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Productivity of winter maize as affected by varieties and fertilizer levels

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Abstract

Grain yield production of maize is greatly affected by varieties and fertilizer levels. This study was conducted to determine the effects of different rates of fertilizers (nitrogen, phosphorus, potassium fertilizers and farmyard manures) on grain yield and yield attributing traits of different maize varieties during winter seasons of 2009/10 and 2010/011 at the research farm of National Maize Research Program, Rampur, Chitwan, Nepal. Six levels of fertilizers [Control (Zero fertilizer), FYM @ 10 t/ha, FYM@ 10 t/ha plus 60:30 20 kg NPK/ha, FYM@ 10 t/ha plus 120: 60: 40 kg NPK/ha, FYM@ 10 t/ha plus 180: 90: 60 kg NPK/ha, and 120: 60: 40 kg NPK/ha] and four maize varieties (Rampur Composite, Manakamana-4, Across9942 × Across 9944 and S99TLYQ-B) were evaluated in randomized complete block design with three replications. The results showed that grain yield was non-significant for maize genotypes but the fertilizers levels were highly significant for grain yield. Rampur Composite produced the highest grain yield (5195 kg/ha), followed by Manakamana-4 (5074 kg/ha), Across9942 × Across9944 (5052 kg/ha) and S99TLYQ-B (4789 kg/ha) with the application of NPK 180: 90: 60 kg/ha plus FYM 10 t/ha. This information is useful in generating suitable fertilization packages for obtaining higher grain yield of maize varieties.

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Introduction

Maize (*Zea mays* L.) has the highest productivity per unit area as compared to other cereal crops. It ranked third among the cereal crops in the world after wheat and rice. In Nepal, it is the second most important staple food crop in terms of both area and production after rice but it is the first staple crop for hills. In Nepal, maize has been grown over an area of 954158 hectares in 2017/18 with a production of 2555847 tons and a productivity of 2.67 t/ha (MoALD, 2018). The production of maize is low as compared to other countries.

The production can be improved or increased through adequate nutrient management practices. Maize being the heavy feeder crop, a balanced dose of organic and inorganic application of fertilizer is needed for increased productivity. Fertilizer management is crucial for maize cultivation (Baral et al., 2015). Manures and fertilizers both play an important role in maize cultivation. N is usually applied in 3 equal splits at sowing, knee-high stage and tasseling stage. als/ha of grain yields and likewise, it can be reduced or

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increased as per its expected yield. Phosphorus (P) is the next most important plant nutrient after N which is found difficult in most soils. It has a beneficial effect on root growth and plant health. This nutrient should be applied initially at the early stage because of its low solubility in water. It should be applied in a moist zone to be transformed quickly for early absorption by the plant. The dose of P should be balanced with the dose of N applied. Potassium is considered to be the 3rd most essential fertilizer element, it is not found deficient in most of the soils. It is essential for the vigorous growth of the plant and for so many other metabolic activities.K application through fertilizers has been responding satisfactorily (Regmi et al., 2002). Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production. Farmers applying 20-25 t/ha of compost/FYM (manures) are not sufficient to replenish the harvested nutrients and hence need a sufficient amount of mineral fertilizer addition with heavy manure application (Joshy, 1997). Adhikary et al. (2001) reported that the highest maize grain yield (4.65 t/ha) could be obtained when the crop is fertilized by 20 t of compost plus 100: 75: 40 kg/ha of N, P_2O_5, and K_2O in the acidic soils of Malepatan, Pokhara. Adhikary and Ranabhat (Adhikary and Ranabhat, 2004) studied the economics of manure and fertilizer application on maize production and concluded that most economic dose of fertilizer was 100: 75: 40 kg N, P_2O_5 and K_2O/ha from inorganic sources and 20 t/ha of compost that contained 280 kg N, 184 kg P_2O_5 and 216 kg K_2O. Adhikary et al. (2007) studied the effect of fertilizer and agricultural lime on grain yield of different maize genotypes in the Western hills of Nepal and reported that improved maize variety (Manakamana-1) did not differ in grain production with the local variety when supplied with fertilizers at 60: 30: 30 kg N, P_2O_5 and K_2O and 4 t/ha of agri-lime. Adhikary (2008) also studied the effects of nitrogen on maize inbred (NML-1) and reported that increased seed yield (2.85 t/ha) was obtained with this variety when supplied with 180 kg N and crop planted at the density of 66,666 plants/ha and crop fertilized along with the recommended dose of P and K fertilizers. Series of experiments were conducted to evaluate the effects of fertilizers on different maize genotypes during the years 2009 and 2010. The results revealed that the highest grain yield of 6.28 t/ha was produced by the S99TLYQ-B when the crop was fertilized with 120: 60: 40 kg N, P_2O_5 and K_2O/ha and 10 t/ha of compost (NARC, 2010). Hence, balanced dose of fertilizers is needed to increase the crop yield of maize in acid soils. The number of fertilizers to be applied in maize depends largely on the genotypic makeup of plants.

The objective of these experiments were to study the response of fertilizer nutrients at different levels on the different maize genotypes in the soil condition of Rampur, Chitwan, Nepal.

Materials and Methods

Experimental site

The site was located in central Nepal at 27° 40’ N latitude and 84° 19’ E longitude with an elevation of 228 m above mean sea level and had a subtropical climate (NMRP, 2011). Maize was planted on sandy silt loam, acidic soil (pH 5.54). Fertilizer was applied in the form of Urea, di-ammonium phosphate (DAP), and murate of potash (MoP). Entire dose of DAP and MoP were applied at the time of sowing while half of the urea was first top-dressed at the knee-high stage and second top-dressed at tasseling stage. The average data derived from both years on maximum temperature ranged from 21.95 (January) to 36.35 0C (April), the minimum temperature varied from 9.4 (January) to 24.65 0C (October). There is no rainfall in

November and January, minimum rainfall (1.1 mm) occurred in January and maximum rainfall occurred in 99.35 mm (April). Similarly, average data on relative humidity showed that minimum humidity (76.8%) occurred in April and maximum relative humidity (99%) occurred in December. The details of weather data of individual year were shown in Table 2.

Table 1. Monthly mean weather condition during crop growing season (October-April) in 2009/10 and 2010/11 winter seasons at Rampur, Chitwan, Nepal

Month	Maximum temperature (0C)		Minimum temperature (0C)		Rainfall (mm)		Relative humidity (%)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
October	31.4	31.4	26.5	22.8	101	48.6	97.0	97.5
November	27.1	27.1	21.6	17.0	0.0	0.0	99.0	98.8
December	24.0	24.0	16.0	9.1	2.2	0.0	99.0	99.0
January	20.0	23.9	10.3	8.5	0.0	0.0	94.6	100.5
February	25.4	26.1	11.9	15.1	0.0	34.9	89.5	96.3
March	33.1	31.1	19.1	18.9	0.0	34.4	82.2	83.2
April	38.1	34.6	23.3	19.6	165	33.7	75.4	78.2

**Source: (NMRP, 2011)*

Experimental design, treatments and crop management

This experiment was conducted at the farm of National Maize Research Program, Rampur, Chitwan, Nepal during the winter season of the year 2009/10 and 2010/11.The crop was planted in October and harvested in April. Twenty four treatment combinations consisting of six levels of fertilization and four maize genotypes were replicated three times and laid out in a randomized complete block design. The details of the treatment combinations are given in the following Table 1. Row to row spacing 75 × 25 cm was maintained. The net harvested area was 7.2 m^2. The gross plot size was 12 m^2.

Table 2. The details of the treatments used in experiment in 2009/10 and 2010/11 winter seasons at Rampur, Chitwan, Nepal

Genotypes	Fertilizer rates
V1= Rampur Composite	F1=Control (Zero fertilizer)
V2= Manakamana-4	F2= FYM @ 10 t/ha
V3=Across9942 × Across9944	F3= FYM@ 10 t/ha plus 60:30 20 kg NPK/ha
V4= S99TLYQ-B	F4=FYM@ 10 t/ha plus 120: 60: 40 kg NPK/ha

	F5=FYM@ 10 t/ha plus 180: 90: 60 kg NPK/ha
	F6= 120: 60: 40 kg NPK/ha

Data recorded

Observations were taken on plant height, ear height, cob length, no. of Kernel rows per cob, no. of kernels per rows, and grain yield. Plant height and ear height were recorded at just near to harvesting and the rest of the data were recorded after harvesting. At maturity, central two rows from each the plot were separately harvested and the fresh ear weight was measured in each plot. Grain yield (kg/ha) at 15% moisture content was calculated using fresh ear weight with the help of the below formula given by Carangal et al. (1971), Shrestha et al. (2019) and Upreti et al. (2020).

$$\text{Grain yield}\left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{FWT}\left(\frac{\text{kg}}{\text{plot}}\right) \times (100 - \text{HMP}) \times \text{SCF} \times 10000}{(100 - \text{DMP}) \times \text{NPA}}$$

Where,

FWT : Fresh weight of ear in kg per plot at harvest

HMP : Grain moisture percentage at harvest

DMP : Desired moisture percentage, i.e. 15%

NPA : Net harvest plot area, m2

SCF : Shelling coefficient, i.e. 0.8

Statistical analysis

Data were statistically analyzed. Analysis of variance for all data was analyzed using the MSTAT computer program. The significant differences between genotypes were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez and Gomez 1984; Shrestha, 2019).

Results and Discussion

The interaction between different fertilizer levels and varieties on grain yield showed that the highest grain yield (5195 kg/ha) was obtained in Rampur Composite followed by Manakamana-4 (5074 kg/ha) and Across9942 × Across9944 (5052 kg/ha) under treatment of application of NPK 180: 90: 60 kg/ha plus FYM 10 t/ha. Similarly, S99TLYQ-B produced the highest grain yield (4789 kg/ha) under the same level of fertilization (Figure 1).

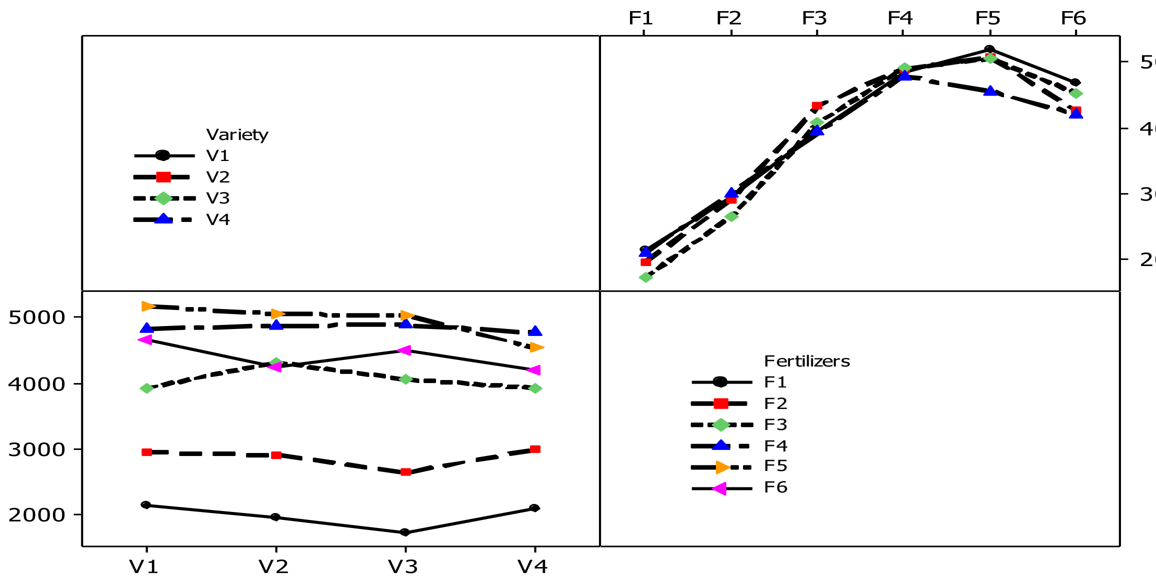

Figure 1. Schematic diagram for interaction effect between maize genotypes and fertilizer levels.

The increasing amount of nitrogen and phosphorus fertilizer application increased yield attributing traits in maize. The highest yield attributing traits namely cob length, no. of kernel rows per cob and no. of kernels per kernel rows were found under the level of fertilization (180:90:60 kg NPK plus 10 t FYM/ha) in Rampur Composite, Manakamana-4, Across9942 × Across9944. Gokmen et al. (2001) and Wajid et al. (2007) reported that 1000 grain weight increased with increasing N levels. Gungula et al. (2007) and Dawadi (2009) observed a number of kernels/ear and number kernel rows/cob increased with increasing nitrogen levels. The increase in 1000-grain weight with increasing P levels might be due to improvement in the source-sink relationship. These results are supported by the findings of Ahmad (1989) and Toor (1990).

Table 3. Effect of different level of manures and fertilizers on different maize genotypes in 2009/10 and 2010/11 winter seasons at Rampur, Chitwan, Nepal

Treatments	Cob length (cm)		Kernel rows per cob (No.)		Kernel per kernel row (No.)		Grain yield (kg/ha)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
V1F1	11.4	9.66	10.7	10.4	22.6	14.86	2860	1443
V1F2	12.2	11.6	12	11.93	24.2	17.53	3740	2180
V1F3	13.8	14.13	12.8	13.6	31.1	28.33	4960	2927
V1F4	14.1	14.46	13	13.86	30.5	30.4	5840	3863
V1F5	14.2	15.13	13.1	14	31.9	30.8	6260	4130
V1F6	13.8	13.86	12.6	13.73	29.1	29.46	5630	3733
V2F1	10.4	9.06	11.5	10	21.1	15.53	2240	1677
V2F2	11.7	11.6	13.3	11.7	25.3	21.86	3830	2010
V2F3	13.8	14.6	15.2	13.4	28.5	30.2	5340	3333
V2F4	14.3	14.73	15.3	13.86	30.2	31	5960	3837

V2F5	14.9	14.86	15.5	14.26	31.7	31.73	5990	4157
V2F6	14.2	13	15.1	12.93	30.7	27.2	5280	3240
V3F1	9.7	8.33	11.7	9.2	19.7	13.8	2300	1163
V3F2	11.6	10.8	13.7	11.53	25.5	21.13	3360	1953
V3F3	12.6	13.2	15.7	12.03	29.3	30.4	5120	3033
V3F4	13.3	13.66	15.7	13.33	28.8	29	6190	3630
V3F5	13.4	13.93	16.3	13.43	30.9	29.53	6280	3823
V3F6	13.2	13.2	15.1	13.16	29.1	28.23	5770	3290
V4F1	9.9	7.2	11.6	9.33	20.7	12.66	2750	1460
V4F2	11.7	10.2	13.5	10.13	25	20.06	3920	2083
V4F3	14.3	13.53	14.9	12.26	28.3	25.4	4990	2890
V4F4	14.9	13.73	15.2	12.13	32.5	29.73	5740	3380
V4F5	13.9	13.13	14.9	12.53	30.5	26.06	5760	3817
V4F6	14.1	13.4	14.9	12.03	29.1	28.6	5280	3140
Mean	13	12.54	13.9	12.28	27.8	25.14	4810	2925
CV(%)	4.62	9.36	7.52	7.99	6.25	14.63	15.32	17.44
F-test (V)	**	**	**	**	Ns	Ns	Ns	Ns
(F)	**	**	**	**	**	**	**	**
(V × F)	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
LSD (0.05)	0.402	0.788	0.701	0.658	1.428	2.468	605	419

***Highly significant at 0.01 level, *Significant at 0.05 level and Ns: non-significant.*

In 2009/10 and 2010/11, the effect of genotypes was observed to be non-significant whereas the effect of fertilizers was found to be highly significant. The increasing amount of fertilizer up to 180 N kg/ha, phosphorus 90 kg/ha, and potassium 60 kg/ha increased the grain yield in both years. Singh et al. (2000) indicated that grain increased with the increase in nitrogen level from 0-200 kg/ha. Khan et al. (2014) found an increasing amount of phosphorus increased the grain yield of maize at a constant level of 150 N kg/ha application; the maximum grain yield (5356 kg/ha) was recorded in Jalal variety when it was fertilized with 150:100 N:P kg/ha. In 2009/10 the highest grain yield (6068 kg/ha) was obtained at the highest level of fertilization (180:90:60 NPK kg/ha plus FYM 10 t/ha). The variety Rampur composite produced highest grain yield (4882 kg/ha) followed by Across9942 × Across 9944 (4837 kg/ha) and Manakamana-4 (4773 kg/ha) Similarly in 2010/11, grain yield was increased with an increased level of fertilization. The highest grain yield (3873 kg/ha) was obtained at the highest level of fertilization (180:90:60 NPK kg/ha plus FYM 10 t/ha). The variety Rampur composite produced highest grain yield (3046 kg/ha) followed by Manakamana-4 (3042 kg/ha) and Across9942 × Across 9944 (2816 kg/ha) (Table 4).

Table 4. Grain yield under different fertilizer levels and genotypes in 2009/10 and 2010/11 winter seasons at Rampur, Chitwan, Nepal

Treatments	Grain yield (kg/ha)	
Fertilizer levels	2009/10	2010/11
F1 (Control)	2538	1436
F2 (FYM 10 t /ha)	3713	2057
F3 (60:30:20 NPK plus FYM 10t/ha)	5103	3046
F4 (120:60:40 NPK plus FYM 10t/ha)	5938	3787
F5 (180:90:60 NPK kg/ha plus FYM 10 t/ha)	6068	3873
F6 (120:60:40 NPK kg/ha)	5490	3351
CV(%)	15.32	17.4
F-test	**	**
LSD (0.05)	221.5	419.1
Genotypes		
V1 (Rampur Composite)	4882	3046
V2 (Manakamana-4)	4773	3042
V3 (Across9942 × Across9944)	4837	2816
V4 (S99TLYQ-B)	4740	2795
CV(%)	15.32	17.4
F-test	Ns	Ns
LSD (0.05)	605	342.2

***Highly significant at 0.01 level, *Significant at 0.05 level and ns, non-significant.*

Conclusions

The study showed that maize genotypes namely Rampur Composite, Manakamana-4, Across9942 × Across 9944 and S99TLYQ-B produced higher grain yield of 5195, 5074, 5052 and 4789 kg/ha respectively with the application of NPK @ 180: 90: 60 kg/ha plus FYM 10 t/ha. Similarly, produced the highest grain yield (kg/ha). The yield attributing traits namely cob length, no. of kernel rows per cob and no. of kernels per kernel rows were found higher at the fertilization rate of 180: 90: 60 kg NPK/ha plus FYM 10 t/ha so such fertilization rate is suitable for maize varieties at Rampur, Chitwan, Nepal during winter seasons.

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