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Research Article

Effect of Nutrient Management on Two Varieties (Hybrid and Local) of Maize in Western Inner Terai of Nepal

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Abstract

In Nepal, the productivity of maize is very low in comparison with developed countries. The use of hybrid varieties with proper nutrient management helps to unlock the high yielding potential of maize. So, the experiment was conducted at Fulbari, Dang, Nepal from June 30, 2019 to October 16, 2019 to find the yield performance of two maize varieties (Local and Hybrid) under different nutrient management. The study was conducted in factorial randomized complete block design with three replications and eight treatments. Treatments consist of different combinations of two maize varieties (Local and hybrid) and four different nutrient management practices. Significant effects of Nutrient management were observed on plant height, leaf area index (LAI), kernels per row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. Similarly, significant effects of varieties was observed on plant height, leaf number, LAI, cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. Interaction effect of Nutrient management and varieties was found significant on LAI, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. The overall performance of hybrid maize under Leaf color chart (LCC) based nutrient management was found better than other treatments. Therefore, production of Hybrid maize under LCC based nutrient management is suggested.

Keywords: Maize; Nutrient management; Dang; Leaf colour chart

Introduction

Maize is one of the most important cereal crops in the world and known as "Queen of Cereals". It is the second most important crop after rice in term of area and production (Bk *et al*., 2018) and share 6.54% in Agriculture Gross Domestic Product of Nepal (Pandey and Basnet, 2018). In Nepal, Maize is grown in 882395 hectare (ha) with production of 2145291 ton and productivity of 2.431ton ha^{-1} and contributes about 23.15% of total edible production (MoAD, 2016). Maize is considered as most important staple food crop for mountainous people whereas in Terai 80% of production is being utilized for poultry and animal feed (Kandel *et al*., 2017). It has been estimated that for next two decades the overall demand of maize will be increased by 4% to 6% per annum resulting from the increase demand for human consumption and livestock feed (Bk *et al*., 2018).

In Nepal, area under maize cultivation has been increasing year by year but the productivity remains same. Undoubtedly, the production of maize per unit area is very poor in comparison with developed countries like France (9.5 ton ha^{-1}), United States (9.5 ton ha^{-1}), Canada (8.5 ton ha^{-1}) and Argentina (7.5 ton ha^{-1}) (Kandel *et al*., 2019). There are several factors that limit the productivity of maize. To enhance the production, fertilizer management is one of the most important aspects. Maize is heavy feeder, demands high amount of N, P and K. N, P, K are vital plant nutrients that determines yield and productivity of maize (Adediran and Banjoko, 1995; Chen *et al*., 1994). However, the imbalanced and inadequate use of chemical Fertilizers by Nepalese farmers in intensive cropping system has caused stagnation in productivity. Too low and too high N,P,K dose reduces the yield and yield parameters of maize (Asghar *et al*., 2010). Plants cannot complete their life cycle and accomplish their physiological functions in absence of these nutrients. Their deficiency leads to decrease in growth and yield of the crop. Hence, optimum level of N,P,K application is important to achieve desirable crop growth and productivity.

Therefore, the present study was carried out to find the effect of fertilizer and varieties on yield and yield attributing traits of maize. This experiment will help to know location specific and variety specific appropriate fertilizer recommendation for maize crop.

Materials and Methods

Description of Experimental site

The field experiment was carried out at Fulbari, Dang, Nepal which is geographically located at 27°47' North latitude, 85° 20' East longitude with altitude of 603 meters above the mean sea level. The research was conducted from June 30, 2019 to October 16, 2019. After land preparation and before sowing crop, soil sample were taken randomly from six different spots at two different depths 0-15 cm and 15-30 cm using tube auger to record initial soil physical and chemical properties of experimental sites. Soil sample from different spots were air dried, grounded and sieved through 2mm sieve separately for determination of physical and chemical properties of soil (Table 1). The experimental site falls under the subtropical humid climate belt of Nepal. Maximum and minimum temperatures, total rainfall, relative humidity and wind speed were recorded during the maize growing season and is presented in Fig. 1.

Table 1: Physical and chemical properties of the soil of experimental site, Fulbari, Dang 2019

Properties	Average content	Rating
Physical properties		
Sand (%)	63.0	
Silt (%)	30.0	
Clay (%)	7.0	
Textural class/ Rating		Sandy Loam
Chemical properties		
Soil Ph	5.35	Acidic
Soil organic matter (%)	3.87	Medium
Total Nitrogen (%)	0.08	Low
Available Phosphorous (kg ha^{-1})	56.0	High
Available Potassium (kg ha^{-1})	251.62	Medium

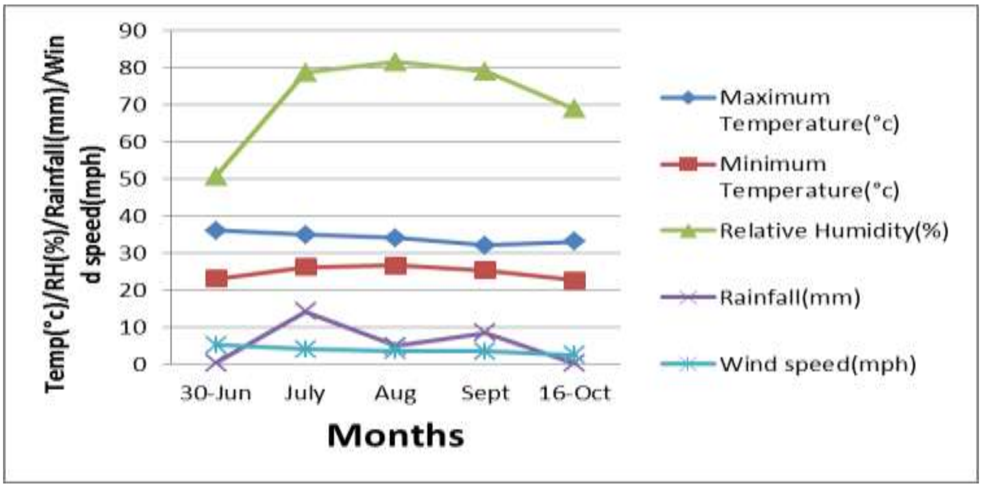

Fig. 1: Agro-metrological data of experimental site from June 30, 2019 to October 16, 2019.

Design of Experimental Plot and Treatment Combination

The experiment was conducted in the factorial randomized complete block design with 8 treatments and 3 replications consisting of 24 plots. The treatments consist of combination of two maize varieties and four different nutrient management (Table 2). Each individual plot of size 16m^2 (8m×2m) within each replication was separated by 0.5 m. The gap of 1m was maintained between two replications. Seeds were sown in line with spacing of 80 cm × 25 cm. Altogether 10 rows and 8 hills per row of maize were maintained in each plot.

Cultural Practices

Deep ploughing of land is done by Tractor followed by harrowing with disc harrow. Leveling of land was done manually. Different doses of fertilizer were applied as per treatments. Pre-sowing irrigation was applied and additional irrigation requirement was fulfilled by natural rainfall. Bold and disease-free seeds at the rate of 20 kg ha^{-1} were used. Manual weeding was done two times at 20 days after sowing (DAS) and 40 DAS. . Harvesting was done when the plants turned yellow and ear husk turned brown by cutting plants with sickles at the ground level. Dehusking and shelling of cob was done manually after two days of sun drying.

Observation Recorded

Six middle plants from second row were selected for observation of plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row and kernels per cob. Net plot area of 8.4 m^2 was selected in each plot excluding the border rows and second row. Plants under net plot area were harvested for observation of test weight, biological yield and economic yield. Harvest index (HI) was then calculated by following formula.

$$Harvest\ index = \frac{Economic\ Yield\ in\ ton\ per\ hectare}{Biological\ Yield\ in\ ton\ per\ hectare}$$

Statistical Analysis

Microsoft Office Excel 2010 was used for Data entry and processing whereas Analysis of Variance of all the parameters was done by using ADEL-R (CIMMYT Mexico) software.

Table 2: Treatments combination and description

Varieties	**Description**
Local (L)	Local variety is Sano Pahelo Makai. Good for roasting/popping, Low yield Low, suitable for sandy soils in mid-hills, poor drought resistance
Hybrid (H)	Hybrid variety is JKMH-502. The domain area for this variety is terai, inner terai, river basin, valley, lower hills above 700 meter above sea level.
Different nutrient management	**Description**
No fertilizer (No)	No fertilizer was applied
Farmer's Practice (Fp)	No fertilizers were applied during land preparation. 150 gm urea per plot was applied during knee high stage
Recommended dose (Rd)	Recommended dose of N:P:K (60:30:30) were applied. Full dose of phosphorous, Potassium and half dose of Nitrogen were applied during land preparation and remaining half dose of nitrogen were applied in two equal splits at knee high stage and tasseling stage.
Leaf colour Chart (LCC) Based Fertilizer	Different amount of fertilizer was applied based on N deficiency shown by LCC tool.
Treatments	**Description**
T_1 (L+No)	Local + No fertilizer
T_2 (H+No)	Hybrid+ No fertilizer
T_3 (L+Fp)	Local + Farmer's Practice
T_4 (H+Fp)	Hybrid+ Farmer's Practice
T_5 (L+Rd)	Local + Recommended dose
T_6 (H+Rd)	Hybrid+ Recommended dose
T_7 (L+LCC)	Local + Leaf colour Chart (LCC) Based Fertilizer
T_8 (H+LCC)	Hybrid+ Leaf colour Chart (LCC) Based Fertilizer

Results and Discussion

Effect of Nutrient management on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

The plant height was highly significant with different nutrient management practices. The highest plant height was found in plot with recommended dose of fertilizer (195.8 cm) whereas the lowest plant height was found on the plot with no fertilizer (155.88 cm). Similar result was also found by Setty (1981) who recorded increase in plant height from 190 cm to 201 cm with increase in nitrogen from 60 kg ha^{-1} to 180 kg ha^{-1}. Similarly, leaf number was found non- significant with different treatment. There was no significant difference in number of leaf at different fertilizer doses. Different treatments have highly significant effect in the leaf area index (LAI). The LAI in recommended dose plot was found to be highest (0.215) and the lowest LAI was found in plot with no fertilizer applied (0.14). Similar result was reported by Kumar *et al*. (2018) who found that application of nitrogen fertilizer based on LCC threshold $\leq$ 5 recorded significantly higher leaf area per plant (2962cm^2 plant^{-1}), LAI (2.47). Cob length and kernel rows per cob was found non-significant with the different treatment of fertilization. This result is in agreement with Itnal and Palled (2001). Kernels per row significantly varied with the treatment. Highest kernels number per row was found in LCC based plot (25.17) meanwhile least kernel per row was found in control plot (21.83). Kernels per cob were significant with different nutrient management practices. Highest kernels per cob was found to be in LCC based plot (335.17) meanwhile least kernels per cob was found in control plot (278). Test weight significantly varied with different nutrient management practices. The highest test weight was found to be 309.33gm from LCC based plot and least test weight was recorded to be 278.52gm from control plot. Similar result was obtained by Kumar *et al*. (2018). Biological yield showed significant variation with treatment. Recommended dose plot gave highest biological yield (5.01 ton ha^{-1}) and Control plot gave least biological yield (4.8 ton ha^{-1}). Economic yield also varied significantly with treatment. Highest economic yield was recorded to be 5.68 ton ha^{-1} from LCC based plot .Least economic yield was recorded in control plot with 3.38 ton ha^{-1}. Significantly, higher Grain and Stover yield was registered with N application at LCC threshold along with increased grain weight under the field study conducted at Agricultural Research Station, Karnataka by Shivakumar *et al*. (2017). Jayaprakash *et al*. (2006) reported that application of higher levels of fertilizers (200, 175, 150 and 125 % NPK) increased the grain yield of maize by 30, 26, 22 and 11 per cent; respectively over 100 percent recommended NPK. Application of 200 percent NPK recorded significantly higher Stover yield of 10.31ton ha^{-1} over 100 per cent recommended NPK (9.10 ton ha^{-1}). Likewise, Harvest index also showed significant variation with treatment. The highest HI was found on LCC based plot (1.38) whereas lowest HI was found on control plot (0.70). Mean effects of nutrient management practices on different traits of Maize is illustrated in Table 3 and Table 4.

Effect of two different varieties (local and Hybrid) on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

Plant height was highly significant in both hybrid and local varieties of maize. The plant height of local variety was higher (202.2383 cm) than that of hybrid variety (160.7492 cm). Leaf number significantly varied with both treatments and the highest leaf number was found in local variety (14.25) whereas least in hybrid variety (12.58333). LAI significantly varied with the treatment where highest LAI was found in plot with local variety (0.210667) and least LAI was found in the plot with hybrid variety (0.17525). In local variety cob length, rows of kernel per cob, kernels number per row, kernels per cob and test weight were recorded to be 13.83 cm, 11.92, 23.58, 286.83 and 259.92 gm respectively. These all parameters were lower with respect to hybrid variety of maize. Similar result was found by Emmanuel *et al*. (2014) whose study showed that hybrid maize varieties outperform local open pollinated varieties under conventional farming practices meanwhile local maize outperform hybrid under small-scale intensive production practiced. However, in hybrid maize cob length, rows of kernel per cob, kernels number per row, kernels per cob and test weight were recorded to be.52 cm, 13.67, 24.58, 336.58 and 321.44gm respectively. These all data showed good performance of hybrid over local maize. Biological yield, Economic yield and Harvest index varied significantly with treatments. Biological yield of local variety of maize was observed relatively higher (5.64 ton ha^{-1}) than that of hybrid maize (5.40 ton ha^{-1}). However, hybrid maize gave higher economic yield than of local maize. The economic yield of hybrid maize was recorded to be 6.82 ton ha^{-1} which was roughly double of economic yield of local maize i.e. 3.48 ton ha^{-1}. As a result, hybrid maize gave greater Harvest index viz. 1.34. Meanwhile, local maize gave lowest HI (0.65). Shrestha *et al*. (2018) suggested that Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize. Proper nitrogen applications as basal doses at planting stage, split doses at critical growth stages namely knee high, and flowering stages are necessary for higher grain yield. Mean effects of two different varieties on different traits of Maize is illustrated in Table 3 and 4.

Table 3: Mean effects of Nutrient management on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

Treatments	Plant height (cm)	Lea f number	LAI	Cob length (cm)	Rows of Kernels per cob	Kernels per row
No	155.88b	13a	0.1425c	13.5a	12.66667a	21.83333b
Fp	179.29a	13.3333a	0.202833b	14.26333a	12.66667a	24.66667a
Rd	195.8a	13.66667a	0.214833a	14.27333a	12.5a	24.66667a
LCC	194.99a	13.66667a	0.211667ab	14.65333a	13.33333a	25.16667a
Std MSE (±)	17.08426	1.386585	0.009432	1.23947	0.841625	1.449548
LSD (.05)	21.15533**	NS	0.011679**	NS	NS	1.794966**
CV%	9.413142	10.3348	4.887984	8.745598	6.579482	6.018886
Grand Mean	181.4938	13.41667	0.192958	14.1725	12.79167	24.08333
L	202.2383a	14.25a	0.210667a	13.82667a	11.91667b	23.58333a
H	160.7492b	12.58333b	0.17525b	14.51833a	13.66667a	24.58333a
Std MSE (±)	17.08426	1.386585	0.009432	1.23947	0.841625	1.449548
LSD (0.05)	14.95908**	1.214102*	0.008259**	NS	0.736932**	NS
CV (%)	9.413142	10.3348	4.887984	8.745598	6.579482	6.018886
Grand mean	181.4938	13.41667	0.192958	14.1725	12.79167	24.08333

CV: Coefficient of variation, LSD: Least significant differences, StdMSE (±): Standard mean sum of error, Mean separated by LSD and column represented with same letters are non-significant at 5% level of significance, * represents significant, ** represents highly significance

Table 4: Mean effects of Nutrient management on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

Treatments	Kernels per cob	Test weight (gm)	Biological yield (ton ha^{-1})	Economic yield (ton ha^{-1})	HI
No	278b	278.52c	4.795142b	3.376479c	0.704057c
Fp	318.5a	282.425b	4.89372b	4.97579b	0.737765c
Rd	315.1667a	292.46b	5.007005a	5.551251b	0.961739b
LCC	335.1667a	309.325a	4.928285b	5.687687a	1.375738a
StdMSE (±)	18.96504	6.297242	0.132803	0.270857	0.051851
LSD(.05)	23.48428**	7.797831**	0.164449**	0.3354**	0.064207**
CV (%)	6.084225	2.166364	2.40548	5.256069	5.200807
Grand Mean	311.7083	290.6825	5.520864	5.153218	0.996983
L	286.8333b	259.9275b	5.640266a	3.480353b	0.65409b
H	336.5833a	321.4375a	5.401461b	6.826084a	1.341557a
StdMSE (±)	18.96504	6.297242	0.132803	0.270857	0.051851
LSD (0.05)	16.60589**	5.513899**	0.116283**	0.237164**	0.045401**
CV (%)	6.084225	2.166364	2.40548	5.256069	5.200807
Grand mean	311.7083	290.6825	5.520864	5.153218	0.996983

Table 5: Mean Interaction effects of Nutrient management and varieties (local and Hybrid) on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

Treatments	Plant height (cm)	Leaf Number	LAI	Cob length (cm)	Rows of kernel per Cob	Kernels per row
L+No	181.23333abc	14.00000a	0.1686667d	14.00000a	12.00000bc	23.33333bc
L+Fp	207.7200ab	16.66667a	0.1976667bc	13.48667a	11.66667c	21.00000cd
L+Rd	214.7333a	14.33333a	0.2376667a	13.52000a	11.33333c	24.33333b
L+LCC	205.2667ab	14.00000a	0.2386667a	14.30000a	12.66667abc	25.66667b
H+No	130.5333d	12.00000a	0.1163333e	13.00000a	13.33333ab	20.33333d
H+Fp	150.8667cd	12.00000a	0.2080000b	15.04000a	13.66667a	24.66667b
H+Rd	176.8667bc	13.00000a	0.1920000bc	15.02667a	13.66667a	25.00000b
H+LCC	184.7300abc	13.33333a	0.1846667cd	15.00667a	14.00000a	28.33333a
StdMSE (±)	427.121	3.929167	0.00008945	1.658587	00.8291667	1.98333
LSD (0.05)	NS	NS	0.01645961**	NS	NS	2.45091***
CV (%)	11.38712	14.77426	4.901473	9.087044	7.118587	5.847648
Grand mean	181.4938	13.41667	0.1929583	14.1725	12.41667	24.08333

Table 6: Mean Interaction effects of Nutrient management and varieties (local and Hybrid) on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

Treatments	Kernels per cob	Test Weight (gm)	Biological Yield (ton ha^{-1})	Economic yield (ton ha^{-1})	HI
L+No	283.3333c	262.14673e	376811e	3.437440c	0.9097275c
L+Fp	249.6667d	273.2633d	5.410628d	3.629611c	0.6709242e
L+Rd	289.3333c	245.0333f	6.216908b	3.357145c	0.5400699f
L+LCC	325.0000b	259.2667e	6.165411b	3.503220c	0.4889140f
H+No	272.6667cd	294.8933c	3.088454f	3.687728c	1.1917491b
H+Fp	341.0000b	319.8867b	6.176812b	5.120014b	0.8046065d
H+Rd	345.3333b	325.3833b	5.797101c	8.018232a	1.3334083a
H+LCC	387.3333a	345.5867a	6.343478a	8.478631a	1.3864655a
StdMSE (±)	369.9292	37.0457	0.01735628	0.0743258	0.00288447
LSD (0.05)	33.47254***	10.59219***	0.2292755**	0.4744596**	0.0934679**
CV (%)	6.170365	2.093811	2.386279	5.29433	5.386978
Grand mean	311.7083	290.6825	5.520864	5.153218	0.9969831

Interaction Effect of Nutrient management and varieties (local and Hybrid) on plant height, leaf number, leaf area index (LAI), cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize

The interaction effects of variety and different nutrient management on LAI were found significant with treatments whereas plant height and leaf number were found non-significant with treatments. The significantly higher LAI (0.2386667) was observed in local variety of maize under LCC based fertilization and the lowest LAI was obtained in hybrid maize under no fertilizer application (0.1163333). The interaction effects of variety and nutrient management practices on yield attributes were found significant. The highest interaction effect of variety and nutrient management practices on kernels number per row

(28.33333) was observed in hybrid maize under LCC based fertilization and least number of kernels per row (20.33333) was observed in hybrid maize under no fertilization. Similarly, the best interaction effect for kernels per cob (387.3333) was obtained in hybrid maize under LCC based fertilization and poor interaction (249.6667) was observed in local maize under farmer's practice. Likewise, significantly higher test weight under variety and nutrient management practices interaction was found in hybrid maize under LCC based fertilization (345.5867 gm) meanwhile the least test weight was observed in local maize under recommended dose fertilization (245.0333 gm). Interaction effect of variety and nutrient management practices on biological yield, economic yield and harvest index were obtained significant with treatments. The best interaction effect of variety and nutrient management practices for biological yield was found in hybrid maize under LCC based fertilization (6.343478ton ha^{-1}) meanwhile the poor interaction (294.8933ton ha^{-1}) was observed in hybrid maize under no fertilization. Likewise, significantly higher economic yield due to variety and nutrient management interaction was obtained in hybrid maize under LCC based fertilizer (8.478631ton ha^{-1}). However, the lowest economic yield (3.357145ton ha^{-1}) was obtained in local maize under recommended dose fertilization. In addition, best interaction effect of variety and nutrient management practices on harvest index was obtained in hybrid maize under LCC based fertilization (1.3864655) whereas the least harvest index was observed in local maize under LCC based fertilization (0.4889140). Abera *et al*. (2017) stated that interaction of maize varieties with different nitrogen fertilizer rates significantly affected all yield and yield components of maize. Leaf area and leaf area index of maize varieties were significantly affected by application of nitrogen fertilizer rates. Application of half and full recommended nitrogen fertilizer produced mean grain yield advantages of 31 and 41% over control. Mean Interaction effects of Nutrient management and varieties (local and Hybrid) on different traits of Maize is illustrated in Table 5 and 6.

Conclusion

From this experiment we concluded that between local and hybrid maize, hybrid maize was found superior as overall performance was better in all nutrient management practices. Similarly, among all the nutrient management approach, LCC based nutrient management gave better results. In addition, best interaction between variety and nutrient management practices was found in hybrid maize under LCC based nutrient management. Therefore, it is recommended to cultivate hybrid maize variety under LCC based nutrient management for higher production and productivity.

Author's Contribution

All authors contributed equally in all stages of research and preparation of manuscript. Similarly, final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare no conflicts of interest.

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