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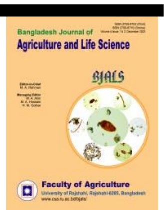

Strategic Amelioration of Integrated Organic Manure and Microbial Fertilizer on the Reduction of Chemical Phosphorus Level in Maize Field

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ABSTRACT

A field experiment was conducted at the Agronomy field laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, during the period from November 2019 to April 2020 to find out the effect of organic manure and microbial fertilizer on the reduction of chemical phosphorus level in maize field. The experiment consisted of one maize variety: BARI Hybrid Bhutta-9 and different treatments *viz.* T_1 = 100% P_2O_5, T_2 =100% P_2O_5+ Microbial fertilizers (MF), T_3 =75% P_2O_5+25% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_4 = 50% P_2O_5+50% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_5 = 25%P_2O_5+75% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_6 =100% Organic Phosphorus (OP) + Microbial fertilizers (MF), and T_7 = 100% Organic Phosphorus (OP). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The highest value for several parameters such as plant height (182.71 cm), leaf area (3221.67 cm^2), total dry matter (103.96 gm^{-2}), SPAD value (15.34), cob length (21.26cm), grain yield (10.94 t ha^{-1}), stover yield (16.49 t ha^{-1}), biological yield (27.43 t ha^{-1}), and harvest index (39.85%) were recorded fromT_3. On the other hand, the values considering plant height (159.60cm), leaf area (2759.41 cm^2), total dry matter (80.31gm^{-2}), SPAD (11.57), cob length (20.96cm), grain yield (9.22 t ha^{-1}), stover yield (15.13 t ha^{-1}), biological yield (24.35 t ha^{-1}), harvest index (37.47%) were recorded when 100% chemical phosphorus was applied in T_1. From all observations it can be concluded that T_3 treatment always gave the highest yield. So, it will be beneficial for the farmer if they use these treatments.

Introduction

Maize (*Zea mays* L.) is the most important cereal in the world (Mohammed *et al.*, 2023). Only the USA, China and Brazil contribute 63% to the global maize production whilst Mexico, Argentina, India, Ukrain, Indonesia, France, Canada and South Africa are also major maize producing countries (FAO, 2021).

Many factors like soil fertility imbalanced, weed infestation etc. limit its yield worldwide. Different management practices are adopted to increase and optimize the maize yields.For example, use of organic manures besides inorganic fertilizers often leads to increased soil organic matter and improve soil structure, water holding capacity, nutrient cycling and helps to maintain soil nutrient status, Cation Exchange Capacity (CEC) and soils biological activity (Farooqi *et al*, 2023). Although chemical fertilizers are important input to get higher crop productivity, but over dependence on chemical fertilizers is associated with declines in some soil properties and crop yield over time and causes serious land problems such as soil degradation (Shi *et al.*, 2023).

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Maize has starch rich endosperm and fat rich embryo. Nutritionally it can be compared with rice and wheat. Its grains have high nutritive value containing 66.2% starch, 11.1% protein 7.12% oil and 1.5% minerals, moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g. grains (Haq and Ahmed, 2023). Maize starch is used in food, chemical textile paper and plastic industries. The important industrial uses of maize lies in the manufacture of starch and other agro-industrial bio products such as glucose, high fructose sugar, maize oil, oil cake syrup, baby foods and breakfast cereals.

Maize is grown as fodder and its grains are for both human consumption and as dairy and poultry feed in many areas of Bangladesh. In Bangladesh maize is extensively used as poultry feed. The total maize cultivated area in Bangladesh was 3.96-million-hectare, production was 27.59 million metric tons and national average yield was 6.97 ton per hectare in 2015-16 (DAE, 2017). Bangladesh is an Argo based country, although her food production is not increasing sufficiently to keep space with the additional population every year. The production area of maize is increasing day by day and the farmers are also interested to grow it. This crop has been included in the crop diversification programmer. Nowadays, attention to biological fertilizer has been increased due to countries development, prices of chemical fertilizers and attention to sustainable agricultural systems (Turan *et al*., 2022). Maize quality and quantity increased by utilization of fertilizer, (bio fertilizers especially) is the most important objectives of these products in worldwide (Moridi *et al*., 2019). Biological phosphate fertilizers containing beneficial bacteria and fungi increased phosphate solutions by increasing soil acidic or alkali phosphatase enzyme, which can be absorbed by plants easily. Soil chemical and biological characteristics improved by biofertilizer more over due to the use of low doses of chemical fertilizers, agricultural production will be free from contaminants (Cozzolino *et al*., 2021, Billah *et al*., 2019).

Keeping all these aspects in consideration, the present study was therefore, conducted to evaluate the effects of organic and microbial fertilizer on growth and yield of maize and to assess their residual impacts on soil property therefore the present piece of work was designed to find out the influence of organic manure and microbial fertilizer on the reduction of chemical phosphorus level in maize field with following objectives- i) To evaluate the effect of organic manure and microbial fertilizer on the growth and yield of maize. ii) To observe their effect on the reduction of chemical phosphorus level in maize field.

Materials and methods

Experimental site and soil

The experiment was conducted at the Agronomy field laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi. Geographically the experimental field is located at 24°22′36″ N latitude and 88°38′27″ E longitude at an average altitude of 71 ft above sea level. The experimental area belongs to the sub-tropical climate under central southern part of high ganges river floodplain i.e. under the agro-ecological zone-11 (AEZ-11). The land of the experimental field was flat well drained and above flood level (medium high land). The soil was sandy loam textured having pH value of 7.4. The experimental area was previously cropped with jute (*Corchorus capsularis*) in the preceding Kharif season.

Experimental treatments and design

The treatments used in the experiment consisted of the one maize variety: BARI Hybrid Bhutta-9 and different treatments T_1 = 100% P_2O_5, T_2 =100% P_2O_5+ Microbial fertilizers (MF), T_3 =75% P_2O_5+25% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_4 = 50% P_2O_5+50% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_5 = 25%P_2O_5+75% Organic Phosphorus (OP) + Microbial fertilizers (MF), T_6 =100% Organic Phosphorus (OP) + Microbial fertilizers (MF), and T_7 = 100% Organic Phosphorus (OP).The experiment was laid out in a Randomized complete Block design (RCBD) with three replications. The size of each unit plot was $10m^2$ (5m×2m). Total number of unit plots were 21. To maintain proper moisture level in the plot according to treatments 1.5m gap within the plots and 2m gap within the blocks were maintained.

Microbial fertilizer application

Microbial fertilizer with the effective viable count of ≥ 2 million g^{-1} used in this study was supplied by the ACI Co. Ltd. It was a mixed microbial fertilizer with lignite as the base material. Microbial fertilizer was applied at the rate of 20 kg ha^{-1} and was divided into two slots; first, the 30kgha^{-1} seed was inoculated with 15 kg ha^{-1} MF and secondly, it was sprayed (5 kg ha^{-1} MF mixed with water) in the rhizosphere just after tillering stage. The high-throughput sequencing of the MF was done by the ACI Co. Ltd. Seeds were soaked in water overnight dried on blotting paper and mixed with microbial fertilizers and finally sown in the field manually.

Crop cultivation and agronomic management

The land was first opened with power tiller on 15 November 2019. Later on, the land was ploughed and cross ploughed three times followed by laddering.

Individual plots were prepared by repeated spading until the soil achieved a good tilth and was ready for sowing. The weeds and stables were removed to clean the land. In order to supply water irrigation channels were made around the experimental plots. Fertilizers were used as a general dose in the experimental plots includes- Urea @225 kg ha^{-1}, P_2O_5 @60 kg ha^{-1} and K_2O@120 kg ha^{-1}. One third of urea along with whole P_2O_5 and K_2O were applied during final land preparation and were thoroughly mixed to the soil. From the rest of first half urea was top dressed at first irrigation (21 DAS, Critical stage) and last half of urea was applied at 2^{nd} irrigation, (42 DAS).

Seeds were sown on 9^{th} December 2019 in 75 cm apart rows by hard drilling of a depth of 3-4 cm deep furrows with country plough and two seeds were placed within the furrow for the purpose of establishing one plant $hill^{-1}$ in 25 cm apart. The seeds were sown continuously in the furrow at the rate of 30kg ha^{-1}. After sowing the seeds were covered by soil with little pressure by hand. The seedling emerged out within 6-8 days after sowing (DAS). Necessary gap filling and thinning were done at 14 DAS maintaining desired number of plant(s) $hill^{-1}$. Weeding was done three times at 30, 45 and 70 DAS.Only one healthy seedling $hill^{-1}$ was kept and the rest were thinned out. Earthing up was done by spade at 45 DAS to prevent lodging of plants. The plot was irrigated two times during the growing period of crop. First irrigation was applied at 35 DAS and second at 70 DAS. Drainage was done by using drainage channels when necessary. Leaf blight disease was found in the experimental field. It was not observed on the economic threshold level (ETL). This disease was controlled by spaying tilt 250 EC @ 2ml/L. Malathion was applied to control aphid.

Sampling

For collecting data on plant growth and yield and yield components five plants were randomly selected and marked with bamboo sticks in each plot. At maturity, the experimental crops were harvested plot wise. Prior to harvesting, $1m^2$ plant sample were selected randomly and uprooted from each plant for data recording. The harvested crops from plots were bundled separately, tagged and brought to clean threshing floor. The same procedure was followed for sample plants (5 plants from each plot). Harvested crops were sun dried then shelled and grains were cleaned properly plot-by-plot. Grains and Stover were sundried thoroughly before their weights.

Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged with Duncan's Multiple Range test (DMRT) using the statistical computer package program, Stat view and SPSS.

Results

During our study, growth, yield contributing characters, and yield of maize were evaluated. Plant height was significant at 30, 60, 90 and 120 DAS due to different fertilizers treatments.

At 30 DAS, the highest plant height was found (47.48cm) in T3 which reduced slightly by 6.82% and 14.55% for T2, T1, respectively, However, plant height reduced significantly by 19.08 %, 21.84 %, 22.89 %, 30.58 % for treatments T4, T5, T6, T7, respectively, compared with T3 (Table 1). At 60 DAS, Plant height was found highest (72.43cm) in T3 which reduced slightly by 12.01% and 14.42%, for treatments T2, T4, respectively, However, plant height reduced significantly by 15.25 %, 24.34 %, 27.60 %, 33.81 % for treatments T1, T5, T6, T7, respectively, compared with T3 (Table 1).Similarly at 90 DAS, highest plant height (151.52 cm) was found in T3 treatments which reduced slightly by 7.69 and 9.95 for T2, T1, respectively. However, plant height reduced significantly by 15.84%, 23.20%, 24.82% and 31.76% for treatments T4, T5 T6 and T7, respectively, compared with T3 (Table 1) At 120 DAS, Taller plants (182.71 cm) were found in T3 or control fertilizer treatment which reduced slightly by 10.40% for T2 and reduced significantly by 12.64%. 18.77%, 24.23% 27.6%, 33.65% for T1, T4, T5, T6 and T7, respectively (Table 1).

Significant differences in leaf area index were observed within different fertilizer treatments at all observations. At 30 DAS, the highest leaf area index (99.34cm2) was found in T3 which reduced slightly 13.44, 16.33, 21.00 for treatment T2, T1 and T4, respectively, However, the leaf area index significantly reduced by 28.03, 31.81, 38.78 for T5, T6 and T7, respectively, compared with T3 (Table 1). At 60 DAS, the highest leaf area index (1356.03cm2) was found in T3 treatments which reduced slightly by 9.77% and 13.56% for treatment T2, T1, respectively, However, leaf area index reduced significantly by 20.84, 20.89, 23.99, 33.27 % for T4, T5, T6 and T7, respectively, compared with T3 (Table 1). At 90 DAS, the highest leaf area index (3221.67) was found in T3 which reduced slightly by 10.87 in T2, However, the leaf area index significantly reduced by 14.44, 17.54, 26.27, 26.32 and 42.52% for treatments T1, T4, T6, T5and T7, respectively, compared with T3 (Table 1).

In case of total dry matter production, remarkable differences were observed at all observations i.e. at 30, 60, 90, 120 DAS. At 30 DAS. The highest (18.19 gm-2) TDM was found in T3 which reduced slightly by 7.42, 14.01 and 21.60 % for T2, T1 and T4, respectively. The TDM reduced significantly by 31.66, 35.01, 41.12% for T5, T6 and T7, respectively, compared with T3 (Table 2). At 60 DAS, the highest (31.61 gm-2) TDM was found in treatment T3 which reduced slightly by 9.41% in T2, The TDM reduced significantly by 22.45, 30.73, 40.84, 45.83, 49.55% for T1, T4, T5 T6 and T7, respectively, compared with T3 (Table 2). Similarly, at 90 DAS, the highest (67.95 gm-2) TDM was found T3 which reduced slightly by 6.38% in T2. The TDM reduced significantly by 22.76, 27.36, 33.77, 38.81 and 45.93% for T1, T4, T5, T6 and T7, respectively, compared with T3. At 120 DAS, the highest TDM (259.91gm2) was found in T3 which slightly reduced by 9.33% in T2. The TDM reduced significantly by 22. 75, 26.81, 29.63, 31.84 and 43.60% for T1, T4, T5, T6, T7, respectively, compared with T3 (Table 2).

Table. 1. Effect of organic phosphorous and microbial fertilizer on plant height and leaf area index of maize

Treatments	**Plant height(cm)**				**Leaf Area index (cm^2)**		
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T_1	40.57± 3.65abc	61.38±3.21ab	136.44 ±4.16ab	159.60±4.85b	83.12± 3.19abc	1172.20±68.61ab	2759.41± 112.17bc
T_2	44.24± 3.25ab	61.37±3.79ab	139.86 ±4.16ab	163.70±6.41ab	85.99 ± 6.13ab	1223.47±78.14ab	2871.63 ± 200.24ab
T_3	47.48± 2.64a	72.43±4.30a	151.52 ±6.06a	182.71±9.08a	99.34 ± 9.25a	1356.03±105.24a	3221.67 ±104.89a
T_4	38.42± 3.07abc	61.98±1.47ab	127.52 ±6.34 bc	148.41±5.31bc	78.47± 6.29abc	1073.32±76.68bc	2656.54 ± 163.30bc
T_5	37.11± 3.19abc	54.80±6.83bc	116.37 ±.10cd	138.43±6.60cd	71.49 ± 9.58bc	1072.73±77.26bc	2373.47±.146.37c
T_6	36.61± 2.91abc	52.44±3.38bc	113.91 ±5.85cd	132.25±6.58cd	67.74 ± 6.60bc	1030.87 ±76.50bc	2383.86 ±78.99c
T_7	32.96± 3.47c	47.94±4.50c	103.39 ±7.65 d	121.23±6.41d	60.81± 3.20c	877.72 ± 85.26c	1851.92 ±157.42d
LSD	9.65	10.99	17.68	19.97	20.47	41.63	49.96
CV (%)	13.93	10.59	7.95	7.63	13.91	12.91	9.56

In its column lower case lettering is used to show the significance differences between different between different types of treatments at P<0.05 level. Values show standard errors (SE)± mean of 3 replicates T_1= 100% P_2O_5, T_2= 100% P_2O_5+ MF, T_3= 75% P_2O_5+25% OP+MF, T_4= 50% P_2O_5+50% OP+ MF, T_5=25% P_2O_5+75% OP+MF, T_6= 100% OP+MF, T_7=100% OP, CV=Co-efficience of Variation. LSD= Least Significant Differences.

Table. 2. Effect of organic phosphorous and microbial fertilizer on TDM and SPAD value of maize

Treatments	TDM g plant^{-1}				SPAD value		
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS
T_1	15.64± 1.34ab	24.55±1.30bc	52.48 ± 366bc	80.31± 12.813bc	48.48 ± 3.33ab	27.85 ± 2.29ab	11.57± 0.68bc
T_2	16.84± 1.44a	28.68±1.04ab	63.61 ± 3.48ab	94.26 ±19.662ab	52.01 ± 3.73ab	29.74 ± 2.24ab	12.09 ± 0.68b
T_3	18.19± 1.47a	31.66±2.18a	67.95 ± 3.37a	103.96 ± 12.040a	55.63 ± 3.72a	33.15 ±2.56a	15.34 ±1.24a
T_4	14.263± 1.91ab	21.93±1.29cd	49.36 ± 3.46c	76.09 ± 9.820c	45.13 ± 3.69ab	26.89 ±1.41ab	10.77 ± 0.78bcd
T_5	12.43± 0.68bc	18.73±2.06de	45.00 ± 4.77cd	73.37 ± 9.820cd	42.91 ± 3.12bc	26.12±1.82b	9.94 ±0.85bcd
T_6	11.82± 1.24bc	1.15±1.02de	41.58 ± 3.64cd	70.86 ± 7.849cd	40.50 ± 3.09cd	24.87 ±1.42b	9.10 ±0.65c
T_7	10.71± 0.79c	15.97±124e	36.74 ± 4.20d	58.63 ± 7.022d	35.39 ± 3.25d	23.13 ± 1.69b	8.38 ±0.65d
LSD	4.03	4.58	11.6	14.29	10.4	5.96	2.47
CV (%)	16.15	11.54	13	10.25	12.98	12.42	12.78

In its column lower case lettering is used to show the significance differences between different between different types of treatments at $P<0.05$ level. Values show standard errors (SE)± mean of 3 replicates T_1= 100% P_2O_5, T_2= 100% P_2O_5+ MF, T_3= 75% P_2O_5+25% OP+MF, T_4= 50% P_2O_5+50% OP+ MF, T_5=25% P_2O_5+75% OP+MF, T_6= 100% OP+MF, T_7=100% OP, CV=Co-efficience of Variation. LSD= Least Significant Differences.

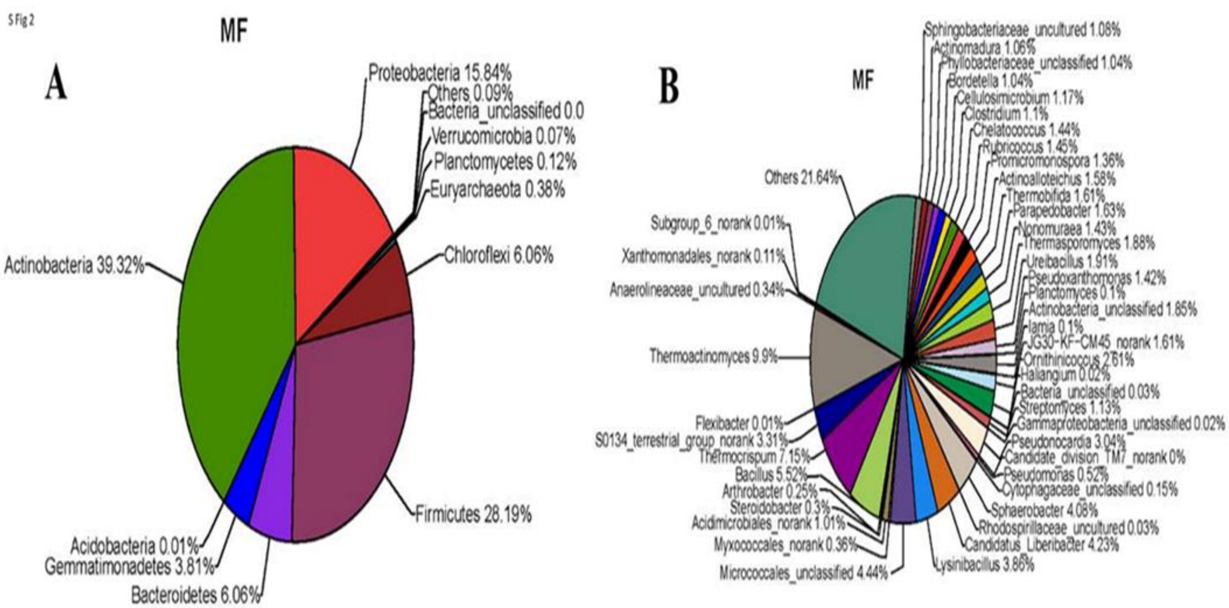

Fig. 1. Microbial community structure of microbial fertilizers (A) phylum and (B) Genus level

Table- 3: Effect of organic phosphorous and microbial fertilizer on yield components and yield of maize

Treatments	Cob length(cm)	Grain cob^{-1}	1000 grain weight (g)	Grain yield t ha^{-1}	Stover yield t ha^{-1}	Biological yield t ha^{-1}	Harvest Index %
T_1	20.96 ± 1.17	296.67 ± 16.63ab	295.67 ± 18.67bc	9.22 ± 0.47b	15.13± 0.29b	24.35 ± 0.76bc	37.87 ± 0.75b
T_2	21.09 ± 1.19	310.56 ± 13.47ab	316.00 ± 19.29ab	9.74 ± 0.43ab	16.13 ± 0.15a	25.87 ± 0.58ab	37.63 ± 0.84b
T_3	21.26 ± 2.36	332.22 ± 13.13a	349.33 ± 19.46a	10.94 ± 0.80a	16.49 ± 0.03a	27.43 ± 0.84a	39.85 ± 1.68ab
T_4	20.82 ± 1.17	282.56 ± 15.99bc	281.67 ± 12.99bc	8.82 ± 0.41bc	13.87 ± 0.19c	22.69 ± 0.60cd	38.86 ± 0.78b
T_5	20.78 ± 1.17	272.78 ± 12.52bc	262.67 ± 12.41bc	8.45 ± 0.40bc	12.87 ± 0.26d	21.32 ± 0.66de	39.65 ± 0.67ab
T_6	20.68 ± 1.17	266.11 ± 14.53bc	276.33 ± 14.35bc	8.01 ± 0.40bc	12.05 ± 0.14e	20.06 ± 0.53e	39.93 ± 0.96ab
T_7	20.49 ± 1.2	243.89 ± 8.01c	247.67± 16.48c	7.45 ± 0.65c	10.00 ± 0.49f	17.45 ± 1.10f	42.72 ± 1.27a
LSD	2.15	41.63	49.96	1.69	0.79	2.26	1.52
CV (%)	11.75	8.3	9.84	10.24	5.02	5.68	4.59

In its column lower case lettering is used to show the significance differences between different between different types of treatments at $P<0.05$ level. Values show standard errors (SE)± mean of 3 replicates T_1= 100% P_2O_5, T_2= 100% P_2O_5+ MF, T_3= 75% P_2O_5+25% OP+MF, T_4= 50% P_2O_5+50% OP+ MF, T_5=25% P_2O_5+75% OP+MF, T_6= 100% OP+MF, T_7=100% OP, CV=Co-efficience of Variation. LSD= Least Significant Differences.

SPAD value showed significant differences at all observations followed by 30, 60, 90 and 120 Days after showing. At 30 DAS, the highest SPAD value was observed in (55.63) T3 which slightly reduced by 6.51, 12.85 and 18.87% in T2, T1 and T4, respectively, and significantly reduced by 22.86, 27.19 and 36. 38% in T5, T6 and T7,
respectively, compared with T3 (Table 2). At 60 DAS, the highest SPAD value was observed in (33.15) in T3 which slightly reduced by 10.29, 15.99 and 18.88% in T2, T1, and T4 respectively, and significantly reduced by 21.20, 24.98 and 30.23% in T5, T6 and T7, respectively, compared T3 (Table 2). At 90 DAS, the highest SPAD value was observed (15.34) in T3 which slightly reduced by 12.09% in T2 and significantly reduced by 8.38, 9.10, 9.94, 10.77 and 11.57 % in T1, T4, T5, T6, T7, respectively.

Significant differences were found in the number of grains per cob due to different fertilizer treatment (Table 3). The highest number of grains per cob (332.22) was observed in T3 which slightly reduced by 6.52 and 10.70% in T2 and T1, respectively, and significantly reduced by 14.95, 17.89, 19.89 and 26.59% for T4, T5, T6 and T7, respectively. There was significant difference found in 1000-grain weight of maize due todifferent fertilizer treatments. The highest 1000 grain weight (349.33g) was observed in T3 which slightly reduced by 9.5% for T2 and significantly reduced by 15.36, 19.39, 20.89, 24.80 and 29.10% for T1, T4, T6, T5 and T7, respectively, (Table 3). There were significantly differences found in grain yield due to different fertilizer treatment. The highest grain yield (10.94 t ha-1) was observed in T3 and which slightly reduced by 10.96% for T2 and significantly reduced by 9.74, 9.22, 8.82, 8.45, 8.01 and 7.45 % for T2, T1, T4, T5, T6 and T7, respectively (Table 3). Significant differences were found in Stover yield due to different treatment. The highest (16.49 t ha-1) was observed in T3 which reduced slightly by (2.18%) in T2 and significantly reduced by 8.25, 15.88, 21.95, 26.95 and 39.36 % in T1, T4, T5, T6 and T7, respectively. (Table 3). Biological yield showed significant differences due to different fertilizer treatments. The highest value for biological yield (27.43 t ha-1) was observed in T3 which reduced only by (5.69%) in T2 and significantly reduced by 11.22, 17.28, 22.27, 26.87 and 36.38 %in T1, T4, T5, T6 and T7, respectively. (Table 3).

Different treatment showed significant influence on harvest index. The highest harvest index (42.72) was observed in the treatment T7 which nearly similar with treatment T6. The harvest index reduced slightly by 6.53%, 6.71%, 7.19% in T6, T3 and T5, respectively and significantly decreased by 90.04%, 11.35% and 11.91% in the treatment T4, T1 and T2, respectively. (Table 3).

Discussion

Organic manure and microbial fertilizer can have a significant positive impact on the plant height of maize. These nutrients can also increase plant height indirectly by improving soil structure and water retention. Healthy soil is more likely to retain water and nutrients, which can help plants to grow taller and stronger. Significantly the highest plant height was recorded from the combination of 75% P_2O_5 with 25% Organic Phosphorus (OP) and Microbial fertilizers (MF). This result is comparable to the findings of Gao *et al*., 2020 who reported that application of organic manure and microbial fertilizer in combination increased maize plant height by 20% compared to the control treatment.

MF can also help to increase the production of plant hormones, such as auxins and gibberellins. These hormones play a role in regulating plant growth and development, and when they are produced in higher levels, they can promote increased leaf area. This increased nutrient uptake can in turn lead to larger and more expansive leaves (Badiani*et al.,* 2023). During this observation, LAI was found minimum at 90 DAS, which is supported by Tripathi *et al*. (2022).

Phosphorus is considered as a key component of nucleic acids, which are necessary for cell division and growth. Organic phosphorus also helps to promote root development, which allows plants to take up more nutrients and water from the soil. The increased soil organic matter content improves water retention and nutrient availability. This can lead to increased maize growth and dry matter production. The combined application of organic manure and microbial fertilizer has shown synergistic effects on maize dry matter production. Li *et al.,* (2023) reported up to 25% increases in maize dry matter production with this combined application. This result is comparable to the findings of the experiment. Studies revealed that both organic manure and microbial fertilizer can increase SPAD values in maize (Fuzy *et al.*, 2023) due to the fact that it provides a slow-release source of nutrients, such as nitrogen, phosphorus, and potassium, which are essential for maize growth.

Both OP and MF contribute to increase soil organic matter content, which enhances water retention capacity, nutrient cycling, and soil structure. Healthy soil (fertile soil) provides a favorable environment for wheat roots to thrive, allowing them to efficiently absorb nutrients and water, leading to better crop yields. These nutrients can reduce the need for chemical fertilizers, minimizing environmental impact and promoting sustainable agricultural practices. By providing a natural source of nutrients and enhancing soil health, these fertilizers contribute to more eco-friendly approach, leading to better crop yields (Kumar *et al*., 2022), The highest yield results for yield and yield contributing characters were recorded from the combination of 75% P_2O_5 with 25% Organic Phosphorus (OP) and Microbial fertilizers (MF). This result considering yield parameters and yield were supported by Khan *et al.*, (2019).

Conclusion

Considering most of the yield-contributing traits and overall yield performance of maize, it was observed that organic manure supplies all the essential nutrients required by plants, though in limited quantities. It helps maintain the soil's C:N ratio and enhances soil fertility and productivity. The application of biofertilizers also offers numerous benefits — they can replace 25–30% of chemical fertilizers and increase grain yield by 10–40%. Moreover, biofertilizers aid in decomposing plant residues, stabilizing the soil's C:N ratio, and improving soil texture, structure, and water-holding capacity.

Authors' Contribution

Conceptualization, MNY, MTAK and MS; Methodology, TMRR, MMI, MNS, MTAK and MS; Formal analysis, MMI, MNS, MNY and MTAK;Investigation, MNY, TMRR, MNI, MNS, MTAK and MS; Data curation, MNI, MNS and TMRR; Writing original draft preparation, TMRR, MNI and MNS; Writing review and editing, MNY, MTAK and MS; Visualization, TMRR, MMI, MNS, MTAK and MS; Supervision, MTAK.

Conflict of Interest

The authors declare no conflicts of interests.

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