Research Article

Biodiversity Assessment of Weed Communities in Tube-Well Irrigated Wheat Fields in District Layyah, Punjab, Pakistan

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Abstract |Wheat (*Triticum aestivum* L.) is a most imperative cereal and used staple food due to its source of indispensable nutrients such as proteins, vitamins, and minerals. Weeds compete with wheat plants for essential resources (nutrients, light, space, and gases) and ultimately reduce yield. The current study was conducted during 2021 – 2022 in the wheat fields of three tehsils of district Layyah to investigate the weed biodiversity. Weeds biodiversity data was recorded by a random quadrate sampling method using the quadrate of 5 m^2. Phyto-sociological attributes such as density, frequency, cover, relative density, relative frequency, relative cover, and importance values index were measured for each field. The importance value index and Simpson's biodiversity index were also calculated. Weeds community in the study areas encompasses 18 weed species with 17 Genera and 11 families. The dominant families of weed flora were *Poaceae* (22.22%), *Fabaceae* (16.66%), *Ammaranthaceae* (11.11%), and *Brassicaceae* (11.11%). The dominant weed species in study area were *Anagallis arvensis* (78.63%), *Phalaris minor* (6.7%), *Melilotus indica* (4.22%), *Avena futua* (3.5%), *Chenopodium album* (1.51%), *Sisymbrium irio* (1.05%), *Medicago denticulata* (0.70%), *Sonchus asper* (0.54%), *Rumex dentatus* (0.44%), *Cronopus didymus* (0.33%) and *Fumaria indica* (0.31%). Therefore, it is concluded that this study aims to helpful the distribution patterns and importance of different weed species in district Layyah and providing valuable insights for targeted weed management in wheat cultivation.

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Introduction

Wheat is a widely cultivated cereal grain and one of the most important staple foods worldwide. It is a rich source of carbohydrates, dietary fiber, and essential nutrients such as proteins, vitamins, and minerals (Baniwal *et al.*, 2021). Wheat-based products like bread, pasta, and breakfast cereals are consumed by millions of people worldwide, providing energy and nourishment. Wheat belongs to the family Poaceae, which includes other important crops like rice, maize, barley, and oats. Wheat is primarily grown in temperate regions, but it can also be cultivated at higher altitudes in tropical areas during the

winter season. Wheat holds the top position among cereals in terms of both cultivation area (219.42 million hectares) and production (758.38 million metric tons) (USDA, 2018). Pakistan is an agricultural country, and wheat is one of the major cereal crops that significantly contributes to the country's economy it was cultivated in an area of 9.593 Mha and the yield was about 27.10 million tons in season 2020-21 (GoP, 2021).

Wheat production is hindered by various factors, both biotic and abiotic, among which weed infestation stands out as one of the most damaging. Weed interference can cause significant yield losses in wheat, ranging from 20% to 60%, depending on the specific environmental conditions and the extent of weed infestation. Weeds, defined as unwanted plants growing in cultivated crops, pose a significant threat to wheat production as they compete with the main crop for essential resources such as nutrients, water, space, gases, and light (Marwat *et al*., 2013; Hassan *et al*., 2023). They have extensive root systems and canopy structures that enable them to outcompete wheat for these resources, leading to reduced growth and yield of the crop. Some weed species release chemical compounds into the soil through their root exudates (Hassan *et al*., 2023), which can inhibit the growth of nearby plants, including wheat. This allelopathic effect further hampers wheat productivity and can result in yield losses. Weeds can serve as hosts for pests and diseases that can directly or indirectly affect wheat. They provide shelter and resources for insect pests and can act as reservoirs for various plant pathogens, which can spread to nearby wheat plants, leading to yield reduction (Kumar *et al*., 2021; Hassan *et al*., 2022).

The detrimental impact of weeds on wheat production in Pakistan has been well-documented. It has been estimated that weeds cause an annual loss of 28 billion PKR to the wheat crop alone and an overall loss of 130 billion PKR to the agricultural sector of Pakistan (Hassan *et al*., 2023). These losses are not unique to Pakistan, as other countries such as Australia and the United States have also reported significant economic losses due to weed infestation in their crops (Adkin and Navie, 2006). Weeds can be found in almost every corner of agricultural land, leaving no space untouched. They can belong to various plant families, including grassy monocots from the Poaceae family, sedges from the Cyperaceae family, and dicots from angiosperm families such as Fabaceae, Brassicaceae, and Convolvulaceae (Sosa *et al*., 2016). The manifestation of weeds not only decreases crop production but also contributes to an increased susceptibility to insect attacks, which can become more severe over time. Additionally, weed infestation can lead to poor-quality produce and pose challenges in water management (Matloob *et al*., 2015).

The presence of different weed species in wheat-growing regions, as reported by researchers in the country indicates the diversity and potential impact of weeds on crop yield (Tauseef *et al*., 2012; Kakhki *et al*., 2013; Khan *et al*., 2016; Fazal *et al*., 2019). Among the frequently occurring and densely populated weeds mentioned, *Phalaris minor*, *Medicago sp*., *Avena fatua*, *Cronopus didymus*, and *Chenopodium album* are particularly problematic. These weeds are known for their aggressive growth, fast reproduction, and ability to adapt to various environmental conditions. Their high population densities and competitive nature make them more detrimental to wheat crops (Qureshi and Bhatti, 2001).

To mitigate the negative impact of weeds on wheat yield, farmers employ various weed control strategies and practices. These include cultural practices (crop rotation, proper tillage, and seedbed preparation), chemical methods (herbicide application), and biological approaches (using natural enemies of weeds and allelopathy). Integrated weed management strategies that combine multiple control methods are often recommended to effectively manage weed populations and minimize yield losses in wheat crops with ensuring sustainable crop production (Buhler, 2002).

Weed infestation is considered a major ecological problem that poses a serious threat to crop production. Different regions and crops are affected differently, with weed dominance and impact varying based on factors such as weed species, environmental conditions, and agricultural practices. Weed management strategies tailored to specific regions and crops are necessary to mitigate their negative effects and improve agricultural productivity (Maclaren *et al*., 2020). Considering the significance of weed control, it is crucial to investigate the distribution patterns and importance of different weed species in wheat crops in various regions. This understanding will facilitate the development of effective weed management strategies. However, no study has been conducted thus far

on determining the distribution patterns of weeds in wheat crops specifically in Layyah district. Therefore, this study aims to fill this research gap by examining the distribution patterns and importance of different weed species in selected sites of three tehsils of district Layyah, providing valuable for further research endeavors in the research area and in adopting control measures of various weeds to enhance wheat yield.

Materials and Methods

Study area

The current survey was conducted during 2021 – 2022 in the wheat fields of three tehsils (tehsil Karor at basti sargani, Layyah at chak no. 150, and Choubara at bas ti sahoo wala) of district Layyah to investigate the weed biodiversity which were irrigated only by tube-wells water. Layyah is located 145 meters above sea level, between 30.85 North latitude and 71.09 East longitude, in the Southern-West of the Punjab province of Pakistan (Figure 1). It features a desert area with a temperature of 45-106 °F and expands 629100 hectares with three tehsils. The cultivated area is approximately 491000 hectares. Weed communities are grown with the cultivation of wheat in November-December.

From each site, three replicates were used to determine the numbers and varieties of weeds by a random quadrate method using the quadrate of 5 m^2. All the weed species were recorded and counted. The weeds were collected twice a time from selected areas, and species were identified with the help of authentic available literature (Nasir and Ali, 1972; Ali and Qaiser, 2004). and also verified from the herbarium sheets of the Botany Department of Islamia University of Bahawalpur.

Soil samples were taken from each sampled field at a depth of 20 cm and water samples were taken from the sources that were used for irrigation the soil. These samples were observed and analyzed for their physical and chemical properties in the laboratory.(Table 1)

Table 1: *Soil analysis of three selected sites.*

Soil samples	Site name	EC (cm)	Soil pH	Organic matter (%)	Phosphorus Ppm	Soil texture
1	Karor	85	8.2	48	10	Sandy loam
2	Layyah	78	8.1	62	7	Sandy loam
3	Choubara	79	8.1	52	7	Sandy loam

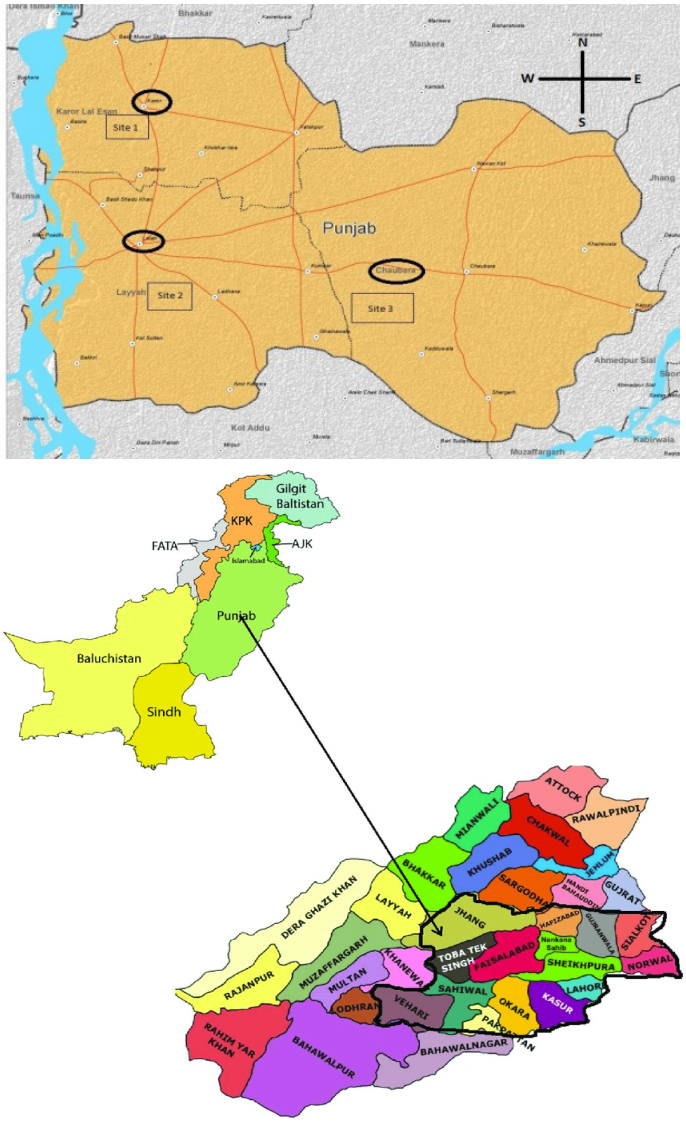

Figure 1: *Site 1 (Karor), site 2 (Layyah), and site 3 (Choubara). Map of Layyah showing the sited of study in district Layyah showing three sites of study in three tehsils (Karor, Layyah, and Choubara).*

Phytodiversity data

The data was collected by quadrate sampling method from each site. Phytosociological attributes such as density, frequency, cover, relative density, relative frequency, relative cover, and importance values index were measured for each field (Oosting, 1956; Ambasht, 1990).

Density

Density represents the no. of individuals in a unit area. The density was calculated by this formula;

$$Density = \frac{Total\ no\ of\ individuals\ of\ Species}{Total\ area\ (all\ quadrates)}$$

Relative density

The density of one species as a percent of the total

Table 2: *Water analysis of three selected sites.*

Water samples	Site name	E.C cm	Ca+Mg (meq/l)	Na (meq/l)	CO_3 (meq/l)	HCO_3 (meq/l)	SAR	RSC
1	Karor	1050	5.33	5.17	0.44	5.30	3.10	0.41
2	Layyah	700	4.60	2.40	0.57	3.75	1.50	Nil
3	Choubara	3620	14.94	21.26	0.67	4.70	7.70	Nil

density of all species was calculated by the following formula;

$$Relative\ density = \frac{Density\ of\ species}{Total\ density\ of\ all\ species} \times 100$$

Frequency

Frequency represents the presence or absence of species and it was calculated by this formula;

$$Frequency = \frac{No\ of\ quadrate\ where\ species\ occ}{Total\ no\ of\ Quadrates}$$

Relative frequency

The frequency of single species as a percent of the frequency of total species was calculated by this formula;

$$Relative\ frequency = \frac{Frequency\ of\ species}{Total\ frequency\ of\ all\ species} \times 100$$

Cover

Percentage of an area that is covered by a species. The cover of each species was calculated by this formula;

$$Cover = \frac{Total\ area\ covered\ by\ a\ specie}{Total\ area\ sampled}$$

Relative cover

The cover of one species as a percent of the cover of all species and was calculated by the following formula;

$$Relative\ cover = \frac{Cover\ of\ species}{Total\ area\ sampled\ (total\ cover)} \times 100$$

Importance Value Index

The importance value index can be calculated by the sum of the relative density, relative frequency, and relative cover of a species.

Importance Value Index = Relative density+ Relative density+ Relative cover

Simpson Diversity Index

While the Simpson Diversity Index was calculated according to the following formula;

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

Statistical Analysis

Data of all weed species was arranged and then applied to statistical analysis by using Microsoft Excel software 2010.

Results and Discussion

Weed species that were recorded during the present study during a single season survey of wheat fields were *C. arvensis, R. dentatus, P. minor, M. indica, C. album, C. murale, L. aphaca, S. conoidea, A. arvensis, A. futua, M. denticulata, S. irio, F. indica, A. tenuifolius, H. vulgare, C. didymus, S. viridis and S. asper. The most frequent species were R. denticulata, M. indica, A. arvensis* and *A. futua*. The same results of phytodiversity of weeds were reported by Malik *et al.* (2012), who studied the presence of *A. arvensis, C. album, C. arvensis, C. didymus, Medicago sp., P. minor, Melilotus sp., Rumex sp., F. indica, A. tenuifolius* and *S. irio* in the wheat fields of Punjab. The most prominent weeds studied by Kaya and Zengin *et al.* (2000) and Khan *et al.* (2004). Danijela and Zoran (2004) reported most prevalent weed was *C. arvensis*. A similar study was conducted by Waheed *et al.* (2009) on the wheat fields of the Rahim Yar Khan district except for a few weed species. Hussain (1983) reported that weeds with high density exert more allelopathic and competitive effects on the crop plants that ultimately reduced the growth rate and production. *P. minor* and A. futua were recorded from most parts of Pakistan (Qureshi and Bhatti, 2001; Hassan and Marwat, 2001); Marwat *et al.*, 2006; Ullah *et al.*, 2011). Qureshi *et al.* (2014) reported the same weeds such as *A. futua*, *A. arvensis, P. minor, A. tenuifolius, C. album, Meliloyus sp., F. indica, Medicago sp.*, and *C. arvensis* in Khanpur Dam.

Weed species density plays a significant role in crop

plant growth and production when weed density is more than one meter square then there will be a noticeable effect on the crops. The competition of weeds with main food crops is the major reason for a decrease in crop production, so it is important to control the weed infestation from the crops. Most crops are infested with weeds during irrigation and with the addition of nutrients to crops. Because of these factors cause the rapid growth of weeds. Based on data that was taken during a study of fields of wheat crops, it is suggested to remove all types of weeds within one to two months after sowing the wheat (Pragada and Venkaiah, 2012).

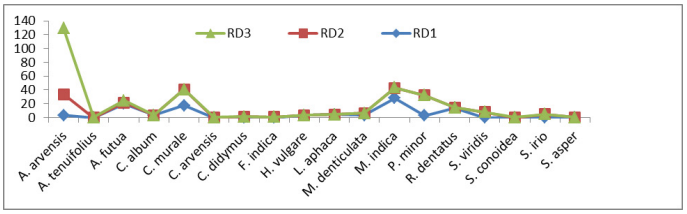

Figure 2: *Relative density of weeds in wheat fields of three sites. RD1= Relative density of site 1, RD2= Relative density of site 2, and RD3= Relative density of site 3.*

The value of the relative density of plant weed species showed variations, the highest value of the relative density of *A. futua, C. album, M. denticulata, M. indica*, and *R. dentatus* was recorded in site 1. While *H. vulgare* and *L. aphaca* were only observed at site 1 the relative density of S. asper was equal at site 2 and site 3. At site 2, the highest value of relative density was observed in *C. murale* and *P. minor* and *C. didymus, S. viridis*, and *S. irio* were only present at site 2. A. arvensis and F. indica relative density were highest at site 3. *A. tenuifolius, C. arvensis*, and *S. conidia* were calculated only at site 3 (Figure 2). The same results were recorded by Hussain *et al.* (2012) in various districts of Punjab, they reported that F. indica in all fields of Chakwal district with *C. arvensis, M. denticulata, A. arvensis*. In Jehlum, the most abundant species were *M. denticulta, A. arvensis, F. indica* and *C. album*. In Rawalpindi 19 dominant weed species were *C. album, Anagallis arvensis, F. indica, A. futua, M. denticulata, R. dentata*, and *P. minor*.

The highest value of the relative frequency of C. murale, M. indica, and R. dentatus was recorded at site 1. While *H. vulgare* and *L. aphaca* were only observed at site 1. At site 2, the highest value of the relative frequency was detected in *M. dentatus while, C. didymus, S. viridis*, and *S. irio* were only present at site 2. *A. arvensis, A. futua, C. album, F. indica*, and *S. asper* relative frequency was highest at site 3. *A. tenuifolius, C. arvensis*, and *S. conidia* were recorded only at site 3 (Figure 3). The highest value of the relative cover of C. album was recorded at site 1. While *H. vulgare* and *L. aphaca* were only observed at site 1. At site 2, the highest value of the relative cover was detected in *C. murale, M. dentatus. M. indica, P.minor, R. dentatus*, and *S. asper* while, *C.didymus, S. viridis*, and *S. irio* were only present at site 2. *A. arvensis, A. futua,* and *F. indica* relative cover was highest at site 3. *A. tenuifolius, C. arvensis*, and *S. conidia* were recorded only at site 3 (Figure 4). The highest value of the importance value index of *A. futua, C. murale, M. denticulata, M. indica*, and *R. dentatus* was recognized in site 1. While H. vulgare and L.aphaca were only observed at site 1. At site 2, the highest value of the importance value index was detected in *P. minor* and *S. asper* while, C. didymus, *S. viridis*, and *S. irio* were only present at site 2. *A. arvensis, C. album,* and *F. indica* importance value index were highest at site 3. *A. tenuifolius, C. arvensis*, and *S. conidia* were recorded only at site 3 (Figure 5). Gupta *et al.* (2008) recorded *A. arvensis* and *C. album* as the most abundant weed species that actively compete with wheat crops for light, space, and moisture. At site 1, The highest value of the Simpson's biodiversity index was recorded and the lowest value of the Simpson's biodiversity index was observed at site 3 (Figure 6).

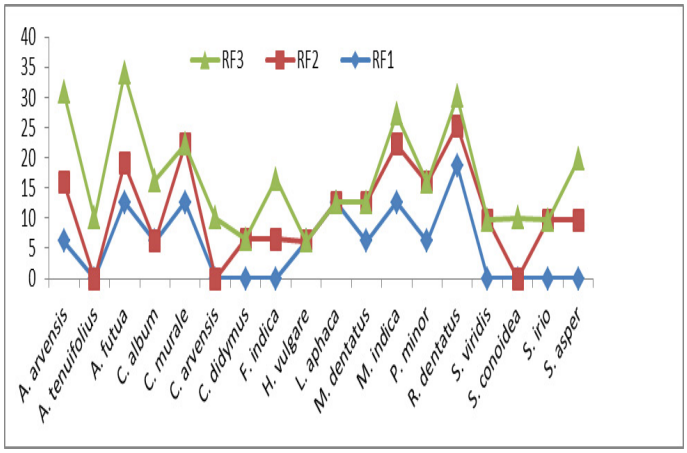

Figure 3: *Relative frequency of weeds in wheat fields of three sites. RF1=Relative frequency of site 1, RF2= Relative frequency of site 2, and RF3= Relative frequency of site 3.*

The weed community in the study areas comprises 18 weed species with 17 Genera and 11 families. The dominant families of weed flora were Poaceae (22.22%), Fabaceae (16.66%), Ammaranthaceae

Table 3: *Biodiversity of weed species in wheat fields of three sites.*

No.	Weed species in wheat	Family	Common name	Group
1	*Anagallis arvensis* L.	Primulaceae	Blue boti	Dicot
2	Asphodelus tenuifolius L.	Asphodelaceae	Pyazi, Bhokal	Monocot
3	Avena futua L.	Poaceae	Jungli jai, Wild oat	Monocot
4	*Chenopodium album* L.	Amaranthaceae	Bathu, White goosefoot	Dicot
5	Chenopodium murale L.	Amaranthaceae	Karund, Nettle-leaf goosefoot	Dicot
6	Convolvulus arvensis L.	Convolvulaceae	Lehli, Field bindweed	Dicot
7	Coronopis didymus L.	Brassicaceae	Jungli halon	Dicot
8	Fumaria indica H.	Fumariaceae	Pitpapra, Shahtra	Dicot
9	Hordeum vulgare L.	Poaceae	Jao	Monocot
10	Lathyrus aphaca L.	Fabaceae	Jungli matter, Yellow pea	Dicot
11	Medicago denticulata L.	Leguminoseae	Toothed bur clover	Dicot
12	Melilotus indica L.	Fabaceae	Senji	Dicot
13	*Phalaris minor* Retz.	Poaceae	Dumbi sittee	Monocot
14	Rumex dentatus L.	Polygonaceae	Jugli palak. Toothed dock	Dicot
15	Setaria viridis L.	Poaceae	Green foxtail	Monocot
16	Silene conoidea L.	Caryophyllaceae	Sand catchfly	Dicot
17	Sisymbrium irio L.	Brassicaceae	London rocket	Dicot
18	Sonchus asper L.	Asteraceae	Dodhak	Dicot

(11.11%), and Brassicaceae (11.11%). The dominant weed species in the study area were *Anagallis arvensis* (78.63%), *Phalaris minor* (6.7%), *Melilotus indica* (4.22%), *Avena futua* (3.5%), *Chenopodium album* (1.51%), *Sisymbrium irio* (1.05%), *Medicago denticulata* (0.70%), *Sonchus asper* (0.54%), *Rumex dentatus* (0.44%), *Cronopus didymus* (0.33%) and *Fumaria indica* (0.31%). Analogous results were collected from the Khanewal district by Usman *et al.* (2020) reported that the monocot family was dominant in the weeds of wheat fields. Our results are also in line with Sher *et al.* (2011), who recorded that Poaceae was a dominant family in the southern part of District Swabi, Pakistan. Durga and Misra (2014) reported that grass species under coconut trees were limited due to low light intensity while non-grassy sciophyte weeds were common. The same results were seen in the present research only 4 species of monocots such as Avena futua, Hordeum vulgare, *Setaria viridis*, and *Phalaris minor* were present in the present study of wheat fields of district Layyah. Noxious weed dominancy is related to certain specific features such as deep root system, various modes of propagation, and twining nature (as in Convolvulus arvensis). These adaptable morphological characteristics enable the weeds to utilize the maximum available resources (Waheed *et al.*, 2009). Certain weeds like Convolvulus arvensis and Lathyrus aphaca due to climbing nature cause problems in harvesting and threshing. These same weed species have been also reported from the different fields of Pakistan by Ayaz *et al.* (1995); Qureshi and Bhatti (2001); Hussain *et al.* (2003); Cheema *et al.*(2005); Akhtar *et al.* (2007); Waheed *et al.* (2009).

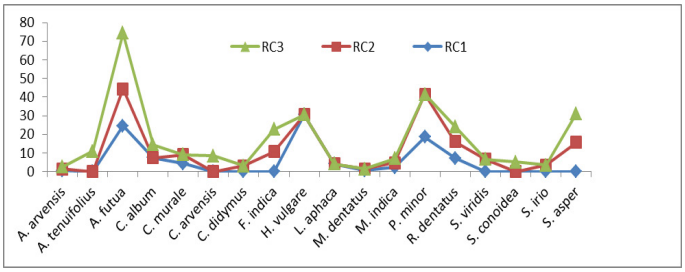

Figure 4: *Relative cover of weeds in wheat fields of three sites. RC1= Relative cover of site 1, RC2= Relative cover of site 2, and RC3= Relative cover of site 3.*

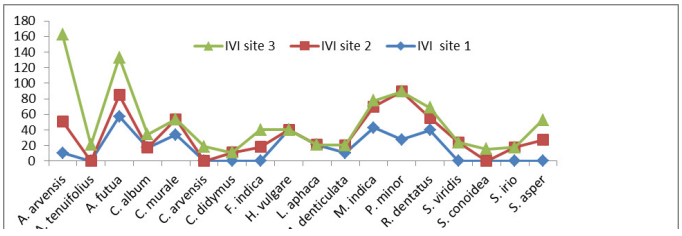

Figure 5: *Importance value index of weeds in wheat fields of three sites. IVI1= Importance value index of site 1, IVI2= Importance value index of site 2, and IVI3= Importance value index of site 3.*

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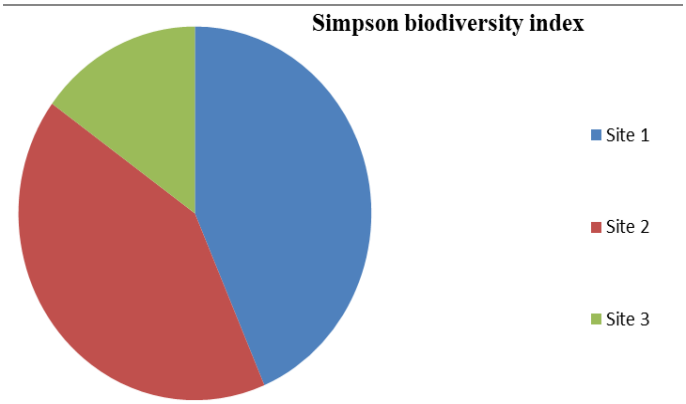

Figure 6: *Simpson biodiversity index of weeds in wheat fields of three sites.*

Conclusions and Recommendations

Weeds are a major threat to crop plants. It was concluded that weed species with high frequency were found to compete better to reduce the growth and yield of the wheat crop. This research presents a relevant report of weed flora flourishing in the wheat fields of Layyah. Thus, the narratives of the existing exploration would be valuable in forging a considerable weed management plan as well as in making an insightful discernment in selecting herbicides. This comprehensive analysis supports the potential of integrated management to mitigating weeds negative impacts and improving wheat production, emphasizing the need for sustainable practices to ensure food security. It is recommended that weed infestation be addressed by all concerned quarters to control weeds through the use of appropriate measures that would prominently increase wheat yield.

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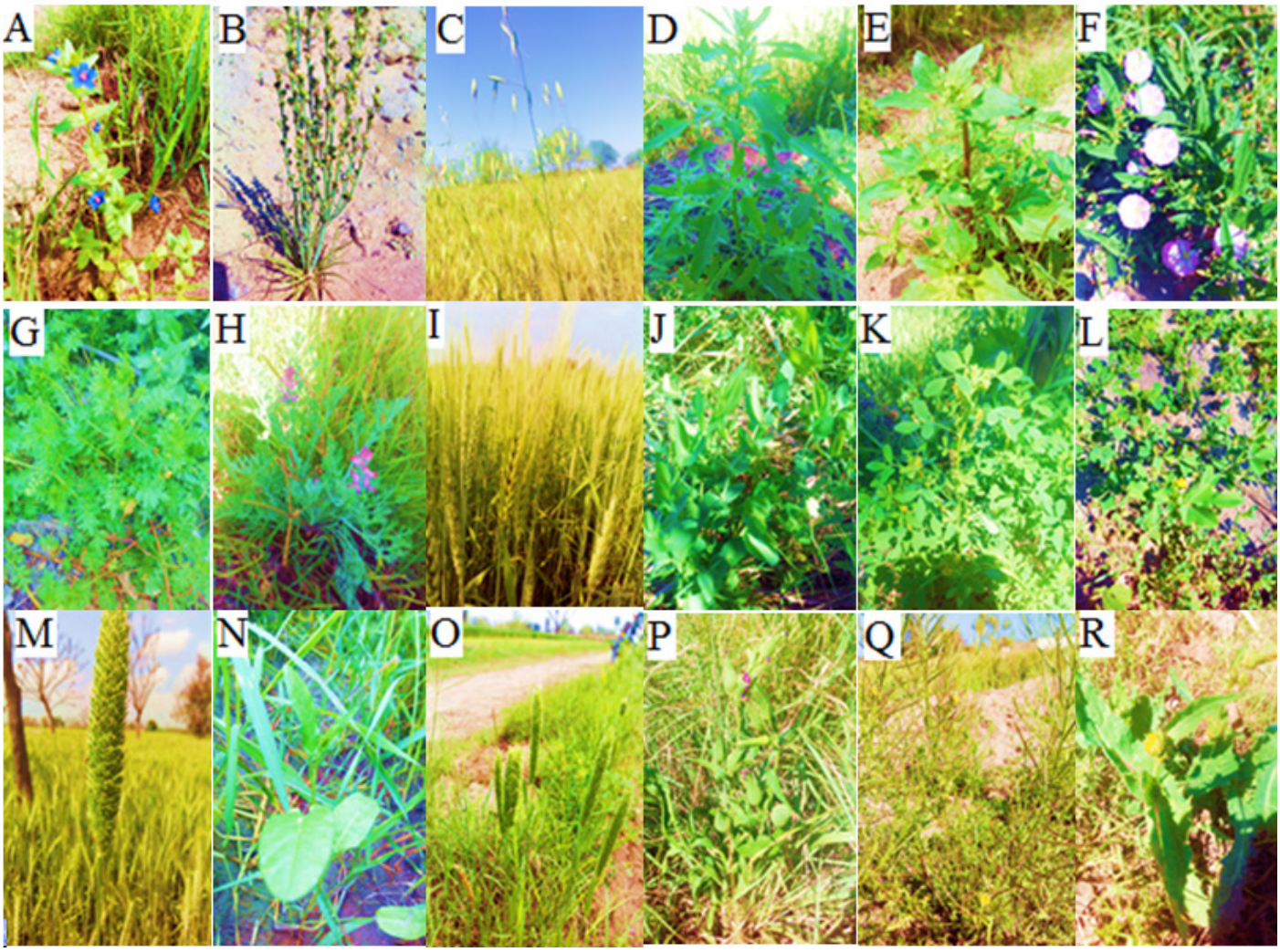

Figure 7: *A(Anagallis arvensis), B(Asphodelus tenuifolius), C(Avena futua), D(Chenopodium album), E(Chenopodium murale), F(Convolvulus arvensis), G(Coronopis didymus), H(Fumaria indica), I(Hordeum vulgare), J(Lathyrus aphaca), K(Melilotus indica), L(Medicago denticulata), M(Phalaris minor), N(Rumex dentatus), O(Setaria viridis), P(Silene conoidea) Q(Sisymbrium irio) and R(Sonchus asper).*

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Novelty Statement

Muhammad Shahid Hassan, Hassan Raza Javeed, Sabahat Zafar, Laraib Kanwal, Seerat Mariyum, Areej Fatima and Areeba Bashir: Created research plan, analyzed the data and wrote the manuscript.
Nargis Naz: Critically analyzed the data and played advisory tole in tesearch plan and statistical analysis.
Muhammad Imran Atta: Critically analyzed the data.

Author's Contribution

The present study is a pioneer in understanding persistent patterns of weeds in wheat fields of district Layyah. This ecological study helps weed management in near future in relation it's competitative behaviour with the growing wheat crop.

Conflict of interest
The authors declared that the present study was performed in the absence of any conflict of interest.

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