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Research Article

Effect of different levels of nitrogen on growth and yield of hybrid maize (*Zea mays* L.) varieties

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ABSTRACT

Nitrogen (N) fertilizer is considered as one of the most important factors affecting growth and grain yield of hybrid maize. This study was conducted to determine the effects of different rates of nitrogen and varieties on growth and yield of hybrid maize in Lamahi Municipality, Dang, Nepal from June to October, 2019. Three levels of hybrid maize varieties (10V10, Rajkumar F1 and NMH-731) and four levels of nitrogen (160, 180, 200 and 220 kg N ha^{-1}) were evaluated using two factorial randomized complete block design with three replications. The results showed that grain yield and yield attributing traits of hybrid maize varieties increased with the increasing level of nitrogen from 160 to 220 kg ha^{-1}. The application of nitrogen @ 220 kg N ha^{-1} produced the highest grain yield (10.07 t ha^{-1}), cob length (16.33 cm), no of rows per cob (14.97), no of grains per row (33.37), cob diameter (4.54), thousand grain weight (276.77 g), stover yield (12.91 t ha^{-1}), biological yield (23.00 t ha^{-1}), harvest index (43.80), gross return (NRs. 208940 ha^{-1}), net return (NRs.104488 ha^{-1}) and B:C ratio (2.001). The hybrid maize variety 10V10 produced the highest grain yield (9.35 t ha^{-1}), net returns (NRs. 91740.66 ha^{-1}) and B:C ratio (1.91) accompanied by the highest cob length (16.25 cm), and as number of grains per row (32.35) as compared to other varieties. This study suggested that maize production can be maximized by cultivating hybrid maize variety 10V10 with the use of 220 kg N ha^{-1} in inner Terai region of Nepal.

Keywords: Maize, fertilizer, hybrid varieties, yield

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INTRODUCTION

Maize is one of the world's leading crops ranked in the third position in the world cereal crop production after wheat and rice (FAO, 2018). It is a short duration, quick growing and widely grown crop with high potential, there are no cereal crops with such an immense potentiality, so it is called as "queen of cereals" (Begam *et al*., 2018). It is a multipurpose traditional crop generally grown for food, feed and fodder (KC *et al*., 2015). Maize is considered as nutritious food/feed as it contains about 72% starch, 10% protein, 9.5% fiber, 4% fat and supplies energy density of 365 Kcal/100 g (Nuss & Tanumihardjo, 2010).

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Maize is the second most important staple crop in Nepal after rice but it is the first staple crop for hill people. About 2.9 million mt of maize is required per year for food (Timilsina *et al*., 2016). It has been grown over an area of 9,40,886 hectares in 2019/20 with a production of 26, 53,243 mt, and a productivity of 2.82 mt ha^{-1} in Nepal (MoALD, 2020). Its share on AGDP is 9.5% and on GDP is 3.15% (MoALD, 2020). In Nepal, the demand for maize has been growing constantly by 5% in the last decade (Sapkota & Pokhrel, 2010). The increasing trend of poultry and livestock along with population and household income has led to more demand for maize grain (Tripathi *et al*., 2016). It is the principal source of animal feed for different feed industries in the Terai region of Nepal (KC *et al*., 2015). A study on maize utilization revealed that 60%, 25%, and 3% of the grain were used for animal feed, food, and seed respectively in hill districts. Whereas the remaining amount of the maize (12%) was sold to different buyers (Timilsina *et al*., 2016). It has been estimated that for the next two decades the overall demand for maize will be increased by 4% to 6% per annum due to the increasing livestock and poultry industry (BK *et al*., 2018). The demand for poultry feed and animal feed has been increased by 13% and 8.5% over the last five years in Nepal (Timilsina *et al*., 2016). To fulfill the growing feed demand, Nepal is importing about 45% of maize from India (NMRP, 2017).

Despite the increase in land under maize production, the final yield is still low and there is a higher yield gap. Nearly half the area under maize is planted with traditional varieties i.e. home saved seeds, which are continuously at the risk of degenerating (due to open pollination) as well as manures and fertilizers are not applied in sufficient quantities (Koirala, 2002). Declining soil fertility, low yield potential of the existing genotype, limited and irregular access to improved seed and quality fertilizers, and the emergence of new pest species are main constraints for maize production (NMRP, 2017). Thus, maize productivity could be improved by growing new high-yielding varieties under the most favorable cultural practices with the application of the needed nutrients in the proper amount and time. Fertilizer management is crucial for maize cultivation (Baral *et al*., 2015). Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production (Adhikary *et al*., 2020). Among the fertilizers, N is very important because this element is responsible for major activities for the growth and development of maize crops (Jat *et al*., 2013). Nitrogen (N) is a primary nutrient and has a decisive role in the improvement of crop production (Szulc *et al*., 2016). Nitrogen fertilizer is universally accepted as a vital plant nutrient and a major yield determining factor required for optimal maize production, as it is a nitro-positive crop (Adediran & Banjoko, 1995; Shanti *et al*., 1997). The response of maize plants to the application of N fertilizers varies from variety to variety, location to location, and also depends on the availability of the nutrients (Onasanya *et al*., 2009). Grain yield, days to flowering, plant height, ear height, kernel rows per ear, no. of kernels per row, ear length, and thousand-grain weight significantly affected due to growing seasons and split applications of nitrogen (Adhikari *et al*., 2016). Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number, ultimately increasing the productivity (Uribelarrea *et al*., 2004; Khaliq *et al*., 2009).

Varieties also play an important role in crop yield. Cultivars suited to particular agro-ecological regions, season, purpose, and maturity should be selected to get optimum yield (Zaidi *et al*., 2017). Two types of cultivars commonly being used are synthetic and hybrid cultivars. Maize hybrids play a pivotal role while deciding about the type and amount of fertilizer to meet the requirements for growth and development throughout the life span of the crop (Chandrashekra *et al*., 2000; Khaliq *et al*., 2008). Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize (Shrestha *et al*., 2018). Nitrogen

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fertilizer application had profound effects on grain yield and yield attributing traits of maize hybrids. The application of nitrogen fertilizer at the rate of 150 kg ha^{-1} increased the grain yield and yield attributing traits namely number of cobs/ha and thousand grain weight in hybrid maize varieties (Sharma *et al*., 2019). Moreover, most of the farmers in Nepal use a high amount of N fertilizer haphazardly, since there is little information available on the doses and timing of N application on hybrid maize variety. But the hybrid variety with appropriate nitrogen doses is most important to maximize maize yield. So far large numbers of experiments have been carried out throughout the country to find out the optimum level of nitrogen in maize. However, area-specific researches have not yet been done on a different level of nitrogenous fertilizer especially with hybrid maize varieties under local environmental and soil conditions. The objective of the present study was to evaluate effect of different levels of nitrogen on the growth and yield of maize hybrid maize varieties in the inner Terai condition of Nepal.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in a research plot of the Agronomy farm of IAAS, Prithu Technical College, Lamahi municipality, ward No. 3 of Dang district from June 30 to 16 October, 2019. The experimental site is situated 410 km west of Kathmandu, the capital of Nepal. Geographically, it is located at 27.9904' N Latitude and 82.3018' E Longitudes at the elevation of 300 masl. This location falls in the inner Terai region, Province-5 of the Mid-Western Development Region of Nepal.

Experimental details and cultural practices

The experiment was laid out in two factorial Randomized Complete Block Design (RCBD) with three replications. Three hybrid maize varieties, namely 10V10, Rajkumar F1, and NMH-731 were evaluated under four levels of Nitrogen fertilizer (160 kg ha^{-1}, 180 kg ha^{-1}, 200 kg ha^{-1} and 220 kg ha^{-1}) (Table 1). These hybrid varieties were received from local agrovet of Lamahi, Dang. There were total of thirty-six plots with each plot having the size of 9.45m^2 (4.2m x 2.25m) where maize was sown. Two border rows were taken as non-sampling rows and eight samples were taken randomly from the remaining central rows from each plot.

Table 1. Different factors used as treatments in the experiment

SN	Factors	Symbols
Factor A: Varieties		
1	10V10	V1
2	Rajkumar F1	V2
3	NMH-731	V3
Factor B: Different levels of N (kg ha^{-1})		
1	160	F1
2	180	F2
3	200	F3
4	220	F4

FYM was applied as the main source of organic fertilizer in the field. The FYM @5 t ha^{-1} was uniformly incorporated into the soil in all experimental plots. Nitrogen, phosphorous, and potassium were supplied through urea (46%N), Single superphosphate (SSP) (16%P2O5), and the Muriate of potash (MOP) (60% K_2O). NPK Fertilizers were applied in 4 doses: F1 (160:60:40), F2 (180:60:40), F3 (200:60:40), F4 (220:60:40) kg ha^{-1}.

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Half dose of nitrogen and full dose of P and K were applied during the sowing as a basal dose and remaining dose of N was applied at top dressing at knee high stage and tasseling stage. Seed sowing was done with 75cm row to row and 25cm plant to plant spacing. Weeding and irrigation was done as per recommendations of National Maize Research Program, Rampur, Chitwan, Nepal. As a basal application full dose of phosphorus, full dose of potassium and one third of urea was applied as band placement 5 cm apart from maize row at 5 cm depth. First part of nitrogen was used at the time of sowing, second part was applied as side-dress (top dress) at knee high stage and finally last part was side dressed at tasseling stage. Two manual weeding were done throughout the maize growing period, first weeding was done at 25 days after sowing (DAS) and second weeding and earthing up were performed at 55DAS. Irrigation was done as per the requirement.

Data observation

To evaluate the effect of different level of N on the yield and performance of hybrid maize; data were collected for growth parameters such as 50% Tasseling, 50% Silking days and ASI (Anthesis Silking Interval). Plant height was taken at 90 DAS. Yield and yield attributing characters like cob length, diameter of the cob, number of rows per cob, number of grains per row, thousand grain weights, grain yield, Stover yield, biological yield, harvest index etc. were also recorded. Grain yield of maize was estimated using formula adopted by Carangal *et al*. (1971), and Shrestha *et al*. (2018) by adjusting the grain moisture at 15% and converted to the grain yield kg per hectare. Economic analysis was done at the end of the experiment

Statistical analysis

All collected data were processed in MS Excel. The data were checked for meeting all ANOVA assumptions and subjected to Analysis of variance (ANOVA) using software R-Studio. For segregation of means, Duncan's Multiple Range Test (DMRT) was used. The significant differences between varieties were determined using the least significant difference (LSD) test at 5% level of significance (Gomez & Gomez 1984; Shrestha, 2019).

RESULTS AND DISCUSSION

Effect on phenology

Days to 50% tasseling and 50% silking were significantly ($p \leq 0.05$) influenced by hybrid maize varieties. Statistically, NMH-731 variety had undergone early tasseling (53.42 DAS) and early silking (57.17 DAS), whereas Rajkumar F1 variety had undergone late tasseling at 55.16 DAS and late silking at 59.16 DAS (Table 2). Early tasseling and silking of NMH-731 might be due to its genetic characteristics. Azam *et al.* (2007) also reported that different varieties have different tasseling and silking days. Different varieties had not significantly ($p \leq 0.05$) affected the Anthesis Silking Interval. Various levels of N were found statistically non-significant to days to 50% tasseling and ASI and significant to 50% silking days. However, an increased in N level from 160 kg ha^{-1} to 220 kg ha^{-1} decreased the tasseling, silking and ASI (Table 2). This result agreed with those reported by Dawadi and Sah (2012), who reported that the increasing nitrogen level from 120 kg ha^{-1} to 200 kg ha^{-1} decreased the tasseling, silking and ASI days. Similarly, Rai (1961) and Yadav (1990) also reported that higher application of Nitrogen dose induced early tasseling and silking stage of maize. The earliness of Silking, tasseling and ASI with higher nitrogen application might be because of inducing early and rapid growth of plant.

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Effect on plant height

Plant height at 90 DAS was found statistically significant ($p \leq 0.05$) due to various levels of N. While there was no significant change observed due to different varieties on plant height at 90 DAS. The maximum plant height was found in plot with 220 kg N ha^{-1} (199.92cm) whereas the minimum plant height was found on the plot with 160 kg N ha^{-1} (185.75cm) which was statistically at par with 180 kg ha^{-1} i.e. 188.72cm (Table 2).

Table 2. Effect of different levels of nitrogen and varieties on tasseling, silking, anthesis silking interval and plant height of hybrid maize in Dang, Nepal in 2019

Treatments	50% Tasseling (DAS)	50% Silking (DAS)	ASI	Plant height (cm)
Varieties				
10V10	54.25^{ab}	58.25^{ab}	4	190.59
Rajkumar F1	55.16^{a}	59.16^{a}	4	191.091
NMH-731	53.42^{b}	57.17^{b}	3.75	193.89
F-test	*	**	NS	NS
Different Level of N (kg ha^{-1})				
160	54.88	59.22^{a}	4.33	188.72^{b}
180	54.78	58.66^{ab}	3.88	185.75^{b}
200	54.23	57.89	3.66	193.3^{ab}
220	53.23	57.00^{c}	3.77	199.92^{a}
Grand Mean	54.27	58.19	3.91	191.85
F-test	NS	**	NS	**
LSD (0.05)	1.65	1.27	1.31	7.45
CV (%)	2.65	2.23	20.96	3.97

*NS = non-significant at 5% level of significance, *=Significant at 5% level of significance, **=Significant at 1% level of significance*

With the higher dose of N application, the cell division, cell elongation, nucleus formation, green foliage, and thus the chlorophyll content increases which increased the rate of photosynthesis and extension of stem resulting in increased plant height (Thakur *et al*., 1997; Diallo *et al*., 1996). Our findings were in similarity to those of Sharifil and Namvar (2016) found the maximum plant height (185.2 cm) with the application of 225 kg N ha^{-1}. Dawadi and Sah (2012) also reported the increased nitrogen level from 120 kg ha^{-1} to 200 kg ha^{-1} also increased the plant height of hybrid maize varieties. Bakht *et al*. (2006), Khan *et al*. (2011) additionally reported that with the increasing N level the plant height automatically increased. An increase in plant height due to high N may be attributed to better vegetative development that resulted in increased mutual shading and internodal extension.

Effect on cob length

Cob length as influenced by both varieties and N level are presented in table no 4. The effect of different varieties and nitrogen levels on cob length was highly significant. Variety 10V10 produced the highest cob length (16.25cm). The shortest cob length was produced by variety Rajkumar F1 (14.69cm) which was statistically at par with NMH-731 (14.75cm). The highest N level (220 kg ha^{-1}) produced the longest cob length (16.33cm) which at par with the cob length under 200 kg N ha^{-1} (15.62cm). The shortest cob (14.26cm) length under the lowest N level which again at par with cob length under 180 kg N ha^{-1} (14.71cm) (Table 3). Pokharel *et al*. (2009) noted the longest cob length with 210 kg N ha^{-1}. Similarly, a positive correlation between the level of Nitrogen and length of cob was reported by Santos *et al*. (2002), Turgut (2004), and Ahmad (2018). The probable reason for longer cob length at a higher level of N could be due to optimum utilization of solar light, higher assimilated production and its conversion to starches resulted in higher ear length as reported by Derbay *et al*. (2004).

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Effect on numbers of rows per cob

Statistical analysis revealed a significant ($p \leq 0.05$) change in the number of rows per cob due to different levels of Nitrogen. But numbers of rows per cob due to varieties were statistically non-significant. Although, Nitrogen dose 160 kg ha^{-1} had the least rows per cobs (12.98). Nitrogen doses 180 kg ha^{-1}, 200 kg ha^{-1} and 220 kg ha^{-1} had a statistically similar number of rows per cob i.e., 14.27, 14.56 and 14.97 respectively (Table 3). Similar results were obtained by Majid *et al*, (2017), Gungula *et al*. (2003), Waqas (2002), who found the increase in grain row per cob with the increase in N level.

Effect on number of grains per row (NGPR)

The data on the number of grains per row are presented in table 4, which indicated significant ($p<0.05$) change in no of row per cob due to varieties and N levels. Variety 10V10 had the highest number of grains per row (32.35) which at par with NMH-731 (30.98). Nitrogen dose 220 kg ha^{-1} had the maximum number of grains per row (33.37) which was statistically similar to N level 200 kg ha^{-1} (32.20) (Table 3). This result agreed with those reported by Sharifi and Namvar (2016), who recorded the maximum number of grains per row (32.2) by the application of 225 kg N ha^{-1} than lower doses. An increase in the number of grains per row at higher nitrogen levels might be due to the lower competition for nutrients that allowing the plants to accumulate more biomass with a higher capacity to convert more photosynthesis into sink resulting in more grains per row. The number of grains per row plays an important role in determining the final grain yield. Dawadi and Sah (2012) suggested a decrease in the number of grains per ear row under lower N application might be attributed to poor development of sinks and reduced translocation of photosynthates.

Effect on diameter of cob

Statistically, variety NMH-731 had shown the greater cob diameter (4.40 cm) followed by Rajkumar F1 and 10V10 i.e., 4.35 cm and 4.24 cm respectively. Similarly, Nitrogen dose of 220 kg ha^{-1} had a greater cob diameter of 4.54 cm. Whereas, Nitrogen dose of 160 kg ha^{-1} had the least cob diameter (4.10 cm) (Table 3).

Table 3. Effect of different levels of nitrogen and varieties on yield attributing traits of hybrid maize in Dang, Nepal in 2019

Treatments	Cob length (cm)	No of rows per cob	No of grain per row	Cob diameter (cm)
Varieties				
10v10	16.25^{a}	14.48	32.35^{a}	4.24^{b}
Rajkumar F1	14.69^{b}	14.15	29.18^{b}	4.35^{ab}
NMH-731	14.75^{b}	13.95	30.98^{a}	4.40^{a}
F test	**	NS	**	*
Different level of N (kg ha^{-1})				
160	14.26^{b}	12.97^{b}	27.58^{c}	4.10^{c}
180	14.71^{b}	14.26^{a}	30.18^{b}	4.30^{b}
200	15.62^{a}	14.56^{a}	32.20^{a}	4.40^{ab}
220	16.33^{a}	14.96^{a}	33.37^{a}	4.54^{a}
Grand Mean	15.23	14.19	30.83	4.33
F-test	**	**	**	**
LSD (0.05)	0.81	0.79	1.75	0.15
CV (%)	5.41	5.75	5.81	3.62

*NS = non-significant at 5% level of significance, *=Significant at 5% level of significance, **=Significant at 1% level of significance*

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A similar result was obtained by Majid *et al*. (2017), who observed the highest cob diameter with the application of 225 kg N ha^{-1}. Similarly, Saleem *et al*. (2017), Oktum and Oktern (2005) noted the significant increment in cob diameter with increasing level of Nitrogen. The increment of cob diameter could be due to the supply of sufficient nitrogen. A higher cob diameter was obtained from higher dose of Nitrogen application due to sufficient availability of Nitrogen which is responsible for cell division and cell elongation (Shamim *et al*., 2015).

Effect on thousand grain weight

Grain weight is a typical measure of grain yield and reflects grain growth and plumpness. Statistical analysis revealed a significant ($p \leq 0.05$) change in 1000 grain weight due to different levels of Nitrogen while there was no significant change observed due to varieties. Nitrogen dose 220 kg ha^{-1} had the highest 1000 grain weight (276.77 g) whereas Nitrogen dose 160 kg ha^{-1} (253.55g) had shown least 1000 grain weight which was statistically at par with 180 kg ha^{-1} (254.52g) (Table 4). These observations were fully recorded by Wajid *et al*. (2007). They reported 1000 grain weight of 210.43 g by the application of 250 kg N ha^{-1}. Similar result was obtained by Sharar *et al*. (2003), who reported the 1000 grain weight of 226.5 gm by the application of 210 kg N ha^{-1}. Karki (2002), Akbar *et al*. (2002) and Gokmen *et al*. (2001) reported the increase in 1000 grain weight with the increasing dose of Nitrogen due to a higher amount of photosynthates to the grains.

Effect on grain yield

Statistical perusal of data uncovered that the effect of varieties had no significant effect on grain yield but different levels of Nitrogen had a significant effect on grain yield. Nitrogen dose 220 kg ha^{-1} produced the highest grain yield (10.077 t ha^{-1}) and Nitrogen dose 160 kg ha^{-1} produced the lowest grain yield (7.255 t ha^{-1}) (Table 4). Our outcomes were in similarity to those of Shrestha *et al*. (2018), who found that applying a high dose of N at the rate of 200 kg N ha^{-1} produced the highest grain yield. Sharifi and Namvar (2016), also reported the highest grain yield by the application of 225 kg N ha^{-1}. Similarly, the result reported by Fedotkin and Kravtsov (2001) found significantly higher grain yield up to 240 kg N ha^{-1}. Onasanya *et al*. (2009) and Zeidan *et al*. (2006) also reported that with the increasing Nitrogen dose, the maize grain yield also increased. An increase in grain yield at higher N levels might be due to the lower competition for nutrients which leads to more canopy of plant contributing higher photosynthetic activity to accumulate more biomass with the bold grain.

Effect on Stover yield

Statistical analysis revealed a significant change in Stover yield due to different levels of Nitrogen and varieties had no significant effect on Stover yield. Nitrogen dose of 220 kg ha^{-1} had the highest Stover yield (12.91t ha^{-1}). Whereas Nitrogen dose 160 kg ha^{-1} had shown the lowest Stover yield i.e., 10.91 t ha^{-1} (Table 4). Singh *et al*. (2000), Sanjeev *et al*. (1997) reported that stover yield increased with the increase in nitrogen level. Similarly, Krishnamoorthy *et al*. (1974) reported the increase in Nitrogen level from 60 kg ha^{-1} to 240 kg ha^{-1} effectively improved stover yield. Ullah *et al*. (2007) also reported that increased stover yield with increasing nitrogen levels.

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Table 4. Effect of different levels of nitrogen and varieties on grain yield, stover yield, biological yield, thousand grain weight and harvest index of hybrid maize in Dang, Nepal in 2019

Treatments	1000 grain weight (g)	Yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Varieties					
10v10	254.5	9.358	11.96	21.33	43.71
Rajkumar F1	270.83	8.616	11.55	21.25	42.55
NMH-731	264.083	8.941	12.3	20.15	41.76
F test	NS	NS	NS	NS	NS
Different level of N (kg ha^{-1})					
160	253.55^{b}	7.25^{c}	10.91^{c}	18.14^{c}	39.85^{b}
180	254.22^{b}	8.94^{b}	11.73^{b}	20.68^{b}	43.08^{a}
200	268.00^{ab}	9.61^{ab}	12.20^{ab}	21.82^{ab}	43.97^{a}
220	276.77^{a}	10.07^{a}	12.91^{a}	23.00^{a}	43.80^{a}
Grand Mean	263.13	8.972	11.93	20.91	42.68
F-test	*	**	**	**	**
LSD (0.05)	18.13	82.2	0.74	1.26	2.37
CV (%)	7.04	9.37	6.37	6.19	5.68

*NS = non-significant at 5% level of significance, *=Significant at 5% level of significance, **=Significant at 1% level of significance*

Effect on biological yield

Statistical perusal of findings demonstrated that fertilizer doses had significantly ($p \leq 0.05$) affected the biological yield while there was no significant change observed due to varieties on biological yield. Nitrogen dose of 220 kg ha^{-1} had the highest biological yield (23.00t ha^{-1}), followed by 200 kg ha^{-1} (21.82t ha^{-1}) and 180 kg ha^{-1} (20.68t ha^{-1}) respectively (Table 4). Similarly, the lowest biological yield was found in nitrogen dose of 160 kg ha^{-1} (18.14 t ha^{-1}). Our results were in similarity with Hammad *et al*. (2011), Khaliq *et al*. (2009) and Abera *et al*. (2013) who reported a significantly increase in biomass yield at higher Nitrogen dose.

Effect on Harvest Index

Harvest Index indicates the efficiency of assimilating partition to the parts of economic yield of maize plants (i.e., cob). Higher harvest index indicates better translocation of assimilates to cob. Different level of Nitrogen showed significant differences in harvest index. There was no significant change observed due to varieties on Harvest Index. Nitrogen doses 220 kg ha^{-1}, 200 kg ha^{-1} and 180 kg ha^{-1} had shown statistically similar i.e., 43.80, 43.97, 43.08 Harvest Index respectively but Nitrogen dose 160 kg ha^{-1} had least harvesting index i.e., 39.85 (Table 4). Our results agreed with those of Sharifi and Namvar (2016) found the maximum harvest index (42.1%) with the application of 225 kg N ha^{-1}. Similarly, Wajid *et al*. (2007) also found the increase in harvest index with increasing fertilizer dose up to 250 kg N ha^{-1}.

Effect on Cost of cultivation

Treatments, Varieties and different level of Nitrogen had shown no any significant effect on the cost of cultivation (Table 5).

Effect on Gross Return

Different level of Nitrogen showed significant effect on the gross return whereas variety showed non-significant effect on the gross return. Nitrogen dose 220 kg ha^{-1} had shown the

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highest Gross return (NRs. 208.94 thousand ha^{-1}), followed by 200 kg ha^{-1} (NRs. 196.91 thousand ha^{-1}) and 180 kg ha^{-1} (NRs. 182.67 thousand ha^{-1}) respectively. Nitrogen dose 160 kg ha^{-1} had least Gross return (NRs.143.60 thousand ha^{-1}) (Table 5).

Effect on net return

Average net return was significantly affected by varieties as well as different levels of Nitrogen. Variety 10V10 produced the best net returns (NRs. 91.74 thousand ha^{-1}) followed by NMH-731 (NRs. 78.20 thousand ha^{-1}) and variety Rajkumar F1 gave the least net returns (NRs. 76.69 thousand ha^{-1}). Showing a significant effect on Nitrogen doses, 220 kg ha^{-1} gave the highest net returns (NRs. 104.488 thousand ha^{-1}) followed by 200 kg ha^{-1} (NRs. 93.55 thousand ha^{-1}) and 180 kg ha^{-1} (NRs. 80.38 thousand ha^{-1}). Nitrogen dose 160 kg ha^{-1} had the lowest net return (NRs. 42.42 thousand ha^{-1}) (Table5).

Table 5. Effect of different levels of nitrogen and varieties on economics of hybrid maize in Dang, Nepal in 2019

Treatments	Cost of cultivation NRs. ha^{-1} (,000)	Gross return NRs. ha^{-1} (,000)	Net return NRs. ha^{-1} (,000)	Benefit cost Ratio
Varieties				
10v10	100.32	192.06	91.74^{a}	1.91^{a}
Rajkumar F1	102.82	175.02	72.20^{ab}	1.70^{b}
NMH-731	105.32	182.00	76.69^{b}	1.72^{b}
F-test	NS	NS	*	*
Different level of N (kg ha^{-1}) (B)				
160	101.2d	143.60c	42.42c	1.42c
180	102.28	182.67^{b}	80.38^{b}	1.78^{b}
200	103.37	196.91^{ab}	93.55^{ab}	1.90^{ab}
220	104.46	208.94^{a}	104.48^{a}	2.01^{a}
Grand Mean	102.82	183.03	80.21	1.77
F-test	NS	**	**	**
LSD (0.05)	1.25	18.47	18.47	0.18
CV (%)	0	10.32	23.55	10.38

*NS = non-significant at 5% level of significance, *=Significant at 5% level of significance, **=Significant at 1% level of significance*

Effect on Benefit: Cost Ratio

Average B: C ratio was found to be 1.77 which signified fairly beneficial cultivation practice. Varieties significantly affected B: C ratio. Variety 10V10 had resulted the highest B:C ratio i.e. (1.91) and varieties NMH-731 and Rajkumar F1 had statistically similar B:C ratio i.e. (1.72) and (1.70) respectively. Different levels of Nitrogen were also found to have significant effect on B: C ratio. Nitrogen dose 220 kg ha^{-1} resulted in higher B: C (2.001) ratio. The least B: C ratio (1.42) was resulted by fertilizer dose 160 kg ha^{-1}, signifying higher cost of production than benefit (Table 5).

Correlation studies

Statistically, highly significant positive correlation was observed between the grain yield and cob length, number of rows per cob and cob diameter (Figure 2, 3 and 4) Grain yield and length of cob (cm) showed highest and positive correlation in the experiment. It means when increase the length of cob increases the final grain yield where coefficient value r^2 (=0.54) (Figure 2). It means the contribution of length of cob on final grain yield is 54%. Similarly, the coefficient of determination (r^2) value for row of cob and diameter of cob was 0.48, 0.40 (Figure 3 and 4)

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respectively. It means the contribution of row of cob and diameter of cob on final grain yield is 48% and 40% respectively.

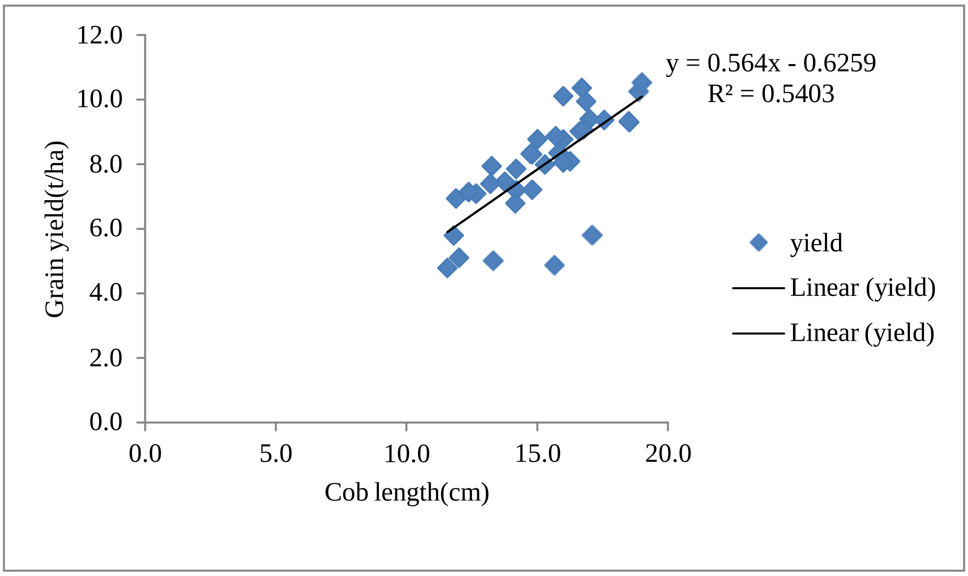

Figure 2. Effect of cob length on grain yield in Lamahi, Dang, Nepal in 2019

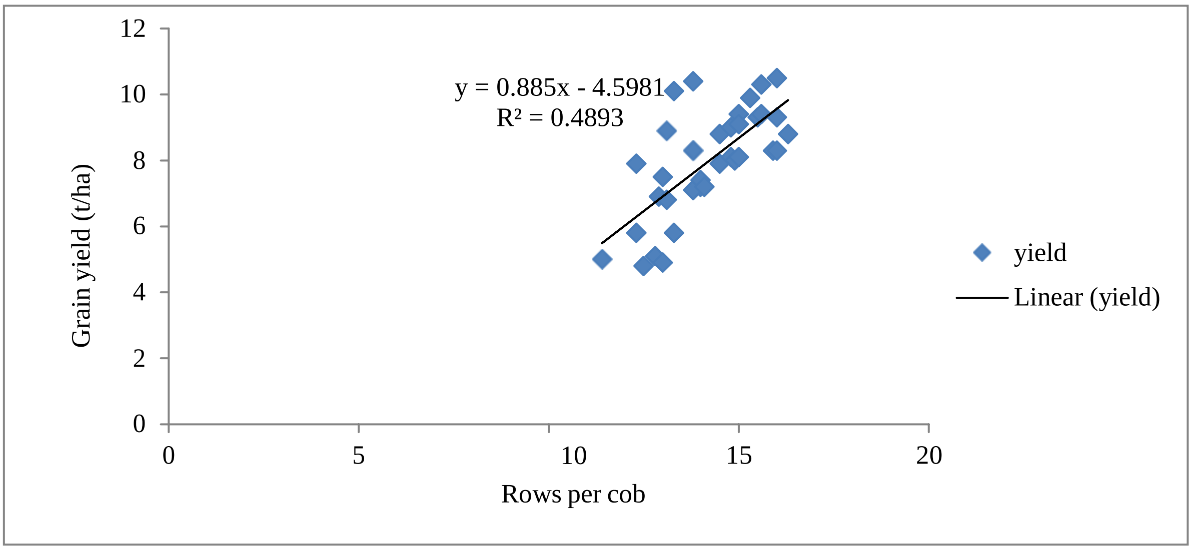

Figure 3. Effect of number of rows of cob on grain yield in Lamahi, Dang, Nepal in 2019

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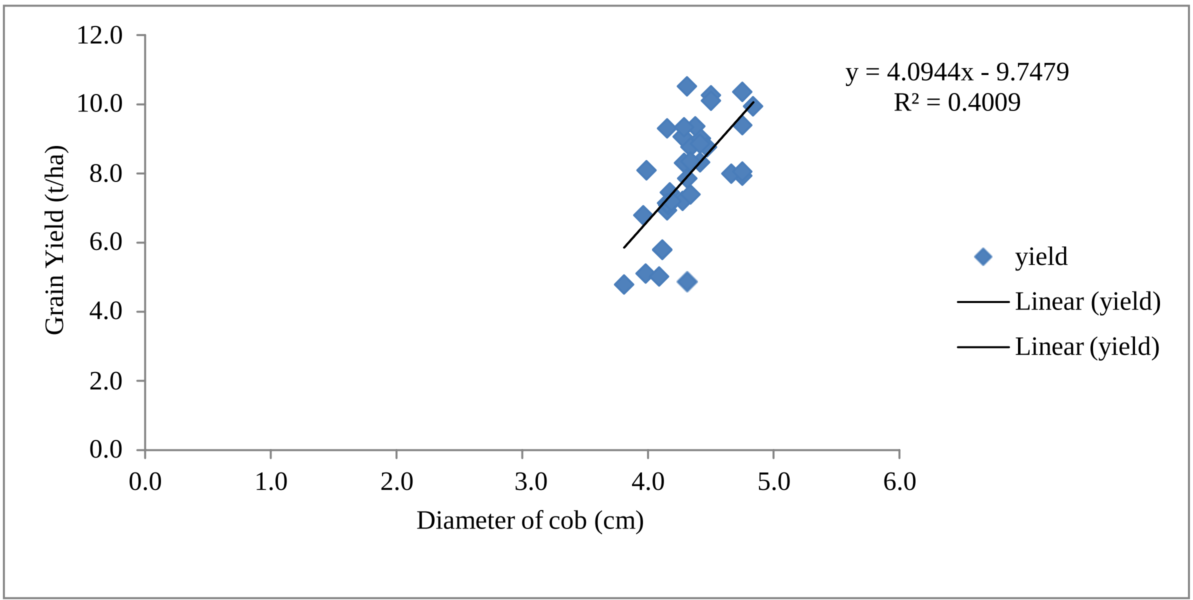

Figure 4. Effect of diameter of cob on grain yield in Lamahi, Dang, Nepal in 2019

CONCLUSION

Different varieties and different level of N have significantly affected yield and yield components of maize. The highest maize yield and yield components was found under 220 kg N ha^{-1} and 10V10 variety. The implication of this study concluded that hybrid maize should be planted under N level 220 kg ha^{-1} to ensure maximum economic grain yield per production area. However, since, this study was focus on mere one season and one location; it needs further study for recommendation of specific N level for specific variety.

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Authors' Contributions

K. Adhikari and S. Bhandari conducted the trial and recorded data, analyzed and wrote the final manuscript. K. Aryal and M. Mahato supervised the experiment and J. Shrestha helped in data analysis and edited the initial version of this manuscript.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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