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EFFECTS OF NITROGEN RATE ON PERFORMANCE OF WHEAT (*Triticum aestivum*) IN JALINGO, TARABA STATE OF NIGERIA

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ABSTRACT

Field experiments were conducted in the 2017 and 2018 dry seasons at the Taraba State College of Agriculture, Department of Crop Science Irrigation Research Farm-Nukkai in Jalingo to investigate the response of wheat (*Triticum aestivum* L.) varieties to nitrogen rate. The experiments were laid out in a split-plot design with seven nitrogen rates (0, 30, 60, 90, 120, 150, and 180 kg N ha^{-1}) assigned to the main plot and three wheat varieties, Cettia, Lifen, Reyna-28 assigned to the subplot. The treatments were replicated three times. The subplot size was 3 m x 2 m (6 m^2) but this paper focuses on nitrogen rate only. Data were collected on percentage seedlings establishment count, number of fertile tillers, Plant height, number of spikes m^{-2}, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of 1000 grain weight, grain yield and harvest index. All the data collected were subjected to Analysis of Variance (ANOVA) and means were separated using the Least Significant Difference (LSD) procedure. The results revealed that nitrogen fertilization had a significant effect ($P \leq 0.05$) on wheat yield and yield components but percentage seedlings establishment count remained unaffected at varying nitrogen rates. Plant height was best at 180 kg N ha^{-1} while fertile tillers, all the yield characters, and final grain yield performed best at 120 kg N ha^{-1}. In conclusion, a Nitrogen rate of 120 kg N ha^{-1} proved to be the best rate for higher grain yield.

A nitrogen rate of 120 kg ha^{-1} is recommended for irrigated wheat production in the study area however, the addition of 180 kg N ha-^{1} should be used for animal pasture production in the area.

Keywords: nitrogen rate, wheat (*Triticum aestivum* L.), establishment count, fertile tillers, Plant height, yield and yield attributes, and harvest index

1.0 INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important staple crop around the world. Its importance has risen even more due to frequently experienced food shortages and its role in world trade. Wheat ranks first among the cereal crops, accounting for 30% of all cereal food worldwide and major food for over one-third of the world population It provides about 20% of the total food calories directly or indirectly for the human race [1]. In Nigeria, wheat is mainly cultivated under irrigation conditions in the northern part of the country (Gombe, Borno, Yobe, Bauchi, Jigawa, Kano, Zamfara, Katsina, Sokoto, Kebbi, Adamawa, and Plateau states) where suitable low temperature (<25^{0} C) exist during the cold harmattan period from November to March [2]. There is an increase in domestic demand for baked and pasta products in the country with the national requirement of about 4.0 million metric tonnes annually. However, local production is only 2.2% of its national requirement while the remaining is imported [3]. Nitrogen is the most important nutrient supplied to most non-legume crops, including wheat. It is the most important constituent of plant proteins and is required throughout the crop growth period from the vegetative stage to harvesting. Muhammad *et al.*[4] reported that the increase in biomass production such as straw and biological yields was more pronounced with nitrogen nutrition application. Nitrogen fertilizer is known to affect the number of tillers per m^2, number of grains spike, spike length and weight, 1000-grain weight, and grain yield of wheat [5-6]. The application of nitrogen is known to mainly increase the grain yield, biological yield, and other characteristics including plant height and 1000 seed weight [7]. Given the importance of nitrogen fertilization, Shirazi *et al.*[8] stated that increased vegetative growth, spike length, spike-bearing tillers, and plant height efficiently can be attributed to nitrogen fertilization which greatly helps the plant to expose its potential to grow vigorously. The application of the appropriate rate of N fertilizer is considered to be a primary means of increasing wheat grain yield, improving nitrogen uptake and use efficiency and consequently nitrogen harvest index (Fageria, 2014) in [10]. Therefore, the availability of nitrogen to wheat during various phases of its growth and development is an important factor influencing the yield and quality of grain [11]. Asghar *et al*.[12] reported that among the factors responsible for the low yield of wheat, the deficiency of nitrogen in our soils is considered the most important and that wheat yield will increase with the increasing rate of nitrogen application. With the high demand and low production of domestic wheat in Nigeria coupled with the status of the soil on which wheat is grown in Nigeria, the present study was therefore designed to determine the effect of nitrogen rate on the growth and yield of Wheat (*Triticum aestivum*).

2.0 MATERIALS AND METHODS

Field experiments were conducted in the 2017 and 2018 dry seasons at the Taraba State College of Agriculture, Department of Crop Science Irrigation Research Farm-Nukkai in Jalingo which is located within latitude 8^0 55′0″ N and longitude 11^0 19´25″ E at altitude 1600.23 m above sea level in Southern Guinea Savanna [13]. Jalingo experiences a wet and dry tropical climate with the rainy season from May to October with a mean annual rainfall of 750 to 1000mm while the dry season commences in November and ends in March or April [14]. The two experiments were laid in a complete randomized block design, with seven (7) nitrogen fertilizer rates (0′ 30, 60, 90, 120, 150, and 180 kg Nha^{-1}). The field was cleared, ploughed, harrowed, and levelled to achieve the required tilt for small grains. Wheat seeds obtained from Lake Chad Research Institute were treated with Apron star at the rate of 10 g to 10 kg of seeds and sown by dibbling at a row spacing of 30x25 cm in the middle of November. The sources of fertilizer were NPK 15:15:15 and Urea (46:0:0). Half of each rate was applied in the respective plots at the time of sowing and the other ½ top-dressed at the tillering stage. Due to the texture of the soil (silt-clay) and the period (dry season), water was applied to the field at 7-day intervals commencing at sowing and irrigation continued until the grain filling reached the soft dough stage. Post-emergence application of Bentazone at 1.5 kg ai ha^{-1} (2.5 L ai ha^{-1}) was applied at 4 weeks after sowing as recommended. Data were collected on a number of tillers plant^{-1}, fertile tillers plant^{-1}, non-fertile tillers plant^{-1}, plant height plant^{-1} (cm^2), number of spikes m^{-2}, number of grains spike^{-1}, weight of 1000 grains, grain yield and harvest index. The crop was harvested at physiological maturity at an area of 1m^2 of each plot, sundried, and threshed to obtain the grains. All the data collected were subjected to Analysis of Variance (ANOVA) appropriate to randomize complete block design and means were separated using Least Significance Difference (LSD) at a 5% level of significance as described by Gomez and Gomez [15]. The package used was GENSTAT Version 4.0

3.0 RESULTS AND DISCUSSION

Percentage seedling establishment

The effects of nitrogen rate on the percentage of seedlings establishment are presented in Table 1. In both 2017 and 2018 and combined, the result showed no significant difference in respect to nitrogen rate on percentage seedlings establishment. This suggests that when high-quality seeds are sown under favorable conditions for germination, good stands can be obtained. This result is supported by Maqsood *et al.*[16] who reported that the impact of different nitrogen rates was found to be non-significant for seedlings establishment count.

Plant height plant^{-1}

The data result on the effect of nitrogen rate on plant height for 2017, 2018, and combined is presented in Table 1. There was highly significant effect of nitrogen fertilizer rate on plant height in all the sampling periods of both seasons. From the combined result, maximum and minimum plant Plant heights plant^{-1} of 31.69 and 20.46 cm were obtained from 180 kg N ha^{-1} and 0 kg N ha^{-1} respectively. The increased plant height in response to increasing nitrogen rate could be attributed to the significant role nitrogen plays in internode elongation and greater capacity of metabolites building as a result of enlarged plant leaf area at higher doses during the vegetative growth. The result agrees with the result obtained by Amjed *et al.*[17] that maximum plant height was produced from 180 kg N ha^{-1} and minimum plant height was produced from 0 kg N ha^{-1}. Other authors also observed that an increase in nitrogen fertilization increased plant height [18-19].

Fertile tillers plant^{-1}

The effect of nitrogen rate on number of fertile tillers plant^{-1}for 2017 and 2018 dry seasons and combined is shown in Table 1. In both seasons and combined, the result indicates that 120 kg N ha^{-1} recorded significantly the highest number of fertile tillers plant^{-1}. Ishete and Tana [20] also reported an increase in the number of fertile tillers in response to the increased application rates of nitrogen fertilizer. Asif *et al*.[21] also observed a significantly increased number of fertile tillers per unit area by increasing nitrogen fertilization rates. This result is concurrent with Mengistu [22] in Ishete and Tana [20] who recorded the highest number of fertile tillers in treatment that received 175 kg N ha^{-1} than control. Yousaf *et al*.[11] reported that the application of 120 kg N ha^{-1} significantly produced the highest number of fertile tillers plant^{-1}.

Number of spikes^{-2}

Table 2 presents the results on the effects of nitrogen rate on the numbers of spikes m^{-2} in the 2017, and 2018 dry seasons and combined. The results showed a highly significant difference in nitrogen rate on the number of Spikes m^{-2} in both dry seasons and combined. Nitrogen rate 120 kg N ha^{-1} produced the highest number of spikes m^{-2} and its minimum values were recorded in 0 kg N ha^{-1}. The number of spikes m^{-2}increased with an increased rate of nitrogen. Amjed *et al*.[23] reported that increasing the nitrogen rate from 0-120 kg N ha^{-1}**increases the number of spike m^{-2}and the number of grains spike^{-1}.** With the increase of nitrogen, the number of spikes m^{-2} and the number of grains spike^{-1} increase. Shahzad *et al*.[24], Abedi *et al*.[25] and Kandil *et al*.[26] reported similar results in wheat.

Number of grains spike^{-1}

The data results on the number of grains spike-^{1} as presented in Table 2 show a highly significant difference in nitrogen rate on the number of grains spike-^{1} in both seasons and combined. Nitrogen at 120 kg ha^{-1} resulted in the highest number of grains per spike and the minimum number of grains spike^{-1} was observed from the control.

Table 1: Effects of Nitrogen Rate on Number of Percentage Seedlings Establishment, Plant Height (cm) at Different Days after Sowing and Fertile Tillers per Plant in Jalingo During 2017, and 2018 Dry Seasons and Combined

Nitrogen Level ($Kgha^{-1}$)	% Seedlings Establishment			Plant Height						Fertile Tillers		
	2017	2018	Combined	2017 50DAS	2018 50DAS	Combined	2017 70DAS	2018 70DAS	Combined	2017	2018	Combined
0	96.94	87.36	92.15	21.83	19.08	20.46	50.86	48.52	49.69	10.52	8.20	9.36
30	97.64	86.33	91.99	23.44	20.29	21.86	52.5	49.88	51.02	12.57	9.91	11.24
60	97.50	89.31	93.40	25.66	22.30	23.98	53.93	51.76	52.84	15.97	11.56	13.76
90	96.67	87.08	91.88	27.29	23.57	25.43	58.33	54.74	56.54	17.93	14,00	15.96
120	95.50	90.28	93.89	29.76	25.35	27.56	62.33	59.33	60.83	22.82	17.53	20.18
150	96.11	86.53	91.32	31.49	27.47	29.48	65.30	63.14	64.22	20.42	15.67	18.04
180	97.22	86.53	91.88	33.20	30.19	31.69	67.97	66.06	67.01	18.51	14,18	16.34
P of F	0.34	0.90	0.819	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
LSD	1.497	8.145	3.922	0.574	0.169	0.283	1.069	0.271	0.522	0.50	0.476	0.327

DAS = Days after Sowing FTL = Fertile tillers ** = Highly Significant ($P \leq 0.01$)

Table 2: Effect of Nitrogen Rate on Number of Spikem^{-2}, Number of Grains Spike^{-1}, Weight of 1000 Grains, Grain Yield, Harvest Index for 2017 and 2018 and Combined

Nitrogen Rate	Number of Spike m^{-2}			Number of Grains Spike^{-1}			Weight of 1000 Grains			Grain Yield			Harvest Index		
(Kgha^{-})	2017	2018	Combined	2017	2018	Combined	2017	2018	Combined	2017	2018	Combined	2017	2018	Combined
0	206.01	94.11	150.06	28.19	27.00	27.60	31.81	28.61	30.21	2163	1236	1699	27.31	23.04	25.61
30	271.89	116.78	194.33	32.88	29.36	31.12	33.26	29.09	31.17	2341	1511	1926	28.18	24.05	25.68
60	303.22	137.89	220.56	38.62	35.51	37.07	36.04	30.62	33.33	3002	1842	2422	28.54	25.59	27.06
90	349.67	221.22	285.44	44.33	42.04	43.19	39.60	31.39	35.50	3672.	2700	3186	30.58	33.08	31.83
120	390.22	290.44	340.33	53.91	50.69	52.30	43.01	33.80	38.40	4349	3815	4082	32.57	33.83	33.20
150	362.00	274.80	318.00	47.58	45.18	46.38	38.25	32.90	35.57	4247	3590	3918	28.34	29.64	28.99
180	367.33	227.00	297.17	45.15	42.89	44.02	35.56	33.52	34.54	3828	3428	3628	24.91	26.10	25.51
P of F	<.001	<.001	<001	<.001	<.001	<001	<.001	<.001	<001	<.001	<.001	<001	<.001	<.001	<001
LSD	1.441	0.948	0.817	1.133	2.040	1.105	0.638	0.224	0.320	42.78	40.10	27.77	0.328	0.448	0.263

This trend might be due to the role of nitrogen in flowering, seed formation, and crop maturation. These findings conform with the findings of Maqsood *et al*.[16] who reported that the application of 120 kg N ha^{-1} gave maximum grains $spike^{-1}$ than control and that beyond the limit above 120 kg N ha^{-1} leads to a decline in the number of grains $spike^{-1}$. Abedi *et al*.[27] reported that number of grains $spike^{-1}$ significantly increased with increasing nitrogen fertilization rates. This result is similar to that of Ahmed and Terence [28], who reported that 120-60-50 N P K kg ha^{-1}, produced the maximum number of grains $spike^{-1}$ as compared to the other treatments including the control. This result disagrees with the report of Gevrek and Atasoy [29] that nitrogen application had no significant effect on the number of grains $spike^{-1}$.

Weight of 1000 grain

The effect of nitrogen rate on 1000 grain weight for 2017, 2018, and combined as presented in Table 2 shows that plants fertilized with 120 kg N ha^{-1} differ significantly from other rates with the highest values of 31.81, 28.61, and 30.21 for 2017, 2018 and combined respectively. The lowest weight was recorded from the control. The application of nitrogen increased the protein percentage, which in turn increased the grain weight. The high 1000-grain weight with high nitrogen rate application might be attributed to a better nutritional status of plants, which resulted in good grain filling and development and such a positive linear response of 1000-grain weight [30-31]. In line with this result, Rahman *et al*.[32] reported of maximum 1000 grain weight for wheat in two consecutive years by application of 120 kg N ha^{-1}.

Grain yield

Grain yield was significantly affected by nitrogen rate, Table 2. The highest and lowest grain yields of 4349.3 and 3827.6 kg ha^{-1} for 2017, 3814.6 and 3427.9 kg ha^{-1} for 2018 with the combined value of 4082 and 1699 kg ha^{-1} were obtained from 120 kg N ha^{-1} and the control respectively. This was attributed to the significant increase in the yield components most especially, the number of grains $spike^{-1}$ and weight of 1000 grains. These results are in full agreement with the findings of Laghari *et al.*[33] in Leghari and Hafeez.[34] recorded the maximum grain yield at 120: 60: 60 NPK kg ha^{-1}. This research agrees with the report of Gionvani *et al*. [35] that higher grain yield at higher nitrogen fertilization rates could be explained by better performance of grain yield components, especially the number of fertile tillers, number of grains $spike^{-1,}$ and flag leaf length. The reduction in grain yield during 2018 is attributed to higher temperatures in the season as presented in Table 3.

Table 3: Monthly Average Weather Data for Experimental Site for 2017 and 2018 Dry Seasons

	2017			2018		
Month	Temperature Min (^{0}C)	Temperature Max (^{0}C)	Relative Humidity (%)	Temperature Min (^{0}C)	Temperature Max (^{0}C)	Relative Humidity (%)
November	19.50	33.30	43	20.70	35.20	60
December	19.40	34.70	27	21.60	35.40	36
January	19.70	35.10	31	22.80	37.00	32
February	21.70	36.50	31	24.10	37.60	35
March	25.90	38.80	51	24.50	39.30	55

Source: Department of General Studies, Taraba State College of Agriculture Jalingo, 2017 to 2018

This is supported by FAO (2019) which reported lower world wheat production of 734 million metric tons in 2018-2019 as compared to 771 mmt in 2017-2018 due to diverging weather conditions. This result is confirmed by Sjerven [36] and GIEWS [37].

Harvest Index

Application of nitrogen under different rates significantly affected the harvest index of wheat for both seasons and combined as shown in

Table 2. From the combined result, the maximum harvest index (33.20) was observed at 120 kg N ha^{-1} followed by 90 kg N ha^{-1} and the minimum harvest index (25.51) was recorded from 180 kg N ha^{-1} which was statistically to control and 30 kg N ha^{-1}. This might be attributed to excess vegetative growth accompanied by a decreased number of grains and grains weight traits that contributed to total grain yield in higher nitrogen rate, while in control and lower nitrogen rate the nutrients might have been exhausted during vegetative growth. The results concur with Laghari *et al.* (2010) that the maximum harvest index was recorded at 120-60-60 NPK kg ha^{-1} level. This result is supported by Asif *et al.* [21]. The results of this study disagree with the findings of Mahjourimajd *et al.*[38] who reported that the harvest index showed no direct response to varying nitrogen application and Tamang *et al.* [39] who reported that the highest harvest index was recorded at low nitrogen application level.

Conclusion

From the results of this study, it can be deduced that the growth parameters, yield, and yield parameters significantly responded to increasing nitrogen rate. The highest values of growth characters were observed at 180 kg N ha^{-1}.The highest values of yield and yield characters were observed at 120 kg N ha^{-1}. Thus, for the best grain yield and considering the economy and efficient nitrogen use, 120 kg N ha^{-1} was found to be more remunerative than 180 kg N ha^{-1}. The reduction in the growth, yield, and yield parameters in the 2018 dry season is caused by higher temperatures in the season.

Recommendations

Based on the findings from this study, it is recommended that the application of 120 kg N ha^{-1} should be used for irrigated wheat production in the study area. However, the addition of 180 kg N ha-^{1} may be useful for animal pasture production.

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