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Effect of varied seeding densities on growth, yield and yield attributes of different wheat (*Triticum aestivum* L.) genotypes of Pothohar region

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Abstract

Seeding density is a key factor that affects grain yield and quality of wheat. An indiscrimination in seeding density has been observed across the wheat growing areas of Pothohar region. Hence optimization of planting density of Pothohar wheat genotypes is vital to boost its yield in rainfed areas as well as in the country. It is of particular significance in wheat production system as it can be controlled. Therefore the objective of this study was to determine the optimum plant stand of three different wheat genotypes (Fatehjang-16, BARS-09 and 13FJ35) of Pothohar region to attain maximum economic yield. Field experiments were conducted at Barani Agricultural Research Station, Fateh Jang during Rabi season of 2016-17 and 2017-18 with varying seed rates *viz*: (S1) 75, (S2) 100, (S3) 125, and (S4) 150 kg ha^{-1}, respectively. Varied seed rates significantly or non-significantly affected all plant traits understudy. However, seed rate of 125 kg ha^{-1} revealed higher germination percentage (75%), plant height (112.33cm), coleoptile length (3.95cm), Nodes per stem (4.66), shoot length (11.51cm), root length (15.36 cm) and grain yield in Fatehjang-2016. However, BARS-09 showed maximum tiller count (430.67/m^2) with less plant height (66.33 cm) and grain yield (2971 kg/ha) at same seeding density. On the contrary, 13FJ35 lacked in all parameters accompanied with grain yield (3086 kg/ha) that is at par with BARS-09. The results clearly reflect that Fatehjang-2016 can be effectively used for general cultivation and higher economic yield returns in Pothohar region with optimum seed rate of 125 kg ha^{-1}.

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Introduction

Wheat (Triticum aestivum) is a prime member of the family Poaceae and major staple food in Pakistan (Ahmad *et al.,* 2018), plays pivotal role in the development of civilization (Martin and Leonard, 1976). Wheat is one of the most extensively grown cereal crop in world and is known as the first domesticated plant (Tanner and Raemkers, 2001). It serves as staple food to nearly one third of the world's population. It is speculated that the global wheat demand may rise upto 775 million tonnes by 2020 and 60% in total by 2050 (Rosegrant and Agcaoili 2010), in order to attain this target the annual wheat production will have to increase upto 2.5 to 4 % of the global mean yield (Mujeeb-Kazi *et al.,* 2013).

According to international wheat production statistics, Pakistan is the world's eighth largest producer of wheat crop and it is grown almost in every part of the country (Pakistan Bureau of Statistics, 2018). It contributes 9.1 percent to the value added in agriculture and 1.7 percent to GDP. Wheat was cultivated on an area of 8734 thousand hectares with production of 25492 million tonnes (Pakistan Economic Survey, 2017-18).

Wheat grain yield and quality is significantly affected by the seed rate applied, hence adjustment of seeding scheme is one of the most pivotal crop management techniques. A decline in wheat grain yield and rise in production cost has been observed while practicing indiscrimination in seeding schemes. Therefore an optimal seeding rate is recommended for higher yield in wheat. It is of particular importance in wheat production because in most cropping systems it is under the farmer's controlling systems (Slafer and Satorre, 1999). Optimum plant densities diverge greatly between areas, soil, sowing time, climatic conditions and varieties (Darwinkel *et al.,* 1977). Decline in yield often occurs where optimal seeding rate increases, (Beuerlein and Lafever, 1989; Harrison and Beuerlein, 1989). Currently, the seed rate used for wheat ranges from 250 to 400 viable seeds per square meter. However, differential performances of varieties pertaining to tiller formation and survival as well as the crop environment, should be taken into account for attaining proper seed densities (Comissão Brasileira de Pesquisa de Trigo, 2007).

A close association exists between wheat stands and yield components (Zhen–Wen *et al.,* 1988). Previous research indicated that seeding rates considerably affected biological yield (Ayaz *et al.,* 1997), achieved stands (Stoppler *et al.,* 1990), spike number and weight (Ozturk *et al.,* 2006). In favourable environments, there is a uniform yield due to regular tiller formation and distribution of photosynthesis products that ultimately contributed to grain yield (Rickman *et al.,* 1983). On the other hand, tiller development in stress conditions is irregular; resulting in development of a high rate of underdeveloped or weak tillers which contest with normal tillers and significantly affect plant grain yields (Martin, 1987). Higher seeding density can be a best practice to compensate for decreased tiller development and promote more main stem spikes that can be advantageous, for the varieties that tend to produce lesser tillers (Coventry *et al.,* 1993; Staggenborg *et al.,* 2003). In addition, adjusting the seeding density to environmental (favourable or unfavourable) conditions adequate the level of competition between tillers, especially around tillering initiation. A better understanding of genotypic response in tillering to environmental and management practices can be useful in adjusting the seed rate thereby increasing grain yield.

The objectives of this research, therefore, were to optimise the seeding density of given genotypes for Pothohar wheat growers and to conclude how different seeding densities can alter yield and to understand better interactive influence of seed rates and genotypes, in order to provide better substitute management practices to farmers facing problem of low grain yields.

Materials and methods

Experimental material, site and design

The field trials were conducted during the Rabi season of 2016-17 and 2017-18 at the field area of Barani Agricultural Research Station Fateh Jang located at 33.54998 North and 72.57929 East 504m above sea level. The climate was sub humid with rain-fed agriculture. The soil texture was sandy loam with pH 7.81 and deficient in Phosphorus & Potassium. Three different wheat genotypes (Fatehjang-2016, BARS-09 and 13FJ35) were sown at varying plant densities of (S1) 75, (S2) 100, (S3) 125, and (S4) 150 kg ha^{-1}, respectively.

The experiment was carried out in split; first half was executed in laboratory conditions with three genotypes grown at varying seed densities in pots with growing media however, the second half was grown in field with 3 genotypes at 4 varying seed densities in triplicate using Randomized Complete Block Design in Factorial arrangement following the procedure of Gomez and Gomez (1984). The row to row distance was maintained at 30cm with 4 rows per treatment of 4m length; however the total plot size was 4.8m^2. All other agronomic practices were kept constant for all treatments. Sowing was performed with single seed coulter hand drill on 25 October 2016 and 2017 respectively, during Rabi season. Nutrients were readily applied at 90-60-30 NPK kg ha^{-1} in the form of urea, DAP (di-ammonium phosphate) and sulphate of potash respectively. All N, P and K were applied during final land preparation at the time of sowing. Weed management practices were done manually for reducing weed-crop competition once before the canopy closure.

Observation and sampling

As the experiment was carried out in split; data collection for the following 10 parameters was also bifurcated into two parts. Data collections for germination percentage, coleoptile length, root & shoot length has been conducted in laboratory whereas, the data collection for other traits was carried out in field.

Germination percentage

Counting was made after first seedling emergence, and computed by the formula given below, derived by Smith and Millet (1964):

$$\text{Germination Percentage (\%)} = \frac{\text{Total no. of seedlings emerged}}{\text{Total no. seeds sown}} \times 100$$

Root length (cm)

Root length was measured after 2 weeks of seed germination with the help of scale and average was computed for statistical analysis.

Shoot length (cm)

Shoot length was measured after 2 weeks of seed germination by using scale and mean was worked out.

Coleoptile length (cm)

Coleoptile length was noted after it attained the maximum length as indicated by the emergence of primary leaf from the coleoptile. Coleoptile length was measured by scale and mean was computed.

Plant height

The plant height was measured from ground level to the top of the spike termination node at harvest through measuring tape in centimeters.

No. of Tillers/ m^2

Number of tillers was counted from m^2 area at time of maturity.

Days to 50% heading

Days to 50% heading (stage when ears emerged after the unfolding of the flag leaf) were documented from the date of sowing to the date of 50% heading (Muller, 1991).

Nodes per stem

Number of nodes was counted prior to maturity.

Days to maturity

Days to physiological maturity were note down as the period from date of sowing to the date of maturity (when 90% of the crop turned yellow).

Grain yield

Wheat bundles were harvested and threshed from each sub plot separately. The average grain yield was recorded in kg per plot and then converted into kg per hectare.

Experimental design

Two factors (wheat genotypes and seed densities) were analysed in RCBD, factorial arrangement. The experimental data was collected and subjected to Analysis of Variance (ANOVA) test using Statistix 8.1 computer Analytical Software (2005), the treatment means were differentiated using Least Significance (LSD) test at P<0.05 (Gomez and Gomez, 1984).

Results and discussions

Response of genotypes

Highly Significant or non-significant differences amongst all genotypes for different characters have been observed that clearly represents the wide range of expression for the characters under study (Table 1). Among all the genotypes, Fatehjang-2016 excelled in germination percentage (70.833 %), Plant height (106.83 cm), Coleoptile length (3.29 cm), Nodes per stem (3.58), Root length (12.35 cm), Shoot length (9.54 cm), Days to heading (126), Days to maturity (170) and grain yield (3403 kg/ha^{-1}). However, BARS-09 revealed maximum no. of tillers (369.67/ m^{2}) with less plant height (63.33 cm) showing less tendency to lodging with less dry matter production (Table 1).

It also exhibited shoot length (9.16 cm) and root length (11.01 cm) at par with Fatehjang-2016. On the contrary, 13FJ35 revealed lowest germination percentage (56.66 %), Plant height (63.08 cm), Coleoptile length (2.87 cm), Nodes per stem (3.16), Shoot length (8.64 cm), Root length (10.12 cm), Days to heading (114), Days to maturity (155) and grain yield (2786.8 kg/ha^{-1}) (Table 1). Less number of days to maturity and early heading has been witnessed in 13FJ35 with lower yield index. Least count of tillers/ m^{-2} has been observed in 13FJ35 among all genotypes. An increase in seeding density can enhance grain yield in genotypes with reduced tillering ability, whereas showing decline in ear weight. Seeding density proved to have a major influence on thousand grain weight there by increasing over all yield (Valério *et al.,* 2013). Present study represents a variable response of genotypes to different seed rates applied hence affirming the findings of Geleta *et al.,* (2002) who also reported a variable response of different genotypes towards varied seed rates.

Table 1. Growth and Yield related traits of different wheat genotypes averaged across seed rates evaluated at Barani Agricultural Research Station, Fatehjang during 2016-17 & 2017-18.

Plant Trait	Genotypes			LSD Value
	Fatehjang-2016	BARS-09	13FJ35	
Germination Percentage (%))	70.833 a	62.083 b	56.667 b	(6.13)
Plant Height (cm)	106.83 a	63.33 b	63.08 b	10.34
Coleoptile Length (cm)	3.29 a	2.95 ab	2.87 b	0.36
No. of Tillers (m^{-2})	320.33 b	369.67 a	148.92 c	(26.85)
Nodes per Stem	3.58 a	2.75 b	3.16 ab	(0.67)
Shoot Length (cm)	9.54 a	9.16 ab	8.64 b	(1.10)
Root Length (cm)	12.35 a	11.01 b	10.12 c	(0.93)
D.O.H 50%	126.75 a	120.58 b	114.58 b	6.13
D.O.M	170.42 a	159.83 b	155.33 b	5.88
Grain Yield	3403.3 a	2793.26 b	2786.8 b	(118.93)

Values of LSD within a row are shown in parentheses for each trait is significant/ highly significant at (P≤0.05).

In order to attain maximum yield returns and amenable quality in spring wheat varietal selection, seeding density and N management are key decisions. Moreover, an interaction can occur among management aspects and new varieties that have varied morphological characters. Thus, varietal/ cultivar selection plays a pivotal role in determining the economic yield and quality. Genotypes differ greatly in grain yield potential, protein content and other agronomic traits. Our results affirm the findings of Otteson *et al.,* (2007); they reported that specific genotypes responded differently to varying seed rates.

Effect of varied seeding densities

A highly significant or non-significant effect has been found in case of varied seeding densities on different yield attributes of all three genotypes (Table 2). However, seed rate (125 kg/ha) revealed significantly higher germination percentage (68.33 %), Plant height (82.22 cm), Coleoptile length (3.29 cm), No. of Tillers/ m^{-2} (301),Nodes per stem (3.88), Root length (14.72 cm), Shoot length (10.39 cm), Days to heading (124), Days to maturity (164) and grain yield (3259.8 kg/ha)(Table 2).

Over all wheat sown at lower densities i.e. 100 or 125 kg/ha showed increased plant height, Nodes per stem, root and shoot length along with higher grain yield index (Table 2).

Table 2. Growth and Yield related traits of wheat as affected by various seed rated averaged across genotypes evaluated at Barani Agricultural Research Station, Fatehjang during 2016-17 & 2017-18.

Plant Trait	Seed Rates (kg ha^{-1})				LSD value
	75	100	125	150	
Germination Percentage (%))	63.88 ab	63.33 ab	68.33 a	57.22 b	(7.08)
Plant Height (cm)	78.44 b	77.22 b	82.22 a	73.11 b	11.46
Coleoptile Length (cm)	3.04 ab	3.00 ab	3.29 a	2.082 b	0.42
No. of Tillers (m^{-2})	250.67 b	247.56 b	301.11 a	252.56 b	(31.01)
Nodes per Stem	2.88 b	3.33 ab	3.88 a	2.55 b	(0.77)
Shoot Length (cm)	8.15 b	9.21 ab	10.39 a	8.80 b	(1.27)
Root Length (cm)	10.12 b	12.01 ab	14.72 a	11.62 ab	(1.07)
D.O.H 50%	102.00 d	110.78 b	124.56 a	118.22 ab	7.07
D.O.M	155.13 b	161.33 a	164.78 a	158.00 ab	6.79
Grain Yield	2903.6 bc	3011.0 b	3259.8 a	2803.4 c	(137.33)

Values of LSD within a row are shown in parentheses for each trait is significant/ highly significant at ($P \leq 0.05$).

Our results are in conformity with the findings of Malik *et al.,* (2009) who also reported that lower seeding densities had better grain yield due to vigorous crop growth and less plant population.

Increased seed densities however result in higher plant per unit area along with tall crop stature thus resulting in competition for nutrient acquisition and decline in grain yield. Seeding density greatly effects inter and intra plant competition for nutrients, light, space and water acquisition. Lower seeding densities cause reduction in interplant competition at vegetative growth whereas; due to higher number of tillers the intraplant competition could be enhanced at grain filling stage (Ozturk *et al*., 2006).

Our results are in line with the findings of Ayalew *et al.,* (2017) who also concluded that wheat should be sown at seed rate of 125 kg ha^{-1} for higher grain yield provided all other agronomic practices must be kept constant.

Interactive effects of genotypes and seeding densities

It can be assessed form the results that interactive effect of genotypes and seed rates was found significant for about all plant traits (Table 3). Maximum germination percentage (75 %), Plant height (112.33 cm), Coleoptile length (3.95 cm), Nodes per stem (4.66), Root length (15.36 cm), Shoot length (11.51 cm), Days to heading (132), Days to maturity (171) and grain yield (3722.3 kg/ha) were found in Fatehjang-2016, whereas BARS-09 showed high no. of fertile tillers m^{-2} (430.67) when sown at seed rate of 125kg/ ha. Present study clearly reflects that lower seed rate of 125kg/ha had better crop stand and plant population.

Table 3. Growth and Yield related traits of different wheat genotypes as affected by varied seed rates evaluated at Barani Agricultural Research Station, Fatehjang during 2016-17 & 2017-18.

	Wheat Genotypes												LSD value
	FJ-16	BARS-09	13FJ35	FJ-16	BARS-09	13FJ35	FJ-16	BARS-09	13FJ35	FJ-16	BARS-09	13FJ35	
Plant Trait	Seed Rates												
	75			100			125			150			
Germination Percentage (%))	73.33 ab	61.66 bcde	56.66 de	70.00 abc	61.66 bcde	58.33 cde	75.00 a	70.00 abc	60.00 cde	65.00 abcd	55.00 de	51.66 e	(10.83)
Plant Height (cm)	105.67 a	64.33 b	65.33 b	102.67 a	64.33 b	64.67 b	112.33 a	66.33 b	68.00 b	106.67 a	58.33	54.33 b	20.69
Coleoptile Length (cm)	3.04 b	3.05 b	3.03 b	3.06 b	3.04 b	2.90 b	3.95 a	2.86 b	3.07b	3.12 b	2.86 b	2.47 b	0.72
No. of Tillers (m^{-2})	116.67 f	326.67 bcd	308.67 cde	114.00 f	354.33 bc	274.33 de	155.00 f	430.67 a	317.6 bcd	155.00 f	367.00 b	260.67 e	(53.71)
Nodes per Stem	3.00 bc	2.33 c	3.33 abc	3.66 abc	3.33 abc	3.01 bc	4.66 a	3.02 bc	4.00 ab	3.04 bc	2.35 c	2.33c	(1.35)
Shoot Length (cm)	7.81 d	7.27 d	9.37 abcd	10.71 ab	7.52 d	9.10 bcd	11.51 a	10.32 abc	9.34 abcd	8.13 cd	9.46 abcd	8.81 bcd	(2.20)
Root Length (cm)	10.26 de	9.97 e	11.31 cd	11.21 cd	12.82 bc	12.00 cd	15.36 a	13.91 ab	14.89 a	11.87 cd	11.86 cd	10.64 de	(1.86)
D.O.H 50%	125.00 abc	113.33 cd	102.47 e	125.67 ab	115.67 bc	112.26 cd	132.67 a	126.33 ab	111.57 cd	123.67 abc	118.00 bc	110.67 d	12.26
D.O.M	172.00 a	150.67 e	156.33 d	170.33 a	158.33 bcd	155.33 de	171.00 a	169.33 ab	150.00 e	168.33 abc	157.00 cd	155.67 de	11.76
Grain Yield	3250.3 bc	2685.0 gh	2775.3 fgh	3471.7 b	2886.0 efg	2675.3 gh	3722.3 a	2971.0 def	3086.0 cde	3169.0 cd	2630.7 h	2610.7 h	(237.86)

Values of LSD within a row are shown in parentheses for each trait is significant/ highly significant at ($P \leq 0.05$).

The results showed that highest grain yield was obtained at 125 kg ha^{-1} in Fatehjang-2016 (3722.3 kg ha^{-1}) as compared to other seed rates, perhaps due to more ground cover and increase in plant m^{-2} that results in more no. of tillers m^{-2} with well filled spikes and healthy seeds which ultimately heightens the overall grain yield (Said *et al.,* 2012). Planting density greatly affects the yield associated traits in wheat (Zecevic *et al.,* 2014), thus an optimum seed rate of 250-350 germinating seeds per m^2 is recommended for a sufficient number of good spikes accompanied with adequate yield and quality structure (Salah El-Hendawy, 2016). Our findings are in line with the findings of Khan *et al.,* (2003), who also reported that higher seed rate produced lower yield in comparison to lower seed rates. They obviously hike up the expenditure and add nothing to farmer yield. Researchers and farmers also reported that aphid attack was profound in dense crop. In addition such crops become more prone to lodging due to increase in interplant competition (Khan *et al.,* 2004). However, crop sown at a lower seed density of 125 kg ha^{-1} revealed an enhanced spike length, grain yield and other parameters (Nizamani *et al.,* 2014). The variation in plant height of the studied varieties was attributed to difference in their genetic makeup (Khokhar *et al.,* 1985 and Khaliq *et al.,* 1999). Likewise Tahir *et al.,* (2019) established that wheat sown from 10th to 25th November harvested maximum grain yield at seeding density of 125 kg ha^{-1} whereas late sowing with higher seed rates of 150 and 175 kg ha^{-1} revealed an even higher grain yield. Similar results were reported by Khan *et al.,* (2004), Laghari *et al.,* (2011), Nizamani *et al.,* (2014) and Lashari *et al.,* (2016) who found that wheat was quite responsive to increased seed rate; the higher seed rate produced greater plant population m^{-2} suggesting that 125 kg ha^{-1} seed rate is optimum for achieving good crop growth and higher grain yields.

However, our results are in contrast with the findings of Said *et al.,* (2012) who concluded that in-order to get maximum yield potential of wheat it must be planted from 1st November to 15th November at 150 kg ha^{-1} seeding density. Similar results were reported by Ozturk *et al.,* (2006) that who reported that seeding at higher density of 575 seeds m^{-2} results in more number of spikes m^{-2} thereby increasing the total grain yield. Baloch *et al.,* (2010), also found that higher seed rate of 150 kg ha-1 revealed maximum grain yield than lower densities in wheat.

The findings of this research clearly reflect that the plantation of wheat (spring) in Pothohar region with lesser seed rate results in higher yield index and quality, thereby enhancing the economic returns to the farmer with less expenditure on inputs.

Conclusion

In the light of aforementioned research results the genotype Fatehjang-2016 performed best at seeding density of 125 kg/ha. It excelled in all parameters including germination percentage, plant height, coleoptile length, nodes per stem, shoot length, root length, days to 50% heading, days to maturity and grain yield from other genotypes. Therefore, seed rate of 125 kg/ha is highly recommended for obtaining higher yield in wheat genotype Fatehjang-2016 for Pothohar region.

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