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Sustainable Optimization Of Maize Yield And Yield Traits Through The Integrated Use Of Organic Manures And Nitrogen Levels

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ABSTRACT

The optimization of maize production through sustainable approaches is essential to meet growing food demands while preserving soil health. Therefore, the integrated use of organic manures and nitrogen fertilization presents a sustainable approach for enhancing crop productivity and nutrient use efficiency. This experiment was conducted in Agronomy Research Farm Amir Muhammad Khan Campus Mardan, the university of Agriculture Peshawar during Kharif 2022 to study the Yield and yield attributes of maize as effected by different organic manures and nitrogen levels. The experiment was laid out in the randomize complete block design having three replications. The experiment was consisted of two factors, factor A was organic manures (control, poultry manure, farmyard manure and compost) and factor B was nitrogen levels (0, 120 and 150 kg ha-1). Findings shows that, Organic manures and nitrogen levels significantly affected days to tasseling, days to silking, leaf area, plant height, ear length, thousands grain weight, biological yield and grain yield. Less days to tasseling (61.92 days) and silking (68 days) were observed in those plots where poultry manure and Nitrogen at the rate of 150 kgha-1 were applied. Greater leaf area (266.70 cm), plant height (220.58 cm), thousands grain weight (29.47 g), grain ear-1 (419.98), ear length (224.20 cm), higher grain yield (2118 kg ha-1) and biological yield (7582 kg ha-1) were recorded in those plots where compost and Nitrogen at the rate of 150 kg ha-1 were applied. From the present study it is concluded that compost and nitrogen at the rate of 150 kg/ha can increase yield and yield attributes of maize in agro climatic conditions of Mardan.

DOI: Availability

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INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Poaceae is one of the most important cereal crops, ranking third after wheat and rice in the world as well as in Pakistan and the second most important crop in KPK after wheat (Ullah *et al.*, 2015). It is cultivated both in irrigated and rainfed areas (Zhang *et al.*, 2019). About two-thirds of the total world production of maize is used for livestock feed as a raw material for industry and manufacturing foodstuffs such as dextrose and glucose (Chandrasekaran *et al.*, 2015). Maize is grown for food, feed and fodder purposes in Pakistan and plays an important role in the human diet and animal feed and provides an adequate amount of protein (Habib *et al.*, 2016). It has the potential to produce a large quantity of grain per unit area. Maize is a (relatively short duration crop. It is successfully cultivated twice a year as a spring and autumn crop (Du Plessis, 2003). Its grain has a high nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, and 1.7% ash (Ratnavathi, 2019). The environmental conditions of Pakistan are favorable for the better production of maize, similar to those of other nations of the world (Rizwanullah *et al.*, 2023). However, several factors contribute to the reduction of maize yield. Among these, nutrient availability in the soil is the major limiting factor influencing maize productivity (Subedi and Ma, 2009).

Nitrogen, being an essential nutrient, considerably influences growth, yield, and biomass production in maize (Asibi *et al.*, 2019). An important component of chlorophyll, it directly affects photosynthesis, promoting green leaves and stems and overall vegetative development (Bossard and Rejmanek, 1992). Higher leaf area per plant and better grains quality are made possible with the application of fertilizers like nitrogen, phosphorus, and potassium (Bennett *et al.*, 1953). Nitrogen, when applied in sufficient amount, prohibits severe reductions in yield compared to recommended level (Yadav *et al.*, 2017). Therefore, the time and quantity of application is critical factor to obtain better crop growth and development (Andrade *et al.*, 2005). Further, it enhances soil fertility and crop productivity while improving the nutritional value of maize fodder by increasing crude protein and reducing fiber content (Iqbal *et al.*, 2015).

Besides chemical fertilizers, organic amendments like farmyard manure (FYM) and poultry manure are widely used for sustainable nutrient management (Subbaiah, 2019). FYM is an organic manure composed of animal waste with a mixture of residual farm materials, which can supply much of the essential plant nutrients (Khayat, 2021). Its uses in agriculture tend to

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be limited because of its bulkiness and high quantity requirements (Angus *et al.*, 2009). First, the long duration taken by FYM to decompose makes it slow in releasing its nutrients to plants (Rasool *et al.*, 2007). Enhancing the nutrient release efficiency of FYM by soil amendment has been one of the most important research areas, especially in low organic matter oils (Rashmi *et al.*, 2022). However, it remains a crucial element of sustainable agriculture. It contributes to the soil organic matter, increases microbial activity, and makes overall improvements in soil health and fertility (Tahat *et al.*, 2020). It also helps improve soil structure and sustains reasonable cropping development and yield (Lal, 1991).

Poultry manure has been proposed to be a good method, environmentally friendly and cost-effective for improving the physical and chemical status of degraded humic trophic alfisols (Bhunia *et al.*, 2021). Poultry manure is an exceptional source of organic fertilizer, which contains high percentage of nitrogen, phosphorus, potassium and other important nutrients readily available for the plant uptake as compared to other organic sources (Hue and Silva, 2000). it improves the physical characteristics and condition of the soil and improves nutrient uptake and crop productivity (Agegnehu *et al.*, 2016). The poultry manure improves soil properties by improving soil organic matter content of the soil, which stimulates the structure and aggregate stability, thereby improving the aeration, buffering of soil reaction, water holding capacity, cation exchange capacity and microbial activities (Are *et al.*, 2017).

Manure composting is a useful method of producing a stabilized product that can be stored or spread with little odor, pathogens, weed seeds or fly breeding potential (Aliyara *et al.*, 2020). Composting also improves holding characteristics and reduces volume and weight (Iqbal *et al.*, 2010). The Disadvantages of composting include nutrient losses, especially N, requirements more time for decomposition, cost-effective and equipment and labor intensive (Ayilara *et al.*, 2020).

Keeping the above scenario in view, the current field study was conducted aims to find the best organic manure for maize crop, optimize the level of Nitrogen for maize crops productivity and to find out the best combination for obtaining higher yield and yield components of maize crop.

MATERIALS AND METHODS

EXPERIMENTAL SITE AND PROCEDURE

The field experiment was conducted at Palatoo Research Farm, Amir Muhammad Khan Campus Mardan, during summer 2022, to evaluate the individual and interactive effect of

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different organic manure and nitrogen levels on growth and yield attributes of maize. The experiment was laid down in a Randomized Complete Block Design (RCBD) with the factorial arrangement of each treatment, which was replicated three times. It was two factor experiment, factor A included three different organic manures (control, FYM, compost and poultry), and facto B included three nitrogen levels (0, 120 and 150 kg ha^{-1}). Nitrogen was applied a two-split dose: half at sowing time and the remaining was applied at the first irrigation after seedlings emerged. Organic manure was applied at the rate of 8 tons ha^{-1}. The size of plot was kept 4 m × 3 m with row-to-row distance 75 cm and plant-to-plant distance 25 cm. A maize hybrid (30k) was used in the experiment. The field was ploughed twice with a Rotavator and cultivator before being leveled using a back leveler. Irrigation was provided based on climatic conditions and crop water requirements. All agronomic practices were kept consistent and uniform for all experimental plots.

TABLE 1: DETAILS OF EXPERIMENTAL FACTORS.

S.No	Factor A (Organic Matter)	Factor B (Nitrogen Levels
1	Poultry Manure	120 kg ha^{-1}
2	Farm Yard Manure	150 kg ha^{-1}
3	Compost	

DATA PARAMETERS

Data were taken on different essential yield parameters. Days to tasseling were taken by counting the days from sowing to the time when 80% tasseling of the plants in a plot. The same method was applied for days to silking, which was counted from the date of sowing to the date when 70% of the plants complete silking n each plot. Plant height was measured by randomly picking five plants from each subplot, measuring them in meters, and taking the average reading. For ear length, individual measurements were taken from five ears randomly selected from each plot, and the average was calculated. Grains per ear were determined by randomly selecting five ears per plot, counting the number of grains, and calculating the mean. Thousand-grain weight (g) was measured based on samples of 1000 grains from each plot, weighed with a digital balance and recorded in grams.

BIOLOGICAL YIELD

Data on biological yield was recorded by cutting the central four rows in each subplot, plant along with ears was weighed and then by formula was converted into kg ha^{-1}.

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$$Biological\ yield = \frac{Biological\ yield\ of\ four\ central\ rows}{No.\ of\ rows\ harvested \times row\ to\ row\ distance \times row\ length} \times 1000$$

GRAIN YIELD (KG HA-1)

Data regarding grain yield was computed by reaping the plants in each plot and threshed and the grain yield of each sub-plot was converted in kg per ha by below formula.

$$\text{Grain yield} = \frac{\text{Grain yield of four central rows}}{\text{No of rows x R - R distance x row length}} \text{ x } 10000\ m^2$$

STATISTICAL ANALYSIS

Data were statistically analyzed using analysis of variance technique appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability, when the F-values were significant (Jan et al., 2009).

RESULTS

DAYS TO TASSELING

Data regarding days to tasseling of maize as affected by different organic manures and diverse level of Nitrogen is present in figure 1 (a). Statistical analysis of data showed that organic manures and nitrogen levels significantly affected days to tasseling. Data revealed that less days to tasseling were taken by the plots with the application of Nitrogen 150 kg ha^{-1} (61.92). The control takes more days to tasseling (64.67). The data also revealed that among the organic manures, Poultry manure takes fewer days to tasseling (62 days) followed by compost and FYM manure. While the control took more days to tasseling (64.44 days). The interaction was also found to be significant. Minimum days to tasseling was observed (60.67 days) with the application of poultry manure and 150 kg N ha^{-1}.

DAYS TO SILKING

Data regarding days to silking are shown in figure 1 (b). Statistical analysis revealed that both organic manure and nitrogen levels significantly affect silking of maize. Nitrogen at the rate of 150 kg/ha takes less days to silking (68 days) followed by Nitrogen at the rate of 120 kg ha^{-1} (69.25 days). Maximum days to silk was noted in control plots (70.17). Among the organic manures, poultry manure took less days to silk (68 days) followed by compost (69.22 days) and FYM (69.22). Maximum days to silking was noted in the control (69.78 days). The interaction was also found to be significant. Minimum days to silking was observed (60.67 days) with the application of poultry manure and 150 kg N ha^{-1}.

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LEAF AREA

Data regarding leaf area is present in figure 1 (c). Statistical analysis of the data revealed that both organic manures and nitrogen levels significantly affect the leaf area of maize. Maximum leaf area (266.7) was observed with the application of 150 kg N/ha. Minimum leaf area (203.44) was observed with 0 kg N ha^{-1}. Among the organic manures, maximum leaf area was observed (265.84 cm) in compost application, followed by poultry manure and FYM. Minimum leaf area (216.24 cm) was observed in the control. The interaction was also found to be significant. Among all interactions, maximum Leaf area was recorded (296.53 cm) with the application of compost and 150 kg N ha^{-1}. These results are confirmed by Salman et al 2023, who reported that the leaf area of maize is significantly higher with Compost (22.3 %) compared to the control.

PLANT HEIGHT

Data regarding plant height is present in figure 1 (d). Statistical analysis of data revealed that both organic manures and nitrogen levels significantly affect plant height. Maximum plant height (220.58 cm) was recorded with the application of 150 kg N/ha. Minimum plant height (186.71cm) was recorded with 0 kg N ha^{-1}. Among the organic manures, maximum plant height was recorded in compost application, followed by poultry manure and FYM. Minimum plant height (181.96 cm) was recorded in control application. Interaction was also found to be significant. Among all interactions, maximum plant height (230 cm) was recorded with the combined application of compost and 150 kg N ha^{-1}.

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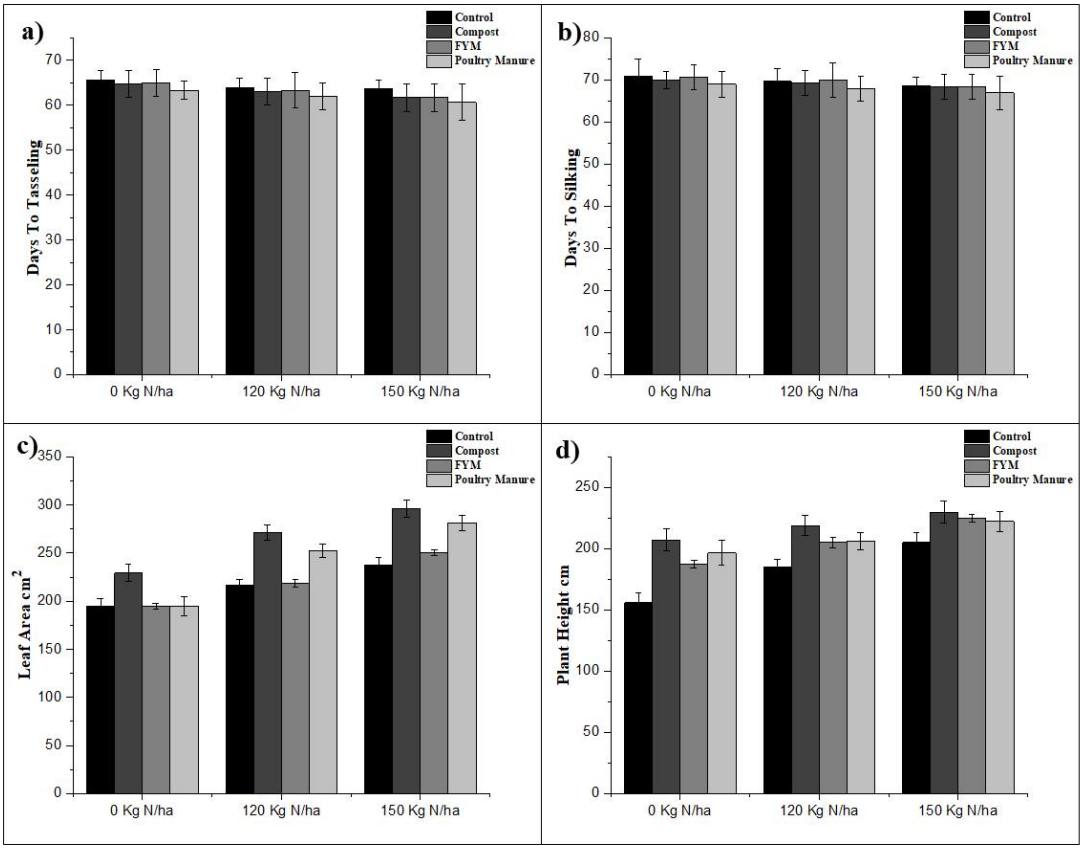


Figure 1: The figures illustrate the response of different phenological and growth attributes maize in response to various organic manures and nitrogen levels, where a) Days to Tasseling, b) Days to silking, c) Leaf area and d) Plant height, respectively.

EAR LENGTH

Data regarding ear length is given in 2 (a). Statistical analysis of the data showed that both the organic manures and Nitrogen levels significantly affect the Ear length of maize. Maximum Ear length (18.68 cm) was observed with the application of 150 kg N/ha. Minimum was observed (16.40 cm) with 0 kg N ha^{-1}. Among the organic manures, maximum Ear length was noted (18.32 cm) with the application of Compost, followed by poultry manure and FYM. Minimum was noted (17.04 cm) in control application. The interaction was also found significant. Maximum Ear length (18.32 cm) was noted with the application of Compost and 150 kg N ha^{-1}.

GRAIN EAR^{-1}

Data regarding grain per ear is given in figure 2 (b). Statistical analysis of the data revealed that both organic manures and nitrogen levels significantly affect the the grain per ear of maize. Data showed that maximum grain per ear (419.98) was observed with the application of 150 kg N/ha. Minimum was observed (347.84) with 0 kg N ha^{-1}. Among the organic manures,

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maximum grain (397.73) per ear was noted with the application of poultry manure, followed compost and FYM. Minimum grain per ear (361.56) was observed in control. The interaction was also found significant. Maximum grain per ear (436.33) was noted with the application of poultry manure and 150 kg N ha^{-1}.

THOUSAND GRAIN WEIGHT

Data regarding Thousand grain weight of maize was present in figure 2 (c). Which stated that different levels of nitrogen and different FYM significantly affected Thousands grain weight of maize. The maximum thousands grain weight (29.47 g) was observed with the application of 150 kg N ha^{-1}. Minimum thousand (22.97g) grain weight was observed with 0 kg N ha^{-1}. Maximum thousand grain weight was recorded with compost application followed by control and FYM. The minimum thousands grain weight (28.68 g) was recorded with the application of poultry manure. The interaction was also found to be significant. Among the interactions, maximum Thousands grain weight was recorded (30.33 g) with the application of compost and 150 kg N ha^{-1}.

BIOLOGICAL YIELD

Data regarding biological yield are present in figure 2 (d). Analysis of the data revealed that both Organic manure and nitrogen had a significant affected on the biological yield of maize. Statistical analysis of the data showed that maximum biological yield (7908 kg ha^{-1}) was observed with the application of 150 kg N ha^{-1}. Minimum was recorded (6007 kg ha^{-1}) with 0 kg N ha^{-1}. Among the organic manures, maximum biological yield (8553 kg ha^{-1}) was observed with the application of compost, followed by poultry manure and FYM. Control plot produced a lesser (5465 kg ha^{-1}) biological yield. The interaction was also found to be significant. Maximum biological yield (8893 kg ha^{-1}) was observed with the application of compost and 150 kg N ha^{-1}. Minimum was observed (5465 kg ha^{-1}) with the control application.

GRAIN YIELD

Data regarding grain yield is given in figure 2 (f). Statistical analysis of data showed that both organic manures and N levels significantly affected grain yield of maize. Data showed that maximum grain yield (2027.6 kg ha^{-1}) was observed with the application of 150 kg N ha^{-1}. Minimum grain yield (1710.8 kg ha^{-1}) was observed with 0 kg N ha^{-1}. Among organic manures, maximum grain yield (2118.6 kgha^{-1}) was observed with the application of compost. Minimum grain yield (1608.1 kg ha^{-1}) was observed with control application. The interaction was also found to be significant. Maximum grain yield (2142 kg ha^{-1}) was observed with the application

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of Compost and 150 kg N ha^{-1}.

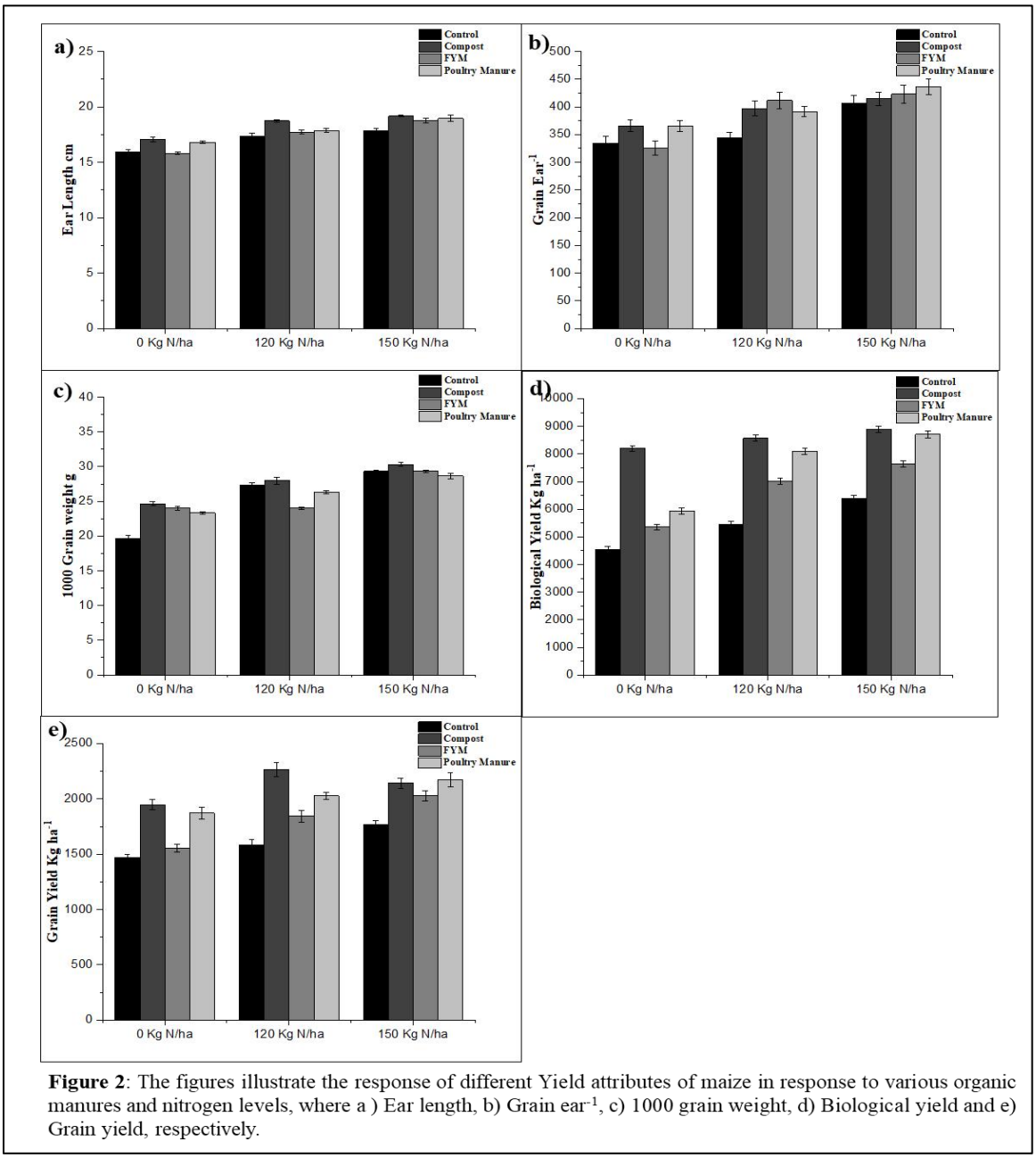


Figure 2: The figures illustrate the response of different Yield attributes of maize in response to various organic manures and nitrogen levels, where a) Ear length, b) Grain ear^{-1}, c) 1000 grain weight, d) Biological yield and e) Grain yield, respectively.

DISCUSSIONS

The combine use of different organic manure with nitrogen levels is a promising method for improving crop productivity and maintaining sustainability (Iqbal *et al.*, 2019). Conventional methods, such as the use of synthetic fertilizers, cause severe problems with soil degradation and environmental hazards (Ashitha *et al.*, 2021). Organic manure maintains soil fertility and structure while enhancing microbial activity and nutrient cycling (Watson *et al.*, 2002). If

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organic manure is applied strategically with appropriate nitrogen levels, such combinations may promote the growth and yield attributes of maize (Gao *et al.*, 2020). Thus, integrated nutrient management will favor the sustenance of soil health and crop performance.

The current study has found a remarkable role of the integrated use of different organic manures with nitrogen levels on growth, phenological and yield attributes of maize. The stimulation of phenological traits such as days to tasseling and silking could be due to both poultry manure and increased nitrogen levels, which generally improve nutrient availability and rapid plant growth rate (Javeed *et al.*, 2014). Nitrogen speeds up the vegetative growth stage, poultry manure increases the release of both quick and slow nutrients because of its high decomposition rate (Nahm, 2003). Thus, sufficient flowering resources are available to maize plants, in contrast to those on control plots that experience nutrient deficiency and delayed growth (Uhart and Andrade, 1995). Ultimately, poultry manure with adequate nitrogen rapidly matures crops and establishes synergies of organic and inorganic fertilizers for effective maize production (Essilfie *et al.*, 2024).

Increase in plant height of maize in response to compost in conjunction with 150 kg N ha-1 area aligns with previous studies that illustrate enhancement in growth parameters with the combined use of inorganic nitrogen with organic manures. For instance, several studies reported that poultry manure and compost improve nutrient availability and soil health, thereby enhancing plant height compared to controls. Similarly, studies also indicated that when poultry manure was applied (Rayne *et al.*, 2020; Ayeni and Adetunji, 2020). It increased the nitrogen and phosphorus content, leading to taller maize plants. In addition, other researchers established that combinations of organic amendments with N fertilizers, such as urea or NPK, give better growth responses than either one alone through synergism in nutrient release and uptake. (Ayoola and Makinde, 2009).

The increase in maize ear length at 150 kg N ha-1 with compost application could be because of a more readily available nutrient needed for ear development. Nitrogen promotes cell division and also the formation of grain, while compost improves the soil fertility and nutrient-retaining capacity, resulting in longer ears (Agarwal *et al.*, 2022). Application of compost with high N sources together resulted the highest ear length, which shows the advantages of using both organic and inorganic fertilizers for maximizing the ear size compared to control treatment or treatments with less nutrients (Montemurro *et al.*, 2006).

The enhancement in the grain number ear 1 and 1000 grain weight due to the application of

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150 kg of N ha-1 along with poultry manure can be attributed to the improvement in nutrient supply that is essential for kernel development and filling (Tesfaye *et al.*, 2020). Nitrogen plays an important role in protein synthesis and metabolic energy maintenance, assuring a higher grain set, while poultry manure serves as a rich source of readily available nutrients that augment plant vigor. The significant interaction between poultry manure and high nitrogen applied levels resulted in the highest ear grain count per ear, suggesting that organic and inorganic fertilizers in tandem increase reproductive yield components more effectively than either one alone or even under control conditions (Nahm, 2003).

Enhancements in biological and grain yield were observed in maize with the combined application of compost and 150 kg N ha^{-1} due to the improved nutrient availability and soil health that together allow the plant to grow more and fill grains efficiently (Dawar *et al.*, 2024). Nitrogen, as one of the most critical nutrients for maize, plays an important part in various physiological processes such as photosynthesis and protein synthesis, leading to biomass accumulation and grain production (Asibi *et al.*, 2019). Compost improves soil fertility by enhancing soil structure, moisture retention, and microbial activity, which aids nutrient uptake and sustains plant growth (Singh *et al.*, 2020). This finding supports earlier research that showed integrated application of organic and inorganic fertilizers enhances not just yield components but also improves stability of yield and resource-use efficiency as compared to sole application of either organic or inorganic fertilizers (Chen *et al.*, 2024; Sharma *et al.*, 2024). The combination of compost and nitrogen fertilizer thus helps in optimizing vegetative and reproductive growth stages whereas the highest biological yield of 8893 kg ha^{-1} and grain yield of 2142 kg ha^{-1} were obtained, both of which are greatly over the control treatments that were severely deficient in nutrients (Devi *et al.*, 2025). So, the present findings show that integrated nutrient management involving compost or poultry manure and adequate nitrogen fertilization is more effective in enhancing maize growth than individual sources of fertilization.

CONCLUSION AND RECOMMENDATION

Considering all the results presented, it is concluded that application of compost and nitrogen enhanced grain yield of maize. The influence of various compost and nitrogen levels was found significant on yield and yield components of maize. The application of Compost and nitrogen at the rate of 150 kg/ha enhanced yield and yield attributes of maize under agro- climatic condition of Mardan. Similarly, it is further concluded from the study that maize hybrid gives higher grain yield with application of Compost and Nitrogen fertilizer. Hence it is

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recommended that dose of Compost and Nitrogen at the rate of 150 kg/ha can be applied to maize hybrid in the region of Mardan for attaining the optimum yield of maize. Further it is recommended that more varieties of maize can be tested for the same dose of compost and nitrogen for improving the grain yield of maize.

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