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Research Article

Parameters of weed management under different cropping systems in Uttar Pradesh

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Abstract

Data were collected during 2012-13 from a randomly selected 334 farmers through a multi-stage and proportionate sampling across the selected districts of Moradabad, Sambhal and Bulandsahar of Uttar Pradesh to devise weed management strategies in wheat crop. Rice-wheat, sugarcane-wheat, maize-wheat, urd-wheat and bajra-wheat were the main crop rotations in the sampling areas.

Majority of the farmers were middle aged, literate, lived in joint families, had membership of some organization (mainly cooperative societies) and more than 10 years of experience in agriculture. They sought information regarding cultivation of wheat crop from other farmers, agriculture officers, newspapers, TV and input dealers. Most of the farmers had purchased seed from government agencies and private input dealers apart from using their own seed.

Most of the farmers had applied herbicides to control weeds across the crop rotations wherein Mandusi (*Phalaris minor)* and Bathua (*Chenopodium album)* emerged as the major weeds. They used knapsack sprayers fitted with cut nozzle for application of herbicides. About half of them sprayed herbicides themselves. Merely 5.39 percent of the farmers had increased dose of herbicide over last year. Only 2.40 percent of the farmers had used herbicide twice during the crop season. Majority of the farmers had applied 2,4-D (44-60%) and sulfosulfuron (11.54-52%) across crop rotations. Isoproturon has been applied by the farmers to control *Phalaris minor*. Irrespective of level of education, some of the farmers were aware of different agronomic management practices to control weeds. None of the farmers had adopted zero tillage and residue retention as a strategy to control weeds in wheat crop. They need to be educated about timely sowing (Last week of October to 20th November), zero tillage technique, timely and uniform spray using flat fan nozzle, herbicides rotation and crop rotation strategies to control weeds.

Key words: Weed control, wheat, Uttar Pradesh, *Phalaris minor, Chenopodium album*

1. Introduction

India has achieved a wheat production of 92.46 million tonnes (4th advance estimate) during 2012-13 marginally lower than previous year (94.88 million tonnes). Uttar Pradesh, the highest wheat producing state in the country has produced 30.30 million tonnes wheat from 9.73 million ha area with an average productivity of 3113 kg per ha. Despite of decline in production at all India level, Uttar Pradesh could maintain its production level. There is a lot of scope in increasing wheat production in Uttar Pradesh. A number of factors have been identified affecting wheat production including weed infestation (Yaduraju *et al.*, 2006) and weeds cause significant annual regional productivity losses in rice-wheat system (Harrington *et al.,* 1992).

Weeds not only reduce the yield but also make the harvesting operation difficult (Chhokar *et al.,* 2012). The losses depend on weed species and density, time of emergence, wheat cultivar, planting density, soil and environmental factor (Afentouli and Eleftherohorionos, 1996; Chhokar and Malik, 2002; Malik and Singh, 1993; Cudney and Hill, 1979; Khera *et al.,* 1995; Malik and Singh, 1995; Mehra and Gill 1988). Researchers varied in their assessment of yield losses due to weeds. Depending on the intensity of the weeds, yield losses were estimated in the range of 10 to 80%. Weeds account for about one third of total losses caused by the pests of wheat (Ladha *et al*., 2000; Timsina and Connor, 2001).

The yield losses due to type and intensity of weeds can be as higher as about 65 per cent depending on the crop, degree of weed infestation, weed species and management practices (Yaduraju *et al*., 2006). In extreme cases, the losses caused by weeds can be up to complete crop failure (Malik and Singh, 1995). The cases of complete crop failure were quite common during late seventies in the absence of effective herbicides and again in mid nineties due to heavy population of *P. minor* after the evolution of resistance against isoproturon. Under both the situations, some of the farmers were forced to harvest their immature wheat crops as fodder (Malik and Singh, 1993; Chhokar and Malik, 2002).

Weed flora of crop differs from area to area and field to field depending on environmental conditions, irrigation, fertilizer use, soil type, weed control practices and cropping sequences (Anderson and Beck, 2007; Chhokar and Malik, 2002; Chhokar *et al.,* 2007 a&b; Dixit *et al*., 2008 a&b; Froud-Williams *et al.,* 1983). Most of the farmers use herbicides to control weeds (Singh, 2007). For controlling broadleaved weeds along with grasses, application of isoproturon in combination with 2,4-D or metsulfuron-methyl (MSM) is recommended (Pandey *et al*., 2006, Singh and Singh, 2002). Among the herbicides, isoproturon and pendimethalin are being used for the last two decades in wheat for management of grassy weeds (Walia *et al.,* 1998 and Chopra *et al.,* 2001). Regular use of the same herbicide year after year has led to herbicide resistance. There is possibility that resistance will extend to alternate herbicides. There are also greater chances of weed flora shift.

A number of studies on weeds have been conducted, the contribution of many such studies to improved planning of extension strategies has often been disappointing (Llewellyn *et al*., 2005). Integrated knowledge of weed control will help in increasing the life of existing herbicides and make the weed management cost effective and efficient (*Chhokar et al.,* 2012). An attempt has been made to explore the weed management options adopted by farmers across different crop rotations in Uttar Pradesh and devise a suitable strategy.

2. Materials and methods

The study was conducted during 2012-13 in randomly selected Moradabad, Sambhal and Bulandsahar districts of Uttar Pradesh in the North Western India. From each district, atleast four villages were selected and from each village at least 15 farmers were randomly selected depending upon the number of farmers adopted a particular crop rotation. In Bulandsahar district 100 farmers were selected from villages Akbarpur foja (25), Nrayanpu (25), Alawarahimpur (25), Pipala (25). In Moradabad district 112 farmers were selected from five villages namely Rampurmengan (25), Milk Mo. Jamapur (25), Chak Khitanpur (25), Dayanathpur (15), Guretha (22). In Sambhal district 122 farmers were selected from villages Asaltpurjarai (20), Ratanpura (21), Kaneta (20), Kurkawali (31), Khuhera (30). The total sample size was 334 from all the selected districts. The weeds were ranked on the basis of severity. Very serious, serious and not serious were given 3,2&1 scores. The composite score was calculated on the basis of ranking given by the farmers. For example *Phalaris minor* was ranked first by 10 farmers, second by 8 farmers and third by 2 farmers. The score was (10x3)+(8x2)+(2x1). The total score was 48.The main cropping systemsin thestudy area were rice-wheat, sugarcane-wheat, maize-wheat, urd-wheat and bajra-wheat.

Table 1. District wise number of farmers following different crop rotations

Crop rotation	Bulandsahar	Moradabad	Sambhal
Rice-wheat	39	47	47
Sugarcane-wheat	25	41	38
Maize-wheat	24	-	2
Urd-wheat	-	24	7
Bajra-wheat	12	-	28

3. Results and discussion

3.1 Socio-personal profile of respondents: A majority (57.78 %) of the farmers were middle aged followed by old (39.52%) and a few young (2.69%). It was observed in Uttar Pradesh that the young generation was not interested in agriculture profession and they look towards other occupations as a source of livelihood. Majority of the farmers were literate (83.23%). The analysis has indicated that 27.25 percent of the farmers were educated upto matric followed by equal percentage (15.27%) of middle and intermediate (10+2), graduate (11.68%), primary (9.28%) and post graduate (4.49%). About 17 percent of the farmers were illiterate in the study area. The farmers had shown keen interest in providing good education to their children so that they may get better jobs outside their locality and live a better

life. About one third of the farmers (33.53 %) had 11-20 years experience in agriculture. It is a matter of concern that only 9.58 percent of the farmers had less than 10 years of experience in agriculture. The average experience was 16 years. Agriculture requires physically fit and young generation; however, the job has been entrusted to the older generation.The findings have clearly indicated that both joint family (53.59%) and nuclear family (46.41%) systems were prevalent in the rural society. The farmers who traditionally preferred joint family system are opting for nuclear families. Almost one third of the farmers had more than 8 family members and 28.74 percent of the farmers had 5-6 family members. A good trend was observed and 18.26 percent of the farmers, particularly young ones had 1-4 members in their family which indicates that young generation is cautious about a small family to provide better education, health and living conditions to their kids. Most of the farmers (58.98%) were members of cooperative credit societies to avail loan facilities for agriculture inputs particularly fertilizers. Some of them were members of other organizations (9.58%) and Panchayat (8.38%). A majority of the surveyed farmers had 1-2 ha (37.72%) land followed by upto 1 ha (34.13%), 2-4 ha (21.86%) and more than 4 ha (6.29%). All categories of the farmers were included in the survey.

Table 2. Education level and sources of information used by the farmers

Education	Magazine	Other farmers	Agriculture Department	Institution	Agriculture University	Newspaper	Radio	TV	Private Dealer
Illiterate	0	29 (8.68)	23 (6.89)	1 (0.30)	3 (0.90)	0	11 (3.29)	20 (5.99)	10 (2.99)
Primary	0	40 (11.98)	36 (10.78)	0	0	10 (2.99)	6 (1.80)	20 (5.99)	24 (7.19)
Middle	0	27 (8.08)	15 (4.49)	1 (0.30)	1 (0.30)	16 (4.79)	9 (2.69)	13 (3.89)	20 (5.99)
Matric	14 (4.19)	37 (11.08)	47 (14.07)	1 (0.30)	4 (1.20)	30 (8.98)	11 (3.29)	30 (8.98)	26 (7.78)
Intermediate	11 (3.29)	24 (7.19)	23 (6.89)	5 (1.50)	4 (1.20)	23 (6.89)	8 (2.40)	18 (5.39)	24 (7.19)
Graduate	7 (2.10)	18 (5.39)	21 (6.29)	2 (0.60)	6 (1.80)	27 (8.08)	9 (2.69)	22 (6.59)	18 (5.39)
PG	5 (1.50)	5 (1.50)	12 (3.59)	3 (0.90)	5 (1.50)	12 (3.59)	3 (0.90)	8 (2.40)	3 (0.90)
Total	37 (11.08)	180 (53.89)	177 (52.99)	13 (3.89)	23 (6.89)	118 (35.33)	57 (17.07)	131 (39.22)	125 (37.43)

Figures in parentheses indicate percent (n=334)

The farmers, irrespective of education level rely on multiple sources for getting agriculture related information. More than half of the farmers were using other farmers and state department of agriculture for getting agriculture information. Mass media like TV (39.22%), newspaper (35.33%) and radio (17.07%) were also used by a good number of farmers. Magazine was used by those farmers who were better educated. Private dealers (37.43%) have also been used by the farmers particularly for getting input related information like chemicals and seed (Table 2). These input dealers were local persons who have ventured into business and enjoy a good relationship with the farmers. Therefore, they trust the dealers too, being one of their own. However, being a businessperson, most of the time they convince the farmers to use a chemical or variety which give them more profit margin.

Table 3. Major cropping systems and area under wheat

Cropping system	Total land (acres)	Area under wheat (acres)	% area under wheat
Bajra-Wheat	166.5	130	78.08
Maize-Wheat	98	44.5	45.41
Rice-Wheat	561	358.5	63.90
Sugarcane-Wheat	656	243	37.04
Urd-Wheat	84	68.5	81.55

There is a need to train these input dealers about various agro-products so that right information is communicated to the farmers. To transfer technologies to the farmers in an effective manner, the extension agencies should use multi sources. The highest area sown under wheat was 81.55 percent in urd-wheat rotation followed by bajra-wheat (78.08%), rice-wheat (63.90%), maize-wheat (45.41%) and sugarcane-wheat (37.04%) (Table 3). Less area under wheat in some of the rotations was mainly due to crop diversification in this area.

3.2 Sources of seed: Seed is a major component to enhance wheat production and source of seed makes a lot of difference in tackling a number of issues such as weed infestation, disease control, etc. It was interesting to note that majority of the farmers had purchased seed either from government (61.98%) or private input dealers (21.26%). Some of the farmers had used their own seed (16.77%). The seed policy of the government has motivated the farmers to purchase seed from government or private dealers. The farmers have realised the importance of quality seed to enhance wheat productivity.

The farmers having bajra-wheat, sugarcane-wheat have used nitrogen and phosphorous as per recommendation, whereas the farmers following maize-wheat, rice-wheat and urd-wheat applied less nitrogen (Table 4). Under the urd-wheat rotation, application of less nitrogen is justified due to a leguminous crop preceding wheat crop.

Table 4. Rotation wise average nutrient usage (kg/acre)

Crop rotation	Recommendation	N	P	K	Zn	S
Bajra-Wheat		63.10	27.75	10.59	6.4	0.40
Maize-Wheat		55.65	22.83	6.20	6.81	1.42
Rice-Wheat	NPK 60:24:16	58.10	23.45	9.18	6.38	0.12
Sugarcane-Wheat		60.05	24.23	5.40	6.81	0.96
Urd-Wheat		53.23	19.57	3.92	5.00	0.00

Table 5. Performance of wheat varieties grown by farmers under late and timely sown condition

Variety	Production condition	Zone	Year of release	Percent farmers growing	Av. Yield (q/acre)	TS by farmers (%)	Av. Yield under TS	LS by farmers (%)	Av. Yield under LS
DBW 14	LS	NEPZ	2002	0.90	14.33	0.90	14.33		
DBW 16	LS	NWPZ	2005	3.29	16.95	2.99	17.8	0.30	17
DBW 17	TS	NWPZ	2006	10.48	19.06	6.29	20.43	4.19	18.29
HD 2009	TS	NWPZ	1975	0.30	12	0.30	12.00	–	–
HD 2285	LS	NWPZ	1983	0.30	13	–	–	0.30	13.00
PBW 154	TS	NWPZ	1988	0.60	15.5	–	–	0.60	15.5
PBW 226	LS	NWPZ	1989	5.99	13.73	3.59	17.25	2.40	15.00
PBW 343	TS	NWPZ	1995	30.24	17.98	25.75	17.3	4.49	14.6
PBW 373	LS	NWPZ	1996	11.38	16.25	7.49	19.32	3.89	15.46
PBW 502	TS	NWPZ	2003	20.66	18.28	18.26	19.77	2.40	15.38
PBW 550	TS	NWPZ	2007	6.89	19.61	4.19	18.29	2.69	14.44
Super 172	TS	NWPZ		0.30	20.00	–		0.30	20.00
UP 2338	TS, LS	NWPZ	1994	4.79	17.19	1.50	15	3.29	14.32
UP 2382	TS	NWPZ	1998	2.40	16.31	1.50	15.67	0.90	14.8
UP 2425	LS	NWPZ	1999	0.30	15.00	0.30	15	–	–
UP 2526	LS	NWPZ	2005	0.30	12.5	–	–	0.30	12.5
WH 542	TS	NWPZ	1992	0.30	18.00	–	–	0.30	18
WH 711	TS	NWPZ	1977	0.60	16.00	–	–	0.60	16

LS (Late sown), TS (Timely sown),NEPZ (North Eastern Plain Zone) and NWPZ(North Western Plain Zone).

Phosphorous is slightly lower than recommendation. Contrary to the other parts of the country, almost half of the farmers have applied potash in wheat crop. Some of the farmers had applied zinc and sulphur. It was observed that the input dealers advise the farmers to apply sulphur even in areas which are not deficient. There is a need to advise the farmers to get their soils tested so that they apply nutrients on the basis of actual requirements.

All the farmers had applied nitrogen across crop rotations, phosphorous (90-100%) and zinc (48-92%) was applied by majority of the farmers, whereas potash was also applied by many farmers (38.7 -57.69%). None of the farmers used sulphur in urd-wheat crop rotation despite the micro nutrient was used by 26.92 percent of the farmers in other crop rotations.

Thirty percent of the farmers still grow PBW 343 wheat variety which was released in 1995 followed by PBW 502 (20.66%), DBW 17 (10.48%). PBW 550 gave the highest yield (19.61q/acre) and grown by 6.89 percent of the total farmers surveyed. There are a number of other varieties grown by the farmers (Table 5). The farmers grow varieties which were released two to three decades back. It was also recorded that the farmers prefer timely sown varieties under late sown conditions and *vice versa.* There are three possibilities (i) either the farmers are not aware of their production conditions, or (ii) the varieties perform better under both the conditions. (iii) Inter alia, there is also a possibility for a lag in the seed chain for recent varieties or less demand for seed production/ low availability of recent varieties seed in the market or preference of adopted varieties due to some quality parameters.

The latter possibility is supported by the findings which indicated that most of the timely sown varieties are performing at par with late sown varieties under late sown conditions too. The findings give a clue for the breeders whether they should breed those varieties which prefer better under both late and timey sown conditions so that the farmers can grow them under both the production conditions.

Table 6. Yield under different tillage system

Tillage	% farmers	Average yield (q/acre)
Conventional tillage	57.49	16.84
Rotary tillage	42.51	18.61

Most of the farmers' still follow conventional tillage (57.49%) but 42.52 percent of the farmers had adopted rotary tillage to save fuel, time and labour. They got better yield under rotary tillage (18.61q/acre) compared to conventional tillage (16.84 q/acre) (Table 6) which motivated the farmers to adopt rotary tillage.

3.3 Weed management strategies: Most of the farmers (91.62%) were not aware of the extent of loss caused by weeds in wheat crop. About 5.39 percent of the farmers reported that the yield loss in wheat may be 10-20 percent, while 2.99 percent of the farmers told that it may be 20-40 percent (Table 7). Depending on the intensity of these weeds, yield losses vary and it may be a complete failure of the crop (Chhokar *et al.*, 2012).

Table 7. Perception of farmers about grain yield loss due to weeds (n=334)

Loss (%)	Frequency (%)
10-20	18 (5.39)
20-40	10 (2.99)
Can't say	306 (91.62)

A majority of the farmers (64.07%) used knapsack sprayers having cut nozzle (61.38%) and they had also been using flat fan nozzle (51.50%). Some of the farmers used power sprayer in sugarcane-wheat (4.49%), bajra-wheat (0.60%) and rice-wheat (1.50%) rotations. Majority of them (52.59%) sprayed herbicides themselves while 33.84 percent had used labour for the job. Only 5.39 percent of the farmers had increased dose of herbicide over last year. Only 2.40 percent of the farmers had used herbicide twice during the crop season. Majority of them reported that the weeds were controlled properly. Merely 14.37 percent of the farmers mentioned that weeds were not controlled properly but hardly any one used the herbicide twice (Table 8). It is an indication of resistance developing against herbicides being used by the farmers. Malik and Singh (1995) reported from their field survey that resistance to isoproturon in *P. minor* was observed in 67 percent of fields under rice-wheat rotations, in comparison to 8, 9 and 16 percent when wheat is rotated respectively with rice, berseem and sunflower.

The farmers reported that there is no difference in the weed spectrum under conventional and rotary tillage. Therefore, a common table is generated. *Phalaris minor* was ranked the major weed under bajra-wheat, maize-wheat and urd-wheat crop rotation. It was interesting to note that *Chenopodium album* was ranked first under rice-wheat and sugarcane-wheat rotations followed by *Phalaris minor* (Table 9). In Ratlam district (MP) *Chenopodium album* was the major weed in wheat crop (Tomar *et al.* 2008).Across the crop rotations, mandusi (*Phalaris minor)*and bathua (*Chenopodium album)* emerged as the major weeds. Some of the other weeds were wild oat (*Avena ludoviciana*), motha (*Cyperus rotundus*), gajar ghas (*Fumaria parviflora*), chatri (*Vicia sativa*), hirankhuri (*Convolvulus arvensis*), krishananeel (*Angallis arvensis*), kantili (*Circium arvense*) , poa ghas (*Poa annua*), *etc.*

Table 8. Particulars in relation to weed control under different cropping system

Particular	Bajra-Wheat	Maize-Wheat	Rice-Wheat	Sugarcane-wheat	Urd-Wheat	Total
Sprayer						
Knapsack	31 (9.28)	20 (5.99)	71 (21.26)	71 (21.26)	21 (6.29)	214 (64.07)
Power	2 (0.60)	0.00	5 (1.50)	15 (4.49)	0.00	22 (6.59)
Type of nozzle used						
Flat	19 (5.69)	16 (4.79)	66 (19.76)	54 (16.17)	17 (5.09)	172 (51.50)
cut	19 (5.69)	4 (1.20)	148 (44.31)	29 (8.68)	5 (1.50)	205 (61.38)
Hollow cone	0.00	0.00	4 (1.20)	3 (0.90)	7 (2.10)	14 (4.19)
Sprayed by						
Self	36 (10.78)	9 (2.69)	72 (21.56)	41 (12.28)	18 (5.39)	176 (52.69)
Labour	12 (3.59)	11 (3.29)	39 (11.68)	40 (11.98)	11 (3.29)	113 (33.83)
Both	0.00	0.00	7 (2.10)	5 (1.50)	0.00	12 (3.59)
Increase dose over last year	2 (0.60)	0.00	5 (1.50)	8 (2.40)	3 (0.90)	18 (5.39)
Used same herbicide as last year						
Yes	17 (5.09)	4 (1.20)	73 (21.86)	16 (4.79)	2 (0.60)	112 (33.53)
Herbicide used twice during season	0.00	0.00	2 (0.60)	0.00	6 (1.80)	2.40
Weed controlled properly						
No	11 (3.29)	3 (0.90)	7 (2.10)	18 (5.39)	9 (2.69)	48 (14.37)

Table 9. Ranking of weeds in wheat crop across crop rotations

Weed	Bajra-Wheat (n=40)		Maize-Wheat (n=26)		Rice-Wheat (n=133)		Sugarcane-Wheat (n=104)		Urd-Wheat (n=31)	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Mandusi *(Phalaris minor)*	71	I	21	I	144	II	61	II	20	I
Bathua(*Chenopodium album*)	36	II	19	II	161	I	72	I	13	II
Motha (*Cyprus rotundus*)	26	III	–	–	40	III	9	V	4	III
Gajari (*Fumaria parviflora*)	2	V	–	–	1	VIII	13	III	1	IV
Poa ghas (*Poa annua)*	–	–	–	–	–	–	9	V	–	–
Kantili (*Circium arvense*)	–	–	–	–	–	–	6	VII	–	–
Chatri (*Vicia sativa)*	–	–	–	–	7	V	11	IV	–	–
Jangli palak (*Rumex retroflex*)	2	V	–	–	4	VI	2	VIII	–	–
Wild oat (*Avena ludoviciana*)	3	IV	–	–	11	IV	1	X	–	–
Hirankhuri (*Convulvulus arvensis*)	–	–	–	–	2	VIII	–	–	–	–
Krishananeel (*Anagallis arvensis*)	–	–	–	–	1	VIII	–	–	–	–

Table 10. Herbicides use frequency in different cropping system

Crop rotation	Herbicide used		
	Yes	No	Total
Bajra-Wheat (n=40)	31 (77.5)	9 (22.5)	40 (100)
Maize-Wheat (n=26)	22 (84.62)	4 (15.38)	26 (100)
Rice-Wheat (n=133)	120 (88.24)	13 (11.76)	133 (100)
Sugarcane-Wheat (n=104)	97 (93.27)	7 (6.73)	104 (100)
Urd-Wheat (n=31)	21 (67.74)	10 (32.26)	31 (100)

A majority of the farmers (87.13%) had applied herbicides to control weeds across the crop rotations. A good number of the farmers (12.87%) did not apply herbicide under urd wheat (32.26%), bajra-wheat (22.5%), maize-wheat (15.38%), rice-wheat (11.76%) and sugarcane-wheat (6.73%) as evident in Table 10. Crop rotation was the main reason for not using herbicide.

Broadleaf weeds being a major problem in these areas, a majority of the farmers had applied 2,4 D(44-60%) and sulfosulfuron (11.54-52%) across crop rotations (Table 11). Isoproturon has been applied by the farmers to control *Phalaris minor* which has shown resistance in Haryana and Punjab particularly in the rice wheat crop rotation. Some of the farmers reported that they are observing resistance against Isoproturon in some fields. The other herbicides used were metribuzin, metsulfuron, pendimethalin, clodinafop and fenoxaprop. Chhokar *et al.*,(2007a) and Singh *et al.,* (2004 a&b) have reported that metsulfuron, 2,4-D and carfentrazone were applied to control broad-leaved weeds in wheat. The application of 2,4-D at inappropriate time as well as on sensitive cultivar can lead to yield reduction due to malformation (Pinthus and Natoowitz, 1967; Bhan *et al.,* 1976; Balyan and Panwar, 1997).

Table 11. Type of herbicides used by farmers according to crop rotations

Crop rotation	Bajra-Wheat (n=40)	Maize-Wheat (n=26)	Rice-Wheat (n=133)	Sugarcane-Wheat (n=104)	Urd-Wheat (n=31)
2,4-D	24 (60.0)	16 (61.54)	59 (44.36)	57 (54.81)	18 (58.06)
Sulfosulfuron	21 (52.50)	3 (11.54)	42 (31.58)	–	5 (16.13)
Metribuzin	1 (2.50)	–	3 (2.26)	–	–
Metsulfuron	–	–	3 (2.26)	2 (1.92)	–
Clodinafop	–	3 (11.54)	5 (3.78)	–	–
Isoproturon	15 (37.50)	1 (3.85)	31 (23.31)	28 (26.92)	14 (45.16)
Fenoxaprop	–	–	3 (2.26)	–	–
Pendimethalin	–	–	14 (10.53)	–	6 (19.35)
Don't know	4 (10.0)	1 (3.85)	19 (14.29)	2 (1.92)	2 (6.45)

Figures within parentheses indicate percent to the total sample in the particular crop rotation

Table 12. Frequency of different weeds not controlled properly

Weed	Frequency (%)
Poa ghas	6 (1.80)
Kantili	2 (0.06)
Motha	4 (1.20)
Mandusi	4 (1.20)
Hirankhuri	1 (0.03)

Circium arvense, *Cyprus rotundus*, *Phalaris minor* and *Convolvulus arvensis* were not controlled properly as reported by a few farmers (Table12). The main reason for poor weed control was growing the same crop every year (4.79%).

Table 13. Reasons of poor weed control

Reason	Frequency (%)
Cultivation of same crop every year	16 (4.79)
Herbicide not timely sprayed	1 (0.03)
Lack of knowledge about herbicide	2 (0.06)
Lack of knowledge about proper timing of spray and dose	5 (1.50)
Poor quality herbicide	3 (0.90)
Rain after spray	3 (0.90)
Resistance	1 (0.03)

The other reasons were untimely spray of herbicide, lack of knowledge about herbicides, lack of proper timing about spray and dose, poor quality of herbicides, rain after spray and resistance (Table 13).

The farmers suggested that weeds can be managed by timely use of herbicide (7.49%), crop rotation (5.39%), more cultivation (3.29%), manual weeding (2.69%) and knowledge of herbicides (0.06%).

Irrespective of level of education, some of the farmers were aware of different agronomic management practices to control weeds. The level of awareness was not very encouraging and it varied for different strategies, increased seed rate (2.69-12.87%), early sown (1.80-7.78%), zero tillage (1.50-10.78%), residue retention (1.50-7.49%) and crop rotation (2.99-20.96%) at different levels of education (Table 14). Awareness about crop rotation was more compared to other management practices to control weeds in wheat crop.

Table 14. Education level and knowledge about agronomic management practices to control weeds

Education	Increase seed rate	Early sown	Zero tillage	Residue retention	Crop rotation
Illiterate	26(7.78)	17(5.09)	21(6.29)	25(7.49)	41(12.28)
Primary	17(5.09)	10(2.99)	5(1.50)	6(1.80)	20 (5.99)
Middle	31 (9.28)	19(5.69)	22(6.59)	13(3.89)	37 (11.08)
Matric	43 (12.87)	26(7.78)	36(10.78)	17(5.09)	70(20.96)
Intermediate	29(8.68)	20(5.99)	24(7.19)	13(3.89)	43(12.87)
Graduate	20(5.99)	15(4.49)	14(4.19)	7(2.10)	33(9.88)
Post-Graduate	9(2.69)	6(1.80)	6(1.80)	5(1.50)	10(2.99)

Figures within parenthesis indicates percent (n=334)

Table 15. Education level of farmers and adoption of agronomic management practices

Education	Increase seed rate	Early sown	Zero tillage	Residue retention	Crop rotation
Illiterate	13(3.89)	12(3.59)	0.00	0.00	32(9.58)
Primary	7(2.10)	5(1.50)	0.00	0.00	9(2.69)
Middle	13(3.89)	15(4.49)	0.00	0.00	22(6.59)
Matric	31 (9.28)	23(6.89)	0.00	0.00	51(15.27)
Intermediate	16(4.79)	20(5.99)	0.00	0.00	33(9.88)
Graduate	11(3.29)	9(2.69)	0.00	0.00	25(7.49)
Post-Graduate	4(1.20)	6(1.80)	0.00	0.00	7(2.10)

Figures within parenthesis indicates percent (n=334)

Though some of the farmers were aware of the different agronomic management practices to control weeds, level of adoption was dismal. None of the farmers had adopted zero tillage and residue retention as a strategy to control weeds in wheat crop. The problem of *P. minor* was less under zero tillage system due to less soil disturbance. As a result, *P. minor* seeds present in lower soil layer fail to germinate due to mechanical impedance (Chauhan *et al.,* 2003; Sharma *et al.,* 2002). Residue retention was not adopted by the farmers. Crop residue physically impede seedling growth or inhibit germination and growth by allelopathy (Crutchfield *et al.,* 1986; Wicks *et al.,* 1994) and it can prove effective in controlling weeds in wheat crop. Irrespective of education level, a few farmers adopted increased seed rate (1.20-9.28%), early sowing (1.50-6.89%) and crop rotation (2.10-15.27%) strategies (Table 15).

It may be summarized that weeds cause significant losses to wheat crop which can be minimized by adopting appropriate weed management strategies. *Phalaris minor* and *Chenopodium album* were the top ranked weeds across wheat based crop rotations. Most of the farmers applied herbicides to control broad leaf weeds. Herbicide rotation, use of flat fan nozzle or hollow cone nozzle, application of herbicides at appropriate time (30-35 days after sowing) helps in controlling weeds. Some of the farmers were aware of crop rotation, higher seed rate, retention of crop residue on soil surface, zero tillage technology of wheat sowing as weed management strategies.

Adoption of these strategies has to be stepped up to enhance wheat production and avoid herbicide resistance in this area.

References

1. Afentouli CG and IG Eleftherohorinous. 1996. Littleseed canarygrass (*Phalaris minor*) and short spiked canarygrass (*Phalaris brachystachys*) interference in wheat and barley. *Weed Science* **44**:560-565.
2. Anderson RL and DL Beck. 2007. Characterizing weed communities among various rotations in central South Dakota. *Weed Technology* **21**:76-79.
3. Balyan RS and RS Panwar. 1997. Herbicidal control of time of application of isoproturon in the control of weeds in wheat (*Triticum aestivum*). *Indian Journal of Weed Science* **20**:10-14.
4. Bhan VM, PS Negi, RS Chaturvedi and DBB Chaudary. 1976. Spike malformation by 2,4-D in dwarf wheats. *Indian Journal of Weed Science* **8**:53-59.
5. Cavan G, J Cussans and SR Moss. 2000. Modelling different cultivation and herbicide strategies for their effect on herbicide resistance in *Alopecurus myosuroides*. *Weed Research* **40**:561-568.
6. Chauhan DS, RK Sharma and RS Chhokar. 2003. Comparative performance of tillage options in wheat (*Triticum aestivum*) productivity and weed management. *Indian Journal of Agricultural Science* **73**(&):402-406.
7. Chhokar RS and RK Malik. 1999. Effect of temperature on the germination of *Phalaris minor* Retz. *Indian Journal of Weed Science* **31**:73-74.
8. Chhokar RS and Malik RK. 2002. Isoproturon resistant *Phalaris minor* and its response to alternate herbicides. *Weed Technology* **16**:116-123.
9. Chhokar RS, RK Sharma, and Indu Sharma. 2012. Weed Management Strategies in Wheat – a review. *Journal of Wheat. Research* **4**(2):1-21.
10. Chhokar RS, RK Sharma, AK Pundir and RK Singh. 2007a. Evaluation of herbicides for control of *Rumex dentatus, Convolvulus arvensis* and *Malva parviflora*. *Indian Journal of Weed Science* **39**:214-218.
11. Chhokar RS, RK Sharma, GR Jat, AK Pundir, and MK Gathala. 200b. Effect of tillage and herbicides on weeds and productivity of wheat under riec-wheat growing system. *Crop Protection* **26**:1689-1696.
12. Crutchfield DA, GA Wicks and OC Burnside. 1986. Effect of winter wheat (*Triticum aestivum*) straw mulch level on weed control. *Weed Science* **34**:110-114
13. Cudney DW and JE Hill. 1979. The response of wheat grown with three population levels of canarygrass to various herbicide treatments. *In : Proceeding of western society of weed science* (Deptt. Bot. Plant Sci., Univ. California, River Side, CA, 92521, USA) **32**:55-56.
14. Chopra Nisha, Harpal Singh, HP Tripathi, NK Chopra, N Chopra and H Singh. 2001. Performance of metsulfuron methyl and pendimethalin alone and their mixtures with isoproturon on weed control in wheat (*Triticum aestivum*) seed crop. *Indian Journal of Agronomy* **46**(4):682-688.
15. Dixit A, AK Gogoi and JG Varshney. 2008a. Weed Atlas-District-wise distribution pattern of major weed flora in prominent crops. Vol I, National Research Centre for Weed Science, Jabalpur, India, pp 127.
16. Dixit A, AK Gogoi and JG Varshney. 2008b. Weed Atlas-District-wise distribution pattern of major weed flora in prominent crops. Vol II, National Research Centre for Weed Science, Jabalpur, India, pp 88.
17. FHD Emden and RS Llewellyn. 2006. No-tillage adoption decisions in southern Australian cropping and the role of weed management. *Australian Journal of Experimental Agriculture*, **46**:563-569
18. Froud-Williams RJ, RJ Chancellor and DSH Drennan. 1983. Influence of cultivation regime upon buried weed seeds in arable cropping systems. *Journal of Applied Ecoloogy* **20**:199-208.
19. Harrington, LM, M Morris, PR Hobbs, VP Singh, HC Sharma, RP Singh, MK Chaudhary and SD Dhiman. 1992. Wheat and rice in Karnal and Kurukshetra districts, Haryana, India. Exploratory survey report. Hisar, New Delhi, India Mexico and Philippines: CCS Haryana Agricultural University, Indian Council of Agricultural Research, Centro International de Mejoramiento de Maizy Trigo, and International Rice Research Institute, Pp 40-42.
20. Khera KL, BS Sandhu, TS Aujla, CB Singh and K Kumar. 1995. Performance of wheat (*Triticum aestvum*) in relation to small canarygrass (*Phalaris minor*) under different levels of irrigation, nitrogen and weed population. *The Indian Journal of Agricultural Sciences* **65**:717-722.
21. Ladha JK, M Fischer Hossain, PR Hobbs and B Hardy. 2000. Progress towards improving the productivity and sustainability of rice wheat systems: a contribution by the consortium members. IRRI Discussion pp 40.
22. Malik RK and Singh S. 1993. Evolving strategies for herbicide use in wheat. Resistance and integrated weed management. *Proceedings of Indian Society of Weed Science International Symposium on Integrated*

Weed management for Sustainable Agriculture, 18-20 November, 1993, Hisar. India **1**:225-238.

23. Malik RK and Singh S. 1995. Littleseed canarygrass (*Phalaris mionr Retz.)* resistance to isoproturon in India. *Weed Technology* **9**:419-425.

24. Mongia AD, RK Sharma, AS Kharub, SC Tripathi, RS Chhokar and Jag Shoran. 2005. Coordinated research on wheat production technology in India, Karnal. Research Bulletin no. 20, Directorate of Wheat Research. 40 p.

25. Pandey IB, DK Dwivedi and SC Prakash. 2006. Impact of method and levels of fertilizer application and weed management on nutrient economy and yield of wheat (*Tritium aestivum*). *Indian Journal of Agronomy* **53**(3):193-198.

26. Pinthus MJ and Y Natowitz. 1967. Response of spring wheat to the application of 2,4-D at various growth stages. *Weed Research* **7**:95-101.

27. Llewellyn RS, DJ Pannell , ARK Lindner and SB Powles. 2006. Targeting key perceptions when planning and evaluating extension. *Australian Journal of Experimental Agriculture* **45**(12):1627-1633.

28. Llewellyn RS, DJ Pannell, ARK Lindner and SB Powles. 2005. Targeting key perceptions when planning and evaluating extension. *Australian Journal of Experimental Agriculture* **47**:57–70.

29. Sharma RK, RS Chhokar and DS Chauhan. 2002. Zero Tillage Technology in Rice-Wheat System: Retrospect and Prospects. *Indian Farming* **54**(4):12-17.

30. Singh G, VP Singh and M Singh. 2004a. Effect of carfentrazone-ethyl on nongrassy weeds and wheat yield. *Indian Journal of Weed Science* **34**:19-20.

31. Singh VP, G Singh and M Singh. 2004b. Effect of triasulfuron on nongrassy weeds and wheat yield. *Indian Journal of Weed Science* **36**:262-264.

32. Singh Govindra and Mahendra Singh. 2002. Bio-efficacy of metsulfuron methyl in combination with isoproturon for control of grassy and non grassy weeds in wheat. *Indian Journal of Weed Science* **34**(1&2):9-12.

33. Singh RK, DK Singh and RP Singh. 1997. Weed crop completion in wheat as affected by different weed species. *Indian Journal of Weed Science* **29**:109.

34. Singh R and Anuj Kumar. 2007. Weed control strategies adopted by farmers in wheat crop. *Agricultural Extension Review* **19**(2):13-14& 25.

35. Timsina J and DJ Connor. 2001. Productivity and management of rice - wheat cropping systems: issues and challenges. *Field Crops Research* **69**(2):93-132.

36. Tomar SS, RL Rajput and NR Paradkar. 2008. Study on weed flora of major rabi crops in Mandsor and Ratlam district of M.P. *BhartiyaKrishiAnusandhanPatrika* **23**(3&4):149-152

37. Walia US, LS Brar and BK Dhaliwal. 1998. Perfromance of clodinafop and fenoxaprop-p ethyl for the control of *Phalaris minor* in wheat. *Indian Journal of Weed Science* **30**(1&2):38-50

38. Wicks GA, DA Crutchfield and OC Burnside. 1994. Influence of wheat (*Triticum aestivum*) straw mulch and metolachlor on corn (*Zea mays*) growth and yield. *Weed Science* **42**:141-147.

39. Yaduraju NT, MBB Prasad Babu and Chandla Poonam. 2006. Herbicide use. In"Agriculture and Environment". Swaminathan MS and Chadha KL (Eds). Malhotra Publishing House, New Delhi, India. *Pp* 192-210.