

Maize (*Zea mays* L.) Productivity in Response to Nitrogen Management in Pakistan

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How to cite this paper: Gul, H., Rahman, S., Shahzad, A., Gul, S., Qian, M., Xiao, Q. and Liu, Z. (2021) Maize (*Zea mays* L.) Productivity in Response to Nitrogen Management in Pakistan. *American Journal of Plant Sciences*, 12, 1173-1179.

<https://doi.org/10.4236/ajps.2021.128081>

Received: July 17, 2020

Accepted: August 1, 2021

Published: August 4, 2021

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Abstract

Nitrogen (N) plays a vital role in the productivity of maize (*Zea mays* L.). To investigate the fertilizer effects of N on the yield and growth of maize hybrid variety (Gorilla), the experiment was carried out at the research farm of University of Swabi, Pakistan, during summer 2017-18. Four levels of N (Urea, Urea + Farm Yard Manure (FYM), Urea + Compost, Urea + Poultry Manure (PM)) were set in the present study. Randomized complete block design (RCBD) was used with split-plot arrangement with N administering to main plot. Results showed that yield and other traits, *i.e.* plant height, ear length, ear weight, kernel yield, kernels ear⁻¹ and harvest index (HI) were significantly affected by Nitrogen. In current study, the maximum performances of plant height (231.46 cm), ear length (12.17 cm), kernels ear⁻¹ (434.83), kernel yield (2095.7 kg·ha⁻¹), total kernel weight (350.75 kg·ha⁻¹), biomass yield (4015.3 kg·ha⁻¹) and HI (37.31) were recorded under the treatment of UREA + PM, and followed by UREA + FYM. Besides, the applications of organic manure in combination with nitrogen significantly increased yield and its components. Application of 50% of N and 50% of poultry manure produced higher performance for the traits of plant height, ear length, kernels ear⁻¹, total kernels weight ear⁻¹, kernel yield, and biomass yield.

Keywords

Maize (*Zea mays* L.), Nitrogen, Yield, Yield Components, Pakistan

1. Introduction

Maize (*Zea mays* L.) is an important cereal and multipurpose crop belonging to

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family *Poaceae*, providing a lot of benefits such as food for human, feed for animals and poultry, and is used as a fodder for livestock, as well. It is very rich in raw material and is extensively used in industry for many purposes such as in the preparation of cornstarch, dextrose, corn syrup, and corn flakes. The kernel is composed of about 72% starch, 10% protein, 5% oil, 2% sugar, 1% ash and a little bit of water. The contribution of maize when added to agriculture is about 2.7% and 0.5% to GDP (Pakistan Bureau of Statistics). During 2016-2017 the increase occurring in total maize sowing area was about 1334 thousand hectares expressing notable increase of 12% over the previous year sowed area of 1191 thousand hectares. During 2016 the output of maize stayed at high record of 6.130 million tons, representing a vital increase of 16.3% over the previous production of 5.271 million tons (Pakistan Bureau of Statistics).

High production has been obtained on basis of strenuous use of agricultural inputs together with increase in sowing area. In modern agriculture system, growers apply a high amount of fertilizers and chemical plant protection measures for high crop yield. However, their random applications cause diverse harms, including soil degradation, ground water contamination, higher NO_3^- in vegetables and sometimes much more investment which alternatively makes the system unstable and unsustainable. Because of high prices of fertilizers and importance of farmyard manure, green manure and other kinds of manures sustaining long-term soil fertility next to conclave timely necessity of nutrients current attentiveness in manuring re-emerged. Due to these considerations, we need to construct a potential balance between the sum of urea as nitrogen source and organic manures for better yield performance in maize [1].

Nitrogen plays a main role in promoting soil productivity and growing crop efficiency [2]. Grain yield (43% - 68%) and biomass (25% - 42%) of maize also increased as the result of nitrogen fertilization [3]. There is a synergistic relation between organic manure and urea as nitrogen source. These studies showed that integrated nutrient application improved the soil fertility and crop yield as compared to the single use of organic or inorganic source in term of nutrient supply [4]. The positive interaction of nitrogen and farm yard manure (FYM) build up more soil nitrogen [5]; moreover single impact of FYM results in increased maize production, if more OM (44%) in soil, increased porosity (25%), improve water holding capacity sixteen times [6]. The attention is taking by FYM, green manure and poultry manure (PM) in prolong term soil fertility and crop productiveness as compared to high fertilizer prices.

Nitrogen also plays a crucial role in physiological and metabolic functions [7]. The lack of nitrogen in maize production is typically limiting factor for early stages of growth and for kernel filling. Several scientists reported that increasing in maize yield was due to the prolific amount of nitrogen [8]. The inorganic fertilizers are expensive while the organic manure is somewhat cheap and can serve as the alternative of inorganic fertilizers, improving the soil quality beyond of fertility the crops [9]. Poultry manure is the magnificent organic manure because it possesses high quantity of nutrients, *i.e.* N, P, K, and supplementary mi-

cronutrients [10]. Besides, split doses of N application at various growth stages maximize grain yield of maize crop [11] [12]. Summarily, together use of organic and inorganic fertilizers seems to be the possible solution to balance the crop's requirements and soil improvement, and synergistically maximize nutrient utilization efficiency, as well. Correct time and order of application nitrogen plays a key role proficient use.

2. Materials and Methods

2.1. Maize Hybrid Variety and Experiment Design

The experiment focused on widely used maize hybrid variety, Gorilla, to dissect the productivity responding to nitrogen management. The conducted research was accomplished in randomized complete block design (RCBD) with three replications at the research farm of University of Swabi, Khyber Pakhtunkhwa, Pakistan, in summer of 2017/18. Nitrogen (N) factor was applied to each plot with four different treatments, *i.e.* urea (100%, CK), urea (50%) + farm yard manure (FYM) (50%), urea (50%) + poultry manure (PM), urea (50%) + compost (50%), respectively.

The seeds were sown in ridges with distance of 75 cm between rows and 20 cm between plants with 22 shoots each row. Phosphorous was applied as a source of DAP (Diammonium Phosphate) as 90 kg·ha⁻¹ as a basal dose. Before sowing, maize hybrid seeds were treated with disinfectant Confidor WG 70 (Water Dispersible Granules) to avoid soil borne pest and disease. The urea was used as fertilizer for nitrogen source. The pot doses of nitrogen were applied 1/3 in seedling stage, 2/3 at elongating stage. All other agronomic methods were used common and similar for all treatments.

2.2. Data Collection and Statistical Analysis

Data for plant height (cm) was collected two weeks after pollination. While datasets for ear length (cm), ear weight (g), kernels per year, total kernel weight (kg per ha), kernel yield (kg·ha⁻¹), and biomass yield (kg·ha⁻¹) were collected after naturally drying of all harvested ears and stalks. Harvest index (HI) was calculated via kernel yield divided by biomass yield.

Datasets of eight traits were input into Microsoft-Excel (version 365), and the means were calculated. Multiple comparisons of the means for each trait at different N levels were carried out by the software Statistix 8.1.

3. Results and Discussion

3.1. Plant Height

Data concerning plant height are presented in **Table 1**. Significant difference was present in treatments as compared to control (Value). Among the treatments there was a significant difference found *i.e.* plants treated with urea + PM showed higher plant height 231.46 cm followed by Urea + compost, urea + FYM *i.e.* 225.75 cm and 211.06 cm, respectively. For maize hybrid, application of N

Table 1. Responses of plant height, ear length and ear weight of maize to the application of urea either alone or in combination with FYM, PM and compost.

Treatment	Plant height (cm)	Ear length (cm)	Ear weight (g)
Urea	208.56 B*	12.10 A	150.06 C
Urea + FYM	211.06 B	12.17 A	154.38 B
Urea + PM	231.46 A	10.71 B	165.19 A
Urea + Compost	225.75 A	10.42 B	163.02 A

*Capital letters refer to the significant level of 0.05, and those means followed by the same capital letter refer to non-significance ($P > 0.05$), while those followed by different to significant difference ($P < 0.05$). The same as the following tables.

with some other manures, *i.e.* PM, compost, even FYM, tends to promote higher plant height rather than N alone (**Table 1**). Similar trends were also documented by the other reports [13] [14] [15].

3.2. Ear-Related Traits

Significant differences were observed among the four treatments for both two ear-related traits, *i.e.* ear length and ear weight (**Table 1**). Higher ears length was recorded under both treatments of urea 12.10 cm and urea + FYM 12.17 cm, while shorter at both urea + PM (10.71 cm) and urea + compost 10.42 cm (**Table 1**). Similar trends were also noted by previous studies [16].

Differed from ear length, ear weight responded oppositely to fertilizer treatments (**Table 1**). Relatively higher ear weight was achieved at both treatments of urea + PM 165.19 g and urea + compost 163.02 g. These results indicated that the combined application of urea + PM and urea + compost tended to produce shorter but heavier ears in maize, in accordance with the reports of Ali *et al.* [11].

3.3. Kernel Yield and Other Kernel-Related Traits

Data regarding number of kernels ear⁻¹ are presented in **Table 2**. The maximum kernels ear⁻¹ were recorded in the plot where urea + PM (435) applied followed by the urea + compost (424) than urea + FYM (375) and urea alone (360) (**Table 2**). PM and compost combined with urea caused significant positive effects to increase the number of kernels for maize ears (**Table 2**). Our results are in line with [13] [17].

Similar to the number of kernels ear⁻¹, the total kernel weight ear⁻¹ was highly recorded at urea + PM followed by the urea + compost, then urea + FYM and urea alone (**Table 2**). The highest value was 350.75 g, followed by 347.29 g, than 321.29 g and 308.71 g respectively. Similar trends were also documented by Ali and colleagues [11].

Kernel yield data are showed in (**Table 2**). Kernel yield was significantly affected by nitrogen as compared to other treatment ($P < 0.05$). The kernel yield was recorded maximum in the treatment of Urea + Poultry. In general, application of manure increased grain yield as matched to the control. Among all the treatments the highest kernel yield was recorded under the treatment of Urea +

Table 2. Responses of kernels ear⁻¹, total kernel weight ear⁻¹ and kernel yield of maize to the application of urea either alone or in combination with FYM, PM and compost.

Treatment	Kernels ear ⁻¹	Total kernel weight ear ⁻¹ (g)	Kernel yield (kg·ha ⁻¹)
Urea	360 B	308.71 C	1873.1 B
Urea + FYM	375 B	321.29 B	2061.2 A
Urea + PM	435 A	350.75 A	2095.7 A
Urea + Compost	424 A	347.29 A	1958.1 AB

Table 3. Responses of biomass yield and harvest index to the application of urea either alone or in combination with FYM, PM and compost.

Treatment	Biomass yield (kg·ha ⁻¹)	Harvest index (%)
Urea	3748.6 B	30.06 C
Urea + FYM	4015.3 A	36.44 AB
Urea + PM	3709.5 B	37.31 A
Urea + Compost	3769.0 B	35.96 B

PM, followed by Urea + FYM, turned to Urea + Compost and lowest at control that is (2095.7 kg·ha⁻¹), (2061.2 kg·ha⁻¹), (1958.1 kg·ha⁻¹) and (1873.1 kg·ha⁻¹) respectively. The significant promotion of manures and compost to the performances of kernel weight per ear and kernel yield were also documented previously in maize production [13] [17].

3.4. Biomass Yield

Data regarding biomass yield were shown in **Table 3**. High biomass yield was recorded in those plots of urea + FYM, followed by urea + compost, urea and then urea + PM. The highest value was 4015.3 kg·ha⁻¹, followed by 3769.0 kg·ha⁻¹, 3748.6 kg·ha⁻¹ and 3709.5 kg·ha⁻¹, respectively. However, except the treatment of urea + FYM, the other treatments including urea, urea + PM, and urea + compost produced similar biomass yield, with non-significant differences (**Table 3**). Similarly, a few researchers also documented the positive effects to HI by integrating application of inorganic and organic nitrogen to maize hybrids [11] [18].

3.5. Harvest Index

Harvest index (HI) data is present in **Table 3**. The maximum harvest index was recorded in the plot where urea + PM was applied then followed by urea + FYM, then urea + compost and turned to urea alone. The highest HI was noted at urea + PM, while minimum lower was observed in control (urea alone). The highest value is 37.31%, followed by 36.44%, 35.96% and 30.06%, respectively (**Table 3**). Our results are in line with [11] [18].

4. Conclusion and Recommendation

Based on the present research, the following conclusions and recommendation

were drawn for utilization of best fertilizer level in future programs. From the above experiment it is concluded that Nitrogen treatments improve the yield and quality of hybrid maize variety Gorilla. All the parameters showed minimum values at control, suggesting that combining utilization of urea with other manure or compost tends to increase the yield and yield related traits of maize hybrids in Pakistan. These results indicated that the farmers in Pakistan could achieve higher yield performance of maize hybrids by alternating the expensive nitrogen fertilizer to cheaper manure, to construct a more efficient farming cycling with an environmentally friendly or more sustainable system.

Acknowledgements

The authors were grateful to the Department of Agriculture, University of Swabi, KPK, Pakistan for providing research support and facilities for conducting this experiment. This work was supported by the Project of Maize Germplasm Protection of the Ministry of Agriculture and Rural Affairs (2019NWB036-04-08), and Fundamental Research Funds for the Central Universities (XDJK2017C031).

Authors Contributions

H. Gul and S. Rahman performed the experiment, data collecting and analyzing; H. Gul, S. Rahman, S. Gul, and Z. Liu wrote the manuscript draft; M. Qian, Q. Xiao, Z. Liu, and A. Shahzad reviewed and edited the manuscript.

Conflicts of Interest

All the authors have no conflict of interest regarding publication of this manuscript.

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