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ORIGINAL RESEARCH

Comparison between vermicompost and town refuse rates after addition on leek and onion growth under calcareous soil conditions

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Abstract

Purpose: Globally, organic waste is a significant environmental problem in many regions of the world. The present study aimed to compare vermicompost and town refuse applications for the growth promotion of onion and leek plants, phosphorus uptake, and microbial biomass in soil under calcareous soil conditions.

Method: The top 30 centimeters of the soil were taken from Burj El-Arab City in Alexandria, Egypt. Each pot was transplanted with two similar-sized seedlings of each plant for onion (*Allium cepa* L.) and Leek (*Allium porrum* L.). Each seedling had two or three pairs of fully developed leaves. Four rates of vermicompost and town refuse were used as follows: 0, 10, 15, and 20 tons/fed and blended with the soil before planting. With six replications, a randomized complete block design (RCBD) was used to create the experiment.

Results: After 45 days, all leek and onion plants were harvested. The results demonstrated that the leek and onion growth, P uptake, soil microbial biomass, and available P in soil increased significantly with increasing vermicompost or town refuse rates. The responses of plants to vermicompost rates were higher than the same rates of town refuse.

Conclusion: Under the same conditions of this experiment, we can recommend that, add the high rate of vermicompost was achieved better growth and P content in soil and plant for both plants. Also, we still need more studies for other plants, different soil types, comparisons with other organic sources, and higher rates of vermicompost.

Keywords: Leek, Onion, Organic waste, Town refuse, Vermicomposts

Introduction

Like all affluent nations, Egypt is grappling with a serious food crisis that will worsen unless concerted measures are made to increase agricultural productivity (Shaheen et al. 2007). One of the principal vegetable crops farmed in Egypt is the onion (*Allium cepa* L.), which is cultivated for both domestic and international trade (El-Desuki et al. 2006). The leek (*Allium ampeloprosom* L.), which differs morphologically from onions, is a major crop in the *Alliaceae* family. Leeks are valuable, not only as culinary spices but also as immense medicinal plants (Shahrajabian et al. 2021).

Vermicomposts (V) are produced from organic wastes by mesophilic processes involving earthworms and microorganisms. They are highly microbially active, totally stable chemical molecules that are finely split (Ahmad et al., 2021). It is possible to use vermicomposting to turn organic waste into fertilizer that is appropriate for sustainable agriculture (Liégui et al. 2021). Earthworms are the technique's main proponents because they contribute to the indirect activation of populations of microbes via the fragmentation and consumption of fresh organic waste. This is because they increase the surface area of waste for microbial colonization, which significantly increases microbiological activity Enebe and Erasmus (2023), making it suitable for plant development (Rehman et al. 2023). The majority of nutrients are present in vermicompost in forms that are easily taken by plants, and it has a high water-holding capacity, a low C: N ratio, and high porosity (Domfnguez 2004). Town refuse (T) compost is produced from the aerobic-thermophilic decomposition process of city waste (Alhassan et al. 2021). Numerous researches have typically demonstrated that applying compost made from city waste has encouraged a favorable effect on a wide range of plants (Wong 2022). It has been shown that adding town refuse to soil enhances aspects of its physical characteristics, including bulk density, porosity, and ability to

store water (Hiranmai et al. 2023). In addition, it enhances the proportion of organic carbon in the soil and its ability to exchange cations (Singh et al. 2020). This investigation aims to recycle organic waste in agriculture and identify the effect of town refuse rates and vermicompost on the growth of leek and onion plants, Phosphorus uptake, soil P availability, and microbial biomass in soil under calcareous soil conditions.

Materials and methods

Soil preparation

The sample of soil was taken in Burj El-Arab City, Alexandria, Egypt, from the topsoil (0–30 cm). It was air-dried, smashed, and filtered via a two-mm sieving size (No. 10 mesh) to homogenize the soil. The methods for conducting soil analyses were discovered by (Page et al. 1982) (Table 1).

Table 1. A few basic chemical and physical characteristics of soil

Soil properties	Soil texture	pH (1:1)	EC dSm ⁻¹ (1:1)	O.M (%)	Total CaCO ₃ (%)	Available	
						P (mg/kg)	N (mg/kg)
Values	Sand clay loam	8.2	1.12	0.23	18.47	6.6	83

Organic fertilizers (vermicompost and town refuse) analysis

According to (Jackson 1973), pH and EC of organic fertilizers were determined in the extract 1:5 (w/v water). The Nessler method was used to calculate total N (Chapman and Pratt (1978)). The vanadomolybdo phosphoric method was used to calculate total P (Jackson 1973). Total K, Ca, and Mg according to (Page et al. 1982). The diethylene triaminepenta acetic acid extracting (0.005M DTPA, 0.1 TEA,) solution at pH 7.3 (Lindsay and Norvell (1978)) was employed to extract micro-nutrients (Fe, Mn, Cu, and Zn) from Organic fertilizers, and the Organic fertilizers extracts were analyzed using atomic absorption spectrophotometer. (Allison 1965) modified the Walkley-Black technique to measure total organic carbon (Table 2).

Table 2. Chemical analysis of organic fertilizers used for the pot experiment

Organic fertilizers	pH	EC dSm ⁻¹	O.C (%)	N	P	K (%)	Mg	Ca	Fe	Zn Mn Cu		
										(mg/kg)		
Vermicompost	6.9	4.48	19.2	1.58	1.09	1.05	0.54	1.13	2750	159	115	68
Town refuse	7.4	2.3	20.5	1.47	0.48	0.83	1.06	1.82	980	122	89	40

Experimental Procedures

At Alexandria University's Faculty of Agriculture (Saba Basha), there was a pot experiment in the greenhouse. Two seedlings per pot were selected from uniform seedlings of leek (*Allium porrum L.*) and onion (*Allium cepa L.*), each with two or three pairs of completely grown leaves. Basal applications of N, P, and K fertilizers were added to each kg of soil at the rate of 120 mg N as NH₄NO₃, 120 mg K as K₂SO₄, and 150 mg calcium superphosphate. For every pot, three equal doses of the N fertilizer were added at a rate of 40 mg/20 ml of water. The soil was placed in the pots after the P and K fertilizers were added. Four rates of vermicompost and town

refuse were applied as follows: 0, 10, 15, and 20 tons/fed before filling the pots with soil. Tap water was used to water pots regularly until 70% of the soil field capacity was reached. After 45 days of transplanting, every plant was collected. The roots and shoots were separated. From the base to the tip of the tallest leaf, the height of the plant was measured by a meter ruler (Fageria et al. 2006). Distilled water and tap water were used to wash the shoots. After being dried for 48 hours at 70 °C (Steyn, 1959) to a consistent weight in a forced-draft oven, the shoots were weighed, recorded, and milled for analysis. H₂SO₄-H₂O₂ was used to wet digest plant material samples (Lowther 1980).

Quantifying root length (RL)

Using a 0.5-mm sieve, we extracted half of the plant roots from the soil and rinsed them with tap water. For two to three minutes, layers of paper towels were placed over the roots to absorb any last traces of moisture (Schenk and Barber, 1979). Using the line intersect method, three root samples weighing 0.3 g of fresh weight were utilized to calculate the (RL) which can be calculated using the following equation (1) (Tennant, 1975).

$$RL \text{ (cm)} = \frac{RFW}{0.1 \text{ g}} \times N \times 1.5714 \quad (1)$$

Where RL= root length (cm), RFW = root fresh weight (g), N =sum of horizontal and vertical crossing.

- Root surface area (SA)

Surface area of a 1 cm root cylinder (SA) was calculated as follows (2) (Barber 1995).

$$SA = 2\pi \times r_0 \times RL \quad (2)$$

Where:

SA= surface area of the root cylinder

r₀ = root radius

RL = root length.

- Root Radius (r₀)

Estimation of root radius (r₀) (cm) was based on the assumption that the specific weight of root is almost equal to that of water, 1 g cm⁻³ (Barber 1995) as follows (3).

$$r_0 = \sqrt{\frac{RFW}{\pi RL}} \quad (3)$$

Where

RFW = total root fresh weight

RL = root length.

- Mean half distance between roots (r₁)

Mean half distance between neighboring roots (r₁) was calculated according to the following formula (4) (Schenk and Barber, 1979).

$$r_1 = \sqrt{\frac{V}{\pi RL}} \quad (4)$$

Where

V= volume of the soil in the pot (cm³).

RL= root length per pot.

Microbial biomass in soil

The techniques outlined by (Vance et al. 1987) served as the foundation for the measurements of microbial biomass C. Purified CHCl₃ was used to fumigate the soil samples for a whole day. Following the removal of the CHCl₃, 0.5 M of K₂SO₄ was used for one hour on an end-over-end shaker to extract the C from both fumigated and non-fumigated samples. Samples that had been fumigated and those that had not were filtered successively using filter paper (Whatman filter grade 42). A spectrophotometer was used to measure the liquid supernatant at 280 nm.

Phosphorus content in plant and soil

The content of phosphorus in plants was measured using the vanadomolybdophosphoric technique (Jackson 1973). Using the NaHCO₃ (0.5 N, pH = 8.5) method (Olsen et al. 1954), the available P in the soil was collected at harvest time, and its concentration was determined using the ascorbic acid molybdenum blue method at a Spectrophotometer wavelength of 406 nm Murphy and Riley (1962).

The vanadomolybdophosphoric approach was used to determine the amount of phosphorus present in plants (Jackson 1973). The available P in the soil was collected at harvest time using the NaHCO₃ (0.5 N, pH = 8.5) method (Olsen et al. 1954). Its content was then measured using the ascorbic acid molybdenum blue method at a spectrophotometer wavelength of 406 nm Murphy and Riley (1962).

Statistical methods

According to Gomez and Gomez (1984), the treatments were set up in a randomized complete block design (RCBD) with six replicates. Duncan's LSD was used to compare the treatments using the CoStat computer tool (CoStat, Ver. 6.311, 2005) at a 5% level of probability.

Results and discussion

Plants dry weight

The plant dry weight of leek and onion increased significantly with increasing vermicompost and town refuse rates (Fig. 1). Stated differently, the plant dry weight of leek and onion at high vermicompost rates (20V) was raised by about 2.32-fold and 2.29-fold than the plant dry weight of leek and onion without vermicompost (control), respectively. In addition, the plant dry weight of leek and onion treated with high town refuse rates (20T) increased by about 2-fold and 1.95-fold compared with the control, respectively.

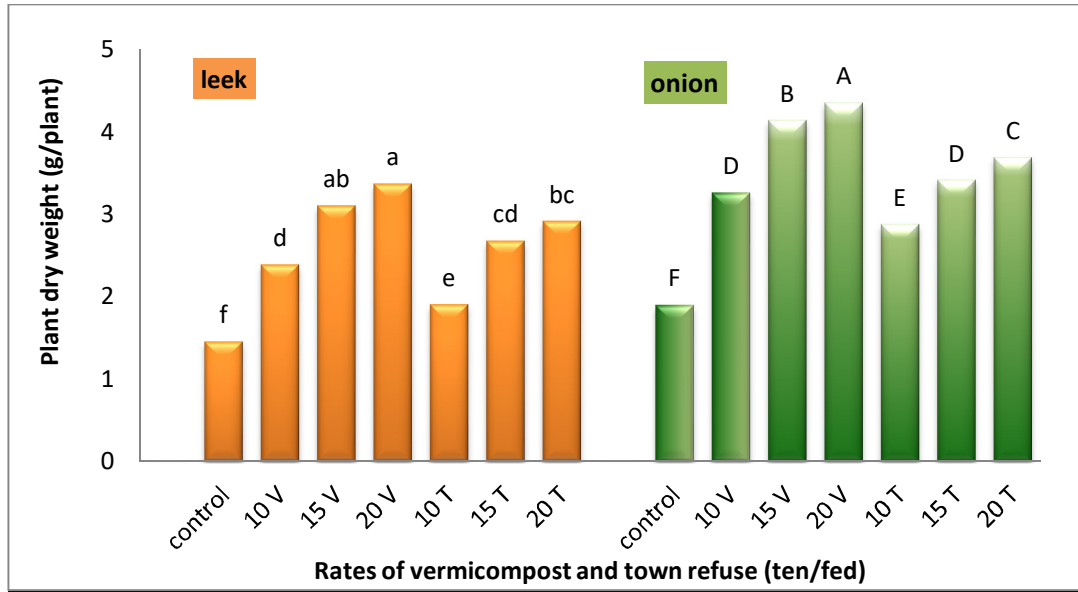


Fig. 1 Plant dry weight (g/plant) of leek and onion plants that are impacted by different rates of vermicompost and town refuse

(different letters denote significant variations between rates of vermicompost and town refuse, $P \leq 0.05$), small letters for leek and capital letters for onion plants

The plant dry weight of both leek and onion at each rate of vermicompost was significantly higher than the same rate of town refuse. Otherwise, the dry weight of leek at high vermicompost rates (20V) rose by about 1.15 fold compared to the dry weight of leek at high town refuse rates (20T). Similarly, the dry weight of onions at high vermicompost rates (20V) increased by about 1.18 fold compared to the dry weight of onion plants at high town refuse rates (20T). The same trend was observed for different organic fertilizer rates.

In the present study, the plant dry weight of both leek and onion increased significantly with adding and increasing organic fertilizers (vermicompost and town refuse) rates. This result is consistent with (Elsayed et al. 2020) who found that using organic fertilizers enhances the growth of plants. Organic fertilizers improve soil's physical, chemical, and microbial properties which lead to enhance the growth of plants and increased crop production (Ye et al. 2022).

The plant dry weight of leek and onion at each rate of vermicompost was significantly higher than the same rate of town refuse. This result agrees with (Dheware et al. 2020) who found that higher growth in guava (*Psidium guajava* L.) by application of vermicompost compared to other organic sources. (Pawar et al. 2020) found that using vermicompost improved the yield, growth, and fruit quality of sweet oranges. Vermicompost contribution to enhance the soil's fertility and health may help explain this beneficial impact on plant growth (Al Jaouni et al. 2019). Because vermicompost contains several necessary nutrients, such as P and K, it encourages the appearance of plants (Fernández-Gómez et al. 2010). Vermicompost's increased microbial activity promotes better plant growth. (Rehman et al. 2023). According to (Ravindran et al. 2019), humic acid and plant hormones, which are necessary for plant growth, are abundant in vermicompost. (Manivannan et al. 2009) state that the application of vermicompost enhanced the physical properties of the soil, facilitating cation exchange, greater water drainage, plant root aeration, and a longer supply of nutrients. The plants then absorbed the nutrients, which improved growth and increased bean development, yield, and quality. Vermicompost contains a variety of

enzymes, including cellulase, lipase, chitinase, and amylase, which can decompose organic material in the soil to produce nutrients that plant roots can access (Chaoui et al. 2003). The process of increasing photosynthesis through chlorophyll biosynthesis involves the uptake of plant nutrients such as nitrogen, and magnesium that is supplied by vermicompost (Al Jaouni et al. 2019). High concentrations of humic acids, auxins, and cytokines found in vermicompost might additionally play a significant role in the growth of plant height, shoot dry weights, and leaf area (Arancon et al. 2011).

Root growth

Based on root growth parameters (root length (RL) and root surface area (SA), as shown in (Figs 2 and 3), RL and SA of both leeks and onions increased significantly with increasing vermicompost and town refuse rates. In contrast, the mean half distance between roots (r_1) decreased with increasing vermicompost and town refuse rates (Fig. 4).

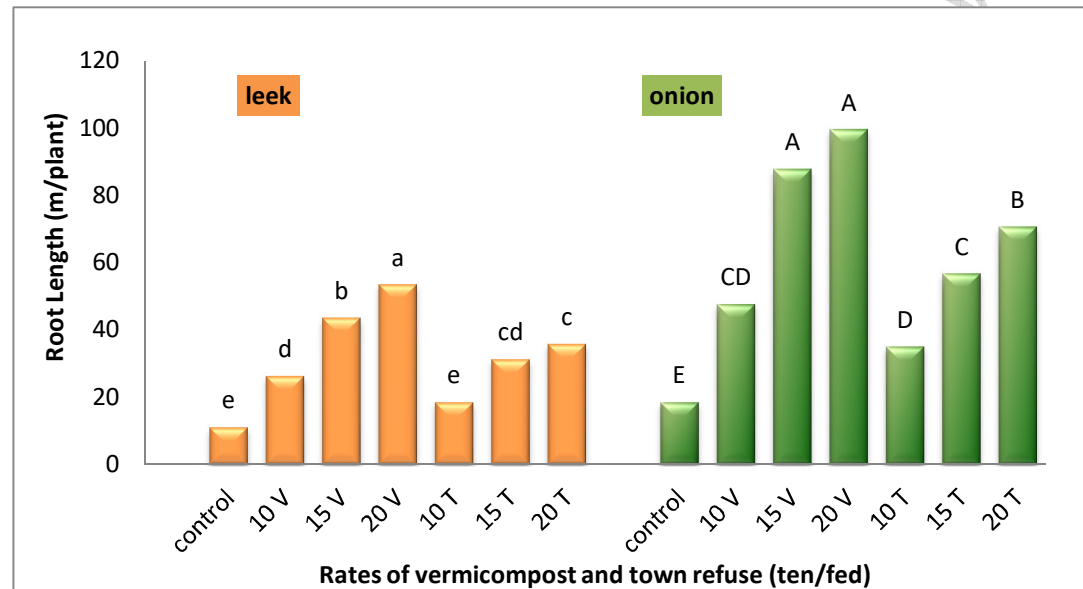


Fig. 2 Root length (m/plant) of leek and onion plants that are impacted by different rates of vermicompost and town refuse

(different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants)

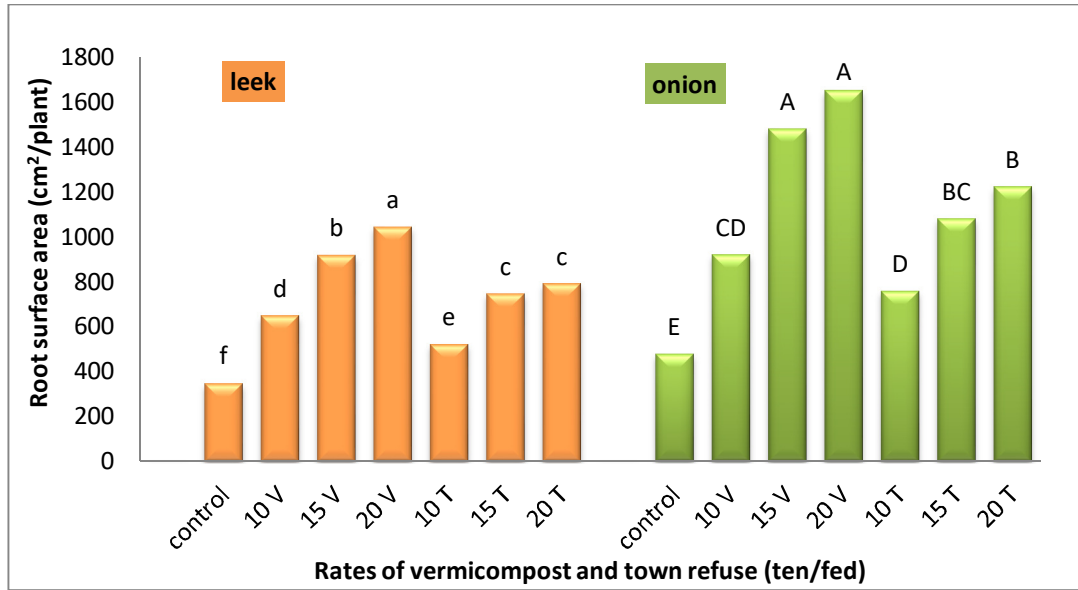


Fig. 3 Root surface area (cm²/plant) of leek and onion plants that are impacted by different rates of vermicompost and town refuse (different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants).

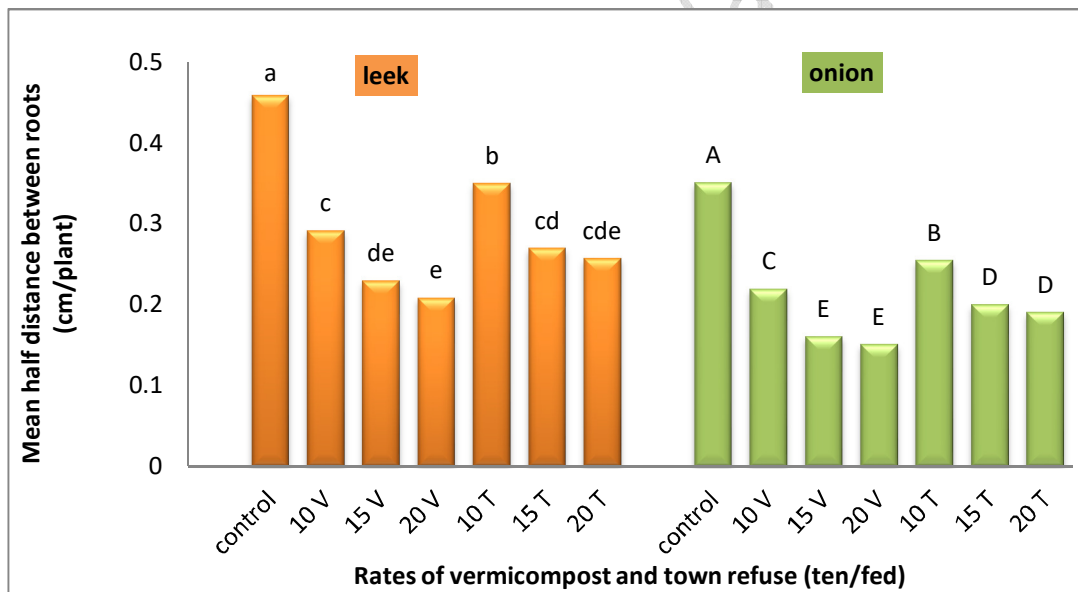


Fig.4 Mean half distance between roots (cm/plant) of leek and onion plants that are impacted by different rates of vermicompost and town refuse (different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants).

The root growth of both leek and onion increased significantly with increasing organic fertilizers (vermicompost and town refuse) rates. Similarly, (Nagavardhanam 2017) found that using organic fertilizers enhances plant root growth.

The root growth of leek and onion at each rate of vermicompost was significantly higher than the same rate of town refuse supply. Likewise, (Jjagwe et al. 2020) discovered that higher root growth in Maize (*Zea mays L.*)

when vermicompost was applied compared to other organic sources. Along the same vein, (Rashtbari et al. 2020) stated that the use of vermicompost rose the root growth of canola in comparison to plant canola application with town refuse. Also, (Ravindran et al. 2019) found that vermicompost could be applied as a soil amendment to enhance the root growth because it is rich in substances required for plant development, such as humic acid and plant hormones. Humic acid and physiologically active substances such as plant growth regulators are found in higher concentrations in vermicompost (Parthasarathi 2006). Furthermore, increasing root dry weight was seen in vermicompost due to its high cytokinin, auxin, and humic acid concentrations (Arancon et al. 2011). Applying vermicompost might raise the amount of phosphorus, nitrogen, and organic matter in the soil, which would encourage the growth of plants and root length (Zhang et al. 2011). Additionally, vermicompost possesses some hormones that can enhance the growth of plants, increase root biomass, and encourage the beginning of roots (Bachman and Metzger (2008). In an environment rich in nutrients and hormones, root development and branching increase (Forde and Lorenzo (2001).

RL and SA of both leek and onion at each rate of vermicompost were significantly higher than the same rate of town refuse. In contrast, r_1 of both leek and onion at each rate of town refuse was significantly higher than the same rate of vermicompost.

Phosphorus in plant and soil

Plant phosphorus content

The outcomes demonstrated that both plants P concentrations (leek and onion) increased significantly with increasing vermicompost and town refuse rates (Fig. 5).

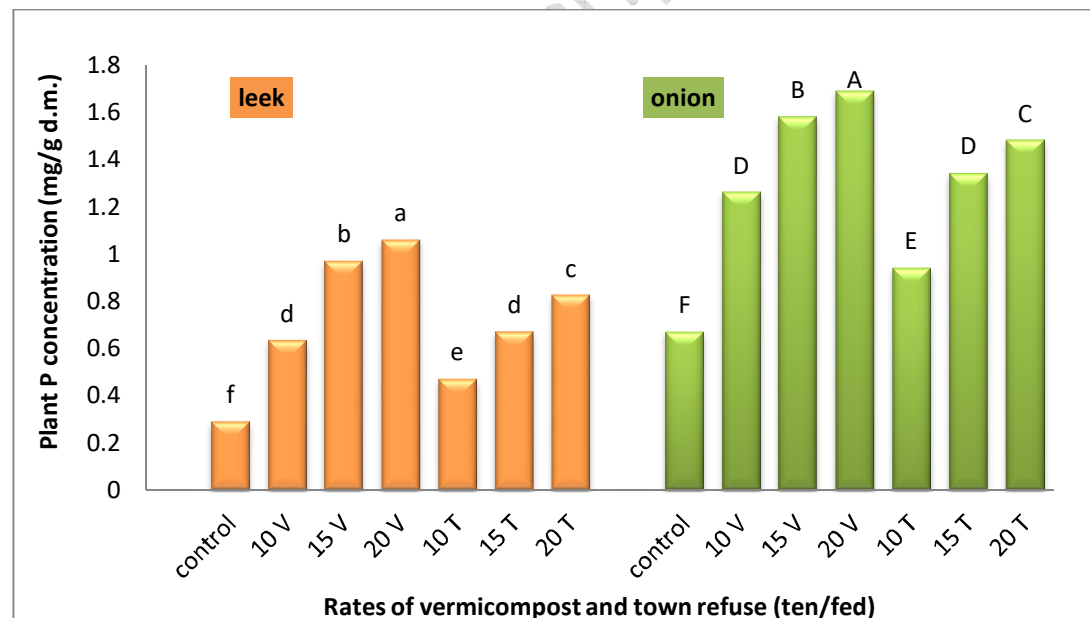


Fig.5 Plant P concentration (mg/gd.m.) of leek and onion plants that are impacted by different rates of vermicompost and town refuse

(different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants.

At each rate of organic fertilizers, the P content of plants treated with vermicompost was significantly higher than the town refuse. In other words, the plant P content of leek at high vermicompost rates (20V) raised by about 1.28 fold than the plant P content of leek at high town refuse rates (20T). In the same line, the plant P content of leek at rates (15V and 10V) increased by about 1.44 and 1.43 fold than the plant P content of leek at rates (15T and 10T) respectively. Also, the plant P content of onion at vermicompost rates (10 V, 15 V, and 20 V) increased by (1.34-fold; 1.17-fold; and 1.14-fold) compared to the plant P content of onion at town refuse rates (10 T, 15 T and 20 T) respectively.

The plant P uptake and soil available phosphorus increased significantly with increasing vermicompost and town refuse rates as compared to the same plants without organic source addition.

Plant phosphorus uptake

The response of plants P to increase vermicompost and town refuse rates was vigorous (Fig. 6). In other words, the plant P uptake of leek at high vermicompost and town refuse rates (20 V and 20 T) had about 8.35-fold and 5.65-fold than the plant P uptake of leek without vermicompost and town refuse rates application (control) respectively. In the same line, the plant P uptake of onion at high vermicompost and town refuse rates (20 V and 20 T) had about 6.36-fold and 4.59-fold than the plant P uptake of onion without adding organic sources (control) respectively.

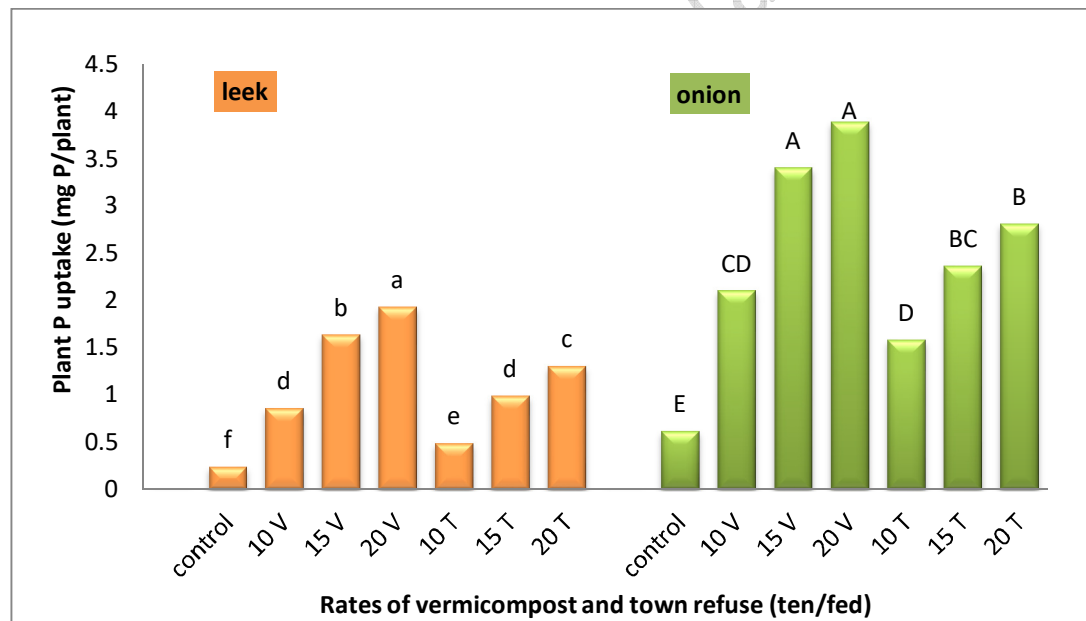


Fig.6 Plant P uptake (mg P/plant) of leek and onion plants that are impacted by different rates of vermicompost and town refuse

(different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants.

The plant P uptake of both leek and onion at each rate of vermicompost was significantly higher than the same rate of town refuse. In other words, the plant P uptake of leek treated with vermicompost rates (10 V, 15 V, and 20 V) raised by (1.74-fold; 1.65-fold; and 1.48-fold) as compared to the plant P uptake of leek treated with town refuse rates (10T, 15T and 20T) respectively. In the same line, the onion P uptake with vermicompost rates (10

V, 15 V, and 20 V) raised by (1.33-fold; 1.44-fold; and 1.38-fold) compared to onion P uptake with town refuse rates (10T, 15T and 20T) respectively.

Along the same vein, (Syarifinnur et al. 2022) found that plant P uptake of maize and soil available phosphorus increased with increasing organic fertilizers. The high rates of vermicompost application provided uptake of P in plants (Paul and Bhattacharya 2012). Vermicompost enhanced available nutrients, which led to increasing leaf nutrient concentrations in mango (Adak et al., 2014). Furthermore, because vermicompost contains P (Fernando and Arunakumara 2021) and humic acids (Arancon et al., 2005).

Available phosphorus in soil

The available phosphorus in soil increased significantly with adding and increasing vermicompost and town refuse rates (Fig. 7).

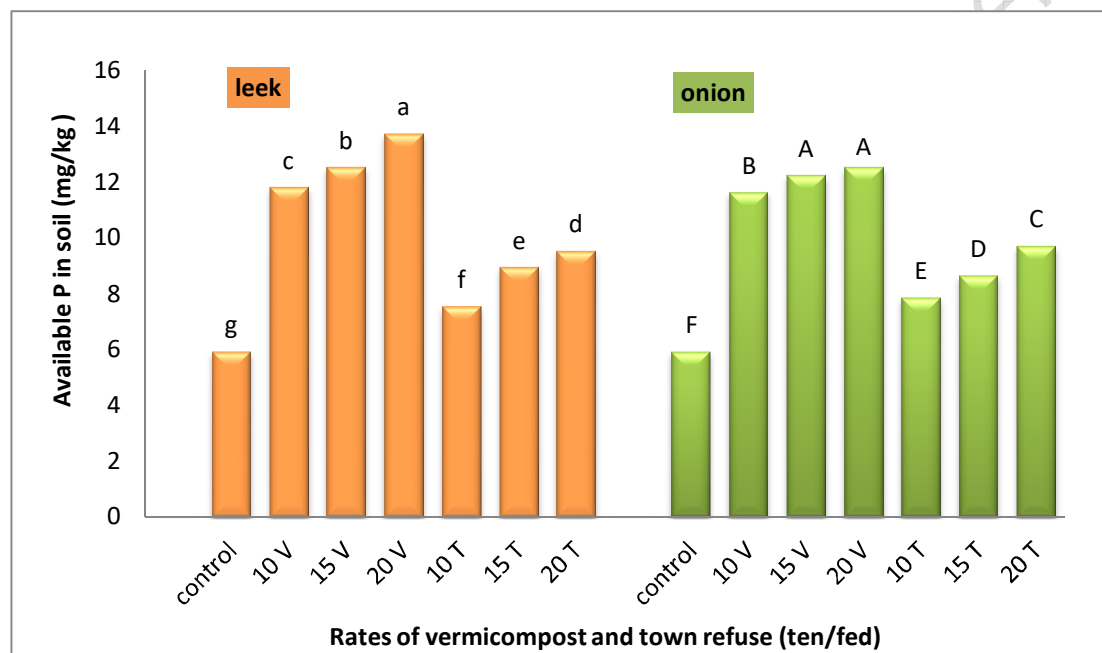


Fig.7 Available P in soil (mg/kg) of leek and onion plants that are impacted by different rates of vermicompost and town refuse

(different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants.

At each rate of vermicompost, the soil available phosphorus was significantly higher than the same rate of town refuse. In other words, the available phosphorus in the soil planted with leek at all vermicompost rates (10 V, 15 V, and 20 V) raised by (1.57-fold; 1.4-fold; and 1.44-fold) compared to soil available phosphorus planted with leek at all town refuse rates (10 T, 15 T and 20 T) respectively. In the same line, the soil available phosphorus planted with onion at vermicompost rates (10 V, 15 V, and 20 V) increased by about (1.48-fold; 1.41-fold; and 1.29-fold) compared to the soil available phosphorus planted with onion at all town refuse rates (10 T, 15 T, and 20 T) respectively.

The plant P uptake and soil available phosphorus of both leek and onion plants at each rate of vermicompost supplied was significantly higher than the same rate of town refuse. Similarly, the vermicompost application

Provided P uptake in guava (Abou El Seoud et al. 2022). (Al Jaouni et al. 2019) also discovered that the date palm fruit plant's P content increased when applying vermicompost. Also, the vermicompost application provided P uptake in plants due to the presence of humic acids (Arancon et al. 2005) addition of vermicompost led to increase microbial activity which led to an increase in plant P uptake (Manivannan et al. 2009). Furthermore, vermicompost has a high concentration of P organic and inorganic chemicals, which microorganisms may readily transform into forms that are useful (Khosravi et al. 2018).

Soil microbial biomass

The microbial biomass in the soil improved significantly with adding and increasing vermicompost and town refuse rates (Fig. 8). In other words, the response of microbial biomass in the soil to increase vermicompost and town refuse rates was vigorous.

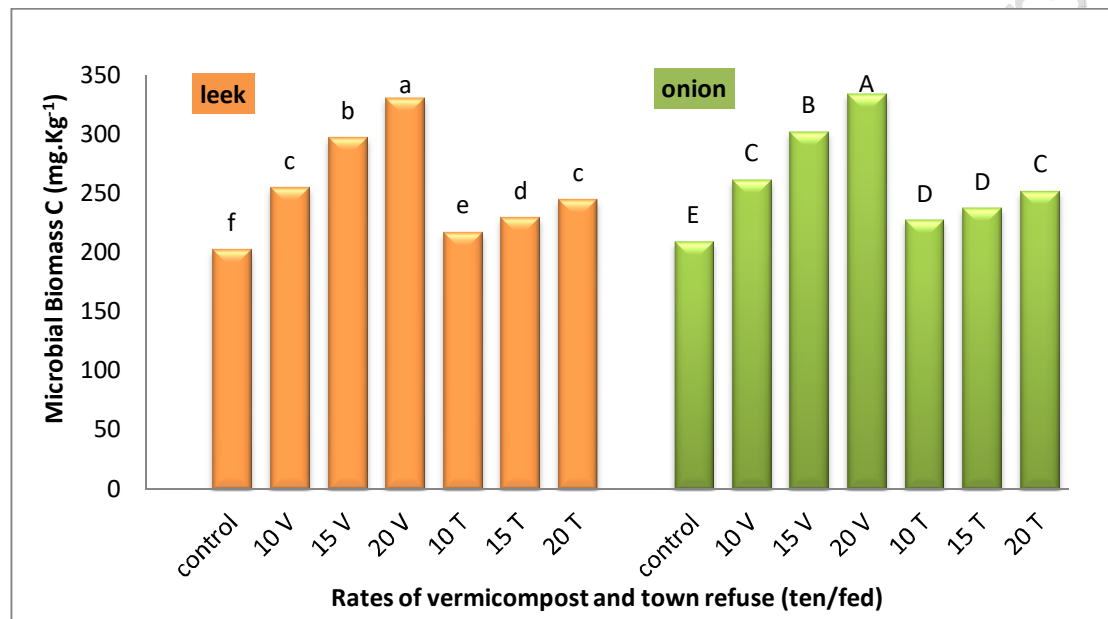


Fig.8 Microbial Biomass C (mg. Kg⁻¹) of leek and onion plants that are impacted by different rates of vermicompost and town refuse (different letters denote significant variations between rates of vermicompost and town refuse, ($P \leq 0.05$), small letters for leek and capital letters for onion plants).

The microbial biomass in the soil at each rate of vermicompost was significantly higher than the same rate of town refuse. In other words, the soil microbial biomass cultivated with leek at all vermicompost rates (10 V, 15 V, and 20 V) was augmented by (1.17-fold; 1.29-fold; and 1.35-fold) compared to the soil microbial biomass planted with leek at all town refuse rates (10 T, 15 T and 20 T) respectively. In the same line, the soil microbial biomass planted with onion at all vermicompost rates (10 V, 15 V, and 20 V) was augmented by about (1.15-fold; 1.27-fold; and 1.32-fold) compared to the soil microbial biomass planted with onion at all town refuse rates (10 T, 15 T and 20 T) respectively.

The soil microbial biomass increased significantly with increasing vermicompost and town refuse rates. In the same line, Pathma and Sakhivel (2012) found that vermicompost causes increasing soil microbial biomass. Similarly, (Liu et al. 2003) showed that organic fertilizers increased soil microbial biomass. Using organic fertilizers with soil will build up high bacterial populations that improve plant growth (Ali Saab et al. 2021).

The soil microbial biomass at each rate of vermicompost was significantly higher than the same rate of town refuse. (Gómez-Brandón et al. 2016) showed that vermicompost increased soil microbial biomass. Several researches have shown that applying vermicompost, increased soil organic matter, biomass of soil microorganisms, and microbial soil activity (Al-Tawarah et al. 2024). The vermicompost material contained a great population of fungi and bacteria Singh and Suthar (2012). The counts of bacteria increased due to the Passage of waste into the worms' digestive tract (Koubová et al. 2015). The addition of substrate carbon in organic residues stimulates the indigenous soil microbiota so soil microbial biomass increases with increasing vermicompost rates (Kumar et al. 2017).

Under the same conditions of this experiment, we can recommend that, adding the high rate of vermicompost was achieved better growth and P content in soil and plant for both plants. Also, we still need more studies for other plants, different soil types, comparisons with other organic sources, and higher rates of vermicompost.

Conclusion

Under the same conditions of this experiment, we can recommend that a rate of 20 tons/fed of vermicompost achieve better growth and P content in soil and plant for leek and onion. Indeed, our finding showed that available phosphorus in soil increased significantly with adding and increasing vermicompost and town refuse rates; in addition, soil microbial biomass increased with increasing vermicompost rates. The response of plants P to increase vermicompost and town refuse rates was vigorous. However, we still need more studies for other plants, different soil types, comparisons with other organic sources, and higher rates of vermicompost.

Author Contributions: Conceptualization and design of the work, E.R.M. and A-E.I.I.; methodology, E.R.M. and A-E.I.I. and M.A.A.A.; software, E.R.M., and M.A.A.A.; formal analysis, M.A.A.A. and E.R.M.; investigation, A-E.I.I. and R.J.B.; resources, A-E.I.I. and R.J.B.; writing—original draft preparation, E.R.M. and A-E.I.I. and M.A.A.A.; writing—review and editing, A-E.I.I. and R.J.B. All authors provided critical feedback and helped shape the research, analysis and manuscript. Also, all authors discussed the results and contributed to the final manuscript. All authors read and approved the final manuscript.

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