GROWTH AND YIELD ATTRIBUTES OF WHEAT AT DIFFERENT SEED RATES

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ABSTRACT

Optimum seeding rate is one of the most important production factors for higher grain yield as well as for quality crop. Indiscriminate use of seeding rates not only increases production costs but usually decrease wheat grain yield. Field trials were conducted at Sindh Agriculture University Tandojam, Pakistan during 2007-08 to evaluate the effect of different seed rates (125, 150, 175 and 200 kg ha^{-1}) on growth, yield and nutrient uptake of wheat varieties (TD^{-1}, TJ-83 and Mehran-89). Seed rates significantly affected all the plant traits. Crop sown at low seed rate of 125 kg ha^{-1} had better growth, yield, nutrient uptake and low lodging tendency. Maximum tillers, spike length, grains spike^{-1}, grain weight spike^{-1}, seed index, biological yield, grain yield, harvest index, dry matter, crop growth rate and low lodging were found in TD^{-1} sown at 125 kg ha^{-1} seed rate. However, higher seed rates (200 kg ha^{-1}) resulted in delayed maturity, greater internode length and higher lodging in Mehran-89. However, TJ-83 was inefficient and recorded minimum values of all the growth, yield, nutrient uptake and traits. It was concluded that wheat variety TD^{-1} could be sown at optimum seed rate of 125^{-1}50 kg ha^{-1} for better growth, yield, nutrient uptake and minimum lodging tendency.

Key Words:* *Wheat, seed rate, growth, yield, nutrient uptake, lodging

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INTRODUCTION

Optimum seeding rate is considered an important management factor for improving yield of wheat. It is of particular importance in wheat production because it is under the farmer's control in most cropping systems (Slafer and Satorre, 1999). Optimum plant densities vary greatly between areas, climatic conditions, soil, sowing time, and varieties (Darwinkel *et al.* 1977). If optimal seeding rates exceed, yield reductions often occur (Beuerlein and Lafever, 1989; Harrison and Beuerlein, 1989). Previous research as shows that seeding rates significantly affected biological yield (Ayaz *et al.* 1997), achieved stands (Stoppler *et al.* 1990), spike number and weight (Ozturk *et al.* 2006). Higher seeding rates compensate for reduced tiller development and promote more main stem spikes which can be favorable, especially for cultivars that tend to produce fewer tillers (Coventry *et al.* 1993; Staggenborg *et al.* 2003). A close relationship exists between wheat stands and yield components (Zhen–Wen *et al.* 1988). The objectives of this research, therefore, were to determine how different seed rates can alter yield and to understand better interactive effect of seed rates and varieties to provide better alternative management practices to farmers facing problem of low grain yields.

MATERIALS AND METHODS

Experimental Location and Treatments

Field investigations were conducted during 2007-08 growing season at Department of Agronomy, Sindh Agriculture University Tandojam, Pakistan located at 25^{o}25’60’N 68^{o}31’ 60E. Soil of the experimental site was clay loam, non-saline, low in organic matter (0.56-0.59%) and low in available phosphorus (3.25-3.50 mg kg^{-1}) and high in exchangeable potassium (168 mg kg^{-1}). Three wheat varieties (TD^{-1}, TJ-83 and Mehran-89) were sown at different planting densities (125, 150, 175 and 200 kg ha^{-1}). The experiment was conducted in randomized complete block design in factorial arrangement with three replications following the procedures of Gomez and Gomez (1984). In each sub-plot having net plot size of 15 m^{-2}, the 33 rows were maintained at recommended row to row distance of 15 cm (Khoso, 1990).

Recommended land preparation operations were performed for equal distribution of irrigation and fertilizers. Sowing was done with a single coulter hand drill. First irrigation was applied 20 after days sowing. The crop was subsequently irrigated as per need of the crop and soil during growth and development. Nutrients were applied at 120-60-60 NPK kg ha^{-1} in the form of urea, di-ammonium phosphate and sulphate of potash respectively. All P, K and half N were applied during final land preparation at the time of sowing. The second half of N was split applied at 2nd, 3rd and 4th irrigations in equal amount. Weed management practices were done manually for reducing weed-crop competition once before the canopy closure.

Observation and Sampling

Growth analysis was done during flowering stage 70 DAS, Bauer *et al.* (1984)] following the procedures of Thomas *et al.* (2003). Leaf area index (LAI) was calculated as ratio of the leaf surface area to the ground area occupied by a plant stand. Crop growth rate (CGR) was calculated as plant's dry weight increase per unit of dry weight per unit area per unit time e.g. (W2–W1)/(t2–t1) g $^{m-2}$ day^{-1}. The plant N concentration was calculated by micro Kjeldahl Method (AOAC, 1990), P and K by Method 54a and 58a, respectively, US salinity Lab. Staff, (1954). The obtained values of nutrient concentration were multiplied with total dry matter of plant for NPK uptake.

At complete loss of green color, the maturity days were counted as difference between sowing to harvest date in each treatment. Before crop harvest, the lodging was measured following the methods of Fischer and Stapper (1987); Rawson and Macpherson (2000) as; crop lodging from vertical (90o) x % area lodged. At harvest, 25 plants were randomly selected from each treatment for measuring different plant traits. Plant height was measured from ground level to the top of the spike termination node. Tiller count was done from $^{m-2}$ area in each treatment and these tillers were also used for nodes $stem^{-1}$ and internode length (through measuring tape). Spike length was measured from 25 randomly selected spikes through measuring tape. These spikes were separately threshed and grains were counted and weighed on top loading digital balance. The 1000 grains were weighed on same electronic balance for seed index. Biological and grain yield were recorded from two central rows harvested in each experimental unit. Subsequently samples were oven dried at 80oC for maximum 36 hours to estimate dry matter yield. Harvest index was calculated as a ratio of grain yield to total biological yield. Two factors (wheat varieties and seed rates) were analyzed in RCBD, factorial arrangement. Data were statistically analyzed with MSTATC computer software, the means were separated using LSD test ($P<0.05$) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth, Yield and Nutrient Uptake Traits

Varietal Response

Among the varieties, TD^{-1} had maximum tillers (403 $^{m-2}$), leaf area index (3.7) and crop growth rate (9.6 g $^{m-2}$ day^{-1}), maturity days (127), dry matter (9.5 t ha^{-1}), spike length (12.1 cm), grains $spike^{-1}$ (41.9), 1000 grain weight (38.7 g), biological yield (10.8 t ha^{-1}), grain yield (3.9 t ha^{-1}) and harvest index (35.6%). Contrary to that, Mehran-89 showed maximum plant height (94 cm), nodes $stem^{-1}$ (5.5), internode length (10.9 cm) with higher lodging tendency (13.1 %). The nutrient uptake trend was found non-significant ($P<0.05$). Nutrient uptake ranged between 78.4 to78.5 (N), 12.9 (P) and 74.0-74.1 (K) kg ha^{-1} (Table I). These results agree with findings of Otteson *et al*. (2007). They reported that individual genotypes responded differently to varying seeding rates. Bairwa *et al*. (2000) also stated that grain and straw yields included N, P and K uptake differed within varieties and increased with increased seed rates from normal. Genetic variability also play role for nitrogen uptake in wheat (Dhugga and Waines, 1989; Ortiz-Monasterio *et al.* 1997). In this study, lodging tendency was pronounced due to height and internode length in Mehran-89, followed by TJ-83. Hafner (2001) reported that most modern cereal cultivars have relatively short strong stems and transmit the aboveground forces to the root system, because most of the wheat lodging that occurs is believed to be root lodging. Large differences amongst wheat varieties have been observed for lodging tendency (Crook and Ennos, 1994; Berry *et al.* 2003).

Effect of Seed Rates

Lower seed rate (125 kg ha^{-1}) significantly produced maximum tillers (439 $^{m-2}$), dry matter (10.6 t ha^{-1}), leaf area index (2.9), crop growth rate (10 g m^{-2} day^{-1}), spike length (14.5 cm), grains $spike^{-1}$ (48.8), grain weight $spike^{-1}$ (2.6 g), 1000 seed weight (41.4 g), biological yield (11.5 t ha^{-1}), grain yield (4.4 t ha^{-1}), harvest index (37.6) and nutrient uptake (94.1, 18.3 and 96.5 kg ha^{-1} N, P and K, respectively). Varieties with lower seed rate also showed early maturity (131 days), short internodes (7.6 cm) and less lodging (4.2%). Wheat sown at 125 and 150 kg ha^{-1} seed rates had significantly higher plant height (83.2 and 82.7 cm) and nodes $stem^{-1}$ (5.3 and 5.3), respectively. Both seed rates were statistically at par. Wheat sown at higher seed rates (200 kg ha^{-1}) had significantly higher internode length (11.6 cm), maturity days (143) and lodging tendency (16.4%) (Table II). These results agree with those reported by Mazurek *et al*. (1984) who reported that lower seeding rates had better yield due to vigorous crop growth. Higher rates increased lodging due to tall plants and thus reduced 1000 grain weight and yield.

Table-I ***Growth, yield and nutrient uptake traits of various wheat varieties averaged across seed rates evaluated at Sindh Agriculture University, Tandojam during 2007-08***

Plant trait	Varieties			LSD (P≤0.05)
	TD-1	TJ-83	Mehran-89	
Tillers (m^{-2})	403a	371b	370b	(6.20)
Plant height (cm)	57.6c	76.4b	94.0a	(1.28)
Nodes $stem^{-1}$	3.6c	4.7b	5.5a	(0.08)
Internode length (cm)	8.2c	10.3b	10.9a	(0.26)
Leaf area index	3.7a	3.3b	3.3b	(0.06)
Crop growth rate ($g\ m^{-2}\ day^{-1}$)	9.6a	6.9b	7.0b	(0.11)
Days to maturity	127c	136b	14a	(1.50)
Dry matter ($t\ ha^{-1}$)	9.5a	8.5b	8.5b	(0.78)
Lodging score (%)	3.7c	11.8b	13.1a	(0.16)
Spike length (cm)	12.1a	10.4b	10.4b	(0.18)
Grains $spike^{-1}$	41.9a	36.5b	36.5b	(0.74)
Grain wt. $spike^{-1}$	2.2a	1.7b	1.7b	(0.02)
Seed index (1000 grain wt.)	38.7a	30.3b	30.5b	(0.58)
Biological yield ($t\ ha^{-1}$)	10.8a	9.7b	9.7b	(0.91)
Grain yield ($t\ ha^{-1}$)	3.9a	2.7b	2.7b	(1.01)
Harvest index (%)	35.6a	27.5b	27.5b	(0.14)
N-uptake ($kg\ ha^{-1}$)	78.5	78.4	78.5	-
P-uptake ($kg\ ha^{-1}$)	12.9	12.9	12.9	-
K-uptake ($kg\ ha^{-1}$)	74.0	74.1	74.0	-

Values of LSD within a row are shown in parentheses for each trait is not significant at ($P \le 0.05$).

Table-II ***Growth, yield and nutrient uptake traits of wheat as affected by different seed rates averaged across varieties at Sindh Agriculture University, Tandojam during 2007-08***

Plant trait	Seed rates ($kg\ ha^{-1}$)				LSD (P≤0.05)
	25	150	175	200	
Tillers (m^{-2})	439a	386b	366c	335d	(7.15)
Plant height (cm)	83.2a	82.7a	73.1b	64.8c	(1.47)
Nodes $stem^{-1}$	5.3a	5.3a	4.6b	3.3c	(0.09)
Internode length (cm)	7.6d	9.6c	10.4b	11.6a	(0.29)
Leaf area index	2.9a	3.1b	3.9c	3.8d	(0.07)
Crop growth rate ($g\ m^{-2}\ day^{-1}$)	10.0a	8.2b	7.0c	6.0d	(0.13)
Days to maturity	131d	134c	138b	143a	(1.73)
Dry matter ($t\ ha^{-1}$)	10.6a	9.1b	8.6c	7.1d	(0.45)
Lodging score (%)	4.2d	5.9c	11.7b	16.4a	(0.19)
Spike length (cm)	14.5a	12.0b	9.5c	7.8d	(0.21)
Grains spike	48.8a	42.1b	35.7c	26.5d	(0.85)
Grain $wt.spike^{-1}$	2.6a	2.3b	1.3c	1.2d	(0.03)
Seed index (1000 grain weight g)	41.4a	35.9b	30.6c	24.8d	(0.24)
Biological yield ($t\ ha^{-1}$)	11.5a	10.3b	9.9c	8.5d	(0.39)
Grain yield ($t\ ha^{-1}$)	4.4a	3.4b	2.7c	2.0d	(0.55)
Harvest index (%)	37.6a	32.4b	27.4c	23.4d	(0.16)
N-uptake ($kg\ ha^{-1}$)	94.1a	82.1b	71.8c	65.9d	(1.65)
P-uptake ($kg\ ha^{-1}$)	18.3a	15.0b	10.6c	7.7d	(0.27)
K-uptake ($kg\ ha^{-1}$)	96.5a	80.0b	63.2c	56.5d	(1.45)

Values of LSD within a row are shown in parentheses for each trait are not significant at ($P<0.05$).

Interactive Effects of Varieties and Seed Rates

Interactive effects of varieties x seed rates had significant effect on all observed wheat traits except nutrient content and uptake. Maximum tillers (456 m^{-2}), crop growth rate (11.6 g m^{-2} day^{-1}), early maturity (121 days), greater dry matter (11.1 t ha^{-1}), spike length (15.8 cm), grains $spike^{-1}$ (53.4), grain weight $spike^{-1}$ (2.8 g), 1000 grain weight (46.6 g), biological yield (12.4 t ha^{-1}), grain yield (5.5 t ha^{-1}) and harvest index (43.9%) were found in TD^{-1} sown at lower seed rate(125 kg ha^{-1}). However, Mehran-89 had maximum plant height (102.3 and 101.7 cm) and nodes $stem^{-1}$ (6.2 and 6.1) sown at seed rate of 125 and 150 kg ha^{-1}, respectively. Higher seed rates (200 kg ha^{-1}) resulted in greater internode length (12.9 cm) and thus higher crop lodging (23.1%) in Mehran-89.

Nutrient uptake was non-significant. N uptake ranged between 65.1-94.7 kg ha^{-1}, P uptake $7.3^{-1}8.5$ kg ha^{-1} and K uptake 55.9-96.7 kg ha^{-1}. This study revealed that wheat varieties sown at low seed rate of 125 kg ha^{-1} had better crop and nutrient uptake traits. Low seeding rate had minimum lodging and erect plants due to favorable growth condition and less competition for space, nutrients and water and thus minimum or no lodging was noted. However, crop sown at higher seeding rates (200 kg ha^{-1}) recorded late maturity, increased internode length, lodging and thus less grain yield (Table III). The findings of this study agree with those reported by Cheema *et al.* (2003) who reported highest wheat grain yield (4293 kg ha^{-1}) with sowing rate of 125 kg ha^{-1}. However, Kumar *et al*. (2006) and Otteson *et al*. (2007) reported that increasing sowing rates with optimum fertilizer application resulted in increased grain yield, NPK uptake, spike number, grains $spike^{-1}$ and grain yield, as well as N content, increased with increasing seed rates up to 150 kg ha^{-1}. Berry *et al*. (2004) suggested that best husbandry practices, new lodging-proof genotypes provided stronger basal internodes and a wider root plate are recommended for lodging proof wheat crop.

Stapper and Fischer (1990) also concluded that higher yields could be achieved consistently and efficiently only with genotypes that are resistant to lodging. The findings of this research are also confirmed with those reported by Darwinkel (1980) who reported that reducing seeding rates may result in more tillers and spikes $plant^{-1}$, more spikelets and thus higher grain yield. Further, Easson *et al*. (1993) observed that the grain yield was negatively correlated with crop lodging which may decline more than 10%. However, optimum seed rates had little or no effect on lodging. The decline in yield with increased lodging and sowing rate was attributed to the effect of lodging rather than to sowing rate and was associated with a fall in the number of grains $spike^{-1}$ and 1000 grain weight. A comparison of the plants from lodged and un-lodged plots indicated that at the higher sowing rate, lodged plots had less fresh weight per unit area, basal internodes with smaller diameters, fewer support roots per stem, and a lower root dry weight per stem. Collins and Fowler (1992) reported that new genotypes are needed to achieve lodging-proof wheat crops, particularly to provide stronger basal internodes.

CONCLUSION AND RECOMMENDATIONS

Wheat sown at optimum seed rate of $125^{-1}50$ kg ha^{-1} had better growth, yield, nutrient uptake and minimum lodging compared to higher seed rates (175-200 kg ha^{-1}). The interactive effect of TD^{-1} x 125 kg ha^{-1} seed rate was found superior for achieving higher grain yield.

Table-III Growth, yield and nutrient uptake traits of various wheat varieties as affected by different seed rates at Sindh Agriculture University Tandojam during 2007-08.

Plant traits	**Wheat varieties**												**LSD ($P \leq 0.05$)**
	TD^{-1}	**TJ-83**	**Mehran -89**	**TD^{-1}**	**TJ-83**	**Mehran -89**	**TD^{-1}**	**TJ-83**	**Mehran -89**	**TD^{-1}**	**TJ-83**	**Mehran -89**	
	Seed rates												
	125 kg ha^{-1}			150 kg ha^{-1}			175 kg ha^{-1}			200 kg ha^{-1}			
Tillers (m^{-2})	56a	30b	430b	21b	370d	368de	386c	356ef	356ef	48f	330g	327g	(12.39)
Plant height (cm)	2.7g	4.6c	102.3a	2.6g	84.0cd	101.7a	57.5h	71.7e	90.2b	7.5i	65.4f	81.6d	(2.55)
Nodes $stem^{-1}$	.3f	.4bc	6.2a	.3f	5.4b	6.1a	3.6g	4.8d	5.3c	.1i	3.1h	4.6e	(0.16)
Internodes length (cm)	.3h	.9g	8.7f	.2fg	10.1de	10.5cd	8.6f	10.9c	11.7b	.8e	12.2b	12.9a	(0.51)
Leaf area index	.0f	.8g	2.8g	.4e	3.0f	3.0f	4.4a	3.6d	3.8c	.2b	3.7cd	3.7cd	(0.12)
Crop growth rate (g m^{-2} day^{-1})	1.6a	.2c	9.3c	0.1b	7.3f	7.3f	8.9d	6.1g	6.1g	.7e	5.2h	5.2h	(0.22)
Days to maturity	21i	24h	129g	33ef	130fg	134e	138d	142c	141cd	43c	148b	153a	(3.00)
Dry matter (t ha^{-1})	1.1a	0.3b	10.4b	.9c	8.7e	8.7e	9.3d	8.2f	8.2f	.7g	6.8h	6.8h	(0.32)
Lodging score (%)	.6k	.6h	5.3g	.6j	6.6f	7.5e	4.2i	14.5d	16.4c	.6h	21.6b	23.1a	(0.33)
Spike length (cm)	5.8a	3.8b	13.8b	3.3c	11.4d	11.3d	10.5e	9.0f	9.1f	.9f	7.4g	7.3g	(0.36)
Grains $spike^{-1}$	3.4a	5.9b	47.0b	4.1c	41.5d	40.8d	39.2e	33.6f	34.5f	0.9g	25.0h	23.8h	(1.48)
Grain wt. $spike^{-1}$	.8a	.6b	2.6b	.5c	2.2d	2.2d	1.7e	1.2g	1.1g	.6f	1.1h	1.0h	(0.04)
Seed index (1000 grain wt. g)	6.6a	8.9d	38.6g	1.7b	33.0e	33.0h	36.1c	27.1e	28.6i	0.4c	22.2f	21.9i	(0.41)
Biological yield (t ha^{-1})	2.4a	1.1b	11.1b	0.8c	10.1e	10.1e	10.5d	9.6f	9.6f	.5f	7.9g	8.0g	(0.34)
Grain yield (t ha^{-1})	.5a	.8c	3.9c	.1b	3.0e	3.0e	3.4d	2.4g	2.4g	.7f	1.6h	1.7h	(0.17)
Harvest index (%)	3.9a	4.5c	34.5c	7.5b	29.9e	29.8e	32.2d	25.0g	25.0g	8.8f	20.8h	20.7h	(0.28)
N-uptake (kg ha^{-1})	4.3	3.3	94.7	2.7	82.5	81.1	72.1	71.6	71.9	5.1	66.4	66.2	-
P-uptake (kg ha^{-1})	8.5	8.3	18.1	5.1	15.2	14.8	10.6	10.7	10.4	.3	7.5	8.3	-
K-uptake (kg ha^{-1})	6.4	6.7	96.5	0.1	79.5	80.4	63.8	63.8	62.1	5.9	56.3	57.1	-

Values of LSD within a row are shown in parentheses for each trait are not significant at ($P<0.05$).

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