Rice-Wheat-Sugarcane	3 years
Ration Sugarcane	
Rice- Sugarcane- Sugarcane	3 Years
Ration-Toria/Wheat	

Major weeds species of different crops

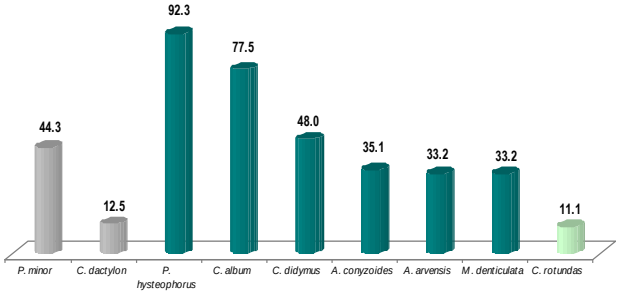
Crops	Grasses	Broad leaved weeds	Sedges
Rice	*Echinochloa colona*	*Alternanthera sessilis*	*Cyperus diffomis*
	Echinochloa crus-galli	*Commellina beghalensis*	*Cyperus iria*
	Echinochloa glaberscens	*Commelina diffussa*	*Fimbristylis miliacea*
	Ischaemum rugosum Salisb	*Sphenoclea zeylanica*	*Scirpus maritimus*
	Leersia hexandra Sw.	*Eclipta prostrata*	*Cyperus rotundus*
	Leptochloa chinensis	*Monochoria vaginalis*	
	Paspalum distichum	Ludwigia octovalvis	
	Digitaria sanguinalis	*Caesulia axiliaris*	
	Eragrostis japonica	*Cynotis axilaris*	
	Eleusine indica	*Marsilea minuta*	
	Bracharia ramosa	*Amaranthus spinosus*	
	Agropyron repens	*Amaranthus virdis*	
	Imperata cylindrical	*Ageratum conyzoides*	
	Cynodon dactylon	*Chorchorus spp.*	
	Physalis minima	*Trianthema monogyna*	
	Ludwigia octovalvis	*Euphorbia hirta*	
		Portulaca oleracea	
		Stellaria media	
		Galinsoga parviflora	
wheat	*Phalaris minor*	*Chenopodium album*	*Cyperus rotundus*
	Avena fatua	*Fumaria parviflora*	
	Avena ludoviciana	*Asphodelus tenuifolius*	
		Convolvulus arvensis	
		Anagalis arvensis	
		Desmodium trifolium	
		Vicia sativa	
		Argemone mexicana	
		Melilotus Indica /alba	
		Lathyrus aphaca	
		Coronopus didymus	
		Poa annua	
Maize	*Echinochloa colona*	*Celosia argentia*	*Cyperus rotundus*
	Echinochloa crus-galli	*Commelina benghalensis*	
	Dactyloctenium aegypticum	*Phylanthus niruri*	
	Eleusine indica	*Solonum nigrum*	
	Cynodon dactylon	*Amaranthus viridis*	
	Sorghum halepense	*Podrtulaca oleraceae*	
		Cyperus rotundus	
		Trianthema portulacastrum	
		Ageratum conyzoides	
		Galinsoga parviflora	
		Setaria glauca	
		Oxallis latifolia	
Small millet	*Echinochloa colona*	*Ageratum Conyzoides*	*Cyperus rotundus*
	Elusine Indica	*Lindernia ciliate*	*Cyperus iria*
	Panicum dichotomiflorum	*Phylanthus niruri*	
		Oxalis latifolia	
		Lindernia cristaceae	
		Eclipta alba	
		Commelina diffusa	
		Equisetum spp	
		Alternenthera sessils	
		Mallugo lotoides	
		Ammannia baccifera	
		Setaria intermedia	
		Euphorbia hirta	
		Alternanthera spp..	
		Aegeratum conyzoides	
		Alternanthera sessillis	
		Commelina benghalensis	
		Hedyotis biflorus	

		Ischaemum rugosum	
		Xanthium strumarium	
		Polygonum plebejum	
		Ipomea spp	
Soybean	*Echinochloa colona*	*Digera arvensis*	*Cyperus rotundus*
	Dactyloctenium aegyptium	*Commelina spp*	
	Panicum spp.	*Cleome viscosa*	
	Eleusine indica	*Celosia argentea*	
		Aegeratum conyzoides	
		Hedyotis biflorus	
		Oxalis latifolia	
		Trianthema portulacastrum	
Sorghum	*Cynodon dactylon*	*Celosia argentia*	
	Digitaria sanguinalis	*Trianthema portulacastrum*	
	Eleusine indica		
Potato	*Phalaris minor*	*Chenopodium album*	*Cyperus rotundus*
		Parthenium hysterophorus	
		Coronopus didymus	
Urd, moong, cowpea, pigeonpea	*Phalaris minor*	*Melilotus indica*	*Cyperus rotundus*
		Medicago denticulata	
		Polygonum spp	
		Coronopus didymus	
		Chenopodium album	
Coriander	*Phalaris minor*	*Fumaria parviflora*	
	Avena ludoviciana	*Anagallis arvensis*	
		Chenopodium album	
		Sorgum halepense	
		Cirsium arvense	
		Medicago denticulata	
French bean	*Cynodon dactylon*	*Chenopodium album*	*Cyperus rotundus*
	Phalaris minor	*Anagallis arvensis*	
		Fumaria parviflora	
		Oxalis latifolia	
		Melilotus alba	
		Vicia hirsuta	
		Melilotus indica	
Brinjal	*Echinochloa colona*	*Gnaphalium indicum*	*Cyperus rotundus*
	Cynodon dactylon	*Eclipta alba*	
	Digitaria sanguinalis		
	Eleusine indica		

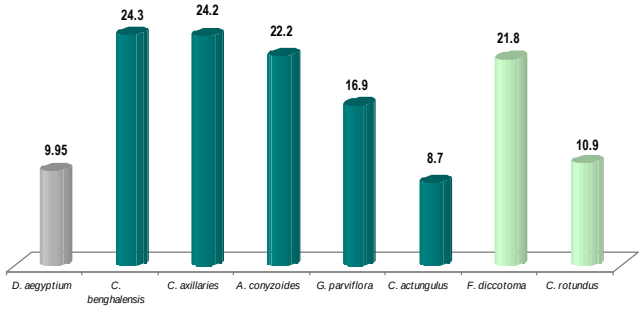
Major Weed species with their Importance Value Index (IVI) in Kumaun & Garhwal regions of Uttarakhand



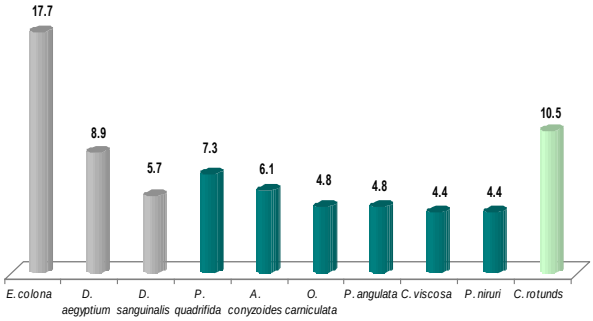
Important weed flora in terms of IVI, in the *tarai* region (<600) in U.S.Nagar District Uttarakhand (Plains)



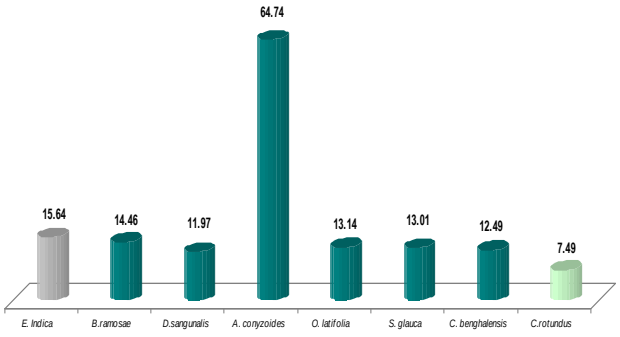
Important and weed flora, in terms of IVI, in the Dehradun and Haridwar Districts (<600) of Uttarakhand (Plains)



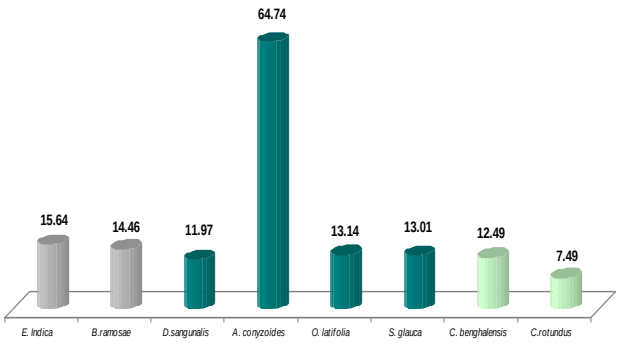
Important weed flora, In terms of IVI, in Nainital and Almora Districts of Uttarakhand (600-1200 ml) Kumaun Districts



Important weed flora, In terms of IVI OF Tehri and pauri Garhwal Districts of Uttarakhand (600-1200 m) Garhwal districts



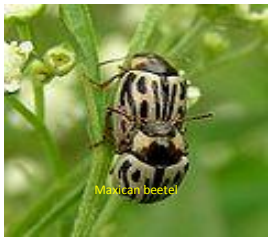
Important weed flora, In terms of IVI (<600-1700m MSL) Tehri and Pauri Garhwal Districts



Important wed flora , in terms of IVI (1200-2000 m MSL) Chamoli District Garhwal districts

Weed management in Non- Cropped areas

1. For biological control of *Parthenium hysterophorus,* Mexican beetle (*Zygogramma bicolorata*) can be used. One adult can feed the entire plant within 6-8 week. About 500-1000 beetles are to be relesed to control the weeds in heavily infested areas.
2. To control weeds on road side, railway tracks, and airports, apply glyphosate 3-4 lit/ha, **care should be taken to protect cropped areas/ornamental plants growing nearby as it is a non-selectivre herbicide.**



Recommended herbicides in different crops

Sl. No.	Crops	Herbicide	Dose kg ha^{-1}	Stages of application
1.	Maize	Atrazine	1.0	Pre-emergence
		Alachlor	2.5	Pre-emergence
2.	Soybean	Alachlor	2.5	Pre-emergence
		Pendimethalin	1.0	Pre-emergence
		Fluchloralin	1.0	Pre-plant incorporation
		Trifluralin	1.0	Pre-plant incorporation
		Metribuzin	0.35	Pre-emergence
		Chlorimuron-ethyl	0.006-0.009	15-20 days stage
		Haloxyfop	0.125	15-20 days stage
		Diclosulam	0.022	Pre-emergence
3.	Urd, moong, cowpea, arhar	Alachlor	2.5	Pre-emergence
		Pendimethalin	1.0	Pre-emergence
		Fluchloralin	1.0	Pre-plant incorporation
		Trifluralin	1.0	Pre-plant incorporation
		Metribuzin	0.35	Pre-emergence
4.	Rice nursery	Thiobencarb	1.0	Pre -emergence
		Anilofos	0.4	First leaf seedling rice turned green
5.	Transplanted rice	Butachlor	1.5	Pre-emergence
		Anilofos	2.4	Pre-emergence
		Pretilachlor	1.0	Pre-emergence
		Thiobencarb	1.0	Pre-emergence
		Almix	0.004	Post-emergence
		Oxadiargyl	0.1	Pre-emergence
		2,4-D	0.5	Post-emergence
		Penoxsulam	0.025	7-10 DAT
		Fenoxaprop-p-ethyl	0.06	25-30 DAT
6	Direct seeded rice	Pendimethalin	1000-1500	Pre-emergence
		Almix	0.004	Post-emergence
		2,4-D	0.5	Post-emergence
		Azimsulfuron	0.035	20 days stage
7.	Wheat	Isoproturon	1.0	30 days stage
		Clodinafop-propargyl	0.06	30 days stage
			0.025	30-35 days stage
		Sulfosulfuron	0.09	30 days stage
		Fenoxaprop-p-ethyl	1.0	30 days stage
		Pendimathalin	0.5	Pre –emergence
		2,4-D	0.004	35-40 days stage
		Metsulfuron-methyl	0.020	35 days stage
		Carfentazone-ethyl	0.012+0.0024	25-30 days stage
		Atlantis (meso+Ido)		
8.	Gram, pea, lentil	Pendimethalin	1.0	Pre –emergence
		Fluchloralin	1.0	Pre-plant incorporation
		Trifluralin	1.0	Pre-plant incorporation
9.	Potato	Paraquat	0.5	Post to weeds before emergence of potato
		Pendimethalin	1.0	Pre –emergence
		Metribuzin	0.35	Pre –emergence
10	Sugarcane	Atrazine	2.0	Pre – emergence
		Metribuzin	1.0	Pre – emergence
		2,4-D	0.5	Pos t- emergence

Integrated weed management technologies

1. Rice

A: Transplanted rice

- Use rice seeds free from weed seeds for raising nursery
- Use wet bed method for raising rice nursery
- Irrigate rice nursery field 8-10 days before seeding to stimulate weed seed germination, which may be destroyed during puddling

- Spray anilofos at 0.4 kg ha^{-1} or thiobencarb at 1.0 kg ha^{-1} when first leaf of rice has turned green
- The weeds remaining thereafter may be mainly uprooted check their transfer to main field during transplanting
- Summer ploughing of main field to destroy weeds and expose soil
- Properly level and bund to facilitate proper puddling and retention of water in the transplanted field. This will help in reducing weed emergence
- Transplant healthy seedlings free from weed seedlings,
- At least two seedlings should be transplanted per hill at proper spacing early in the season to optimize plant Population which would provide competitive advantage to the crop against weeds
- Apply butachlor (1.5 kg ha^{-1}) anilofos (400 g ha^{-1}) pretilachlor (1.0 kg ha^{-1}) oxadiargyl (100 g ha^{-1}) as pre emergence after transplanting. If required depending upon weed infestation and species apply 2,4-D at 500 g ha^{-1} or Almix at 4 g ha^{-1} as post emergence (25-30 DAS) to control sedges and broad leaf weeds or do one manual weeding
- Maintain standing water 3-4 cm in transplanted field at least during early stages to check weed emergence

B. Direct Seeded Rice

- Pre-sowing irrigation 20-25 days before sowing (Stale Seed Bed Technique).
- Use wet bed method for wet seeding of Direct Seeded Rice.
- Seed rate 40 kg ha^{-1} (course rice) and 25-30 kg ha^{-1} (fine rice).
- Maintain a spacing of 20 cmX10 cm so that plant population may compete with initial weeds.
- Pendimethalin @1kg ha^{-1} within 0-3 DAS fb metsulfuron methyl 4 g ha^{-1} at 25-30 DAS and one hand weeding if needed (40-45 DAS) for dry direct seeded rice.
- Anilofos @400 g ha^{-1} applied 7-10 DAS as pre emergence 25-30 DAS as post emergence in wet seeded rice.

Wheat

- Apply paraquat @ 0.5 kg ha^{-1} to kill the weeds of preceeding crop or weeds emerged before sowing of wheat in case of Zero Tillage.
- If grassy weeds are dominating spray clodinafop 60 g $ha^{-1,}$ in case of a mix population of weeds, a follow up application of MSM (4 g ha^{-1}) will be beneficial.
- Apply isoproturon 1kg ha^{-1} fb 2, 4-D 0.5 kg ha^{-1} or MSM 4 g ha^{-1} to control mixed weeds flora.
- Apply sulfosulfuron 25 g ha^{-1} at 25-35 DAS fb manual weeding is effective in wheat crop.

Sugarcane

- After emergence of sugarcane irrigate at 40-45 days stage and do hoeing to destroy emerged weeds at this stage followed by spray within 3-4 DAP of atrazine at 2.0 kg ha^{-1} or metribuzin at 1.0 kg ha^{-1} before emergence of weeds
- Irrigate field as and when required to maintain proper soil moisture

- 2,4-D at 500 g ha^{-1} may be sprayed to control *Ipomoea* spp
- In ratoon crop do mulching with the available trash (after harvest of main crop)

Soybean

- Spray alachlor at 2.5 kg ha^{-1} or pendimethalin at 1.0 kg ha^{-1} or metribuzin at 350 g ha^{-1} as pre-emergence or fluchloralin at 1.0 kg ha^{-1} or trifluralin at 1.0 kg ha^{-1} as pre plant incorporation (PPI). This will provide effective control of annual grassy weeds.
- Do manual uprooting of left over weeds and broad leaf weeds not controlled by these herbicides.

Potato

- In case of non-availability of mulching material, spray paraquat at 500 g ha^{-1} when weeds have emerged but potato emergence is not more than 5 %. It should be followed by earthing up at appropriate stage
- Pendimethalin at 1.0 kg ha^{-1} or metribuzin at 350 g ha^{-1} may be applied as pre-emergence followed by manual weeding and earthing up at appropriate stage.

French bean

- Pendimethalin 0.75 kg ha^{-1} may be sprayed as pre-emergence followed by one hand weeding at 40 DAS.
- Alternatively, two hand weedings twice at 20 and 40 DAS may also be used.

Chemical methods of weed management in pulses and oilseed

Greengram, Blackgram, cowpea and pigeonpea

- Alachlor 2.5 kg ha^{-1}, pendimethalin 1.0 kg ha^{-1} or metribuzin 0.35 kg ha^{-1} as pre emergence or fluchloralin 1.0 kg ha^{-1} or trifluralin 1.0 kg ha^{-1} as pre plant incorporation.

Sunflower

- Alachlor 1.0 to 1.5 kg ha^{-1} as pre emergence.

Gram, pea and lentil

- Pendimethalin 1.0 kg ha^{-1} as pre emergence or fluchloralin or trifluralin 1.0 kg ha^{-1} as pre plant incorporation.

Rapeseed and Mustard

- Fluchloralin 1.0 kg ha^{-1} as pre-sowing soil incorporation or Pendimethalin 1.0 kg ha^{-1} as pre-emergence.

Chemical methods of weed management in Millets

Millets

Sorghum

- Atrazin 1.0 kg ha^{-1} as pre emergence.

Finger millet/Barnyard millet

- In irrigated areas, 2, 4 – D sodium salt 0.75 kg ha^{-1} after crop emergence
- Isoproturon 0.5 kg ha^{-1} as pre-emergence. In assured rainfall and irrigated areas atrazine 0.5 – 1.0 kg ha^{-1} as pre-emergence.

Chemical methods of weed management in Vegetables

Coriander, Brinjal, Tomato and Capsicum

- Pendimethalin 1.0 kg ha^{-1} as pre emergence.

Onion, Garlic

- Pendimethalin 1.0 kg ha^{-1} as pre emergence or Oxadiazone 1 kg ha^{-1} or Oxyflurofen 0.25 kg ha^{-1}.

Carrot and Radish

- Alachlor 2.0 to 2.5 kg ha^{-1} as pre emergence

Cauliflower

Alachlor 2.5 to 3.0 kg ha-1 or Pendimethalin 1.0 kg ha-1 as pre emergence

Technical Achievements at Pantnagar Centre

Physiological studies

1. **Herbicide Resistance**: Survival of *P. minor* plants at recommended doses of isoproturon was noticed for the first time in 2008. About 40-49 % population of from different locations in the districts of Udham Singh Nagar and Nainital survived at 1.0 kg isoproturon. In subsequent years of study (2009 and 2010), the same trend is being observed for the *P minor* seeds collected from different areas in the districts of Nainital, Udham Singh Nagar and adjoining areas of UP.
2. **Control of *Cyperus rotundus* by Glyphosate:** Though glyphosate is providing satisfactory control of this sedge at 0.75-1.5 kg/ha, the tuber viability was retained at all the doses of the herbicide. Methodology to determine tuber viability must be carefully decided.

Weed Seed Bank:

Long term effect of Tillage in Rice-Wheat cropping system: Weed seed bank was higher in conventional tillage as compared to zero tillage.

DSR-Chickpea:

Weedy check and Butachlor + HW (one) recorded higher weed seed bank than other treatments.

Rice – wheat:

Hand weeding twice and butachlor treatments recorded higher weed seed bank than other treatments.

Maize-Pea:

Weedy check had higher seed bank whereas mechanical weeding (twice), atrazine alone and atarzine + 2,4-D recorded similar weed seed bank.

Long terms trials

Establishment trial

Long term effect of tillage in rice-wheat cropping system, the tillage and weed control treatment in both the crop did not influence the grain and straw yield. Wheat sown with zero till methods gave significantly higher grain and straw yield over conventional method of sowing. The highest grain yield of wheat was obtained with twice hand weeding and at par with application of isoproturon 1.0 kg + MSM 4 g ha^{-1}. In rice application, of butachlor 1.5 kg ha^{-1} fb 2,4-D 0.5 kg ha^{-1} also yielded at par yield over the twice hand weeding.

Maize-Pea

In maize-pea cropping system, different weed control methods in maize crop showed the significant effect on grain yield of pea and the higher grain yield of pea was recorded with mechanical (30&60 DAS) weeding and application of pendimethalin 0.75 kg ha^{-1} fb one hand weeding. In maize crop, application of atrazine (1.0 kg ha^{-1}) recorded the highest grain yield.

Direct Seeded Rice –Chickpea

In the DSR-chickpea system, application of anilofos and butachlor followed by one hand weeding was found effective against the grasses and recorded at par grain yield. Different weed management practices chickpea had no effect on the emergence of weeds and the subsequent crop in rice.

Rice-wheat

Long term use of herbicide in rice wheat cropping system, the grain and straw yield of wheat was influenced significantly due to sub-plot treatments. While rice was affected due to main plot treatments. The highest grain yield of wheat was recorded with isoproturon 0.75 kg ha^{-1} along with urea (1%) and in rice it was recorded with, twice hand weeding (30 & 60DAT). Application of bispyribac sodium as post-emergence recorded highest grain yield in rice, while in wheat highest grain yield was recorded with application of clodinafop 60 g ha^{-1} fb 2, 4- D 0.5 kg ha^{-1}.

Weed management in Cropping System

Year 1992

Rice-wheat

Significantly highest grain yield was recorded from two hand weeding in rice and with post-emergence application of Isoproturon in wheat crop, grain yield reduced drastically. Weeds were reduced effectively under butachlor and hand weeding twice over weedy check.

Year 1993

Butachlor 1.5 kg ha^{-1}, weeding 30 & 60 days after transplanting in rice and isoproturon 1.0 kg ha^{-1} and weeding 30 & 60 days after sowing in wheat in rice-wheat cropping system have no change in weed flora.

Year 2004

Weed management practices followed in wheat influenced grain yield of rice when grown subsequently in rotation. Mechanical weeding practices in wheat caused significant increase in grain yield of rice as compared to application of isoproturon at 1.0 kg ha^{-1} as post emergence.

Year 1995

During *Kharif* two hand weedings in rice gave significantly higher yield over weedy check. Whereas during *rabi* season, WD-HW produced grain yield of wheat at par with HW-HW. That the total weed density and population of *Caesulia axillaries* was reduced during 1995 when compared with that year of 1990 base year, whereas there was much increase in the total weed density and individual weed spp. of *Phalaris minor*, *Chenopodium album*, *Melilotus* spp. and *Anagalis arvensis* in wheat during 1994-95 over that of 1990-91 the base year except whereas butachlor and isoproturon were used continuously.

Year 2008

Rice based cropping system

In direct seeded rice based cropping system of rice-field pea, rice-linseed, rice-chickpea, rice potato and rice wheat gave higher grain yield when supplemented with hand weeding twice at 20 and 45 days after sowing over the weedy plot among all cropping system.

In direct seeded rice based cropping system the highest reduction in grain yield under weedy situation was recorded in rice-berseem fb rice-linseed and rice-chickpea cropping system. However, lowest reduction due to weeds was obtained in rice-potato cropping system over hand weeding.

Year 2009

Rice-wheat and soybean-wheat

In both rice -wheat and soybean-wheat cropping systems, during winter season the population of *P. minor* was very high and maximum weeds emerged during 30-60 day growth stage. Among the sedges, *C. rotundus* was noticed only in soybean-wheat cropping system while it was absent in the rice-wheat system. During the rainy season the population of *C. rotundus* and the BLW, *Lindernia* spp. was obtained highest in rice and soybean crop rotation at 60 to 90 days crop growth stage.

Other Cropping Systems

The highest weed density was recorded in soybean –wheat system during *khari*f season while in *rab*i season, it was highest under rice-wheat followed by maize-sugarcane-ratoon-wheat. During *kharif* season the population of *Echinochloa colona* under maize-sugarcane-ratoon -wheat system was reduced drastically while during *rabi* there was also drastic reduction in the population of *Phalaris minor* and *Chenopodium album* in rice-sugarcane-ratoon-wheat -maize-potato-wheat and maize-sugarcane-ratoon-wheat systems were observed.

Herbicide testing, leaching behavior, persistence, residues and toxicity

Long term trial

Year 1996-2010

1. Residues of butachlor in transplanted rice and isoproturon in wheat at harvest were non-detectable in soil, straw and grain after continuous use in rice –wheat cropping system and there was no residue buildup. Ground water was not found to be contaminated with these herbicides (1996-2010)

Persistence studies

Wheat

Year 2007

Isoproturon residues (0.001µg g-1) were not detectable when applied at 1.0 kg ha-1 in wheat at 75 days of application. Residues were observed till 60th day of application (5.73 % persistence) in soil. No residue was detected in soil, wheat grain and straw at harvest

Year 2008

Fenoxaprop-p-ethyl applied at 180 g ha-1 dissipated more than 96 % in soil after 45th day of its application and no detectable residue (0.003 µg g-1 soil) was observed on 60th day. Wheat straw, grain and soil were free from fenoxaprop residues at harvest.

Year 2009

Clodinafop propargyl, applied at the recommended dose dissipated 87.5 % on 7th day of application and completely dissipated from the soil by 10th day (0.002 µg g-1) and residues were undetectable in soil, wheat straw and grain at harvest.

Year 2010

Sulfosulfuron applied at 25 and 50 g ha-1 persisted till 15th and 30th days respectively. No detectable residue (0.001 µg g-1 soil) was observed after 45th day of application. At harvest no residues was detected in grain, soil and straw

Rice

Year 2006

Butachlor was below detectable limit at both recommended and double the recommended doses in soil. The limit of detection was 0.001µg g-1. Butachlor residue levels were below in rice grain and straw at harvest

Year 2007

Anilophos persisted for more than 60 days at double dose and residues was not found in soil, rice straw and grain at harvest.

Year 2008

Pretilachlor in soil were detected upto 60 days after treatment at recommended dose (0.75 kg ha-1). Residues were below detectable limit (0.005µg g-1) in soil, rice grain and straw at harvest of crop.

Year 2009

Anilophos dissipated 97.29 and 94.66 % after 45 and 60 days of treatment at 0.4 and 0.8 kg ha-1 respectively. Anilophos residues were below detection (0.002 µ g g-1) in grain, soil and straw at harvest of crop.

Year 2010

Oxyflurofen herbicide in rice applied at 240 and 480 g ha-1 dissipated up till 60th day after application. However, no detectable residue (<0.005 µg g-1) was found on 90th day of application. At harvest no residues was detected in soil, grain and straw.

Maize

Year 2007

Pendimethalin residues were observed after 90 days of application in soil at 2.0 kg ha-1. Only 2.05 % residues persisted in soil on 90th day. Non detectable residues was observed in soil on 120th day and the residues of pendimethalin was not found in winter maize cobs, straw and soil at harvest of the crop (2007)

Year 2008

No detectable atrazine residues (0.001µg g-1) applied at 4 kg ha-1 in winter maize was observed after 135 days of application in soil. No residue was detected in soil, maize cobs and straw at harvest (2008).

Soybean

Year 2006

Pendimethalin residues were not observed after 90 days of application in soil at 1.0 kg ha-1. 99.00 % residues dissipated in soil on 90th day. Non detectable residues were observed in soil on 120th day at both lower and higher doses. Residues of pendimethalin (0.005 µg g-1) were not found in soybean pods, straw and soil at harvest of the crop

Year 2007

Chlorimuron-ethyl in soil persisted for more than 45 days at higher dose application (12 g ha-1). It dissipated 93.45 % on 45th day, while at recommended dose it persisted to only 30 days thereafter it was below detectable limits (0.005µg g-1). Residues were below detection limit at harvest in soil, soybean pods and straw

Year 2008

Alachlor (2.5 and 5.0 kg ha-1) residues in soil, soybean pods and straw was non detectable (0.001µg g-1) at harvest time. In soil it persisted for more than 60 and 75 days at both doses respectively. (2008)

Potato

Year 2006

Pendimethalin dissipated 98.99 and 99.52 % after 90 and 100 days of treatment at 1.0 and 2.0 kg ha-1 respectively. Pendimethalin residues were below detection (0.002 µg g-1) in soil and potato tuber at harvest of crop. (2006)

Water

Year 2007

2,4-D persisted in for 30 days in water and residues were below detectable limit on 45th day of application at both recommended and double recommended doses. The limit of detection of 2,4-D in water was 0.005 µg mL-1. On addition of herbicide physicochemical properties of water were slightly affected.

Year 2008

The residues of paraquat were detectable up to 20 days at higher dose treatment but no residues were detected after 20 days at both the levels of application. The limit of detection by spectroscopic method was 0.05 mg L-1. The pH, EC and free CO2, carbonate and bicarbonate contents increased after treatment whereas dissolved oxygen decreased.

Leaching

Year 2007

Sulfosulfuron leached upto 35-40 cm soil depth showing high mobility in soil. Maximum concentration of the sulfousulfuron at both recommended and double recommended dose was at 10-15 cm soil column depth, deeper depths showed lower concentrations.

Year 2009

Leaching of metsulfuron-methyl showed the residue concentration was maximum at the middle of column mainly at the depth from 30 to 40 cm, indicating high mobility of metsulfuron methyl in soil column.

Year 2010

Oxyfluorfen at recommended and double recommended doses did not moved beyond 10 cm soil column indicating low mobility of oxyfluorfen in soil column.

Pendimethalin residue concentration was maximum at the upper soil layer mainly at the depth from 0 to 5 cm of column at both doses. Pendimethalin did not moved beyond 10 cm soil column showing little leachability of herbicide.

Farmer's field

Year 2008-2010

At farmers fields at harvest of wheat isoproturon & clodinafop-propargyl and in rice, butachlor & pretilachlor herbicide residues was below detectable limits in wheat and rice soil, grain and straw

i) Cereal Crop

Wheat

Year 1992

The application of Tralkoxydin 0.25-0.8 kg ha^{-1} provide effective control of *Phalaris minor* and *Avena ludovicina* in wheat crop from and all the doses either applied alone or in combination with 2,4-D, except Tralkoxydin 0.8 kg ha^{-1}, produced grain yield significantly higher than weedy check.

Fluroxypyr 0.20 and 0.25 kg ha^{-1} along with Isoproturon 0.75 kg ha^{-1} produced grain yield at par with weed free condition.

Tribennuromethyl at 5.0 and 7.5 g ha^{-1} tank mixed with isoproturon 0.5 kg ha^{-1} produced maximum yield which at par with weed free situation.

Application of Isoproturon as broadcasted along with urea either before or after first irrigation produced similar yield to applied through sprayer. Isoproturon 1.0 and 1.25 kg ha^{-1} produced at par grain yield with weed free condition.

Ready mix formulation of isoproturon along with 2,4-D found to be effective as tank mixture of 2,4-D and isoproturon at respective doses on associated weeds in wheat crop. The grain yield of wheat as isoproturon applied 2500 and 1875 g ha^{-1} of ready mixed formulation were similar to that of isoproturon +2,4-D tank mix 2000 +710 g and 1500 + 550 g isoproturon (50 WP) and 2,4-D, respectively.

Year: 1993

Tank mixture of Isoproturon and Difenzoquat 1+1,1+0.75 and 1.0 +0.50 kg ha-1 provided satisfactory control of he associated weeds an produced similar wheat grain yield over weed free treatment fb application of Isoproturon 1.0 kg ha-1 tank mixed with Fluroxypyr at 0.20 kg ha-1.

Year: 1995

Diclofopmethyl is highly effective to control the Avena ludoviciana. Its efficacy was relatively less on *Phalaris minor* than the *A. ludoviciana* and late application of this herbicide reduces the weed control efficacy. Weed control spectrum of diclofopmethyl (0.70, 0.84, 1.12 kg ha-1) and isoproturon 0.50, 0.75, 1.0 kg ha-1) in wheat is increased by various tank mixed combination of these two herbicides.

Year: 1996

Metribuzin at 210 g ha-1 and higher doses was effective to controlling *P. minor* but its higher doses reduced the number of shoots and number of spikes of wheat crop.

Year: 1998

Application of Fenoxaprop-p-ethyl 80 and 90 g ha-1 at 35 days stage of crop provided effective control of *Phalaris minor* and *A. ludoviciana* in wheat. Non grassy weeds were not controlled by the application of this herbicide and its delayed application also reduced the weed control efficacy of grassy weeds.

Metsulfuron-methyl (MSM) was highly effective to control the non grassy weeds in wheat crop. The application of metsulfuron methyl at 2.0 g ha-1 with surfactant (0.1%) was as effective as it's applied alone without surfactant 4.0 g ha-1. This was also compatible with isoproturon, Urea, Carbendazin and Monocrotophos. Weed control spectrum was winded due to application of MSM 2 g ha-1+ surfactant (triton 0.1%) with Isoproturon as tank mixture applied at 30 days stage of crop.

Year: 1999

Phalaris minor and most of the non grassy weeds in wheat were controlled effectively by the application of Sulfousulfuron 25 g ha-1 applied 30 days after first irrigation . Application of lower doses before or after first irrigation and at 20 g ha-1 after irrigation had poor weed control efficacy. Application of sulfusulfuron before irrigation had adverse effect on crop.

Density of *P. minor* and *Chenopodium album* in wheat was reduced due to application of trifluralin 1.0 &2.0 kg ha-1 applied next day after sowing and produced grain yield of wheat similar to application of isoproturon 1.0 kg ha-1. Pre-emergence application of granular formulation of this herbicide was found ineffective, tank mixing of Trifluralin with isoproturon had no additional advantage over alone application of Isoproturon.

Clodinafop – propargyl effectively control the *P.minor* and *A. ludoviciana* but ineffective on all the non grassy weeds.

Dicamba was found to be compatible with Isoproturon as tank mixture and increased the weed control spectrum in wheat crop. Its effectively reduce the density of *L. aphaca, M. denticulata* and *Melilotus* spp. which are normally not controlled by the application of Isoproturon and 2, 4-D.

Wheat varieties PBW 343, PBW233, UP 2338 and UP 2425 were found to be non susceptible to fenoxaprop–p-ethyl, tralkoxydim, sulfosulfuron and clodinafop-propargyl.

Year 2000

Dithopyr at various doses was not very effective in controlling the *P. minor*. However, at 300 g ha-1 it was quite effective on non grassy weeds like *Melilotus alba*, *Medicago denticulata*, *Melilotus indica*, *Lythrus aphca* and *Chenpodiium album*. Dithopyr 180 + pendimethalin 450 g ha^{-1} was compatible and effectively control the of *P. minor* and non grassy weeds and yielded at par with weed free situation.

Year 2002

Application of mesosulfuron and idosulfuron (12+2.4 g ha-1) were found highly effective to control *P. minor* and non grassy weed in wheat. Which normally not controlled non grassy weeds by the application of 2,4-D.

Affinity 1.75 kg ha-1 (isoproturon 750 g+ carfentazone-ethyl 11.25 g ha-1) was found to be compatible in provided higher degree control of *P. minor* and non grassy weeds in wheat.

Carfentazone- ethyl 20 g ha-1 alone provided almost complete control of *C. album. M. alba, M . indica. L. aphaca, V. sativa, M. denticulata* and *R. acetosella*. and found to be compatible with clodinafop, fenoxaprop and isoproturon as tank mixture.

Year 2004

Tanks mixing of surfactant "Active 80" at 1250 ml ha-1 increased weed control efficacy of Isoproturon in wheat.

Carfentazone ethyl was found to be compatible with clodinafop, fenoxaprop and isoproturon as tank mixture.Traisulfuron 25 g ha-1 was effective against *C. album, M. indica* , *M. alba* . *Vicia* spp., *C. didymus* and *R. acetosella* and provide its only control 50% of *M. denticulata* and *L. aphaca*.

Year 2007

Application of Pinoxaden up to 50 g ha^{-1} had no adverse effect on wheat crop. Rice cultivars Pant Dhan18,Pusa 44, Govind and Pant Sugandha 17 were more competitive against weeds than Sarjoo 52, Narendra 359, Pant Dhan 12 and 16, VL Dhan Dhan 206 and pant Sugandha 15.

Year 2008

Application of UPH 906 at 40.2 g ha-1 with surfactant recorded higher grain yield and similar to that with out surfactant with its higher dose (49 g ha-1)

Rice

Year 1993

Weed density and dry weight were reduced due to application of 2,4-D ethylester or granular formulation 0.75 kg ha-1 applied either before transplanting or at the time of transplanting .

Year- 1995

Anilofos granules 0.4-0.6 kg ha^{-1}applied at 3 and 6 days after transplanting of rice provided effective weed control in rice but reduce the efficacy of herbicide with its delay application. Anilofos EC formulations at various doses applied upto 9 days after transplanting were effective in controlling the weeds. Anilofos is compatible with metsulfuronmethyl and chlorimuronemethyl as tank mixtures. Combinations of these herbicides provide wider weed control spectrum in transplanted rice.

Year- 1996

Fenoxaprop-p-ethyl 75 and 90 g ha^{-1} applied at 15 days stage of crop was more effective in reducing the density and dry matter of weeds in transplanted rice than its delay application (25 DAS).

Year- 1997

An application of Acetochlor 100 and 150 g ha^{-1} was found more effective than as applied at 75 g ha^{-1} in controlling weeds in transplanted rice. Efficacy of this herbicide reduced when applied 7 days after transplanting over the application of one day after transplanting. Acetochlor applied 100 g ha^{-1} one DAT produced grain yield similar to application of Butachlor 1.5 kg ha^{-1} as well as weed free situation of crop.

Year- 1998

Pretilachlor 0.75 and 1.0 kg ha^{-1} controlled annual grasses and most of the annual sedges in transplanted rice and producing grain yield at par with weed free situation Bentazon were found to be highly effective on sedges but it ineffective to grassy weeds. Tank mixtures of these herbicides with herbicides effective on grasses may provide wider weed control spectrum with high efficiency.

Year -1999

Anilofos and triclopyr were compatible with each other in controlling weeds in transplanted rice. Its application of tank mix combination provides to control the grassy, as well as non grassy weeds also.

Year 2000

Pretilachlor 0.75 kg ha^{-1}, oxadiargyl 100 g ha^{-1} and riceguard 325 g ha^{-1} provided safe and effective control of weeds in transplanted rice. These herbicides were effective on grassy as well as non grassy weeds and yielded at par with weed free condition

Triazolopyramidine sulfonamide at 20 and 25 g ha^{-1} was found to be promising against wide spectrum of weeds in transplanted rice these doses provided effective control of weeds and yields at par with weed free treatment.

Year 2002

Pretilachlor 750 g and its higher doses applied as pre-emergence was very effective to reduce the *E. colona* in transplanted rice and gave grain yield at par with weed free treatment. *Caesulia axillaries* was not controlled by this herbicide.

Clefoxydim and Quinclorac were found to be promising in controlling *Echinochloa colona* in rice nursery without any phytotoxicity in rice seedlings.

Year 2005

Penoxsulam 22.5 g ha^{-1} gave effective control of grassy and non grassy weeds and yielded highest grain yielded higher under transplanted rice.

In transplanted rice, butachlor fb Almix resulted highest weed control efficiency and higher grain yield as well as added net return as compared to application of butachlor fb 2,4-D and anilofos fb almix.

Year 2006

Application of Anilofos granules (30%) with emulsifier was more effective than its formulation with out emulsifier for effective weed control in transplanted rice.

Karishma 2.75 g ha^{-1} of product produce more grain yield of rice than application of butachlor at 3.0 kg ha^{-1} of its product amount.

More than 20 plants of *E. crusgalli* m^{-2} reduced grain yield of rice significantly and the potential yield loss due to uncontrolled weeds reach upto rice 54.8%. In transplanted rice the population of 35 plants of *E. crusgalli* (m^{-2}) reduced at least 75 per cent of grain yield of transplanted rice.

Year 2008

Oxyflurofen 150 g ha^{-1} and pretilachlor 750 g ha^{-1} gave higher weed control efficiency as well as grain yield of transplanted rice.

Year 2009

Application of oxyflurofen in transplanted rice at 150 g ha^{-1} was found most effective than this herbicide applied at its lower dose 100 g ha^{-1} oxyflurofen in rice at 150 g ha^{-1} yielded similar to the weed free treatment.

Year 2010

Sponser sample of butachlor molecule applied at 1250 and 2000 g ha^{-1} was found more effective in controlling weeds like *E. colona*, *E. crusgalli* etc. than the market sample of butachlor at same doses in transplanted rice.

Direct seeded rice (DSR)

Among the efficacy of herbicides in direct dry seeded rice, combined application of fenoxaprop + (chlorimuron 60+ metsulfuron 20 g ha^{-1}) recorded the highest grain yield fb application of fenoxaprop + ethoxysulfuron 60 + 15 g ha^{-1} and alone application of bispyribac Na 25 g ha^{-1} which were at par with twice hand weeding.

Application of penoxsulam + cyhalofop-butyl in transplanted and direct seeded rice 150 g ha^{-1} was found most effective than this herbicide applied at lower dose 105 g ha^{-1}. Weed free in transplanted as well as in direct seeded rice yielded higher over the all other treatments. The ready mix combination of penoxsulam + chyhalofop at all its doses was found more effective over the all herbicidal treatments applied alone in transplanted rice as well as direct seeded rice.

Sugarcane

Year 2006

Pre-emergence application of metribuzin at 800 g ha^{-1}or ametryn at 2.0 kg ha^{-1} with two hoeing given at 60 and 90 days after planting (DAP) produced cane yield at par with three hoeing at 30,60 and 90 days after planting on spring planted sugarcane crop.

Year 2008

Metribuzin fb hoeing fb 2,4-D caused significant increase in cane yield over atrazine fb 2,4-D. The cane yield under atrazine and 2,4-D was almost statistically similar but it was significantly lower than atrazine fb 2,4-D.

Year 2009

In sugarcane ratoon crop the lowest density and dry weight of weeds was obtained with thrice hand weeding (30,60 and 90 DAS) which was at par with application of Metribuzin 880g ha^{-1} fb one hoeing at 45 DAS, and application of 2,4-D at 500g ha^{-1}.

iii) Oil seed

Soybean

Year 1992

Diuron 0.5, 1.0 and 1.5 kg ha^{-1} applied 7 or 10 days after sowing was highly toxic to soybean crop. Application at 0.5 and 1.0 kg ha^{-1} immediately after planting was safe, provided effective control of weeds and produced grain yields at par with weed free and more than the application of Alachlor 2.5 kg $ha^{-1.}$

Pre emergence application of metribuzin 0.252, 0.70 kg ha^{-1} and clomazone at 0.75 and 1.0 kg ha^{-1} were effective against grassy and non grassy weeds and producing grain yield or soybean at par with weed free treatment.

Year 1993

Trianthema monogyna, Celosia argentea, Cleome viscosa and *Cucumis trigonus.* It was effective on grassy weeds application at early stage was more effective than at later stage. Lactofen 150 g ha^{-1} applied at 1 week stage produced grain yields higher than alachlor at 2.5 kg ha^{-1}.

Clomazone was effectively control the most of the weeds except the *C. argentea*. While the application of metribuzin controlled almost all the weeds whether applied as pre emergence or 7 days after sowing. It proved toxic to soybean as applied as early post emerge application.

Year 1995

Sequential application of pendimethalin 1.5 kg ha^{-1} (one day after sowing) followed by application of chlorimuronmethyl 6.0 or 9.0 g ha^{-1} provides effective control to grassy and non grassy weeds in soybean , Similarly sequential application of alachlor at 2.50 kg ha^{-1} followed by chlorimuron 6.0 or 9.0 g ha^{-1} also provides effective weed control of wider spectrum.

Anilofos EC as well as granular formulation 1.0 to 2.0 kg ha^{-1} applied as pre emergence provides effective control of annual grasses in soybean and yielded similar to application of alachlor 2.5 kg ha^{-1} and pendimethalin at 1.5 kg ha^{-1} applied as pre emergence.

Year 1997

Weeds in soybean were effectively controlled by the application of chlrimuronmethyl 6, 9 and 12 g ha^{-1} applied 1 or 3 days after sowing this herbicide was effective on *Echinochloa colonam*, *Celosia*

argentea, *Trianthema monogyna* and *Cyperus rotundus.* Application of metachlor and alachlor could not control *T. monogyna, C. argentea* and *C. rotundus.*

Acetochlor 1.5 and 2.0 kg ha^{-1} as pre –emergence effectively controlled the *E. colona* in soybean and it was ineffective on non grassy weeds.

Year 1998

In soybean application fenoxaprop-p-ethyl was effective in controlling *Echinochloa colona.* Weed control efficacy increased with increase in its doses from 50 to 100 g ha^{-1} without phytotoxicity effect on crop. Application at 14 days stage was more effective than the application after sowing at 21 days. Lactofen controlled *Celosia argentia*, *Trianthema monogyna* but not effective to *E. colona*. Tank mixed application of Lactofen and Fenoxaprop-p-ethyl (120 g+ 50 or 90 g + 70 g ha^{-1}) provided effective control of grassy as well as non grassy weeds in soybean and yielded at par with weed free treatment.

Year 1999

Pre plant incorporation of Trifluralin 1.25 kg ha^{-1} and pre emergence application of oxyflurofen 500 g ha^{-1} provided effective weed control in soybean and producing grain yield similar to weed free condition.

Application of basagran in soybean was very effective against non grassy weeds but ineffective on grasses. Its tank mixing with blazer was compatible with increased weed control spectrum and efficacy.

Year 2000

Pre emergence application of oryzalin 1.25 and 1.5 kg ha^{-1} and oxyflurofen 180 g ai ha^{-1} were effective in controlling annual grassy weeds in soybean and yielded similar grain yield to weed free treatment.

Non grassy weeds in soybean were controlled effectively with application of bentazone at 1.2 kg ha^{-1} but it was not effective on grassy weeds. Pre plant incorporation of Fluchloralin 960 ha^{-1} superimposed with post emergence application of betazon at 960 g ha^{-1} widened weed control spectrum providing effective control of both grassy as well as non grassy weeds.

Application of Haloxyfop at 75 and 100 g ha^{-1} was found to be safe for soybean crop. Application at 14 days after sowing was more effective against annual grassy weeds than application at 21 days stage of crop.

iv) FODDER CROPS

Year 2005

Berseem

Coronopus spp. reduced significantly by solarization for 4 and 6 weeks. Soil solarization for 6 weeks exhibited green forage yield of Barseem at par with weed free condition.

Year 2002

Sorghum

Atrazine 0.5 kg applied as pre emergence followed by 0.5 kg ha^{-1} at 10 days gave highest green fodder an dry matter yield followed by Atrazine at 1.0 kg ha^{-1} applied as pre emergence 47.2 t and 14.5 t , respectively which were at par to the yield obtained with weed free situation.

v) Vegetables Crops

Potato

Year: 2002

Application of clomazone along with pendimethalin (250+500 g ha^{-1}) applied as pre-emergence as tank mixture and chlorimuronmethyl 6 g ha^{-1} as pre emergence provided effective weed control in potato and tuber yields obtained at par with weed free treatment.

Year: 2003

Unchecked weed growth caused 36.8 per cent reduction in tuber yield as compared with two hand weedings. Application of Metribuzin followed by earthing up being on par with application of Paraquat, Pendimethalin two hand weeding and Prometryn treatments provided maximum tuber yields as compared to rest of the treatments.

Chlorimuronmethyl being at par with weed free treatment provided significantly higher seed yield than rest of the treatments. Isoproturon 1.0kg ha^{-1} also proved effective and gave seed yield at par with application of Chlorimuron-ethyl 4 g ha^{-1} as pre- emergence.

Year: 2004

Paraquat 0.5 kg ha-1 as pre emergence in potato crop on weeds, pendimethalin 1.0 kg ha-1 or metribuzin at 0.5 kg ha-1 each followed by earthing up produced potato tuber yields at part with two hand weeded weeding.

Year: 2007

Metribuzin 0.5 kg ha^{-1} + mulching with straw being on par with Metribuzin + earthing up and Metribuzin applied alone provided tuber yield of potato.

Year: 2010

The bio-efficacy of Paraquat dichloride 24% against weed in potato recorded that Paraquat dichloride (new) applied 400 g ha^{-1} recorded more weed control efficiency than the existing Paraquat dichloride applied at 500 g ha^{-1}.

French bean

Year 2000

Application of Linuron at 1.0 kg ha^{-1} as pre emergence was found to be effective for controlling weeds in french bean grown as a seed crop.

Year 2003

Critical duration of crop weed competition in french bean was found to be during 30 to 90 days after sowing.

Okra

Year 2000

In a seed crop of okra effective weed control with higher seed yields was obtained due to pre emergence application of pretilachlor, pendimethalin each at 1.0 kg ha^{-1} and anilofos at 400 g ai ha^{-1}.

Year 2002

Pea

Increasing the dose of clomazone either alone or combined with Pendimethalin did not increase seed yield significantly. Application of chlorimuron ethyl, pendimethalin and prometryn at higher doses gave significantly more yield than their lower doses**.**

Year 2002

Coriander

Among the treatments, Imazethapyr at 90 g ha^{-1}, being on par with application of fenoxaprop-p-ethyl 80 g ha^{-1}, produced significantly higher seed yields than rest of the herbicides. Increasing dose of imazethapyr (60 to 90 g), metribuzin (210 -490 g ha^{-1}), clodinafop and fenoxaprop-p-ethyl (40-80 g ha^{-1}) gave significantly higher seed yield than their lower doses.

Significantly higher seed yield was noted with weed free plots as compared to rest of the treatments. Among herbicidal treatments, chlorimuron-methyl 4 g and isoproturon 1000 g ha^{-1} produced significantly higher seed yields than rest of the herbicidal treatment.

Transfer of Technology

- The mean potential yield loss due to uncontrolled weeds was 52.8% in wheat and 15.0% in rice grain yield at farmer's field as compare to the Recommended Weed Management practices.
- On farmers field, application of Isoproturon 1.0 kg ha^{-1} alone or along with MSM recorded 3.6% reduction in grain yield as compared to weed free situation where as in rice application of Butachlor 1.5 kg ha^{-1} or Anilofos 0.4 kg ha^{-1} fb 2,4-D 0.5 kg ha^{-1} or Almix 4.0 g ha^{-1} or alone application of Bispyribac Sodium 25 g ha^{-1} recorded 2.7% reduction in grain yield as compared to weed free.
- The larvae, eggs and adults of *Zygogramma* beetles were highest in the month of July to September. Maximum 75-80 per cent damage of *Parthenium* was observed during the early September when the *Zygogramma* population was also higher than rest of the months.
- In the demonstration of pulses, except weed free, application of Clodinofop 60 g ha^{-1} fb one hand weeding recorded the highest grain yield in all the pulses viz., lentil, chickpea and pea etc.
- In wheat demonstration, Metribuzin (300 g) was found more effective against the weeds among all the herbicides applied. The yield loss in wheat due to uncontrolled weed was 47.9% over the weeds free situation.

Impact Assessment

1. Yield loss due to weeds and improvement under recommended weed management practices

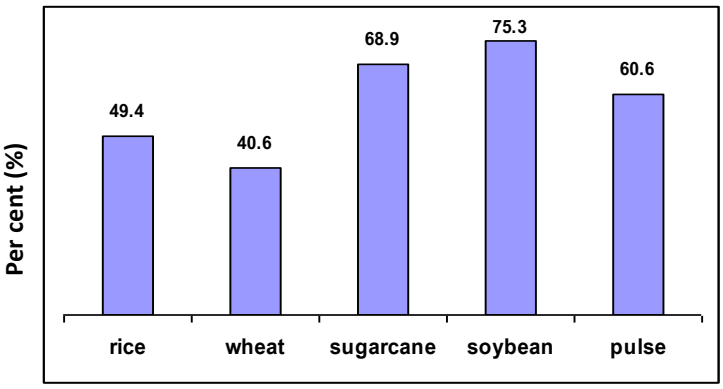


Fig:1 Yield loss (%) under weedy situation in different crops (mean values of data collected over eight years during 2002-2010)

Maximum yield loss due to weeds occur in soybean (75.3%) followed by sugarcane (68.9%) and pulses (60.6%). In rice and wheat reduction in yield occur between 40-50% due to weeds (fig: 1).

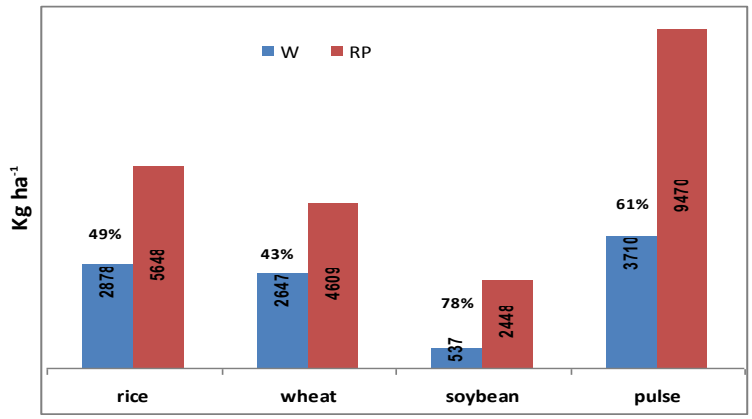


Fig: 2 Yield differences under weedy and recommended weed management practices) (mean values of data collected over eight years during 2002-2010) (values in percentage indicate yield loss under weedy situation)

Adoption of recommended weed management technologies enhances yield 2-3 fold in different crops (fig: 2).

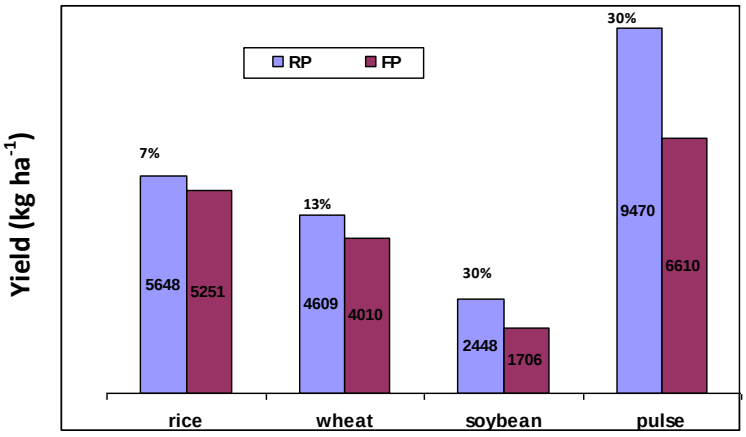


Fig: 3 Differences in yield between recommended weed management practices vs Farmer's practices (mean value of data collected for 2002-2010 from several locations in each year)

Due to adoption of recommended weed management practices, about 30 per cent increase in grain yield was recorded compared to farmers' practices in pulses and soybean and 7 and 13 per cent in rice and wheat, respectively. (fig: 3).

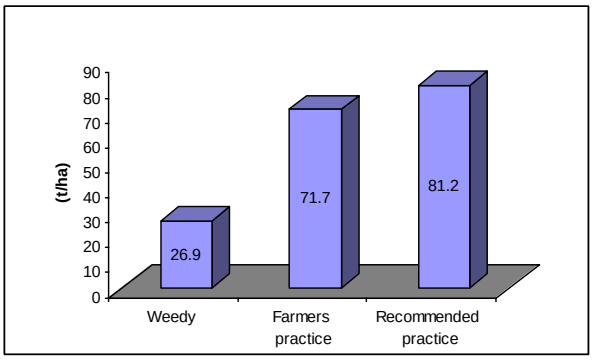


Fig 4: Yield differences in sugarcane under weedy situation, farmers practices *vs* recommeneded weed management practices.

In sugarcane 67 per cent yield reduction was observed under weedy condition compared to recommended weed management practices. Under farmer's practices of weed management the reduction in yield was still about 12 per cent (fig 4).

2. Adoption level of recommended weed management practices by farmers of the state

Data from survey conducted for seven years (2001-07) in major crops at farmers fields in the states of UP and Uttarakhand reveals that recommended weed management practices are being adopted by 57-60 per cent farmers in rice and wheat crops and about 39 per cent in sugarcane. About 1-3 per cent farmers growing rice and sugarcane and about 16% farmers growing wheat did not adopt any weed management practices.

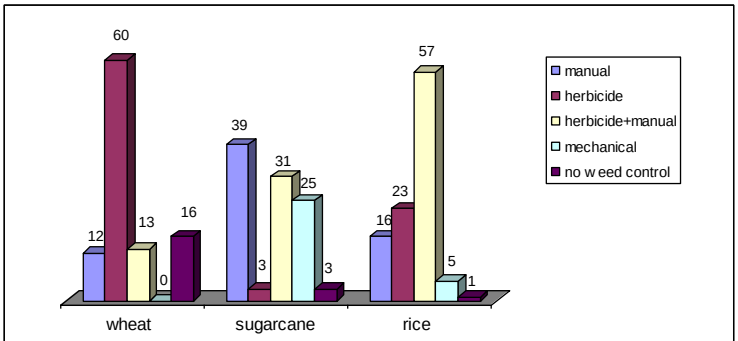


Fig. 5 Weed managment practices adopted by the famers (per cent)

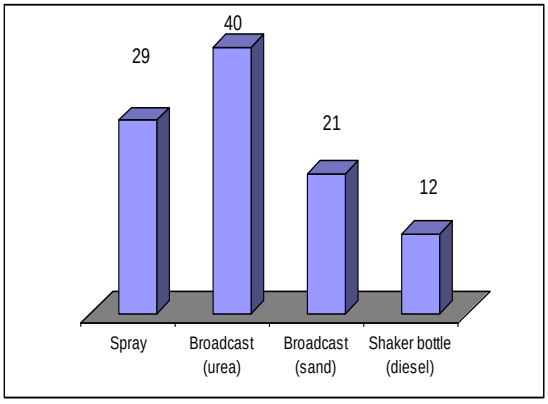


Fig 6. Method of herbicide application by the farmer's in transplanted Rice (per cent)

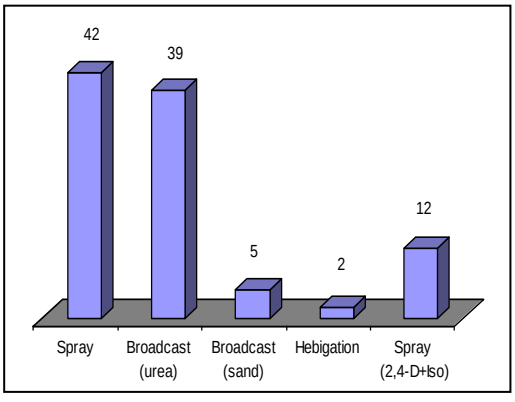


Fig 7. Method of application of isoproturon by the farmer's in wheat (per cent)

3. Economics

The survey conducted at farmer's field reveled that recommended weed management practices reduced the added cost due to weed management practices compared to farmers' practices and weedy, however, it increased the added net return due to herbicidal treatment and good weed management. No weed management (weedy) recorded zero value for both cost and return. (Fig -8,9)

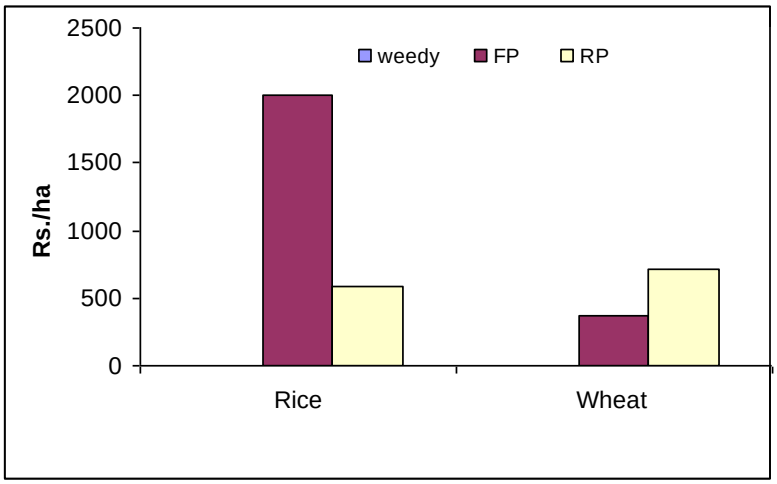


Fig 8: Added cost due to herbicidal treatments (Rs ha-1) in rice and wheat (mean value of data collected for 2003-2010 from several locations in each year)

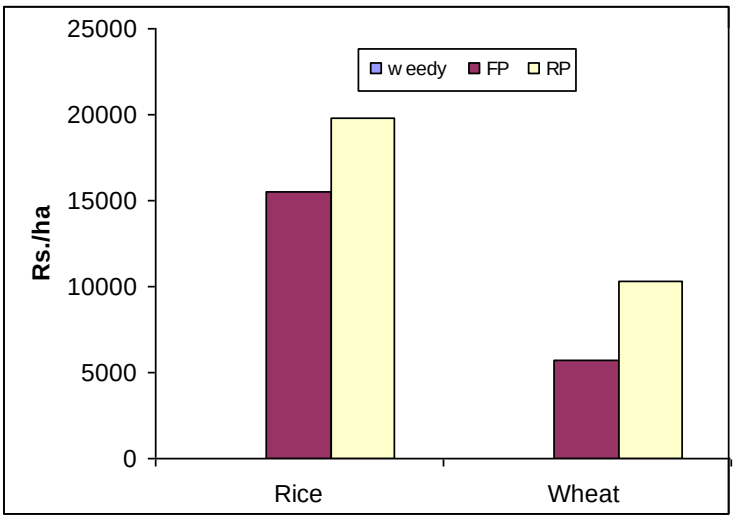


Fig 9: Added net return due to different herbicidal treatments (Rs ha^{-1}) in rice and wheat (mean value of data collected for 2003-2010 from several locations in each year)

3. **Recommendation of Weed management Technologies: State Package of Practices**

State Name	Crop Name	Dominated Weed Name	Recommendation for the state
Uttarakhand	**Maize**	*Aegeratum conyzoides* *Celosia argentia* *Commelina benghalensis* *Cynodon dactylon* *Cyperus rotundus* *Dactyloctenium aegyptium* *Echinochloa colona* *Galinsoga parviflora* *Oxalis latifolia* *Trianthema portulacastrum*	Minimum two hand weeding at 20& 35 DAS are required. Apply atrazine 2.5 kg /ha or alachlor 2 kg/ ha as pre emergence.
Uttarakhand	**Rice**	*Agropyron repens* *Alternanthera sessillis* *Caesulia axillaris* *Commelina benghalensis* *Cynodon dactylon* *Cyperus iria* *Echinochloa colona* *Fimbristylis miliacea* *Galinsoga parviflora* *Eclipta prostrata* *Ischaemum rugosum* *Leptochloa chinenesis* *Cynotis oxalaries* *Echinochloa crusgalli* *Paspalum distichum* *Digitaria sanguinalis* *Eragrostis japonica* *Eleusine indica* *Brachiaria ramosa* *Cyperus rotundus* *Cyperus difformiss* *Trianthema monogyna*	Summer ploughing of main field to destroy weeds and expose soil and wet bed method for raising rice nursery. Anilofos 0.4 kg/ha or thiobencarb 1.0 kg/ha when first leaf of rice has turned green. Butachlor 1.5 kg/ha, anilofos 400 g/ha, pretilachlor 1.0 kg/ha or Thiobencarb 1.0 kg/ha as pre-emergence after transplanting. If required 2,4-D 500 g/ha or almix 4 g/ha as post-emergence to control sedges and broad leaf weeds. Pendimethalin 1.0 kg /ha within 0-3 DAS fb metsulfuron methyl 4.0 g/ha at 25-30 DAS and one hand weeding (40-45 DAS) if needed in Direct Seeded Rice.
Uttarakhand	**Sorghum**	*Celosia argentia* *Cynodon dactylon* *Digitaria sanguinalis* *Eleusine indica* *Trianthema portulacastrum*	Atrazine 1.0 kg/ha as pre-emergence.
Uttarakhand	**Soybean**	*Aegeratum conyzoides* *Celosia argentia* *Commelina benghalensis* *Cyperus rotundus* *Echinochloa colona* *Eleusine indica* *Hedyotis biflorus* *Oxalis latifolia* *Trianthema portulacastrum*	Alachlor 2.0 kg/ha or Metalachlor 1.0 kg/ha as pre-emergence or fluchloralin or trifluralin 1.0 kg/ha as pre-plant incorporation or metribuzin 350 g/ha as pre-emergence fb one hand weeding at 30-35 DAS.
Uttarakhand	**Sugarcane**	*Aegeratum conyzoides* *Alternanthera sessillis* *Brachiaria ramosa* *Commelina benghalensis* *Cynodon dactylon* *Echinochloa colona* *Eleusine indica* *Hedyotis biflorus* *Ischaemum rugosum* *Sorghum halepense* *Xanthium strumarium* *Cyperus rotundus* *Melilotus spp* *Medicago denticulata* *Polygonum plebejum* *Ipomea spp*	Irrigate field at 40-45 Days stage and do hoeing at this stage fb spray atrazine 2.0 kg/ha within 3-4 DAP on metribuzine 1.0 kg/ha or Pendimethalin 1.0 kg/ha as pre-emergemnce. Apply 2,4-D 0.5 kg/ha for control of *Ipomea* spp. Spray gramaxone 2.5 l/ha before emergence of sugarcane to control *Cyperus rotundus.*

Uttarakhand	**Wheat**	*Anagallis arvensis* *Chenopodium album* *Coronopus didymus* *Fumaria parviflora* *Melilotus alba* *Phalaris minor* *Poa annua* *Vicia sativa* *Cyperus rotundus* *Melilotus indica* *Convolvulus arvensis* *Lathyrus aphaca*	Pendimethalin 1.0 kg/ha as pre emergence. Isoproturon 1.0 kg/ha or isoproturon 1.0 kg/ha + 2,4-D 0.5 kg/ha or clodinafop-propargyl 0.06 kg/ha or sulfosulfuron 0.025 kg/ha fb one hand weeding. Apply 2,4-D 0.5 kg/ha at 30 days stage or metsulfuron methyl 0.004 kg/ha at 35-40 days stage for control of broad leaved weeds and sedges.
Uttarakhand	**Potato**	*Cyperus rotundus* *Phalaris minor* *Chenopodium album* *Parthenium hysterophorus* *Coronopus didymus*	Paraquat 500 g/ha when weeds have emerged but potato emergence is not more than 5 % fb. by earthing up. Pendimethalin 1.0 kg/ha or metribuzin 350 g/ha as pre-emergence fb. one hand weeding and earthing up at appropriate stage.
Uttarakhand	**Urd, moong, cowpea, pigeonpea**	*Echinochloa colona* *Trianthema monogyna* *Celosia argentia* *Digera arvensis* *Commelina benghalensis* *Eleusine indica* *Cyperus rotundus*	Alachlor 2.5 kg/ha, pendimethalin 1.0 kg/ha or metribuzin 0.35 kg/ha as pre-emergence or fluchloralin 1.0 kg/ha or trifluralin 1.0 kg/ha as pre-plant incorporation.
Uttarakhand	**Gram, pea, lentil**	*Melilotus indica* *Medicago denticulata* *Polygonum spp* *Phalaris minor* *Coronopus didymus* *Chenopodium album* *Cyperus rotundus*	Pendimethalin 1.0 kg/ha or alachlor 4.0 l/ha as pre-emergence or fluchloralin or trifluralin 1.0 kg/ha as pre-plant incorporation.
Uttarakhand	**Coriander**	*Fumaria parviflora* *Anagallis arvensis* *Chenopodium album* *Sorghum halepense* *Cirsium arvense* *Phalaris minor* *Medicago denticulata* *Avena ludoviciana*	Pendimethalin 1.0 kg/ha as pre-emergence.
Uttarakhand	**French bean**	*Cynodon dactylon* *Cyperus rotundus* *Chenopodium album* *Anagallis arvensis* *Fumaria parviflora* *Oxalis latifolia* *Phalaris minor* *Melilotus alba* *Vicia hirsuta* *Melilotus indica*	Pendimethlain 0.75 kg/ha as pre emergence fb one hand weeding at 40 DAS. Two hand weeding at 20-40 DAS may also be used.
Uttarakhand	**Brinjal**	*Gnaphalium indicum* *Digitaria sanguinalis* *Eleusine indica* *Eclipta alba* *Echinochloa colona* *Cynodon dactylon* *Cyperus rotundus*	Pendimethalin 1.0 kg/ha as pre-emergence.

Research programme under taken at Present at the centre G.B.P.U.A &T, Pantnagar

(A) NETWORK TECHNICAL PROGRAMME (2010-11)

WS 1.0	**Weed survey and surveillance**
WS 1.2	**Resistance of *P. minor* to isoproturon**
WS 1.3	**Propagation potential of *Cyperus rotundus***
WS 1.4	**Seed longevity of weeds associated with major cropping system under arable conditions**
WS 1.4 & 1.5	**Physiological studies: photosynthetic rate, chlorophyll fluorescence and toxicity of herbicides and recovery time in long term herbicide trial in rice-wheat cropping system**
WS 2.0	**Long term trials on weed management in crops and cropping systems**
WS 2.1	**Effect of sowing time and weed control methods in direct dry seeded rice**
WS 2.2	**Effect of rice establishment techniques under different weed control method**
WS 2.3 (a)	**Effect of direct rice based cropping systems on weed dynamics and crop productivity**
WS 2.3 (b)	**Efficacy of herbicides to control weed in direct dry seeded rice**
WS 2.7	**Integrated weed management studies in sugarcane ratoon**
WS 2.9	**Study on long term effect of tillage in rice-wheat cropping system**
WS 2.10	**Long term effect of weed management practices in rice-wheat cropping system**
WS 2.11	**Impact of weed management practices in direct seeded rice-chickpea cropping system.**
WS 2.12	**Impact of long term use of herbicide in rice (transplanted) wheat cropping system**
WS 2.13	**Impact of weed management practices in maize-pea cropping system**
WS 2.14	**Weed seed bank in long term herbicide and tillage trials in different cropping systems**
WS 4.0	**Herbicide testing, leaching behavior, persistence, residues and toxicity**
WS 4.1	**Studies on herbicide residues in food chain, soil and ground water**
WS 4.1.1	**Residue analysis of isoproturon in wheat and soil**
WS 4.1.2	**Residue analysis of butachlor in rice and soil**
WS 4.1.3	**Persistence and residue analysis of clodinafop-propargyl in soil and wheat crop**
WS 4.1.4	**Persistence and residue analysis of anilofos in soil and rice crop**
WS 4.3.1	**Leaching behaviour of metsulfuron-methyl in soil**
WS 4.4	**Testing of herbicide residue at farmers field**
WS 4.4.1	**Isoproturon residues in grain, straw and soil in wheat at farmer's fields**
WS 4.4.2	**Butachlor residues in grain, straw and soil in rice at farmer's field**
WS 5.0	**Transfer of technology**
WS 5.1	**Management of parthenium hysterophorus by *Zygogramma* beetles**
WS 5.2	**Yield loss estimation**
WS 5.3	**On farm trials (OFT)**
WS 5.3.1	**Comparative performance of herbicides for control of weeds in wheat**
WS 5.3.2	**Comparative performance of herbicides for control of weeds in rice**
WS 5.4	**Impact analysis on weed management**

(B) Station programme

WS 6.0 **Weed management in specific crops**

WS 6.1 **Demonstration on weed management technology in wheat crop**

WS 6.2 **Demonstration of weed management technology in pulse crop**

WS 6.3 **Competitive ability of rice cultivars against weeds**

WS 6.4 **Studies bio efficacy, phytotoxicity, carry over and residual effect of butachlor 50% ec (machete) in transplanted rice.**

WS 6.5 **Studies on bio-efficacy of Penoxsulam 1.02% w/w (1.0% w/v) + Cyhalofop - butyl 5.1% w/w 5.0% w/v) in transplanted rice**

WS 6.6 **Evaluate the efficacy of Penoxsulam 1.02%w/w (1.0%w/v) + Cyhalofop- butyl 5.1%w/w (5.0%w/v) for weed control in direct seeded rice**

WS 6.7 **Bio-efficacy evaluation of Paraquat dichloride 24% sl against weeds in potato crop**

WS 6.8 **Effect of various doses of oxyflurofen on mentha and associated weeds**

WS 7.0 Extension activities

WS 7.1 **Trainings on weed management technology and herbicide application techniques**

WS 7.2 **Large area demonstration**

WS 7.3 **Organization of farmers' fair**

WS 7.4 **Celebration of parthenium awareness week (august 7-13, 2010)**

Proposed Technical Programme (2011-12)

(A) NET WORK TECHNICAL PROGRAMME

WS 1.0 Weed Survey/ Surveillance, Weed Physiological Studies

WS 1.1 Weed Survey/ Surveillance

WS1.2 Monitoring of resistance of *Phalaris minor* to Isoproturon in wheat

WS 1.2a Biology and management of isoproturon resistant *P. minor*

WS 1.2d Validation of isoproturon resistance

WS1.3 Effect of Glyphosate on propagation potential of perennial weeds-*Cyperus rotundus* (3 years permanent plot)

WS 1.4 Weed Seed longevity of weeds associated with major cropping systems under arable conditions.

WS 1.5 Crop weed toxicity of herbicide and recovery time

WS 1.6: Physiological studies in long term net work trials

WS 2: Weed management in crops and cropping systems

WS- 2.1: Effect of time of sowing and weed control methods in direct seeded rice

WS 2.2: Effect of rice establishment techniques under different weed management practices

WS 2.3: Efficacy of herbicides for controlling weeds in direct seeded rice

WS-2.4: Evaluation of metribuzin in combination with clodinafop, sulfosulfuron and pinoxaden for weed control in wheat

WS 2.5: Bio-efficacy of pinoxaden 5 EC in combination with broadleaf herbicides against complex weed flora in wheat.

WS 2.7: Weed management in sugarcane ratoon

WS- 2.9: Long term trial on tillage in different cropping systems

WS-2.10: Long term herbicide trial in different cropping systems Rice- Wheat System

WS 2.12: Rice-wheat cropping system

WS 4.0: Herbicide residues, persistence, leaching behavior and toxicity

WS 4.1: Studies on herbicide residue in food chain, soil and ground water

WS 4.2: Studies on herbicide persistence in water

WS 4.3: Characterization of leaching behavior of herbicide in soil.

WS 4.4: Persistence of herbicides to be tested at farmers' field (soil and crop produce).

WS 4.6 Adsorption and desorption behavior of herbicides

WS 5.0: Transfer of Technology

WS 5.1: Parthenium- management by *Zygogramma* beetles

WS 5.3: Yield loss estimation

WS 5.4: On Farm trial (OFT)

WS 5.5: Impact analysis on weed management

(B) NET WORK TECHNICAL PROGRAMME at STATION

WS 6.0 Weed management in specific crops

WS 6.1 Rice

WS 6.1.1 Studies on bio-efficacy, phytotoxicity, carry over and residual effect of Butachlor 50% EC (Machete) in transplanted rice

WS 6.1.2 Evaluation of bio-efficacy of Triasulfuron (Logran 20 WG) against weeds in transplanted rice, crop safety and its effect on succeeding crop

WS 6.1.3 Studies on bio-efficacy of penoxsulam 1.02% w/w (1.0% w/v) + cyhalofop - butyl 5.1% w/w 5.0% w/v) in transplanted rice

WS 6.1.4 Studies on bio-efficacy of penoxsulam 1.02% w/w (1.0% w/v) + cyhalofop - butyl 5.1% w/w 5.0% w/v) in direct seeded rice

WS 6.2 Wheat

WS 6.2.1 Studies on the bio-efficacy and phytotoxicity of ACM-9 on wheat and their carry over effect on succeeding crop (rice)

WS 6.2.2 Studies on bio-efficacy, phytotoxicity, compatibility, varietal tolerance and residual effect of Pyroxsulam 9% WDG for weed control in wheat

WS 6.2.3 Studies on bio-efficacy, phytotoxicity, compatibility, varietal tolerance and residual effect of Pyroxsulam 9% WDG + Sulfosulfuron 75 WG for weed control in wheat

WS 6.3 Potato

WS 6.3.1 Studies on the bio-efficacy and phytotoxicity effect of Oxyflurofen 23.5 EC in potato and succeeding crop

WS 6.4 Evaluation of Oxyflurofen (23.5 EC) for weed control in Mentha crop

WS 7.0 Extension Activities:

WS 7.1 Trainings on weed management technology and herbicide application techniques

WS 7.2 Organization of Farmer's fair

WS 7.3 Organization of Parthenium Awareness Week

FURTURE RESEARCH THRUST DURING XII FIVE YEAR PLAN

1. Weed survey work has to be continued to cover the whole area under the responsibility of the university. Weed map has to be prepared after the completion of the survey.
2. A survey of weed control practices adopted by the farmers in different crops and cropping system including vegetables, medicinal and aromatic and horticultural crop is required to understand local practices and adoption of the practices recommended on the basis of research.
3. Quite good amount of work has been done on the use of herbicides in different crops. There is necessity to have adoptive trials at the farmer's fields to popularize the recommendations that have emerged from research.
4. Most of the work on weed control in the past has been based of single crop. Very little work has been done on weed control in cropping systems. This aspect needs intensive investigation considering integrated approach of weed management.
5. Problem of perennial weeds like *Cyprus rotundus, Sorghum halepance, Cynodon dactylon* and *Lantana camera* etc. has not received due attention of the scientists. This problem has yet to be solved.
6. Every year some varieties of different crops are evolved. There is necessity of continuous screening of the varietal response to herbicides in common use.
7. Studies on herbicide residues in soil-water-plant system needs investigation as no significant work has been done on this aspect. This work also needs to take up the specific locations after developing good residue laboratories equipped with modern instruments.
8. Bio-assay techniques for most of the newly developed products are not available. Such techniques need standardization.
9. Work on ecological studies in this area is meagre, such specialized studies are also required to be taken up.
10. Physiological and bio- chemical studies on herbicides are meagre. Such specialized studies are required to understand the mode of action of herbicides.
11. Studies on use of safeners are also required to widen the selectivity and spectrum of weed control.
12. Integrated weed management practices needs to be worked out for major crops and cropping sequence along with different tillage option becoming cost effective for growing field crops.
13. Evaluation of new herbicides at different rates and methods of application for controlling weeds of different crops.
14. Management of aquatic weeds has to be taken up in a systematic way.
15. Management of weeds in non crop situation other than aquatic weeds.
16. There is a strong need to develop an approach and practices for eco-friendly system for weed management.
17. Utilization of weeds for mankind welfare is also a challenge before scientist.
18. Emphasis may be given on fast and automatic degradable compounds because of environmental stress all over the world.
19. Management of herbicides resistance.
20. Development of cost effective, environmentally safe and user friendly technology to overcome weeds menace.
21. Future research thrust and prioritization of the centre

1. Budget Proposal under XII five year plan (2012-13 - 2016-17) DWSR Pantnagar

AICRP-Weed Control (ICAR)

(Rs in Lakh)

Budget Head	2012-13	2013-14	2014-15	2015-16	2016-17	Total	ICAR Share	State Share
A. Recurring								
Pay & Allowances	55.01	69.05	83.00	99.90	120.10	427.06	320.29	**106.77**
Traveling Allowances	3.00	3.60	4.32	5.18	6.22	22.32	16.74	5.58
Contingency	3.20	3.84	4.61	5.53	6.64	23.82	17.87	5.96
Contractual workers	3.60	4.00	4.40	5.00	5.40	22.40	16.80	5.60
Information Technology	2.00	2.40	2.88	3.46	4.15	14.89	11.17	3.72
Total A	**66.81**	**82.89**	**99.21**	**119.07**	**142.51**	**510.49**	**382.87**	**127.63**
B. Non recurring								
Equipment	25.0	28.0	30.0	70.5	100.00	253.5	190.13	63.38
Vehicle with Trolley	7.0	-	-	-	-	7.0	5.25	1.75
Lab/Field store building construction	40.0	50.0	-	-	-	90.0	67.5	22.5
Total B	**72.0**	**78.0**	**30.0**	**70.5**	**100.0**	**350.5**	**262.88**	**87.63**
Grand Total (A+B)	138.81	160.89	129.21	189.57	242.51	860.99	645.75	215.26
ICAR Share	**104.11**	**120.67**	**96.91**	**142.18**	**181.88**	**645.74**	**484.31**	**161.45**
State share	**34.70**	**40.22**	**32.30**	**47.39**	**60.62**	**215.25**	**163.68**	**53.86**

Note: The financial requirement for additional post (enclosed) may please be provided separately.

Requirement of staff and other infrastructural facilities of DWSR (AICRP) Centre Pantnagar

1) Facilities proposed (Scientific and other supporting staff) other than existing position

Sl. No.	Name of the post	Staff number	Justification
1	Junior Research Officer (Microbiology)	One	Micro biological studies under DWSR (AICRP) Programme
2	Post Doctorate fellow Agronomy/Soil Science/Physiology	One	Helping to Scientific data generation and reporting of the project programme etc.
3	Senior Research Fellow Agronomy/ Economics	One	Helping the data generation, recording field observation and conducting the experiment at station / On farm trials at various location on farmers field.
4	Junior Research fellow B Sc. (Ag)/BSc	Two	Supporting the experiment executive and helping data recording etc.
5	TII Inter (Agriculture)/BSc (Ag.)	Two	Field work planning execution of the programme and supporting to data collection work etc.

2) List of Equipments required

Sl No.	Equipment	Number	Cost (Lakh)	Justification
1.	Photo copier	One	1.5	Official document photo copy
2.	Printer	Five	2.5	for official work / documentation of scientists working in weed control DWSR Pantnagar
3.	Computer	Five	2.0	-------Do ------
4.	Video Camera	One	0.5	Documentation of experimental/ on farm trials/ large area adoption at farmer field etc.
5.	Book rack	Five	0.5	Stocking of books/records
6.	Power tiller with agriculture implements	One	4.0	use to prepare the fixed plot in long term trials and seed bank studies in experimental area etc.
7.	Sprayer (manual/ Power operated)	Four	0.5	Field preparation/ Weed management at station and on farm trial/Large area adoption at farmers fields
8.	Tractor with mount sprayer	One	8.0	Field preparation and weed management etc.
9.	Bio hazard chamber	One	12.0	Studies on weedy rice
10.	Infrared thermometer	One	2.0	Studies for plant Canopy temperature
11.	Plant efficiency analyzer/ chlorophyll fluorescence meter	One	6.0	To measure chlorophyll fluorescence/ herbicide physiology
12.	Infrared gas Analyzer (IRGA)	One	20.0	Measurement of photosynthesis / herbicide physiology
13.	Water analysis kit	One	1.0	Physicochemical analysis of water
14.	GC-MS-MS	One	60.0	Pesticides residue analysis
15.	HPLC- (with PDA detector)	One	18.0	Studies on the residue analysis
16.	Vehicle with trolly	One	7.0	Strengthening On weed control programme over the state of the Uttarakhand at farmers field
17.	LC-MS/MS	One	100.0	For identification of pesticide metabolites
18.	GPS	Two	2.0	For recording geographical data
19.	Buchii vacuum rotavator	One	2.0	For drying of samples in pesticides analysis
20.	Temperature control shaker	One	3.0	For routine analysis of pesticide at controlled temperature
21.	Centrifuge	One	1.0	Pesticide residue analysis
	Total	Rs. 160.5		

3) Construction of New Building

Sl.No.	Particulars	Number	Cost (Lacs)	Justification
1	Constitutional of weed control UG/PG Lab construction	One	50.0	Develop advance weed management programme technology through practical knowledge and taught teaching to the UG and PG students and developed the information centre for the farmers purpose.
2	Lab Equipment required as PG and UG Students	Each one	10.0	
3	Construction of field lab cum store building along with drying floor and open shed area at crop research centre	One	30.0	Proper management of weed and crop sample, crop produce and field implements etc
		Total	90.0	