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Weed seed bank and weed flora dynamics as influenced by weed management practices in wheat and rice under wheat-rice cropping system

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ABSTRACT

To study the effect of weed control methods on weed seed bank and composition of weed flora in wheat and rice under wheat-rice system, a field experiment was conducted at crop research center of GBPUAT, Pantnagar during *rabi* and *kharif* of 2001-02 and 2002-2003. The weed seed bank studies revealed that application of herbicides has no significant effect on the weed seed bank of soil. Weed control treatments isoproturon + hand weeding in wheat and butachlor + hand weeding in rice recorded less number of weed seeds (14450, 3800 and 605 of *Phalaris minor, Chenopodium album* and *Melilotus alba,* respectively in wheat and 2650, 2048 and 4265 of *Echinochloa colona, Echinochloa crusgalli* and *Paspalum scrobiculatum,* respectively in rice). Under the influence of different weed management practices, there was significant negative relationship of grain yield with weed dry weight and weed seed bank in both wheat and rice. Among herbicide treatments, isoproturon (1.0 kg/ha) + hand weeding; butachlor (1.5 kg/ha) + hand weeding followed by isoproturon (1.0 kg/ha) +2,4-D (0.5 kg/ha); butachlor (1.5 kg/ha) *fb* 2,4-D (0.5 kg/ha) + organic matter through *Sesbania aculeata* were found effective in reducing total weed population, weed dry matter and weed seed density there by increasing yield of wheat and rice.

Key words : Weed seed bank, Weed flora, Weed control methods, Wheat, Rice.

Rice-wheat is the most adopted cropping sequence in India, covering an area of 11 m/ha, suffers heavily due to severe weed infestation owing to congenial weather conditions and cropping history of land. The severe competition by weeds results in yield reduction as high as 40-60% depending upon the intensity and the type of weed flora (Singh *et al.* 2003). Species composition and density of the weeds are influenced by cropping history, agronomic practices especially weed control measures, tillage methods and also soil and climate conditions of the region. Species composition of weed vary from field to field and among area within the field which has direct relation with weed seed bank of the soil. Although seed bank and the resulting weed population are composed of many species, a few dominant species generally comprises 70 to 90% of the total weed flora (Wilson 1988). Keeping this in view, the present investigation was carried out to find out the effect of weed control methods on weed seed distribution in soil and dynamics of weed flora in wheat and rice.

MATERIALS AND METHODS

A field experiment was conducted at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Udham Singh Nagar) during *rabi* and *kharif* seasons of 200-02 and 2002-03. The soil of the experimental plot was sandy loam in texture, medium in organic carbon (0.68), low in available nitrogen (260 kg/ha) and medium in available phosphorus (37.8 kg/ha) and potassium (264.3 kg/ha) having a pH of 7.8. There were seven treatment combinations *viz.,* T_1- Isoproturon 1 kg/ha at 30-35 days after sowing as post-emergence and butachlor 1.5 kg/ha at 2-5 days after transplanting as pre-emergence, T_2 - Isoproturon 1 kg/ha + 2,4-D 0.5 kg/ha at 30-35 days after sowing as post-emergence and butachlor 1.5 kg/ha *fb* 2,4-D 0.5 kg/ha 20 days after transplanting as post-emergence, T_3- Isoproturon 1 kg/ha + 2,4-D 0.5 kg/ha and butachlor 1.5 kg/ha *fb* 2,4-D 0.5 kg/ha + OM (Sesbania), T_4 - Clodinafop 60 g/ha at 30-35 days after sowing as post- emergence *fb* 2,4-D 0.5 kg/haat 20 days after application of clodinafop and Treatment 2 in rotation with pretilachlor 0.75 kg /ha at 2-5 days after transplanting as pre-emergence, T_5- Clodinafop 60 g /ha *fb* 2,4-D 0.5 kg/ha and treatment 4 + OM (sesbania), T_6 - Isoproturon 1 kg/ha *fb* hand weeding at 45 days after sowing and butachlor 1.5 kg/ha *fb* hand weeding at 45 days after transplanting, T_7 - Weedy and weedy.

The experiment was laid out in randomized block design with three replications. Wheat cv. *UP 2425* was sown on December 10, 2001 and December 4, 2002 while rice cv. *Narendra 359* was transplanted on July 24, 2002 and July 10, 2003. After the harvest of wheat *Sesbania* *aculeata* was sown on May 8, 2002 and May 2, 2003 and turned over at 55 to 60 days stage on July 8, 2002 and June 30, 2003. Isoproturon was sprayed at spray volume of 1200 liters/ha and clodinafop at the spray volume of 600 liters/ha. In rice, butachlor, pretilachlor and 2,4-D were sprayed with spray volume of 600 liters/ha. Weeds were recorded species wise in each plot at 30, 60, 90 and 120 days after sowing/transplanting of the each crop, using quadrate of ($0.25m^2$) from the area marked for the observations. The count was expressed as number of weeds/m^2. Soil, samples from each plot were taken manually with a khurpi from an area of 100 cm^2 and up to a depth of 10 cm. In the extraction method, seeds were separated from soil by washing through sieve with 4 mm and 0.25 mm screens. The retained contents were air-dried, stored under an illuminated magnifier and seeds were removed, identified and determined for their number per/m^2. Response curve of linear type of equation $y = a + bx$ of grain yield on weed seed bank and weed dry weight were fitted using least square technique as given by Snedecer and Cochran (1967).

RESULTS AND DISSUCION

Effect on weed seed bank

Seed density of *Phalaris minor, Chenopodium album, Melilotus* spp. and other weeds was non-significant under different treatments, however higher seed density was recorded under weedy condition. The population of *Phalaris minor* which escaped isoproturon or clodinafop application would have contributed substantially to the seed bank because of its high seed production capacity (Table 1). *Phalaris minor* has the ability to produce 17 to 19 thousand seeds per plant (Singh *et al.* 1999) in one season with 88 to 96% viability and germination (Yadav 2002). Under different herbicide treatments, major contribution towards weed seed bank was of *Chenopodium album* (47.0 to 57.5%) followed by *Phalaris minor* (21 to 27%), but under weedy condition contribution of *Chenopodium album* was 60.7% and that of *Phalaris minor* was 19.4%. Therefore, even after satisfactory control in terms of crop weed competition, this weed may continue to be problematic in the successive years in continuous rice-wheat system because of its high seed production capacity.

Seed density of *Echinochloa colona, Echinochloa crusgalli, Paspalium scrobiculatum* and other weeds did not show any significant variation due to different treatments, though higher seed density was observed under weedy condition and lower number of weed seeds were under butachlor + hand weeding followed by butachlor *fb* 2,4-D + organic matter through *Sesbania aculeata* and butachlor rotated with pretilachlor *fb* 2,4-D + organic matter through *Sesbania aculeata* (Table 1). Under different herbicide treatments in rice, major contribution towards weed seed bank was of *Paspalum scrobiculatum* (21.23%) followed by *Echinochloa colona* (13.17%) and *Echinochloa crusgalli* (10.14%), but under weedy conditions major contribution was of *Echinochloa colona* (23.4%) followed by *Echinochloa crusgalli* (21.1%) and *Paspalium scrobiculatum* (16.9%). Viability of *Echinochloa* spp. is reported to be less than 10% after two and half year of burial in soil (Egley and Chandler 1976) so, the *Echinochloa* plants escaping the treatments did not contribute much to the seed bank. Control of weeds before reproductive phase might have caused reduction in seed bank of these weeds which has resulted into decreased population.

Effect on weeds and weed dynamics

The experimental fields had 14 weed species (3 grassy, 10 non-grassy and 1 sedge) during *rabi* and 14 weed species (6 grassy, 4 non-grassy and 4 sedges) during *kharif*. *Phalaris minor* was the most dominant weed in wheat at all the stages during both the years in weedy-weedy treatments, which contributed 100 to 90% at harvest. Contribution of other weeds was negligible at all the stages and it ranged from 0 to 9.1% at different stages. *Phalaris minor* was the most dominant weed at all stages of crop growth. *Chenopodium album* and *Melilotus alba* were the major non-grassy weeds in wheat. Singh *et al.* (2003) also reported that *Phalaris minor, Chenopodium album, Melilotus* spp., *Polygonum* spp., *Cynadon dactylon* and *Cyperus rotundus* were the major weeds of wheat in rice-wheat system at Pantnagar. Density of *Chenopodium album* and *Melilotus alba* decreased with the advancement of crop due to suppression by other weeds and the crop itself (Table 2) . Yadav (1993) also reported that density of non-grasses decreased with the crop growth because of their poor competing ability.

Echinochloa colona was the most dominant weed, as it contributed highest number (9.0% at 60 days) towards total weed density. The density of *Echinochloa colona* and *Echinochloa crusgalli* was the highest. *Echinochloa colona, Echinochloa crusgalli* and *Paspalum scrobiculatum* were the major grasses in rice. *Echinochloa colona* and *Echinochloa crusgalli* contributed 5.3% to the total weed density at 60 days of the crop. *Paspalum scrobiculatum* contributed 10% at 60 days of the crop. Singh *et al.* (2003) also reported that *Echinochloa colona, Echinochloa crusgalli* and *Paspalum* spp. were the major weeds of rice in rice-wheat system at Pantnagar (Table 3).

Effect on weed dynamics

In *rabi*, higher population and dry weight of *Phalaris minor, Chenopodium album* and of other weeds were recorded in plots kept weedy in wheat than other herbicide treatments. All the herbicide treatments reduced

Table 1. Efect of weed control methods on weed seed bank (no./m^2 upto 10 cm soil depth) of different weed species after wheat and paddy harvest (mean of two years)

	Treatments		Wheat				Paddy			
	Wheat	Paddy	*P. minor*	*C. album*	*M. alba*	others	*E. colona*	*E. crusgalli*	*P. scrobiculatum*	others
T_1	Isoproturon	Butachlor	14905	39380	655	14133	3780	3094	4746	10750
T_2	Isoproturon + 2,4-D	Butachlor *fb* 2,4-D	14890	39550	645	14191	3729	3075	4700	10688
T_3	Isoproturon + 2,4-D	Butachlor *fb* 2,4-D+OM	14908	38975	613	14075	2650	2078	4393	10520
T_4	Clodinafop *fb* 2,4-D	T_2 with pretilachlor in rotation	14610	38000	590	13335	3751	3080	4707	10699
T_5	Clodinafop *fb* 2,4-D	T_4 + OM	14499	38053	603	13309	2689	2060	4645	10600
T_6	T_1 + HW at 45 DAT	T_1 + HW at 45 DAS	14450	38000	605	15000	2650	2040	4265	10505
T_7	Weedy	Weedy	17615	55144	871	17188	9694	8749	6989	16043
LSD (P=0.05)			NS	NS	NS	NS	NS	NS	NS	NS

DAT- Days after transplanting, OM - Organic matter, DAS - Days after sowing, HW - Hand weeding

Table 2. Effect of weed control methods on density (no. /m^2) and dry weight (g/m^2)of different weed species at 60 DAS and grain yield of wheat (mean of two years)

	Treatments		*P. minor*		*C. album*		*M. alba*		Others		Grain yield (kg/ha)
	Wheat	Paddy	Density	Dry weight	Density	Dry weight	Density	Dry weight	Density	Dry weight	
T_1	Isoproturon	Butachlor	5.5 (250)	3.2 (28.50)	0.0 (0.0)	0.0 (0.00)	1.3 (9.5)	0.12 (0.14)	1.5 (11.5)	0.54 (0.96)	2143
T_2	Isoproturon+2,4-D	Butachlor *fb* 2,4-D	5.4 (257)	4.0 (65.66)	0.0 (0.0)	0.0 (0.00)	0.4 (2.0)	0.05 (0.50)	1.3 (9.5)	0.22 (0.28)	1775
T_3	Isoproturon+2,4-D	Butachlor *fb* 2,4-D + OM	4.9 (145)	3.4(33.99)	0.0 (0.0)	0.0 (0.00)	0.0 (0.0)	0.0 (0.00)	1.1 (4.0)	0.70 (1.53)	2453
T_4	Clodinafop *fb* 2,4-D	T_2 with pretilachlor in rotation	3.1 (73)	3.2 (31.49)	1.0 (6.0)	0.20 (0.25)	1.2 (12.0)	0.42 (0.66)	1.3 (6.5)	0.23 (0.31)	1834
T_5	Clodinafop *fb* 2,4-D	T_4 + OM	3.6 (74)	3.1 (31.12)	0.9 (4.5)	0.11 (0.13)	1.6 (12.5)	0.22 (0.31)	1.2 (5.0)	0.24 (0.31)	2150
T_6	T_1 + HW at 45 DAT	T_1 + HW at 45 DAS	0.0 (0.00)	0.0 (0.00)	0.0 (0.0)	0.0 (0.00)	0.0 (0.0)	0.0 (0.00)	0.0 (0.0)	0.0 (0.00)	3342
T_7	Weedy	Weedy	6.0 (405)	5.3 (221.96)	2.9 (23.0)	0.83 (1.32)	2.8 (23.0)	0.81 (1.34)	1.5 (7.0)	0.93 (1.82)	801
LSD (P=0.05)			2.0	1.08	1.0	0.26	0.9	0.27	0.5	0.31	847

Orginal value are given in parentheses DAT- Days after transplanting, OM - Organic matter, DAS - Days after sowing

Table 3. **Effect of weed control methods on density (no. /m²) and dry weight (g/m²) of different weed species at 60 DAT and grain yield of paddy (mean of two years)**

Treatments		*E. colona*		*E. crusgalli*		*P. scrobiculatum*		others		Grain yield (q/ha)
Wheat	Paddy	Density	Dry weight	Density	Dry weight	Density	Dry weight	Density	Dry weight	
T_1 - Isoproturon	Butachlor	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.4 (0.65)	0.6 (1.29)	0.6 (1.35)	0.5 (3037)	55.89
T_2 - Isoproturon + 2,4-D	Buta *fb* 2,4-D	0.4 (0.65)	0.7 (1.70)	0.3 (0.50)	0.4 (1.60)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	56.92
T_3 - Isoproturon + 2,4-D	Buta *fb* 2,4-D + OM	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	59.57
T_4 - Clodinafop *fb* 2,4-D	T_2 with pretilachlor In rotation	0.7 (1.15)	0.4 (3.24)	0.0 (0.00)	0.0 (0.00)	0.4 (0.65)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	55.05
T_5 - Clodinafop *fb* 2,4-D	Treat- 4 + OM	0.8 (2.00)	0.8 (2.97)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	58.05
T_6 - T_1+ HW at 45 DAT	T_1+ HW 45 DAS	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	61.40
T_7 - Weedy	Weedy	1.9 (6.15)	2.6 (12.79)	1.4 (3.65)	1.3 (3.59)	2.1 (10.85)	2.4 (12.21)	3.8 (65.0)	3.7 (42.09)	50.99
LSD (P=0.05)		0.6	0.86	0.5	0.43	0.7	0.8	1.3	1.23	3.46

Orginal value are given in parentheses DAT-Days after transplanting, OM-Organic matter, DAS-Days after sowing, HW- Hand weeding

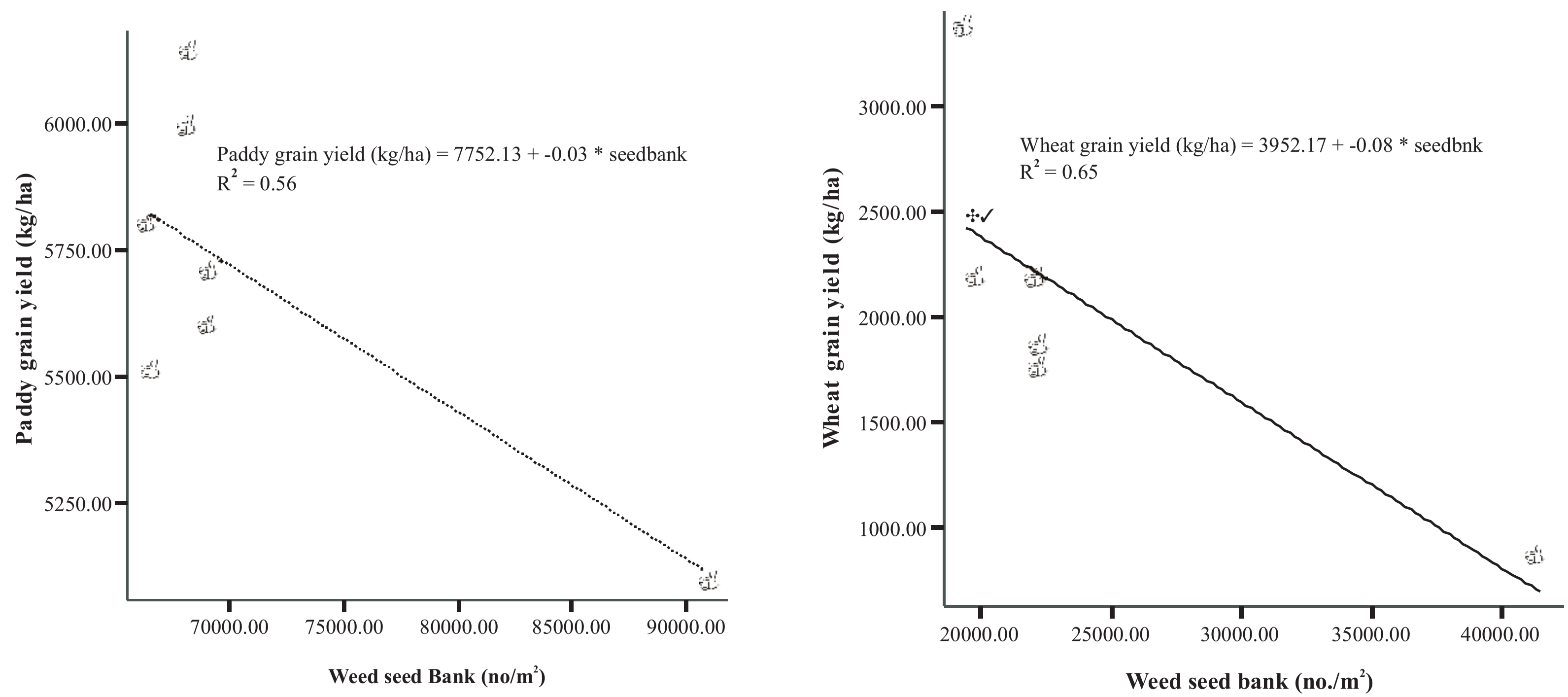

Fig. 1. Regression analysis of wheat and paddy grain yield and weed seed bank after wheat harvesting, respectively

total weed density and total weed dry matter production. Isoproturon + hand weeding and clodinafop *fb* 2,4-D with and without organic matter in *kharif* were effective in suppressing weeds (Table 2) and reducing dry matter production. Nandal and Singh (1994) also reported that isoproturon in combination with hand weeding surpassed the other weed control treatments and significantly reduced fresh weight of annual grasses.

In *kharif*, density and dry weight of *E. colona, E. crusgalli, P. scrobiculatum* and of other weeds was higher under weedy condition as compared to other treatments. All the treatments reduced the total weed density and total weed dry matter production (Table 3). Butachlor *fb* 2,4-D + organic matter through *Sesbania aculeata* and butachlor + hand weeding were effective in controlling all the weeds at 60 days and later intervals and dry matter production was zero. The combination of herbicides and manual weeding *viz.,* butachlor + hand weeding, in rice was significantly superior in reducing weed population and dry weight of weeds (Nandal *et al.* 1998). Butachlor + 2,4-D was found best for control of weeds and reduction in dry weight (Raju and Reddy 1990).

Effect on yield

Significantly lower grain yield under weedy condition (801kg/ha) as compared to herbicide treatments *viz.,* isoproturon + hand weeding (3342 kg/ha), isoproturon + 2,4-D with organic matter in *kharif* (2453 kg/ha) and clodinafop *fb* 2,4-D with organic matter in *kharif* (2150 kg/ha) in wheat was a result of crop weed competition. There was reduction in grain yield of 50 to 60% under weedy condition. Losses in wheat grain yield due to uncontrolled weeds have been reported to be 31.8 to 61.5% by Singh (1982) at Pantnagar. Significantly lower grain yield under weedy condition (5100 kg/ha) as compared to herbicide treatments *viz.,* butachlor + hand weeding (6140 kg/ha), butachlor *fb* 2,4-D + organic matter through *Sesbania aculeata* (5957 kg/ha) and butachlor rotated with pretilachlor *fb* 2,4-D + organic matter through *Sesbania aculeata* (5810 kg/ha) in rice as a result of crop-weed competition. There was reduction in grain yield of 15 to 20% under weedy condition. Similar observations regarding effect of weedy conditions on grain yield of transplanted rice have also been reported by Singh *et al.* (2003).

Relationship analysis

Under the influence of different weed management practices, there was significant negative relationship of grain yield with weed dry weight and weed seed bank in both wheat and rice (Fig. 1). However degree of relationship was comparatively stronger in wheat. This is justified by the fact that higher weed seed bank increases weed intensity in subsequent crop which in turn increases weed dry weight accumulation. These results are in tune with findings of Angiras *et al*. (2010). Thus, for any weed management practice planning, weed seed bank of previous crop should also be kept under consideration.

On the basis of present investigation, it was concluded that treatment of isoproturon at 1.0 kg/ha + 2,4-D at 0.5 kg/ha as post-emergence butachlor at 1.5 kg/ha as pre-emergence *fb* 2,4-D at 0.5 kg/ha as post-emergence along with organic matter through *Sesbania aculeata* in rice was found superior in suppressing the weeds, reducing weed seed bank and consequently increasing grain yield of wheat and rice in wheat-rice cropping system. Also weed seed bank has profound impact on weed intensity and weed dry weight of the subsequent crop in wheat-rice system. So for effective weed management practice enumeration of weed seed bank is of prime importance.

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