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Phytosociological study of weeds in major *rabi* season crops of Bundelkhand region

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Abstract
The present study was conducted to investigate weed flora diversity in crops during *rabi* season of 2019-20 at the Research and Students Instructional Farm of College of Agriculture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India. This study identified and quantified the floristic composition of weeds in three different crops. The number of monocot species recorded in the study was 4 (20%), while the number of dicot species was 16 (80%). Out of 20 weed species 17 were annual and remaining 3 were perennial. The frequency, density, abundance and their relative values were studied. The results obtained indicated that *Cyperusrotundus* and *Cynodondactylon* were the most important weed of all three crops. Importance Value Index (IVI) value of *Cyperusrotundus* in chickpea and lentil was 110.56 and 192.66, respectively while IVI value of Cynodon*dactylon* in mustard was 128.99 showing dominance of these weeds in concerned crops. Shannon diversity index was highest in chickpea (1.46) followed by mustard (1.13) and 0.54 in lentil crop. Weed flora in lentil when compared with mustard was found more dissimilar (0.882) than between lentil and chickpea. Weed species were uniformly distributed in chickpea crop than mustard and lentil as indicated by Evenness Index. Results obtained from this study would be useful in makingan efficient weed management strategy and further research towards new or improved weed control measures.

Keywords: Bundelkhand, *rabi* crops, weed diversity, weed survey

1. Introduction
There are approximately 250,000 species of plants worldwide of those about 3% or 8000 species behave as weeds. Weeds are troublesome in many ways. Primarily, they reduce crop yield by competing of water, liter, soil nutrients and space. Weeds produce the chemical substances which are toxic to crop-plants (allelopathy), animals and humans (Kumari, 2016) [4]. In India, pulses are the most important group of food grains next to cereals. These are essential for nutritional security, soil health management, sustainable agriculture and economic viability. Bundelkhand region of Uttar Pradesh used to produce pulses like Chickpea, Lentil, Pea, Pigeon pea, Blackgram and Greengram, oilseeds like Sesame, Mustard, and cereal like Rice, Wheat and Millets. Most of the crops in the region are grown under limited resource conditions. These crops are suffering a lot by heavy weed infestations. Crop weed competition is most common under limited resource conditions. Weeds compete with cultivated crops for resources such as water, nutrients and light. Weeds infestation also encourage other biotic stresses like pest and disease problems, serve as alternate host for deleterious insects and pathogens, which ultimately increases the cost of production, reduces the production and market value of crops. Out of total losses due to various biotic factors weeds are known to account for one third. The extent of crop yield losses, vary depending on the crop and associated agro-ecological factors. The weeds in cereals, pulses and oilseed crops alone cost the nation an economic loss over Rs. 50,000 crores per annum (Yaduraju *et al*, 2015) [11].
Therefore, the management of weeds is a must consideration for crop production. Other aspects, such as, phytosociology and reciprocal relations of weeds and crop needs to be studied as thoroughly as possible. It is, therefore, necessary to make a detailed survey of weeds in crop fields, their distribution, and relative occurrence in specific crops. The importance of studying the weed dynamics in a cropping system has been reported to facilitate formulation of an appropriate management strategy (Derksen *et al.*, 2002) [3]. A clear knowledge about the existence of different weed flora under different cropping systems is therefore needed to gain a better understanding in suggesting appropriate weed management strategy for farmers. The present study was carried out to study the weed flora of various crop and cropping system to create a base line data for framing management strategies.

2. Materials and Methods

The study was conducted at the Research and Students Instructional Farm of College of Agriculture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India. University is located in Bundelkhand Region of Uttar Pradesh (25.50^0 N latitude and 80.34^0 E longitude). The climate of region is typical subtropical with long dry season from late September to late June and wet season from July to September with hot desiccating winds in summer (May-June) with intensive evapotranspiration losses.

This field-based survey was carried out in February month of 2020 within the 2019-2020 cropping season. At this stage, approximately two months would have gone after weeding. This time chosen for observation because, most of the weeds were well established, most of them were in flowering or seed setting stages. Frequent visits were made to the crop fields and the specimens collected were identified with the help of available literature.

Weed species compositions in the fields were assessed by throwing 1.0 m^2 quadrate randomly in 10 different locations in each field. The structure and composition of vegetation in the agricultural fields have been compared in terms of frequency, density, abundance and their relative values were derived from the primary data (Curtis 1959) [5].

2.1 The method for calculating various phytosociological attributes studied are described as

Frequency (F) = Number of quadrates in which the species occurs /Number of quadrates studied Relative Frequency (RF) = (Frequency value for a species/Total of Frequency value for all the species)× 100

Density (D) = Total number of individuals of a species in all the quadrates/Number of quadrates studied

Relative Density (RD) = (Density value for a species/Total of Density value for all the species) × 100

Abundance (A) = Total number of individuals of a species/Number of quadrate in which the species occurs

Relative abundance (RA) = (Abundance value for a species/Total of abundance value for all the species) x 100

2.2 Importance Value Index (IVI) (Phillips 1959)

Important Value Index is valuable statistical measures for the analysis of phytosociology and plant community and it provides an overall idea of a species and its importance in the plant community. It is derived by summing up Relative Frequency, Relative Density and Relative Abundance.

Importance Value Index (IVI) = RA + RD+ RF

2.3 Species Diversity Index (Shannon-Weiner 1963) [9]

Shannon-Weiner Index (1963) is one of the widely used indices for measuring species diversity. Shannon-wiener index (H) = - S [Pi (ln Pi)]

Here Pi = (Number of individual of one weed species/Total number of all individual of weed species) × 100

2.4 Evenness index (Pielou 1977) [6]

Evenness index (E) =H /Hmax. or = H/ Log S

Here H = Shannon wiener diversity index

S = Total number of species

2.5 Species Richness: Species richness is another mode of expression of the diversity and based on the total number of species and total number of individuals in a sample or habitat.

2.6 Richness Index D = S/√N Where, 'D' is the index value 'S' total number of species 'N' total number of individuals of all species.

2.7 Similarity Index (Sorensen's Index)

Similarity index (S) = 2C/ (A+B)

Here A = Number of species in one crop, B = Number of species in another crop, C = Number of species common in both crop

2.8 Dissimilarity index

Dissimilarity index = 1- S, HereS =Similarity index

3. Results and Discussion

3.1 Composition of weed species

Twenty weed species belonging to 15 families were found in all the different crop fields. The type and number of weeds vary in the different cropsstudied. Maximum number of weed species were present in the chickpea crop (12), followed by mustard crop (10) and lentil crop (07).The floristic composition of recorded weed species was grouped into Monocotyledons and Dicotyledons. The number of monocot species recorded in the study was 4 (20%), while the number of dicot species was 16 (80%). Out of 20 weed species 17 were annual and remaining 3 *viz. Convolvulus arvensis, Cynodon dactylon and Cyperus rotundus* were perennial. Family Asteraceae, Chenopodiaceae, Poaceae, Fabaceae, Polygonaceae, Euphorbiaceae were represented by 2 specieseach; the other remaining 8 families were represented by 1 species (Table 2).

3.2 Frequency, Density and Abundance

The frequency, density and abundance of various weed species under the prevailing environmental set up presented in Table 3. In chickpea field, highest frequency (1.0) of weed population was recorded for *Cyperus rotundus*, followed by 0.9 for *Eclipta alba* and *Euphorbia hirta* while 0.7 for *Anagallis arvensis*. In Lentil *Cyperus rotundus* occurred with 1.0 frequency while *Chenopodium album, Covolvulus arvensis, Eclipta alba* and *Vicia sativa* showed frequency of 0.9. Weed *Polygonum erectum* exhibits lower frequency of 0.3only. In mustard crop,highest frequency of 0.8 was observed for *Cynodon dactylon*, while *Cyperus rotundus*had 0.6 frequency. Minimum frequency of 0.1 was associated with *Chenopodium murale*, *Argemone mexicana*, *Fumaria parviflora* and *Euphorbia hirta*. Among various weed species, 4 species were common in chickpea and lentil crop, 5 weeds were common in chickpea and mustard, while only 1 weed species was common in lentil and mustard crop. Weed species *Cyperus rotundus* was common in all three crops.

Weed species *Cyperus rotundus* showed highest density (37) which was followed by *Eclipta alba* (18) in chickpea while *Polygonum erectum and Phalaris minor showed lowest density* (0.2).In Lentil weed density value ranges between 0.6 to 108. Minimum density value of 0.6 was observed by *Polygonum erectum, while highest density value (108) was recorded by Cyperusrotundus.* Most of the weed species reflecting lower density values indicating single plant dominated community structure of the weed flora of the lentil field. In mustard field weed species *Cynodondactylon* and *Cyperusrotundus* was dominantcommunity over others. Weed density value ranges between 0.4 to 50.8, highest with *Cynodon dactylon* and lowest (0.4) with *Euphorbia hirta* and *Fumaria parviflora*.

The weeds with maximum abundance in chickpea and lentil crop was *Cyperus rotundus* with abundance value 37 and 108, respectively while in mustard crop *Cynodon dactylon* with 63.5 abundance value. In mustard, the weed *Leucas aspera* showed least abundance value of 3.67, while abundance value of other dominant weeds were25.37 (*Cyperus rotundus*), 20 (*Euphorbia dracunculoides), 18 (Sonchus oleraceous) and 12 (Argemone mexicana). Cyperus rotundus* proved dominant species in chickpea and lentil crop and *Cynodon dactylon* in mustard crop. This is likely to be as a result of difference in cultural and weed management practices.

3.3 Relative values of Frequency, Density, Abundance and Importance Value Index

Values represented in Table 4 reflectconsiderable variation among the different observed weed species. The lower relative frequency values represent less occurrence and higher frequency values represent more occurrence of weed species.In chickpea crop,highest relative frequency was noticed with *Anagallis arvensis* (15.38) and minimum (2.98) with *Polygonum erectum* and *Phalaris minor*. Maximum relativedensity (52.33), relative abundance (43.20) and IVI value 110.56 found with *Cyperus rotundus* was most dominant among the observed weed community. In Lentil, *Cyperus rotundus* also showed maximum value ofrelative frequency (18.19), relative density (88.45), relative abundance (86.02) and IVI value 192.66.Weed species *Chenopodium album* (IVI 24.20) and *Convolvulus arvensis* (IVI 18.75) also observed as important among broadleaf weeds. Yadav *et al.* (2013) observed *Chenopodium album* and *Convolvulus arvensis* as major broadleaf weed of lentil crop at Merrut of Uttar Pradesh. Weed species *Polygonum erectum* proved less important weed species with minimum IVI value (7.53). These results were similar with the findings of Sankar and Satapathi (2015).Relative frequency (27.59), relative density (62.33), relative abundance (39.08) and IVI value (128.99) of *Cynodon dactylon* was recorded in mustard crop. Thus, *Cynodon dactylon*is the dominant weed species of the concerned crop. Observations described above clearly indicate that *Cyperus rotundus* in chickpea and lentil crop, and *Cynodon dactylon* in mustard crop have been found to be most frequently distributed and important weed species. Rathod *et al*. (2017) [7] also found *Cynodon dactylon* as major weed among grasses and *Cyperus rotundus* as major sedge weed of chickpea in Karnataka.

3.4 Diversity indices

Shannon's H Index of weed flora diversity was found higher in chickpea crop (1.46) and mustard (1.13), which was recorded lower in lentil crop (0.54).Chickpea and mustard crops showed the highest diversity in the crop with Shannon index (H > 1.0). Similar pattern has also been observed in case of Shannon Evenness Index (E) and Richness Index (Table 5).The highest evenness index was found in chickpea (0.588) which means weed species were uniformly distributed in it. Whereas, the lowest was in lentil. The Evenness index is very low for the lentil crop which therefore indicates the species were clustered within their habitat and therefore not evenly spaced.

The similarity index showed the pattern of similarity between crops/ sites/ treatments. Chickpea crop show a high similarity index (0.455) of weed flora with mustard and (0.421) in lentil (Table 6). Weed flora in lentil when compared with mustard found more dissimilar (0.882) than between lentil and chickpea (Table 7). Difference in canopy structure as well as cultural practices could be the reason of this diversity, similarity and dissimilarity.

Table 1: Land use history of the different crop fields.

Particulars	Chickpea plot	Lentil plot	Mustard plot
Field Establishment year	2016-17	2016-17	2016-17
Previous crop	Sesame	Blackgram	Blackgram
Plot size (ha)	1 ha	1 ha	2 ha
Sowing of crop	1stweek of November, 2019	1st week of November, 2019	2nd week of November, 2019
Cultural practices-/herbicide used	Pendimethalin and Hand weeding	Pendimethalin and Hand weeding	Hand weeding
Time- plots were weeded before start of this study	2nd week of December, 2019	2nd week of December, 2019	1st week of December, 2019

Table 2: Floristic composition of the weed flora in the crop fields

S no	Botanical Name	Family	Group	Common Name	Life cycle
1	*Anagallisarvensis*	Primulaceae	Diocot	Blue pimpernel	Annual
2	*Argemonemexicana*	Papaveraceae	Dicot	Mexican poppy	Annual
3	*Asphodelustenuifolius*	Liliaceae	Monocot	Wild onion	Annual
4	*Chenopodium album*	Chenopodiaceae	Dicot	Lambs quarter	Annual
5	*Chenopodiummurale*	Chenopodiaceae	Dicot	Nettle leaf	Annual
6	*Convolvulus arvensis*	Convolvulaceae	Dicot	Field bind weed	Perennial
7	*Cynodondactylon*	Poaceae	Monocot	Bermuda grass	Perennial
8	*Cyperusrotundus*	Cyperaceae	Monocot	purple nut sedge	Perennial
9	*Digeraarvensis*	Amaranthaceae	Dicot	False Amaranth	Annual
10	*Eclipta alba*	Asteraceae	Dicot	False daisy	Annual
11	*Euphorbia dracunculoides*	Euphorbiaceae	Dicot	Dragon Spurge	Annual
12	*Euphorbia hirta*	Euphorbiaceae	Dicot	Snake weed	Annual
13	*Fumeriaparviflora*	Fumariaceae	Dicot	Fumatori	Annual
14	*Lathyrusaphaca*	Fabaceae	Dicot	Yellow pea/ vetching	Annual
15	*Leucasaspera*	Lamiaceae	Dicot	Lucas	Annual
16	*Phalaris minor*	Poaceae	Monocot	small canary grass	Annual
17	*Polygonumerectum*	Polygonaceae	Dicot	Erect knot weed	Annual
18	*Rumexcrispus*	Polygonaceae	Dicot	Curly Dock	Annual
19	*Sonchusoleraceous*	Asteraceae	Dicot	Common sowthistle	Annual
20	*Vicia sativa*	Fabaceae	Dicot	Common vitch	Annual

Table 3: The frequency, density and abundance of different weed species at the observation site

Weed species	Crop- Chickpea			Crop- Lentil			Crop-mustard		
	F	D	A	F	D	A	F	D	A
Anagallisarvensis	1	1.6	2.29	-	-	-	-	-	-
Argemonemexicana	-	-	-	-	-	-	0	1.2	12
Asphodelustenuifolius	0	0.5	1.67	-	-	-	-	-	-
Chenopodium album	-	-	-	1	4.6	5.1	-	-	-
Chenopodiummurale	-	-	-	-	-	-	0	0.4	4
Convolvulus arvensis	1	1.2	2	1	1.4	1.6	-	-	-
Cynodondactylon	1	3.3	6.6	-	-	-	1	51	63.5
Cyperusrotundus	1	37	37	1	108	108	1	15	25.3
Digeraarvensis	0	1	2.5	-	-	-	0	2.4	8
Eclipta alba	1	18	20.1	1	3.7	4.1	-	-	-
Euphorbia dracunculoides	1	1.4	2.8	-	-	-	0	6	20
Euphorbia hirta	1	4.4	4.89	-	-	-	0	0.4	4
Fumeriaparviflora	-	-	-	-	-	-	0	0.4	4
Lathyrusaphaca	-	-	-	1	1	1.7	-	-	-
Leucasaspera	-	-	-	-	-	-	0	1.1	3.67
Phalaris minor	0	0.2	1	-	-	-	-	-	-
Polygonumerectum	0	0.2	1	0	0.6	2	-	-	-
Rumexcrispus	1	1.8	3.6	-	-	-	-	-	-
Sonchusoleraceous	-	-	-	-	-	-	0	3.6	18
Vicia sativa	-	-	-	1	2.8	3.1	-	-	-

F=Frequency, **D**=Density, **A**=Abundance

Table 4: The relative frequency, relative density, relative abundance and IVI of different weed species at the observation site

Weed species	Crop- Chickpea				Crop- Lentil				Crop-mustard			
	RF	RD	RA	IVI	RF	RD	RA	IVI	RF	RD	RA	IVI
Anagallisarvensis	15	2.26	2.67	15	-	-	-	-	-	-	-	-
Argemonemexicana	-	-	-	-	-	-	-	-	3.45	1.47	7.38	12.31
Asphodelustenuifolius	4.5	0.71	1.95	7.1	-	-	-	-	-	-	-	-
Chenopodium album	-	-	-	-	16	3.8	4.1	24.2	-	-	-	-
Chenopodiummurale	-	-	-	-	-	-	-	-	3.45	0.49	2.46	6.4
Convolvulus arvensis	9	1.7	2.34	13	16	1.2	1.2	18.8	-	-	-	-
Cynodondactylon	7.5	4.67	7.72	20	-	-	-	-	27.59	62.33	39.08	128.99
Cyperusrotundus	15	52.3	43.3	111	18	88	86	193	20.69	18.65	15.59	54.93
Digeraarvensis	6	1.41	2.93	10	-	-	-	-	10.34	2.94	4.92	18.21
Eclipta alba	13	25.6	23.53	63	16	3	3.3	22.7	-	-	-	-
Euphorbia dracunculoides	7.5	1.98	3.28	13	-	-	-	-	3.45	0.49	2.46	6.4
Euphorbia hirta	13	6.22	5.72	25	-	-	-	-	10.34	7.36	12.31	30.01
Fumeriaparviflora	-	-	-	-	-	-	-	-	3.45	0.49	2.46	6.4
Lathyrusaphaca	-	-	-	-	11	0.8	1.3	13.1	-	-	-	-
Leucasaspera	-	-	-	-	-	-	-	-	10.34	1.35	2.26	13.95
Phalaris minor	3	0.28	1.17	4.4	-	-	-	-	-	-	-	-
Polygonumerectum	3	0.28	1.17	4.4	5.5	0.5	1.6	7.53	-	-	-	-
Rumexcrispus	7.5	2.55	4.21	14	-	-	-	-	-	-	-	-
Sonchusoleraceous	-	-	-	-	-	-	-	-	6.9	4.42	11.08	22.39
Vicia sativa	-	-	-	-	16	2.3	2.5	21.1	-	-	-	-

RF= Relative Frequency, **RD**= Relative Density, **RA**= Relative Abundance, **IVI**= Importance Value Index

Table 5: H Index, Evenness IndexandRichness Index

Crops\ Indices	Shannon Diversity Index (H)	Shannon Evenness Index (E)	Richness Index
Chickpea	1.46	0.588	0.451
Lentil	0.54	0.276	0.200
Mustard	1.13	0.491	0.350

Table 6: Similarity Index

Crops	Chickpea	Lentil	Mustard
Chickpea	-	0.421	0.455
Lentil	-	-	0.118
Mustard	-	-	-

Table 7: Dissimilarity Index

Crops	Chickpea	Lentil	Mustard
Chickpea	-	0.579	0.545
Lentil	-	-	0.882
Mustard	-	-	-

4. Conclusion

It was concluded that the land use such as cultivation practices, use of inputs, crops and cropping systems, weed management practices and other cultural practices affects the weed flora composition. The presence of some weeds in two or three crops indicates their wider adoptability while restriction of some weeds to particular crop shows their requirement for special condition in order to grow. This survey will provide a base for future weed surveys. However, extensive field studies would be necessary to quantify the abundance and diversity of weeds under various cropping systems of Bundelkhand.

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