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Characterization of Weed Flora and Weed Management Practices in Rice under Different Cropping Systems in Western Gangetic Plains of India – A Case Study

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ABSTRACT

Weed density and yield of rice in western IGP were examined in transplanted rice crop under rice-wheat, rice-pea-rice and rice-sugarcane-ratoon-wheat/fallow cropping systems. *Echinochloa crusgalli* was dominant after rice-wheat and rice-pea-rice sequence, but it was completely suppressed after the sugarcane sequence. Among sedges, *Fimbristylis milliacea* was dominant after rice-wheat and *Cyperus difformis* after rice-pea-rice. In the sugarcane system, *Cyperus rotundus* became the main weed. The yield loss from weeds in unweeded plots was highest in the rice-wheat system, followed by rice-pea-rice, and was least in the sugarcane system. Under farmers' weed management practices, there were yield losses due to weeds ranging from 13.1 to 22.4%. The total cost of weed management in transplanted rice was higher in rice-wheat system than in rice-pea-rice or rice-sugarcane system.

INTRODUCTION

In the Indo-Gangetic plains of India, transplanted rice is grown in different cropping systems. The dominant cropping system of the region is rice-wheat, occupying around 11 million hectare area, on which research work has been focused. In the western part of this region, rice-sugarcane is also an important cropping system. Rice-pea-rice is becoming popular, comprising a summer rice crop planted in February and harvested in June i. e. before the onset of monsoon. The productivity of this crop is quite high (8-10 t ha^{-1}) and the area under this system is increasing, though it requires lot of irrigation water, as the crop is grown in hot summer. In these two cropping systems, rice-sugarcane-ratoon-wheat/fallow (Rice-sugarcane system) and rice-pea-rice, crop management practices are quite different which may consequently affect the weed flora of the region. Weeds cause considerable yield loss in these crops. In direct seeded rice, yield loss due to weeds can be 40% to complete crop failure. In transplanted rice, yield loss is of the extent of 20-40%. A recent survey conducted in sugarcane crop in this area has shown that weeds remain a major threat to sugarcane and *Cyperus* and *Ipomoea* spp. have been identified as the most problematic weeds for which no good control measures are available. Not much work has been done on rice-pea-rice system and specific weed management practices for rice grown in summer have not been recommended. Hence, it was planned to characterize the weeds appearing in these cropping systems and survey the weed management practices followed by the farmers in these cropping systems. This will provide information on the efficacy of the practices followed, perception of the farmer about weed problems, his knowledge about the control measures, and gaps in the knowledge, crop productivity, and the constraints faced by the farmers. The information generated will be useful to farmers elsewhere in the Gangetic plains towards east, where weed species are common and adoption of summer Boro rice is increasing at a faster pace. There is emphasis on crop diversification in the country and alternate cropping systems will become more important. Hence, it will be desirable to generate sufficient data on weed ecology of these systems

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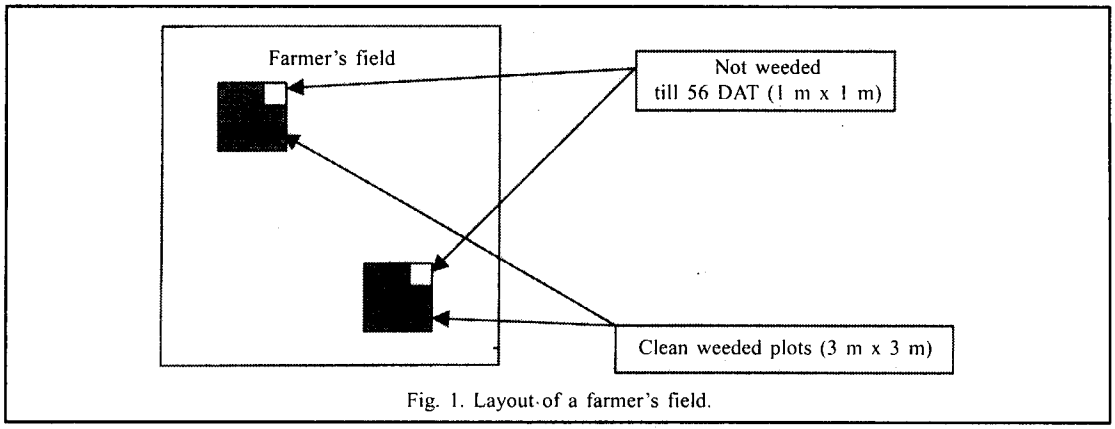

Fig. 1. Layout of a farmer's field.

so that weed-free yields can be determined and cost-effective weed management strategies developed.

With above points in view, on-farm trials and survey were conducted with the objective to describe the weed flora in **kharif** rice grown in different rice cropping systems (rice-sugarcane-ratoon-wheat/fallow, rice-pea-rice and rice-wheat cropping), weed management practices in these cropping systems and assess yield losses due to weeds under farmers' weed management.

MATERIALS AND METHODS

Farmers' fields around G. B. Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar district, Uttaranchal state (India) were marked for the study. Fifteen farmers practising each system were identified in different villages. In each field, after rice transplanting two quadrats (each 3 m x 3 m) were marked out and within each of these a sub-plot (1 m x 1 m) was marked out in the corner of each main plot (Fig. 1). In the sub-plot, no weed control/hand weeding was practised and at 28 and 56 days after transplanting (DAT) the weeds present were counted by species in the 1 m x 1 m area. At 56 DAT, all the weed growth in 1 m x 1 m was cut at ground level, separated by species, dried and weighed. The remaining portion (8 m^{-2}) of the larger plots was clean weeded by hand at seven days intervals commencing 7 DAT.

At harvest grain from 2 m x 1 m plot was harvested from each of the clean weeded plots. Grain was also harvested and weighed from two 2 m x 1 m plots from the farmers' field, one plot being taken adjacent to each of the clean weeded plots. Weed management practices were recorded on each of the fields included in the study.

RESULTS AND DISCUSSION

Weed Density and Dry Weight

There were large variations in weeds under these different cropping systems. Among the sedges, *Cyperus iria* was prominent in rice fields under rice-pea-rice system (Table 1). Its density was less in rice-wheat, and still less in sugarcane system. *Cyperus difformis* was prominent in rice-wheat and rice-pea-rice systems and totally absent in

Table 1. Density (No. m^{-2}) 28 and 56 DAT and dry weight (g m^{-2}) of sedges in unweeded rice plots at 56 DAT

Species	Rice-wheat			Rice-pea-rice			Rice-sugarcane		
	Density		Dry	Density		Dry	Density		Dry
	28 DAT	56 DAT	weight	28 DAT	56 DAT	weight	28 DAT	56 DAT	weight
Cyperus iria	0.3	5.2	7.3	10.1	18.4	27.6	0.0	2.5	3.6
Cyperus difformis	14.3	22.5	37.9	29.0	26.0	41.5	0.0	0.0	0.0
Cyperus rotundus	41.0	8.5	7.0	11.9	8.4	12.7	169.8	59.7	16.7
Fimbristylis milliacea	144.5	73.0	85.6	2.1	16.5	28.9	9.3	7.0	13.7

Table 2. Density (No. m^{-2}) 28 and 56 DAT and dry weight (g m^{-2}) of grasses in unweeded rice plots at 56 DAT

Species	Rice-wheat			Rice-pea-rice			Rice-sugarcane		
	Density		Dry	Density		Dry	Density		Dry
	28 DAT	56 DAT	weight	28 DAT	56 DAT	weight	28 DAT	56 DAT	weight
Echinochloa colona	8.9	14.4	17.3	2.8	7.5	99.3	8.2	1.2	0.9
E. crusgalli	31.0	22.5	62.2	32.9	26.9	67.9	7.5	1.5	1.2
Ischaemum rugosum	0.6	2.4	20.8	0.0	0.0	0.0	0.0	0.0	0.0
Digitaria spp.	4.2	1.3	0.9	0.7	0.0	0.0	0.0	0.0	0.0
Leptochloa chinensis	0	8.1	14.8	0	0.00	0.00	0	6.1	4.8

sugarcane system. On the contrary, *Cyprus rotundus* was dominant in sugarcane based system followed by rice-wheat. Population and dry weight of *Fimbristylis milliacea* were very high in rice-wheat system, followed by rice- pea-rice system, and much less in sugarcane system. Among grasses, density and biomass production of *Echinochloa colona* and *E. crusgalli* were highest (Table 2). *E. colona* was dominant in rice-pea-system, whereas *E. crusgalli* in both the systems without sugarcane. In sugarcane system, both these species were negligible. *Ischaemum rugosum* and *Digitaria* spp. were present only in rice-wheat system. *Leptochloa chinensis* was not observed at 28 DAT in any of the systems and was completely absent in rice-pea-rice system at 56 DAT also. But at 56 DAS, it was present in two other systems. Overall sugarcane in the cropping system checked weed growth in following rice crop. The density of non-grasses was quite low, except *Alternanthera sessilis*, which had good presence (41.1 m^{-2}) in rice-pea-rice system (Table 3).

Relative weed density and biomass of different weed types (sedges, grasses and non-grasses) were compared under weedy condition and farmers' weed management practices for all the three cropping systems. In rice-wheat system, the density of sedges was highest (>70% at 28 days and >60% at 56 DAT), followed by grasses and non-grasses, but in terms of biomass grasses had >6% share, followed by sedges and non-grasses (Fig. 2). The relative density and biomass of weeds had similar trend in weedy as well as farmers' managed plots. Thus, in rice-wheat system, grasses would cause maximum harm to rice crop.

In rice-pea-rice system, the relative density of different weed types in unweeded plots at 56 DAT was nearly of same order, but under farmers' practices, density of grasses was higher–50% of the total, followed by sedges and non-grasses (Fig. 2). At 28 DAT relative density of sedges was higher in weedy plots than in farmers' managed plots. In biomass, grasses were very dominant contributing 71.5% under weedy conditions and 83.3% under farmers' practices. Thus, grasses were the most damaging weeds in rice-pea-rice system, even more than in rice-wheat system.

In rice-sugarcane-ratoon-wheat/fallow system, grasses were checked. Here in number, sedges were dominant (Fig. 2) and in unweeded plots they contributed more than 85% at 28 DAT and 50.1% at 56 DAT, whereas under farmers' practices, its relative density was 67.7% at 56 DAT. Next in number were non-grasses and grasses were few. In terms of biomass, under unweeded conditions, non-grasses

Table 3. Density of non-grasses (No. m^{-2}) in unweeded rice plots

Species	Rice-wheat		Rice-pea-rice		Rice-sugarcane	
	28 DAT	56 DAT	28 DAT	56 DAT	28 DAT	56 DAT
Eclipta alba	4.2	2.9	0.4	1.1	0	0
Commelina benghalensis	2.9	4.0	1.3	1.1	4.0	1.0
Alternanthera sessilis	0.4	0	16.1	41.1	0	0
Parthenium hysterophorus	1.1	0	0	0	3.8	0.5
Cyanotis axillaris	0	0	0	2.5	3.6	0

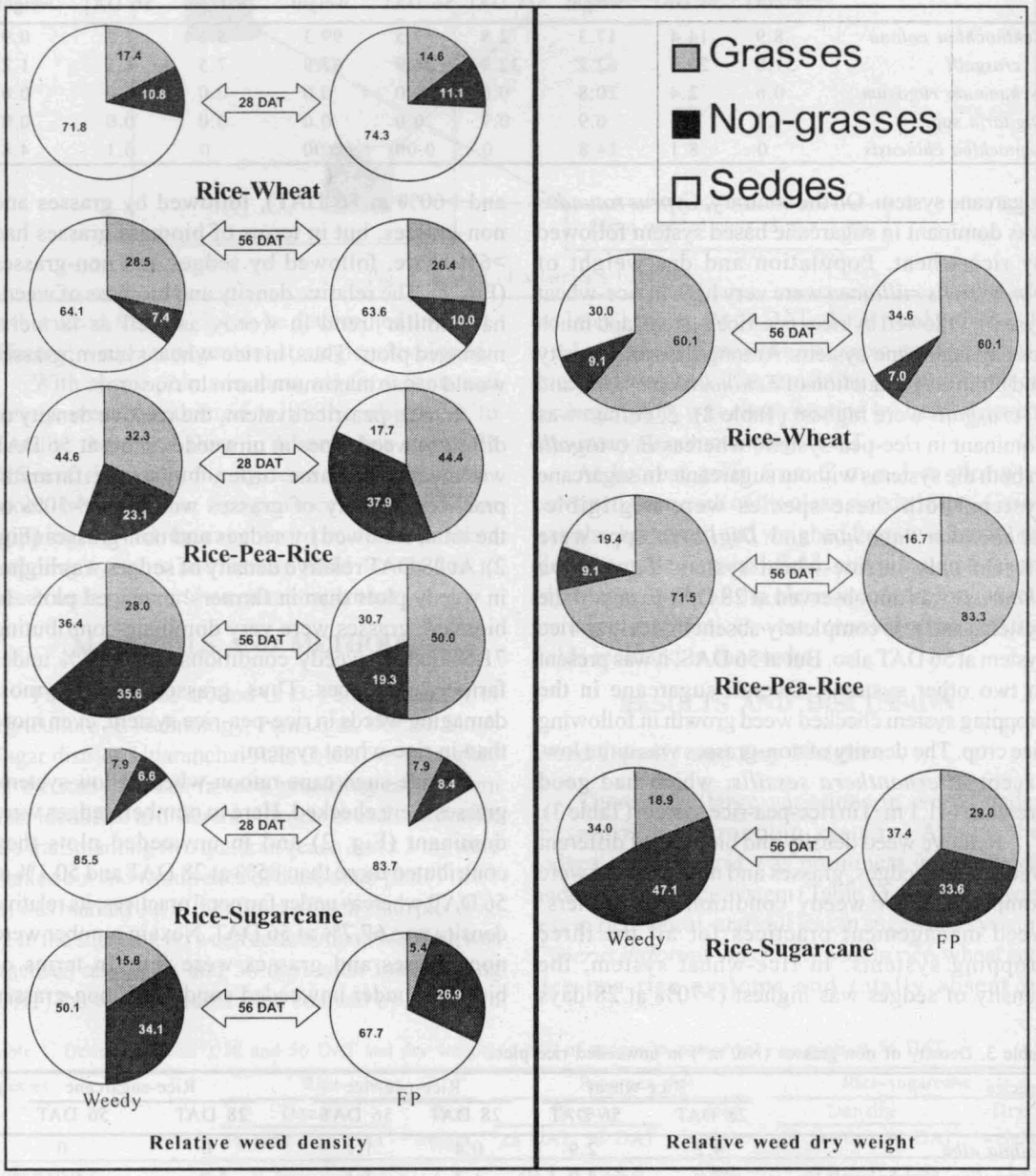

Fig. 2. Relative weed density and relative weed dry weight at 28 at 56 DAT.

Table 4. Weed management cost in rice under different cropping systems

Rice-wheat				
Butachlor :	1.0 kg a. i. ha^{-1} fb weeding (1-2)			23.5%
Cost (Rs. ha^{-1})	373+	(i) 1406=2143		
		(ii) 850=1587		
Weeding only	(i) 21-29 DAT	(ii) 50-60 DAT		76.5%
Cost (Rs. ha^{-1})	1827	825		
Rice-pea-rice				
Butachlor 0.75-1.0 kg a. i. ha^{-1}		Rs. 345 ha^{-1}		100%
fb Weeding (1-2)	(i) 30-45 DAT	Rs. 790 ha^{-1}		60%
	(ii) 45-60 DAT	Rs. 480 ha^{-1}		40%
Rice-sugarcane system				
Butachlor 0.75 kg a. i. ha^{-1}	Rs. 450 ha^{-1}	13.3%		20%
Anilofos 0.30 kg a. i. ha^{-1}	Rs. 360 ha^{-1}	6.7%		
fb Weeding (1)	Rs. 716 ha^{-1}		Total cost Rs. 1166, 1076	
Weeding only	(i) 25-29 DAT		(ii) 53-56 DAT	
Cost (Rs. ha^{-1})	1458	66.7%	875	13.3%

contributed maximum i. e. 47.1% followed by sedges (34.0%) and grasses (18.9%). Under farmers' practices, biomass of non-grassy weeds was only 33.6%, whereas those of sedges 37.4%. Thus, under farmers' weed management practices, there was better control of non-grasses.

Weed Management Practices Adopted

In rice-wheat system butachlor at 1.0 kg ha^{-1} was used by 23.5% farmers and it was supplemented with 1-2 manual weedings where the cost of first weeding was Rs. 1406 ha^{-1} and Rs. 850 ha^{-1} for the second weeding with common cost of Rs. 737 ha^{-1} for butachlor. Majority of the farmers (76.5%) did not use herbicide and weeded the rice crop twice at 21-29 and 50-60 DAT. In this case, the cost of first weeding was Rs. 1827 ha^{-1} and of second weeding Rs. 825 ha^{-1} (Table 4).

In rice-pea-rice system, butachlor at 0.75-1.0 kg ha^{-1} was used by all the farmers out of which 60% farmers supplemented herbicide with one weeding 30-45 DAT and 40% farmers did two weedings after herbicide application where second weeding was done 45-60 DAT (Table 4). The first weeding cost was Rs. 790 ha^{-1} and Rs. 480 ha^{-1} for second weeding with common cost of Rs. 345 ha^{-1} for herbicide application.

In rice-sugarcane-ratoon-wheat/fallow system 13.3% farmers used butachlor at 0.75 kg ha^{-1} and 6.7% farmers used anilofos at 300 g ha^{-1} and cost of herbicide application was Rs. 450 and 360 ha^{-1}, respectively. In both the cases, one manual weeding was done which costed Rs. 716 ha^{-1}. The remaining 80% farmers did not use herbicides, out of these 66.7% farmers did not do manual weeding 25-29 DAT at the cost of Rs. 1458 ha^{-1} and 13.3% farmers did two weedings where the cost of second weeding was Rs. 875 ha^{-1} (Table 4).

The overall weed management cost in transplanted rice with herbicide followed by weeding/weedings ranged from Rs. 1587-2143 in rice-wheat, Rs. 875-1185 in rice-pea-rice and Rs. 1076-

Table 5. Weeding cost in different systems (Rs. ha^{-1})

System	Herbicide fb weeding	Weeding only
Rice-wheat	1587-2143	1827-2652
Rice-pea-rice	875-1185	-
Rice-sugarcane system	1076-1166	1458-1951

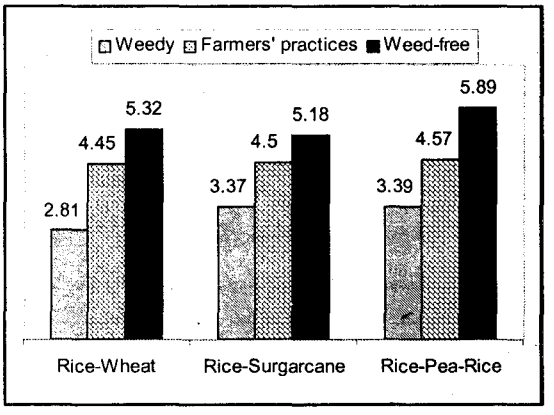

Fig. 3. Rice grain yield (t ha^{-1}) on farmers' field under different cropping systems.

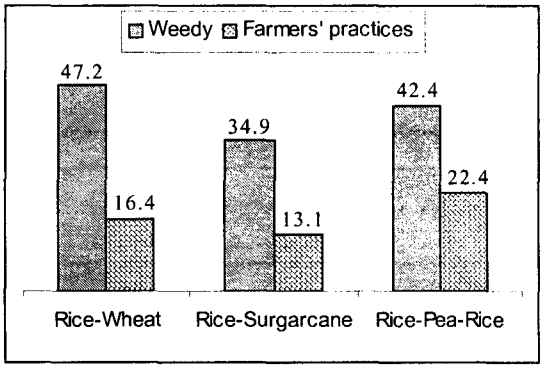

Fig. 4. Rice grain yield loss (%) on farmers' field under different cropping systems.

1166 ha^{-1} in rice-sugarcane system (Table 5) where only weeding/weedings were done. The total cost ranged from Rs. 1827-2652 ha^{-1} in rice-wheat and Rs. 1458-1851 in rice-sugarcane system.

Rice Yield

Rice yield under weed-free conditions was highest (5.89 t ha^{-1}) in rice-pea-rice sequence followed by rice-sugarcane-ratoon-wheat/fallow and rice-wheat sequences (Fig. 3). Under farmers' practices, rice yield under the three cropping systems was at par i. e. around 4.5 t ha^{-1}. In weedy check, in rice-pea-rice and rice-sugarcane system, rice yield was very close, but in rice-wheat system, rice yield in weedy check was lowest (2.81 t ha^{-1}). The yield loss caused by weeds in unweeded plots was maximum (47.2%) under rice-wheat sequence, followed by rice-pea-rice (42.4%) and rice-sugarcane (34.9%) system (Fig. 4). In farmers' management, yield losses due to weeds varied from 13.1% in rice-sugarcane-ratoon-wheat/fallow system to 22.4% in rice-pea-rice system. Thus, farmers' weed management practices need improvement and by doing so, rice yield can be raised by 16.1% in rice-wheat system and 22.4% in rice-pea-rice system. The study brings out important differences in weed flora in rice crop under different cropping systems which will have implications for weed management in rice-sugarcane system which checks weed growth more particularly the growth of grassy weeds. Rice yield can be raised by improving farmers' weed management practices.