Long-term effect of herbicides on weed diversity indices in rice-wheat cropping system

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Abstract

A long-term experiment on rice-wheat cropping system has been in operation at Department of Agronomy of CSKHPKV, Palampur from 2000 till 2018. The soil of the test site was silty clay loam in texture, acidic in reaction and low in available N, P and K. The nine treatments so tested included farmers' practice, continuous use of herbicides (butachlor + 2,4-D) with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous use of isoproturon + 2,4-D or alternate use of isoproturon and clodinafop along with 2,4-D in wheat, alternate use of butachlor with pretilachlor with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous use of isoproturon + 2,4-D or alternate use of isoproturon and clodinafop along with 2,4-D in wheat. Lower weed diversity was recorded in both the crops where herbicide application was done during both the year of study. Herbicide application greatly influenced the population of the weeds as compared to Farmer's practice. The value of Shannon winer and Simpson index was lower in chemical treated plots as compared to Farmer's practice.

Key words: Weed diversity, rice wheat cropping system, diversity index.

Rice-wheat cropping system is one of the most widely practiced cropping systems in India as well as world. It occupies an area of about 12.33 million hectares area in India of which about 10 million hectares is in the Indo-Gangetic plains. This system is covering an area of 26 million ha, spread over the Indo-Gangetic Plains (IGP) in South Asia (about 12.37 million ha) and China (Balasubramanian *et al.* 2012). Indo-Gangetic Plains (IGP) comprises the states of Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Bihar, parts of Rajasthan, Madhya Pradesh and West Bengal. Continuous adoption of rice-wheat system has led to a major problem of weed infestation. Weeds by virtue of their wider adaptability and faster growth dominate the crop habitat and reduce the crop yield. Weeds are the major constraints in increasing the productivity of rice- wheat cropping system resulting in the average losses of about 20 to 55 per cent or even greater depending on their types and intensity (Teja *et al.* 2016 and Kumar *et al.* 2013) Weeds are the most underestimated crop pests in agriculture causing maximum reduction/loss in the yields of crops as compared to other pests and diseases. In order to achieve weed control in the later stages and to maintain better field conditions not a single approach *i.e.* either use of herbicides or manual/mechanical weeding is convenient. Herbicides not only save time and money but also allow coverage of more area in short period in carrying-out timely control of weeds. The acute problems of both grassy and broad leaf weeds is becoming very common in wheat growing areas of northern India, which often results in huge yield losses and makes the weed control more complex (Singh *et al.* 2003). These indices give us the picture of occurrence and abundance of different weed species, hence present study was undertaken.

Materials and Methods

The field experiment was conducted at the Research Farm of Department of Agronomy, Forages and Grassland Management, CSKHPKV, Palampur (H.P.) India. Geographically the site of the experiment is situated at. 32°6′N latitude and 76°3′E longitude at an altitude of about 1223.7 meters above mean sea level. Temperature during the cropping period ranged between 18.56 to 31.52°C, the humidity 42.52% to 94.25% with 7.2-11.0 hours day length and a moderate to high rainfall. The soil of the experimental site was silty clay loam in texture with pH 5.6, organic carbon 0.74%, total nitrogen 339(kg/ha), available phosphorus 22 kg/ha and potassium 249 kg/ha. The nine treatments so tested included farmers' practice, continuous use of herbicides (butachlor + 2,4-D) with 100% N through in organics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous use of isoproturon + 2,4-D or alternate use of isoproturon and clodinafop along with 2,4-D in wheat, alternate use of butachlor with pretilachlor with 100% N through inorganics or 25% N substitution through fresh *Lantana* leaves in rice followed by continuous use of isoproturon + 2,4-D or alternate use of isoproturon and clodinafop along with 2,4-D in wheat. Species-wise weed count was taken at monthly interval from 50 cm × 50 cm quadrat area in each treatment. The weed count so obtained was converted into number/m^2 by multiplying the average count of the weed with factor 4.The formula to find the Index is:

Jaccard Index = (the number in both sets) / (the number in either set) * 100

The same formula in notation was: $J(X, Y) = |X \cap Y| / |X \cup Y|$

Simpson's Diversity index

Simpson Diversity index (Tena *et al.* 2012) is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the large quantity of each species.This index represents the probability that two individuals randomly selected from a sample will belong to different species.It can be measured with the following formula:

$$D = \frac{n\,(n-1)}{N\,(N-1)}$$

Where, D= Simpson's index, n= total number of organisms of a particular species, N=total number of organisms of all species, Simpson's Diversity index = 1-D

Shannon Wiener Diversity Index

This was originally developed for use in information science. It accounts for the order or abundance of a species within a sample plot. This is often used for identifying areas of high natural or human disturbance.

H = SUM [(pi) xln(pi)] E=H/Hmax.

Where, SUM = Summation pi= Number of individuals of species I /total number of samples S = Number of species or species richness Hmax. = Maximum diversity possible

Species richness

Species richness is a measure of the number of species found in a sample. Since the larger the sample, the more species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. This particular measure of species richness is known as D, the Menhinick's index.

$$D = s / \sqrt{N}$$

Where S equals the number of different species represented in your sample, and N equals the total number of individual organisms in the sample.

Results and Discussion

Weed diversity indices (rice)

Different weed indices *viz.* Shannon winer, Simpson, Similarity index and species richness have been presented in Table 1. Shannon winner index accounting for the order or abundance of a species with in a community was the lowest in 'continuous use of herbicide in rice with substitution of 25 per cent N through *Lantana* and rotational use of herbicide in wheat' during 2016 and 'continuous use of herbicide in both the crops with substitution of 25 per cent N through *Lantana* in rice' during 2017. The highest value for this index was obtained in Farmer's practice followed by continuous use of herbicide in both the crops. Simpson index of diversity have shown similar trend which was highest in Farmer's practice during both the years. This was lowest in 'continuous use of herbicide in rice and rotational use of herbicide in wheat' and 'continuous use of herbicide in both the crops with substitution of 25 per cent N through *Lantana* in rice' during 2016 and 2017, respectively. It was indicated by these indices that weed diversity was more in Farmer's practice. Species richness was highest in continuous use of herbicide in rice and rotational use of herbicide in wheat and continuous use of herbicides in both the crops with substitution of 25 per cent N through *Lantana* in rice during 2016 and 2017, respectively. Lower value of species richness was recorded in Farmer's practice which indicated that more population of weed in this treatment. Similarity index revealed that weed community under all the treatments have much in common as Farmer's practice. Diversity of weed species decreased due to different herbicide treatments were also supported by other studies. Edesi *et al.* (2012) reported that decreasing trends of Shannon's index with herbicide use as compared to conventional and organic farming. Similarly, Jones and Smith (2007) has also reported

Table 1. Effect of treatments on different diversity index in rice

Treatment		Shannon- Winer Index		Simpson's index		Specie richness		Similarity index	
Rice	**Wheat**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Farmer's practice	Farmer's practice	2.432	2.401	0.913	0.907	0.62	0.63	1.0	1.0
Butachlor 1.5 kg/ha *fb* 2, 4 DEE 1.0 kg/ha (100% Fert.)	Isoproturon 1.0 kg/ha + 2, 4- D 0.75 kg/ha	2.432	2.401	0.911	0.905	0.68	0.69	1.0	1.0
Butachlor 1.5 kg/ha *fb* 2, 4 DEE 1.0 kg/ha (100% Fert.)	Clodinafop 75 g/ha /* isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha	2.363	2.362	0.092	0.902	1.07	1.01	1.0	1.0
Butachlor 1.50 kg/ha *fb* 2,4-DEE 1.0 kg/ha (75% N Fert.+25% N through *Lantana*)	Isoproturon 1.0 kg/ha + 2, 4- D 0.75 kg/ha	2.382	2.332	0.9136	0.900	0.62	1.21	1.0	1.0
Butachlor 1.50 kg/ha *fb* 2, 4-DEE 1.0 kg/ha (75% N Fert.+25% N through *Lantana*))	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	1.591	2.383	0.908	0.904	0.62	0.85	1.0	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha* (100% Fert.)	Isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha	2.406	2.311	0.911	0.891	0.89	0.85	1.0	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha* (100% Fert.)	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	2.420	2.398	0.911	0.906	0.73	0.74	1.0	1.0
Pretilachlor 0.75 kg/ha / Butachlor 1.5 kg/ha* (75% N Fert. + 25% N *Lantana*)	Isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	2.400	2.3592	0.911	0.903	1.07	1.04	1.0	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha* (75% N Fert. + 25% N *Lantana*)	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha)	2.380	2.344	0.909	0.902	1.08	1.07	1.0	1.0

*Rotational use, *fb* followed by

Table 2. Effect of treatments on different diversity index in wheat

Treatment		Shannon- Winer Index		Simpson's index		Species richness		Similarity index	
Rice	Wheat	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Farmer's practice	Farmer's practice	2.0244	2.0856	0.8569	0.8637	0.4825	0.53	1.0	1.0
Butachlor 1.5 kg/ha *fb* 2, 4 DEE 1.0 kg/ha (100% Fert.)	Isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha	1.9489	2.0061	0.8446	0.8476	0.5614	0.68	1.0	1.0
Butachlor 1.5 kg/ha *fb* 2, 4 DEE 1.0 kg/ha (100% Fert.)	Clodinafop 75 g/ha /* isoproturon 1.0 kg/ha+ 2, 4-D 0.75kg/ha	1.9583	2.077	0.8479	0.8635	0.6727	0.72	1.0	1.0
Butachlor 1.50 kg/ha *fb* 2,4-DEE 1.0 kg/ha (75% N Fert.+25% N through *Lantana*)	Isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha	1.9114	2.0289	0.8374	0.8522	0.6512	0.74	1.0	1.0
Butachlor 1.5 kg/ha *fb* 2, 4-DEE 1.0 kg/ha (75% N Fert.+25% N through *Lantana*)	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	1.9186	2.0251	0.8389	0.8475	0.7500	0.77	1.0	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha*(100% Fert.)	Isoproturon 1.0 kg/ha + 2, 4-D 0.75 kg/ha	1.9280	1.9713	0.8404	0.8427	0.6727	0.66	0.9	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha*(100% Fert.)	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	1.9083	2.0639	0.8409	0.8494	0.7986	0.80	1.0	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha*(75% N Fert. + 25% N *Lantana*)	Isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha	1.8711	2.0635	0.8345	0.8626	0.7324	0.69	0.9	1.0
Pretilachlor 0.75 kg/ha/ Butachlor 1.5 kg/ha*(75% N Fert. + 25% N *Lantana*	Clodinafop 75 g/ha/* isoproturon 1.0 kg/ha +2, 4-D 0.75 kg/ha)	1.8596	1.9617	0.8413	0.8204	0.9705	0.90	1.0	0.9

*Rotational use, *fb* followed by

that highest species richness at untreated plots and the smallest at herbicide treated plots in a short-term trial.

Weed diversity indices (wheat)

Data on different diversity indices *viz.*shannon-winer, simpson, similarity index and species rich ness have been presented in Table 2. Shannon winner index accounting for the order or abundance of a species with in a community was the lowest in 'rotational use of herbicide in both the crops with substitution of 25 per cent N through *Lantana* in rice' as compared to Farmer's practice which have higher value of this index during both the year of study. Simpson index of diversity have shown similar trend which was highest in Farmer's practice during 2016-17 and 2017-18. This index had lowest value in 'rotational use of herbicide in rice with substitution of 25 per cent N through *Lantana* and continuous use of herbicide in wheat' during2016-17 and 'rotational use of herbicide in both the crops with substitution of 25 per cent N through *Lantana* in rice' during 2017-18. It was indicated by these indices that weed diversity was more in Farmer's practice. Species richness was highest in 'rotational use of herbicide in both the crops with substitution of 25 per cent N through *Lantana* in rice' during both the year of study. Lower value of species richness was recorded in Farmer's practice which indicated that more population in this treatment. Similarity index revealed that weed community under all the treatments have much in common as Farmer's practice. Similar results were also reported by Jones and Smith (2007) and Edesi *et al.* (2012). Pawlonka and Rymuza (2014) has confirmed significant species richness decrease after 6-years of chlorsulfuron application.

Conclusion

Herbicide application greatly influenced the population of the weeds. The value of Shannon winer and Simson index was lower in chemical treated plots as compared to Farmer's practice. Numerically lower value of diversity indexes were recorded in herbicide treated plots as compared to herbicide treated plots.

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