Journal of Pure and Applied Agriculture (2025) 10(2): 78-87
ISSN (Print) 2617-8672, ISSN (Online) 2617-8680
http://jpaa.aiou.edu.pk/

Comparing the efficiency of chemical fertilizers against bio-solids for P-utilization by maize under alkaline calcareous soil conditions

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Abstract

Maize is a widely grown cereal crop that serves multiple purposes regarding food and industrial use. Climatic conditions of Pakistan are arid to semi-arid, and our soils are also phosphorus deficient. To combat this problem, phosphatic fertilizers are applied but low solubilization and high prices of phosphatic fertilizers are the major constraints in use of P fertilizers in large amounts. The common inorganic P sources are very costly, and have low fertilizer use efficiency; therefore, bioavailability of P needs to be enhanced using innovative measures. Keeping in view, a pot study was performed for enhancing maize growth and P bioavailability from treated bio-solid in comparison to conventional P fertilizers. De-watered treated bio-solid was used. Hybrid (PFP209) variety of maize crop was used against various sources of P fertilizers. There were 9 treatments with 3 replications: T1 = Control (ck); T2 = DAP @ 80 kg ha^{-1}; T3 = Nitrophos @ 130 kg ha^{-1}; T4 = Fe_2SO_4 Treated Bio-solid-I @ 400 kg ha^{-1}; T5 = Fe_2SO_4 Treated Bio-solid-I @ 800 kg ha^{-1}; T6 = Fe_2SO_4 Treated Bio-solid-I @ 1200 kg ha^{-1}; T7 = KH_2PO_4 Treated Bio-solid-II @ 400 kg ha^{-1}; T8 = KH_2PO_4 Treated Bio-solid-II @ 800 kg ha^{-1} and T9 = KH_2PO_4 Treated Bio-solid-II @ 1200 kg ha^{-1}. It was noticed that both treated bio-solids when applied at higher rates (1200 kg ha^{-1}) produced significant beneficial effects on plant biomass. The highest values for most growth parameters were recorded with bio-solid-II treated with KH_2PO_4 @ 1200 kg ha^{-1} with plant height (192.17 cm), shoot dry weight (178.5 g), root dry weight (89.33 g), stem diameter (28.5 mm), P content in shoot (0.51 mg g^{-1}) and root (0.36 mg g^{-1}) of maize.

Keywords: Alkaline calcareous soil, Bio-solid, Chemical fertilizers, Maize, Phosphorus bioavailability, Yield

To cite this article: Haider, K., Tahir, M. A., Sabah, N. U., & Hamza, A. (2025). Comparing the efficiency of chemical fertilizers against bio-solids for P-utilization by maize under alkaline calcareous soil conditions. *Journal of Pure and Applied Agriculture, 10*(2), 78-87.

Introduction

Maize (*Zea mays* L.) is one of the world's most important cereal crops, widely cultivated for food, feed, and industrial purposes due to its high productivity and adaptability to diverse agro-ecological conditions (Zia et al., 2023; Abbas et al., 2025). Its growth and yield are influenced by both genetic and environmental factors, including nutrient availability, pest pressure, and soil conditions. Insect pest infestations can cause significant yield losses in maize production (Ahmad & Ahmad, 2018), while plant-parasitic nematodes have been reported to adversely affect maize roots and nutrient uptake (Rubab et al., 2020). Proper nutrient management is essential for optimal maize growth, as studies have shown that combining natural and synthetic nutrient sources, particularly potassium and nitrogen fertilizers, enhances crop performance and yield attributes (Mehmood et al., 2022; Azam et al., 2023; Latif & Abbas, 2025). Similarly, the integration of urea with liquid organic fertilizers has been found to improve maize growth and yield (Jamilah et al., 2024). However, adverse soil conditions such as contamination with industrial waste can negatively impact maize development and productivity (Kekere et al., 2024). Over the past two decades, significant progress in maize breeding, agronomic practices, and nutrient management has contributed to improved productivity and sustainability of maize production systems (Zia et al., 2023; Abdullah et al., 2025).

Phosphorus (p) is an important macronutrient besides growth and development of the maize (*Zea mays* L.). It is especially important in many physiological processes and biochemical processes which include energy transfer, photosynthesis, movement as well as cell division of nutrients (Abid & Latif, 2023). It is an important part of adenosine triphosphate (ATP) that is the major source of cell energy. It is also a part of the structure of nucleic acids (DNA and RNA), phospholipids and coenzymes. Phosphorus is especially important in the development of robust root systems in maize. The availability of phosphorus that is adequate promotes the growth of roots, making the plant respond to water and nutrients in deeper deposits of earth. Enhanced root branching increases the surface area for nutrient uptake. Phosphorus contributes to the structural integrity of the plant, reducing lodging (Lynch, 2012). Adequate phosphorus improves the dietary first-class of maize grains via enhancing starch and protein synthesis (Vance, et al., 2003).

Municipal solid waste is an undesirable byproduct of contemporary living produced by city dwellers these include all garbage that is under the authority of local government agencies or representatives. 60–90% of municipal solid waste can be composted. Paper, glass, wood, plastic, soil, chemicals, food, debris of plant, sexual metal, textile, and rock are included in its composition. Of all municipal solid waste (MSW), 50–70% is composed of organic materials. Only biodegradable compost feedstock should ideally include food scraps, papers, cardboard, wood, and non-compost solid waste (glass, metals, and plastics). The better the final compost is for agricultural use, the less non-biodegradable material will be in the feed stock (Ungureanu et al., 2025). The nutrient-rich organic products which are obtained by the process of treatment of the domestic sewage are bio-solids, are subjected to dewatering processes to decrease their water content, thereby reducing volume and simplifying handling, transportation, and disposal. Efficient dewatering is essential for maximizing the effectiveness and affordability of wastewater treatment processes (Bonney et al., 2025).

Anaerobic digestion (AD) is a natural biological reaction where organic materials are broken down into biogas (methane and carbon dioxide) using huge proportions of anaerobic bacteria without oxygenation. It is usually adopted in the biological treatment of solids in wastewater. AD stabilizes organic matter in solids of wastewater, lowers pathogen components, eliminates organic odor, and minimizes about 25 percent of the total volume of solids also referred to as sludge. The product of this process is stabilized product less in number of solids and fewer nutrients such as ammonia-nitrogen. The AD process may be divided into three distinct phases that are conducted by diverse groups of microorganisms. These steps include the decomposition of proteins, cellulose, lipids, and other forms of complex organic substances down to simpler bodies that are water-soluble hence dissolution of covalent bonds of the compounds (Callegari et al., 2025). Bio solids (BS) can minimize or replace the usage of chemical fertilizers since they include all the macro- and micronutrients that plants need. The application rate of BS is often determined by the amount of nitrogen (N) that requires to be supplied to a specific crop. BSN can cover both short-term and long-term crop N needs because they contain both organic and inorganic forms of N, which are both readily available and released gradually (Binder et al., 2002).

Treated bio-solids are the processed remains of sewage sludge and offer potentially excellent choice as source of fertilizer that may be used to stabilize the soil condition (Ji et al., 2021). Bio-solids also include macronutrients such as nitrogen and phosphorus in addition to micronutrients such as zinc and copper. Soil pH and microbial action are the determining factors on the bioavailability of P through bio-solids (Rahman et al., 2020). Introduction of bio-solids into the soil has the potential of increasing P availability hence enhancing the growth of maize. Use of agricultural bio-waste and municipal waste (sewage sludge) has been reported to improve soil physio-chemical aspects i.e., soil pH and availability of nutrients in soil and result in improved P uptake in crops (Sah et al., 2025). An analysis of the effect of bio-energy wastes (beet sugar) on the P uptake in wheat and maize indicated that the use of the wastes improved the soil characteristics and the soil P uptake indicating that bio solids can also be used as an alternative source of P (Khatun et al., 2020; Silva-Leal et al., 2021). Treated bio-solids (BS) improve soil organic matter content and resultant improvement in structure, porosity, water holding ability, aeration, fertility status and overall health of soil (Srivastava & Macdonald, 2025; Bonney et al., 2025; Shu et al., 2025). Use of treated BS especially when mixed provides an environmentally friendly supplementary option to the traditional phosphatic fertilizers for the growth of maize and phosphorus bio availability (Vera-Garcia et al., 2023). Bio-solids can reduce or eliminate the use of chemical fertilizers because the former contain all the macro- and micro-elements which the plant requires (Lin et al., 2024). Dosage of BS use is usually enriched with higher level of N and P that crops need (Donald et al., 2025, Desjardins et al., 2025). Being composed of both inorganic and organic P, they are both easily released and readily available to meet both short- and long-term crop needs of nitrogen. Municipal solid waste (MSW) is being used to maintain the long-term productivity of agro-ecosystems and protect soil environment against over cropping (Pamuru et al., 2024; Desjardins et al., 2025). Organic carbon and other nutrients, especially the N and P are strong contributors to the nutrient accessibility of a plant. Keeping in view, this study was aimed at finding out how the treated bio-solids use could contribute to P availability and growth of maize crop.

Material and Methods

At research area, College of Agriculture, University of Sargodha, Sargodha, Punjab, Pakistan, a pot experiment was carried out to evaluate the effect of P-release enhancement by AD technique using bio-solid relative with DAP in alkaline calcareous soil using maize as test crop in 2024. The soil was evaluated in terms of physical and chemical property before the pot experiment as provided in table 1. One of the pots sampled randomly was filled up with soil in the study area and maize cultivated. The sampling devices were used to obtain the soil of different points in study with a depth between 0 and 30 cm. Composite soil sample was then made. The soil sample gathered was cleaned manually by eliminating any rubbish and stones before it could be carried to the laboratory. The last preparation was done by washing the sample over a 2mm sieve and drying it in the air. Those methods of the standard soil analysis that are given in the 60th edition of the US laboratory staff handbook (US Salinity Laboratory Staff, 1954) were used. De-watered treated bio-solid was prepared using anaerobic digestion method (AD method). Hybrid (PFP209) variety of maize crop was used against various sources of P fertilizers. There were 9 treatments with 3 replications: T1 = Control (ck); T2 = DAP @ 80 kg ha^{-1}; T3 = Nitrophos @ 130 kg ha^{-1}; T4 = Fe_2SO_4 Treated Bio-solid-I @ 400 kg ha^{-1}; T5 = Fe_2SO_4 Treated Bio-solid-I @ 800 kg ha^{-1}; T6 = Fe_2SO_4 Treated Bio-solid-I @ 1200 kg ha^{-1}; T7 = KH_2PO_4 Treated Bio-solid-II @ 400 kg ha^{-1}; T8 = KH_2PO_4 Treated Bio-solid-II @ 800 kg ha^{-1} and T9 = KH_2PO_4 Treated Bio-solid-II @ 1200 kg ha^{-1}.

Hybrid maize crop seeds (FH 1046) were planted in pots during the growing season. Every pot had a layer of glass-wool at the bottom, followed by a filter sheet. Following that, the earthen pots were filled with the necessary amount of damp soil, weighing 12 kg pot^{-1}. Every pot held four seeds, and every treatment was repeated three times. A precise amount of water will be applied in accordance with the needs of the maize plants. Regular controls were implemented to maintain soil moisture levels at 60% of their maximal capacity to hold water. During the crop's growth period, maize was subjected to all agronomic techniques. Maize plants were trimmed after emergence so that there would only be one plant left for analysis and harvesting. The data regarding several yield indicators were recorded on each pot before the latter was harvested after maturity. Nevertheless, when the maize was harvested, biological as well as economic yield had been observed. The germination of plants took a period of 15 days and plants were then selected to undertake the study to compare the effects of bio-solid along with DAP on yield and biomass production.

Data concerning positioning was also retrieved using the global positioning system (GPS) in the process of choosing the site of the experiment. Moreover, the invasion of weeds and plant diseases has been controlled during the use of the study by utilizing all possible agronomic approaches. Some of the physiological parameters which were investigated after 60 days of application of the treatments included total, a, and b chlorophyll concentrations, plant fresh and dry biomass, plant height and stem diameter. Standard methods were applied for determining these parameters as reported (Handbook 60, 1965).

Table 1 Characteristics of original soil used for study

Parameter	Values
Saturation percentage (%)	29
pH_s	8.15
EC_e (dS m^{-1})	1.28
Bicarbonates (HCO_3^-) m mol L^{-1}	4.95
Chlorides (Cl^{-1}) m mol L^{-1}	4.80
Sulphates (SO_4^{2-}) m mol L^{-1}	3.05
Calcium + Magnesium (Ca^{2+}+ Mg^{2+}) m mol L^{-1}	4.81
Sodium (Na^+) m mol L^{-1}	7.41
Sodium adsorption ratio (SAR) (m mol L^{-1})$^{1/2}$	4.77
Texture	Sandy clay loam
Organic matter (%)	0.49
Calcium carbonates (%)	6.1
Available phosphorus/ Olsen P (mg kg^{-1})	8.0
Soil total P (g kg^{-1})	1.6

Plant analysis

Standard procedures employed to assess yield contributable factors inclusive of numbers of rows of cobs, number of grains in cobs, diameter of cob, length of cob, grain biomass and grain yield of available P concentration in the plant sample. The plants were harvested and packed in polythene bags and transferred to lab where further analysis was carried out. Physiological parameters during the plant growth period, including plant fresh and dry biomass (g), plant height (cm), stem diameter (mm) and chlorophyll concentration (SPAD) were recorded. Standard methods described in handbook 60 of USDA were used to evaluate yield contributing attributes such as number of rows per cob, number of grains per cob, cob diameter, cob length, 1000 grain yield, and available K concentration in plant sample. For the purpose of study, the following common methods used were used to estimate the data for these parameters. After harvest plants were packed into polythene bags and shifted into lab for further analysis. For measuring plant height using simple measuring tape was used to measure plant height. After removing the grains from each cob, length (mm) of cob was measured by using Guage and cob diameter (mm) was measured by using digital vernier caliper having least count value (0.01 mm).

The concentration of P was determined in a given plant sample, and this was compared to the quantity of P fertilizer that had been used. The efficiency of P was computed by using formula as suggested by Fernández et al. (2009):

$$\text{P use efficiency} = \frac{\text{Shoot dry weight + Root dry weight}}{\text{P content in root + shoot}} \quad (1)$$

Statistical analysis

The test of means, concerning the influence of nutrient seed priming with Zn metal on maize growth and yields was performed with the help of analysis of variance (ANOVA) technique. Data was also tested by using the least significant difference (LSD) test at the probability level of 5 percent (Steel et al., 1997).

Results and Discussion

Plant height

The bar graph illustrates the effect of different treatments on a plant height of maize (Fig. 1). Among all treatments, T6 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 1200 kg/ha) showed the highest value (192.67 cm), indicating a strong positive effect of iron sulfate application. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) also produced higher values (192.17 cm) and ranked as 2nd best treatment. The control treatment exhibited the lowest value of maize plant height

(171.67 cm). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

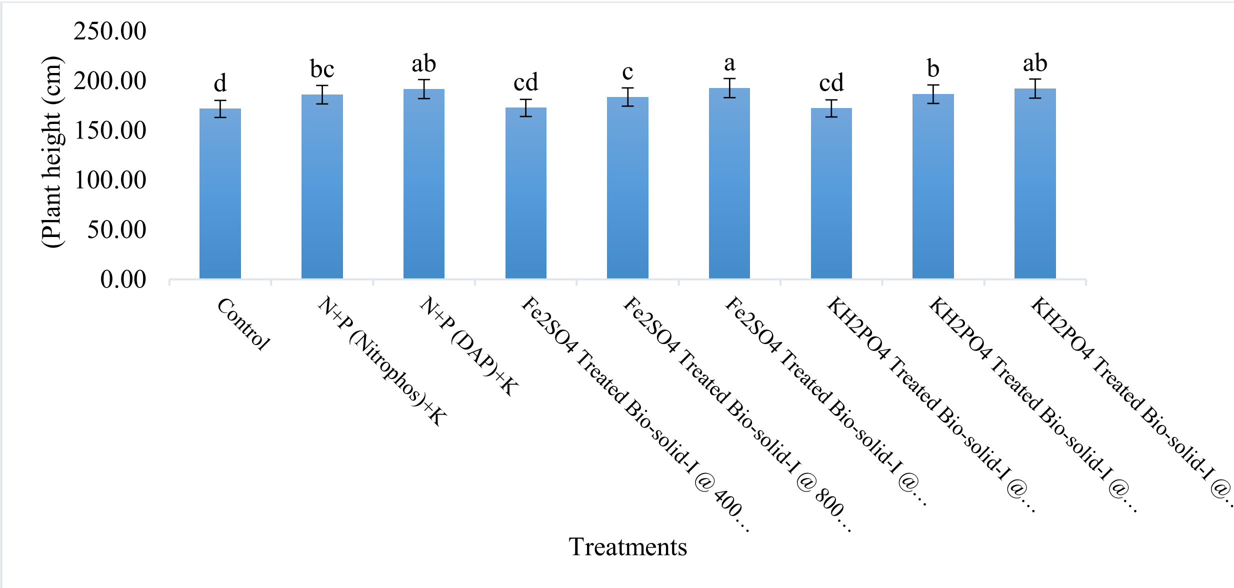

Fig. 1 Impact of treated bio-solids waste on plant height (cm) of maize plant

Shoot dry weight (SDW)

The results clearly show that treated bio-solids have positive effect on maize shoot dry weight (Fig. 2). The control treatment had the lowest shoot dry weight (75 g), demonstrating the negative impact of nutrient deprivation on plant biomass. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) produced highest values (192.17 g) and ranked as best treatment. Treatment T6 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 1200 kg ha^{-1}) gave 2nd highest value of SDW (171.5 g). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

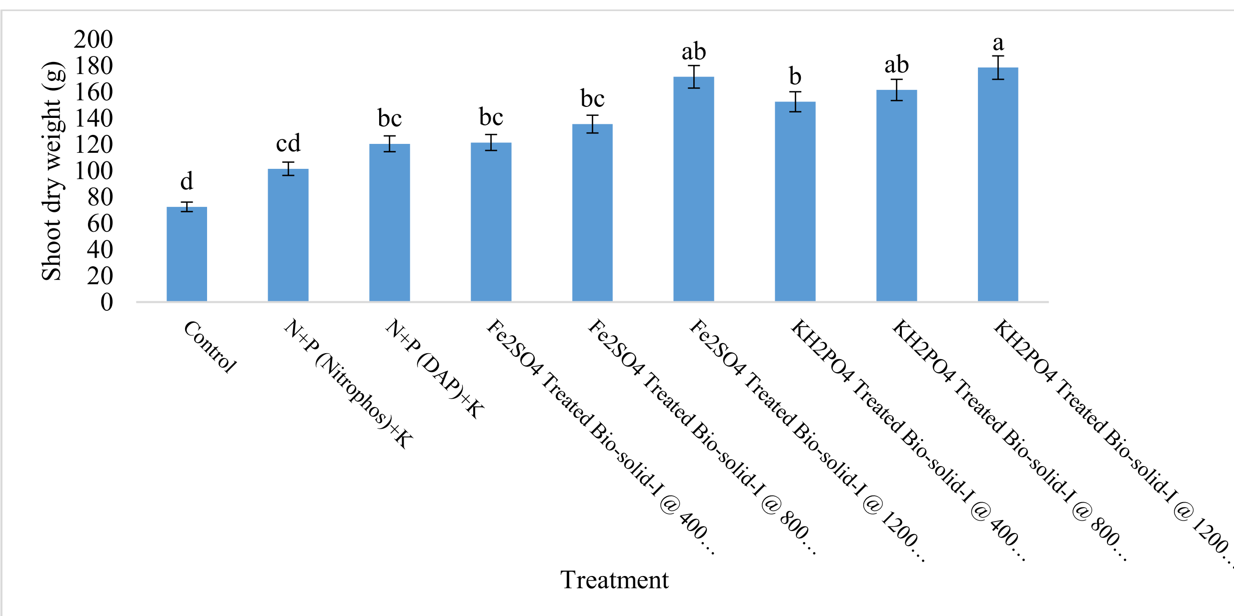

Fig. 2 Impact of bio-solids waste on SDW (g) of maize plant

Shoot dry weight (SDW)

The results clearly show that treated bio-solids have positive effect on maize shoot dry weight (Fig. 2). The control treatment had the lowest shoot dry weight (75 g), demonstrating the negative impact of nutrient deprivation on plant biomass. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) produced highest values (192.17 g) and ranked as best treatment. Treatment T6 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 1200 kg ha^{-1}) gave 2nd highest value of SDW (171.5 g).

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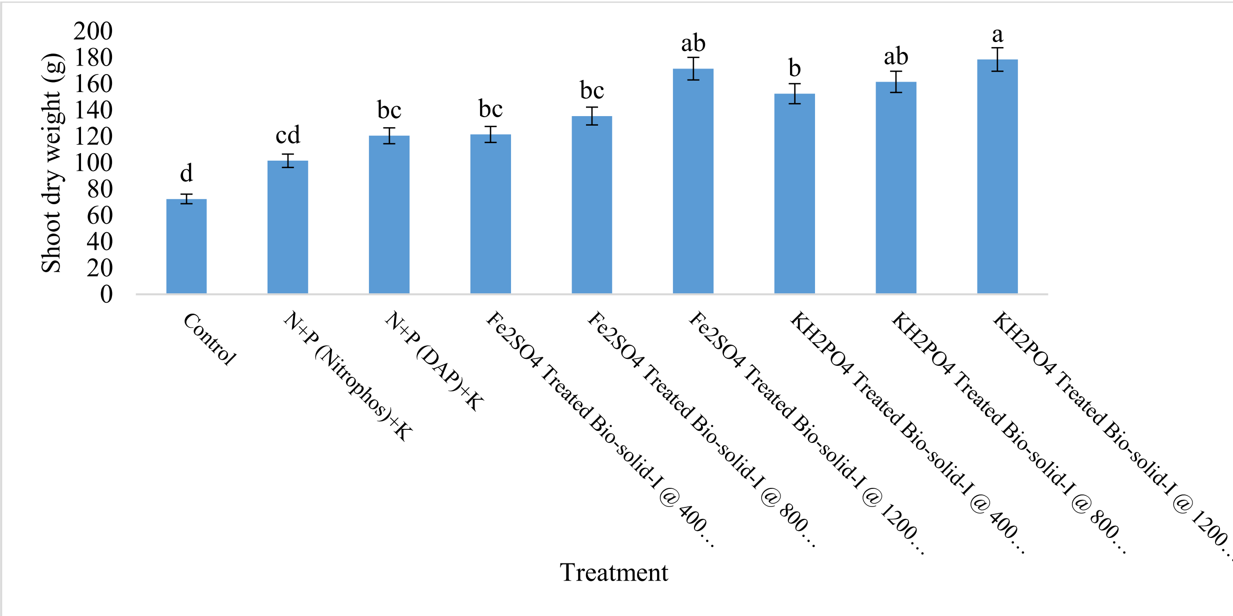

Fig. 2 Impact of bio-solids waste on SDW (g) of maize plant

Root dry weight (RDW)

The results clearly show that treated bio-solids have positive effect on maize root dry weight (Fig. 3). The control treatment had the lowest root dry weight (36.17 g), demonstrating the negative impact of nutrient deprivation on plant biomass. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1}(T9) produced highest values (89.33 g) and ranked as best treatment. Treatment T6 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 1200 kg ha^{-1}) gave 2nd highest value of RDW (85.6 g). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

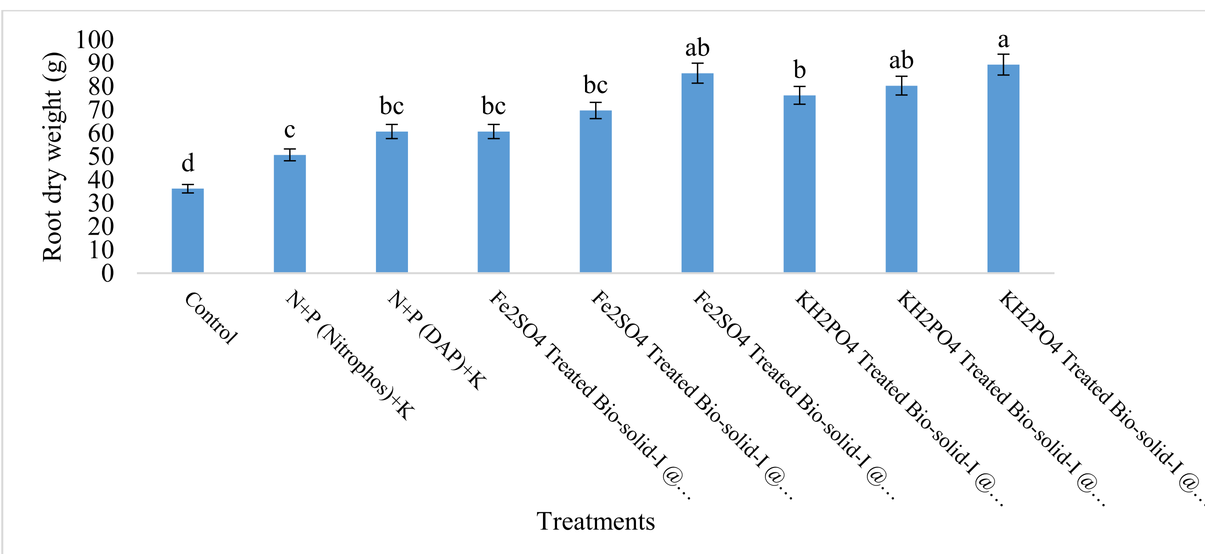

Fig. 3 Impact of bio-solids waste on RDW (g) of maize plant

Stem girth

The use of treated bio-solids enhanced maize stem birth, with values ranging from 22.5 mm in control plants to 29.5 mm in optimal treatments. The bar graph illustrates the effect of different treatments on a stem girth of maize (Fig. 4). Among all treatments, T6 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 1200 kg ha^{-1}) showed the highest value (29.5 mm), indicating a strong positive effect of iron sulfate application. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) also produced higher values (28.5 mm) and ranked as 2nd best treatment. The control treatment exhibited the lowest value of maize stem girth (22.5 mm). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

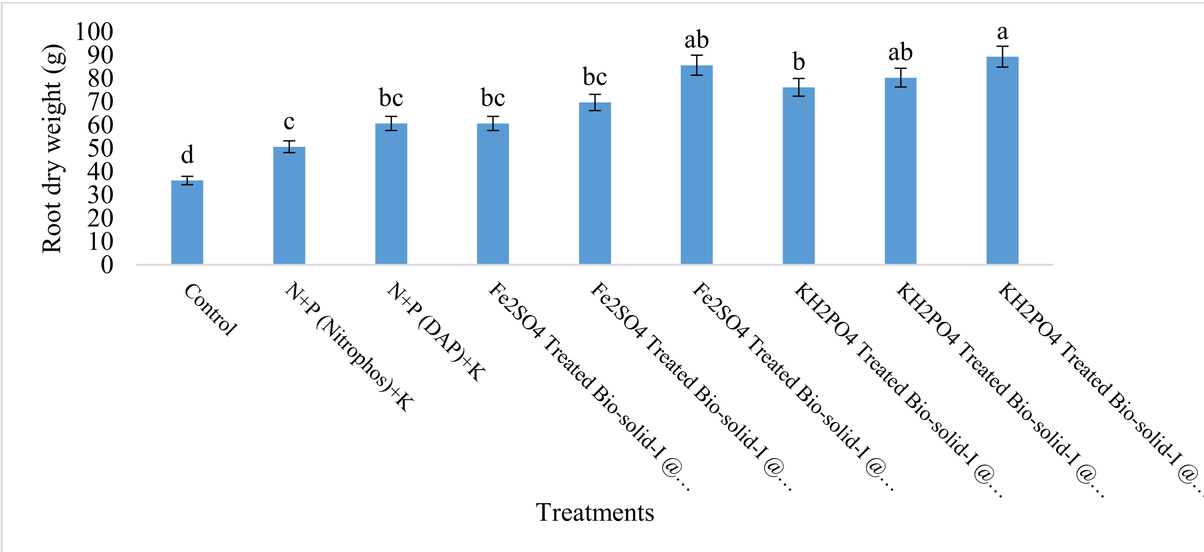

Fig. 3 Impact of bio-solids waste on RDW (g) of maize plant

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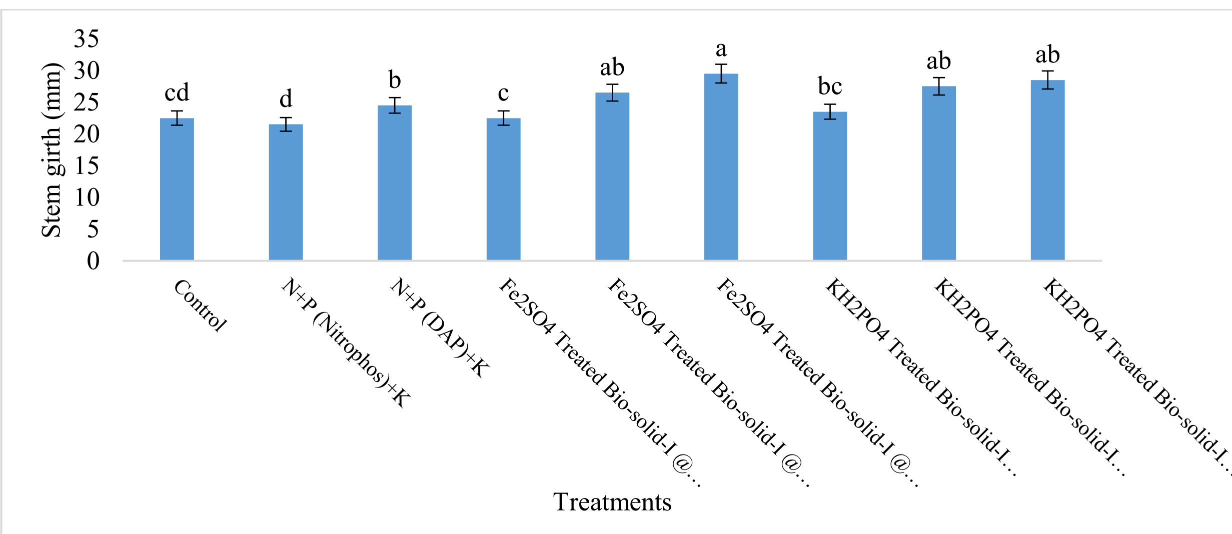

Fig. 4 Impact of bio-solids waste on stem girth (mm) of maize plant

P content in shoot

Application of processed bio-solid significantly enhanced the amount of phosphorus (P) in maize plants implying that they are effective sources of sustainable P. KH_2PO_4 amended bio-solid (TBP) produced exceptional P build-up in plants where the P levels increased by 40-50 % when compared to controls. The results clearly indicated that treated bio-solids have positive effect on maize plant P content (Fig. 5). The control treatment had the lowest P content (0.22 mg P g^{-1} of dry weight), demonstrating the deficient supply of nutrient effect on plant biomass. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) produced highest values (0.51 mg P/g of dry weight) and ranked as best treatment. Treatment

T5 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 800 kg ha^{-1}) gave 2nd highest value of P content in shoot (0.41 mg P g^{-1} of dry weight). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

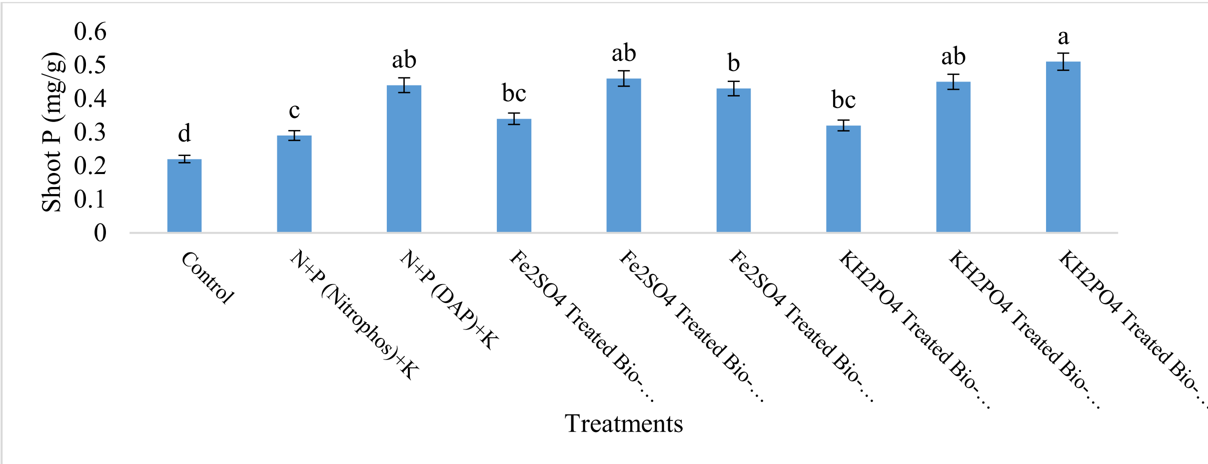

Fig. 5 Impact of bio-solids waste on leaf chlorophyll content of maize plant

P content in root

Treated bio-solid addition improved the amount of phosphorus (P) in maize plants significantly indicate the effectiveness of these sources for sustainable P provision. KH_2PO_4 amended bio-solid (TBP) produced exceptional P build-up in plants where the P levels increased by 40-50 percent when compared to controls. The results clearly indicated that treated bio-solids have positive effect on maize plant P content (Fig. 6). The control treatment had the lowest P content (0.12 mg P g^{-1} of dry weight), demonstrating the negative impact of nutrient deprivation on plant biomass. Treated bio-solid- II with KH_2PO_4 @ 1200 kg ha^{-1} (T9) produced highest values (0.36 mg P g^{-1} of dry weight) and ranked as best treatment. Treatment T5 i.e. treated bio-soild-I with Fe_2SO_4 (TBF @ 800 kg ha^{-1}) gave 2nd highest value of P content in root (0.35 mg P/g of dry weight). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

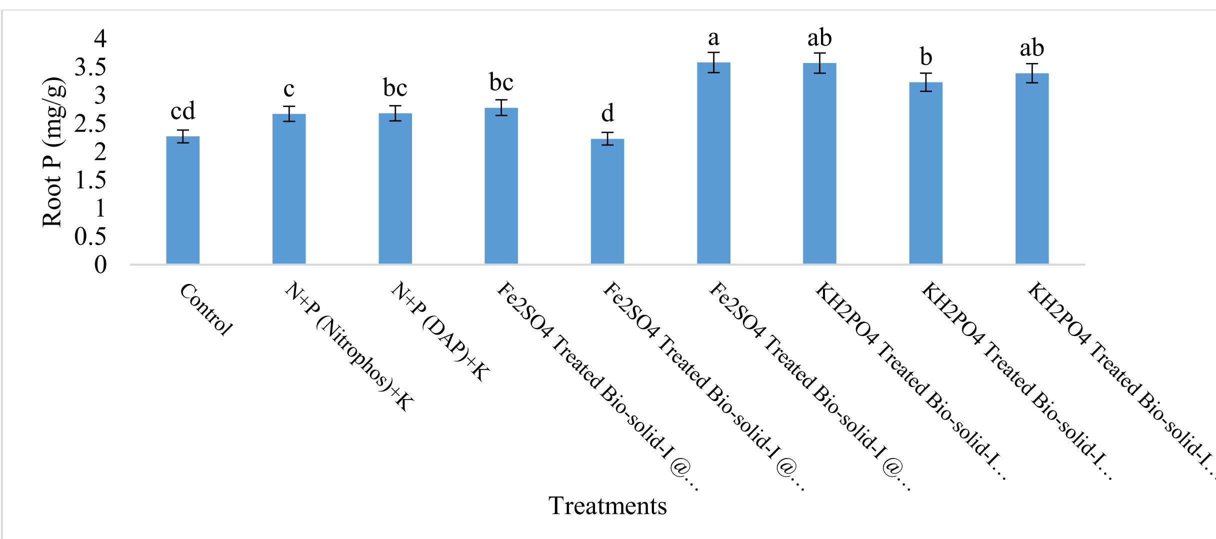

Fig. 6 Impact of bio-solids waste on P content in shoot mg g^{-1} of maize plant

Leaf chlorophyll content by SPAD

Application of treated bio-solid significantly enhanced chlorophyll levels in maize leaves, according to the SPAD reading, and this reflects photosynthetic vitality and vitality of the plant (Fig. 7). The control treatment had the lowest chlorophyll content (29.5), demonstrating the negative impact of nutrient deprivation on chlorophyll content. Treated Bio-solid–II performed better than bio-solid-I. Treated bio-solid-II with KH_2PO_4 @ 800 kg ha^{-1} (TBP) produced highest values (42.5) and ranked as best treatment. Treatment T7 i.e. treated bio-soild-II with KH_2PO_4 @ 400 kg ha^{-1} (TBP @ 400 kg ha^{-1}) gave 2nd highest value of SDW (41.5 g). The control treatment exhibited the lowest value of maize plant height

(2.14 mg P g^{-1} of dry weight). Thus, higher rates of both treated bio-solids gave better results as compared to lower rates and control.

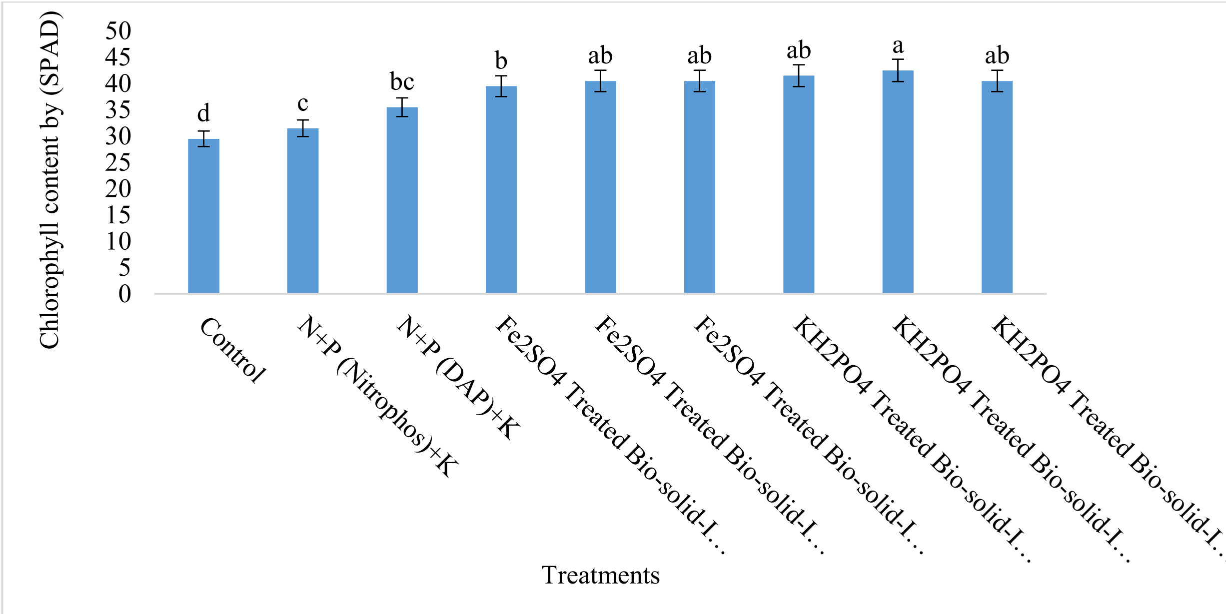

Fig. 7 Impact of treated bio-solids waste on P content in root mg/g of maize plant

Discussion

Phosphorus (P) is a major nutrient needed by all plants to grow especially in maize where it determines root formation, energy transfer (ATP) and grain production. Historically, phosphorus is provided in terms of chemical fertilizers; including single super phosphate (SSP), diammonium phosphate (DAP), and triple super phosphate (TSP) (Hao et al., 2017; Gong et al., 2021). The issues surrounding the enviro-physiological effects of these traditional P fertilizers, their sustainability, and their economic feasibility have generated the need to identify alternative fertilizers such as bio-solids treated sources. The treated bio-solids are the organic materials that are nutrient-rich obtained by treating sewage sludge. Properly stabilized (e.g. during composting, liming or during thermal treatment), bio-solids are a useful amendment to soils, potentially contributing slow-release phosphorus, soil structure and microbial activity. Bio-solids unlike traditional P fertilizers are also good sources of organic matter that facilitate positive changes in soil physical, chemical and biological characteristics thus resulting in an increase in nutrient use efficiency (Rahman et al., 2020; Lin et al., 2024).

Experimental outcomes of this research indicated that the maize plants that received treated bio-solids exhibited a similar or even better growth parameters (plant height, biomass accumulation and root development) than the plants that were treated using conventional P fertilizers. The rate of mineralization of P from the organic sources could act as one reason as it involves slow release and encourages fixation hence promoting long term availability. Desjardins et al. (2025) reported that bio-solids may contain micronutrients (e.g., Zn, Fe, Cu) that are often absent in synthetic fertilizers, thereby contributing to improved overall plant nutrition, growth, and yield in crops such as maize. Unlike chemical fertilizers which can also break down in one growing season, bio-solids can enhance soil fertility in several growing seasons because of their organic matter contents and their low rate of nutrient release. Greater benefits can be achieved by longer term use that would result in lowering the input cost incurred by farmers and enhancing the friendly environment in terms of nutrient management. Other research studies also reported similar findings (Vera-Garcia et al., 2023; Khatun et al., 2020).

It was reported that treated bio-solids are the processed remains of sewage sludge and offer potentially excellent choice source of fertilizer that may be used to stabilize the soil condition such as soil pH thereby improving nutrient availability to plants and resultantly improving in growth parameters and nutrient acquisition (Ji et al., 2021). Stabilized bio-solids (BS) provide numerous agronomic advantages. They are wealthy in vital plant nutrients, such as nitrogen, phosphorus, and potassium, which can reduce the need for chemical fertilizers. The organic matter in BS improves soil structure, complements moisture retention, and increases microbial activity, leading to more healthy soils due to slow-release nature of bio-solids use with chemical fertilizers (Lawrencia et al., 2021).

The fact that bio-solid that is treated with supplements not only enhances the availability of P but also improves the capacity of the plant to absorb and use it effectively depicting their effectiveness in scenario of low P growth medium. This is very important in sustainable agriculture whereby the efficiency of resource consumption needs to be maximized so that the cost of inputs and environmental load may be reduced.

Regular bio-solid applications alter phosphorus dynamics and can result in P release into water bodies when the soil capacity to retain phosphorus is saturated (Sun et al., 2025). The study is important contribution to the existing body of literature on several studies supporting the observed claim that treated bio-solid have environmental sustainability and agronomic efficacy to replace chemical fertilizers. The results indicated that bio-solids can serve as an effective source of nutrients most specifically phosphorus, in the growth of maize. Wheaton et al. (2025) and El-Damarawy et al. (2025) also reported similar findings reporting buildup in soil P levels due to application of bio-solids. However, the care should be taken for use of these BS as the repeated application of BS may results in the risk of P buildup in the soil, an aspect that has already been witnessed in the surroundings of production plants that in most cases have very intense P indexes in the soil (Antille et al. 2013a; Antille et al., 2013b; Antille et al., 2014).

Conclusion

The present study results revealed that bio-solid applications could enhance the maize crop yield. It may also enhance growth and harvest of plants. Treated BS not only enhance plant growth performance but also improve P use efficiency (PUE) thus confirmed the efficacy of treated bio-solids in promoting maize growth and phosphorus (P) bioavailability. Use of KH_2PO_4 treated bio-solid performed better by increasing P content in maize plant parts and growth media. Bio-solid application at different levels of dose highest result was observed where the bio-solid TBF (treated bio solid with Fe_2SO_4) applied is 1200 kg ha^{-1}. Use of treated bio-solid with KH_2PO_4 @ 1200 kg ha^{-1} enhanced maize growth and also nutritional status of soil.

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