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# EFFECTS OF ORGANIC MANURE WITH INORGANIC FERTILIZERS ON GROWTH, YIELD AND QUALITY TRAITS OF HYBRID MAIZE IN SUMMER SEASON

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## ABSTRACT

The field experiment was conducted to evaluate farm yard manure and poultry manure for the fertilizer management and productivity of hybrid maize under Agro-Ecological conditions of Tandojam during the summer season of 2019. In this study, randomized complete block design was set with three replications, and total nine treatments of both organic and inorganic fertilizers were included. Results demonstrated that both types of fertilizers had notable impacts on the growth, yield, and quality of hybrid maize. The maximum plant height (cm), cobs plant $^{-1}$, cob length (cm), cob girth (cm), grains cob$^{-1}$, 100 grain weight (g), grain yield (kg ha$^{-1}$), protein (%) and oil content (%) were obtained from the crop fertilized with 15 t FYM + 100% NPK ha$^{-1}$ and 15 t FYM + 75% NPK ha$^{-1}$ respectively. The findings of the current study indicated that using 15 t FYM + 100% NPK ha$^{-1}$ significantly enhanced the growth, yield, and quality traits of hybrid maize and increased the NPK concentration in plants, while it was at the par with15 t FYM + 75% NPK ha$^{-1}$ as compared to rest of treatments. Therefore, it is suggested that incorporating organic manures into farming practices helps to reduce the use of inorganic fertilizers and enhance the agronomic and quality parameters of maize.

**Keywords:** Maize, organic, inorganic, fertilizers, yield, quality

## INTRODUCTION

Maize crop productivity in alluvial soils has been significantly increased using various organic and inorganic fertilizers. According to Oyedeji (2016) the improvements in maize growth, yield, quality, and soil chemical properties were also due utilized both types of fertilizers by farmer. Maize (*Zea mays* L.,) is an important cereal crop that serves as a source of food for humans and animals worldwide (Chandrasekaran *et al*., 2010). It is known as the "Queen of Cereals," and widely cultivated across the globe/globally (Preetha and Stalin in 2014). Maize is one of the essential food crops of Pakistan and the third most essential cereal following wheat and rice. Maize can be cultivated successfully and widely in the country (Akbar *et al*., 2008) under a location between 24-37° North latitude in a subtropical region of Asia. It covers 8.5 percent of the total cereal cropped area, contributes 3.4 percent to agriculture's value-added, and accounts for 0.6 percent of the GDP. According to the GoP (2020-21), the total cultivated area of the maize crop is 1,418,000 hectares with a production of 8.465 million tonnes. The average yield in both rainfed and irrigated areas is 3458 kg ha$^{-1}$. Enhancing the maize production is vital to meet the food and nutritional demands of humans and animals as well. However, worldwide, soil fertility is a critical limiting factor for maize production and average yield (Tahir *et al*., 2008). Compared to other cereals, the maize crop is more exhaustive and has greater potential for nutrient uptake from the soil during its growth and development period (Masood *et al*., 2011). Therefore, providing the appropriate dose of necessary nutrients is crucial, and this can be achieved through the application of various organic or inorganic sources (Asghar *et al*., 2010). Intensive agriculture has shown that the use of inorganic fertilizers alone is not beneficial as it contributes to soil degradation (Zhao *et al*., 2009), further, the loss of organic matter in the soil causes degradation, which leads to soil acidity, nutrient imbalances, and reduced crop productivity (Sharma and Mittra, 1991). Organic manures play a crucial role in increasing organic matter and maintaining the physical, chemical, and biological conditions of the soil. Additionally, they supply macro and micronutrients to crops, making them effective for crop production (Prabu and Uthaya, 2006), and the aim of reducing the cost of fertilizing crops and using renewable forms of energy, as well as the use of organic fertilizers has gained popularity worldwide. The combination of organic and inorganic fertilizers has become the best practice for plant nutrient management, sustainable crop production, and optimizing the social, economic, and eco-friendly agriculture (Amanullah, 2016). Available evidence has shown that the integration of organic manures with inorganic nutrients has met crop plants' nutrient demands (Bhattacharyya *et al*., 2008). The nutrients, such as nitrogen, phosphorus, potassium, and other elements, hold significant physiological importance in the making of chlorophyll, nucleotides, phosphatides, alkaloids, enzymes, hormones, and vitamins that resulted in improved growth and increased yield of crops (Okoko and Makworo, 2012). Maize's high grain yield is dependent on its growth, which relies on the balance of nutrient accumulation in different plant parts during the vegetative phase (Thomas and Howarth, 2000). Consequently, a combined application of farmyard manure and minerals causes more nutrient immobilization in the soil and higher accumulation in plants (Salazar *et al*., 2005b). This increase in nutrient accumulation, maintenance, and remobilization of photosynthates leads to an enhanced plant height, leaf area and crop growth rate and increased grain yield (Huang *et al*., 2007). Incorporation of organic sources with mineral nitrogen and phosphorus resulted in increased corn yield and its yield components due to increased soil nutrients, higher fertilizer use efficiency, and uptake of NPK elements (Abdas *et al*., 2009). The mixing of different organic materials with inorganic nutrients has been shown to be an effective way to regulate nutrient availability in soil (Hagedorn *et al*., 1997) and decrease leaching while improving soil status (Shilpha *et al*., 2017). According to the findings of Tolessa and Friesen (2001a) the use of farmyard manure combined with chemical fertilizers resulted in a significant improvement in both the growth and yield characteristics of maize. This was due to the high organic nutrient content present in farmyard manure-treated soils as compared to those treated with poultry manure and press mud in the summer season (Salazar *et al*., 2005). Moreover, the application of Gliricidia and farmyard manure caused in a rapid immobilization of soil minerals and improved soil nutrients status (Mohanty *et al*., 2011), this improvement of the availability of nutrients in the soil and plants was recorded under the application of farm yard manure up to 16 t $ha^{-1}$. While the utilization efficiency of nitrogen also showed a progressive decline in mineral N, from 31.2% in the soil without farmyard manure application (Hani *et al*., 2019). Considering the importance of integrated use of organic and inorganic fertilizer sources, the current study was designed to examine the judicious use of organic and inorganic fertilizers on the nutrient management, growth and productivity of maize.

## MATERIALS AND METHODS

### Experimental site and weather

A field experiment was conducted during the summer season at the Student's Experimental Farm, Sindh Agriculture University. The experimental farm is located in the lower region of Sindh, approximately 20 km from Hyderabad city in Sindh, Pakistan and has a geographical location of 25.4299° N latitude and 68.5426° E longitude. The climatic condition of the region was tropical and sub-tropical that was characterized by hot, dry monsoon summer. The average rainfall of 123 mm was recorded during the cropping season. While the average daily temperature was about 30.5 $^{o}$C from July to December, presented in (Fig.1).

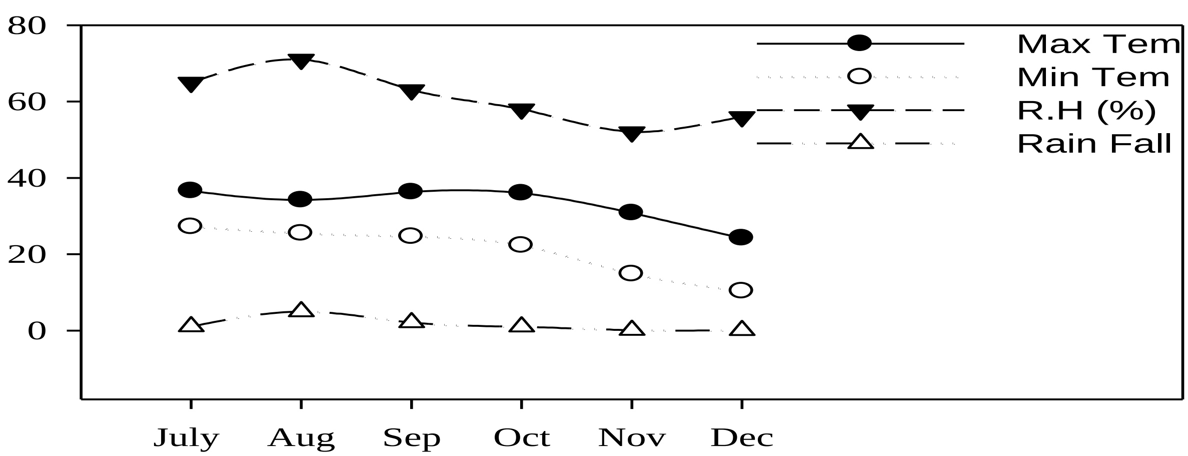


Fig. 1. The average monthly weather data of the experimental site. Maximum and minimum average temperature 45.28 $^{o}$C and 20.01 $^{o}$C respectively was observed during July to Dec 2019 year.

**Soil sampling and analysis**

In the pre-experiment of the summer 2019 year, the soil samples were obtained from randomly locations of experimental area at 0-30 cm soil depth by soil-auger. All soil samples were processed for air-drying, grounding, and sieving to ensure that the resulting particle size was less than 2mm. The Physico-chemical analysis of experimental soil analyzed for total N (%) by Kjeldahl's method, P and K (mg $kg^{-1}$) by AB-DTPA method, organic matter by Walkely-Black method and soil pH by digital pH meter, respectively at Central Analytical Laboratory, Directorate of Soil Salinity and Reclamation Research Institute, Tandojam. The experimental soil was a silty clay loam as presented in (Table 1).

Table 1. Physical and chemical properties of the experimental soil.

| **Soil characteristics** | **0-30 cm depth** |
|---|---|
| **Physical properties** | |
| Soil texture | Silty clay loam |
| Sand (%) | 17.70 |
| Silt (%) | 46.51 |
| Clay (%) | 34.22 |
| **Chemical properties** | |
| pH (1: 2.5 water suspension) | 7.8 |
| EC ($dSm^{-1}$) | 1.21 |
| N (%) | 0.07 |
| P (mg $kg^{-1}$) | 0.83 |
| K (mg $kg^{-1}$) | 74 |

The properly decomposed organic manures, such as FYM (Farm yard manure) and PM (Poultry manure), were thoroughly incorporated with the soil according to treatments before eight weeks of sowing. The complete mineral fertilizers consisting of phosphorus and potassium, along with one-fourth of the nitrogen in the form of DAP, SOP, and Urea, were applied during the sowing period. The remaining nitrogen was divided into three parts, where one-fourth was applied during the knee height stage, one-fourth during the pollination stage, and the remaining one-fourth was applied during the grain filling stage. After land preparation, the ridges were prepared by using a Ridger machine with the recommended planting geometry. The maize variety (Hicorn-339) was sown on ridges at both sides with dibbling by hand. The recommended seed rate (25 kg $ha^{-1}$) was sown at a planting depth of 2.5 cm was sown keeping a distance of 75 cm and 22.5 cm between rows and plants, respectively. Maize crop was irrigated based on their water requirements and soil moisture levels. The first irrigation was applied 21 days after sowing (DAS), with subsequent irrigations applied at 15-day intervals. The control growth-reducing factors, hand weeding and other plant protection measures were applied as needed.

**Source of organic manures**

Properly decomposed FYM and PM were obtained from the Livestock Department and Poultry Production Department, Faculty of Animal Husbandry and Veterinary Sciences, SAU, Tandojam. The nutrient contents, including N, P and K in farm yard manure were (0.92 %), (31 %) and (0.44 %) respectively. The poultry manure contained (1.77 %), (0.65 %) and (0.89 %) N, P and K, respectively (Table 2). The treatments comprised of organic and inorganic fertilizers, including F1 (Control), F2 (15 t FYM alone), F3 (15 t FYM + 50% NPK), F4 (15 t FYM + 75% NPK), F5 (15 t FYM + 100% NPK), F6 (10 t PM alone), F7 (10 t PM + 50% NPK), F8 (10 t PM + 75% NPK), F9 (10 t PM + 100% NPK).

**Methodology for growth, yield and quality parameters**

The standard procedure was used to measure the growth, yield and quality parameters.

**Growth traits**

The height of the plant was measured through a measuring tape and was considered from ground level to the collar of the upper leaf, which included the developed leaf sheath. The leaf area per plant was calculated by multiplying the leaf length and the widest middle portion of the leaf and then multiplying the product by a correction factor of 0.75 (Hunt, 1978a; Rajeshwari *et al*., 2007). The leaf area index (%) was calculated by

dividing the leaf area of the plant by the ground area covered by the plant, as described by Radford (1967) and Diwaker and Oswalt (1992). Furthermore, ten plants were selected to measure the crop growth rate (g$^{-2}$ day$^{-1}$) at the tasseling stage using the following formula: CGR = (W1 - W2) / (T2 - T1) as given by (Hunt, 1978).
Whereas: CGR = Crop growth rate, W1 = Plant dry weight m$^{-2}$ at time t1, W2 = Plant dry weight m$^{-2}$ at time t2, t1 = Time of 1st harvest, t2 = Time of 2nd harvest

**Yield traits**

The number of cobs per plant was determined by recording the total number of cobs in selected plants and then calculating the average number of cobs per plant. Furthermore, average measurements for cob length (cm), cob girth (cm), grains per cob, and 100-grain weight (g) of selected plants were recorded using measuring tape from each plot. After harvesting, the total weight of the grain was recorded and then used to calculate the grain yield (kg ha$^{-1}$) using the following formula: Grain yield (kg ha$^{-1}$) = (Grain yield in kg plot$^{-1}$) / (Plot size in m$^{-2}$) x 10000.

**Quality traits**

Protein content was determined through the Micro-Kjeldhal method, as followed by Piper (1966). Protein (%) was calculated by using the formula: Protein (%) = Nitrogen × Factor 6.25. At the same time, oil content (%) was determined with Soxhlet apparatus using solvent as n-hexane through the Soxhlet extraction method described by AOAC, (1990); Abdulkadir and Abubakar (2011).

**Plant analysis**

Ground maize plant samples (0.5 g) were digested in a conical flask containing 10 mL of $H_2SO_4$ and 2 mL of perchloric acid, following the method described by Chapman and Pratt (1961). N (%), P (%), and K (%) content in the plant samples were tested by grinding them into powder and analyzing them using the Kjeldahl apparatus for nitrogen (%) as described by Jackson (1973). The phosphorus and potassium (%) were analyzed using the nitric acid, perchloric acid and ammonium molybdate yellow color through the AB-DTPA method as described by Murphy and Riley, (1962); Harron *et al*. (1983), This method is also known as the acid wet digestion method (Rowell, 1994).

**Statistical analysis**

The data collected during the research were analyzed statistically using the "analysis of variance technique" (Fisher, 1950) to examine the impact of combined fertilizers on the growth and yield parameters of maize. To evaluate the statistical significance of the mean differences between treatments, a least significant difference (LSD) test was conducted at a 0.05 probability level (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

The optimum required of nutrients to crop is an important to obtain maximum productivity of field crop. Deficiency and excesses of nutrients adversely effect on maize growth and development (Edwards and Purcell, 2005). Therefore, the proper dose of required nutrients is important, which could be obtained from organic or inorganic sources (Asghar *et al*., 2010).

**Growth traits**

The obtained results showed that the growth traits such as plant height (cm), leaf area plant$^{-1}$, leaf area index (%) and crop growth rate (g, cm day$^{-1}$) were significantly influenced by different treatments of organic and inorganic fertilizers (Fig. 2). The better vegetative growth of maize crop is mostly associated with the availability of macro and micronutrients in soil which might have enhanced physiological activities of plant during growth. The maximum plant height (187.97 cm) at tasselling was found under the application of farmyard manure with inorganic fertilizers treatment F5 (15 t FYM + 100% NPK ha$^{-1}$), which was statistically at par with F4 (15 t FYM + 75% NPK ha$^{-1}$), F9 (10 t PM + 100% NPK ha$^{-1}$) and F8 (10 t PM + 75% NPK ha$^{-1}$) which produced (186.21, 185.41 cm) and (184.41 cm) plant height respectively. The main reason for this phenomenon was attributed to the elongation of new cells that were formed by intercalary meristem at the base of internodes during the growth and development of maize. The sole application of organic manures F2 (15 t FYM ha$^{-1}$) and F6 (10 t PM ha$^{-1}$) recorded plant height (114.71 cm) and (106.67 cm) respectively, but which was higher than (85.64 cm) obtained from F1 (control). The better leaf area

(4869.91 - 4776.50 $cm^{-2}$ $plant^{-1}$), leaf area index (3.89 - 3.80 %) and crop growth rate (2.87 - 2.21 g $m^{-2}$ $day^{-1}$) were observed in F5 (15 t FYM + 100% NPK $ha^{-1}$) and F4 (15 t FYM + 75% NPK $ha^{-1}$) respectively, it was statistically similar with the gradually reduced leaf area (4366.27 - 4260.22 $cm^{-2}$ $plant^{-1}$), leaf area index (3.49 - 3.40 %) and crop growth rate (1.91 - 1.87 g $m^{-2}$ $day^{-1}$) were found in the treatments F9 (10 t PM + 100% NPK $ha^{-1}$) and F8 (10 t PM + 75% NPK $ha^{-1}$) respectively. In comparison, the lowest leaf area (1355.20 $cm^{-2}$ $plant^{-1}$), leaf area index (1.08%) and crop growth rate (0.56 $gm^{-2}$ $day^{-1}$) were recorded in F1 (control). The application of farmyard manure with inorganic nutrients had a positive relationship with growth parameters than poultry manure application. This might be due to the least losses of available minerals and reduced nutrient mobilization throughout the growth period of maize. Results of this study agree with previous research of Sivaranjani, (2018), Tolessa and Friesen (2001b), who suggested that the addition of organic manures along with NPK increased crop productivity in terms of plant height, leaf area and leaf enhancement as compared to sole organic manure and sole inorganic fertilizer, because integrated fertilizers provide all the essential nutrients to plants for their physiological activities (Afzal *et al*., 2005). Moreover, the integrated use of organic and inorganic sources of fertilizers causes rapid immobilization of soil minerals, resulted in enhanced growth and productivity (Avasthe, 2011). Furthermore, Akbar *et al*., (2002) and Rasheed *et al*., (2004) who also observed the increases in plant height with the increasing level of NPK fertilizer and different organic manures. The maximum per unit area of leaf and a strong rate of leaf senescence of maize plant, as well as enhanced leaf area index and invariably fresh forage yields of maize under combined fertilizers application (Makinde *et al*., 2001).

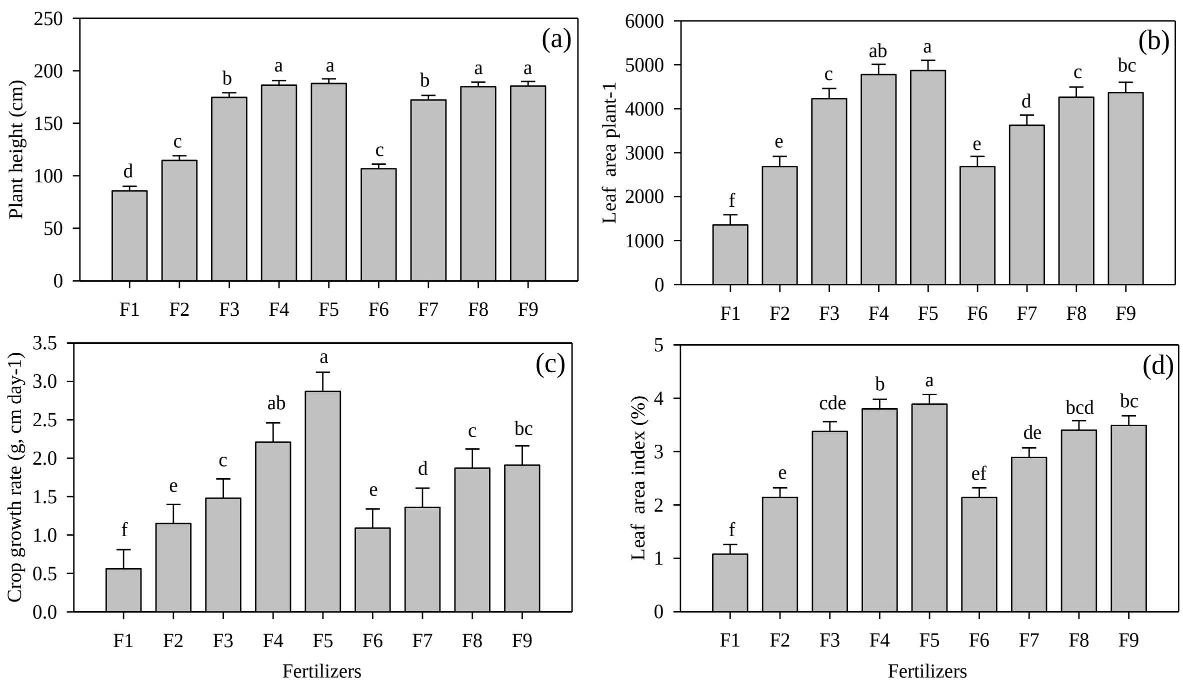


Fig. 2. Effect of organic and inorganic fertilizers on growth traits of maize.

**Yield related traits**

The present data exhibited that the increasing inorganic NPK rate up to 50% $ha^{-1}$ with organic sources led to significant ($p<0.05$) enhancement in cobs $plan^{-1}$, cob length (cm), cob girth (cm), grains $cob^{-1}$, 100 grain weight (g) and grain yield (kg $ha^{-1}$) (Fig. 3). The maximum cobs $plant^{-1}$ (1.21), cob length (14.50 cm), cob girth (13.93 cm), grains $cob^{-1}$ (347.50), 100 grain weight (26.33 g) and grain yield (5790.00 kg $ha^{-1}$) were obtained from F5 (15 t FYM + 100% NPK $ha^{-1}$). The slight reduction in cobs $plan^{-1}$ (1.15), cob length (14.17 cm), cob girth (13.90 cm), grains $cob^{-1}$ (338.70), 100 grain weight (25.33 g) and grain yield (5579.00 kg $ha^{-1}$) also observed in F4 (15 t FYM + 75% NPK $ha^{-1}$). However, application of poultry manure with mineral fertilizers as F9 (10 t PM + 100% NPK $ha^{-1}$) and F8 (10 t PM + 75% NPK $ha^{-1}$) showed statistically similar values of cobs $plan^{-1}$ (1.00 - 0.96), cob length (13.83 - 13.73 cm), cob girth (12.56 - 12.27 cm), grains $cob^{-1}$ (312.63 - 306.87), 100 grain weight (24.66 - 24.00 g) and grain yield (4491.33 - 4328.09 kg $ha^{-1}$). The reason for such improvement in yield and their traits might be due to increased soil nutrient supplying capacity and nutrients uptake by maize plants. Whereas minimum cobs plan$^{-1}$ (0.51), cob length (9.30 cm), cob girth (9.70 cm), grains cob$^{-1}$ (188.30), 100 grain weight (15.33 g) and grain yield (1782.73 kg ha$^{-1}$) were recorded where fertilizers were not applied. Our results endorse with the findings of Shah and Ahmad (2006) and Laekemariam and Gidago (2012) who reported that the FYM in combination with NPK complex fertilizer significantly produced higher yield and yield characters like number of cobs, number of kernels per cob and 1000 grain weight. Likewise, kernel yield and harvest index were significantly enhanced as affected by conjunctive use of N fertilizer along with farm yard manure under different drought stresses (Shah *et al*., 2009).

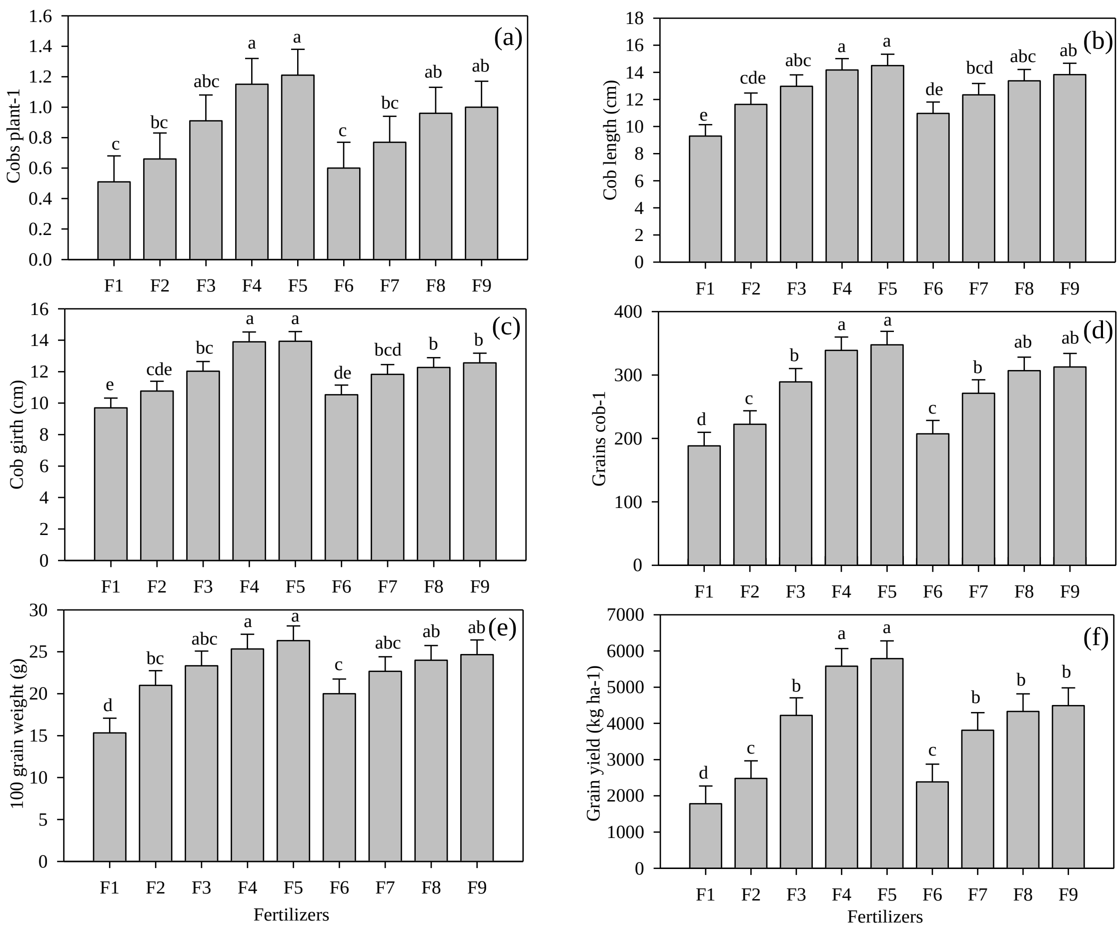


Fig. 3. Effect of organic and inorganic fertilizers on yield and yield traits of maize.

**Quality traits**

Protein and oil content are both the most important quality characteristics of maize. It is proved from the statistical analysis of variance that the organic and inorganic fertilizers had a significant ($p<0.05$) effect on quality traits of maize (Fig. 4). The organic and inorganic treatments significantly differed in protein and oil content of maize grain. The highest protein content (10.00 %) and oil content (5.50 %) were recorded under the fertilizer treatment of F5 (15 t FYM + 100% NPK ha$^{-1}$). However, it was followed by F4 (15 t FYM + 75% NPK ha$^{-1}$) which also gave (9.57 %) and (4.59 %) protein and oil content respectively. With regards to poultry manure application, the treatments F9 (10 t PM + 100% NPK ha$^{-1}$) and F8 (10 t PM + 75% NPK ha$^{-1}$) showed statistically similar values of protein (9.50 - 9.00 %) and oil content (4.51 - 4.00 %) respectively. The combined application of organic and inorganic sources of fertilizers might have enhanced the fertility of soils that caused better synthesis of protein and oil content in maize grain. Furthermore, the sole application of farmyard manure and poultry manure showed protein (5.33 %) and oil content (3.52 %) respectively and this was significantly higher than (4.02 %) protein and (2.02 %) oil content also noted in control treatment. Our results are in accordance with the previous study of Mucheru-Muna *et al*., (2014) who suggested the integrated fertilizer application in agro-ecosystems is highly important in improving quality of maize crop. The better uptake of vital nutrients by maize plants has been shown to enhance the quality of the grain, resulting in healthier and better-developed seeds with increased levels of amino acids, starch, carbohydrates, and proteins (Gao *et al*., 2020). Moreover, this could be due to the increased availability and supply of nutrients, which might have improved the quality production of seed and facilitated the transfer of assimilates in maize plants (Anees *et al*., 2016). Moreover, the availability of nitrogen from organic or inorganic sources increases the process of carbohydrate metabolism that resulted in enhanced quality production of maize (Sirajuddin and Lasmini, 2010).

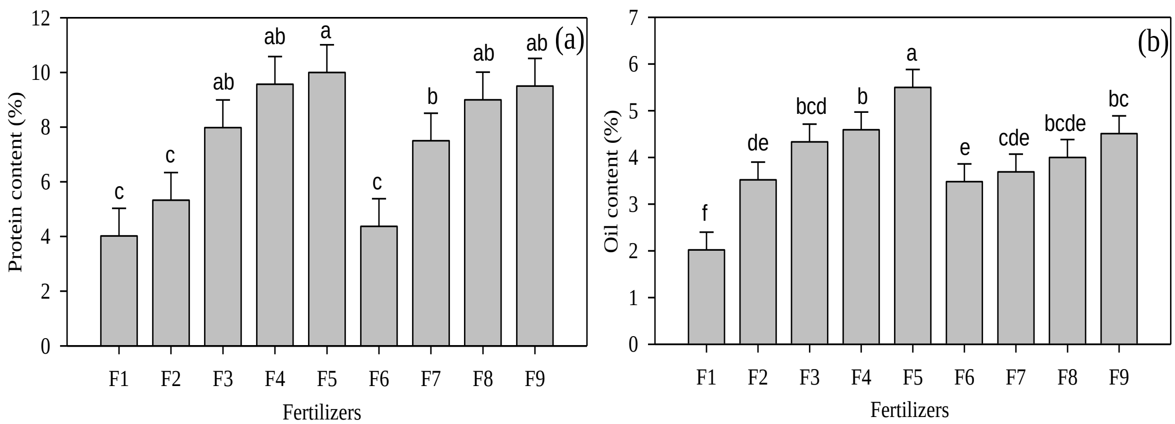


Fig. 4. Effect of organic and inorganic fertilizers on quality traits of maize.

Table 2. Effect of organic and inorganic fertilizers on NPK (%) concentration in plant of maize.

| **Fertilizers** | **N (%)** | **P (%)** | **K (%)** |
|---|---|---|---|
| $F_1$ = (Control) | 0.26 e | 0.10 f | 0.35 f |
| $F_2$ = (15 t FYM alone) | 0.31 de | 0.14 d | 0.45 de |
| $F_3$ = (15 t FYM + 50% NPK) | 0.32 d | 0.16 c | 0.51 bc |
| $F_4$ = (15 t FYM + 75% NPK) | 0.47 b | 0.17 bc | 0.70 a |
| $F_5$ = (15 t FYM + 100% NPK) | 0.56 a | 0.23 a | 0.73 a |
| $F_6$ = (10 t PM alone) | 0.27 de | 0.11 ef | 0.40 ef |
| $F_7$ = (10 t PM + 50% NPK) | 0.31 de | 0.12 e | 0.42 de |
| $F_8$ = (10 t PM + 75% NPK) | 0.38 c | 0.14 d | 0.47 cd |
| $F_9$ = (10 t PM + 100% NPK) | 0.45 b | 0.18 b | 0.56 b |
| LSD 0.05 | 0.05 | 0.01 | 0.05 |

Figure sharing same letters did not differ significantly at 0.05 level of probability using LSD test.

**NPK (%) concentration**

The N, P, and K content in maize plant was significantly increased with increasing application of organic with inorganic fertilizer sources (Table 2). The higher concentration of N, P and K in maize plants (0.56 %), (0.23 %) and (0.73 %) was recorded where full dose of recommended NPK with farmyard manure F5 (15 t FYM + 100% NPK $ha^{-1}$) was applied. However, it was at the par with F4 (15 t FYM + 75% NPK $ha^{-1}$) which showed (0.47 %), (0.17 %) and (0.70 %) N, P and K content in maize plants respectively. Furthermore, statistically similar values of N, P and K in maize plants (0.45 - 0.38 %), (0.18 - 14 %) and (0.56 - 0.47 %) respectively were obtained from the treatments F9 (10 t PM + 100% NPK $ha^{-1}$) and F8 (10 t PM + 75% NPK $ha^{-1}$). However, least concentration of N, P and K (0.26 %), (0.10 %) and (0.35 %) in maize plants was noted from F1 (control). Present results indicate that organic and inorganic fertilizers have a major effect on the NPK content in maize plants. These results agreed with Ali (2009) who also observed that the soil applied farmyard manure with minerals increased the concentration of macro-micronutrients in plants. The higher uptake and utilization of nutrients by maize plants was noted under the application of FYM with mineral fertilizer as compared to FYM alone and mineral fertilizers (Gondek and Mazur, 2005). Moreover, studies conducted by Sial *et al*. (2007) and Bokhtiar and Sakurai (2005) have shown that organic manuring resulted in higher concentrations of phosphorus, potassium, calcium, and magnesium compared to mineral fertilizers. Consequently, the combination of mineral NP and FYM proved to be the most effective in terms of improving maize stover yield and NPK nutrient uptake, surpassing the benefits of their sole application (Yadav *et al*., 2006).

## CONCLUSION AND RECOMMENDATIONS

It was concluded that the growth, yield, and quality traits of hybrid maize and the NPK concentration in plants significantly increased with the application of 15 t FYM + 100% NPK $ha^{-1}$. These results were similar to those obtained using 15 t FYM + 75% NPK $ha^{-1}$ of recommended inorganic fertilizers. Thus, it is recommended that applying organic materials help reduce the dependence on inorganic fertilizers while improving the agronomic and quality parameters of maize.

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## REFERENCES

Abdas, H.H., A.H. Abdel-Hameed, E.H.A. Nofal and M.F. Abdel-Aziz (2009). Induced of cattle waste combined with elemental sulphur, nitrogen and phosphorus on wheat succeeded by maize grown on a calcareous clay-loamy soil. *Journal of Agriculture and Sciences Mansoura University*, 34 (1): 597-610.

Abdulkadir, M. and G.I. Abubakar (2011). Production and refining of corn oil from hominy feed a by-product of dehulling operation. *Journal of Engineering and Applied Science*, 6 (4): 7-13.

Afzal, A., M. Ashraf, S.A. Asad and M. Farooq (2005). Effect of phosphate solubilizing microorganisms on phosphorus uptake, yield and yield traits of wheat (*Triticum aestivum* L.) in rainfed area. *International Journal of Agriculture Biology*, 7 (2): 207-209.

Akbar, H., M. Jan., M.T. Jan and Ihsanullah (2002). Yield potential of sweet corn as influenced by different level of nitrogen and plant population. *Asian Journal of Plant Science*, 6: 631- 633.

Akbar, M., M.S. Shakoor, A. Hussain and M. Sarwar (2008). Evaluation of maize 3-way crosses through genetic variability, broad sense heritability, characters association and path analysis. *Journal of Agricultural Research*, 1 (46): 39-45.

Ali, R.D. (2009). Determination of Fe, Cu and Zn contents of wheat and corn grains from different growing site. *Journal of Animal and Veterinary Advances*, 8 (8): 1563-1567.

Amanullah, H (2016). Influence of organic and inorganic nitrogen on grain yield and yield components of hybrid rice in Northwestern Pakistan. *Rice Science*, 23 (6): 326-333.

Anees, M.U., H.Z. Khan and Z. Ahmed (2016). Role of amendments and micronutrients in maize (*Zea mays* L.) sown in calcareous soils. *American European Journal of Agriculture and Environmental Sciences*, 16 (4): 795-800.

AOAC (1990). Official methods of analysis. Association of Official Analytical Chemists. 15th Arlington, Virginia, USA.

Asghar, A., A. Ali, W.H. Syed, M. Asif, T. Khaliq and A.A. Abid (2010). Growth and yield of maize (*Zea mays* L.) cultivars affected by NPK application in different proportion. *Pakistan Journal of Science*, 62 (4): 211-216.

Avasthe, R (2011). Response of rainfed maize (*Zea mays* L.) to nitrogen management in mid hill acidic soil of Sikkim. *Indian Journal of Agronomy*, 56: 232-236.

Bhattacharyya, R., S. Kundu, V. Prakash and H.S. Gupta (2008). Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas. *European Journal of Agronomy*, 28 (1): 33-46.

Bokhtiar, S.M. and K. Sakurai (2005). Integrated use of organic and chemical fertilizer on growth, yield and quality of sugarcane in high Ganges River flood plain soils of Bangladesh. *Communication of Soil Sciences and Plant Analysis*, 36: 1823-1837.

Chandrasekaran, B., K. Annadura and E. Somasundaram (2010). Nutrient management. In: *A Textbook of Agronomy*. Published by New Age International (P) Ltd., Publishers, pp. 548.

Chapman, H.D. and P.F. Partt (1961). Methods of analysis for soil, plants and water. University of California, Berkely, CA, USA.

Diwaker, B. and D.L. Oswalt (1992). Research planning and data handling. ICRISAT, Andra Pradesh, India, pp. 89.

Edwards J.T. and L.C. Purcell. 2005. Soybean yield and biomass responses to increasing plant population among diverse Maturiy groups: I. agronomic characteristics. *Crop Sciences*, 45: 1770-1777.

Fisher, R.A. (1960). Technique of analysis of variance. Hand Book of Agriculture Statistics, pp. 29; 110.

Gao, C., A.M. El-Sawah, D.F.I. Ali, Y. Alhaj Hamoud, H. Shaghaleh and M.S. Sheteiwy (2020). The integration of bio and organic fertilizers improve plant growth, grain yield, quality and metabolism of hybrid maize (*Zea mays* L.). *Agronomy*, 10 (3): 319-325.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedure for Agricultural Research, (2 eds.), Wiley, New York, USA. pp. 680.

Gondek, K. and B.F. Mazur (2005). The effect of mineral treatment and the amendments by organic and organomineral fertilizers on crop yield, plant nutrient status and soil properties. *Plant and Soil Environment*, 51: 34-45.

GoP (2020-21). Pakistan Economic Survey 2020-21. Ministry of Finance, Islamabad, Pakistan.

Hagedorn, F., K.G. Steiner, L. Sekayange, and W. Zech (1997). Effect of rainfall pattern on nitrogen mineralization and leaching in a green manure experiment in South Rwanda. *Plant and Soil*, 195 (2): 365-375.

Hani, N.B., E.A.D. Al-Ramamneh, M.O.A.W.I.Y.A. Haddad, A.R. Al-Tawaha and Y. Al-Satari (2019). The impact of cattle manure on the content of major minerals and nitrogen uptake from 15N isotope-labeled ammonium sulphate fertilizer in maize (*Zea mays* L.) plants. *Pakistan Journal of Botany*, 51 (1): 185-89.

Harron, W.R.A., G.R. Webster and R.R. Cairns (1983). Relationship between exchangeable sodium and sodium adsorption ratio in a solonetzic soil association. *Canadian Journal of Soil Science*, 63 (3): 461-467.

Huang, B. W. Sun, Y. Zhao, J. Zhu, R. Yang, Z. Zou and J. Su (2007). Temporal and spatial variability of soil organic matter and total nitrogen in an agricultural ecosystem as affected by farming practices. *Geoderma*, 139 (3-4): 336-345.

Hunt, R (1978). Plant growth analysis. The institute of Biologies studies in Biology. *Edword Arnold (Pub) Ltd*, 96: 8-38.

Hyunju, J., Y.J. Seong, K.J. Gap and J. Eluisu (1996). Effect of cattle manure application on the soil properties, yield and quality of silage cultivated on paddy land. *Journal of the Korean Society of Grassland Science*, 16 (1): 81-86.

Jackson, M.L. (1958). Soil chemical analysis. *Prentice Hall: Englewood Cliffs, NJ, USA*.

Laekemariam, F. and G. Gidago (2012). Response of maize (*Zea mays*) to integrated fertilizer application in Wolaita, South Ethiopia. *Advances in Life Science Technology*, 5: 21-30.

Makinde, E.A., A.A. Agboola and F.I. Oluwatoyinbo (2001). The effects of organic and inorganic fertilizers on the growth and yield of maize in a maize/melon intercrop. *Moor Journal of Agricultural Research*, 2: 15-20.

Masood, T., A. Gul, F. Munsif, F. Jalal, Z. Hussain, N. Noreen and K. Nasiruddin (2011). Effect of different phosphorus levels on the yield and yield components of maize. *Sarhad Journal of Agriculture*, 27 (2): 167-170.

Mohanty, M., K.S. Reddy, M.E. Probert, R.C. Dalal, A.S. Rao and N.W. Menzies (2011). Modelling N mineralization from green manure and farmyard manure from a laboratory incubation study. *Ecological Modelling*, 222 (3): 719-726.

Mucheru-Muna, M., D. Mugendi, P. Pypers, J. Mugwe, J. Kungu, B. Vanlauwe and R. Merckx (2014). Enhancing maize productivity and profitability using organic inputs and mineral fertilizer in central Kenya small-hold farms. *Experimental Agriculture*, 50 (2): 250-269.

Murphy, J.A.M.E.S. and J.P. Riley (1962). A modified single solution method for the determination of phosphate in natural waters. *Analytica Chemical Activities*, 27: 31-36.

Okoko, E.N.K. and S. Makworo (2012). Evaluation of the effect of compost and inorganic fertiliser on maize yield in Kenya. *Kenya Agricultural Research IRRC, Kissi, Kenya*. 44: 12-18.

Omar, A.E.A. (2014). Effect of FYM and phosphorus fertilization on yield and its components of Maize. *Asian Journal of Crop Sciences*, 6: 1-12.

Oyedeji, F.N. (2016). Analysis of the effect of organic and inorganic fertilizer on growth performance and yield of maize. *Stem Cell*, 7 (1): 4-9.

Piper, C.S. (1966). Soil and Plant Analysis. *Academic press, New York*.
Prabu, K., G. and K.B. Uthaya (2006). Use of organics for crop production under rainfed situation-A review. Agriculture Review, 27: 208-215.
Preetha, P.S. and P. Stalin (2014). Response of maize to soil applied zinc fertilizer under varying available zinc status of soil. *Indian Journal of Science and Technology*, 7: 939-944.
Radford, P.J. (1967). Growth analysis formulae. Their use and abuse. *Crop Science*, 7: 171-175.
Rajeshwari, R.S., N.S. Hebsur, H.M. Pradeep and T.D. Bharamagoudar (2007). Effect of integrated nutrient management on growth and yield of maize. *Karnataka Journal of Agriculture Sciences*, 20 (2): 399-400.
Rasheed, M., T. Mahmood, M.S. Nazir, W.A. Bhutta and A. Ghaffar (2004). Nutrient efficiency and economics of hybrid maize under different planting methods and nutrient levels. *International Journal of Agriculture and Biology*, 6 (5): 922-925.
Rowell, D. L. (1994). The preparations of saturation extracts and the analysis of soil salinity and sodicity. *In soil science methods and applications*. Ed. D.L. Rowell. Longman Group, UK.
Salazar, F.J., D. Chadwick, B.F. Pain, D. Hatch and E. Owen (2005). Nitrogen budgets for three cropping systems fertilised with cattle manure. *Bioresource Technology*, 96 (2): 235-245.
Shah, S.T.H. and M.I. Ahmad (2006). Effect of integrated use of farm yard manure and urea on yield and nitrogen uptake of wheat. *Journal of Agriculture and Biological Sciences*, 1: 60-65.
Shah, S.T.H., M.S.I. Zamir, M. Waseem, A. Ali, M. Tahir and W.B. Khalid (2009). Growth and yield response of maize (*Zea mays* L.) to organic and inorganic sources of nitrogen. *Pakistani Journal of Life Sciences*, 7: 108-111.
Sharma, A.R. and B.N. Mittra (1991). Effect of different rates of application of organic and nitrogen fertilizers in a rice-based cropping system. *Journal of Agricultural Science* (Cambridge), 117: 313-318.
Shilpha, S.M., T.M. Soumya, L.S. Pradeep and L. Rajashekhar (2017). Study of nitrogen release pattern in different oil coated urea fertilizers in light textured soils. *International Journal of Current Microbiology*, 6 (11): 1282-1289.
Sial, R.A., E.H. Chaudhary, S. Hussain and M. Naveed (2007). Effect of organic manures and chemical fertilizers on grain yield of maize in rain- fed area. *Soil Environment*, 26: 130-133.
Sirajuddin, M., and S.A. Lasmini (2010). Growth response and yield of sweet corn (*Zea mays* saccharata) at various times of application of nitrogen fertilizers and straw mulch thickness. Agroland: *Journal of Agricultural Sciences*, 17(3): 184-191.
Sivaranjani, C., K.M. Sellamuthu, R. Santhi, and S. Maragatham (2018). Effect of graded levels of fertilizers with FYM on yield and NPK uptake by hybrid maize in verticustropept. *International Journal of Current Microbiology Applied Science*, 7 (4): 3494-3498.
Tahir, M., A. Tanveer, A. Ali, M. Abbas and A. Wasaya (2008). Comparative yield performance of different maize (*Zea mays* L.) hybrids under local conditions of Faisalabad-Pakistan. *Pakistan Journal of Life science*, 6 (2): 118-120.
Thomas, H. and C.J. Howarth (2000). Five ways to stay green. *Journal of Experimental Botany*, 51: 329-337.
Tolessa, D. and D.K. Friesen (2001a). Effect of enriching farmyard manure with mineral fertilizer on grain yield of maize at bako, western ethiopia. *Integrated Approaches to Higher Maize Productivity in the New Millennium: Proceedings of the Seventh Eastern and Southern Africa Regional Maize Conference, Nairobi, Kenya*, 5-11 February 2002 (335). CIMMYT.
Tolessa, D. and D.K. Friesen (2001b). Effect of enriching farmyard manure with mineral fertilizer on grain yield of maize at bako, western ethiopia. *Integrated Approaches to Higher Maize Productivity in the New Millennium: Proceedings of the Seventh Eastern and Southern Africa Regional Maize Conference, Nairobi, Kenya*, 5-11 February 2002 (335). CIMMYT.
Yadav, R.P., P. Singh, R.K. Aggarwal and M.K. Yadav (2006). Improved technology for sustainable production of maize (*Zea mays* L.) in Shivalik foothills of Himachal Pradesh. *Indian Journal of Dryland Agricultural Research and Development*, 21 (1): 1-6.
Zhao, Y., P. Wang, J. Li, Y. Chen, X. Ying and S. Liu (2009). The effects of two organic manures on soil properties and crop yields on a temperate calcareous soil under a wheat-maize cropping system. *European Journal Agronomy*, 31: 36-42.

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