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Weed species diversity: cropping sequences influence under mid hill conditions of Himachal Pradesh

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Abstract

An appraisal of weed species association was undertaken in a continuing experiment during *kharif*- 2021 and *rabi*- 2022 at Bhadiarkhar farm of CSKHPKV, Palampur in order to study the impact of various cropping sequences on weed diversity. Ten cropping sequence viz., C_1-maize–wheat, C_2-maize–gobhi sarson + toria, C_3-dhaincha–early cabbage–french bean, C_4-sunhemp–vegetable pea–frenchbean, C_5-maize + soybean–chickpea + linseed, C_6-rice–wheat+gram, C_7-hybrid sorghum + hybrid bajra–oats + sarson, C_8-Hybrid sorghum + hybrid bajra–ryegrass + berseem, C_9-baby corn–broccoli–French bean,C_{10}-okra-turnip–tomato were tested. In each season thirteen weed species were found predominant in the experimental field. Weed density data were collected at monthly interval and seasonal weed diversity indices were worked out. The difference in the number of species between treatments was not large. Diversity indices were highest in the low disturbance sequences, particularly those with intercropping systems. Weed species assembly showed little discrimination across treatments confirming the ability of seed banks to buffer disturbances across a variety of cropping systems. The use of diversity indices revealed part of the complexity of weed communities associated with disturbance in cropping systems which may be more meaningful to weed management.

Key words: Weeds, Cropping sequences, Diversity indices, species richness

The story of agriculture is the story of weed interference. Weeds are objectionable and interfere with the activities or welfare of humans. Weed competition reduces crop yield significantly and adds further cost to crop production owing to their management (Gharde *et al.* 2018). Yield loss due to weeds depends on several factors such as density, time of emergence, type of weed, and crop type. After millennia of weed control we still have weeds. This situation has led many growers to observe that “the weeds always win” (Kumar *et al.* 2020). One of the most important reasons weeds are so successful is their biodiversity. Biodiversity is an inevitable consequence of the struggle an individual weed species undergoes in the presence of neighbours, and by occupying a physical space in an agroecosystem. Weeds started competing with crop plants for light, water and nutrients and also act as a shelter to many detrimental pests and diseases of the crops which in turn results in significant yield reduction (Ekwealor *et al.* 2019). Weed in one of the most limiting factor in crop production which estimated to cause yield loss of 23 to 65 per cent under various cropping systems (Adeux *et al.* 2021; Saqib *et al.* 2022). Assessment of yield and economic losses due to weeds in agriculture is an important aspect to devise appropriate management strategies against them. Plant diversity exists in agro-ecosystems at various levels as a result of interactions between plant genetic resources, abiotic and biotic habitats, and management practices. As productivity is typically prioritized, the notion of diversity in modern industrial agriculture may appear irrational. Diversity may be extremely low in a single field, yet it may be higher at the landscape level due to crop rotations and intercropping for longer period of time. Most of the farming practices substantially restrict plant diversity in favour of a single crop species, to the point that plant diversity would simply not exist in the field if weeds did not exist. Despite management attempts, weeds persist in most agricultural systems, often as dominating populations of one or diverse species combinations (Shrestha *et al.* 2022). The significance of diversity in crop management is determined by the overall goals of the farming system, which may include maximizing economic production or optimizing sustainability. Studying weed diversity and dynamics is helpful to understanding the dominance or absence of a particular species in a crop/cropping system, devise means and ways to reduce their population and find out ways to delay or avoid the development of resistance by them against a herbicide along with identification of suitable crops for crop rotation and modify agronomic practices in favour of healthy crop growth (Kumar *et al.* 2023). Therefore, present study was undertaken to have an appraisal on weed diversity under diverse cropping sequences.

Materials and Methods

The study was carried out in a continuing experiment under the aegis of All India Coordinated Research Project on integrated farming system (AICRP-IFS), at Bhadiarkhar farm of the university. The site lies under mid hill sub humid agro climatic zone (Zone- IV). Ten cropping sequences grown were replicated thrice under Randomized Block Design (RBD). The cropping sequences grown were C_1-maize–wheat, C_2-maize–gobhisarson+toria, C_3-dhaincha–early cabbage–french bean, C_4-sunhemp–vegetable pea–frenchbean, C_5-maize+soybean–chickpea+linseed, C_6-rice–wheat+gram, C_7-hybrid sorghum+ hybrid bajra – oats + sarson, C_8-Hybrid sorghum + hybrid bajra–ryegrass + barseem, C_9-baby corn–broccoli–French bean, and C_{10}-okra-turnip–tomato. The crops in each cropping sequence were sown at optimum date of sowing at respective season with optimum spacing, seed rate and fertilizer in accordance with the recommended package of practices for the crops. The data on weeds were recorded at monthly interval to determine various parameters pertaining to diversity. The season-wise various weed diversity indices i.e., Shannon Index (Shannon and Weaver 1963), Simpson's index (Simpson 1949) and Similarity index (Jaccard 1908) were worked out following standard procedures.

Shannon Index(H): It is calculated as follow:

$$H = \frac{\Sigma\,(pi)}{\ln pi}$$

Where (pi) is the proportion of the total number of individuals in the population that are in species '1'.

Simpson's index (D): It was calculated as

$$D = \frac{\sum_{i=1}^{s} n(n-1)}{N\,(N-1)} \quad \text{or} \quad \sum_{i=1}^{s} (n/N)^2$$

Where, n =Total number of organisms of a particular species, N = Total number of organisms of all species, s = the number of species with this index

Simpson's index of diversity: = 1 – D= $1 - \sum_{i=1}^{s} p_i^2$

Similarity index (SI):

SI= 2C\S$_1$+S$_2$Where, C = number of species the two communities have in common, S_1 & S_2 are the total number of species found in community 1 and 2, respectively.

Results and Discussion

The weed flora associated in different crops during the *kharif* season (Table 1) and the *rabi* season (Table 2) irrespective of the cropping sequence was diverse with 13 weed species occurring in *kharif* season and 13 in *rabi* season. In the *kharif* season menace of weeds like *Alternanthera philoxeroides*, *Artemisia vulgaris*, *Ageratum conyzoides*, *Bidens pilosa*, *Commelina benghalensis*, *Galinsoga parviflora*, *Digitaria sanguinalis* was prevailed throughout the crop growth period, however, some weeds like *Cyperus* spp., *Echinochloa* spp., *Monochoria vaginalis*, *Phyllanthus niruri* were found to be occur late in the season. On an average, *Ageratum conyzoides* (24%) was the most dominant weed followed by *Cyperus* spp. (20%), *Artemisia vulgaris* (11%), *Galinsoga parviflora* (10%), *Digitaria sanguinalis* (8%), *Commelina benghalensis* (7%), *Echinochloa* spp. (6%), *Alternanthera philoxeroides* (3%), *Phyllanthus niruri* (3%), *Monochoria vaginalis* (2%), *Coronopus didymus* (2%) and *Bidens pilosa* (2%). These results are in conformity with earlier findings of Chander *et al.* (2014), Suresha *et al.* (2015), Singh *et al.* (2019).

Table 1. Major weed species present in the experimental field during *kharif* season

Scientific name	Common name	Family	Type
Ageratum conyzoides L.	Neelaphulnu	Asteraceae	Broadleaf
Ageratum houstonianum Mill.	Bill goat weed, Neelaphulnu	Asteraceae	Broadleaf
Alternanthera philoxeroides L.	Alligator weed	*Amaranthaceae*	Broadleaf
Artemisia vulgaris	Mugwort	*Asteracea*	Broadleaf
Bidens pilosa L.	Beggar-ticks and Cobbler's pegs,	*Asteraceae*	Broadleaf
Commelina benghalensis L.	Kanchara	*Commelinaceae*	Grass
Cynodon dactylon L.	Bermuda grass	*Gramineae*	Grass
Cyperus sp. L.	Nutsedge, Motha,	*Cyperaceae*	Sedge
Digitaria sanguinalis L.	Purple crab grass	*Poaceae*	Grass
Echinochloa colona L.	Jungle rice	*Poaceae*	Grass
Galinsoga parviflora Cav.	Gallant soldier and Potato weed	*Asteraceae*	Broadleaf
Ipomoea indica	Blue morning glory , blue dawn flower	*Convovulaceae*	Broadleaf
Monochoria vaginalis	Marshy betelvine,	*Pontederiacdae*	Broadleaf
Paspalum spp.L.	Caterpillar grass	*Graminae*	Grass
Phyllanthus niruri	Gale of the wind,stonebreaker	*Phyllantheceae*	Broadleaf
Polygonum alatum L.	Nepalese knotweed	*Polygonaceae*	Broadleaf
Trifolium repens L.	White clover	*Fabaceae*	Broadleaf

During the *rabi* season, *Poa annua* (25%), *spergula arvensis* (15%), *coronopus didymus* (14%), *Trifolium repens* (10%), *Vicia sativa* (9%), *Phalaris minor* (6%), *Avena fatua* (5%) and *Stelleria media* (4%) were the major weeds. The other weeds viz. *Lolium temulentum, cynodon dactylon, Anagallis arvensis, Raphanus* spp., *Trifolium repens* and as a whole constituted 12 per cent of the total weed flora.

Table 2. Major weed species present in the experimental field during *rabi* season

Scientific name	Common name	Family	Type
Ageratum conyzoides L.	Bill goat weed	*Asteraceae*	Broadleaf
Anagallis arvensis L.	Blue pimpernel, Krishna neel	*Primulaceae*	Broadleaf
Avena fatua L.	Wild oats	*Poaceae*	Grass
Bidens pilosa L.	Hairy beggar sticks	*Asteraceae*	Broadleaf
Capsella bursa-pastoris L.	Sheherd's purse	*Brassicaceae*	Grass
Coronopus didymus L.	Lesser swine-cress	*Brassicaceae*	Broadleaf
Lolium temulentum L.	Ryegrass	*Gramineae*	Grass
Phalaris minor	Gullidanda, Canary grass	*Gramineae*	Grass
Poa annua L.	Annual blue grass	*Gramineae*	Grass
Rhaphanus raphanistrum L.	Wild radish	*Brassicaceae*	Broadleaf
Rumex obtusifolius L.	Broad-leaved dock, Sorrel, wild palak	*Polygonaceae*	Broadleaf
Spergula arvensis L.	Corn spurry	*Caryophyllaceae*	Broadleaf
Stellaria media	Common chickweed	*Caryophyllaceae*	Broadleaf
Trifolium repens L.	White clover	*Fabaceae*	Broadleaf
Vicia sativa L.	Vetch, Matri	*Leguminosae*	Broadleaf

Shannon and wiener Index (H)

Shannon–Weiner diversity index (H) took into account both the number of species (species richness) and how evenly they were distributed in the cropping system. Weed diversity as estimated ranged from 1.04 in maize - wheat to 1.92 in Maize – gobhisarson + toria cropping system in *kharif* followed by 1.50 in Dhaincha – Early cabbage- French beans and 2.20 in maize – wheat cropping system in *rabi* (Table 3). In *kharif* highest value might be due to the effect of previous cropping in which intercropping reduced the weed growth and development. H was generally greater in intercropping system than in monocropping and this effect varied with crop rotation as well as growing season. Factors like soil disturbance, soil fertility, and presence of propagules in field can also affect weed invasion at larger scales. In monocropping system, weed invasion strongly depended on the number of weed species that surrounded the native plant communities (Smith and Knapp, 2001).

Simpsons index of Diversity (S)

Simpson index (S) determines habitat biodiversity of weeds in the cropping sequences. Overall diversity of the systems was 0.15 indicating higher diversity of weed in the cropping sequences. where maximum diversity was recorded in rice- wheat + gram systems (0.15) in *kharif* and Baby corn – broccoli – French beans (0.15) in *rabi* (Table 3). Microclimate prevailed during the cropping season due to mono and inter cropping systems changed the presence as well as growth of various weed species in the cropping sequences which intern affected the simpson diversity values (Lisdayanti and Nurkomar, 2022). However, in both the seasons the habitat biodiversity was noticeable and dynamic owing to various factors of crop growth.

Similarity index (SI)

The similarity index of cropping sequences varied due to season as well as cropping sequences where during *kharif* 92 per cent and 94 per cent similarity in *rabi* was recorded. Among the cropping sequences in *kharif* highest similarity index was noticed in rice-wheat-gram cropping sequence and the lowest was in maize + soybean – chick pea + linseed (Table 3). Similarly, in *rabi* cropping sequences, higher similarity was in baby corn- broccoli – french beans and lowest in dhaincha – early cabbage – french bean

Table 3. Weed diversity indices under various cropping sequences during *kharif 2020*-21 and *rabi* 2021-22

	Cropping sequence	*Kharif* 2020-21			*Rabi* 2021-22		
		Shannon and Wiener Index (H)	Simpsons index of Diversity	Similarity index	Shannon and Wiener Index (H)	Simpsons index of Diversity	Similarity index
C_1	Maize – Wheat	1.04	0.41	0.86	2.20	0.28	0.85
C_2	Maize – Gobhisarson + Toria	1.92	0.41	0.84	1.82	0.52	0.69
C_3	Dhaincha – Early Cabbage – French bean	1.69	0.52	0.73	1.50	0.71	0.54
C_4	Sunhemp – Vegetable Pea – French bean	1.09	0.52	0.72	1.65	0.52	0.69
C_5	Maize +Soybean – Chickpea + Linseed	1.31	0.52	0.71	1.93	0.28	0.85
C_6	Rice – Wheat + Gram	1.61	0.15	0.96	2.09	0.52	0.72
C_7	Hybrid Sorghum + Hybrid Bajra – Oats + Sarson	1.30	0.41	0.83	1.97	0.28	0.85
C_8	Hybrid Sorghum + Hybrid Bajra–Ryegrass + Barseem	1.30	0.41	0.80	1.72	0.41	0.77
C_9	Baby corn – Broccoli – French bean	1.21	0.41	0.91	2.08	0.15	0.92
C_{10}	Okra-Turnip–Tomato	1.64	0.41	0.80	1.82	0.41	0.77
	Overall	1.67	0.15	0.92	2.23	0.00	0.94

which is certainly related to the similarity of cultivation conditions to which all crops were subjected, as well as the physical, chemical characteristics of soil, climate, planting period and weed seed bank. This result is related to the higher distance between rows for monocropping system since a longer period is necessary to cover the soil; this represents more time for weeds to grow between the lines (Nurjanah *et al.* 2021).

Conclusion

Crops with similar diversity levels may have different weed community composition. The presence of some weed species may have more serious implications for management than that of others. Mono cropping systems had a relatively minor effect on diversity indices but a more major role in determining weed communities. These indices applied to weed communities may be valid indicators of the level of stress or disturbance imposed on a cropping sequence. Increasing the diversity of cropping systems could improve production, increase yield stability, reduce nutrient losses and reduce pest and disease incidence.

Conflict of interest: The authors declare no competing interest.

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