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The Effect of Poultry Manure on Growth, and Yield of Tomatoes (*Lycopersicon esculentum* mill) Cultivated in Salt Marsh Soil

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A B S T R A C T

Tomato is an important, popular, and versatile vegetable in the world and ranks number one in its contribution to the diet. One of the most common land degradation processes that affect agricultural production is soil salinization, however, organic production can be utilized to reduce the effect of salinity on many plants. The study aims to investigate the effect of different concentrations (0, 25, 31, 38, and 44%) of poultry manure (PM) on cherry tomato plants grown in marsh soil and to study the effectiveness of fertilizer in improving soil properties. The results showed that the application of PM in marsh soil increased plant height, root length, fresh and dry weight, the number of flowers and fruits and shoot potassium concentration, while shoot sodium concentration was decreased. The present study concluded that treating salt marsh soil with PM levels especially with PM4 level could reduce salinity stress damage on cherry tomato plants, increase biomass production and improve soil properties.

1 Introduction

One of the basic plants in the diet of most people in the world is the tomato plant, Lycopersicon esculentum, (Ohlson *et al*., 2018) which belongs to the Solanaceae family (Ohlson *et al*., 2018). Tomato is enriched with minerals, vitamins, sugars, dietary fibers, essential amino acids, and lycopene (Ud Din *et al*., 2023). It also contain high levels of other bioactive compounds such as phenolics, vitamin C, and antioxidants which are thought to protect and possibly prevent stressful environmental conditions (Najat *et al*., 2018). Lycopene is a natural antioxidant that works effectively to slow the growth of cancerous cells (Ntagkas *et al*., 2020). Tomatoes help maintain strong bones. This is because they contain considerable amounts of calcium and Vitamin K. Both nutrients are essential in strengthening and performing minor repairs on the bones as well as the bone tissue (Amao, 2018). The total area of the world under tomato cultivation is 4.8 million hectares (MHA) with the production of 163 million tons per year (Firdous, 2021). Destructive climate changes are resulting in the degradation of soil, which eventually lowers the overall crop productivity.

Globally, soil salinization is one of the most important issues that affects almost 836 Mha (Xie *et al*., 2020). Salt-affected soils reduce crop yields by disturbing the physicochemical properties and microbial activities in the soils of semi-arid regions (Zhu *et al*., 2021). Salinity

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is one of the most important abiotic stresses that reduce plant growth and development due to the presence of salts in the soil (Zörb *et al*., 2019). Plant roots absorb Na+ and C1− ions from the soil solution and translocate them in the stem and leaves. Due to specific ion toxicity, dehydration occurs which reduces the photosynthetic and respiration activities in plant cells (Acosta-Motos *et al*., 2017). Furthermore, When salts increase in the soil sector, the osmotic pressure in the area of root spread increases, and for the plant to be able to resist these unfavorable conditions in the soil solution, the plant cells raise the internal osmotic pressure of the cytoplasm, and this leads to the plant loses the vital energy necessary for its development and growth (Kim *et al*., 2016), which leads to its weakness and lack of production (Ivushkin *et al*., 2019; Luo *et al*., 2005) Nowadays, different organic amendments such as compost, farmyard manure, biochar, animal manure, and crop residues are being used to mitigate the drastic effects of salinity.

Organic materials such as poultry manure enhance crop yield and soil properties and sequester more carbon (C) in soils(Ud Din *et al*., 2023). Also, Organic materials reduce the salinity stress, Na+ adsorption ratio, and electrical conductivity (EC) by improving the physical, chemical, and biological characteristics of highly deteriorated soil for sustainable crop production (Guo *et al*., 2020). The addition of compost to soil influences plant growth positively even in a stressed environment. Research conducted by (Soremi *et al*., 2017) showed that PM is the most cherished of all animal manures since it contains all the essential plant nutrients such as phosphorous, nitrogen, potassium, zinc, iron, chlorine, calcium, magnesium, boron, copper, molybdenum and sulfur which are responsible for the fertilization of the soils. This makes it the most suitable organic manure for tomato production.

Under salt stress, plants are unable to uptake balanced amounts of nutrients and water from the soil, but the addition of compost improves the organic matter of the soil and provides more surface area for microbes to chelate the salted ions (Cao *et al*., 2019). Moreover, the presence of more functional groups and active sites in compost attracts the salted ions and makes them unavailable for plant intake (Gondek *et al*., 2020). The response of plants to environments with high salt content is one of the most important agricultural topics that botanists are interested due to its close connection to the source of human food. In addition, our country Libya suffers from a high rate of salinity in its lands, we have chosen to conduct this study on one of the important crops of economic and medical importance, which is the tomato plant, to evaluate the effect of poultry manure on the growth and production of cherry tomatoes (Lycopersicon esculentum mill) in salt marsh soil under environmental conditions.

2 Materials and Methods

2.1 Experimental Site

The study was conducted at the Faculty of Science in Botany's department, Misurata, Libya to determine the effects and interactions of marsh soil and PM applications on tomato growth.

2.2 Seed Source

The plant identification was carried out by the author following these references; Cronquist, 1968; Group, 2009). The plant was identified in the plant herbarium of the Botany Department, Faculty of Science, Misurata University. The name of the plant used was *Lycopersicon esculentum* mill.

2.3 Soils Sample Collection

The soil samples of the experiment were collected from marsh soil of the Qasr Ahmed area which is located between longitude (32°15`&32°23`N) and latitude (15°10`&15°16`N) in Misurata/Libya (Assoul *et al*.).

2.4 Levels used in the Study

The control: saline soil without adding PM (0%), and it is symbolized by MP0.

The first level (25%): 1 kg of PM was added to 3 kg of soil, and its symbol is MP1.

The second level (31%): 1.25 kg of PM was added to 2.75 kg of soil, and it is symbolized by MP2.

The third level (38%): 1.5 PM were added to 2.5 kg of soil, and it is symbolized by MP3.

The fourth level (44%): 1.75 kg of PM was added to 2.25 kg of soil, and its symbol is MP4.

2.5 The Edaphic Parameters

The soil analyzed before and after cultivation to evaluate their degree of fertility and granulometric compositions. From the soil, four samples were taken at a depth of 30 cm (about 11.81 in) and then dried

(Alghobar & Suresha, 2017; Disciglio *et al*., 2015), crushed with a mortar, sieved to 2 mm (about 0.08 in), and finally subjected to chemical analysis.

2.6 Soil samples physicochemical analysis

2.6.1 Determination of the pH Values and Electrical Conductivity (EC) of the Soil

The soil electrical conductivity (mmhos cm-1) and PH were measured on aqueous soil extracts (ASE) using an electrical conductivity meter and pH meter. The accuracy of the device has been verified using a 0.01 N KCL solution, which gives a conductivity reading of 1.413 ds/m at a temperature of 25 °C (Page *et al*., 1982) and electrical conductivity (EC) was measured in a 1:10 soil/water solution using an EC meter (Jenway, United Kingdom) (Rayment & Higginson, 1992). The size of the soil particles was determined using a 2 mm sieve, through which the soil texture can be known (Gee & Or, 2002)). The analysis was conducted at the Misurata Agricultural Research Center, as shown in (Tables 1 & 2).

Table (1): Chemical properties of the Qasr Ahmed marsh soil before cultivation

Texture of the Soil	PH	EC ms/cm	Sodium (Na) (ppm)	Potassium (K) (ppm)
Mixed (sandy clay)	9.9	0.448	8232.8	1321.0

Table (2): Chemical properties of the Qasr Ahmed marsh soil after cultivation.

Levels of PM	PH	EC ms/cm	Sodium (Na)/(ppm)	Potassium (K) /(ppm)
PM0(control)	9.9	0.493	85.46	5.95
PM1	7.9	1.207	62.67	9.04
PM2	7.7	1.008	63.05	9.04
PM3	7.2	1.056	55.07	9.9
PM4	7.4	0.637	49.37	9.78

2.7 Experimental Details

The vitality of the seeds of the cherry tomato plant (*Lycopersicon esculentum* mill) was tested, and their germination rate reached 99%. The tomato plant was grown in the greenhouse, and after 6 weeks (about 1 and a half months) of cultivation, when the fourth leaf appeared, the seedlings were transferred in single form to pots with a diameter 20 cm filled with soil mixed with the PM to be studied for its effectiveness. The samples were irrigated with fresh water 2 to 3 times a week. During the follow-up period of tomato plant growth, some morphological and chemical parameters were studied.

2.8 The Morphological Characteristics

2.8.1 Plant Height (cm)

Plant height was taken as the length between the bases of the plant to the tip. Plant height was recorded using a graduated ruler (cm) every two weeks until the end of the growing season.

2.8.2 Number of Leaves and Branches Per Plant

This parameter was measured by calculating all leaves of ten randomly selected plants at different stages of growth at all levels studied. The mean of leaves per plant was recorded.

2.8.3 Number of Flowers and fruits Per Plant

The number of flowers and fruits formed at all levels of the studied PM, from its formation to the end of the experiment, was counted.

2.9 Fresh and Dry Weight of Plant (g):

Plants were harvested after twenty weeks of treatment and shoots were washed with distilled water. Patted dry with paper towels and quickly weighed for determination of fresh weight. Dry mass was determined after drying in an oven (Ohaus) at 80 ºC for 3 days then weighed using a sensitive Metler AND (HR-60) balance.

2.10 Extraction of Plants and ion Analysis

To determine different mineral elements (K and Na), tomato sample collected from each pot was cut into small pieces using a sharp steel knife and dried in an electric oven at 50˚C temperature for about 72 hrs. Then the samples were ground by a grinding mill and used to prepare tomato sample extract by wet oxidation method using a di-acid mixture. Na and K were estimated by flame photometrically at wavelengths 589 and 767 nm, respectively as mentioned by Singh *et al*. (1999).

Statistical Analysis

Data were analyzed by two-way analysis of variance (ANOVA) to explore the general trend of the experimental data. SPSS (version 20) statistical software package (SPSS, Chicago, USA) was employed in the analysis. The means were separated using the Tukey method of the multiple range test at a 5% level of probability.

3 Results

3.1 Plant height, Leaf Number and Branch Number

In the present study, the application of PM in marsh soil had a significant effect (P≤0.05) on the growth parameters of *L. esculentum* mill plants as compared to the control during all weeks of the study (Table 1). Plant height, leaf number and branch number increased in response to PM treatments. Plant height and leaf number were increased with increasing PM levels in the growth media. It result in a (50%) increase in shoot height and leaf numbers at PM4 as compared to the control. While the branch number was maximal at PM2, it was 65 % higher than that at control.

Table (3): Plant height, leaf number and branch number in *L. esculentum* mill grown under different levels of PM (0, 25, 31, 38 and 44%), in salt marsh soil.

Duration (week)	Treatment (PM %)	Plant height	Leaf number	Branch number
8	PM0 (0%)	18 ± 0,4c	4.4 ± 0.7d	0.6±0.03c
	PM1 (25 %)	32 ± 0.2b	7.6 ± 0.6b	1.6 ±0.2b
	PM2 (31%)	33 ± 0.2b	9.6 ±0.5b	2.8 ±0.4a
	PM3 (38%)	38 ± 0.2a	9.6 ± 0.6c	1.6 ±0.2b
	PM4 (44%)	39 ± 0.5a	11.8 ± 0.5a	1.6 ±0.02b
12	PM0 (0%)	34 ± 0.4d	7.8 ± 0.1a	1.4 ±0.1d
	PM1 (25 %)	43 ± 0.5bc	10.4 ±0.5b	3.2 ±0.3b
	PM2 (31%)	44 ± 0.4c	11.4 ±0.6b	4 ±0.3a
	PM3 (38%)	47 ± 0.5b	11.2 ± 0.5b	2.6 ±0.2c
	PM4 (44%)	62 ±0.6a	14.6 ± 0.4a	3.4 ±0.1b
20	PM0 (0%)	41 ± 1d	9.4 ± 1d	1.4 ±0.1c
	PM1 (25 %)	54 ± 0.5c	13.4 ± 0.6c	3.2 ±0.3b
	PM2 (31%)	56 ± 0.3b	15,4 ± 0.5c	4 ±0.2a
	PM3 (38%)	58 ± 0.7b	17± 0.3b	3.4 ±0.1b
	PM4 (44%)	82 ± 0.8a	18.8 ± 0.2 a	3.4 ±0.2b

Plants were grown for 8, 12 and 20 weeks under environmental conditions. Values are means ± standard error (n = 5). Letters indicate a significant difference in means from post hoc Tukey tests (P < 0.05).

3.2 Root Length (cm)

Fig. 1 showed that PM application in salt marsh soil had a significant effect (P≤0.001) on the length of root of *L. esculentum* mill plants. The root length increased with increasing PM levels in the growth media, with the highest value recorded at the PM4 level, which was 1.6 times higher than the plant growth in the control.

3.3 Number of Flowers and Fruits

The application of PM in salt marsh soil had a positive impact on flower and fruit production in *L. esculentum* mill plants, as demonstrated in Fig. 2A and b. The number of flowers and fruits plant per plant was maximally enhanced at the PM4 level, showing an increase of 69% and 80% in flower and fruit yield, respectively, as compared to the control plants.

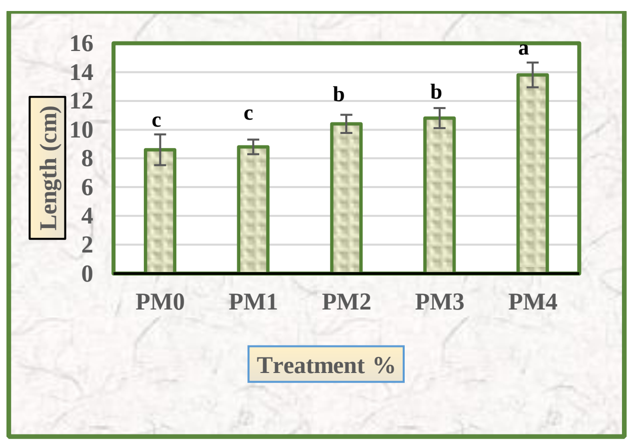

Figure (1): Root length of *L. esculentum* mill plants grown under different concentrations of PM (0, 25, 31, 38 and 44 %), in salt marsh soil, for 20 weeks in environmental conditions. Letters above error bars (n = 5) indicate a significant difference in means from post hoc Tukey tests (P < 0.05).

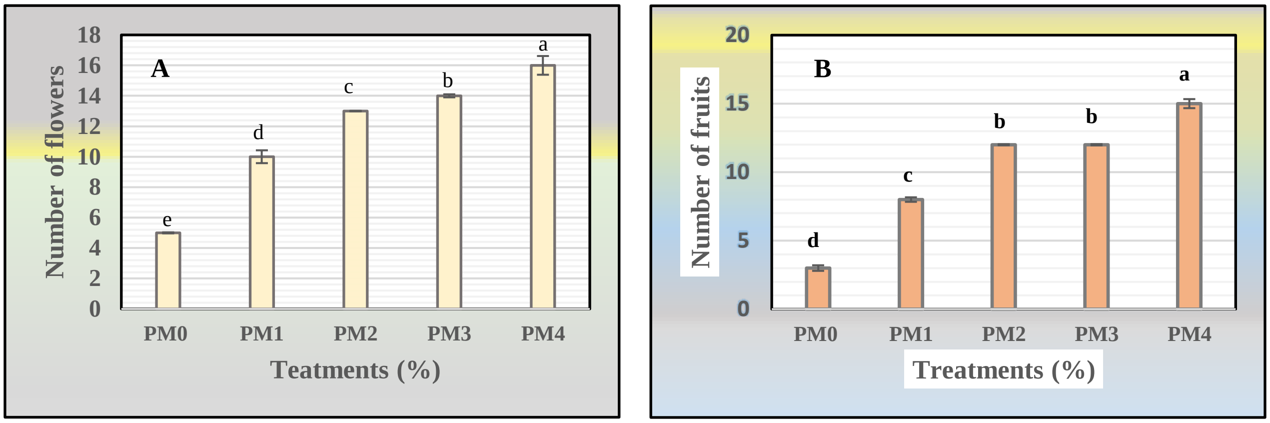

Figure (2): Flowers (A) and fruits (B) numbers of *L. esculentum* mill plants grown under different concentrations of PM (0, 25, 31, 38 and 44 %), in salt marsh soil, for 20 weeks in environmental conditions. Letters above error bars (n = 5) indicate a significant difference in means from post hoc Tukey tests (P < 0.05)

3.4 Plant fresh and Dry Weight

Fig. 3. Showed the effect of different levels of PM on fresh and dry weight for plants grown in marsh salt soil. The results showed that the effect of PM levels was highly significant ($P < 0.01$) on the fresh and dry weight plant per. The fresh weight increased with the increasing PM level in the growth medium. The highest value (23±1 g per plant) was at PM4, and the lowest value (5±0.02g per plant) was at PM0 (control treatment). Furthermore, a similar pattern of response to the application of PM in growth media significantly affected shoot dry weight ($p < 0.01$; fig. 3), with the highest value (8±0.2g per plant) was recorded in PM2 than in PM0 (1.7±0.02g per plant)

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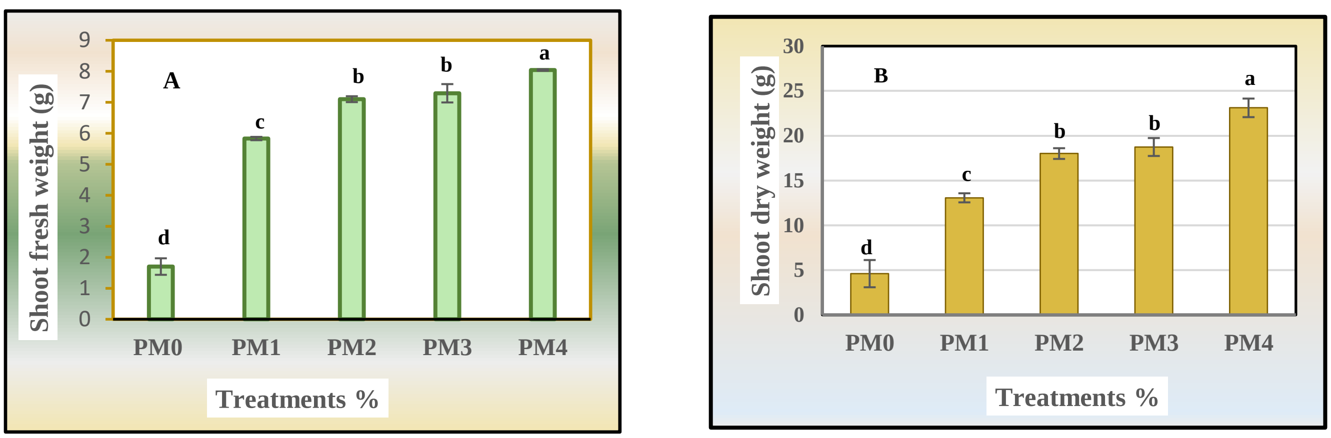

Figure (3): Shoot fresh (A) and dry weight (B) (g per plant) of *L. esculentum* mill plants grown under different concentrations of PM (0, 25, 31, 38 and 44 %), in salt marsh soil, for 20 weeks in environmental conditions. Letters above error bars (n = 5) indicate a significant difference in means from post hoc Tukey tests (P < 0.05)

3.4.1 Ions Concentrations

Shoot K^+ and Na^+ concentrations were significantly affected (*$P < 0.001$*) by the application of PM in salt marsh soil. As shown in Table 4; the shoot K^+ concentration was increased by increasing PM levels, at the PM4 level; the K^+ concentration was 1.4 times greater than at the control (PM0). However, the shoot Na^+ concentration tended to be reduced significantly (*$P < 0.001$*) by an increased PM level in the growth medium, which was 2.2 times lower as compared with the control.

Table (4): Concentration of sodium and potassium in tomato plants treated with different levels of PM.

Treatments (%)	Sodium (Na^+) (ppm/g^{-1})	Potassium (K^+) (ppm/g^{-1})
PM0 (0%)	49.22±0.03a	40.41±0.01 e
PM1 (25 %)	37.05±0.02b	48.06 ±0.03d
PM2 (31%)	33.96 ±0.02c	50.41±0.12 c
PM3 (38%)	29.46±0.14d	56.60±0.03 ab
PM4 (44%)	22.71±0.03e	58.01±0.04a

Significantly, different means are labeled with different letters at $p < 0.05$ (ANOVA followed by Tukey's test).

4 Discussion

Results from this study showed a decrease in the morphological characteristics and yield parameters of tomato under salinity conditions. However, the application of PM reduced the negative impacts of salinity and improved plant growth. In comparison with the control, poultry manure-treated plants showed an increase in plant height (Table 3). The treated plant with PM resulted in higher growth, suggesting that fertilization enhanced the growth of tomatoes. This agreed with the work of Direkvandi *et al*., (2008) and Ayeni *et al*., (2010), who reported a significant increase in plant height as a result of the application of PM. In addition, the application of PM during the growth of the plant under salt-stress increased the number of leaves. A similar result was found in the findings of Singh *et al.*, (2020) and Agbede *et al*., (2008), who found that the application of PM led to an increase in the number of tomato leaves. Our results were also consistent with the research outcomes of Kumar *et al*, (2021) who reported that the reduced number of branches of the *Oenanthe javanica* plant was due to an increased concentration of salts in the growing medium.The increase in the number of branches is consistent with Ewulo *et al*., (2008) study of the effect of PM at concentrations of 0, 10, 25, 50, and 40 tons/ha on tomato growth. The possible reason behind the stunted growth is due to the decreased absorption of essential nutrients in the plant (Zhang *et al*., 2019). High salinity in plants alters cell division, decreases cell size by decreasing water potential, and eventually reduces the dry weight of plants (Safdar,*et al*.,2019). The number of flowers and fruits in tomato plants indicated that there were significant differences ($p<0.05$) among the different rates of PM throughout the growing period. This result is in line with the findings of Agbede *et al*. (2008), who found that the number of fruits in crops significantly increased with an increase in the concentration of PM.

Reduced weight might be due to various other factors, including decreased photosynthetic activity and a drop in turgor pressure under salt stress (Ors *et al.*, 2021). On the other hand, the addition of PM in marsh soil minimized the toxicity of salts to plants, either directly by decreasing the translocation of harmful salts or indirectly by increasing other nutrients (Castiglione *et al.*, 2021). The result here indicates that all levels of PM improve fresh and dry weight compared to the control treatment. These results were supported by Abu Suwar and El Zilal (2010), who stated that fresh and dry weights were increased significantly by PM. The highest dose of manure was used to achieve the maximum dry weight. These results also agreed with Kandil and Gad (2010). In addition, a similar result was found with Aziz *et al*., 2020.

The results of the chemical parameters of the soil samples presented in Tables 1 and 2. The obtained pH values indicated that soil samples before treatment with PM levels were strongly alkaline (Ph 9.9). However, after treatment with PM levels, the pH values reduced with the increase in PM levels. The incorporation of PM lowered the pH of saline-sodic soil due to its acidifying effect by producing and subsequently releasing different organic acids during the mineralization process of the nutrients. The pH of alkaline soil is controlled by Na. However, when PM is used as a source of nutrients, it made free Ca^{2+}, which led to a reduction in soil pH. As a result, Na^+ ions released in soil solutions that were leached down the soil profile (Brady & Weil, 2005). This may be attributed to the sufficient release of nutrients particularly N.P.K contained in the PM applied, as these nutrients improve the growth and yield of crops under stressful environmental conditions.

Potassium plays an important role in different mechanisms like protein synthesis, glycolytic enzymes, and photosynthesis. Treatment plants grown in marsh soil with PM improved the growth rate and productivity of tomato plants growth. This may be due to an increase in the plant's potassium concentration. The increase in the K^+ concentration of tomato due to the application of poultry manure is consistent with using PM as fertilizer for tomato production (Akanni, 2005). It was found that 30 t ha^{-1} PM gave the most growth and highest fruit yield among all PM levels. The reduction in K^+ and the increase in Na^+ shoot concentrations after salinity treatment is because that K^+ and Na^+ are inherently competitive due to their similar physiological properties. Na^+ competes with K+ for binding sites in the cytoplasm, inhibiting K^+-dependent metabolic processes.

5 Conclusions

It is clear that, using different levels of poultry manure is useful for enhancing the growth, development, and yield of tomato crop production under salty soil. In addition, the application of PM in marsh soil has led to improvements in the physical characteristics of the soil and minimized the toxicity of salts to plants, either directly by decreasing the translocation of harmful salts or indirectly by increasing other nutrients. Thus, the best growth was at the highest PM4 level in the growing medium. The study recommend using saline soil and treating it with PM to grow tomatoes (cherry tomatoes). Further research and further investigation are needed on other plants using different concentrations of poultry manure available to improve the specifications and properties of marsh soil.

Contrast of Interest: The authors declare that they have/ have no contrast of interest associated with this manuscript.

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