https://doi.org/10.56093/ijas.v90i3.101452

Research Articles

*Indian Journal of Agricultural Sciences* **90** (3): 477–82, March 2020/Article

# Phytosociological studies on weeds of wheat (*Triticum aestivum*) in the middle Indo-Gangetic plains

SANJEEV KUMAR, J S MISHRA and SHIVANI*

*ICAR-Research Complex for Eastern Region, Patna, Bihar 800 014, India*

Received: 08 May 2019; Accepted: 09 August 2019

ABSTRACT

Wheat (*Triticum aestivum* L.) is the second most important food crop of India next to rice but wheat fields are generally infested with a large number of weeds. Due to their highly competitive ability and allelopathic interference, weeds cause irreversible damage to the crop. The weed inventory surveys and phytosociological studies in wheat fields were conducted in Patna district of Bihar during 2016–18 to identify the weed flora composition, density, frequency and Importance Value Index of 30 major weed species in wheat. In this study, *Asteraceae* was found as the largest family in respect of weed species, whereas *Poaceae* and *Leguminosae* jointly occupied the second position in terms of number of weed species. Phytosociological studies further revealed that *Phalaris minor* (6.21) and *Cynodon dactylon* (5.32) have larger relative frequency among other weed species while *Chenopodium album* and *Avena fatua* have larger relative abundance in the study area. Studies on relative density of weeds revealed that densities of *Phalaris minor* (7.06) and *Chenopodium album* (5.39) were higher over other weed species and similar trends were also observed in respect of Importance Value Index of weeds. The study will be helpful in planning of weed management strategies in wheat crop in the respective area through which the losses in wheat yield could be minimized.

**Key words**: Importance Value Index, Phytosociology, Relative abundance, Relative frequency, Weed flora

Weeds are plants which compete with crop plants for essential growth factors like moisture, nutrients, space, light and exerts lot of harmful effects by releasing allele chemicals into the environment which reduce the quality (Bibi *et al.* 2008) as well as quantity of the crop (Oad *et al.* 2007). Persistence of weeds in a particular location is largely influenced by edaphic, biotic and abiotic factors which affect their occurrence, abundance, range and distribution (Tiwari *et al.* 2014). Phytosociological studies evaluate the weeds population by means of indices that identify the most significant species of an infesting community for which management practices or changes in the system should be determined in order to facilitate their control (Marques *et al.* 2011).

Wheat (*Triticum aestivum*) is a significant *rabi* crop in Patna district both in terms of acreage (68.18 thousand ha) and productivity, i.e. 3618 kg/ha. The wheat fields are infested with a large number of weeds which cause irreversible damage (Duary *et al.* 2015). Apart from the various traditional methods of weed control, wheat suffers a lot and crop-weed competition has been established as major deterrent for low crop productivity (Kumar *et al.* 2018) which results in heavy crop yield losses (28–42.8%) and also increases the harvesting cost (Singh and Singh 2004). Weeds also intensify the disease and insect pest problem by serving as alternative hosts, and uncontrolled weed growth reduced the yield by 57.6–73.2% (Tesfay *et al.* 2014). The extent of damage depends upon the nature of weeds, their density, dominance, ecological success and their association with the crop and other biotic and edaphic factors (Sinha 2017). To understand the dynamics of weeds, it is necessary to identify them because all species are not equally important in the interference imposed on the crop (Mileo *et al.* 2016). Hence, there is a need of documentation of weed species, research aiming at prevention of loss of yield due to weeds in wheat and their management by most economic and feasible method. These objectives can be achieved through a better understanding of different weeds infesting the wheat crop.

## MATERIALS AND METHODS

The present study deals with major weeds of wheat crop in Patna district of Bihar which lies between 24°20'10" N ~ 27°31'15"N (latitude) and 83°19'50"E ~ 88°17'40"N (longitude) with alluvial soil. The study is based on intensive field surveys during the peak period of weed growth in three successive cropping seasons from 2016–18. Field surveys at 100 random wheat fields of Patna district were well explored covering all the geographical areas of the district for weed survey and phytosociological studies. Frequent field surveys were conducted at each site for collection of weed

*Corresponding author e-mail: sanshivani@rediffmail.com

species at different growth stages (20 DAS and 60 DAS). The collected weed plants were pressed, dried, preserved and properly identified with the help of available literature and experts on weed at ICAR-Research Complex for Eastern Region, Patna and Bihar Agricultural University, Sabour (Bihar). Random quadrate method was adopted for weed survey and studying phytosociological attributes of weeds. Weeds from each quadrate were collected separately and identified. Later, these were checked again with the help of regional herbarium, floras, monographs and other relevant literature and consequently correct name was provided to each weed sample. Abundance, density, frequency and their relative values as well as Importance Value Index were calculated as:

$$\text{Frequency (F)} = \frac{\text{Total no. of quadrates in which the species occurs}}{\text{Total number quadrates used}} \times 100$$

$$\text{Density (D)} = \frac{\text{Total no. of individuals of species in all the quadrates}}{\text{Total number quadrates studies}} \times 100$$

$$\text{Abundance (A)} = \frac{\text{Total no. of individuals of a species in all the quadrates}}{\text{Total number of quadrates in which the species occurred}} \times 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of individuals of a species}}{\text{Total frequency of all speices}} \times 100$$

$$\text{Relative density (RD)} = \frac{\text{Density of individuals of a speices}}{\text{Total density of all speices}} \times 100$$

$$\text{Relative Abundance (RA)} = \frac{\text{Abundance of individuals of a species}}{\text{Total abundance of the species}} \times 100$$

Importance Value Index (IVI) = Relative frequency + Relative density + Relative abundance

## RESULTS AND DISCUSSION

*Dominant weed flora*: Weeds evolved as an interfering associate with our crops and compete with the main crop for soil, water, nutrients, light and labour etc. (Kumar *et al.* 2018). Weed flora is an integral part of ecosystem, nevertheless, by definition weeds are unwanted plants and are considered as nutrient competitor with economic crops that's why they face considerable threats in an agro-ecosystem (Iqbal *et al.* 2018). From the findings, it appears that the total number of individual weeds (TNI) vary with species. During survey and phytosociological studies, 44 numbers of weed species were collected from the wheat fields and categorized with their family, type and according to the life span. A total of 19 families were recognized. Among them Asteraceae family belongs to largest number of weed species while Poaceae and Leguminosae family ranked second in terms of number of weed species within the family. Most of the weeds were broad leaf weeds followed by grassy weeds which were categorized as annual weeds and occasionally as biennial and perennial weeds (Table 1).

Table 1 Characterization of weeds species collected from wheat fields in Patna district

| Weed | Family | Type | Life span |
|---|---|---|---|
| *Phalaris minor* L. | Poaceae | Grassy | Annual |
| *Anagallis arvensis* L. | Primulaceae | Grassy | Annual |
| *Oxalis corniculata* L. | Oxalidaceae | Grassy | Annual |
| *Rumex retroflexus* L. | Polygonaceae | Grassy | Annual |
| *Parthenium hysterophorus* L. | Asteraceae | Grassy | Annual |
| *Solanum nigrum* L. | Solanaceae | Grassy | Annual/ Biennial |
| *Xanthium strumarium L.* | Asteraceae | Grassy | Annual |
| *Amaranthus virdis* L. | Amaranthaceae | BLW | Annual |
| *Cirsium arvense* L. | Asteraceae | Grassy | Perennial |
| *Asphodelus tenuifolius* Cav. | Asphodeliaceae | BLW | Annual |
| *Avena fatua* L. | Poaceae | Grassy | Annual |
| *Chenopodium murale* L. | Chinopodaceae | BLW | Annual |
| *Cicharium intybus* L. | Asteraceae | BLW | Perennial |
| *Cyanodon dactylon L.* | Poaceae | Grassy | Perennial |
| *Cyperus rotundus* L. | Cyperaceae | sedge | Perennial |
| *Fumaria parviflora* L. | Papaveraceae | BLW | Annual |
| *Euphorbia hirta L.* | Euphorbiaceae | BLW | Annual |
| *Fumaria indica* (Hausskn) | Papaveraceae | BLW | Annual |
| *Lathyrus sativa* L. | Leguminosae | BLW | Annual |
| *Lepidium sativum* L. | Brassicaceae | BLW | Annual |
| *Malva parviflora* L. | Malvaceae | BLW | Annual Perennial |
| *Medicago polymorpha L.* | Leguminosae | BLW | Annual |
| *Meliolotus indica* L. | Leguminosae | BLW | Annual Biennial |
| *Medicago denticulata* L. | Leguminosae | BLW | Annual Biennial |
| *Polygonum plebejum* R. Br. | Polygonaceae | BLW | Annual |
| *Polypogon monspeliensis* (L.) Desf. | Poaceae | Grassy | Annual |
| *Vicia sativa* L. | Leguminosae | BLW | Annual |
| *Vicia hirsuta* L. | Leguminosae | BLW | Annual |
| *Spergula arvensis* L. | Spergulaceae | BLW | Annual |
| *Chenopodium album* L. | Amaranthaceae | BLW | Annual Perennial |
| *Chrozophora tinctoria* L. | Euphorbiaceae | BLW | Annual |
| *Rumex dentatus* L. | Polygonaceae | BLW | Annual Biennial |
| *Lathyrus aphaca* L. | Leguminosae | BLW | Annual |
| *Abelmoschus moschatus* Medik. | Malvaceae | BLW | Perennial |
| *Convolvulus arvensis* L. | Convolvulaceae | BLW | Annual |
| *Melilotus alba* Medik. | Leguminosae | BLW | Annual Biennial |
| *Barbarea vulgaris* L. | Brassicaceae | BLW | Biennial |

*Contd.*

Table 1 (*Concluded*)

| Weed | Family | Type | Life span |
|---|---|---|---|
| *Trifolium fragiferum* L. | Leguminosae | BLW | Perennial |
| *Physalis mimima* L. | Solanaceae | BLW | Annual |
| *Saponaria vaccaria* L. | Caryophyllaceae | BLW | Annual |
| *Sisymbrium irio* L. | Brassicaceae | BLW | Annual |
| *Croton bonplandianum* L. | Euphorbiaceae | BLW | Annual |
| *Sonchus asper* (L.) Hill. | Asteraceae | BLW | Annual Biennial |
| *Stelleria media* (L.) Vill. | Caryophyllaceae | BLW | Annual |

BLW, Broad leaf weed

*Frequency and density of weeds:* Density (D) measures the number of individuals per unit area, whereas frequency (F) is the proportion of sampling units (e.g. quadrat; field) that contains the species. Frequency reflects both of species' presence or absence and its distribution within a community (Bonham 2013). It is an easy and quick method which is considerably affected by the size and the shape of the sampling units and more dependent on quadrat size than other measures of abundance. Use of large quadrats resulted in more species having 100% frequency, whereas in small quadrats, many frequencies were zero (Roger *et al.* 2015).

The most frequent species were *Phalaris minor* (42%), *Cynodon dactylon* (36%), *Anagallis arvensis* (32%), *Chenopodium album* (32%) and *Lathyrus aphaca* (30%), whereas total number of individual species was found highest with *Phalaris minor* (55/m$^2$), *Chenopodium album* (40/m$^2$), *Parthenium hysterophorus* (38/m$^2$), *Cynodon dactylon* (38/m$^2$), and *Lathyrus aphaca* (34/m$^2$). Density of weeds ranges from 0.4–1.1 in the wheat fields of Patna district (Table 2). *Phalaris minor* (1.1), *Chenopodium album* (0.84), *Parthenium hysterophorus* (0.76), *Cynodon dactylon* (0.76) and *Lathyrus aphaca* (0.68) resulted in maximum weed density of individual weeds in the surveyed area. Therefore, these weeds can be considered as the dominant weed flora among the weed community prevailing over the wheat fields of Patna district. Singh and Singh (2004) under arid conditions of Jodhpur (Rajasthan) also found that a weedy wheat crop infested with *Chenopodium album* (51.31%) and *Chenopodium murale* (24.50%), *Melilotus indica* (6.74%) and *Fumaria parviflora* (5.45%) reduced 42.8 percent yield in comparison to a manually weeded crop (at 25 and 45 DAS).

The controlling mechanism of biodiversity in different ecosystem is mentioned by the theory of species richness which considers resource availability and disturbance as factor for structuring plant communities (Sinha 2017). Generally, species diversity is considered as an important attribute of community organization and corresponds to the number of weed species present in a particular area. It is often related to community dynamics stability, productivity, integration, evolution, structure and competition. Observations indicated that *Phalaris minor* and *Chenopodium album* were the most frequently distributed and most populated weed species in the study area. Almost the same scenario has been observed with abundance too except *Avena fatua* species, which has also shown higher degree of abundance in the surveyed plots.

*Relative abundance*: Relative abundance or degree of

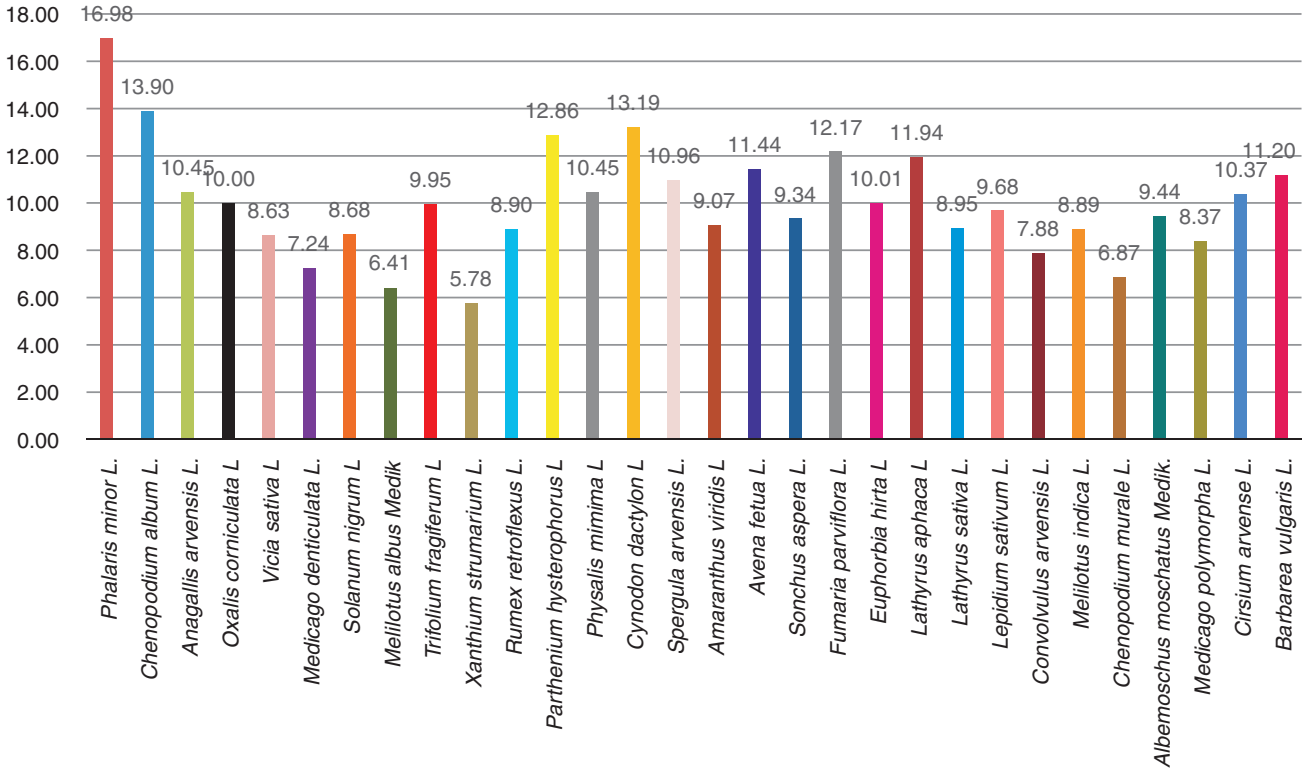


Fig 1 Importance Value Index of weeds in wheat.

dominance of individuals among different species usually refer to as evenness or equitability, and measures the extent to which species are equally represented in a community. There exists a strong correlation between structural diversity and species (Fig 2). The graph reveals that there is abundance of *Oxalis corniculata* (2.13) and *Avena fatua* (3.14) in the wheat fields of selected area whereas, relative abundance value was found higher with the *Chenopodium album* (4.94), *Avena fatua* (4.44), *Oxalis corniculata* (4.41), *Parthenium hysterophorus* (4.13) and *Trifolium fragiferum* (4.03). Most of the weed species with higher density, frequency and abundance were of grass and broad leaf family. These weeds have high fecundity producing hundreds of thousands of seeds during single growing season, reproduce through vegetative propagules and seeds, and have vegetative mimicry with crops in addition to long time seed dormancy. The findings are in conformity with that of Zimdahl (2007).

*Relative frequency*: Relative frequency is the degree of dispersion of target species in the sampling unit in relation to the number of all the species occurred. The relative frequency distribution value reflects significant level of variation among different observed weed species (Table 2). Highest relative frequency was found for *Phalaris minor* (6.21) followed by *Chenopodium album* (5.33). The relative frequency distribution of different weed species reflects lower values which can be interpreted as the relative proportion of occurrence of species to each other is very low (Ilias *et al.* 2018, Pragada *et al.* 2012).

*Relative density*: Significant level of variation in the relative density values among 30 weed species of Patna district was observed (Table 2). Relative density value was found to be the highest for *Phalaris minor* (7.06) followed by *Chenopodium album* (5.39). These two weed species clearly reflects their dominance among the other weed community in the wheat fields. High number of weeds identified in the study area could be attributed to the presence of large weed seed bank in the soil that must have been deposited from previous years. The persistent of weed species gave a severe competition to wheat crop and reduce the economic biomass, *i.e.* grain yield (Murty 2009).

*Importance value index (IVI)*: The Importance Value Index (IVI) of *Phalaris minor, Chenopodium album*, *Cynodon dactylon* L., *Parthenium hysterophorus* L. was most dominant among the observed weed community (Fig 1). The lowest IVI values represented by *Xanthium strumarium, Melilotus albus*, *Chenopodium murale*, *Medicago denticulata* reflects that these weed species rarely grow in the area and need not to be focused for its control. In Patna district *Phalaris minor* is the most dominant weed species and proper control measures should be taken to control this weed species. The IVI values ranged from 5.78–16.98 in the study area confirms the findings of Kumari (2016). Weed species with high IVI and frequency might compete better to reduce growth and yield of associated

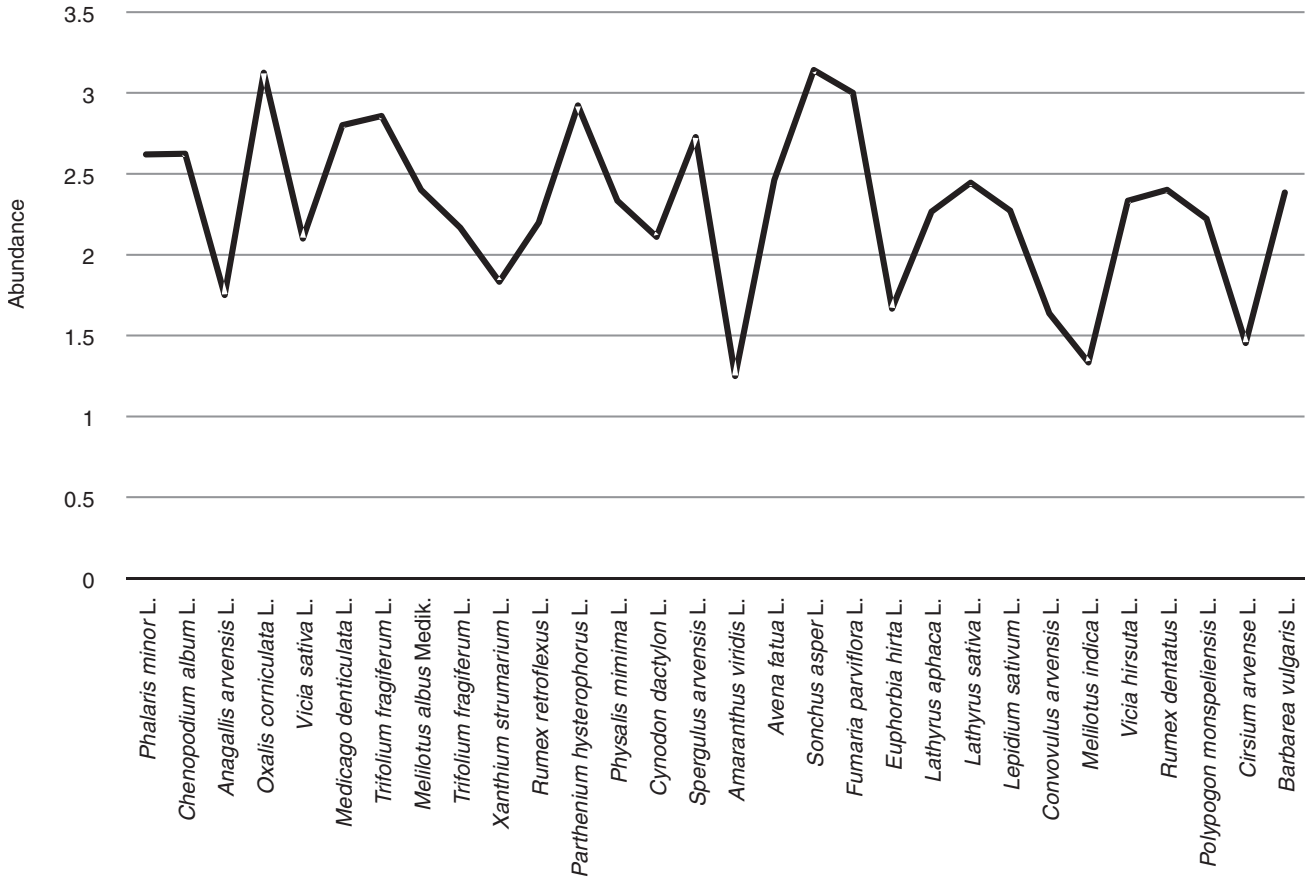


Fig 2 Variation in the abundance of weed species in wheat.

Table 2 Phytosociological attributes of weeds of wheat crop in Patna district

| Weed | TQ | TOI | TNI | F | D | A | RF | RD | RA |
|---|---|---|---|---|---|---|---|---|---|
| *Phalaris minor* L. | 50 | 21 | 55 | 42 | 1.1 | 2.62 | 6.21 | 7.07 | 3.70 |
| *Chenopodium album* L. | 50 | 12 | 42 | 32 | 0.84 | 3.50 | 3.55 | 5.40 | 4.95 |
| *Anagallis arvensis* L. | 50 | 11 | 28 | 32 | 0.56 | 2.55 | 3.25 | 3.60 | 3.60 |
| *Oxalis corniculata* L. | 50 | 8 | 25 | 16 | 0.5 | 3.13 | 2.37 | 3.21 | 4.42 |
| *Vicia sativa L* | 50 | 10 | 21 | 20 | 0.42 | 2.10 | 2.96 | 2.70 | 2.97 |
| *Medicago denticulata* L. | 50 | 5 | 14 | 10 | 0.28 | 2.80 | 1.48 | 1.80 | 3.96 |
| *Trifolium fragiferum* L. | 50 | 7 | 20 | 14 | 0.4 | 2.86 | 2.07 | 2.57 | 4.04 |
| *Melilotus albus* Medik. | 50 | 5 | 12 | 22 | 0.24 | 2.40 | 1.48 | 1.54 | 3.39 |
| *Trifolium fragiferum* L. | 50 | 12 | 26 | 24 | 0.52 | 2.17 | 3.55 | 3.34 | 3.06 |
| *Xanthium strumarium* L. | 50 | 6 | 11 | 12 | 0.22 | 1.83 | 1.78 | 1.41 | 2.59 |
| *Rumex retroflexus* L. | 50 | 10 | 22 | 20 | 0.44 | 2.20 | 2.96 | 2.83 | 3.11 |
| *Parthenium hysterophorus* L. | 50 | 13 | 38 | 26 | 0.76 | 2.92 | 3.85 | 4.88 | 4.13 |
| *Physalis mimima* L. | 50 | 12 | 28 | 24 | 0.56 | 2.33 | 3.55 | 3.60 | 3.30 |
| *Cynodon dactylon* L. | 50 | 18 | 38 | 36 | 0.76 | 2.11 | 5.33 | 4.88 | 2.98 |
| *Spergulus arvensis* L. | 50 | 11 | 30 | 22 | 0.6 | 2.73 | 3.25 | 3.86 | 3.85 |
| *Amaranthus viridis* L. | 50 | 16 | 20 | 24 | 0.4 | 1.25 | 4.73 | 2.57 | 1.77 |
| *Avena fatua* L. | 50 | 13 | 32 | 26 | 0.64 | 2.46 | 3.85 | 4.11 | 3.48 |
| *Sonchus asper* L. | 50 | 7 | 22 | 14 | 0.44 | 3.14 | 2.07 | 2.83 | 4.44 |
| *Fumaria parviflora* L. | 50 | 12 | 35 | 24 | 0.7 | 2.92 | 3.55 | 4.50 | 4.12 |
| *Euphorbia hirta* L. | 50 | 15 | 25 | 28 | 0.5 | 1.67 | 4.44 | 3.21 | 2.36 |
| *Lathyrus aphaca* L. | 50 | 14 | 34 | 30 | 0.68 | 2.43 | 4.14 | 4.37 | 3.43 |
| *Lathyrus sativa* L. | 50 | 9 | 22 | 18 | 0.44 | 2.44 | 2.66 | 2.83 | 3.45 |
| *Lepidium sativum* L. | 50 | 11 | 25 | 22 | 0.5 | 2.27 | 3.25 | 3.21 | 3.21 |
| *Convovulus arvensis* L. | 50 | 11 | 18 | 22 | 0.36 | 1.64 | 3.25 | 2.31 | 2.31 |
| *Melilotus indica* L. | 50 | 15 | 20 | 30 | 0.4 | 1.33 | 4.44 | 2.57 | 1.88 |
| *Vicia hirsuta* L. | 50 | 6 | 14 | 12 | 0.28 | 2.33 | 1.78 | 1.80 | 3.30 |
| *Rumex dentatus* L. | 50 | 10 | 24 | 20 | 0.48 | 2.40 | 2.96 | 3.08 | 3.39 |
| *Polypogon monspeliensis* L. | 50 | 9 | 20 | 18 | 0.4 | 2.22 | 2.66 | 2.57 | 3.14 |
| *Cirsium arvense* L. | 50 | 16 | 26 | 22 | 0.52 | 1.63 | 4.73 | 3.34 | 2.30 |
| *Barbarea vulgaris* L. | 50 | 13 | 31 | 16 | 0.62 | 2.38 | 3.85 | 3.98 | 3.37 |

TQ, Total no. of quadarates; TOI, Total no. of occurence of individual species; TNI, Total no. of individual species in all quadarates in which the species occur.

crop (Marwat *et al.* 2006).

The present study was conducted as a first ever attempt to explore and identify the weeds of wheat crop. From the findings it can be emphasized that major weeds should be controlled at proper time to check reduction in wheat yield. To reduce the seed production weeds must be removed before flowering either with use of herbicides/mechanically or herbicides supplemented with cultural practices (hand weeding). Weeding should be done before booting stage to avoid the gradual development of seed bank in the soil and also to minimize the competition among crop and weeds for water and nutrients. With this type of study the farmers and agriculturists of the study area will be benefitted as it will help in planning a suitable weed management strategy for control of specific weeds or complex weed flora in wheat crop. The information regarding taxonomy and phytosociological attributes of weeds in wheat fields of study area may be communicated to the concerned government and non-government organizations for planning effective weed management strategies and policy for wheat crop.

## REFERENCES

Bibi K B, Marwat Gul Hassan and Noor Maula Khan. 2008. Effect of herbicides and wheat population on control of weeds in wheat. *Pakistan Journal of Weed Science Research* **14**: 111–9.

Bonham C D. 2013. *Measurements for Terrestrial Vegetation*. Hoboken, NJ: John Wiley and Sons Ltd.,USA.

Duary B, Mukherjee A and Bhowmick M K. 2015. Phytosociological attributes of weed flora in major crops of red and lateritic belt of West Bengal. *Indian Journal of Weed Science* **47**(1): 89–92.

Ilias S Travlos, Nikolina Cheimona, Ioannis Roussis and Dimitrios

J Bilalis. 2018.Weed-species abundance and diversity indices in relation to tillage systems and fertilization. *Frontiers of Environmental Science,* April 2018 (https://doi.org/10.3389/fenvs.2018.00011).

Iqbal Muhammad, Khan Shujaul Mulk, Khan, Muhammad Azim, Ahmad Zeeshan and Ahmad Habib. 2018. A novel approach to phytosociological classification of weeds flora of anagro-ecological system through Cluster, Two Way Cluster and Indicator. *Ecological Indicators* **84**: 590–606.

Kumari Ranjana. 2016. Survey of weed flora and the ecological study on weeds adjacent to Jai Prakash University Campus, Chapra (Saran), Bihar. *American Journal of Research Communication* **4**(7): 35–45.

Kumar Sanjeev, Shivani, Mishra J S, Kumar Santosh, Kumar Ujjwal and Bharati R C. 2018. Efficacy of pre- and post- emergence herbicides on complex weed flora in direct-seeded rice (*Oryza sativa*) in the eastern plains. *Indian Journal of Agricultural Sciences* **88**(3): 387–92.

Marwat K B Z, Hussain B Gul, M Saeed and S Din. 2006. Survey on weed problems in wheat crop in district Mardan. *Pakistan Journal of Weed Science Research* **12**(4): 353–8.

Marques L J P, Silva M R M, Lopes G S, Correa M J P, Araiyo M S, Costa E A and Muniz F H. 2011. Phytosociology of weeds in cowpea and cassava crops under the slash- and - burn with plow. *Planta Daninha* **29**: 981–89.

Mileo L J, Silva J F, Albertino S M F, Lette B N Menezes D S and Santos A F. 2016. Phytosociology of weeds in cultivation of two varieties of cassava. *Planta Daninha* **34**(2): 387–96.

Murty P P. 2009. Studies on weed flora of crop fields of North Coastal Andhra Pradesh, India. Ph D thesis, Andhra University, Visakhapatnam, Andhra Pradesh.

Oad F C, Siddiqui M H and Buriro U A. 2007. Growth and yield losses in wheat due to different weed densities. *Asian Journal of Plant Sciences* **6**: 173-6.

Pragada P M and Venkaiah M. 2012. Phytosociological attributes of weed flora in major crops of north coastal Andhra Pradesh, India. *Pakistan Journal of Weed Science* **18**(1): 107–26.

Roger Nkoa, Micheal D K Owen and Clarence J Swanton. 2015. Weed abundance, distribution, diversity, and community analyses. *Weed Science* **63** Special Issue: 64–90.

Sinha M K. 2017. Studies on weed diversity and its associated phytosociology under direct dry seeded rice systems in Koria District (C.G.) India. *Advances in Plants and Agriculture Research* **7**(2): 246–52.

Singh R and Singh B. 2004. Effect of irrigation time and weed management practices on weeds and wheat yield. *Indian Journal of Weed Science* **36**: 25–27.

Tiwari Anushree, Sahu Pankaj K, Shrivastava Atul K and Thomas Moni. 2014. Plant diversity and distribution of weeds in winter season crops of agro-ecosystems in Bilaspur district, Chhattisgarh.*Journal of Biodiversity and Environmental Sciences* **5**(2): 251–59.

Tesfay Amare, Sharma J J and Kassahun Zewdie. 2014. Effect of weed control methods on weeds and wheat (*Triticum aestivum* L.) yield. *World Journal of Agricultural Research* **2**: 124–8.

Zimdahl R L. 2007. *Fundamentals of Weed Science*. 3rd edn. Academic Press, USA: pp 1–689.