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Research Article

Yield Performance of Maize (*Zea mays* L.) Under Different Combinations of Organic and Inorganic Nutrient Management During Spring at Rampur, Chitwan, Nepal

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Abstract

The productivity of maize (*Zea mays* L.) is highly influenced by the combination of different sources of organic and inorganic sources of fertilizers. A field experiment was conducted to study the most suitable combination of different organic and inorganic sources of fertilizers to produce high grain yield of maize in Chitwan. The treatments consist of eight different combinations of organic and inorganic fertilizer sources i.e., T_1 = to supply 120 kg N ha^{-1} as Urea, T_2 = to supply 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as Farm Yard Manure (FYM), T_3 = to supply 60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as poultry manure (PM), T_4 = to supply 60 kg N ha^{-1} as FYM + 60 kg N ha^{-1} as PM, T_5 = to supply 30 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as FYM + 30 kg N ha^{-1} as PM, T_6 = to supply 60 kg N ha^{-1} as Urea + 30 kg N ha^{-1} as FYM + 30 kg N ha^{-1} as PM, T_7 = to supply 30 kg N ha^{-1} as Urea + 30 kg N ha^{-1} as FYM + 60 kg N ha^{-1} as PM and T_8 = control (no fertilizer) are arranged in Randomized Complete Block Design (RCBD) with four replications. The research result showed that, the highest grain yield (3.87 t ha^{-1}) was obtained with 50% N as Urea + 50% N as PM and the least (1.64 t ha^{-1}) was found at control treatment. The higher grain yield in this treatment was associated with maximum number of grain line (12.62), number of grains per cob (316.0) and thousand grain weight (299.9 g). Therefore, based on the research treatments, application of 120 kg nitrogen through the combinations of 50% N as Urea + 50% N as PM can be recommended to the farmers of Chitwan after confirming the results for few years.

Keywords: Maize; Farm Yard Manure; Poultry Manure; Urea; Yield

Introduction

Maize (*Zea mays* L.) is the world's most widely grown cereal and primary staple food crop in many parts of the developing countries. According to Ranum, Pena-Rosas and Garcia-Casal [1] United States, China, and Brazil are the top three maize producing countries in the world, that, produce about 563 of the 717 million metric tons of maize grain per year. It is the second most important crop after rice in terms of area cultivated and grain yield production in Nepal, confirming the food crop to be the way of life for the farmers in hilly areas. It is cultivated in 891,583 hectares of land and is produced 2,231,517 tons of maize grain with the productivity of 2.5 t ha^{-1} [2].

Manures and fertilizers are not applied in adequate amounts due to lack of sufficient manure and fertilizer and poverty [3]. Limited and irregular access of improved seeds and fertilizers specifically to the small farmers in the remote areas is the main constraint for maize production. Most of the farmers are not aware about information on crop management aspects particularly balanced use of fertilizers and management of maintaining optimum plant population per hectare. In sub-tropical inner terai regions like Chitwan, maize is cultivated throughout the year including open pollinated varieties (OPVs), improved varieties, local maize genotypes and hybrids. The demand for maize is increasing widely due to its multiple uses like livestock feed in terai and inner terai, direct human consumption in the hills as a staple food crops and in maize processing based industries. It is expected to be increased further with the establishment of maize-based food industries, poultry, dairy and fish farms.

Degradation of soil fertility is the most important constraint for food grain production in Nepal and an efficient cycling of nutrients through different parts of crop plants, animal body and soil micro-organisms seems to be crucial for the sustainable productivity of the crop in the farming systems [4]. The uses of organic materials like poultry manure and farmyard manure help in the utilization of both major and minor nutrients in the soil body and improve in the physical, chemical and biological properties of soil. Farmers community is now switching towards the use of organic fertilizers in their own fields as a result of disadvantages of inorganic fertilizer in destroying the soil structure. The combined use of organic sources of fertilizers not only supply essential nutrients to the crop plants but also helps in the availability of crop plant nutrients through chemical fertilizers and soil colloidal particles to improve the grain yield as well as soil structure [5]. However, use of inorganic fertilizers alone was found to increase the biological yield of crop to some extent but their haphazard use caused to destroy the soil structure and to pollute the ground water table severely affecting the [6].

Integrated use of organic manures and chemical fertilizers is beneficial in improving yield of crop, soil pH, organic carbon and available nitrogen, phosphorus and potash in sandy loam soil [7]. Considering the above facts, it was thought to conduct the research on the performance of spring maize affected by the use of sole and combined ratio of different ratio of urea, FYM and poultry manure in Rampur Chitwan.

Materials and Methods

The detail of methods and materials used during experimental period has been described under following headings.

Site selection

A field experiment was conducted at National Maize Research Program (NMRP), Rampur Chitwan research field. The area is situated in Central Terai of Nepal in Central development region. The elevation of the sites, i.e. NMRP is at 228 masl.

Physio-properties of soil of experimental site

Soil samples were taken randomly from four different spots of a plot at a depth of 0-15 cm and 15-30 cm using tube auger to record initial physio-chemical properties of soil. The soil sample was air dried ground and sieved through 2 mm sieve and subjected for the analysis of its properties. The physiochemical properties of experimental soil are presented in Table 1.

S.N.	Properties	Average content	Rating
1	Physical properties (%)		
	Sand	61	
	Silt	29	
	Clay	10	
	Textural class/Rating		Sandy loam
2	Chemical properties		
	Soil pH	5.37	Acidic
	Soil organic matter (%)	2.18	Low
	Total nitrogen (%)	0.07	Low
	Available phosphorus (kg ha^{-1})	63.01	High
	Available potassium (kg ha^{-1})	163.5	Medium

Table 1: Physio-chemical properties of soil at the experimental plot, NMRP Chitwan, Nepal, 2017.

The total nitrogen was determined by Kjeldhal distillation unit, available phosphorus by spectrophotometer and available potassium by ammonium acetate method. Organic matter was determined by Walky and Black method, pH (1:1 soil: water suspension) by Beckman Glass electrode pH meter and soil texture by hydrometer method. The physio-chemical properties of the experimental soil are presented in Table 1.

Climatic conditions during experimentation

The meteorological data for cropping season was recorded from the meteorological station of National Maize Research Program (NMRP), Rampur Chitwan and depicted in Figure 1.

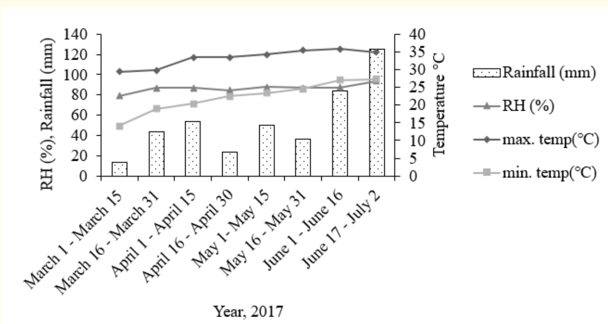

Figure 1: Weather condition on meteorological data at fortnightly intervals during the research period (March 12- July 2, 2017) at NMRP, Rampur Chitwan Nepal.

Nutritional analysis of organic manures

To know the nutritional status of the FYM and Poultry manure, the samples of 500 gram of FYM and Poultry manure sample was taken from Veterinary farm from which manure was purched for research and tested in soil test laboratory located at Hariharbhawan, Lalitpur.

Characteristics	Unit	Value	
		FYM	Poultry manure
Nitrogen	%	0.95	3.51
Phosphorus	%	1.0	4.19
Potassium	%	0.62	4.35
pH	-	7.4	8.8
Moisture	%	43	31.3

Table 2: Chemical analysis of FYM and Poultry manure.

Plant materials

The Rampur Composite cultivar was taken.

Experimental details

The experiment was laid out in simple Randomized Completely Block Design (RCBD) with four replications and eight treatments, where combinations of organic and inorganic fertilizers are the treatments.

Fertilizer application

The treatments consist of eight different combinations of organic and mineral fertilizer combinations. The recommended dose of nitrogen (120 kg ha^{-1}) was applied through combined application of organic and chemical fertilizers to evaluate the best suitable proportions. Chemical fertilizers were applied as urea for the source of nitrogen, single super phosphate for phosphorus (P_2O_5) and muriate of potash for potassium (K_2O). Poultry manure (PM) and farm yard manure (FYM) was applied as a source of organic fertilizer.

Treatment Combinations

Treatments	Percentages of fertilizers use	Dose of Fertilizers (ha^{-1})	Nitrogen supply Through
T_1	100% N as Urea	260.8 kg Urea	120 kg N ha^{-1} as Urea
T_2	50% N as Urea + 50% N as FYM	130.4 kg Urea + 6.3 t FYM	60 kg N ha^{-1} as Urea + 60kg N ha^{-1} as FYM
T_3	50% N as Urea + 50% N as PM	130.4 kg Urea + 1.7 t PM	60 kg N ha^{-1} as Urea + 60 kg N ha^{-1} as PM
T_4	50% N as FYM + 50% N as PM	6.3 t FYM + 1.7 t PM	60 kg N ha^{-1} as FYM + 60 kg N ha^{-1} as PM
T_5	50% N as FYM + 25% N as Urea + 25% N as PM	6.3 t FYM + 65.2 kg Urea + 0.85 t PM	60 kg N ha^{-1} as FYM + 30kg N ha^{-1} as Urea + 30 kg N ha^{-1} as PM
T_6	50% N as Urea + 25% N as PM + 25% N as FYM	130.4 kg Urea + 1.7 t PM + 3.15 t FYM	60 kg N ha^{-1} as Urea + 30 kg N ha^{-1} as PM + 30 kg N ha^{-1} as FYM
T_7	50% N as PM + 25% N as FYM + 25% N as Urea	1.7 t PM + 3.15 t FYM + 65.2 kg Urea	60 kg N ha^{-1} as PM + 30 kg N ha^{-1} as FYM + 30 kg N ha^{-1} as Urea
T_8	Control	No fertilizer application	No fertilizer application

Table 3: Detail of experimental treatments and their symbols in spring maize experiment at NMRP, Chitwan Nepal, 2017**.**

Detail of management practices

Land preparation

The land was ploughed one month ago of seed sowing (Second week of March) to bring the soil under good tilth. Land was prepared by deep ploughing with disk plough after 15 days of broad spectrum herbicide (Glyphosate) application.

Manure and fertilizer application

After 2 deep ploughing; the field was made fine and the FYM and poultry manure was applied. The manure and fertilizer were applied and mixed thoroughly each plot in accordance with treatment assigned. Nitrogen (N), Phosphorus (P_2O_5) and K_2O were supplied thorough organic fertilizers such as FYM and Poultry manure and inorganic fertilizers as Urea, single super phosphate (SSP) and

Muriate of potash (MOP). The recommended dose of fertilizers for improved maize is 120:60:40 kg NPK ha^{-1}. The nitrogen (N) was applied through different sources of organic and inorganic fertilizers. The full dose of phosphorus and potash and half dose of nitrogen were applied at the time of final land preparation. The remaining half dose of fertilizer was applied in two equal splits at knee height stage and tasseling stage of crops.

Seed rate and Sowing

The required amount of seed for planting was calculated for all plots. The seed rate of 25 kg ha^{-1} was used for each treatment. Seed was planted manually using Zabler seed planter maintaining the 2 seeds per spot with the spacing of 60 cm x 25 cm apart for row to row and plant to plant distances.

Weeding

The hand weeding was done for first at 30 DAP and second weeding at 45 DAP i.e. first weeding on April 12 and second on April 27.

Thinning and earthing up

The only one plant per hill was maintained by thinning unwanted plants 20th days after planting followed by earthing up.

Plant protection

Infection of Stem borer was prevented by keeping Carbofuran @ 2-3 granules on the whorl of maize at knee height stage. Leaf blight and stem rotting were found major problem in the experimental maize field.

Harvesting and threshing

After harvesting, the cobs were separated out and remaining biomass was weighed. The number of cobs per plot was counted and weighed. The biomass from each plot was taken and oven dried at 720C for 48 hours. The cobs were dehusked after drying in threshing floor. After taking all the measurements shelling was done, dried at 13% moisture and weighed.

Yield and yield attributes

Cob length and cob diameter

The diameter of these same randomly selected cobs was measured by using veneers caliper. The diameter was taken from middle of the cobs. The diameter was calculated using the formula as given below.

$$\text{Diameter of cob (cm)} = \frac{\text{Circumference of cob}}{\pi}$$

Number of grains per cob

The number of grains per cob was calculated as given below.

The total number of grains per cob = Number of grain rows per cob × number of grains per row.

Thousand grain weight (TGW)

Thousand grain weights was taken from composite sample of the sampling cobs of each plot and then average was taken, weight to record as thousand grain weight and expressed in gram (g).

Grain yield per hectare

From each experimental plots grain yield was recorded. The data was converted and reported as grain yield kg ha-1. The moisture content of grains of each plot was measured by automated moisture meter and final grain yield was adjusted at 13% moisture level by using the formula as given below:

$$\text{Grain yield (kg ha}^{-1}) = \frac{(100 - \text{MC}) \times \text{plotyield (kg)} \times 1000(\text{m}^2)}{(100 - 13) \times \text{net plot area (m}^2)}$$

Where, MC is the moisture content percentage of grain.

Stover yield

All maize plants were harvested at base from the net cultivated area and maize stem was weighted immediately after harvesting. Husk was also included while taking Stover yield. Stover yield was calculated on hectare basis in kg ha^{-1}.

Harvest index

Harvest index (HI) is the ratio of economic yield and biological yield. Harvest index indicates how much biological yield was converted in the economic yield. It was computed by using following formula:

HI = (Economic yield × 100)/Biological yield

Statistical analysis

Analysis of Variance (ANOVA) for all parameters was analyzed by using Gen Stat statistical analysis system. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT) for mean comparison. Correlation and regression analysis were carried out for important parameters.

Result and Discussion

Cob length and Cob diameter

The data on cob length of maize as influenced by fertilizer levels is presented in (Table 4). The longer fertile length of cob (16.01 cm) was found greater in T_6 (50% N as Urea + 25% N as PM + 25%

N as FYM) which was at par with T_1 (100% N as Urea) and T_3 (50% N as Urea + 50% N as PM). The other treatments were also statistically similar with the treatment T_3 and showed the lowest (7.93 cm) in unfertilized plot.

Chan, Van Zwieten, Meszaros, Downie and Joseph [8] reported that, ear length and ear diameter increased when N was applied in integration with organic fertilizers as compared to sole N application. Similar findings were obtained by Mohsin., *et al*. [9]. Healthy plants were produced due to higher availability of nutrients with maximum number of cob rows, ovule and filled enough with starch after fertilization. The continuous filling of kernels with sufficient photosynthates led to increase in length and size of the cob.

Similarly, significantly higher cob diameter (4.36 cm) was recorded from T_7 (50% N as PM + 25% N as FYM + 25% N as Urea) which was statistically at par with T_3 (50% N as Urea + 50% N as PM) and T_6 (50% N as Urea + 25% N as PM + 25% N as FYM). The treatment T_6 and T_2 (50% N as Urea + 50% N as FYM) showed similar cob diameter and least cob diameter (3.47 cm) was found in control.

The cob length and cob diameter increased when N was applied in integration with organic fertilizers led to continuous filling of kernels with sufficient photosynthates as compared to sole N application [8].

Grain number cob^{-1}

The significantly higher number of grains per cob (316.0) was found in the plots in which N supply through 50% N as Urea + 50% N as PM (T_3) which was statistically at par with all the treatments except control. The control plot produced statistically lower grains (194.0) per cob. Desai and Vinodakumar [10] reported that, availability of nutrients especially nitrogen was an important factor to decide the number of grains weight per cob. The increase in number of grains per cob might be attributed to the availability of more nitrogen and other nutrients from urea and PM to the maize plant required for growth and development through the life cycle of maize crop. Number of grain lines per cob is an important yield determining factor in maize. It affects the number of grains per cob and cob weight.

This increase in number of grains per cob might be due to availability of N at proper time, which was required for better growth and development of plants, improvement in moisture retention and soil structure by organic manures. These findings were strongly supported by the results of Chaudhary, Shafiq and Rehman [11]. Numbers of grains per cob were depended on the number of grain rows per cob and number of grains per cob.

Treatments	Percentage of nitrogen supply	Cob length (cm)	Cob diameter (cm)	Number of grains per cob
T_1	100% N as Urea	14.16^{ab}	3.77^{bc}	275.0^{a}
T_2	50% N as Urea + 50% N as FYM	11.65^{b}	3.88^{abc}	285.0^{a}
T_3	50% N as Urea + 50% N as PM	13.98^{ab}	3.77^{bc}	316.0^{a}
T_4	50% N as FYM + 50% N as PM	10.69^{bc}	4.12^{ab}	251.0^{ab}
T_5	50% N as FYM + 25% N as Urea + 25% N as PM	12.09^{b}	3.85^{abc}	282.0^{a}
T_6	50% N as Urea + 25% N as PM + 25% N as FYM	16.01^{a}	4.10^{ab}	295.0^{a}
T_7	50% N as PM + 25% N as FYM + 25% N as Urea	11.68^{b}	4.36^{a}	302.0^{a}
T_8	Control (no nitrogen application)	7.93^{c}	3.47^{c}	194.0^{b}
SEm (±)		1.08	0.17	22.0
LSD = 0.05		3.17	0.50	66
CV, %		17.6	8.8	16.0
Grand Mean		12.27	3.92	274.0

Table 4: Cob length, cob diameter and number of grains per cob as influenced by sole and combined application of organic and inorganic fertilizers at NMRP, Rampur Chitwan in 2017.

Note: Means followed by common letter (s) within each column are not significantly different at 5% level of significance based on DMRT.

Thousand grain weight (TGW)

The data showed that, thousand grain weights were affected significantly by different levels of organic and inorganic fertilizers. Significantly higher thousand grain weights produce i.e. 299.9 g were recorded from fertilized plot through 50% N as Urea + 50% N as PM and lower TGW (164.8 g) was recorded from the unfertilized treatment (Table 5). The increase in thousand grain weights with increased level of PM could be due to balanced supply of food nutrients both from urea and from poultry manure throughout the development of plant. It may also be due to proper dose of nitrogen in addition to urea and poultry manure.

Khaliq, Taseem, Mahmood and Masood [12] stated that, the increase in 1000 grain weight was mainly due to the balanced supply of food nutrients from both urea and poultry manure throughout the grain filling and development period.

Grain yield t ha^{-1}

All data presented in Table 5 clearly showed that significantly highest grain yield of 3.87 t ha^{-1} was recorded from plots where the application of 50% N as Urea + 50% N as PM was applied, followed by T_6 (50%N as Urea + 25% N as PM + 25% N as FYM) and T_7 (50%N as PM + 25%N as FYM + 25%N as Urea). The lowest grain yield of 1.64 t ha^{-1} was recorded from the plots where there was no use of organic and inorganic nitrogenous fertilizers.

The lower N level in the soil results in lower yield due to less available N for the optimum plant growth. The lower N level in the soil results in lower yield due to less available N for the optimum plant growth [13]. The incorporation of organic manure in the soil have thought to reduce the evaporation demand, thus have adequate water for plant root growth, or perhaps due to the softness of soil caused by manure in which the roots may expand rapidly and properly into wet soil to meet plant water requirements [14]. Our results were also similar to the findings of Delate and Cambardella [15] who observed that, integrated N strategies convincingly enhanced corn yield attributes.

Crop yield depends on the accumulation of photos assimilates during the growing period and the way they partitioned between desired storage organs of the plant [16]. Grain yield is a function of interaction among various yield components that are affected differentially by the growing conditions and crop management practices.

The increase in grain yield in case of combined use of fertilizer was mainly due to more number of grains per cob as well as better grain development. The timely availability of N could insure and increase corn productivity by using combination of mineral N and Organic manures in right doses. These results were in line with the findings of Negassa., *et al*. [14] who found that, corn yield was 35% increased by integrated N management.

Harvest index (HI)

The physiological efficiency of a crop plants in converting the photosynthates into grain yield is measured in the form of harvest index. The different levels of organic and inorganic fertilizers had significant effect on harvest index (Table 5). The higher harvest index (0.41) was recorded in T_7 (50% N as PM + 25% N as FYM + 25% N as Urea) which was statistically similar with T_2(50% N as Urea + 50% N as FYM) and T_3 (50% N as Urea + 50% N as PM). The T_3 (50% N as Urea + 50% N as PM) was statistically similar with T_6 (50% N as Urea + 25% N as PM + 25% N as FYM) and T_5 (50% N as FYM + 25% N as Urea + 25% N as PM). The lowest harvest index (0.28) was recorded from T_4 (50% N as FYM + 50% N as PM) which produced HI of 0.34. It might be due to the availability of N throughout the growing season and increase in water holding capacity of soil. Similar results were reported by Brinton and Seekins [17] who reported that, harvest index was significantly affected by N fertilizers in combination with organic manures. Uzoma., *et al*. [18] stated that, higher HI observed in combined application of different sources of organic and inorganic fertilizers might be due to an increase in availability of soil N and uptake by the plant of the micro and macro nutrients required for optimum plant growth.

Stover yield t ha^{-1}

The highest stover yield of (7.34 t ha^{-1}) was produced by T_1 (100% N as Urea) which was statistically at par with T_6 (50% N as Urea + 25% N as PM + 25% N as FYM), T_3 (50% N as Urea + 50% N as PM) and T_4 (50% N as FYM + 50% N as PM) which yields (6.64, 6.53 and 5.76 t ha^{-1}) respectively. The lowest stover yield (3.31 t ha^{-1}) was recorded in T_8 (Control).

Stover yield was significantly influenced by application of nitrogenous fertilizers but not by its supplied sources such as combined use of urea, FYM and poultry manure. The result reveled that nitrogenous fertilizers increased more stover yield than control. Also, similar findings were reported by Ali., *et al*. [19] who indicated that, higher biomass production produced by maize crop was due to greater LAI, plant height, major and micronutrients availability due to supply of nutrients through both the organic and inorganic fertilizers in suitable proportions

Treatments	Percentage of nitrogen supply	Thousand grain weight (g)	Grain yield (ton ha^{-1})	Stover yield (ton ha^{-1})	HI
T_1	100% N as Urea	263.8[b]	3.45[bc]	7.34[a]	0.32[ab]
T_2	50% N as Urea + 50% N as FYM	259.3[bc]	3.14[bc]	4.99[b]	0.39[a]
T_3	50% N as Urea + 50% N as PM	299.9[a]	3.87[a]	6.53[ab]	0.37[a]
T_4	50% N as FYM + 50% N as PM	229.4[c]	2.22[de]	5.76[ab]	0.28[b]
T_5	50% N as FYM + 25% N as Urea + 25% N as PM	252.0[bc]	2.82[cd]	5.46[b]	0.34[ab]
T_6	50% N as Urea + 25% N as PM + 25% N as FYM	262.7[b]	3.66[ab]	6.64[ab]	0.36[ab]
T_7	50% N as PM + 25% N as FYM + 25% N as Urea	256.2[bc]	3.59[ab]	5.21[b]	0.40[a]
T_8	Control (no nitrogen application)	164.8[d]	1.64[e]	3.31[c]	0.34[b]
SEm (±)		9.58	0.22	0.50	0.027
LSD = 0.05		28.16	0.65	1.481	0.08
CV, %		7.7	14.4	17.8	15.2
Grand Mean		248.5	3.05	5.66	0.35

Table 5: Thousand grain weight, Grain yield, stover yield and harvest index of maize as influenced by sole and combined application of organic and inorganic fertilizers at NMRP, Rampur Chitwan in 2017.

Note: Means followed by common letter (s) within each column are not significantly different at 5% level of significance based on DMRT.

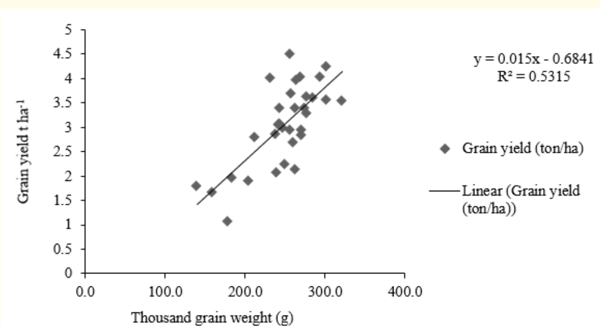

Figure 2: Relationship between thousand grain weight and grain yield at NMRP, Rampur Chitwan Nepal in 2017.

Conclusion

The productivity of maize is highly influenced by combination of different sources of organic and inorganic sources of fertilizers. The application of 120 kg nitrogen through combination of 50% N as Urea + 50% N as PM produced the highest grain yield. Similarly, application of N through 50% N as PM + 25% N as FYM + 25% N as Urea produced maximum HI. The result reveals that, the grain yield and HI are also statistically similar in these treatments. Therefore, application of 120 kg nitrogen through the combinations of 50% N as Urea + 50% N as PM and application of N through 50% N as PM + 25% N as FYM + 25% N as Urea can be recommended for sandy loam soil during spring season under sub-tropical inner terai condition.

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Bibliography

1. Ranum P., *et al*. "Global maize production, utilization, and consumption". *Annals of the New York Academy of Sciences* 1312 (2014): 105-112.
2. MoAD. Statistical information on Nepalese agriculture. Government of Nepal, Ministry of Agricultural Development, Agristatistics section, Singha Durbar, Kathmandu, Nepal (2017).
3. Koirala GP. "Factors affecting maize production, productivity and trade in Nepal". Sustainable maize production systems for Nepal (No. 631.536 RAJ.CIMMYT.) (2002).
4. Adhikary BH and Karki KB. "Use of Fertilizers and Lime for Enhancing Productivity of Maize Genotypes in Western Hill of Nepal". *Nepal Agriculture Research Journal* 8 (2014): 42-49.

5. Elfstrand S., *et al*. “Influence of various forms of green manure amendment on soil microbial community composition, enzyme activity and nutrient levels in leek”. *Applied Soil Ecology* 36.1 (2007): 70-82.

6. Sagardoy JA. “An overview of pollution of water by agriculture”. *Water Reports (FAO)* (1993).

7. Rautaray SK., *et al*. “Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice–mustard cropping sequence under acid lateritic soils”. *Bioresource Technology* 90 (2003): 275-283.

8. Chan KY., *et al*. “Using poultry litter biochars as soil amendments”. *Soil Research* 46.5 (2008): 437-444.

9. Mohsin AU., *et al*. “Effect of nitrogen application through different combinations of urea and farm yard manure on the performance of spring maize (Zea mays L.)”. *Journal of Animal and Plant Sciences* 22 (2012): 195-198.

10. Desai B and Vinodakumar S. “Growth, yield and yield components of hybrid Maize (Zea mays L.) as Influenced by different nutrient combinations under integrated farming system”. *Growth* 7 (2017): 8.

11. Chaudhary MA., *et al*. “Effect of organic and inorganic fertilizer on maize crop response under eroded loess soil”. *Pakistan Journal of Agricultural Sciences* 15 (1998): 39-43.

12. Khaliq Taseem., *et al*. “Effectiveness of farmyard manure, poultry manure and nitrogen for corn (Zea mays L.) productivity”. *International Journal of Agriculture and Biology* 2 (2004): 260-263.

13. Khan., *et al*. "Phenology and crop stand of wheat as affected by nitrogen sources and tillage systems". *Pakistan Journal of Botany* 40.3 (2008): 1103-1112.

14. Negassa W., *et al*. “Determination of Optimum farmyard Manure and NP Fertilizers for Maize on farmers field”. In Seventh Eastern and Southern Africa Regional Maize Conference 11 (2001): 387-393.

15. Delate K and Cambardella CA. “Agroecosystem performance during transition to certified organic grain production”. *Agronomy Journal* 96.5 (2004): 1288-1298.

16. Kumar SS., *et al*. “Effect of Integrated Nutrient Management on Productivity and Profitability of Maize”. *International Journal of Current Microbiology and Applied sciences* 6.12 (2017): 3878-3882.

17. Brinton Jr W F and Seekins MD. “Evaluation of farm plot conditions and effects of fish scrap compost on yield and mineral composition of field grown maize”. *Compost Science and Utilization* 2.1 (1994): 10-16.

18. Uzoma KC., *et al*. “Effect of cow manure biochar on maize productivity under sandy soil condition”. *Soil use and management* 27 (2011): 205-212.

19. Ali K., *et al*. “Management of organic and inorganic nitrogen for different maize varieties”. *Sarhad Journal of Agriculture* 27.4 (2011): 525-529.