DIJBAR
www.daagu.org
Volume-3 Issue-1

Effect of Seed and Nitrogen Rates on Some Phenological and Growth Parameters of Bread Wheat (*Triticum aestivum L.*) under Semi-arid condition in Northeast Ethiopia

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ABSTRACT

Wheat is well adapted to the mid and high land agro-ecologies of northeastern Ethiopia. The use of appropriate seed and nitrogen rates are among the most important agronomic practices that determine the phenological and growth parameters of crops. Field experiment was conducted during 2018/2019 crop season to identify the optimum seed and nitrogen rates that maximize phenological and growth parameters of bread wheat .The experiment was laid out in randomized complete block design (RCBD) with three replications. Treatments consisted of factorial combinations of three seed rates (100, 150 and 200 kg ha^{-1}) and four nitrogen rates (0, 53, 88 and 122kg N ha^{-1}).The result showed that days to heading, grain filling, 90% physiological maturity and harvest maturity were significantly affected by seed and nitrogen rates only but growth like plant height, spike length, numbers of tillers per m^{-2}were significantly ($p \leq 0.05$) affected by interaction effects of seed and nitrogen. Among the main effects and their interaction, 150 kg ha^{-1} seed rate and 122kg ha^{-1} nitrogen rate into the highest phenological and growth parameters. It is concluded that application of 122 kg N ha^{-1} with 150 kg ha^{-1} seed rate may be recommended to obtain optimum phenological and growth parameters.

Keywords: Seed and nitrogen rate, phenological and growth, wheat.

Citation: Mohammed Hussen, Adem Mohammed (2021). Effect of Seed and Nitrogen Rates on Some Phenological and Growth Parameters of Bread Wheat (*Triticum aestivum L.*) under Semi-arid condition in Northeast Ethiopia. Daagu International Journal of Basic & Applied Research-DIJBAR. Volume3, Issue-1, pp (27-37)

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Received: 01-04-2021

Accepted: 27/05/2021

Published: 28/06/2021

OPEN ACCESS

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1. INTRODUCTION

Wheat (*Triticum aestivum* L) is one of the most important cereal crops grown globally and serves as a stable food for about one third of the world population (Hussain and Sheh, 2002). It belongs to the grass family Poaceae and the tribe Hordea.Wheat is one of the most important cereals cultivated in Ethiopia and ranks fourth after tef (*Eragrostis tef*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) in area coverage, while fourth in total production after maize, sorghum and tef (CSA., 2012). Despite the large area under wheat, the national average yield of wheat in Ethiopia is about 2 t ha^{-1} (CSA., 2012).This is definitely below the world's average which is about 3 t ha^{-1} (Hawkesford *et al.,* 2013). In Ethiopia, wheat is cultivated in wide range of altitudes. Most wheat producing areas in Ethiopia lie between 6^{o} and 16^{o} N latitude and 35^{o} and 42^{o}E longitudes of an altitude range from 1500 to 3000 meters above sea level (masl). The most suitable agro-ecological zones, however, fall between 1900 to 2700 meters above sea level (Bekele *et al.,* 2000). Cultivation of local varieties, inadequate and erratic rainfall, poor agronomic practices, diseases and insect pest are among the principal limitations to wheat production in Ethiopia (Gorfu and Hiskias, 2000).Nitrogen (N) and seed rate are important management inputs, which influence phenological and growth parameters of wheat. Nitrogen plays a vital role in all living tissues of the plant (Haftom, 2009). Nitrogen is a constituent of proteins, enzymes, coenzymes, nucleic acids, phytochromes and chlorophyll. Besides, a good supply of nitrogen to the plant stimulates root growth and development as well as uptake of other nutrients (Brady and Weil, 2002).

Although, a number of researches have been conducted on the effect of Nitrogen (N) fertilizer application and seed rate on bread wheat production, such researches are scanty which determine the effect of these two factors on phenological and growth parameters of bread wheat (*Triticum aestivum L.*) in this study area. Hence, this experiment was initiated to identify the optimum seed and nitrogen rates that maximize phenological and growth parameters of bread wheat in Dessie Zuria District of the semi-arid region of northeast Ethiopia.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area was conducted in Dessie Zuria District of the semi-arid region of northeast Ethiopia under rainfed condition during 2018/2019 crop season. It is one of the 106 districts in the Amhara National Regional State, Ethiopia. The altitude ranges from 1600 meter above seas level (m.a.s) to 3800 m.a.s.l. The experimental site is

located at $039^0 30' 22.7''$ E and $11^0 05' 30.8''$ N at an elevation of 2270 m.a.s.l. The study area receives mean annual rain fall of about 1170 mm. The mean annual minimum and maximum temperature are 8.7ºC and 23.8ºC, respectively.

2.2 Treatments and Experimental Design

The experiment consisted of treatments made from factorial combinations of three seed rates (S_1=100, S_2=150 and S_3=200) kg ha^{-1} and four nitrogen rates (N_0= 0, N_1= 53, N_2= 88 and N_3=122) kg N ha^{-1}.The experimental design was Randomized Complete Block Design (RCBD) with three replications. The gross plot size was 2m x 2m (4 m^2) containing 10 rows with 0.2 m inter row spacing. Spacing between blocks was 1m while spacing between plots was 0.5 m. The net plot size was 1.6 m x 1.8 m (2.88 m^2) excluding two outer rows and 0.1 m length from both ends of each plot.

2.3 Experimental Materials and Procedures

The experimental field was prepared using oxen driven local plow (*Maresha*) in accordance with the local farming practices. The land was leveled manually and treatments were assigned randomly. Seed were drilled in rows manually. Blended fertilizer (18.9%N, 37.7% P_2O_5, 6.95%S and 0.18% B) was used as sources of N, P, S and B, respectively. Nitrogen fertilizer was applied according to the treatments. The full dose of the NPSB fertilizer (100 kg ha^{-1}) and one-third of the nitrogen fertilizer were applied as basal at sowing. The remaining nitrogen fertilizer was applied as side-dressing at mid tillering stage of the crop (35 days after emergence).

2.4 Soil Sampling and Analysis

A total of five surface soil (0-30 cm) samples were collected diagonally from the experimental site and one composite soil sample was prepared. Soil sample was analyzed for texture, pH, EC, organic carbon, total nitrogen and available phosphorus (P). Soil texture was determined using the Bouyoucos hydrometer method (Bouyoucos, 1962). The pH of the soil was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter by potentiometer method (Rhoades, 1982). Organic carbon was determined by wet oxidation method as described by (Walkely and Black, 1934). Available P was determined by (Olsen *et al*., 1954) method. Total nitrogen was determined using Kjedahl method as described by (Bremner and Mulvaney, 1982).

2.5 Determinations

Phenological data

Days to 50% crop emergency: It was recorded when 50% of the plants in each plot emerges.

Days to heading (DH): It was determined as the number of days from sowing to the dates of 50% of the spike emerged from the flag leaf ligules.

Days to grain filling period: It was obtained by the number of days to maturity minus the number of days to heading.

Days to 90% physiological maturity (DPM): It was determined as the number of days from sowing to the date when 50% of the peduncle turned to yellow, that is, when no green color remained on glumes and peduncles of the tagged plants.
Days to harvest maturity: It was determined as the number of days from sowing to the date when 100% of the peduncle turned to yellow and whitish color.
Plant height (PH): It was recorded as the average height of main tillers (cm) of twelve randomly selected plants from each plot at maturity. It was measured from ground level to the tip of the spike excluding the awns.
Spike length (SL): It was measured from twelve randomly selected plants of the inner rows and the mean length (cm) was recorded on each plot by measuring from the base to the upper most part of the spike excluding awns at maturity.
Numbers of total tillers per m^2 (NT): It was determined as the capacity of tillering m^{-2} was demarcated before tillering and the number of plants existed in that area was counted at the period of statistical.

Analysis

All the collected data were subjected to Analysis of Variance (ANOVA) and the analysis was made using R-Software (V 3.5.1) appropriate to the design of the experiment. Means of all the treatments were compared using Tukey test.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Properties of the Soil

TABLE 1.Physico-chemical properties of soils at the experimental site in 2018

Soil parameters	
Textural Class	Sandy loam
Bulk density (g/cm^3)	1.36
pH(1:2.5 Water)	6.8
TN (%)	0.1143
OM (%)	2.286
OC (%)	1.326
Av. P($mg\ kg^{-1}$)	10.18
EC(ds/m)	2.45

The result showed that the texture of the experimental site was sandy loam with bulk density of 1.36 g/cm^3. The soil reaction was nearly neutral (pH=6.8). According to FAO (2008), suitable pH for most crops is between 6.5 and 7.5 where nitrogen (N) availability is optimum. The organic matter content was about 2.29%. According to Roy *et al.* (2006), soil with organic matter less than 3.74% is low potential to supply N to plants. The result also showed that low level of total N (0.11%) indicating that the nutrient may be a limiting factor for wheat production in the study area. Total Nitrogen

(%) was rated by Havlin *et al*. (1999) as very low when less than 0.1, low when the value is between (0.1 to 0.15), medium when the value is between (0.15 to 0.25), and high when is greater than 0.25. The available phosphorus content was 10.18mg kg^{-1}.

3.2 Effects of Nitrogen and Seed Rates on Wheat Phenology

3.2.1 Days to 50% emergence: The analysis of variance indicated that the main factor of seed rate and nitrogen level did not show significant ($p \leq 0.05$) difference on days to 50% crop emergence. Similarly, the interaction effect of seed rate and nitrogen level did not significantly influence days to 50% crop emergence.

3.2.2 Days to heading

Days to heading were significantly ($P \leq 0.05$) affected only by the main effects of seed and nitrogen rates. The earliest days to heading was recorded due to the application of the highest seed rate (200 kg ha^{-1}). With regards to the effect of nitrogen, days to heading was significantly delayed with the application of122kg ha^{-1} (Table 2).

TABLE 2. Mean days to heading and physiological maturity of bread wheat as influenced by seed rate and nitrogen rates

Treatments(kg ha^{-1})	DH	DPM	DGF
Seed rates			
100	67^{b}	127^{c}	72.46^{b}
150	64^{a}	126^{b}	$71.57a^{b}$
200	63^{a}	124^{a}	69.92^{a}
Nitrogen rates			
0	61^{a}	123^{a}	69.29^{a}
53	64^{b}	125^{b}	70.04^{a}
88	66^{c}	126^{c}	73.27^{b}
122	68^{d}	129^{d}	73.72^{b}
CV (%)	2.28	0.56	1.28

Note: Means within seed rate, nitrogen rate and their interactions followed by the same letter (s) are not significantly different at 5% probability level.

The result showed that as the seed rate increased, days to heading showed a decreasing trend. This might be due to the fact that increase in seed rate could encourage regular main stem which normally flower earlier than do the secondary tillers. This finding agrees with the report of Abiot (2017) that days to 50% heading were delayed when lower seed rate (100 kg ha^{-1}) were used. Days to heading were also significantly delayed when nitrogen rate was increased. This might be due to the fact that high nitrogen rate enhanced the vegetative growth and photosynthesis rate which prolonged the days to heading. Gheith *et al*. (2013) and Kandil *et al*. (2016) found that the increment in nitrogen concentrations increased the vegetative period of wheat and finally resulted in delayed heading.

3.2.3 Days to grain filling period

Days to grain filling period were significantly ($p \leq 0.05$) influenced only by the main effects of N and seed rate. The longest days to grain filling period were at higher N rates, 88 and 122 kg $ha^{-1}$and for seed rate 100kg ha^{-1}(Table 2). Despite small variability, factors showed a consistent increasing trend in days to grain filling with increasing nitrogen fertilizer and decrease seed rates. The results are in line with that of Sofonyas (2016) who stated that a steady increasing trend in grain filling period with rates of N in wheat was observed.

3.2.3 Days to 90% physiological maturity

The result of analysis of variance showed that days to physiological maturity were significantly ($P \leq 0.05$) affected only by the main effects of nitrogen and seed rates. According to the result, days to physiological maturity was significantly reduced with increasing seed rate. The shortest days to maturity was observed with the highest seed rate (200 kg ha^{-1}) (Table 2). This might be due to high plant population from the high seed rate increased competition for nutrients, soil moisture and light that influence the crop to mature early. The result of this study is in agreement with Alemayehu (2015) and Abiot (2017) who reported that increasing seed rate decreased days to physiological maturity of wheat. In contrast, increasing nitrogen rate delayed physiological maturity of wheat. High nitrogen rate could delay leaves senescence and encourage the crop growth. This condition increased the days required to attained physiological maturity of the crop. Application of low nitrogen rate in wheat shortens the growth phases by accelerating the physiological activities of the crop due to the shortage of plant growth resources (El Hag, 2011).

3.2.4 Days to harvest maturity

The statistical analysis of data has shown that days to harvest maturity were significantly ($P \leq 0.05$) affected by both the main and interaction effects of nitrogen and seed rates. Based on the result of interaction effects, the longest days to harvest maturity were recorded at seed rate of 100 kg ha^{-1} and 122 kg ha^{-1} nitrogen rate (Table 3).

TABLE 3. Mean days to harvest maturity of bread wheat as influenced by seed and nitrogen rates

	Nitrogen rate(N) (kg ha^{-1})				
Seed rate(S) (kg ha^{-1})	0	53	88	122	Mean(cm)
100	132.28^{bc}	139.40^{ef}	142.48^{fg}	144.14^{g}	139.54^{c}
150	129.00^{ab}	133.10^{cd}	139.24^{ef}	142.01^{fg}	135.79^{b}
200	126.61^{a}	128.70^{ab}	136.80^{de}	140.02^{efg}	132.98^{a}
Mean(cm)	129.29^{a}	133.70^{b}	139.50^{c}	142.06^{d}	

Note: CV (%) =1.28. Means within seed rate, nitrogen rate and their interactions followed by the same letter (s) are not significantly different at 5% probability level

According to the results, increasing nitrogen rate delayed harvest maturity of wheat. High nitrogen rate could delay leaves senescence and encourage the crop growth. Application of low nitrogen rate in wheat shortens the growth phases by accelerating the physiological activities of the crop due to the shortage of plant growth resources (El Hag, 2011). Decrease seed rates and increasing in nitrogen rates delayed day to harvest maturity of wheat. This might be due to high level of N application with low seed rates promotes leaf area index while prolongs leaf area duration i.e. delay leaf senescence and the potential photosynthetic capacity of crop is raised.

3.2.5 Effects of Seed and Nitrogen Rates on Bread Wheat Growth Parameters

Plant height

The analysis of variance revealed that both the main and the interaction effects of seed and nitrogen rates significantly ($P \leq 0.05$) affected plant height. Based on the result interaction effects, the highest plant height (99.85cm) was recorded at seed rate of 150 kg ha^{-1} and 122 kg ha^{-1} nitrogen rate whereas the lowest plant height (46.04 cm) was recorded at zero rate of nitrogen with 100 kgha^{-1} of seed rate (Table 4).

TABLE 4. Mean plant height of bread wheat as influenced by seed and nitrogen rates

Seed rate(S) (kg ha^{-1})	Nitrogen rate(N) (kg ha^{-1})				
	0	53	88	122	Mean(cm)
100	46.04^{a}	59.15^{ab}	80.43^{de}	94.74^{ef}	70.09^{a}
150	51.10^{ab}	77.26^{cd}	88.74^{def}	99.85^{f}	79.17^{b}
200	62.82^{bc}	81.42^{de}	89.58^{def}	92.68^{def}	81.63^{b}
Mean(cm)	53.32^{a}	72.61^{b}	86.25^{c}	95.66^{d}	

Note: CV (%) =7.21. Means within seed rate, nitrogen rate and their interactions followed by the same letter (s) are not significantly different at 5% probability level

Increasing seed rates and decrease in nitrogen levels increase plant height. This might be due to strong competition among the plants for light, nutrient and mutual shading. Saad (2010) also stated that the seed rate at 150 kg ha^{-1} showed significantly increased plant height up to 140 kg ha^{-1} nitrogen rate.

Spike length

The result showed that both the main and the interaction effects of seed and nitrogen rates significantly ($P \leq 0.05$) affected spike length of wheat. The highest spike length (8.41 cm) was recorded from the application of 150 kg ha^{-1}seed and 122 kg ha^{-1} nitrogen application (Table 5).

TABLE 5. Mean spike length of bread wheat as influenced by seed and nitrogen rates

Seed rate(S) (kg ha^{-1})	Nitrogen rate(N) (kg ha^{-1})				
	0	53	88	122	Mean(cm)
100	5.41^{abc}	6.36^{bc}	7.63^{de}	8.28^{e}	6.92^{b}
150	4.56^{a}	6.57^{cd}	7.54^{de}	8.41^{e}	6.77^{b}
200	4.42^{a}	5.23^{ab}	6.11^{bc}	7.82^{e}	5.90^{a}
Mean(cm)	4.80^{a}	6.10^{b}	7.10^{c}	8.17^{d}	

Note: CV (%) = 6.06%. Means within seed rate, nitrogen rate and their interactions followed by the same letter (s) are not significantly different at 5% probability level.

According to the result, an increase in seed rate decreased spike length of wheat. The high spike length due to low seed rate could be due to less competition among the plants for growth resources. The result agrees with Gafaar (2007) who reported that increasing seeding rates decreased the spike length in wheat. Regarding the effect of nitrogen, spike length increased with increasing nitrogen rate. Availability of high nitrogen could encourage the crop growth that leads to greater spike length .This finding agreed with Muhammad Yousaf *et al.* (2015) who observed similar effect on wheat. Based on this result, the increased in spike length of wheat at higher nitrogen rate and at lower seed rate might be associated to better utilization of growth resources.

Number of total tillers per m^2

Both the main and the interaction effects of seed and nitrogen rates were significantly ($P \leq 0.05$) affect the number of tillers per m^{2}of wheat. The highest number of tillers (801.33 m^{-2}) was recorded at seed rate of 150 kg ha^{-1} with 122 kg ha^{-1} nitrogen application (Table 6).

TABLE 6. Mean number of total tillers m^{-2}of bread wheat as influenced by seed and nitrogen rates

Seed rate(S) (kg ha^{-1})	Nitrogen rate(N) (kg ha^{-1})				
	0	53	88	122	Mean(m^{-2})
100	272.00^{a}	517.33^{bc}	563.67^{bc}	593.33^{c}	486.58^{a}
150	268.00^{a}	511.00^{bc}	610.67^{cd}	801.33^{e}	547.75^{b}
200	435.33^{b}	559.00^{bc}	741.33^{de}	753.33^{e}	622.25^{c}
Mean(m^{-2})	325.11^{a}	529.11^{b}	638.56^{c}	716.00^{d}	

Note: CV (%) =8.31. Means within seed rate, nitrogen rate and their interactions followed by the same letter (s) are not significantly different at 5% probability level.

Similar results were reported by Khalid *et al*. (2014) who that wheat was quite responsive to increased seed rate. The results of this study also showed that all nitrogen application rates significantly affected vegetative and reproductive growth of the crop depending upon the availability of needed nutrition (Iqbal *et al.*,2010). Based on interaction the result showed that combined application of 150 kg ha^{-1} seed rate with 103.5 kg N ha^{-1} produced more number of tillers per m^{-2}of wheat. At optimum seed

rate, the inter plant competition for space, nutrient, moisture and sun light decrease which results in increases of tillers m^{-2}. Similar results were reported by Shah and Hayat (2016).

4. CONCLUSION

Wheat is one of the major crops selected for food security in Ethiopia. The optimum rate of nitrogen fertilizer and plant density depends on numerous factors such as environmental conditions, management practices and genotypes. This was the primary drivers to conduct this study and identify optimum seeding rate and nitrogen fertilizer to maximum phenology and growth parameters of bread wheat in this study area. Results showed that treatment with seed rate of (150 kg ha^{-1}) has good impact most phonological and growth parameters. Effect of nitrogen rates have also showed highly significant ($P \leq 0.05$) effects on DH, GF, DPM, HM, PH, SL and NT. The highest values of DH, GF, DPM, HM, PH, SL and NT were obtained from the application of 122 kg N ha^{-1}. Most phenology and growth parameters of bread wheat exhibited increasing trend with increasing nitrogen rates. The interaction effects of nitrogen and seed rates significantly ($P \leq 0.05$) affected PH, SL and NT. The highest DH, GF, DPM, HM, PH, SL and NT were obtained from the application of 122 kg N ha^{-1} and seed rate of 150 kg ha^{-1}. From these results, it can be recommended that the, application of the highest rate of nitrogen (122 kg N ha^{-1}) and seed rate of 150 kg $ha^{-1}$are more promising obtain values of phonological and growth parameters.

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ACKNOWLEDGEMENT

This work is a part of my M.Sc. thesis; hence I am thankful to the department of Plant science, Wollo University for providing facilities and my respected advisors for their kind supervision. Thanks are also due to Dessie Zuria Agricultural Office for supporting my work with land, seed, fertilizer and other necessary facilities. Further, my special thanks also goes to my colleague Prof. Mohammed Gufran Khan who helped me during the preparation of this paper and Mr. Abera Ymer and Mr. Esthetu Muluneh for their moral support and encouragement in various aspects during my study period.