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RESEARCH ARTICLE

Nutrients removal by weeds and wheat crop under semi-arid climate of Punjab, India

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ABSTRACT

To evaluate the nutritional losses from weed infestation in wheat crop under semi-arid climate of Punjab, a study was carried in Bathinda district of South-West Punjab. Weed infestation does not significantly influence the soil, pH, EC and organic C of the soil. The values of all nutrients were higher at farmer's field compared to research farms; event though, they belong to similar soil category as per soil fertility. The nutrients mean value was 156.6 kg N/ha, 8.9 kg P/ha, 148.9 kg K/ha and 27.2 kg S/ha for studied locations. However, the average value for N, P, K and S was 136.5, 8.3, 129 and 26.64 kg/ha, respectively under weed infested fields and 147, 8.66, 136.8 and 27.9 kg/ha under weed free fields, when compared with same location fields. Similarly, the mean value for Fe, Cu, Zn and Mn was 5.46, 0.53, 0.99 and 4.43 mg/kg, respectively under weed infested fields of surveyed area. However, slightly higher values were recorded under weed free locations (at research farm locations) with mean value of 5.44, 0.55, 0.91 and 3.97 mg/kg for Fe, Cu, Zn and Mn, respectively. Whereas the mean value at the research farm locations was 5.41, 0.53, 0.88 and 3.91 mg/kg for Fe, Cu, Zn and Mn under weed infested fields.

Keywords: Nutrients removal, Weeds, Wheat, Semi-arid region, Soil nutrient status

INTRODUCTION

About 20% of the world's dietary calorie and protein intake comes from wheat (*Triticum aestivum* L.), a staple crop that contributes to global food security (Gooding and Shewry 2022). The wheat produced worldwide was over 793 million metric tons in 2024–2025 (Statista 2025) and in India 1132.92 lakh tons of wheat was produced from 318.33 lakh hectares area in 2023–2024 with wheat productivity of 3.56 t/ha (GOI 2025). In Punjab, 165.67 lakh tons of wheat was produced during 2022–2023, on an area of 35.17 lakh hectares, with an average productivity of 4.71 t/ha (Anonymous 2024). Both biotic (weeds, insects, pathogens, *etc.*) and abiotic (heat, drought, salt, *etc.*) factors contribute to the low wheat productivity and weeds are one of the main constraints (Walia 2006, Oerke *et al.* 2012, Singh *et al.* 2015). Wheat is infested by grassy and broad-leaved weeds and sedges. According to numerous studies, the amount of wheat yield lost due to weeds can vary from 16 to 60%, depending on the type of weed, its severity, the length of the infestation, the crop plant ability to compete under various agro-ecological conditions (Rao *et al.* 2014, Yaduraju *et al.* 2015). Actual economic losses due to weeds in wheat were estimated, in India, as USD 3376 million (Gharde *et al.* 2018). However, little is known about the nutrient losses caused by various weed infestations in the area throughout the wheat growing phase. Hence, this study was conducted with an objective to evaluate the nutritional losses resulting from weed infestation in the wheat crop for which a survey was carried out during *Rabi* 2024-25, gathering samples of soil, wheat and weeds from the farmer's fields and research farms of the Punjab Agricultural University, Regional Research Station, Bathinda.

MATERIALS AND METHODS

The field survey was carried out in March 2025 during which collection was done of soil samples, weeds, and wheat plants from fields infested with weeds and fields free of weeds in Bathinda district of Punjab (**Table 1**). A total of 40 soil samples, 30 weed samples of 5 common species, 10 and 30 wheat samples from weed free and weed infested fields were collected from eight locations of three blocks in the district. The commonly found weeds in the surveyed fields were *Cyperus iria* Linn., *Heliotropium eichwaldi* Steud. ex. DC, *Trigonella polycerata* Linn., *Parthenium hysterophorus* Linn., *Phalaris minor* Retz. and *Chenopodium album* Linn.

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Table 1. Details of locations of field survey and the samples collection

Site number	Site name and locations	Number of soil and plant samples collected			
		Soil samples	WWFF	WWIF	Common weed species
1	**Research Farm RRS, Bathinda**	5	-	5	5
	30°11'23.8"N 74°56'53.6"E, 30°11'25.5"N 74°57'08.2"E, 30°11'18.1"N 74°56'45.7"E, 30°11'16.7"N 74°56'47.2"E, 30°11'15.6"N 74°56'47.4"E				
2	**Research Farm RRS, Bathinda (weed free field)**	5	5	-	-
	30°11'31.2"N 74°56'50.1"E, 30°11'23.8"N 74°56'55.1"E, 30°11'25.0"N 74°56'56.3"E, 30°11'26.0"N 74°56'53.6"E, 30°11'22.6"N 74°56'51.6"E				
3	**Sekhpura farmers field, Bathinda**	5	-	5	5
	29°59'38.7"N 75°09'40.6"E,29°59'49.4"N 75°09'02.4"E, 29°59'47.2"N 75°09'07.2"E, 29°59'49.7"N 75°09'14.8"E, 29°59'40.1"N 75°09'14.1"E				
4	**Sekhpura Seed Farm RRS, Bathinda (weed free field)**	5	5	-	-
	29°59'21.7"N 75°07'43.5"E,29°59'26.7"N 75°07'42.8"E,29°59'31.1"N 75°07'46.4"E, 29°59'27.6"N 75°07'47.5"E, 29°59'30.0"N 75°07'52.0"E				
5	**Jai Singh Wala**	5	-	5	5
	30°08'02.8"N 74°51'39.4"E,30°08'22.9"N 74°52'02.9"E,30°08'17.7"N 74°51'59.9"E, 30°08'17.5"N 74°51'59.8"E, 30°08'19.9"N 74°52'06.4"E				
6	**Katar Singh Wala**	5	-	5	5
	30°08'46.3"N 74°59'39.9"E,30°08'37.3"N 74°59'47.1"E,30°08'34.2"N 74°59'41.1"E, 30°08'32.6"N 74°59'40.5"E, 30°08'38.2"N 74°59'48.1"E				
7	**Jassi Pauwali**	5	-	5	5
	30°08'58.8"N74°58'18.0"E,30°08'59.1"N 74°58'03.1"E,30°08'51.5"N 74°58'06.2"E, 30°08'58.6"N 74°58'17.0"E, 30°09'01.7"N 74°58'09.7"E				
8	**Jodhpur Romana**	5	-	5	5
	30°09'13.1"N 74°56'56.0"E,30°09'18.1"N 74°56'42.6"E,30°09'21.3"N 74°56'39.3"E, 30°08'53.8"N 74°55'36.2"E, 30°08'53.6"N 74°54'56.9"E				
	Total samples	40	10	30	30

WWFF-Wheat plant from weed free field, WWIF- Wheat plant from weed infested field (as farmers field weed infestations were varied according to management practices adopted by the farmers, only commonly occurring weed plants were considered during the study).

After the soil was air dried, the soil samples were sieved using a 2 mm mesh sieve and placed in polythene bags for further examination. The methods outlined by Jackson (1973) was used to measure the pH and electrical conductivity (EC) of soil in a 1:2 soil-water solution by pH meter and an electrical conductivity meter. The wet digestion method created by Walkley and Black (1934) was used to measure the soil organic carbon. The standard approach of Subbiah and Asija (1956) was used to analyze the amount of available nitrogen. Available potassium (K) was determined using the method described by Rowell (1994), and available phosphorus (P) was determined using the conventional procedure of Olsen *et al.* (1954). Using an atomic absorption spectrophotometer (Varian Model AAS FS 240), the DTPA extractable micro-nutrients (Zn, Fe, Mn, and Cu) were analysed using the procedures described by Lindsay and Norvel (1978).

To remove soil and other impurities, collected plant samples were carefully cleaned with distilled water and allowed to dry for three hours in the shade. After three hours, the samples were weighed, were dried in an oven at 60 ± 5°C until constant weight. The plants dry weight was noted, ground in a Willey mill, and then kept for nutrients analysis. To analyze the nutrients content in plants the standard methods outlined by Piper (2011) were used. The nutrient uptake by plants was calculated as follow:

Macro-nutrient uptake (g/plant) = [Dry matter (g) × Nutrient content (%)]/100

Micro-nutrient uptake (mg/plant) = [Dry matter (g) × Nutrient content (mg/kg)]/1000

The data was subjected to statistical analysis using MS Excel 2007 package.

RESULTS AND DISCUSSION

Soil parameters of the sampling sites

The soil pH, EC and OC of the soil had no significant influence on weed infestation (**Table 2**). However, the pH value varied from 8.1-8.5 at RRS, Bathinda, 8.1-8.5 at Sekhpura, 8.2-9.3 at Jai Singh Wala, 8.2-9.7 at Katar Singh Wala, 8.4-8.7 at Jassi Pauwali and 8.3-9.7 at Jodhpur Romana with average value of 8.26, 8.35, 8.72, 8.66, 8.58 and 8.88, respectively. Yadav *et al.* (2018) observed neutral to alkaline pH in soil of Bathinda district. Further, Yadav (2020) reported that the 0-15 cm soil pH ranged 8.01-9.80 with mean of 8.85 in the cotton-wheat cropping system in Sangat block of Bathinda district as reported earlier by Kalhon *et al.* (2021) and Yadav *et al.* (2023). The soil EC ranged from 0.21-0.29 dS/m with average value of 0.25 dS/m; 0.24-0.35 dS/m; 0.29 dS/m; 0.18-0.45 dS/m; 0.30 dS/m; 0.26-0.52 dS/m; 0.37 dS/m; 0.33-0.45 dS/m; 0.40 dS/m; 0.18-0.48 dS/m; 0.37 dS/m at RRS, Bathinda; Sekhpura; Jai Singh Wala; Katar Singh Wala; Jassi Pauwali and Jodhpur Romana, respectively. The higher soil EC (0.40 dS/m) was recorded at Jassi Pauwali followed by Katar Singh Wala and Jodhpur Romana with average value of 0.37 dS/m compared to other locations. The lower values of electrical conductivity in soils may be attributed to more macro pores, as majority of the soil samples in the area are light textured, resulting in free drainage conditions. The earlier reported EC of arid soils in the Bathinda district, ranged from 0.11-0.18 dS/m in sand-dunes, 0.19-0.27 dS/m in inter dunal soils, and 0.20-0.31 dS/m in alluvial terrace soils, indicating their non-saline nature (Singh and Sharma 2013). Yadav *et al.* (2018)

based on analysis of 2506 soil samples from the Bathinda district found that 85% of the samples were in the normal range (EC <0.8 dS/m) and 15% of the samples had EC > 0.8 dS/m. Further, Yadav (2020), Kalhon *et al.* (2021) and Yadav *et al.* (2023) reported the similar results.

The data of soil pH, EC, OC and macro-nutrients revealed that the soil organic carbon (OC) ranged from 0.23-0.56% with average value of 0.40%, observing higher value of 0.51% at Sekhpura followed by 0.42% at Jassi Pauwali and 0.40% at Jodhpur Romana (**Table 2**). The medium to higher organic carbon content in the soils may be attributed to the proper vegetation, avoiding crop residue burning and incorporation into the soil.

Singh and Sharma (2013) reported about 0.22 %, 0.31% and 0.34% organic carbon in surface horizon of sand dunes, inter dunal and alluvial terraces soils of Bathinda. Yadav *et al.* (2018) observed mean value of OC varied between 0.31 to 0.62% in different blocks of Bathinda and showed that 61 to 70% samples were deficient in organic carbon. Similar results were also reported by Yadav (2020), Kalhon *et al.* (2021) and Yadav *et al.* (2023) in soil of Bathinda district under various cropping system. The weeds infested fields significantly had low amount of macro and micro-nutrient (N, P, K, S and Fe, Cu, Zn and Mn) compared to weed control/ weed free fields, however the amount of nutrients varied according to sampling site and agronomic management during the crop (**Table 2** and **3)**. The value of all nutrients was higher at farmer's fields compared to research farm; however, they belong to similar soil category as per soil fertility. The nutrients value ranged from 125-148 kg N/ha, 7.4-8.9 kg P/ha, 121-138 kg K/ha and 22.4-32.4 kg S/ha with mean value of 136.5, 8.3, 129 and 26.64 kg/ha under weed infested fields, whereas, it ranged from 140-155 kg N/ha, 7.6-9.3 kg P/ha, 128-147 kg K/ha and 23.4-33.5 kg S/ha with mean value of 147, 8.66, 136.8 and 27.9 kg/ha under weed free fields, when compared with same location fields. However, the nutrients ranged from 125-174 kg/ha with mean value of 156.6 kg N/ha, 7.4-10.8 kg/ha with mean value of 8.9 kg P/ ha, 121-201 kg/ha with mean value of 148.9 kg K/ha and 21.5-35.2 kg/ha with mean value of 27.2 kg S/ha in the studied locations. It was also recorded that the macro-nutrient (N, P, K and S) values were higher at farmers fields compared to research farms, may be due to use of higher dose of fertilizers by the farmers than recommended dose for the crops.

Similarly, the micro-nutrients value (**Table 3**) ranged from 4.68-6.42 mg/kg for Fe, 0.35-0.85 mg/ kg for Cu, 0.67-1.32 mg/kg for Zn and 3.75-6.05 mg/ kg for Mn with mean value of 5.46, 0.53, 0.99 and 4.43 mg/kg under weed infested fields of surveyed area, respectively. However, slightly higher values were recorded under weed free locations (at research locations) and values ranged from 4.68-6.19 mg/kg for Fe, 0.38-0.78 mg/kg for Cu, 0.68-1.14 mg/kg for Zn and 3.79-4.12 mg/kg for Mn with mean value of 5.44, 0.55, 0.91 and 3.97 mg/kg under weed free fields. Whereas the corresponding values at the research location ranged from 4.68-6.15 mg/kg for Fe, 0.35-0.75 mg/kg for Cu, 0.67-1.12 mg/kg for Zn and 3.75-4.09 mg/kg for Mn with mean value of 5.41, 0.53, 0.88 and 3.91 mg/kg under weed infested fields.

The micro-nutrient (Fe, Cu, Zn and Mn) values were higher at farmers' fields, may be due to soil application of micro-nutrients fertilizers by the farmers for different crops over the years. Whereas the nutrients values were comparatively low at

Table 2. Range and mean value of soil pH, EC, OC and macro-nutrients of the surveyed fields

Site name*	Soil $pH_{1:2}$	Soil $EC_{1:2}$ (dS/m)	Soil OC (%)	Soil N (kg/ha)	Soil P (kg/ha)	Soil K (kg/ha)	Soil S (kg/ha)
Research Farm RRS, Bathinda	8.1-8.4 (8.2±0.05)	0.21-0.29 (0.25±0.01)	0.38-0.45 (0.40±0.01)	125-135 (130±1.99)	7.40-8.70 (8.20±0.22)	121-132 (126±1.87)	23.4-28.4 (25.6±.84)
Research Farm RRS, Bathinda (weed free field)	8.1-8.5 (8.3±0.07)	0.22-0.29 (0.25±0.01)	0.34-0.38 (0.36±0.01)	140-148 (144±1.36)	7.60-9.20 (8.58±0.27)	128-137 (131±1.64)	24.9-29.8 (27.4±0.84)
Sekhpura farmers field, Bathinda	8.1-8.5 (8.4±0.07)	0.24-0.35 (0.28±0.02)	0.47-0.56 (0.50±0.02)	138-148 (143±1.78)	8.20-8.90 (8.54±0.13)	125-138 (133±2.67)	22.4-32.4 (27.4±1.60)
Sekhpura Seed Farm RRS, Bathinda (weed free field)	8.2-8.5 (8.3±0.06)	0.25-0.34 (0.29±0.02)	0.45-0.56 (0.51±0.02)	145-155 (150±1.71)	8.60-9.30 (8.98±0.12)	135-147 (142±2.24)	23.4-33.5 (28.7±1.68)
Jai Singh Wala	8.2-9.3 (8.7±0.21)	0.18-0.45 (0.30±0.04)	0.23-0.36 (0.28±0.03)	159-171 (165±2.12)	8.30-9.40 (8.80±0.22)	139-165 (150±4.69)	22.4-32.4 (27.2±1.71)
Katar Singh Wala	8.2-9.7 (8.7±0.27)	0.26-0.52 (0.37±0.04)	0.26-0.36 (0.32±0.02)	165-174 (169±1.83)	8.50-9.60 (9.18±0.19)	143-165 (154±4.37)	21.5-32.1 (27.0±1.89)
Jassi Pauwali	8.4- 8.7 (8.6±0.05)	0.33-0.45 (0.40±0.02)	0.34-0.52 (0.42±0.03)	159-175 (165±2.60)	8.30-9.20 (8.84±0.18)	129-165 (143±6.14)	21.5-32.1 (27.0±1.81)
Jodhpur Romana	8.3-9.7 (8.9±0.27)	0.18-0.18 (0.37±0.05)	0.26-0.52 (0.40±0.04)	158-173 (167±2.63)	8.90-10.80 (9.88±0.31)	166-201 (188±6.07)	22.5-35.2 (29.0±2.15)

Values in parentheses denoted the mean± SEM;* Refer table 1 for details

research farms due to use of recommended dose of micro- nutrients fertilizers usually top-dressed through sprays. Global warming, soil, and agricultural practices (*e.g.* tillage, irrigation, and fertilization) have varying potential to affect the abundance and diversity of weed species (Travlos *et al.* 2018) and soil nutrient content.

Punjab state alone consumes 9% of the total fertilizers in India and the use is the highest on per unit area basis at 190.0 kg/ha of the gross cropped area against 88.2 kg/ha in all India. Farmers applied more chemical fertilizers than recommended to raise productivity of high yielding varieties due to higher responsiveness (Anonymous 2025). Earlier, Arora (2020) noted that the imbalanced use of fertilisers in India is evident from the fact that the desirable ratio of N: P: K application is 4:2:1 at national level, while it is 31.4:8:1 in Punjab.

Plant weight, nutrients content and uptake by weeds and crop

The fresh and dry weight of plants and their macro and micro-nutrients content (**Table 4**) revealing that *Chenopodium album* had the maximum weight/plant as compared to wheat plant in both conditions (collected from weed infested and weed free field).

Chenopodium album had higher moisture (12%) as compared to wheat (11%) under weed infested fields while moisture content was 15 % for wheat plant under weed free field at the sampling period. Tehmina and Rukhsana (2010) found that *Chenopodium album* caused a 41.6% decrease in tillering of wheat due to competition for water, nutrients, and light with wheat was drastic reduction in the total dry matter content of wheat. The consumptive use of water of a common weed *Chenopodium album* was 550 mm as against 479 mm for wheat since weed can remove moisture from deeper depths of soil than crops (Hasanuzzaman 2015).

Irrespective of weed species macro-nutrient content in weed plants ranged from 1.1-1.8 % for N, 0.42-0.49% for P, 1.85-8.43% for K and 0.73-0.83% for S with mean of 1.30% N, 0.46% P, 2.36% K and 0.75% S. However, the wheat plant from weed infested field contained N by 1.2-1.6%, P by 0.53-0.59%, K by 2.0—2.8% and S by 0.88-0.95% with mean value of 1.4%, 0.56%, 2.4% and 0.91%, whereas, wheat plant from weed free field contained 1.5-1.6% N with mean value of 1.6%, 0.63-0.65% P with mean value of 0.64%, 2.5-2.8% K with mean value of 2.6% and 0.99-1.01% S with mean value of

Table 3. Range and mean value of soil micro-nutrients of the surveyed fields

Site name*	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Research Farm RRS, Bathinda	4.68-5.65(5.13±0.16)	0.35-0.56(0.46±0.04)	0.67-0.95(0.77±0.05)	3.78-4.01(3.89±0.04)
Research Farm RRS, Bathinda (weed free field)	4.68-5.66(5.17±0.16)	0.38-0.58(0.48±0.04)	0.68-1.01(0.79±0.06)	3.88-4.09(3.95±0.04)
Sekhpura farmers field, Bathinda	5.16-6.15(5.57±0.20)	0.45-0.75(0.60±0.05)	0.78-1.11(0.99±0.06)	3.75-4.09(3.93±0.06)
Sekhpura Seed Farm RRS, Bathinda (weed free field)	5.22-6.19(5.61±0.20)	0.46-0.78(0.62±0.05)	0.79-1.14(1.03±0.07)	3.79-4.123.97±0.06)
Jai Singh Wala	5.06-5.42(5.26±0.06)	0.35-0.48(0.40±0.02)	0.88-1.24(1.05±0.06)	3.76-4.15(4.03±0.07)
Katar Singh Wala	4.75-5.48(5.07±0.13)	0.42-0.83(0.53±0.08)	0.98-1.32(1.16±0.06)	4.05-5.15(4.49±0.22)
Jassi Pauwali	5.09-6.42(5.63±0.27)	0.38-0.55(0.47±0.03)	0.86-1.14(1.02±0.05)	5.15-6.05(5.70±0.19)
Jodhpur Romana	5.35-6.25(5.87±0.16)	0.38-0.85(0.56±0.09)	0.75-1.22(0.96±0.08)	4.15-5.01(4.51±0.16)

Values in parentheses denoted the mean± SEM;* Refer table 1 for details

Table 4. Range and mean value of different plant parameters of the weeds and wheat per plant collected during the study period

Plant species	Fresh weight (g)	Dry weight (g)	N (%)	P (%)	K (%)	S (%)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Cyperus iria Linn.	1.2-1.6 (1.5±0.05)	0.21-0.29 (0.23±0.01)	1.2-1.3 (1.2±0.02)	0.43-0.48 (0.46±0.01)	2.0-2.1 (2.1±0.03)	0.73-0.81 (0.78±0.01)	30.4-34.2 (32.9±0.70)	7.3-7.9 (7.6±0.10)	16.2-17.7 (17.0±0.23)	21.4-23.4 (22.3±0.29)
Heliotropium eichwaldi Steud. ex. DC	3.4-3.8 (3.7±0.06)	0.93-1.28 (1.08±0.06)	1.2-1.3 (1.3±0.02)	0.44-0.48 (0.46±0.01)	2.0-2.3 (2.2±1.03)	0.71-0.83 (0.76±0.02)	31.8-35.4 (33.6±0.47)	7.0-8.0 (7.4±0.14)	16.1-18.7 (17.1±0.44)	21.4-23.8 (22.6±0.38)
Trigonella polycerate Linn.	13.4-15.0 (14.4±0.23)	3.9-5.0 (4.4±0.19)	1.2-1.5 (1.3±0.05)	0.46-0.49 (0.47±0.01)	2.0-8.4 (3.3±1.03)	0.70-0.82 (0.74±0.02)	33.3-40.9 (35.9±0.37)	6.7-7.9 (7.5±0.17)	16.5-18.0 (17.0±0.22)	22.6-24.7 (23.6±0.36)
Parthenium hysterophorus Linn.	45.3-50.6 (48.7±0.78)	13.3-17.0 (14.8±0.63)	1.2-1.7 (1.4±0.08)	0.43-0.48 (0.46±0.01)	1.9-3.0 (2.3±0.15)	0.70-0.81 (0.75±0.02)	32.5-35.4 (34.8±0.46)	6.8-8.2 (7.4±0.22)	15.5-19.0 (17.7±0.53)	19.8-23.7 (22.3±0.63)
Phalaris minor Retz.	17.1-19.1 (18.3±0.29)	5.0-6.4 (5.6±0.24)	1.1-1.8 (1.3±0.10)	0.42-0.48 (0.46±0.01)	1.8-3.0 (2.2±0.17)	0.70-0.77 (0.73±0.01)	34.7-41.2 (37.1±1.17)	7.2-7.6 (7.3±0.05)	17.1-19.2 (18.2±0.32)	22.0-24.5 (23.1±0.36)
Chenopodium album Linn.	476.3-532.2 (512.1±8.22)	411.4-535.1 (457.5±22.0)	1.1 -1.7 (1.3±0.09)	0.43-0.46 (0.45±0.01)	1.9-2.9 (2.1±0.16)	0.70-0.78 (0.74±0.01)	32.9-41.7 (37.4±1.47)	6.9-7.6 (7.2±0.12)	16.7-18.7 (17.5±0.30)	21.0-24.0 (23.0±0.45)
Triticum aestivum-weed infested field	105.3-117.7 (113.2±1.82)	92.7-118.3 (101.8±4.61)	1.2-1.6 (1.4±0.07)	0.53-0.59 (0.56±0.01)	2.0-2.8 (2.4±0.12)	0.88-0.95 (0.91±0.01)	48.0-49.3 (48.5±0.18)	9.2-9.9 (9.6±0.11)	21.9-22.9 (22.6±0.16)	27.4-29.2 (28.3±0.25)
Triticum aestivum- weed free field	112.0-118.8 (115.4±1.94)	98.6-100.9 (99.8±0.68)	1.5-1.6 (1.6±0.03)	0.63-0.65 (0.64±0.01)	2.5-2.8 (2.6±0.08)	0.99-1.01 (0.99±0.01)	50.4-50.6 (50.5±0.07)	9.5-10.2 (9.9±0.20)	23.2-23.5 (23.3±0.08)	28.4-28.5 (28.4±0.02)

Values in parentheses denoted the Mean± SEM

0.99%, which was higher than wheat from weed infested field and weeds. Likewise, micro-nutrients in weed plants ranged from 30.25- 41.69 mg/kg with mean of 35.28 mg/kg for Fe, 6.73-8.17 mg/kg with mean of 7.40 mg/kg for Cu, 15.53-19.17 mg/kg with mean of 17.40 mg/kg for Zn and 19.77- 24.67 mg/kg with mean of 22.82 mg/kg for Mn. The wheat plant from weed infested field contained 48.0-49.3 mg/kg Fe, 9.2-9.9 mg/kg Cu, 21.9-22.9 mg/kg Zn and 27.4-29.2 mg/kg Mn. While wheat plant from weed free field contained 50.4-50.6 mg/kg Fe with mean value of 50.5 mg/kg, 9.5-10.2 mg/kg Cu with mean value of 9.9 mg/kg, 23.2-23.5 mg/kg Zn with mean value of 23.3 mg/kg and 28.4-28.5 mg/kg Mn with mean value of 28.4 mg/kg which was higher than weeds and wheat from weed infested field. The weed infestation reduced the nutrients content by 9.0 % N, 12.3% P, 10.1% K and 8.4% S and Fe, Cu, Zn and Mn by 4.0%, 2.9%, 3.0% and 0.4 % in wheat plants. Different plant species have a variable response to nutrient content because of crop-weed competition and fertility status of the fields.

Macro and micro-nutrients uptake by different plant species as analysed during the study (**Figure 1)** indicated the maximum plant uptake for macro-nutrients (N, P, K and S) by *Chenopodium album* Linn (5.87, 2.05, 9.83 and 33.81 g/plant) followed by *Parthenium hysterophorus* Linn (0.20, 0.07, 0.34 and 1.11 g/plant) and *Phalaris minor* Retz. (0.07, 0.03, 0.12 and 0.41 g/plant). The N, P, K and S uptake by wheat from weed free and weed infested fields were recorded by 1.55 and 1.44, 0.64 and 0.57, 2.62 and 2.40, 9.89 and 9.25 gm/plant (**Figure 1A**). Higher Fe, Cu, Zn and Mn uptake was observed by *Chenopodium album* Linn (0.51, 0.11, 0.26 and 0.33 µg/plant) followed by *Parthenium hysterophorus* Linn (0.51, 0.11, 0.26 and 0.33 µg/plant) and *Phalaris minor* Retz. (0.21, 0.04, 0.10 and 0.13 µg/plant). The Fe, Cu, Zn and Mn uptake by wheat from weed infested and weed free fields were recorded by 4.94 and 5.04, 0.97 and 0.98, 2.30 and 2.33, 2.84 and 2.88 µg/plant (**Figure 1B**).

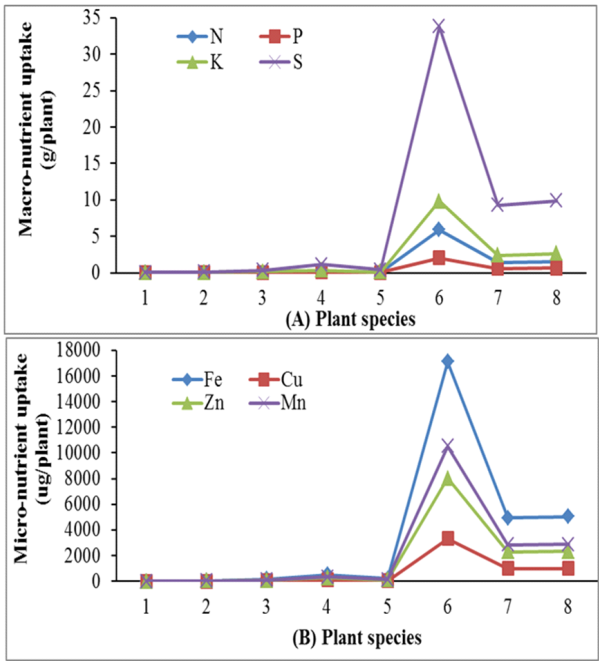

Figure 1. Macro and micro-nutrients uptake by different plant species collected during the study

Plant species 1. *Cyperusiria* Linn.; 2. *Heliotropium eichwaldi* Steud. ex. DC; 3. *Trigonella polycerata* Linn.; 4. *Parthenium hysterophorus* Linn.; 5. *Phalaris minor* Retz.; 6. *Chenopodium album* Linn.; 7. *Triticum aestivum*-weed infested field; 8. *Triticum aestivum*- weed free field.

Higher Fe, Cu, Zn and Mn uptake was observed by *Chenopodium album* Linn (0.51, 0.11, 0.26 and 0.33 µg/plant) followed by *Parthenium hysterophorus* Linn (0.51, 0.11, 0.26 and 0.33 µg/plant) and *Phalaris minor* Retz. (0.21, 0.04, 0.10 and 0.13 µg/plant). The Fe, Cu, Zn and Mn uptake by wheat from weed infested was 4.94 and 5.04, 0.97, respectively and weed free fields were 0.98, 2.30 and 2.33, 2.84 and 2.88 µg/plant (**Figure 1B**), respectively. The weed infestation decreased the N, P, K and S uptake of wheat by 7.1, 10.4, 8.2 and 6.5 %, respectively (**Figure 2A**) and decrease the Fe, Cu, Zn and Mn uptake of wheat by 2.0, 0.8, 1.0 and 1.6%, respectively (**Figure 2B**) due to weed infestation. Nutrient uptake by crops is primarily a function of yield and nutrient content. A weedy crop resulted in the least nutrient uptake. Poor growth and

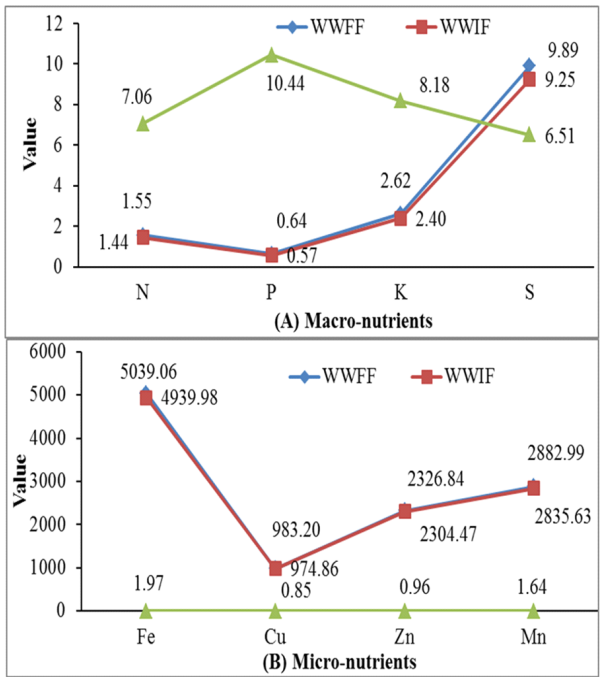

Figure 2. Percent decrease in nutrients uptake by wheat plant due to weeds infestation

(WWFF- Wheat plant from weed free field, WWIF- Wheat plant from weed infested field)

low uptake of nutrients by wheat in weedy field might be due to less photosynthates, then less assimilates to numerous metabolic sinks and ultimately poor development of yield components (Shivran *et al.* 2020). Abouziena *et al.* (2008) reported that an N content of wheat was decreased by 2.7% due to weed infestation.

Conclusions

It could be concluded that weed infestation does not significantly influence the soil, pH, EC and organic C of the soil. However, weeds infested fields had significantly low amount of macro (N, P, K, and S) and micro-nutrient (Fe, Cu, Zn and Mn) compared to weed free fields. The weed infestation decreased the macro and micro-nutrients uptake by wheat and it varied with infested weed species, intensity of weed infestation, soil fertility status and crop cultivation practices used.

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