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Effects of Nitrogen Levels on Growth and Yield of Some Newly Released Wheat Genotypes under Bhairahawa Condition

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ABSTRACT

The newly released wheat varieties with different nutritional demands and their yield potential hinder generalized recommendations for nitrogen (N) fertilization. Field experiments were carried out during 2018/19 and 2019/20 growing seasons to evaluate the response of varying N fertilizer rates on growth and yield parameters of two newly released wheat varieties (Borlaug 2020 and Zinc Gahun-1), one promising line (NL 1179) and Vijay as a check variety. Five N levels (i.e. 0, 50,100,150 and 200 kg N ha^{-1}) were applied in the experiment designed in split plot with three replications. Nitrogen levels and genotypes were allocated as main plot and sub plot treatments, respectively. The combined analysis of both growing seasons indicated that, all newly released and promising genotypes performed better than check variety. NL 1179 recorded the highest grain yield followed by Borlaug 2020 and Zinc Gahun-1. A linear increase of grain yield was observed with increased rate of N from 0 to 200 kg ha^{-1}, while 200 kg N ha^{-1}showed significantly ($p<0.001$) highest grain yield which was statistically at par with 150 kg N/ha. Similarly, gross margin (Rs. 148933 ha^{-1}) was highest with the application of N @ 150 kg ha^{-1}. Interaction effect of genotypes and N levels was not found significant. Thus, it can be concluded that for higher grain production of improved wheat varieties, 150 kg Nha^{-1}could be recommended under Bhairahawa condition.

Keywords: Economics, Nitrogen level, Wheat genotypes, Yield

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most staple food crops in the world and it is one of the most important cereals cultivated in Nepal. Wheat in Nepal stands third in both area coverage and total annual production with productivity of 2.99 t ha^{-1} (MoALD 2022). The production is declined due to various factors like drought stress, late sowing, low-quality seeds, climate variability, and insect pests, but judicial use of fertilizers is also important for wheat production for food security and the environment (Hochman and Horan 2018; Rahman et al 2018). Among various factors responsible for low yield of wheat crop, nutrient management is of key importance. Inadequate and unbalanced use of fertilizers is found associated with decreasing efficiency of nutrient use (Devkota et al 2016; Sapkota et al 2014). This scenario equally enforces the concern authorities and researchers to work towards maximizing wheat yield through the adoption of optimum nutrient rate (Becker et al 2007).

The impact of nitrogen surpasses that of other fertilizers due to its essential role in protoplasm, proteins, and chlorophyll. This leads to an increase in cell size, subsequently resulting in heightened plant height and improved crop yields (Hutchison and Talbot 1983). Boosting crop yield through proper nitrogen fertilization stands as a crucial aspect of effective farm management. The fundamental necessity for achieving high-quality and high-yield wheat is to ensure that the plant receives the ideal amount of nitrogen throughout its growth stages (Dorsheimer and Issac 1982). The reduced wheat yield can be attributed to a range of factors, including the absence of suitable varieties, quality seeds, proper timing of seeding, insufficient fertilization, seed rates, and sowing techniques, among others.

To achieve higher crop yields, it is imperative to implement well-balanced fertilization and improved agricultural practices, as these measures enhance the crop's potential. This underscores the need for more effective methods of diagnosing soil fertility. When fertilizers are applied, the plant's response can be assessed through tissue composition, although the correlation with yield may not always be direct. Furthermore, in semi-arid regions, the response to fertilizers is influenced by the quantity and distribution of precipitation. Nitrogen, being one of the fundamental elements required, plays a crucial role in attaining higher wheat yields (Mengel and Kirkby 1978).

An experimented conducted at National Wheat Research Program during 2019/20 revealed that the Site Specific Nutrient Management Dose (148:65:71 N: P_2 O_5 :K_2 O kg ha^{-1}) and Research Recommended Dose (150:50:50 N: P_2 O_5 :K_2 O kg ha^{-1}) of fertilizers recorded significantly highest grain yield of wheat (Mathura et al 2020). In the study by Devkota et al (2018), it was also noted that wheat yield was significantly greater when using the 180:50:50 N: P2O5:K2O kg ha^{-1} treatment compared to the other treatments. With the increasing population every year, the pressure for increasing food production has also increased to feed the increasing population. This has compelled people to introduce high yielding crop varieties. With the introduction of such high yielding crop varieties, the use of chemical fertilizers has also been increased (Rai and Khadka 2009). Inadequate supply of nitrogen (N) fertilizers can limit the potential productivity of the crop and excessive N causes environmental pollution and economic losses (Rahman et al 2021). The injudicious use of N fertilizers causes lodging in crops and reduced economic yield. Hence the present experiment was carried out to study the response of newly released and promising wheat varieties to different N levels.

MATERIALS AND METHODS

Experimental site and environmental conditions

Field experiments were carried out at National Wheat Research Program (NWRP), Bhairahawa during 2018/19 and 2019/20. Geographically the station is located at 27^0 32' north latitude and 83^0 25' east longitudes with the elevation of 104 masl. The climate is of sub-tropical type. The meteorological data such as maximum and minimum temperature and total rainfall during the entire experimental period were recorded from the meteorological station of NWRP, Bhairahawa and presented in Figure 1 and Figure 2. Rainfall in the study area varied considerably between the two growing years. The total rainfall during the cropping season was 141.7 mm and 333.9 mm in 2018/19 and 2019/20, respectively.

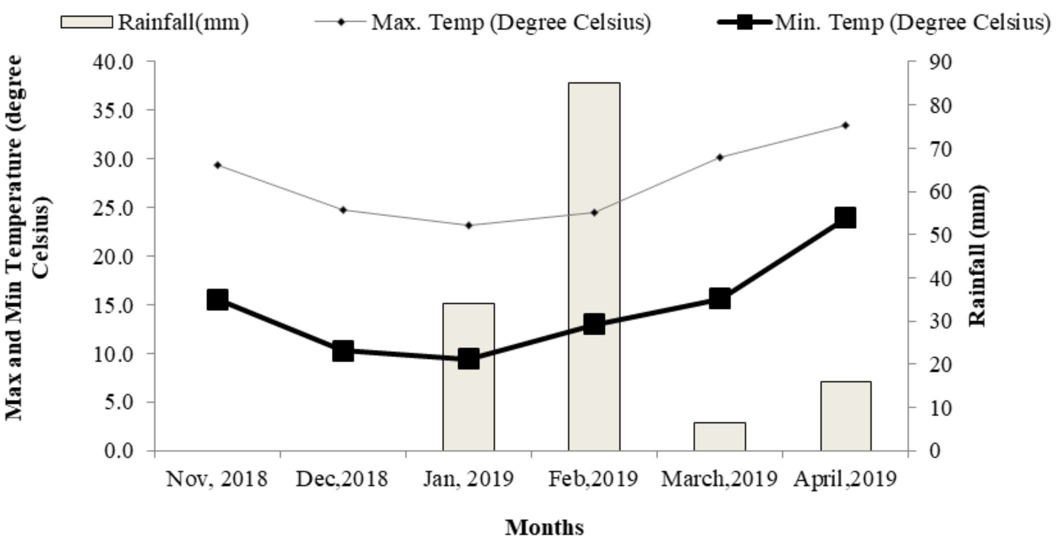

Figure 1: Monthly total rainfall, mean maximum and minimum temperatures during the experiment (2018/19)

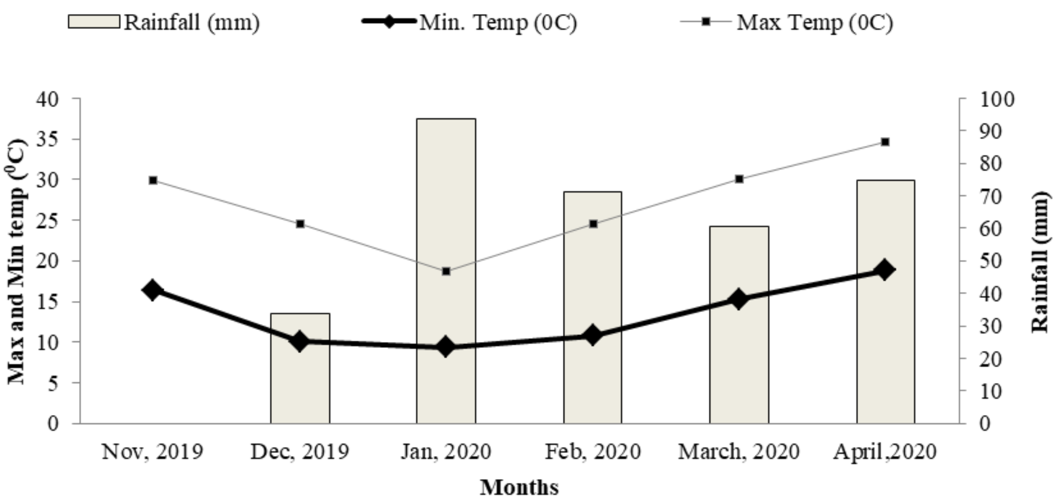

Figure 2: Monthly total rainfall, mean maximum and minimum temperatures during the experiment (2019/20)

Chemical properties of soil (0-15 cm) at the experimental site

Soils samples were taken randomly from three different spots of each replication from the depth of 0-15 cm using tube auger to record the initial soil chemical properties of the experimental site (Table 1). The soil samples were air-dried, grounded and sieved through 2 mm sieve and subject to test their properties. Total N was determined by Macro-Kjeldahl method (Jackson 1967), available phosphorous by Olsen's method (Olsen et al 1954) and available potassium by Flame Photometer method (Knudsen et al 1982)),Organic Matter was determined by Walkey and Black method (1934), pH (1:2.5 soil: water suspension) by Beckman Glass electrode pH meter (Pradhan 2005) and soil texture by hydrometer method (Klute 1986).

Table 1: Chemical properties of soil at the experimental site

Chemical Properties	Content	Category
Soil pH	7.42	Slightly Alkaline
Soil organic matter %	2.16	Low
Total nitrogen %	0.10	Medium
Available Phosphorous (P_2O_5 kg ha^{-1})	51.89	Medium
Available Potassium (K_2O kg ha^{-1})	114.7	Medium

The chemical properties of the soil of the experimental field revealed that soil pH was slightly alkaline with low organic matter content. The available potassium and phosphorous in the soil was medium. Finally, the total N content was also medium according to the rating scale described by Khatri Chhetri (1991).

Experimental design, treatments, crop management and observations

The experiment was laid out in split plot design with five N levels (0, 50, 100, 150 and 200 kg ha^{-1}) as a whole plot and four wheat genotypes; Borlaug 2020, Zinc Gahun-1, NL 1179 and Vijay as a sub-plot which were replicated three times. So, total of 20 treatments in 60 plots of size 2.5 m x 4 m were tested. The crop was planted in 25^{th} November in both seasons at the spacing of 25 cm between rows with continuous seeding. The net harvested area was 6 m^2. Urea, Di-ammonium Phosphate and Muriate of Potash were the source of fertilizers used for supplying nitrogen, phosphorus and potash respectively. In nitrogen omission plot, Single Super Phosphate was applied as a source of phosphorus. Full dose of phosphorous and potassium fertilizers was applied at the time of land preparation. The recommended dose of 50 kg $P_2O_5ha^{-1}$and 50 kg $K_2Oha^{-1}$was applied as basal in all plots at the time of seed sowing. Half dose of N was used at the time of seed sowing as basal dose. The remaining half dose of N was side-dressed at CRI and maximum tillering stage. Sulfosulfuron @ 30 g a.i. per ha was applied to control weed populations in all experimental plots at 35 days after sowing (DAS).

Observations were taken on plant height, spike length, effective tillers per square meter, 1000 grain weight, grain yield and straw yield. The five selected plants were used to measure plant height from ground to tip of spike excluding awn. The average data of five plants height was used as plant height, expressed in cm. Effective tiller per m^{-2} was recorded from net plot area of individual plot. Thousand grains were counted from each net plot yield and weighted with in automatic electronic balance. Grain yield was recorded from net plot area of 6

$m^{2,}$ and expressed in kg ha^{-1} at 12 % moisture content. Harvesting was done manually using hand sickle. Partial budget analysis of grain yield responses for different N fertilizer rates were done following the method used by Nasreen and Farid (2003).

Statistical Analysis

Data were collected and organized in Microsoft Excel, and for each parameter over a two-year period, an analysis of variance was performed using the Split Plot Design design as outlined in GENSTAT. Treatment means were compared using least significant difference (LSD) test at $P \leq 0.05$.

RESULTS

Plant height, panicle length and effective tillers/m^2

The analysis of variance for plant height showed significant difference among N levels and genotypes in both years (Table 2). Interaction was non significant among the four genotypes and the five levels of N. Plant height increased; with increasing N level from the 0 to 200 kg ha^{-1}. Maximum plant height was recorded when N dose was 200 kg ha^{-1}, while minimum plant height was recorded in the control. The plant height for the four genotypes averaged over levels of N showed that Vijay had maximum plant height (97 cm) while minimum plant height was obtained in NL 1307. These results are supported by the findings of Rahman et al (2014), Ullah et al (2018), Liaqat et al (2003), Hussain et al (2006) and Khan et al (2000) who reported that increasing the level of nitrogen increased the plant height. Pooled analysis (Table 4) showed the similar trend and significantly highest plant height was obtained with the application of nitrogen @ 200 kg ha^{-1}which was statistically at par with150 and 100 kg N/ha. Similarly, plant height was affected significantly among tested genotypes and tallest plant height was recorded in Vijay variety and shortest was Borlaug 2020.

Table 2 data show that the N levels and genotypes had significant differences in panicle length. Panicle length of wheat increased from the control level of N to 200 kg ha^{-1}. Significantly highest panicle length was recorded when N dose was 200 kg ha^{-1} while lowest panicle length was recorded in control (0 kg Nha^{-1}). Among the tested genotypes, NL 1307 and NL 1327 recorded highest panicle length in 2018/19 while NL 1179 and Vijay recorded highest in 2019/20. Pooled data showed significantly highest panicle length @ 200 kg Nha^{-1}while lowest panicle length recorded in control plot (Table 4). Panicle length was non significantly differed among tested genotypes.

There were significant differences in effective tillers per square meter due to N levels while the four genotypes had no significant differences in 2018/19 but significantly differed in 2019/20 (Table 2). Total number of tillers per meter square increased from the control level of N to 150 kg ha^{-1}. NL 1327 recorded significantly maximum number of tillers per square meter in 2019/20. Combined analysis revealed that effective tillers per square meter differed significantly due to N levels and highest tillers per square meter was obtained in 150 kg Nha^{-1}but non significant effect on tillers per square meter was found among tested genotypes (Table 4).

Table 2: Effect of different dose of N and genotypes on plant height, panicle length and effective tillers

Treatments	Plant height (cm)		Panicle length (cm)		Effective tillers m^{-2}	
	2018/19	2019/20	2018/19	2019/20	2018/19	2019/20
Nitrogen Levels (A) (kg ha^{-1})						
0	77	67	8	6.5	268	220
50	94	92	10	9.2	277	240
100	98	97	10	9.7	351	324
150	101	96	10	9.8	409	347
200	102	98	11	10.1	379	322
F-test	**	**	**	**	**	**
LSD (0.05)	4.8	2.7	0.8	0.4	55.7	57.1
Genotypes (B)						
NL1307 (Borlaug 2020)	90	84	10	8.8	344	288
NL 1327 (Zinc Gahun-1)	96	91	10	8.5	328	324
NL 1179	95	89	9	9.5	344	290
Vijay	97	97	9	9.5	332	260
F-test	**	**	*	**	ns	**
LSD (0.05)	2.9	1.9	0.5	0.3		30.9
CV %	4.1	2.9	6.9	4.6	16.2	14.2

*** and * denotes significant at 1 % and 5% level of significance respectively, ns indicates non significant*

Thousand grain weight, grain yield and straw yield of wheat

Thousand grain weight is an important yield parameter. The N levels and genotypes significantly affected 1000-grain weight. Nitrogen at high rate produced heavier grains. Application of N@ 150 kg ha^{-1}recorded heaviest 1000 grain weight in both seasons. These results agree with the findings of Hussain (2006) who reported that 1000-grain weight of wheat was significantly affected by different N levels. Among four genotypes, Vijay recorded heaviest 1000 grain weight in both seasons and NL 1307 recorded lowest (Table 3). Similar trend was observed in pooled analysis and results showed that significantly highest 1000 grain weight of 47.8 gram was recorded in 150 kg Nha^{-1}application and Vijay produced significantly highest 1000 grain weigh of 50.9 gram (Table 4).

The analysis of variance for grain yield showed significant difference among N levels in both years while among genotypes, only significant difference was observed in 2018/19 (Table 3). Grain yield increased as amount of nitrogen was increased from the control level to 200 kg ha^{-1}. The nitrogen levels interacted positively with wheat genotypes. The highest grain yield of any crop is the result of all positive relationships of the yield components. Fertilizer; mainly N application enhances the grain yield of wheat varieties. Combined analysis showed the significantly highest grain yield was observed with the application of 200 kg Nha^{-1}which was statistically at par with 150 kg $Nha^{-1}$and non significant effect was observed in tested genotypes (Table 4). The lower grain yield in second growing season (2019/20) as compared to first season (2018/19) might be due to higher rainfall during crop growing season. Similarly, straw yield was significantly differed due to N levels and genotypes (Table 4). The straw yield increased as amount of N applied was increased from the control level to 200 kg $ha^{-1}$and NL 1327 recorded the significantly highest straw yield.

Table 3: Effect of different rates of N and genotypes on 1000 grain weight, grain yield and straw yield of wheat

Treatments	1000 grain weight (gm)		Grain yield (kg ha^{-1})		Straw yield (kg/ha)	
	2018/19	2019/20	2018/19	2019/20	2018/19	2019/20
Nitrogen Levels (A) (kg ha^{-1})						
0	44.0	38.6	1645	1169	2441	1822
50	47.6	41.1	3146	2687	4109	3654
100	49.0	41.9	4242	3738	4917	5150
150	52.1	43.4	5355	4396	6417	5298
200	49.5	40.8	5366	4515	6559	5847
F-test	**	*	**	**	**	**
LSD (0.05)	3.19	2.3	334.2	383.5	694.5	1231.8
Genotypes (B)						
NL1307 (Borlaug 2020)	43.6	37.8	3891	3349	4956	4646
NL 1327 (Zinc Gahun-1)	49.1	36.2	4023	3219	4972	4664
NL 1179	47.7	42.1	4145	3301	4917	4512
Vijay	53.3	48.4	3744	3335	4709	3595
F-test	**	**	**	ns	ns	**
LSD (0.05)	2.35	0.8	165.3			368.2
CV %	6.5	2.8	5.6	7.3	18.1	11.3

*** and * denotes significant at 1 % and 5% level of significance respectively, ns indicates non significant*

Table 4: Effect of different rates of N and genotypes on growth, yield attributes and yield of wheat, (Pooled analysis for two years)

Factor	Plant height (cm)	Panicle length (cm)	Effective tillers/m^2	1000 grain weight (gm)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
N Level (kg ha^{-1}) (A)						
0	72	7.1	244	41.3	1407	2132
50	93	9.5	259	44.4	2916	3881
100	98	9.8	338	45.5	3990	5033
150	99	9.9	378	47.8	4876	5857
200	100	10.4	351	45.1	4941	6203
F test	**	**	**	**	**	**
LSD (0.05)	2.6	0.4	46.6	2.5	328.1	763.6
Genotypes (B)						
NL1307 (Borlaug 2020)	87	9.2	316	40.7	3620	4801
NL 1327 (Zinc Gahun-1)	94	9.3	326	42.7	3621	4814
NL 1179	92	9.5	317	44.9	3723	4715
Vijay	97	9.5	296	50.9	3540	4152
F test	**	ns	ns	**	ns	**
LSD (0.05)	1.5			1.3	140.9	376.5
Interaction						
A x B	**	ns	ns	*	ns	ns
CV (%)	5.1	8.3	16.3	5.3	6.5	18.9

*** and * denotes significant at 1 % and 5% level of significance respectively, ns indicates non significant*

Partial budget analysis

In the present study, the cost for the urea was considered as variable cost where as other costs were constant for each treatment. For the calculation of gross margin, market price of wheat grain and urea was included and price of wheat grain was Rs.32 per kg while urea was Rs. 25 per kg during the preparation of this manuscript. Gross returns were recorded highest of Rs. 158102 per hectare with the application of N @ 200 kg ha^{-1} while gross margin (Rs. 148933ha^{-1}) was highest in application of N@ 150 kg ha^{-1}. Due to higher cost incurred in urea, application of 200 kg Nha^{-1} recorded lower gross margin as compared to 150 kg Nha^{-1}. It revealed that application of N @ 150 kg ha^{-1} was found more economical and profitable.

Table 5: Partial budget analysis for wheat grain yield response for different N levels

Nitrogen level (kg ha^{-1})	Grain Yield (kg ha^{-1})	Gross Returns (Rs. ha^{-1})	Urea (kg ha^{-1})	Variable cost of urea (Rs. ha^{-1})	Gross margin (Rs.ha^{-1})
0	1407	45012	0	0	45012
50	2916	93323	66.2	1655	91668
100	3990	127679	174.8	4370	123309
150	4876	156023	283.6	7090	148933
200	4941	158102	392.2	9805	148297

DISSCUSSION

Grain yield of wheat is influenced by the climate, genotypes, N application rate, N application timing, seed rate and soil fertility, as well as by the interactions between these factors. Belete et al (2018) reported that increasing N application rate increased the grain yield in wheat. Hussain et al (2006) also found similar findings and reported that grain yield and biological yield were statistically similar at doses of 150 kg Nha^{-1} and 200 kg N ha^{-1}. These results also agree with the findings of Rustam and Yasin (1991) and Bakhsh et al (1999), who reported that by increasing the level of nitrogen, the grain yield was also increased.

In addition, the application of nitrogen increased grain yield of the varieties tested as compared to the control in both growing years. The increase in yield of the varieties with increasing N rates up to adequate level might be due to the role of N in increasing the leaf area and promote photosynthesis efficiency which promote dry matter production and increase yield. In line with this, improvements in wheat yield and its components under the acceptable increasing N rates were reported by Sticksel et al (2000).The highest grain yield of any crop is the result of the positive relationships of most yield components due to nitrogen fertilizer application (Rawal et al 2016, Teklu and Hailemariam 2009; Fana et al 2012; Haile et al 2012; Gerba et al 2013). Among all the essential nutrients applied to the plants nitrogen is the major one which has a key role in the process of photosynthesis. Increased rate of photosynthesis by the high dose of nitrogen gave more yield because large amount of dry matter, more assimilates were produced and transported to fill the seeds as a result of more applied nitrogen (Ullah et al 2018). There are many studies which revealed that with increasing the nitrogen rate, biological yield increased (Ghobadi et al 2010). During pollination high levels of nitrogen increased the total dry matter that helps to get more grain yield (McDonald 2002).

CONCLUSION

After completion of two-year experiment, it was concluded that effect of N rate on wheat grain yield was found significantly different. All the tested wheat genotypes responded well with N fertilizer. Similarly, all the tested genotypes gave higher grain yield than check variety (Vijay). Application of N@ 150 kg ha^{-1} gave maximum wheat grain yield for any variety and profit under Bhairahawa condition. However, this finding was based on the single environment so it is better to repeat on wider temporal and spatial scale for a better result.

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AUTHORS' CONTRIBUTION

Narayan Khatri formulated the research project and authored the manuscript. Bisheshwor Prasad Pandey, Nabin Rawal and Prakash Paneru played a part in preparing the manuscript. Khem Raj Pant contributed to the treatment composition, while Chandra Prakash Upadhyay, Chetan Gyawali, Govinda Prasad Poudel and Mamata Bista conducted field experiment and collected data.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

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