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Research Article

Effect of wheat planting density and weed management on nutrient accumulation and uptake of wheat and weeds under agro-climatic condition of Quetta-Pakistan

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Abstract

Weed infestation ranked first as main constraint in agriculture production system because both weeds and crop striving for space, light, water and nutrients. For this purpose, a field trial was designed in CRBD across factorial management during 2017-18. Four different seed rates (100, 125, 150 and 175 kg ha^{-1}) tested against weed management practices (no weeding, herbicide application, hand hoeing and allelopathic weed control) and replicated thrice. The results revealed that seed rate of 125 kg ha^{-1} increased grain yield (4.24 t ha^{-1}). The wheat physiological traits were also improved on this seed rate with CGR (16.80 g m^{-2} day^{-1}) and NAR (4.78 16.80 g m^{-2} day^{-1}). This medium seed rate also increased leaf N, P and K concentration by 34.72, 56.76 and 31.79% over 100 kg ha^{-1}, 11.56, 20.83 and 6.48% over 150 kg ha^{-1}. However, higher seed rate reduced its uptake by 48.84, 57.92 and 11.28% over 125 kg ha^{-1} and 29.84, 60.00 and 10.68% over 150 kg ha^{-1}. The weed whole plants N, P and K concentration and uptake reduced on higher seed rates. While, herbicide application effectively controlled weeds by 90.56% followed by hand hoeing (84.55%). According to linear regression analysis, a positive and significant correlation was noted between grain yield and CGR (r = 0.90) and grain yield and NAR (r = 0.93). Consequently, it can be established from this study that weeds controlled by herbicide application and crop sown with seed rate of 125 kg ha^{-1} minimized weed crop competition and increased crop yield.

Keywords: NPK concentration in wheat leaf and weeds; NPK uptake by wheat and weeds; planting densities; Wheat; Weeds

Introduction

Crop plants compete among themselves and with weeds for the available limited resources of water, light, space and nutrients in agricultural field particularly in the cereals crops **[1]**. Such competition is almost expressed in two forms i.e. intraspecific competition (among the plants of same species) and interspecific competition (among the plants of different species). The competition amongst plants is a kind of interaction that might be proved as positive, negative or neutral interference [2]. In agro-ecological environment, the interaction between crops and weed is always negative due to which this interaction is termed as competition. Different research studies have been carried out in many part of the world to determine the competitive ability of crops against the infesting weed [3, 4]. The competitive interaction between crops and weed or crop competitive ability can be measured by two approaches i.e. weed smothering by crop plant or quantifying crop yield losses by weed which depend on genetic competitive potential of crop cultivars. But crop tolerance and oppressing of weed are isolated identities and it is suggested that the best genotype must possessed these two properties i.e. have the ability to tolerate the existence weed or suppress the weed [5, 6].

Crop competitive ability is not controlled by a single characteristics but it is the combination of total traits that work together against weed. These traits include early vigor [7], leaf area index [8], tillering capacity [9], crop growth rate [10] and management. Rise of crop intensely affect the crop competiveness in cereals because early emergence of crop before weed mean the crop capability to use the available limited means of growth including space, light, nutrient and water more efficiently than weed and resultantly it give the crop to competitive benefit. A study conducted by the researcher to investigate the comparative emergence time of barley and sow thistle weed revealed that the biomass of barley was increased by 90% when it was emerged 4 days before weed (*Sonchus arvensis*), whereas, the later emergence i.e. 8 and 26 days of after weed emergence decreased barley biomass by 50 and 10% respectively [11].

Planting is one of the important agronomic practices that affect yield and yield components of crops. Both extreme rates such as lower and higher seed rates inflicted adverse effects on yield but the optimum seeding rate is considered for better growth and yield [12]. Seed index and grains per spike are two most important yield components that are sensitive to changing seed rates of wheat and ultimately affect grain yield [13]. Under climatic condition of Pakistan, Cheema *et al.* [14] noted that 125 kg ha^{-1} seed rate produced 4300 kg per ha grain yield. The researcher like Kumar *et al.* [15] recorded improvement in grain yield, nutrient uptake and other agronomic trait at higher seed rate. However, Stephen *et al.* [16] observed that higher seed rates increased vegetative growth of wheat and decreased reproductive growth with lower grain yield production. According to Geleta *et al.* [17] that the achievement of greater grain yield with best quality depends on appropriate planting density. There is no consensus among agronomist regarding per unit seeding rate of wheat because its production varies with different climatic and soil conditions. Keeping in view the importance of planting density in minimizing weed crop competition and increasing wheat yield, the objective of research work was to observe the influence of seed rate on weed crop competition for accumulation and uptake of nutrients in wheat as well as in weeds.

Materials and methods

The trial was carried out during 2017-18 to investigate wheat planting densities as an agronomic practice to minimize weed-crop competition integrated with weed management practices for enhancement of wheat yield. Trial was designed in RCBD (randomized complete block design) in factorial arrangement. The tested factors were comprised of four planting density (Factor-A) and four weed management practices (Factor-B) which were replicated thrice. The net plot size was 24 m^2, the details are as under:

Factor (A) = Seed rates = 04

S_1 = 100 kg ha^{-1}

S_2 = 125 kg ha^{-1}
S_3 = 150 kg ha^{-1}
S_4 = 175 kg ha^{-1}
Factor (B) = Weed management techniques = 04
W_1 = No weeding
W_2 = Herbicides application:
i) Bromoxynil+MCPA @750 ml ha^{-1} for broad leaf weeds
ii) Clodinafop-propargyl @ 300 g ha^{-1} for narrow leaf weeds
W_3 = Hand hoeing (after 1st and 2nd irrigation)
W_4 = Allelopathic weed control (sunflower extract @6 L ha^{-1} at 30 + 40 DAS)
Treatment combinations

T1 = W_1S_1	T5 = W_2S_1	T9 = W_3S_1	T13 = W_4S_1
T2 = W_1S_2	T6 = W_2S_2	T10 = W_3S_2	T14 = W_4S_2
T3 = W_1S_3	T7 = W_2S_3	T11 = W_3S_3	T15 = W_4S_3
T4 = W_1S_4	T8 = W_2S_4	T12 = W_3S_4	T16 = W_4S_4

Cultural practices
The field was divided into sub-plots according to the experimental description. Buffer zone was built up between the plots where herbicides were used to control the drifting of herbicides into the no weedy plots. Wheat was sown on 15th November through single coulter hand drill. The seed rates were selected as per treatment indicated under factor A. The recommended N (nitrogen)-P (phosphorus)-K (potassium) fertilizer (120-90-60 kg ha^{-1}) was used. However, nitrogen was applied in two split dosages during 2nd & 3rd irrigations respectively. The crop was irrigated with total of five irrigations.
Weed management techniques
These techniques were applied according to the treatments under factor B. Herbicides were applied for broadleaf weeds on 26 days after sowing and for narrow leaf weeds on 40 days after sowing. Sunflower extract as allelopathic weed control was applied 40 days after sowing.
Soil and plant analysis
A composite soil samples with depth of 15 cm will be collected from the experimental field and analysed for sol texture, pH, EC (electrical conductivity), organic matter and AB-DTPA (ammonium bicarbonate-diethylenetriaminepentaacetic acid), P (phosphorus) and K (potassium). Hydrometer method was used for soil textural analysis [18], the measurement of soil alkalinity (pH) and EC was carried out in 1:5 soil and water suspension at 25 ^oC according to the method described by McKeague [19] and McLean [20] and organic matter by oxidizing method [21, 22]. While, AB-DTPA extraction solution was used for extracting P and K [23]. In the clear filtrate of AB-DTPA soil extract, phosphorus was determined on Spectrophotometer at 880 nm wavelength and potassium on Flame Photometer.
Flag leaf was collected from 10-30 pants in each plot at milking stage. The samples were then put in the paper envelopes, labeled them with permanent marker and delivered to the Laboratory of Soil and Water Testing Laboratory ARI Sariab Quetta the same day and stored them over there at 20 ^oC for next coming working day. The samples were decontaminated and washed following the method of Sonneveld and Dijk [24], oven dried at 80 ^oC, ground to 20 mesh then kept in plastic bags under laboratory temperature of 4 ^oC before conducting the actual analysis.
Weighed 0.5 g of the prepared plant sample and wet digested using hot sulfuric acid and 30% hydrogen peroxide (H_2O_2). Total N, P and K were analysed in this clear digest [25]. For phosphorus, Pipetted 10 ml of the digest into a 100 ml volumetric flask, added 10 ml ammonium-

vanadomolybdate and diluted the solution with Deionized water upto the mark [26]. Then, read the absorbance of the blank, standards, and samples after 30 minutes at 410-nm wavelength on Spectrophotometer. The potassium in the digest was determined directly by Flame Photometer [27]. Kjeldhal method [28] was used for determination of total nitrogen.

Statistical analysis

The collected data was subjected to analysis of variance and LSD test at P level 0.05 was conducted for comparison of mean. Correlation was established among the studied parameters as influenced by various treatments. All the statistical analysis was computed on Statistix 8.1 software (Math Soft Inc., Cambridge, MA, USA).

Results

For minimizing weed crop competition, this study was conducted in two factors comprised of four different planting densities and four weed management practices (no weeding, herbicides application, interculturing and allelopathic weed control). Before the conduct of experiment, soil was analysed for the determination of soil particle size distributin, SOC (soil organic matter), electrical conductivity (EC), soil alkalinity (pH), Kjeldhal nitrogen and labile phosphorus (P) and potassium (K) through AB-DTPA soil extraction. Analytical results revealed that the experimental soil was medium in texture, non-saline, low SOC (0.54%) and low AB-DTPA extractable P (2.88 ppm) but K was high (171 ppm).

Grain yield (t ha^{-1})

The analysis of variance for grain yield showed significant differences for seed rates, weed management and the interaction of seed rates x weed management. Among the four seed rates, the greater grain yield (5.28 t ha^{-1}) was achieved by using the seed rate of 125 kg ha^{-1} followed by 4.56 t ha^{-1} when seed rate of 150 kg ha^{-1} was used, but the increasing seed rate of 175 kg ha^{-1} produced lower grain yield (3.41 kg ha^{-1}) (Table 1).

Grain yield of wheat across different weeds management practices showed significant differences for all weeds management as reflected in (Table 1). The comparison of mean ($P \leq 0.05$) for grain yield revealed that weed control by weedicides application (W2) produced higher grain yield (4.94 t ha^{-1}) followed 4.68 and 4.51 t ha^{-1} where weeds were controlled by interculturing (W3) and allelopathic weed management (W4). But the lower grain yield (2.93 t ha^{-1}) was observed in plot where no weeding was conducted (W1). Statistically, the grain yield at W3 and W4 were at par but significantly higher over W1 (no weeding).

Interactive effect of seed rates x weeds management on grain yield showed significant differences as depicted in (Table 2). The higher gain yield (6.43 t ha^{-1}) was obtained at W2 followed by 6.11 t ha^{-1} at W3 with seed rate of 125 kg ha^{-1}. However, lower gain yield (2.77 t ha^{-1}) was achieved at W1 (no weeding) with seed rate of 100 kg ha^{-1}.

Net assimilation rate (g m^{-2} day^{-1})

Net assimilation rate (NAR) is one of the important components responsible for crop yield. The analysis of variance revealed significant differences for seed rates, weed management and interactive effect of seed rates x weed management. Net assimilation rate was affected across different seed rates as presented in (Table 1) revealed non-significantly higher NAR of 21.28, 20.56 and 19.72 g m^{-2} day^{-1} at seed rate of 125, 150 and 175 kg ha^{-1} respectively. But, the seed rate of 100 kg ha^{-1} produced lower NAR (14.42 g m^{-2} day^{-1}).

The effect of different weed management practices on NAR exhibited statistically significant variations as presented in (Table 1). Maximum NAR of 24.05 g m^{-2} day^{-1} was obtained at W2 followed by 20.88 g m^{-2} day^{-1} at W3 and minimum but

non-significant NAR of 15.67 and 15.37 g m^{-2} day^{-1} was recorded at W4 and W1.
The interaction of seed rates x weed management revealed significant effect on NAR as (Table 2) showed greater NAR of 31.95 g m^{-2} day^{-1} at W2 followed by 25.59 g m^{-2} day^{-1} at W3 with seed rate of 125 kg ha^{-1}. In case of interaction of seed rate of 150 kg ha^{-1} with WI and W4 statistically showed NAR value at par which were higher when compared to seed rate of 100 and 175 kg ha^{-1}. However, the interactive effect of SD1 x W1 and SD4 x W4 produced minimum NAR (13.21 and 12.15 g m^{-2} day^{-1}).

Table 1. Effect of different weed management practices and seed rates on growth traits, leaf NPK concentration, uptake and yield of wheat

Plant traits	Weed management practices				SE	LSD (5%)
	W_1	W_2	W_3	W_4		
Grain yield (t ha^{-1})	2.93c	4.94a	4.68b	4.51b	0.11	0.22
Net assimilation rate (g m^{-2} day^{-1})	20.88b	24.05a	15.67c	15.37c	1.24	2.52
Crop growth rate (g m^{-2} day^{-2})	14.01c	17.20a	16.24b	16.03b	0.25	0.50
N (%)	1.96d	3.51a	3.33b	3.16c	0.02	0.04
P (%)	0.12d	0.55a	0.49b	0.46c	0.01	0.02
K (%)	2.66c	4.26a	2.13b	4.06d	0.05	0.11
N-uptake (kg ha^{-1})	54.02d	106.15a	99.17b	94.25c	2.28	4.66
P-uptake (kg ha^{-1})	7.69d	14.19a	12.75b	11.97c	0.36	0.73
K-uptake (kg ha^{-1})	85.13b	124.11a	123.13a	121.77a	3.34	6.82
	Seed rates (kg ha^{-1})					
	100	125	150	175		
Grain yield (t ha^{-1})	3.82c	5.28a	4.56b	3.41d	0.11	0.22
Net assimilation rate (g m^{-2} day^{-1})	14.42b	19.72a	20.56a	21.28a	1.23	2.52
Crop growth rate (g m^{-2} day^{-2})	14.81b	17.13a	17.22a	14.33b	0.25	0.50
N (%)	2.65c	3.57a	3.20b	2.54d	0.02	0.04
P (%)	0.37c	0.58a	0.48b	0.29d	0.01	0.02
K (%)	3.24d	4.27a	4.01b	3.59c	0.05	0.11
N-uptake (kg ha^{-1})	75.26c	133.13a	97.08b	68.11d	2.28	4.66
P-uptake (kg ha^{-1})	8.98b	15.28a	15.89a	6.43c	0.36	0.73
K-uptake (kg ha^{-1})	105.68 b	121.00 a	120.16 a	107.33 b	3.34	6.82

In each row, means followed by common letter are not significantly different at 5% probability level

Crop growth rate (g m^{-2} day^{-1})

The statistical analysis for CRG across seed rate, weed management and their interactive effect revealed significant differences. Comparison of mean using LSD test at 5% probability indicated significant variation in CGR across different seed rates of wheat (Table 1). The result showed that two seed rates of 125 and 150 kg ha^{-1} produced statistically same CGR values (17.22 and 17.13 g m^{-2} day^{-1}) which were higher over SD1 and SD4. While, the lower but non-significant CGR (14.81 and 14.33 g m^{-2} day^{-1}) were recorded at seed rate of 100 and 175 kg ha^{-1}.

Statistical variations were observed in crop growth rate (CGR) under the influence of different weed controlled strategies. The data reveald that chemically weed control plot showed greater CGR of 17.20 g m^{-2} day^{-1} followed by 16.24 and 16.03 g m^{-2} day^{-1} in plots where weeds were controlled by interculturing (W3) and allelopathic weed control (W4). But, minimum CGR (14.01 g m^{-2} day^{-1}) was recorded in no weeding plot (W1). Statistically, weed management such as

W3 and W4 were at par from each other (Table 1).

The interactive effect of seed rates x weed management on CGR was significant as depicted in (Table 2). Higher CGR (19.69 g m^{-2} day^{-1}) was recorded at W2 with seed rate of 125 kg ha^{-1} followed by 18.89 g m^{-2} day^{-1} at W2 with seed rate of 150 kg ha^{-1}. In case of interaction of seed rate of 175 kg ha^{-1} with WI, W2, W3 and W4 along with SD1 x W1 and SD2 x W1 showed CGR statistically at par. However, the interactive effect of SD1 x W1 produced minimum CGR (13.36 g m^{-2} day^{-1}).

Leaf NPK concentration (%) of wheat as affected by seed rates and weed management

Statistical analysis for leaf nitrogen, phosphorus and potassium concentration across different seed rates and weed management and their interaction exhibited significant differences. The results revealed that Leaf NPK concentration was significantly affected by different seed rates (Table 1). The LSD test for comparison of mean ($p \leq 0.05$) showed higher N (3.57%), p (0.58%) and K (4.27%) concentration at seed rate of 125 kg ha^{-1} followed by 3.20, 0.48 and 4.27% at the seed rate of 150 kg ha^{-1}. While, minimum leaf N and P concentration were observed at the higher seed rate of 175 kg ha^{-1} but in case of K, its minimum concentration was noted at the seed rate of 100 kg ha^{-1}.

The effect of weed management on leaf N, P, and K concentration was significantly different as exhibited in (Table 1). The comparison of mean at 5% LSD test showed higher leaf N (3.51%), P (0.55%) and K concentration (4.26%) at W2 followed by 3.33, 0.49 and 2.13% at W3. While, minimum N (1.96%) and P concentration (0.12%) was noted in plot where weed not eradicated (W1) but minimum K concentration (4.06%) was exhibited in plot where weed were controlled by allelopathic weed management (W4).

The interactive effect of seed rates x weed management on was significant as presented in Table 3. The result showed greater concentration of N, P and K (4.28, 0.77 and 4.93%) at W2 followed by concentration of 4.14, 0.70 and 4.67% at W3 with seed rate of 125 kg ha^{-1} (SD1 x W2 and SD1 x W3). But, their minimum concentration of 1.58, 0.18 and 1.28% was exhibited by the interaction of SD1 x W1 (Table 2).

NPK uptake (kg ha^{-1}) of wheat as affected by seed rates and weed management

Statistical analysis for nitrogen, phosphorus and potassium uptake under the influence of different seed rates and weed management practices and their interaction indicated significant differences. The uptake of nutrients including N, P and K varied significantly across different seed rates (Table 1). The LSD test for comparison of mean ($p \leq 0.05$) showed higher uptake of N (160.16 kg ha^{-1}) and P (15.89 kg ha^{-1}) at seed rate of 150 kg ha^{-1} followed by 158.51 kg N ha^{-1} and 15.28 kg P ha^{-1} at the seed rate of 125 kg ha^{-1}. While, minimum N and P uptake (147.33 and 8.98 kg ha^{-1}) were observed at lower seed rate of 100 kg ha^{-1}. But, in case of K, its maximum uptake was recorded at the seed rate of 125 kg ha^{-1} followed by 97.08 kg ha^{-1} at seed rate of 150 kg ha^{-1} but in the higher seed rate of 175 kg ha^{-1} reduced of K uptake (68.11 kg ha^{-1}). Statistically the uptake of N and P were at par when seed rate of 125 and 150 kg ha^{-1} was used.

Table 2. The interactive effect of seed rates and weed management practices on NAR, CGR, leaf NPK concentration (%) and NPK uptake (kg ha^{-1}) of wheat crop

Seed rates x weed management practices		Growth traits			Leaf nutrient concentration (%)			Nutrient uptake (kg ha^{-1})		
		NAR (g m^{-2} day^{-1})	CGR (g m^{-2} day^{-2})	Grain yield (t ha^{-1})	N	P	K	N	P	K
100 kg ha^{-1}	No weeding	13.21gh	13.36d	2.77i	1.58o	0.18L	1.28j	45.40L	1.48h	65.17i
	Weedicides appl.	22.98bcd	17.21c	4.32e	3.18g	0.47g	3.91de	87.28f	11.76e	138.26ab
	Hand pulling	22.01c-e	14.33d	4.19e	2.98h	0.40h	3.87e	83.03fg	11.53e	113.49def
	Allelopathic weed management	14.11fgh	14.33d	4.01ef	2.86i	0.42h	3.88e	85.33fg	11.16e	112.38def
125 kg ha^{-1}	No weeding	25.59b	14.01d	2.71i	1.87n	0.22k	2.77i	50.61kl	3.66g	89.96h
	Weedicides appl.	31.95a	17.85c	6.43a	4.28a	0.77a	4.93a	143.86a	20.81a	139.61a
	Hand pulling	19.15c-f	18.89ab	6.11ab	4.14b	0.70b	4.67b	133.60b	19.06b	132.10abc
	Allelopathic weed management	18.37def	18.02bc	5.86b	4.00c	0.64c	4.67b	124.45bc	17.58c	125.74bcd
150 kg ha^{-1}	No weeding	20.21cde	14.33d	2.90hi	2.14m	0.21k	3.16h	58.01jk	17.11c	89.68h
	Weedicides appl.	23.98bc	19.69a	5.36c	3.80d	0.60d	4.40c	117.08cd	20.65a	133.65abc
	Hand pulling	17.27efg	17.41c	5.07cd	3.58e	0.56e	4.35c	110.32de	13.64d	131.56abc
	Allelopathic weed management	17.40efg	17.46c	4.88d	3.28f	0.52f	4.11d	102.91e	12.18de	125.74bcd
175 kg ha^{-1}	No weeding	18.47def	14.33d	3.34g	2.26L	0.36k	3.42g	62.04ij	4.95g	95.73gh
	Weedicides appl.	14.55fgh	14.33d	3.66fg	2.80i	0.35i	3.87ef	76.39gh	7.05f	109.71ef
	Hand pulling	12.15h	14.33d	3.34g	2.62j	0.30d	3.58fg	69.72hi	6.76f	111.05ef
	Allelopathic weed	12.48g	14.33d	3.29gh	2.50k	0.28j	3.56fg	64.30ij	6.97f	106.26
S.E.		**2.47**	**0.49**	**0.21**	**0.04**	**0.02**	**0.11**	**4.57**	**0.72**	**6.68**
LSD at 0.05		**5.05**	**1.01**	**0.43**	**0.08**	**0.3**	**0.22**	**9.32**	**1.46**	**13.63**

Mean bearing the same letters are statistically

The effect of weed management practice on wheat's N, P, and K uptake was significantly different as shown in (Table 1). The results revealed that higher N, P and K uptake of 164.11, 14.19 and 106.15 kg ha^{-1} was exhibited at W2 (weedicides application) followed by 163.13, 12.75 and 99.17 kg ha^{-1} at W3 (interculturing). Statistically, all three weed management practices i.e. W2, W3 and W4 showed N uptake at par.

The interactive effect of seed rates x weed management on N, P and K uptake was significant as presented in (Table 2). The result showed greater uptake of N, P and K (179.61, 20.65 and 143.86 kg ha^{-1}) at W2 when seed rate of 125 kg ha^{-1} was used. While minimum N, P and K uptake of 105.17, 1.48 and 45.40 kg ha^{-1} was registered at W1 (no weeding) with seed rate of 100 kg ha^{-1}. Statistically, the higher uptake of N and P at the interaction of SD2 x W2 and SD3 x W2 was found at par (Table 2).

Weed whole plants NPK concentration under the influence of wheat seed rates

The analysis of variance regarding weed whole plants N, P and K concentration exhibited significant differences under the influence of different seed rates. The LSD test for comparison of mean ($p \leq 0.05$) showed significant differences for nutrient concentration (N, P and K) of weed whole plants across different seed rates (Fig. 1a & b). The maximum concentration of N (2.48%), P (0.25%) and K (2.21%) were observed in plot where seed rate of 100 kg ha^{-1} was applied followed by 2.42, 0.19 and 2.12% of N, P and K when seed rate of 125 kg ha^{-1} was used. While, minimum N, P and K concentration of 1.17, 0.13 and 1.25% was recorded where higher seed rate of wheat (175 kg ha^{-1}) was used. Statistically, the N and K concentraton of weed whole plants were registered at par when wheat seed rate of 125 and 150 kg ha^{-1} were applied.

Weed NPK uptake (kg ha^{-1}) under the influence of wheat seed rates

Nutrient uptakes by weed were increased on the expense of decreasing wheat seed rates. The analysis of variance pertaining to N, P and K uptake by weed showed significant differences under the influence of different wheat seed rates. The LSD test for comparison of mean ($p \leq 0.05$) showed significant differences for nutrient uptake (N, P and K) of weed across different seed rates (Fig. 2a & b). The maximum uptake of N (170.17 kg ha^{-1}), P (16.38 kg ha^{-1}) and K (135.51 kg ha^{-1}) were observed in plot where seed rate of 100 kg ha^{-1} was applied followed by 153.42, 11.85 and 119.75 kg ha^{-1} of N, P and K when seed rate of 125 kg ha^{-1} was used. While, minimum N, P and K concentration of 50.0, 5.21 and 46.38 kg ha^{-1} was recorded where higher seed rate of wheat (175 kg ha^{-1}) was used. Statistically, the uptake of N by weed was noted at par when wheat seed rate of 125 and 150 kg ha^{-1} were applied.

Correlation

The extent of relationship as depicted in (Fig. 3a, b & c) showed that wheat grain yield had positive relationship with CGR ($r = 0.90$), NAR ($r = 0.93$) and harvest index ($r = 0.985$). The coefficient of determination (R^2) indicated that the variation in wheat grain yield was due to its association with CGR (90%), NAR (93 %) and harvest index (97%). While, Correlation coefficient (b) indicated that unit increase in various yield components of wheat correspondingly enhanced grain yield by CGR (0.19 t ha^{-1}), NAR (0.16 t ha^{-1}) and harvest index (0.07 t ha^{-1}). The student Test was performed on those growth parameters of wheat which had showed correlations and the calculated T value was examined for grain yield vs CGR (13.92), grain yield with NAR (17.39), grain yield vs harvest index (38.06). These T values were found higher than book value as calculated at 5% probability level which indicates that the correlations are highly significant.

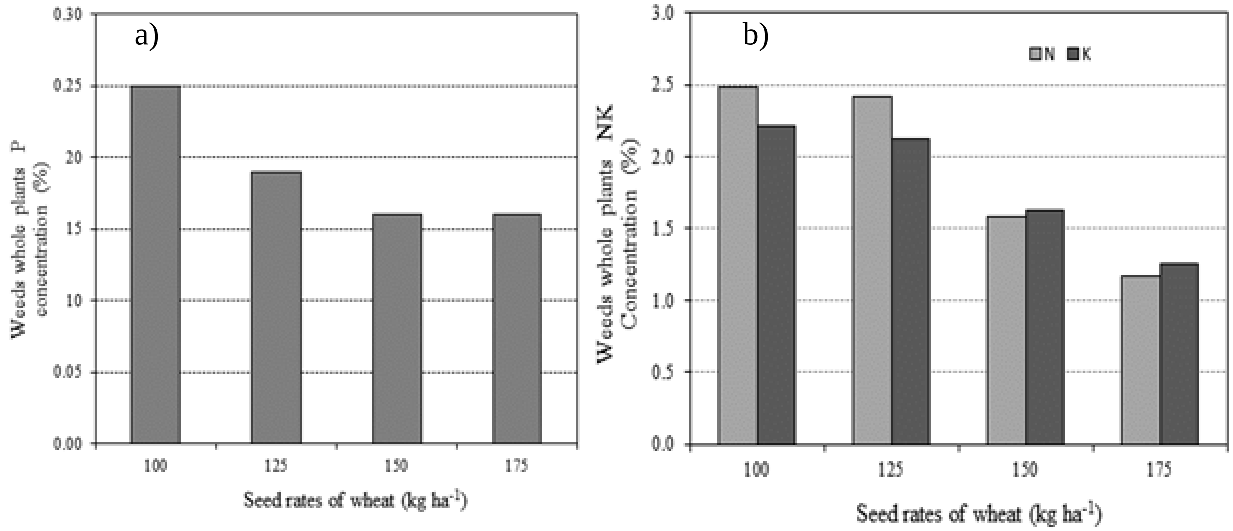

Figure 1. Effect of seed rates on weed whole plants N, K concentration (a) and P concentration (b)

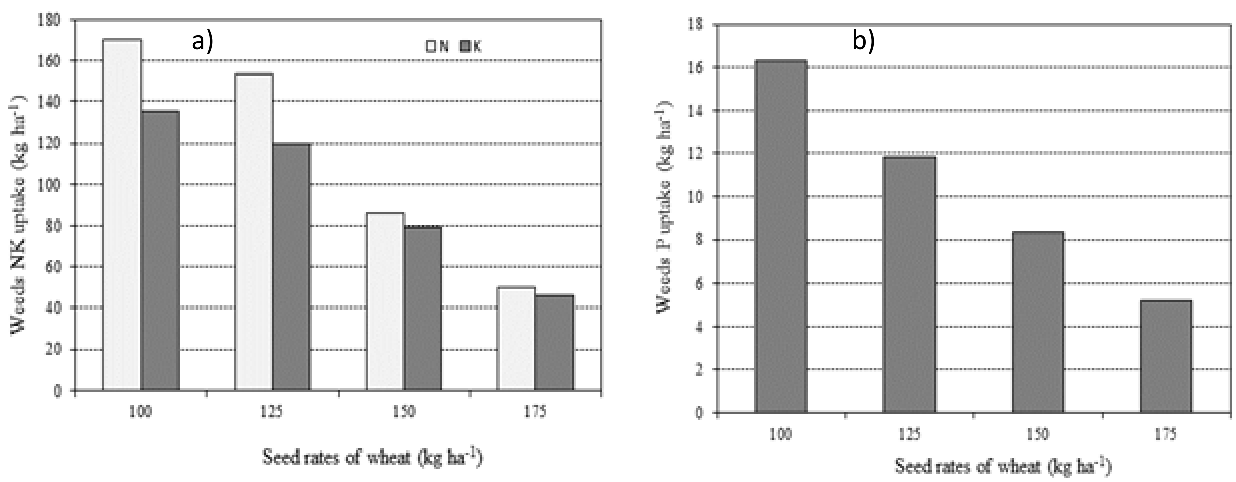

Figure 2. Effect of seed rates on weed N, K uptake (a), and P uptake (b)

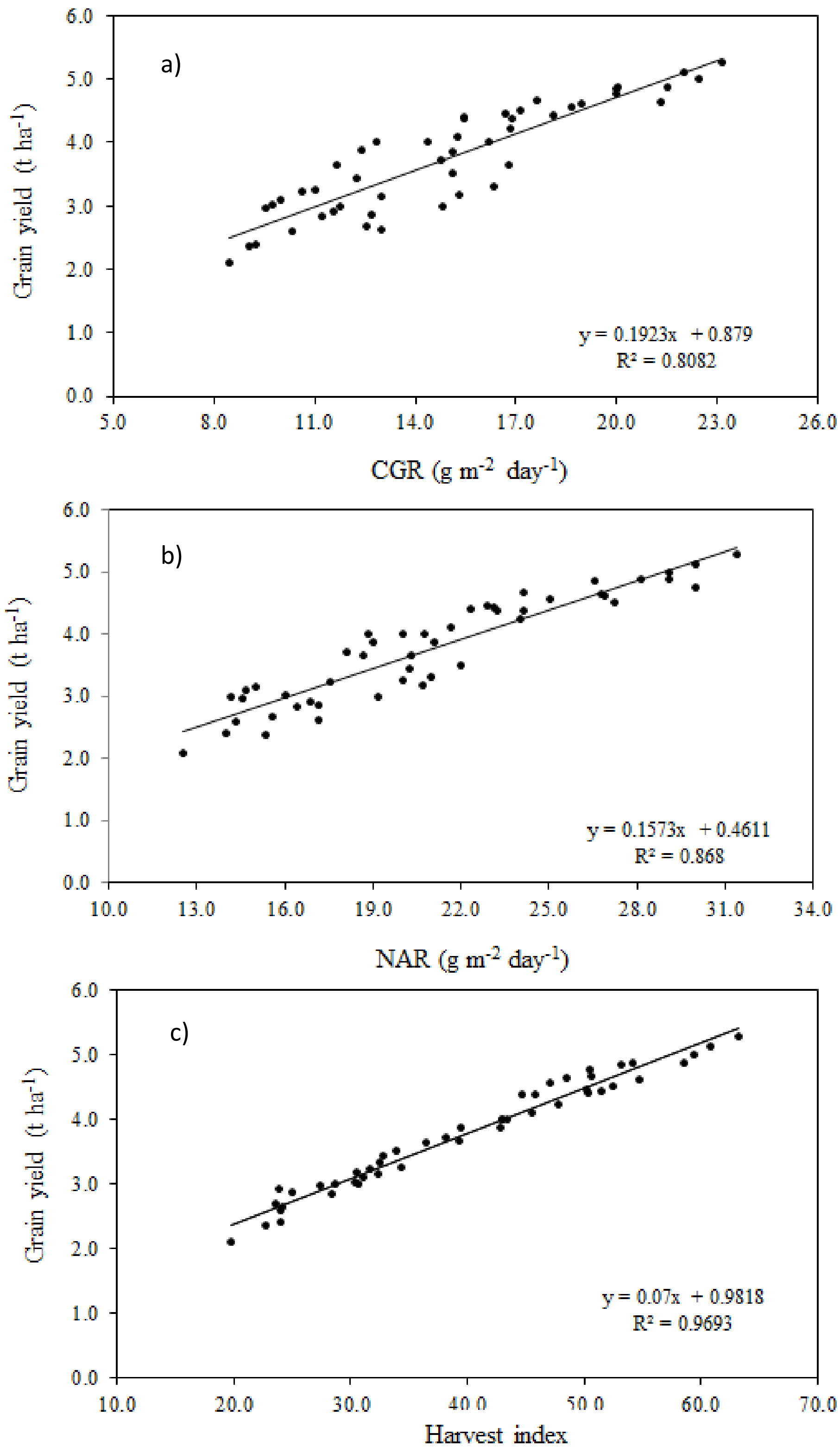

Figure 3. Linear regression between wheat grain yield and CGR (a), grain yield and NAR (b) and grain yield and harvest index (c) as affected by seed rates and weed management practices

Discussion

The best agronomic practices reduce weed crop competition and increase various crops' yield per unit area and particularly of wheat. These practices describe the overall factors responsible for the provision of best growth environment in terms of optimum crop geometry, sustainable nutrient supply capacity of soil, and minimum weed crop competitions. Among them, two agronomic practices such as planting densities and weed management practices are crucial for enhancement of crop growth and yield. A field trail was carried out during 2017-18 at the experimental field of Directorate of Agriculture Research Cereal Crops ARI Sariab Quetta, Pakistan to minimize weed crop competition and increasing wheat yield through these agronomic practices.

The results regarding wheat traits such as CGR, NAR, harvest index, grain yield, nutrient accumulation and uptake and weed whole plants nutrient contents (%) and uptake (kg ha^{-1}) were significantly affected by planting densities and weed management practices.

All morphological features were observed better at medium seed rate of 125 kg per hectare which reflected more yield. Because, the yield reducing factors particularly weed infestation was decreased at average seed rate over lower seed rate. While, the higher seed rate showed lower weed infestation in term of density and biomass. This might be due to the higher competitive nature of wheat plants by occupying more space and better light interception that indirectly prevented the flourishing of weeds over lower seed rates. So in this investigation, the better crop growth and greater grain yield was exhibited on 125 kg seed sown per hectare. It is prerequisite for crop to have optimum space for better root proliferation so that they can efficiently utilize the available resources like moisture, nutrients and light and can enhance competitive nature of the crop stand against weeds. According to Geleta *et al.* **[17]** that the achievement of greater grain yield with best quality depends on appropriate seed rate.

Wheat physiological characteristics as studied during the study were significantly affected by various seed rates. Higher NAR and CGR values were recorded when wheat were planted @ 125 kg per hectare followed by 150 kg seed rate. However, higher seed rate resulted in reducing all the studied physiological traits of wheat. It demonstrates that for obtaining higher grain yield, the enhancement of yield components including studied physiological characteristics are essential. This fact is evidenced from linear regression analysis as given in Fig. 5 revealed that statistically significant and positive correlation was found between wheat grain yield and CGR, NAR as well as harvest index. These growth indices are driven by many factors and seed rate is one of them. Consequently, medium seed rate (125 kg ha^{-1}) perform best for enhancement with respect to physiological characteristics of wheat. Similar findings were stated by Jeffery *et al.* **[29]** that CGR is directly associated to LAI which manifests the interception of light by crop and indirectly by crop density. Because crop density directly and indirectly affect crop growth and productivity. According to Hasanpour *et al.* **[30]** that three planting densities (i.e. 350, 450 and 550 plants m^{-2}) of wheat for leaf area and CGR and their results showed maximum leaf area and CGR on medium planting density.

The increase in nutrient concentration and uptake of wheat was noted in plot when the 125 kg seeds ha^{-1} was used followed by 150 kg seeds ha^{-1}. It means that increase in agronomic as well as physiological characteristics of wheat at the medium seed rate were due to more nutrient accumulation and uptake leading to yield enhancement. The higher seeding rate showed comparatively lower leaf nutrient concentration and uptake which might be due to the increase of intraspecific plants competition for nutrients that resulted in lower grain yield. In case of lower seed rate i.e. 100 kg ha^{-1} resulted in higher weeds density and biomass leading to higher nutrient accumulation and uptake of weed whole plants. Similar results were reported by khan *et al.* **[31]** when they tested different wheat seed rates (100, 130, 160 and 190 kg ha^{-1}) against weeds under field condition and recorded maximum 281.9 spikes m^{-2}, 50.0 grains $spike^{-1}$, 30.26 g seed index of wheat under no wild oat density but increased weed densities reduced all studied parameters of wheat. Together with that 160 kg seeds ha^{-1} reduced wild oat densities with greater wheat yield but greater than this rate resulted in low grain yield. Likewise, Siddiqui *et al.* **[32]** examine the harmful effect of weeds on wheat yield losses and narrated that among these weed species, *Poa annua* caused 76% reduction in grain yield of inqalab 91 while *Rumex dentatus* caused 55% reduction in yield of Punjab 96 indicating better competitive ability against weed infestation.

The integration of weed management with agronomic practices is aimed to minimize the harmful impact of weeds on crop **[33]**. These experimentations indicated that the agronomic and physiological characteristics of wheat were significantly affected by diverse weeds management strategies. The results further revealed that herbicides application (W2) provided effective weed control as compared to no weeding that was closely followed by interculturing (W3). It means that weed infestation is one of main growth and yield constraint of wheat. So, the proper weed control is the pre-requisite of enhancing yield. It is fact that interculturing weed control is effective but its application on large scale is not feasible. The chemical weed control i.e. herbicide application was observed effective equally or more than the interculturing which consequently improved the overall agronomic parameters of wheat crop. The researchers like Kristensen *et al.* **[34]** noted chemically weed control more effective and found 21% higher biological and grain yield highest infested plot. Jabbar *et al.* **[35]** recorded greater harvest index of 40.9% in plot when weeds were controlled by herbicides application (Dicuran MA 60 WP). The wheat physiological characteristics such as NAR and CGR were significantly affected by weed management practices. The maximum, NAR and CGR of wheat was recorded when weed were controlled by herbicides application with closely followed by hand pulling method of weed control. As compared to no weeding, the allelopathic weed control also resulted in increasing physiological traits of wheat but were less effective as compared to herbicides application and hand pulling weed control. This increase in physiological traits might be due to reduction of competition between wheat and weeds for space, moisture, nutrients and light because yield production of most crops particularly of wheat are significantly affected by weeds. Similar effect of weeds control on wheat physiological characteristics were reported by Mubeen *et al.* **[36].** Girma **[37]** revealed that LAI and CGR were decreased by 61-75% due to competition of wild mustard. Fischer **[38]** indicated CGR reduction of wheat related with a simultaneous decline in light interception due to weed infestation. The higher grain yield and harvest index were found at the interaction of 125 kg seeds ha^{-1}xW2 as well as W3 respectively.

Conclusion

From this study, it is inferred that the manipulation of planting density and weed management practices manifested significant variations on wheat traits. During these investigations, it was evidenced that agronomic and physiological traits of wheat along with nutrient accumulation and uptake were increased when optimum seed rate i.e. 125 kg ha^{-1} and chemically control weed management and hand hoeing are adopted. Consequently, these practices minimized weed crop competition and recorded higher wheat yield. The linear regression analysis between yield and yield components under the influence of seed rates and weed management practices were positive and significant which rectifies that enhancement in yield was due to the increase of all agronomic and physiological characteristics and higher nutrient uptake.

Authors' contributions

Conceived and designed the experiments: M Sharif, Performed the experiments: A Sattar, Analyzed the data: A Jan & A Khan, Contributed materials/ analysis/ tools: J Anjum, Wrote the paper: M Sharif & MK Bughti.

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