Effect of Organic Manures and Chemical Fertilizers on Maize Productivity and Soil Properties in the Winter Season

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ABSTRACT

Field experiments were conducted at the National Maize Research Program Rampur, Chitwan, Nepal, during the two consecutive winter seasons of 2018/19 and 2019/20. The objective was to identify the effects of different sources of nutrients on the growth and yield parameters of winter maize and soil properties. The experiment was laid out in a randomized complete block design with three replications and twelve treatments. Combinations of different organic and inorganic sources, including the recommended dose of chemical fertilizer, farmyard manure, poultry manure, biochar, vermicompost, mustard oil cake, sunhemp and bone meal, were tested. Different nutrient levels significantly influenced the maize grain yield. The maximum grain yields of 7102 kg/ha (2018/19) and 6985 kg/ha (2019/20) were obtained with the combined application of 50% recommended dose (RD) of chemical fertilizer along with mustard oilcake at the rate of 5 t/ha, which was at par (6969 kg/ha and 6535 kg/ha) with the sole application of mustard oilcake at 10 t/ha. It can be concluded that the highest grain yield (7043.5 kg/ha) was obtained when 50% of the recommended dose of N, P₂O₅ and K₂O fertilizers were combined with 5 t mustard oilcake/ha application, followed by sole application of 10 t mustard oilcake/ha (6752 kg/ha). Soil properties including organic matter were found to be significantly improved due to the application of a combined application of organic and inorganic fertilizer. Thus, in subtropical conditions, integrated organic manures and chemical fertilizers can enhance soil properties and increase maize productivity during the winter season.

Keywords: fertilizer, inorganic, maize, organic.

सारांश

उत्पादन, जिल्लाको रामपुर विभाग राष्ट्रिय मक्खिनी को अनुसार अन्य कार्यक्रमको परिक्षण समयमा सन् २०१८/१९ र २०१९/२० को तालाबार दुई हिँदौर सिथिमा अन्य योजनाको मार्गमान्य परिक्षण संचालन गरिएको थियो। यस अवस्थानको मुख्य उद्देश्यहरू मक्खिनी व्यस्तजस्त गरिएको बाट मक्खिनी प्रयोग गरिने पाथक तथा क्षेत्रीय विभाग क्षेत्रहरूको प्रयोग बाट मक्खिनी प्रामाण्य तथा सास्त्रिक गुणमा पाने असर तथा मक्खिनी विद्युत तथा बाली उद्योगमा यसले पाने प्रभाव परिमाण नालै थियो। उक्त अनुसन्धानका बाद विभाग प्राकाको एककृत सान्तत्तका व्यस्त्यात्मका विविधतालाई बताउनुभएको जस्तै बताउनुभएको। परिसंचालन में पनि पहाडिको तलहरूको प्रयोग गरिएको थियो। ती विभिन्न उद्यानमा उन्नत मक्खिनी लागि निवास प्रसारित गरिएको विभिन्न कार्यक्रमको नाट्याङ्क, फसलों र हर्षदृष्टिको तला गोवित्रिक तथा वायु योजना, वायु योजना, उपवातिका मक्खिनी प्रयोग क्षेत्रहरूमा गरिएको थियो। यस अनुसन्धानका रामपुर–४ मक्खिनी जात प्रयोग गरिएको थियो। मक्खिनी विभाग क्षेत्रहरूको असर र प्रभाव अध्ययन गर्ने मक्खिनीको वबल, ढेकिस्त्तीर तथा अभ्यासको घटेको पाई।
Effect of organic and chemical fertilizers on maize by P Adhikari et al

INTRODUCTION

Maize is the second most important cereal crop after rice in Nepal and is grown in 9,56,447 ha area with an average productivity of 2.84 t/ha (MOALD 2020). Maize contributes about 3.15% to National Gross Domestic Product and 9.5% in Agricultural Gross Domestic Product (ABPSD 2020). Maize grain is used mainly for feed purposes in the Terai and as a staple food in the hills of Nepal; hence demand of maize grain is increasing due to the growing number of animal farming industries, as maize is the primary ingredient of animal feed (Pokharel et al 2016).

Nepal imported around 5,00,000 tons of maize grain in 2018/19 (MOALD 2020). So, there is an acute need to increase maize production in Nepal to sustain the national demand. The use of improved varieties or hybrids, timely irrigation, and fertilizers, and manure are some of the easy and effective methods to increase the productivity of maize in Nepal. The yield of maize, however, varies from variety to variety, location to location, and depends on the availability of essential factors such as soil nutrient status and application of fertilizers (Kogbe and Adediran 2003). The dose of 120:60:40 kg N, P₂O₅, and K₂O plus 10 ton FYM/ha is recommended for general cultivation of maize in Nepal (NMRP 2018). The blanket recommendation may not address all the soil types and properties, growing conditions, combinations, domains, and social and economic status of the farmers (Adhikari 2014). Nepal, being a mountainous country, there are heterogeneous soil in a different domain, and a tremendous amount of soil minerals are lost in the rainy season due to soil erosion and landslides (KC et al 2013).

Key soil parameters such as soil organic matter, pH, and plant nutrients reflect essential and dynamic soil properties and are governed by physical, chemical, and biological processes in soil (Karlen et al 2003). Among the available soil components, organic matter (OM) is the essential factor as a reservoir of nutrients and water in the soil. Organic sources are the foundation to increase organic matter in the soil (Funderburg 2001). It is crucial to identify the best available organic resources, either the alternatives or their best combined with an appropriate proportion of inorganic fertilizers. Integration of different nutrients is a practice where all sources of nutrients (organic, inorganic, bio-fertilizer) can be combined and applied to soils to enhance crop growth and good yield with the quality product (Mahajan et al 2007).

Maize is an exhaustive feeder hence nutrients requirement in maize are high (Shrestha et al 2018). The productivity of maize is dependent mainly on its nutrient management (Sharma et al 2019). Yield is a function of genotypes, environments, and crop management. Fertilizer management is crucial for maize cultivation (Baral et al 2015, Adhikari et al 2016). Application of proper amount of plant nutrients is necessary for good crop growth and grain yield (Adhikary et al 2012). Integrated nutrient management (INM) is an option as it utilizes available organic and inorganic nutrients to build an ecologically sound and economically viable farming system (Selim 2020). INM has assumed great importance and has a vital role in maintaining soil productivity and crop production.

The use of organics alone does not result in a remarkable increase in crop yields due to their high volume and low nutrient status. Organic manures (i.e. farmyard manure (FYM), poultry manure (PM), vermicompost (VC), oilcake (OC), bone-meal (BM), green manure (GM), crop residues and different inorganic fertilizers are essential components for INM. INM plays a critical role in sustainable agriculture.
Effect of organic and chemical fertilizers on maize by P Adhikari et al

by maintaining the production and productivity of crops (Kundu and Pillai 1992). Excess and repeated use of chemical fertilizers are very costly and harmful for soil health as well. Therefore, integration of organic manure with inorganic fertilizer may maximize crop productivity and improve soil properties (Aulakh 2010). Keeping these factors in consideration, a field experiment was conducted at the National Maize Research Program (NMRP), Rampur, Chitwan, Nepal, to study the impact on soil properties and grain yield of maize due to different sources of organic manures along with chemical fertilizers.

MATERIALS AND METHODS

Experimental site
The field experiment was conducted at the research field of NMRP, Rampur, Chitwan, Nepal. It is situated in central Nepal at 27°37' North latitude, 84°25' East longitude, and at an altitude of 228 meters above sea level (NMRP, 2018) with hot, humid, and sub tropical climate.

Weather conditions of the research site
During the crop growing period (September to April) of the first year (2018/19), the maximum temperature ranged from 23.5 to 33.4°C and the minimum temperature ranged from 8.7 to 26°C with relative humidity from 80.6 to 95.5%. The cumulative rainfall in the experimental period was 467.1 mm. Similarly, in the second year, the maximum temperature ranged from 20.3 to 33.53°C, and the minimum temperature from 9.02 from 23.56 °C with the total rainfall during of 528 mm (NMRP, 2020). Based on the meteorological data of the experimental site the pattern of rainfall was almost similar in both the years. The weather data during the experimental periods is given in Figure 1 and Figure 2.

![Figure 1: Weather data of the experimental site during the crop growing period (September to April) of 2018/19.](image-url)
Effect of organic and chemical fertilizers on maize by P Adhikari et al

Figure 2: Weather data of the experimental site during the crop growing period (September to April) of 2019/20.

Experimental Details
The field experiment was conducted during the two consecutive winters of 2018/19 (2019) and 2019/20 (2020). The experiment was laid out in randomized complete block design (RCBD), comprising twelve treatment combinations with three replications. Seed sowing of the variety Rampur-4, a medium duration open pollinated maize variety, was done on 24 and 27 September respectively in 2018 and 2019. Planting was done at 25-cm interval within plants and the 60-cm interval between rows. The seed was placed in 5-cm depth and 3-5 cm away from the fertilizer spots. Fertilizer was applied as per assigned treatment combinations (Table 1).

Table 1. A detail of the treatments used in the experiments

| Treatment no. | Treatment details |
|---------------|-------------------|
| T1            | 120:60:40 kg NP₂O₅K₂O/ha |
| T2            | 120:60:40 kg NP₂O₅K₂O+ 10 t FYM/ha (Check) |
| T3            | 120:60:40 kg NP₂O₅K₂O+ 10 t FYM + 5 t Biochar/ha |
| T4            | 15 t FYM/ha |
| T5            | 10 t PM/ha |
| T6            | 10 t VC/ha |
| T7            | 10 t OC/ha |
| T8            | 60:30:20 kg NP₂O₅K₂O+ 5 t PM/ha |
| T9            | 60:30:20 kg NP₂O₅K₂O+ 5 t VC/ha |
| T10           | 60:30:20 kg NP₂O₅K₂O+ 5 t OC/ha |
| T11           | 60:60:40 kg NP₂O₅K₂O + 45 kg Sunhemp/ha |
| T12           | 120:40:40 kg NP₂O₅K₂O + 3 t BM/ha |
Effect of organic and chemical fertilizers on maize by P Adhikari et al

50% of recommended nitrogen (N) fertilizer as Urea was applied at seed sowing, and the remaining 50% N at the knee-high and pre tasseling stage equally. All plots received 60 kg/ha Phosphorous (P₂O₅) in the form of Diammonium phosphate and 40 kg/ha Potash (K₂O) in the form of muriate of potash at the time of seed sowing. The assigned amount as described in treatment details of farmyard manure (FYM) biochar, poultry manure (PM), vermicompost (VC), mustard oil cake (OC), and bone meal (BM) were applied at the time of land preparation. Green manure (sun hemp) was uprooted and buried in soil after the first weeding. Other cultural practices were followed as per recommendations for improved maize cultivation.

Soil Physico-chemical properties of the experimental block
The data revealed that the status of the soil before maize planting was moderately acidic, high in total N and available P₂O₅, low in K₂O and medium in OM. The physical and chemical properties of the soil of the research block were as below.

Physical properties: Sand – 65.3%, Silt – 25.9%, Clay – 8.8%, Bulk density- 1.21 g/cc
Chemical properties: pH – 5, OM – 3.4%, Total N – 0.16%, Available P₂O₅ – 299.58 kg /ha, Available K₂O – 83.14 kg/ha

Data collection and statistical analysis
A composite soil sample was taken before seed sowing and after maize harvesting for soil analysis in both years. The recorded data were compiled and arranged systematically. Statistical analysis was performed using CROP-STAT software developed by the International Rice Research Institute (IRRI), 2007 version. The significant differences between genotypes were determined using the least significant difference (LSD) test at a 1% or 5% level of significance (Gomez and Gomez 1984).

RESULTS

Days to anthesis and silking
Days to anthesis and silking were highly significant as influenced by different nutrient sources. As influenced by different nutrient sources in both the years, anthesis and silking were significantly higher (p ≤ 0.05) due to treatment along with the interaction between treatment and year (Table 2).

It has been observed from the pooled analysis that the mean value of anthesis and silking were 71 and 74 days after sowing (DAS), respectively. Anthesis was significantly delayed (75 DAS) with 10-ton VC/ha, whereas it was the earliest (69 DAS) under the application of 10 ton OC/ha. Similarly, a significantly higher difference was observed for silking due to different nutrient sources. Silking was significantly earlier (72-DAS) from 60:30:20 kg NP₂O₅K₂O + 5 t OC/ha and sole application of 10 ton OC/ha, whereas, it was delayed (80 DAS) with the application of 10 ton VC/ha. In general, anthesis and silking period were influenced significantly by different nutrient sources (Table 2).
Table 2. Effects on anthesis and silking due to application of different nutrient sources on maize grown during 2018-2019 and 2019-2020 at NMRP Rampur, Chitwan, Nepal

| Treatments                                      | Days to anthesis | Days to silking |
|------------------------------------------------|------------------|-----------------|
|                                                 | 2019  | 2020  | Pooled | 2019  | 2020  | Pooled |
| 120:60:40 kg NP₂O₅K₂O/ha                        | 74    | 68    | 71     | 76    | 70    | 73     |
| 120:60:40 kg NP₂O₅K₂O + 10 t FYM/ha              | 74    | 67    | 71     | 77    | 70    | 74     |
| 120:60:40 kg NP₂O₅K₂O + 10 t FYM + 5 t Biochar/ha| 74    | 67    | 70     | 78    | 69    | 74     |
| 15 t FYM/ha                                     | 74    | 69    | 71     | 79    | 72    | 76     |
| 10 t PM/ha                                      | 75    | 68    | 72     | 78    | 71    | 75     |
| 10 t VC/ha                                      | 79    | 70    | 75     | 86    | 73    | 80     |
| 10 t OC/ha                                      | 72    | 66    | 69     | 75    | 69    | 72     |
| 60:30:20 kg NP₂O₅K₂O + 5 t PM/ha                | 76    | 69    | 72     | 79    | 71    | 75     |
| 60:30:20 kg NP₂O₅K₂O + 5 t VC/ha                | 77    | 68    | 73     | 80    | 70    | 75     |
| 60:30:20 kg NPK 5 t OC/ha                       | 72    | 67    | 70     | 75    | 69    | 72     |
| 60:60:40 kg NP₂O₅K₂O + 45 kg Sunhemp/ha          | 75    | 69    | 72     | 79    | 71    | 75     |
| 120:40:40 kg NP₂O₅K₂O + 3 t BM/ha               | 74    | 68    | 71     | 77    | 70    | 74     |
| F test (Trt)                                    | **    | *     | **     | **    | **    | **     |
| F test (Trt × Year)                             | **    | **    | **     | **    | **    | **     |
| LSD₀.₀₅                                           | 3.5   | 1.7   | 1.9    | 4.4   | 1.8   | 2.7    |
| CV%                                              | 2.7   | 1.8   | 2.5    | 3.3   | 1.8   | 3.3    |

*=Significant at 5% level of significance, ** = Significant at 1% level of significance.

Plant and ear height

Significant variation was observed on plant and ear height when under different nutrients sources. In the first year, the tallest plant height (221 cm) was observed from 120:60:40 kg NP₂O₅K₂O + 10 t FYM and 10 t OC/ha and the shortest height (188 cm) from 60:60:40 kg NP₂O₅K₂O + 45 kg Sunhemp/ha. Similarly, in the second year, the tallest plant height (205 cm) was recorded with the application of 120:60:40 kg NP₂O₅K₂O + 10 t FYM + 5 t Biochar/ha, and the shortest height (162 cm) was obtained from 10 ton VC/ha (Table 3). The plant height of pooled analysis data revealed that the tallest plant height (209) cm was obtained from 120:60:40 kg NP₂O₅K₂O + 10 t FYM + 5 t Biochar/ha and 10 t OC/ha, respectively. Pooled analysis revealed that plant height was significantly higher (p ≤ 0.05) by different nutrient sources.

Likewise, ear height was significantly influenced by different nutrient sources. The tallest ear height (118 cm) was found from 120:60:40 kg NP₂O₅K₂O, and the shortest height (98 cm) with the application of 60:60:40 kg NP₂O₅K₂O+ 45 kg Sunhemp/ha in the first year. In the second year, maximum ear height (121 cm) was obtained from 120:60:40 kg NP₂O₅K₂O+ 10 t FYM + 5 t Biochar/ha and shortest height (85 cm) from 10 ton VC/ha. Combined analysis showed that the tallest ear height (117 cm) was recorded from 120:60:40 kg NP₂O₅K₂O+ 10 t FYM + 5 ton Biochar/ha, and shorter ear height (97 cm) from 10 ton VC/ha, respectively (Table 3).
Effect of organic and chemical fertilizers on maize by P Adhikari et al

Table 3. Plant height and ear height (cm) as influenced by different nutrient sources on maize during 2018-2019 and 2019-2020 at NMRP, Rampur, Chitwan, Nepal

| Treatments                                      | Plant height (cm) | Combined | Ear height (cm) | Combined |
|------------------------------------------------|------------------|----------|----------------|----------|
|                                                 | 2019  | 2020  |          | 2019  | 2020  |          |
| 120:60:40 kg NP$_2$O$_5$K$_2$O /ha               | 221   | 192   | 206    | 118   | 102   | 110    |
| 120:60:40 kg NP$_2$O$_5$K$_2$O + 10 t FYM /ha    | 206   | 197   | 202    | 112   | 107   | 110    |
| 120:60:40 kg NP$_2$O$_5$K$_2$O + 5 t FYM + 5 ton Biochar/ha | 213 | 205 | 209 | 113 | 121 | 117 |
| 15 t FYM/ha                                     | 202   | 195   | 198    | 109   | 104   | 106    |
| 10 t PM/ha                                      | 201   | 203   | 202    | 105   | 107   | 106    |
| 10 t VC/ha                                      | 205   | 162   | 184    | 108   | 85    | 97     |
| 10 t OC/ha                                      | 216   | 202   | 209    | 111   | 112   | 111    |
| 60:30:20 kg NP$_2$O$_5$K$_2$O + 5 t PM/ha       | 204   | 193   | 199    | 102   | 101   | 102    |
| 60:30:20 kg NP$_2$O$_5$K$_2$O + 5 t VC/ha       | 205   | 188   | 197    | 108   | 103   | 106    |
| 60:30:20 kg NPK 5 t OC/ha                       | 215   | 193   | 204    | 114   | 106   | 110    |
| 60:60:40 kg NP$_2$O$_5$K$_2$O + 45 kg Sun-hemp/ha | 188  | 185   | 187    | 98    | 101   | 99     |
| 120:40:40 kg NP$_2$O$_5$K$_2$O + 15 t BM/ha     | 211   | 185   | 198    | 112   | 102   | 107    |
| F test (Trt)                                    | *     | **    | *      | ns    | **   | *      |
| F test (Trt x Year)                             |       |       |       |       |       |       |
| LSD 0.05                                        | 13.6  | 18.9  | 11     | 13.0  | 12.7 |

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

**Thousand grain weight, grain yield and stover yield**
Sources of different organic manures and inorganic fertilizers significantly (P<0.01) influenced the maize grain yield. The maximum grain yield in 2019 was 7102 kg/ha and 6985 kg/ha in 2020. The thousand grain weight in both year 2019 and 2020 was found non-significant (Table 4). The combined data over both years showed that the maximum grain yield 7043.5 kg and thousand grain weight (426 g) were found with application of 60:30:20 kg NPK 5 t OC/ha (Figure 3 and Figure 4)

Table 4. Effects on grain yield and thousand grain weight due to application of different nutrient sources on maize grown during 2018-2019 and 2019-2020 at NMRP Rampur, Chitwan, Nepal

| Treatments                                      | Grain yield (kg/ha) | Thousand grain wt. (g) |
|------------------------------------------------|---------------------|------------------------|
|                                                 | 2019  | 2020  | 2019  | 2020  |
| 120:60:40 kg NP2O5K2O /ha                       | 6142  | 6461  | 393   | 385   |
| 120:60:40 kg NP2O5K2O + 10 t FYM /ha            | 6264  | 6112  | 432   | 377   |
| 120:60:40 kg NP2O5K2O + 5 t FYM + 5 ton Biochar/ha | 6303 | 6357 | 385   | 397   |
| 15 t FYM/ha                                     | 4005  | 4730  | 393   | 379   |
| 10 t PM/ha                                      | 4380  | 4902  | 403   | 348   |
| 10 t VC/ha                                      | 4229  | 3659  | 373   | 405   |
| 10 t OC/ha                                      | 6969  | 6535  | 424   | 401   |
| 60:30:20 kg NP2O5K2O + 5 t PM/ha                | 4489  | 4689  | 371   | 344   |
| 60:30:20 kg NP2O5K2O + 5 t VC/ha                | 5077  | 5229  | 365   | 424   |
| 60:30:20 kg NPK 5 t OC/ha                       | 7102  | 6985  | 413   | 439   |
| 60:60:40 kg NP2O5K2O + 45 kg Sun-hemp/ha        | 5290  | 5043  | 377   | 375   |
| 120:40:40 kg NP2O5K2O + 3 t BM/ha               | 5951  | 6164  | 421   | 367   |
| Mean                                           | 5517  | 5560  | 396   | 387   |
| F-test                                         | **    | **    | ns    | ns    |
| LSD(0.05)                                      | 1162.03 | 1291.6 | 76.64 | 62.07 |
| CV%                                           | 12.4  | 13.2  | 11.4  | 9.5   |

** = Significant at 1% level of significance, ns = non-significant
Effect of organic and chemical fertilizers on maize by P Adhikari et al

Figure 3: combined grain yield (mean+sem) as influenced by different nutrient sources, tested during the two consecutive winters of 2019 and 2020 at NMRP, Rampur, Chitwan, Nepal.

Figure 4: combined thousand grain weight (mean+sem) as influenced by different nutrient sources, tested during the two consecutive winters of 2019 and 2020 at NMRP, Rampur, Chitwan, Nepal.
Chemical properties of soil as influenced by the application of different nutrient sources

**Influence on soil reaction**

Soil pH was not significantly affected by various nutrient sources; however, variation was observed in individual treatment levels (Table 5). The mean value of soil pH was 5 before maize planting and 5.21 after maize harvest.

**Soil Organic Matter**

Different nutrient sources significantly influenced organic soil matter (SOM). SOM is the foundation for healthy and productive soils. The mean value of SOM was 3.4 % before maize planting and 3.2% after maize harvesting in second season (Table 5). The SOM value ranged from 1.17% at 120:60:40 kg NP₂O₅K₂O/ha to 4.10 % at 120:60:40 kg NP₂O₅K₂O + 10 t FYM/ha followed by 4% at 120:40:40 kg NP₂O₅K₂O + 3 t BM/ha.

Table 5. pH value and organic matter content in the soil before planting and after harvesting maize as influenced by different nutrient sources during winter at NMRP, Rampur, Chitwan, 2019 and 2020.

| Treatments                      | pH before planting of 2018-2019 | pH after harvesting of 2019-2020 | OM % before planting of 2018-2019 | OM % after harvesting of 2019-2020 |
|---------------------------------|---------------------------------|---------------------------------|-----------------------------------|-----------------------------------|
| 120:60:40 kg NP₂O₅K₂O/ha        | 5.20                            | 5.28                            | 2.47                              | 1.17                              |
| 120:60:40 kg NP₂O₅K₂O + 10 t FYM/ha | 5.02                           | 5.37                            | 4.18                              | 4.10                              |
| 120:60:40 kg NP₂O₅K₂O + 10 t FYM + 5 t Biochar/ha | 5.19                           | 5.00                            | 4.22                              | 3.43                              |
| 15 t FYM/ha                    | 5.22                            | 5.37                            | 3.96                              | 3.43                              |
| 10 t PM/ha                     | 5.13                            | 5.36                            | 3.83                              | 2.93                              |
| 10 t VC/ha                     | 5.00                            | 5.39                            | 3.64                              | 3.68                              |
| 10 t OC/ha                     | 4.89                            | 4.79                            | 2.71                              | 3.18                              |
| 60:30:20 kg NP₂O₅K₂O + 5 t PM/ha | 4.83                           | 5.04                            | 3.58                              | 3.01                              |
| 60:30:20 kg NP₂O₅K₂O + 5 t VC/ha | 4.92                           | 5.44                            | 3.66                              | 3.51                              |
| 60:30:20 kg NPK 5 ton OC/ha     | 4.91                            | 4.94                            | 2.15                              | 2.34                              |
| 60:60:40 kg NP₂O₅K₂O + 45 kg Sunhemp/ha | 4.90                           | 5.11                            | 4.64                              | 3.51                              |
| 120:40:40 kg NP₂O₅K₂O + 3 t BM/ha | 4.81                           | 5.41                            | 2.69                              | 4.00                              |
| Mean                           | 5.21                            | 5.21                            | 3.47                              | 3.20                              |
| F test                         | ns                              | ns                              | **                                | *                                |
| LSD (0.05)                     | 0.41                            | 0.71                            | 1.61                              | 1.2                               |
| CV%                            | 4.9                             | 8.1                             | 28.3                              | 17.1                              |

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

**DISCUSSION**

Significant influence of different sources of nutrients could be observed in anthesis and silking, plant and ear height, grain and stover yield, and 1000-grain weight. The results pointed out that the application of 5 ton OC/ha and half recommended dose of chemical fertilizer lowered both grain and stover yields. The contribution of nutrients to growing plants at any stage could be visualized, and therefore, a higher result could be obtained. The anthesis and silking and plant and ear height were significantly higher as influenced by different nutrient sources. Efficient use of nutrients simultaneously decreased the anthesis and silking days.

The grain yield was influenced significantly higher as influenced by different nutrient sources. Different organic manure and inorganic fertilizer sources significantly influenced the maize grain yield (p<0.005).
Effect of organic and chemical fertilizers on maize by P Adhikari et al

Priya et al (2014) reported that the yield advantage was observed in the combination of inorganic fertilizers with the application of bio-fertilizers and green manuring. Shanwad et al (2010) also noted that the enhancement in maize productivity with the combined application of nutrients through organic and inorganic resources. Similar findings have also been reported that the increase in maize yield with the combined application through organic and inorganic resources of nutrients (Singh et al 2018). The combination of organic and inorganic nutrient sources proved better in soil fertility in the long run (NARC1997/98).

The experimental data from our two years' research revealed that the non-significant effect was observed in thousand-grain weight, but individual variation was observed in different levels of treatment. Similar results were reported by Sharif et al (2004) that the 1000-grain weight was significantly affected by the recommended dose of fertilizer in combination with different organic sources. Similar findings were described by Kannan et al (2013). The beneficial influence of integrated supply of nutrients on yield attributing characters, i.e., cobs per plant, grain yield, 1000 grains weight of maize, has been reported by many workers (Chandrashekara et al 2000, Gaur and Kumawat 2004).

The measurement of pH value is an essential indicator for identifying soil's chemical nature, which affects the availability of essential plant nutrients. Soil pH was moderately acidic before maize planting. After two years of maize harvesting pH value slightly increased, which indicates decreases in soil acidity. SOM is the foundation for healthy and productive soils. The addition of OM is a potential increase in available nutrients (Bot 2005). Data showed that sole use of chemical fertilizer decreased OM percentage in soil because chemical fertilizer was well mineralized, whereas integrated use of organic manure increases SOM percentage after crop harvest. In this case, SOM was observed high in FYM, and BM treated plots because it takes time to decompose. It could not be mineralized all during the growth period of the first crop. Due to the nature and pattern of mineralization, the combined use of organic matter improves soil’s physico-chemical properties rather than single organic matter. Data revealed that the supply of different organic sources increases the pH value, indicating a decrease in soil acidity. Data showed that sole use of chemical fertilizer decreased OM percentage in soil because chemical fertilizer was well mineralized, whereas integrated use of organic manure increase OM percentage after crop harvest. Organic matter can also change the level of available nitrogen in the soil.

CONCLUSION

The combined applications of organic manures and chemical fertilizer have proved superior and have noticeably contributed to the soil properties and the performance of maize. The maximum grain yield of maize was obtained with the combined application of 50% of the recommended dose of N, P2O5 and K2O fertilizers and 5 t mustard oilcake/ha. In subtropical conditions, integrated manures and fertilizers can enhance soil fertility status and increase maize productivity during winter conditions.

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