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Research Article

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Identification of Potential Agronomic Practices for Wheat (*Triticum Aestivum*l.) Under Agro-Climatic Condition of District Nowshera, Pakistan

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Abstract

Agronomic management is one of the prime controlling factors to improve productivity. A study was conducted at Cereal Crops Research Institute Pirsabak Nowshera during 2021-22 growing season to standardize crop orientation (North-South and East-West), Row spacing (15, 20 & 30 cm), Seed rate (100, 115 and 130 kg ha-1) and fertilizer (0:0:0, 40:30:20, 80:60:40, 120:90:60, 160:120:80 and 200:150:100 N: P2O5: K2O kg ha-1) in a split plot design replicated thrice. Row orientation did not affect yield and related parameters while row spacing positively affected 1000 seed weight and biological yield whist fertilizer dose and seed rate had improved wheat yield and its attributes. Maximum grain yield (4228 kg ha-1), seed weight (46.79 g), productive tillers m-2 (429) and plant stature (111 cm) were recorded when fertilized with 160-120-80 kg N:P2O5:K2O ha-1. For seed rate, maximum grain yield (3266 kg ha-1), grain weight (41.72 g), total biomass (7756 kg ha-1) and taller plants were recorded when sown at 130 kg ha-1 seed rate. Maximum productive tillers m-2 was observed with 100 kg ha-1 seed rate. All factors showed significant interaction affecting yield and yield attributes. Row orientations affected yield and its components in interaction with fertilizer application, seed rate and row spacing showing a slight edge of the East-West over the North-South row orientation. In conclusion, East-West row direction, fertilizer application at 160:120:80, 30 cm row spacing, and 130 kg ha-1 seed rate could be recommended for acquiring wheat production under the agro-climatic conditions of Nowshera District, Pakistan.

Keywords: Fertilizer dose, row orientation, row spacing, seed rate, wheat.

Introduction

Agriculture is one of the important and largest sectors acting as a backbone for the development of the country's economy. Since independence, the government has prioritized its growth and development for the provision of basic food requirements to its people through interest-free loans and subsidies on various inputs. Wheat crop is an important cereal of the country and its growing conditions and soil status is also favourable, yet many instances persist in the history of the Pakistan when it was imported due to low local crop productivity. This situation was a genuine challenge in front of agricultural scientists all including agronomists, soil scientists, crop protectionists and breeders. It was due to their joint efforts and tireless research that wheat productivity in Pakistan has significantly increased and attained an average yield of 2775 kg ha^{-1} (Govt. of Pak, 2014-15). At Khyber Pakhtunkhwa (KP) level, agriculture serves as the main public profession and contributes 13% to the province GDP (International Growth Center, 2015). However, despite deep alluvial and loess and silt loam soils, average wheat productivity in the province (1.8 t ha^{-1}) and at country level (2.8 t ha^{-1}) is still below then worlds average yield of wheat (Korea 3.82 t ha^{-1} and China 4.76 t ha^{-1}) (Chand *et al*., 2011; Bureau of Statistics, KP. 2015).

Several factors are responsible for obtaining low wheat yield in the country, the most important ones are improper sowing methods and farming practices, poor soil fertility and non-recommended fertilization, insufficient plant population and poor crop husbandry (Ahmad and Khan, 2018). According to Brant (2009), crop yield mainly depend on plant stand design in wheat and other crops that depends mostly on nutrients, light, water and weeds all of which possess important implications on crop yield. Wheat varieties differ in architecture and growth pattern and thus require different row spacing. Higher proportion of incident radiation intercepted by crop canopy and at the soil surface is responsible for maximum yield (Eberbach, 2005). Wider row to row distance is not desirable in row crops because the solar radiation falls between crop rows remains un- utilized. On the other side, in narrow row distance, due to dense population they suffer from shading effect of other plants as well as due to increased plants competition for moisture and nutrients, yield may be reduced (Das, 2011).

Optimum plant population is a major factor for determination the capacity of the crop to utilize resources and produce increased yield. It can be obtained by using recommended seed rate. Environmental conditions affect development and grain yield of wheat and can be adjusted by planting time and seed rate (Ozturk *et al*., 2005). Baloch *et al.* (2010) reported that more grains spike^{-1} and productive tillers m^{-2} can be achieved at 150 kg ha^{-1} seed rate. Khan *et al.* (2001) reported higher yield of wheat at 100-150 kg ha^{-1} seed rate and row- row distance of 27 cm. The relationship between grain yield and plant population is inversely proportional because of the plasticity of wheat which refers to the compensatory capacity of the crop to retain yield by altering yield attributes (Hucl and Baker, 1993).Plant competition for resources especially for nitrogen increases with increase in plant density that affect the yield of crop. Additional nitrogen application can further enhance yield by increasing plant population up to an optimum level. At higher seed rate further increase in nitrogen fertilization can lead to lodging of plants (Nazir *et al*., 2000). In recent years, the use of machinery in farming and the practice of planting crops in rows have been on the rise in Pakistan. This trend is expected to continue growing in the near future. While literature reveals the effectiveness of fertilization and crop management for crop yield and soil fertility restoration(Arif *et al*., 2012; Ahmad and Khan,2014) there is still a lack of awareness on proper row spacing, row direction, seed rate and optimum use of fertilizer required for maximum wheat yield. Manipulation and adjustment of cropping technology is needed with changing yield demand, this study examined the effect of row spacing, row orientation, seed rate and optimum fertilizer dose on yield and yield attributing characters of wheat.

Materials and Methods

Study site: This study was conducted at Cereal Crops Research Institute Pirsabak village of district Nowshera, Khyber Pakhtunkhwa province in Pakistan. The village Pirsabak is located on the bank of river Kabul (**34º 01'** N, **72º 02'** E longitude and 288 m above mean sea level). Soil type of experimental site was silty loam having 0.82 percent organic matter, pH of 8.1, 4.5 – 6.0 mg available phosphorus / kg Olson- P and 100 mg available K / kg of soil.

Experiment layout: The experiment was laid out in randomized complete block design with split plot arrangement having 3 replications; with plot size of 4m ×1.2m and a total of 324 plots. The treatment factors are described as; crop orientations as North-South and East-West similarly, row spacing (15, 20 and 30 cm), seed rate (100, 115 and 130 kg ha^{-1}) and fertilizer doses of 0:0:0, 40:30:20, 80:60:40, 120:90:60, 160:120:80 and 200:150:100 (N: P_2O_5:K_2O kg ha^{-1}). Row orientations and row spacing were allotted to main plot while seed rate and fertilizers to sub plot. The sources of N, P_2O_5 and K_2O were urea, Diammonium phosphate (DAP) and sulphate of potash (SOP), respectively. Nitrogen (N) was applied in two split doses, one at sowing time and other at tillering stage while phosphorous (P) and potassium (K) were applied at sowing time to all treatments. Wheat variety Gulzar-2019 was sown on 15th November, 2021 manually with single row hand drill and harvested on 20th may 2022. Mean monthly temperature, rainfall and stress duration was recorded during the growing season of wheat as presented in Figure 1. Data was recorded on plant height, spikes m^{-2}, biological yield grain yield and thousand grains weight as per standard procedure.

Statistical analysis: Data were analysed for determination of significant variation amongst treatments by using statistix8.1 software. Significantly different means were separated by using LSD at the *p* level of 0.05 and 0.01 as outlined by Steel and Torrie (1984)

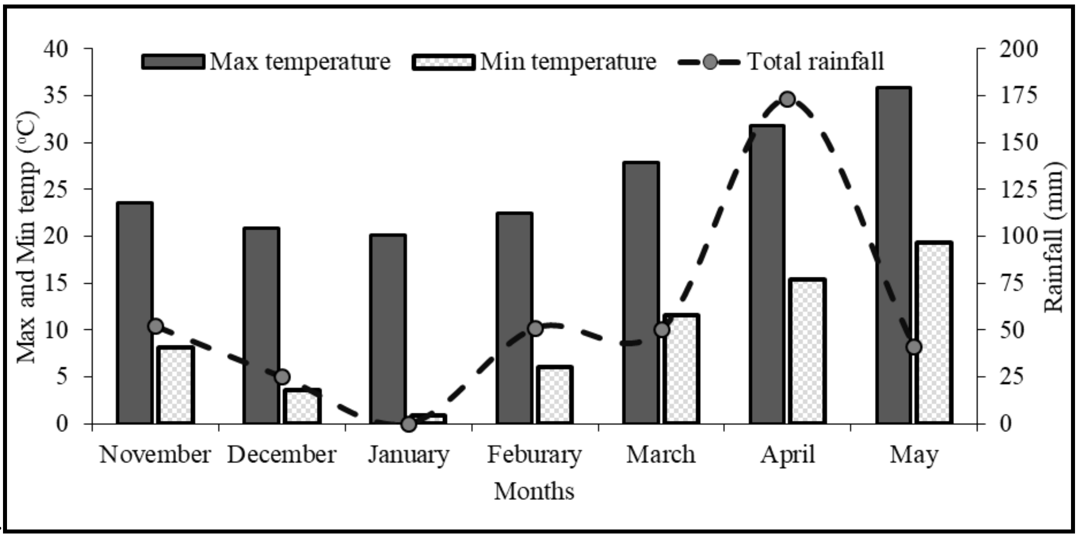

Figure 1. Distribution of rainfall and temperature during the growing season 2021-22.

Results

Results showed non-significant effect of row orientation on either of the yield attribute whilst the row spacing significantly affected 1000 grain weight and biological yield. Row 20 and 30 cm apart recorded 2 and 6% higher 1000 grain weight but 8 and 10% lower biological yield than rows 15 cm apart, respectively. Biological yield produced with 20 and 30 cm row spacing was statistically similar (Table 1). Fertilizer NPK and seed rate levels significantly affected yield and yield attributes of wheat (Table 1). Grain yield (kg ha^{-1}), number of spikes m^{-2}, 1000 grain weight (g), biological yield (kg ha^{-1}) and plant height (cm) recorded by fertilizer levels were in the order; 160:120:80 >200:150:100 >120:80:60> 80:60:40>40:30:20> 0:0:0 $N:P_2O_5:K_2O$ kg ha^{-1} showing increase in grain yield by 167, 148, 133, 96 and 51%, in number of spikes m^{-2} by 92, 77, 59, 24 and 11%, in 1000 grain weight by 35, 27, 22, 15 and 7%, in biological yield by 222, 198, 148, 104 and 61% and in plant height by 20, 15, 14, 12 and 8%, respectively (Table 1). Among seed rates, 130 kg ha^{-1} produced 6 and 5% higher grain yield, 13 and 7% higher number of spikes, 4 and 2% higher 1000 grain weight and 2 and 0.2% higher plant height over 100 and 115 kg ha^{-1} seed rate, respectively. Biological yield in 130 kg ha^{-1} seed was 4% higher over both 100 and 115 kg ha^{-1} seed rate. Seed rate of 100 and 115 kg ha^{-1} were statistically similar in grain and biological yield and in plant height (Table 1).

Table 1. Wheat yield attributes as influenced by row orientation, row spacing, fertilizer NPK levels and seed rate.

Treatment	**Plant height (cm)**	**Number of spikes m^{-2}**	**1000 grain weight (g)**	**Biological yield kg ha^{-1}**	**Grain Yield kg ha^{-1}**
Orientation (OR)					
E-W	103.12	323	40.7	7496	3192
N-S	103.43	320	41.02	7579	3113
Significant	NS	NS	NS	NS	NS
Row spacing (RS)					
RS1 (15 cm)	104.52	105	39.78c	7976 a	3166
RS2 (20 cm)	102.71	103	40.72b	7396 b	3134
RS3 (30 cm)	102.59	103	42.08a	7241 b	3157
LSD (0.05)	NS	NS	0.45	517.92	NS
Fertilizer (F) kg ha^{-1}					
0:0:0 (F1)	92.35d	223 f	34.62f	3390f	1580f
40:30:20 (F2)	100.005c	249 e	37.18e	5454e	2392e
80:60:40 (F3)	104.00 b	278 d	39.95d	6946d	3102d
120:80:60 (F4)	105.52b	356 c	42.41c	8408c	3689c
160:120:80 (F5)	111.11a	429 a	46.79a	10917a	4228a
200:150:100 (F6)	106.17b	395 b	44.22b	10112b	3923b
LSD (0.05)	2.36	7.12	0.61	282.87	69
Seed Rate (SR) kg ha^{-1}					
SR1 (100)	102.35b	340 a	40.00c	7453 b	3079b
SR2 (115)	102.65b	324 b	40.87b	7403 b	3113b
SR3 (130)	104.82a	301 c	41.72a	7756 a	3266a
LSD (0.05)	1.67	5.95	0.43	517.92	49

Mean followed by different letters in each column are differ from each other significantly, NS=non-significant.

Interaction of row orientation and fertilizer dose (OR x F) and row orientation and row spacing (OR x RS) significantly (*p*<005) affected grain yield and yield attributes of wheat (Table 2). Grain yield (4282 kg ha^{-1}), number of spikes m^{-2}, 1000 grain weight, biological yield (kg ha^{-1}) and plant height (cm) were higher by 170, 100, 34, 222 and 21%when crop was sown on East-West oriented rows and fertilized at the rate of 160-120-80 kg $N:P_2O_5:K_2O$ ha^{-1}.East-West oriented rows fertilized with 200-150-100 kg $N:P_2O_5:K_2O$ ha^{-1}showed 148, 83, 26, 201 and 16% increase in the above parameters over the fertilizer control plots in the same row orientation setup.. The North-South row orientation showed statistically similar but 7% and 1% lower grain yield,2 and 3% higher 1000 grain weight and 12 and 5% higher in biological yield (kg ha^{-1}) and 1 and 1% higher plant height with the above mentioned two highest fertilizer doses in East-West row orientation. Number of spikes m^{-2} with the highest doses of fertilizers in East-West orientation were significantly higher (by 14 and 10%) than North-south orientation.

Interaction of row orientation and row spacing (OR x RS) showed that highest grain yield (3313 kg ha^{-1}) was produced when sown on 15 cm apart East-West oriented rows. While grain yield with 20cm row spacing in the same row orientation set up (3146kg ha^{-1})and grain yield with rows 30 cm apart in North-South orientation (3198 kg ha^{-1})were statistically similar with the highest value.(Table 2). The lowest grain yield (3019 kg ha^{-1}) was observed with 15 cm apart North-South oriented rows. Maximum and statistically similar number of spikes m^{-2} were recorded on 15 cm apart in the North-South (340) and East-West (339) oriented rows; both were significantly higher than rest of their combinations whilst the lowest number of spikes m^{-2} (291) was observed with 30 cm apart North-South oriented rows. The 1000 grain weight with row 30 cm apart in North-South(42.25 g) and East-West (41.92 g) oriented rows were statistically similar among themselves and significantly (p<0.05) higher compared to rest of row spacing-row orientation combinations whilst the lowest 1000 grain weight (39.67 g) was observed with rows 15 cm apart in East-West orientation. Biological yield (8052 kg ha^{-1}) and plant height (105.37 cm) were maximum with rows 15 cm apart in East-West orientation but and significantly (p<0.05) than the biological yield and plant height with rows 20 and 30 cm apart in the same row orientation. Biological yield and plant height with all row spacing in the North-South orientation were statistically similar with their maximum values observed with 15 cm row spacing and East-West orientation.

Table 2. Interaction of row orientation with fertilizer levels and row spacing affecting wheat yield and yield attributes.

Treatment	**Plant Height (cm)**	**Number of spikes (m^{-2})**	**1000 grain weight (g)**	**Biological yield (kg ha^{-1})**	**Grain Yield (kg ha^{-1})**
Orientation*Fertilizer					
OR1*F1	91.44f	222 h	34.68f	3328g	1584h
OR1*F2	101.48de	247 g	36.80 e	5349f	2328g
OR1*F3	103.11cd	273 f	39.97d	7037e	3219e
OR1*F4	106.04bc	347e	42.40 c	8532d	3806c
OR1*F5	111.00 a	445a	46.51a	10711ab	4282a
OR1*F6	105.63bc	406b	43.87b	10019c	3931b
OR2*F1	93.26f	223 h	34.56f	3451g	1576h
OR2*F2	99.52e	252g	37.55e	5559f	2456g
OR2*F3	104.89bcd	283f	39.93d	6854e	2985f
OR2*F4	105.00 bcd	364 d	42.43c	8283d	3573d
OR2*F5	111.22a	414 b	47.07a	11123a	4173a
OR2*F6	106.70 b	383 c	44.58b	10206bc	3916bc
LSD (0.05)	**3.34**	**10**	**0.86**	**400**	**98**
Orientation*Row Spacing					
OR1*RS1	105.37a	339a	39.67d	8052 a	3313a
OR1*RS2	102.19b	321 b	40.52bc	7318bc	3146ab
OR1*RS3	101.8b	310c	41.92a	7117c	3116b
OR2*RS1	103.67ab	340a	39.88cd	7900ab	3019b
OR2*RS2	103.24ab	328 b	40.93b	7474abc	3122b
OR2*RS3	103.39ab	291d	42.25a	7363abc	3198ab
LSD (0.05)	**3.14**	**8.41**	**0.63**	**732**	**182**

OR1: orientation of rows at East-West, OR2: orientation of rows at North-South. RSI: row spacing 15 cm, RS2: row spacing 20 cm, RS3: row spacing 30 cm, N:P_2O_5:K_2O @ 0:0:0 (F1), 40:30:20 (F2), 80:60:40 (F3), 120:80:60 (F4), 160:120:80 (F5), 200:150:100 (F6) kg ha^{-1}. Mean followed by different letters in each column are differ from each other significantly

Interaction of row spacing with seed rate (RS x SR) and row orientation with seed rate (OR x SR) had significantly affected yield and yield attributes of wheat (Table 3). Grain yield (3308 kg ha^{-1}) and 1000 grain weight (43.76 g) were significantly (p<0.05) when sown on 30 cm apart rows with 130 kg ha^{-1} seed rate. Rows 15 and 20 cm apart with 130 kg ha^{-1} seed rate produced statistically similar grain yield (, 3235 and 3255 kg ha^{-1}, respectively) to maximum value at 30 cm row spacing with 130 kg ha^{-1}(RS3 * SR3) but their respective 1000 grain weight were significantly lower than the maximum value at RS3 * SR3. Number of spikes m^{-2} (359) and plant height (105.39 cm) were maximum on 15 cm row spacing sown with 130 kg ha^{-1} seed rate. Number of spikes m^{-2} (339) produced on 20 cm rows apart sown with 130 kg ha^{-1}was the second highest value but was significantly (p<0.05) lower than the maximum value. However, plant height at 15 cm row spacing with all three seed rates (100, 115 and 130 kg ha^{-1}), at 20 cm row spacing with 115 and 130 kg ha^{-1} seed rate and at 30 cm row spacing with 130 kg ha^{-1} seed rate were statistically similar. Grain yield and plant height at 20 cm row spacing, number of spikes m^{-2} at 30 cm row spacing, 1000 grain weight at 15 cm row spacing all in interaction with 100 kg ha^{-1} seed rate recorded their lowest values (Table 3).

Data on interaction between row orientation and seed rate (OR x SR) showed that maximum grain yield (3286 kg ha^{-1}), 1000 grain weight (41.73 g) and plant height (104.83 cm) were recorded on East-West oriented rows and number of spikes m-^{2} (338) was maximum in North-South oriented rows all sown with 130 kg ha^{-1} seed rate. However, values of grain yield, number of spikes m^{-2}, 1000 grain weight and plant height were statistically similar at both East-West and North-South oriented rows when grown with 130 kg ha^{-1} seed rate. Grain yield and spikes m^{-2} at rows orientation sown with 100 and 115 kg ha^{-1} seed rate were significantly lower. However, 1000 grain weight at North south orientation with 115 kg ha^{-1} seed rate was statistically similar with the maximum value. Similarly, plant height at East-West orientation with 100 kg ha^{-1} seed rate was significantly lower than rest of the seed rates at either orientation which were statistically similar among themselves (Table 3).

Table 3. Interaction of seed rate with row spacing and row orientation affecting wheat yield and yield attributes.

Treatment	**Plant Height (cm)**	**Number of spikes (m^{-2})**	**1000 grain weight (g)**	**Grain Yield (kg ha^{-1})**
Row spacing*Seed rate				
RS1*SR1	104.58ab	326 c	39.13f	3148bcd
RS1*SR2	103.58abc	334 bc	39.98e	3114bcde
RS1*SR3	105.39a	359a	40.22de	3235abc
RS2*SR1	100.67c	309 d	40.18de	3021e
RS2*SR2	102.58abc	325c	40.81cd	3126bcde
RS2*SR3	104.89ab	339 b	41.18bc	3255ab
RS3*SR1	101.81bc	293 e	40.68cde	3066de
RS3*SR2	101.78bc	301de	41.81b	3098cde
RS3*SR3	104.19ab	309 d	43.76a	3308a
LSD (0.05)	2.90	8.71	0.74	**85**
Orientation of rows*Seed rate				
OR1*SR1	101.74b	312 cd	39.80 d	3122cd
OR1*SR2	102.78ab	325b	40.59bc	3167bc
OR1*SR3	104.83a	333a	41.73a	3286a
OR2*SR1	102.96ab	306d	40.20 cd	3036d
OR2*SR2	102.52ab	315c	41.15ab	3059cd
OR2*SR3	104.81a	338a	41.71a	3246ab
LSD (0.05)	2.36	7.11	0.61	69

OR1: orientation of rows at East-West, OR2: orientation of rows at North-Sowth. RSI: row spacing 15 cm, RS2: row spacing 20 cm, RS3: row spacing 30 cm, SR1: seed rate 100 kg ha^{-1},SR2: seed rate 115 kg ha^{-1}, SR3: seed rate 130 kg ha^{-1}. Mean followed by different letters in each column are differ from each other significantly

Interaction between seed rate and fertilizer dose (SR x F) significantly (p<0.05) affected yield and yield attributes of wheat (Table 4).Grain yield (4349 kg ha^{-1}), number of spikes m-2 (446), 1000 grain weight (47.56 g) and biological yield (11142 kg ha^{-1})were significantly (p<0.05) higher when sown with 130 kg ha^{-1} seed rate and fertilized at the rate of 160-120-80 kg NPK ha^{-1}. All other combinations of seed rate and fertilizer levels yielded significantly lower grain yield and number of spikes m^{-2}than the maximum value, The maximum grain yield and number of spikes m^{-2}, and 1000 grain weight were followed by grain yield (4212 kg ha^{-1}), number of spikes m^{-2} (432) and 1000 grain weight (46.85 g) recorded with 115 kg ha^{-1} seed rate fertilized at the rate of 160-120-80 kg NPK ha^{-1}. However, the 1000 grain weight (46.85 g) and biological yield (10857 kg ha^{-1}) recorded with 115 and 100 kg ha^{-1} seed rate, respectively, and fertilized at the rate of 160-120-80 kg NPK $ha^{-1}$was statistically similar with their maximum values. The lowest grain yield (1529 kg ha^{-1}), number of spikes m^{-2} (213) and 1000 grain weight (34.07 g) were observed when sown with 100 kg ha^{-1} in fertilizer control plots. The lowest biological yield (3321 kg ha^{-1}) was produced when sown with 115 kg ha^{-1} seed rate in fertilizer control plots. while highest plant height (110.94 cm) was produced when sown with 100 kg ha^{-1} seed rate fertilized at the rate of 160-120-80 kg NPK ha^{-1}followed by a statistically similar plant height (110.83 cm) recorded when sown with 130 kg ha^{-1} seed rate fertilized at the rate of 160-120-80 kg NPK ha^{-1} while lowest plant height (91.33 cm) observed when sown with 100 kg ha^{-1} seed rate in fertilizer control plots (Table 4).

Table 5. Interaction of seed rates with fertilizer levels affecting wheat yield and yield attributes.

Treatment	**Plant height (cm)**	**Number of spikes (m^{-2})**	**1000 grain weight (g)**	**Biological yield (kg ha^{-1})**	**Grain Yield (kg ha^{-1})**
Seed rate*Fertilizer					
SR1*F1	91.33g	213i	34.07i	3386i	1529j
SR1*F2	100.94ef	238 k	36.51j	5330h	2340i
SR1*F3	102.50 def	270hi	38.71gh	6875g	3125g
SR1*F4	103.67cdef	343f	41.13f	8209f	3612f
SR1*F5	110.94a	410c	45.95b	10857ab	4122bc
SR1*F6	104.72cde	381 de	43.62de	10061cd	3743e
SR2*F1	93.50 g	226 k	34.4kl	3321 i	1564j
SR2*F2	99.61f	251j	37.27ij	5408h	2318i
SR2*F3	103.22cdef	273h	39.66g	6832g	3053g
SR2*F4	106.22bcd	349 f	42.71e	8270ef	3591f
SR2*F5	109.56ab	432 b	46.85ab	10750ab	4212b
SR2*F6	103.78cde	391 d	44.31cd	9838d	3939d
SR3*F1	92.22g	229 k	35.38k	3463 i	1648j
SR3*F2	100.94ef	260 ij	37.75hi	5624h	2517h

SR3*F3	106.28bcd	291 g	41.49f	7130g	3129g
SR3*F4	106.67bc	375 e	43.4de	8744e	3865d
SR3*F5	112.83a	446a	47.56a	11142a	4349a
SR3*F6	110.00 ab	413c	44.74c	10438bc	4089c
LSD (0.05)	**4.10**	**12.32**	**1.05**	**490.0**	**120**

SR1: seed rate 100 kg ha^{-1}, SR2: seed rate 115 kg ha^{-1}, SR3: seed rate 130 kg ha^{-1}. $N:P_2O_5:K_2O$ @ 0:0:0 (F1), 40:30:20 (F2), 80:60:40 (F3), 120:80:60 (F4), 160:120:80 (F5), 200:150:100 (F6) kg ha^{-1}. Mean followed by different letters in each column are differ from each other significantly

Discussion

This study found that the orientation of rows, when considered individually, did not have a significant impact on yield and its associated attributes. While these findings may differ from some studies in this area, they align with others that emphasize the importance of crop stand density in enhancing yield and its components (Borger *et al*., 2010; Lyon *et al*., 2006). These researchers suggested that sowing wheat in either direction, whether east-west or north-south, increases shading between the rows, thereby influencing weed growth.

Individually, the effect of row spacing on grain weight and biological yield was significant which may perhaps be due to more efficient photosynthetic activity in wide row spacing (Abouziena *et al*., 2008). Moreover, the reduction of row spacing rendered a decrease in grain weight perhaps due to intra and inters plant competition for different resources required for normal plant growth. High plant densities result in high competition for resources, leading to deficient supplies of nutrients and restricting metabolic activity involved in seed formation (Gobeze *et al*., 2012 and Abouziena *et al*., 2008). Row spacing effect was found non-significant on grain yield and plant height and the results are inconformity with the finding of Pandey *et al*. (2013) who evaluated winter wheat cultivars under different row spacing and row direction. However, Hozayn *et al*. (2012) concluded that row spacing significantly influence grain yield and plant height due to shading effect of row spacing on weed control and ultimately enhanced grain yield.

In Pakistan, particularly in Khyber Pakhtunkhwa, wheat productivity remains low primarily due to poor soil fertility and inadequate nutrient management. Consequently, crops consistently show a significant response to fertilizer application, as observed in the improvement of wheat yield and its related attributes. The increase in grain yield and associated traits resulting from fertilizer application is attributed to the enhanced availability and uptake of essential nutrients provided by the fertilizer. Increase in grain yield with increasing nutrients levels might be attributed to more vigorous crop growth, resulting in efficient production and partitioning of photosynthates, increasing the number of productive tillers m^{-2}, and ultimately increasing grain yield of wheat crop (Mengel *et al*., 2006). The present results are in agreement with the finding of Maqsood *et al*. (2002) reporting the highest yield and yield components along with plant height with the application of nitrogen @150 kg ha^{-1}. According to Liakas *et al*. (2001) increasing P and K ratio in plant enhanced the number of productive tillers in wheat and reduced the lodging effect. Similar results were also recorded by Zhang *et al*. (1999) who's confirmed that P increased root length which enhanced uptake of nutrients, number of productive tillers and improved photosynthetic activity resulting in heavier grains. Decrease in yield components with increased fertilizers levels might be due to crop lodging which increase non-productive tiller m^{-2} and decrease grain weight (Doltra *et al*., 2011).

An optimal seed rate is crucial for wheat production, as wheat yield is influenced by environmental factors that can be managed by the farmer through the seed rate and timing of sowing (Ozturk *et al*., 2005). The current study confirmed the significant ($p<0.05$) effect of seed rate and as were already reported significantly higher wheat yield components with improved seed rate by Iqbal *et al*. (2012). Grain yield and its components were enhanced with a higher seed rate, likely due to improved crop stand and increased spikes per unit area (Ahmadi and Hosseinpoor, 2012). This, in turn, led to a higher grain yield along with an increase in biological yield and the number of grains $spike^{-1}$. In contrast, a low-density crop stand allows more space for individual plants to produce a greater number of tillers. However, simply increasing the number of tillers per plant cannot offset the reduction in the number of spikes per square meter compared to higher-density crops (Ahmadi and Hosseinpoor, 2012). Heavier 1000 grain weight recorded with maximum seed rate of 130 kg $ha^{-1}$are supported by Iqbal *et al*. (2012) whilst some other researchers reported reduction in 1000 grain weight with increase in plant density due to intra plant competition for nutrients and other resources (Ahmadi and Hossein poor,2012).

Interaction of crop row direction and fertilizers significantly influenced yield and yield attributes. Values for grain yield and number of spikes m^{-2}were maximum in East-West oriented rows treated with 160:120:80 kg ha^{-1} $N:P_2O_5:K_2O$ which might be due to crop stand at right angle to sunlight (E-W direction),suppressing weed growth and decreasing competition for nutrients (Borger *et al*., 2010). These results were also in agreement with the findings of Brant *et al*. (2009).Applications of Phosphorous along with nitrogen fertilizer significantly increase yield and yield component along with plant height (Ali *et al*., 1997).

Plant stand design and row spacing are the key parameters for the grain yield of wheat crop because crops orientations affect several factors such as light, water and nutrients which responsible for crop production (Brant *et al*.,2009). Row spacing requirements depend on architecture and growth pattern of crops. Uniform row spacing and proper orientations of crops are needed for greater utilization of light, nutrients and moisture throughout the crop profile and maximum photosynthetic efficiency by all the leaves of a plant (Evers *et al*., 2009).The interaction of row spacing with seed rate was found significant for yield and yield attribute in wheat crop and this result was supported by Gozubenli, (2010) who found that planting pattern and crop density increased corn yield. Interactions of seed rate with row spacing, orientation and fertilizers was also found significant for yield and yield attribute in wheat crop and this result was supported by Gozubenli, (2010); Borger *et al*. (2010) and Iqbal *et al*. (2012). Result of the present study revealed that row orientation, seed rate, row spacing and fertilizer levels are important agronomic management practices that should be given due consideration for their optimization to enhance wheat production. However further study should be replicated under various environments.

Conclusions

Higher yield and yield attributes of wheat crop were obtained at fertilizer level of 160:120:80kg ha $^{-1}$ $N:P_2O_5:K_2O$, row spacing 0.3m with seed rate 130 kg ha^{-1}. Row orientations showed no effect on crop productivity individually whilst significantly affecting the yield and yield components of wheat crop in interaction with fertilizer application, seed rate and row spacing showing a slight edge of the East-West over the North-South row orientation. Thus, application of fertilizer at the rate of 160:120:80, row spacing 0.3m and seed rate 130 kg ha^{-1}and crop row orientation on East=West direction could be recommended for achieving the higher yield and yield attributes of wheat crop.

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Conflict of Interest

The authors have no conflict of interest. \

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