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Response of Wheat (*Tritium aestivum* L.) to Variable Seed Rates: the Case of Hawassa Area, Southern Ethiopia

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Wheat serves as a staple food and feed for all over the world. In Ethiopia, wheat is one of the most important cultivated cereals ranking 4th in area coverage, 3rd in total production and 2nd in yield. A wheat seed rate of 125 kg ha^{-1} is usually used across most wheat growing areas of Ethiopia in any production conditions. In order to optimize seed rate and plant density of wheat, an experiment was conducted at the agronomy experiment field, College of Agriculture, Hawassa University, Ethiopia, with variable seed rates of 100, 125, 150 and 175 kg ha^{-1}. For this purpose, an experiment was laid down using a randomized complete block design with three replication and four treatments. The result of the current experiment showed significant difference for number of tillers, plant height, grain yield, and 1000-grain weight whereas non-significant difference were witnessed for spike length. Result of this particular study indicated higher number of effective tillers (10.27), spike length (8.9 cm), 1000-grain weight (41.7 g) and grain yield (25.78 qtha^{-1}) production with 125 kg ha^{-1} seed rate. On the basis of results obtained from this experiment, it is concluded that wheat should be sown with 125 kg ha^{-1} seed rate in the current study area provided that all other agronomic management practices is kept optimal.

Key words: Grain crop, planting density, seed rate, *Tritium aestivum* L. and yield.

INTRODUCTION

Wheat (*Tritium aestivum* L.) is a staple food of the masses and feed for animals all over the world (Abbas et al., 2009). This important cereal crop serves as a stable food for one-third of the world's population (Hussain and Shah, 2002). It is grown on 220 million hectares in almost all countries and climatic regions (Singh and Trethowan, 2007) constituting 15.4% of the world's arable land (Curtis, 2002). According to FAO (2005) report, about 620 million metric tonnes of wheat is produced from 217 million hectares of land. The crop utilizes about 30% of the land area under cereal cultivation and account for about 27% of the world cereal production.

Ethiopia is the second largest producer of wheat in sub-Saharan Africa following South Africa and covering about

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1.61 million hectare of land under rain-fed production system. In Ethiopia, wheat is one of the most important cultivated cereals ranking fourth after teff (*Eragrostis teff*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) in area coverage (CSA, 2007), 3rd in total grain production after Maize and Teff and 2nd in yield next to Maize (Assefa et al., 2015; FAO, 2005). The crop is cultivated by 4.746 million farmers accounting for more than 16.3% of the total cereal production (CSA, 2014). Moreover, the crop plays an appreciable role in supplying the population with carbohydrate, proteins and minerals (Schulthess et al., 1997; Hayatulah et al., 2000). The average per capita consumption of wheat in Ethiopia estimated to be 39 kg year^{-1} during the year 1994 - 1999 (CIMMYT, 2000).

However, the mean national average yield of wheat is 2.45 tonnes ha^{-1} which is 24 and 48% below the African and world average, respectively (FAO, 1994), and 3-4 tonnes ha^{-1} far below the research station yields of over 6 tonnes ha^{-1} in the country (Assefa et al., 2015). This low yield in the country is on account of many production limiting factors, among these planting density of wheat, which determines the proper stand establishment of the growing crop and crop vigor through balancing competition for production resources among plants, which ultimately affects the yield of the crop (Korres et al., 2002) is amongst the important agronomic factors. Thus, keeping the importance of optimal seed rate in view, a research trial was undertaken to optimize this factors for a wheat crop under the agro-climatic conditions of Hawassa southern Ethiopia in 2016 cropping season.

MATERIALS AND METHODS

The experiment was conducted in Southern Ethiopia, Hawassa University College of Agriculture agronomy experimental field during 2016 cropping season with seeding rates of 100, 125, 150 and 175 kg ha^{-1}. The site is located at 7°4' North latitude and 38° 31' East longitude. The altitude of the area is 1700 m.a.s.l. The soil of the site is sandy loam, with 7.9 pH value, which is volcanic origin and described as flovisol. The average rain fall of the area is 900-1100 mm annually, whereas annual maximum and minimum temperature are 27 and 12°C respectively. The experiment was laid out in randomized complete block design with three replications using a total plot size of 49.5 m^2 (5 m width and 9.5 m^2 length) with a spacing of 1 m, 0.5 and 0.2 between blocks, plots and rows respectively.

The data were recorded for effective number of tillers, spike length (cm), plant height (cm), 1000-grain weight (g), grain yield (kg ha^{-1}) and analyzed statistically using SAS computer software version 9.2 (SAS, 2008). Tiller number was counted by considering the fertile tiller per plant randomly taking five plants from each plot of the middle three rows at maturity. Spike length was measured taking five plants from each plot of the middle three rows at maturity. Plant height was measured from ground level to tip of the plant taking five plants from each plot of the middle three rows per plot at maturity. Grain yield was weighted taking five plants from each plot of the middle three rows at maturity and using a sensitive balance. Thousand grain weight was also determined by counting seeds randomly taken from each plot and weighing using sensitive weighting balance.

RESULTS AND DISCUSSION

Number of tillers

The economic yield of most cereals is determined by the number of tillers the plant produces. It has the great agronomic importance as this may compensate the difference in number of plants across plots (Acevedo et al., 1998). The current experiment showed that different seed rate revealed significant difference in number of tillers among the treatments, wherein, the use of 125 kgha^{-1} seed rate produced higher number of effective tillers (10.27) compared with (7.67 and 6.00) tillers produced using a seed rate of 150 and 175 kgha^{-1}, respectively (Table 3), which showed that a lower effective tiller production occurred with an increasing seed rate. This is because the higher the seed rate might increase the competition for space thereby result in lesser number of tillers per plant. Baloch et al. (2010) also reported that, lower seed rates significantly increased the number of fertile tillers produced per plant. However, effective tiller number decreased with increasing seed rate beyond 125 kgha^{-1} while higher number of effective tiller is obtained at 125 kgha^{-1} seed rate. This can be explained that, as the seed rate is higher it result with narrow free space which limit the tillering capacity of the plant. Similar result also reported by Hayatullah et al. (2000), stating a decreasing number of effective tillers beyond the optimal seed rate. This is because, the process of tillering is mainly controlled by genetic and environmental factors (Longnecker et al., 1993; Zencirci 2008), and plant population density can regulate the microenvironment of the production system through affecting the competition for space and production resources. Ozturk et al. (2006), in his work on growth and yield response of facultative wheat to winter sowing, freezing sowing and spring sowing at different seeding rates also demonstrated that, reducing seed rate result in more tillers and spike per plant. Alemayehu et al. (2015) also presented that, the number of fertile tillers showed a decreasing pattern moving from 100, 125 to 150 seed rate ha^{-1} (Table 1).

Days to seedling emergence

In the current experiment, planting with a seed rate of 100, 125 and 150 kg ha^{-1} showed similar and later emergence date as compared to 175 kg ha^{-1} seed rate. However, statistically significant early emergence date was recorded when crop was sown using 175 kg ha^{-1} seed rate. Planting with a seed rate of 125 kg ha^{-1} gave emergence relatively late followed by 100 and 150 kg ha^{-1} seed rate, respectively although the difference was not statistically significant (Table 2).

Table 1. Mean square of ANOVA's of number of tillers, spike length, plant height, 1000-grain weight and grain yield in wheat.

Sources of variation	Degree of freedom	Number of effective tillers	Spike length	Plant height	1000-grain weight	Grain yield
Replication	2	0.15	0.33	5.49	1.00	6.74
Treatment	3	9.24*	0.22**	24.40*	8.72*	148.20*
Error	6	1.04	0.13	1.53	0.98	22.40
Total	11	3.12	0.19	8.48	3.09	

Table 2. Effects of seed rates on germination in wheat

Treatments	Days to germination
Seed rate (kgha^{-1})	
100	6.00[a]
125	6.33[a]
150	5.67[a]
175	4.33[b]
LSD	1.04
CV %	9.38%

Table 3. Mean number of effective tillers and plant height as affected by variable seed rates.

Treatments	Number of effective tillers	Plant height (cm)
Seed rate (kgha^{-1})		
100	8.40[ab]	66.47[c]
125	10.27[a]	69.13b
150	7.67[bc]	70.73[b]
175	6.00[c]	73.27[a]
LSD	2.04	2.47
CV %	12.6%	1.8%

Means sharing the same superscript letter do not differ significantly at P = 0.05 according to the LSD test.

Plant height (cm)

Plant height is regulated by the genetic makeup of the plant and the environmental factors (Shahzad et al., 2007), and planting density determines the growing situation by affecting the competition for space and production resources. The current experiment showed significantly different plant height with varying seed rates, the maximum plant height of 73.27 cm was obtained from 175 kgha^{-1} seed rate followed by 150 kgha^{-1} seed rate which was resulted with a plant height of 70.73 cm (Table 3). Minimum plant height was obtained with the lowest (100 kgha^{-1}) seed rate which produced a plant height of 66.47 cm (Table 3). Increased plant density resulted in increased height of the plants, this is because high plant density remains with minimum space for horizontal expansion of the plant and increase the competition for light interception between plants drives upward growth. The result of the current experiment, is in agreement with Suleiman (2010), who reported that, increase in the seeding rate resulted in a slight increment in the height of plants. Alemayehu et al. (2015) also reported an increasing pattern in plant height with increasing seed rate ha^{-1}. This result, however, did not coincide with Baloch et al. (2010) and Abbas et al. (2009) who reported that increase in the seeding rate resulted in a slight decline in the heights of the plants. This could be because of variable environmental conditions and genetic makeup of the genotypes used in all these studies.

Spike length (cm)

The length of spike plays a vital role in wheat towards the

Table 4. Mean spike length and grain yield as affected by variable seed rates.

Treatments	Spike length (cm)	Grain yield ($qtha^{-1}$)
Seed rate ($kgha^{-1}$)		
100	8.6	18.26^{ab}
125	8.9	25.78^{a}
150	8.5	14.70^{b}
175	8.27	8.99^{b}
LSD	NS	9.5
CV %	4.22%	27.99%

Means sharing the same superscript letter do not differ significantly at P = 0.05 according to the LSD test.

Table 5. Mean 1000-grain weight as affected by variable seed rates.

Treatments	1000-grain weight (g)
Seed rate ($kgha^{-1}$)	
100	39.7^{b}
125	41.7^{a}
150	38.50^{b}
175	38.00^{b}
LSD	1.97
CV %	2.5%

Means sharing the same superscript letter do not differ significantly at P = 0.05 according to the LSD test.

grain per spike and finally the yield (Shahzad et al., 2007). The analysis of variance for spike length shows no significant difference among the treatments (Table 4); however, a relatively higher spike length of 8.9 cm was recorded from 125 kg ha^{-1} seed rate closely followed by 100 kg ha^{-1} seed rate which produced 8.6 cm long spike. Further increase in planting densities beyond 125 kg seed rate ha^{-1} resulted in slight decline in the length of spike (Table 4). Longer spike at 125 $kgha^{-1}$ seed rate can be referred to the ideal plant population in this treatment, which resulted in optimum crop plant competition. This finding is in-line with the findings of Abbas et al. (2009) and Suleiman (2010), who reported a decreasing trend in spike length in both increasing and decreasing direction from the optimal plant population. Similarly, Ozturk et al. (2006) reported more spike production per plant with reducing pattern of seed rate.

Grain yield ($qtha^{-1}$)

The data showed statistically significant difference for grain yield. 125 kg ha^{-1} seed rate produced a higher grain yield of 25.8 $qtha^{-1}$ followed by 100 kg ha^{-1} seed rate which produced a grain yield of 18.28 $qtha^{-1}$ (Table 4). The lowest grain yield was obtained from 175 kg ha^{-1} seed rate followed by 150 kg ha^{-1} seed rate which produced 8.99 and 14.7 $qtha^{-1}$ grain respectively (Table 4). Further decrease in planting densities beyond 125 kg seed rate ha^{-1} resulted in slightly lower grain yield although not statistically different, whereas an increase in seed rate beyond 125 kg ha^{-1} resulted with statistically lower grain yield (Table 4). This finding is in agreement with the finding of Baloch et al. (2010), who reported a decline in yield of wheat with increasing seed rate, this might be explained that dense wheat population creates keen competitions between plants for production resources leading to a decreasing grain yield. Similar finding also reported by Hayatullah et al. (2000), which presented a decreasing pattern in grain yield of wheat with increasing seed rate. This might be due to shrivelled grain and lodging of crop which results from having higher plant population ha^{-1}.

1000-grain weight (g)

The current experiment showed that, variable seed rates has a significant effect on 1000-grain weight. Among seeding rates, the maximum 1000-grain weight (41.7 g) was obtained with 125 $kgha^{-1}$ seed rate followed by 1000-grain weight (39.7 g) obtained from a 100 $kgha^{-1}$ seed rate (Table 5). The relatively lower 1000-grain weight (38 g) was obtained from a seed rate of 175 $kgha^{-1}$ followed by a 1000-grain weight of (38.5 g.) which was obtained from a seed rate of 150 $kgha^{-1}$ (Table 5). This experiment shows that 1000-grain weight declines with increasing seed rate. This might be due to higher planting density on account of higher seed rate used that increased plant competition and eventually declined the grain weight. The result of the current study is in agreement with Shahzad et al. (2007) and Baloch et al. (2010), who reported the negative effect of increasing seed rate on 1000-grain weight. Alemayehu et al. (2015), in his research on effect of seed sources and rates on productivity of bread wheat (*T. aestivum* L.) varieties at Kersa, eastern Ethiopia also reported the production of highest 1000-grain weight at the lowest seed rate. Thus, there is a negative relationship between plant density and 1000-grain weight. This is because at higher plant density most grains would fade at early stage because of competition between growing grains to absorb preserved matters and as the result low grains would produced (Rahim et al., 2012). However, a different result was found by Hayatullah et al. (2000), showing the absence of significant effect of seed rate on 1000-grain weight.

CONCLUSION AND RECOMMENDATION

In the present study, wheat produced higher number of tillers, plant height, 1000-grain weight and grain yield when 125 kg ha^{-1} seed rate is used. Therefore, with the optimal application of all the recommended agronomic practices for the same crop, 125 kg ha^{-1} seed rate can be suggested to achieve better crop performance and higher grain yield of wheat in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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