

Combined use of compost, compost tea, and vermicompost tea improves soil properties, and growth, yield, and quality of (*Allium cepa* L.)

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Abstract

Liquid organic fertilizers are organic solutions that are a valuable choice for sustainable agriculture. In addition, these organic forms play a significant role, in integrated waste management strategies. In this study, a one-way analysis of variance, Pearson correlations and principal component analysis were performed on all traits, to compare the responses of sole application of compost, compost tea, vermicompost tea and their combinations on growth, yield of *Allium cepa* and on soil properties. The results showed that, in most cases with fertilizers treatments, the soil pH, CaCO₃ and bulk density were decreased, while soil organic matter, total N, available P and K were increased. A mixture of 50% compost, 25% compost tea, and 25% vermicompost had more desirable effect on plant height, leaves number, plant fresh weight and plant dry weight. Therefore, application of 50% compost tea and 50% vermicompost tea, it is possible to achieve an acceptable total bulb yield ton/ha, total soluble solids %, and dry matter %. While, available P, K in soil and P % in plant were raised when plants treated with teas sole or combined with compost 50%. Using a mixture of 50% compost, 25% compost tea, and 25% vermicompost tea, was a higher nutrient concentration and had a significant impact on onion plants productivity, and on soil properties.

Keywords: agricultural sustainable; liquid organic fertilizers; onion; PCA; soil characteristics; storability

Introduction

Onion (*Allium cepa* L.) is one of the most widely grown vegetables in the world, and it eaten fresh, as a condiment, or processed. In Egypt, onion is grown not only for local consumption, but also for exportation. Its total cultivated area is approximately 87948 ha, with a total production of approximately 3.0810 million tonnes (FAO, 2019). In 2020, onion total exports were 428 (thousand tons). Using the simultaneous model designed

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by (Bahloul and Abdel Fatah, 2019), it is expected that the total domestic output is anticipated to reach around 3620 thousand tons in 2025, indicating a thirty percent increase over its value in 2020.

Several factors influence agricultural production and productivity. Fertilizers are one of the most important input elements that considerably contributes to crop yield. Lack application of the optimal fertilizers dose might be a significant restriction to maximum onion output. Nitrogen (N) stimulates carbohydrate synthesis while increasing vegetative growth and producing high quality leaves. Potassium (K) is required for leaf photosynthetic activity because it aids in food transport. Aside from that, plants require far more potassium than the soil can provide. (Thompson, 1978; Shamima and Hossain, 2000).

In order to produce larger bulb yields, onions receive excessive quantities of inorganic fertilizers. On the other hand, chemical fertilizers have number of negative consequences for the environment and human health. In addition, synthetic fertilizers are rapidly loss by leaching in drainage water, posing a serious threat to the ecosystem. (Aisha *et al.*, 2007; Hernandez *et al.*, 2010; Shedeed *et al.*, 2014). However, as compared to other vegetable crops, onion consumes mineral fertilizers voraciously and exhausts a disproportionately high amount of nutrients during the growth season. For example, in high yielding locations where onion bulb output might exceed 42 t/ha, onion uses around 145-370 kg N ha. (FAO, 2005).

Therefore, it is necessary to find reliable and effective solution for reducing chemical fertilizers. Recently, Hassanein *et al.* (2021) recommended to involve biostimulants in fertilization programs for achieving a sustainable production system of horticultural crops. Use of organic amendments has been found effective for improving soil aggregation, structure, and fertility, increasing soil microbial diversity, populations, and enzymes, improving moisture-holding capacity of soils, increasing cation exchange capacity (CEC), and finally crop yields (Albiach *et al.*, 2000; Tejada *et al.*, 2018).

Organic matter considered one of the most important factors in maintaining the quality of the soils, because of their role in maintaining soil fertility by decreasing nutrient losses and provides nutrients to the soil in particular nitrogen. In addition, improves soil water holding capacity and helps to improve the soil structure (Amlinger *et al.*, 2007).

Compost is defined as an organic nutrient fertilizer; compost contains amounts of important plant nutrients such as N, P, K, Mg, S, and Ca as well as a diversity of essential micronutrient (Madeleine *et al.*, 2005; Amlinger *et al.*, 2007; Agegnehu *et al.*, 2014). Compost can help to increase productivity and sustainable agriculture by improve plant health, yield and nutritive quality. Moreover, compost can resolve the problem of decreased soil fertility (Madleine *et al.*, 2005). However, crop yields after mineral fertilization are mostly higher compared to pure compost (Amlinger *et al.*, 2007). Compost had a positive effect on the soil structure by lowering soil bulk density because the organic matters is much lighter in weight than the mineral fraction in soils. This positive effect has been associated with an increase in soil porosity with increasing rate of compost (Liu *et al.*, 2007; Brown and Cotton, 2011).

Most important benefit of compost is increased soil organic matter content, supply plant available nutrients and stimulating the growth of plants (Doan *et al.*, 2015). Application of compost at high rates led to increase of N, P and K content in plant (Soheil *et al.*, 2012). Compost tea is water extract of compost, produce by mixing compost with water, retains all the useful components such as, soluble bioactive components, macronutrients and micronutrient nutrients. So, it can increase the soil fertility and improvement of plant growth by addition nutrients, provide nutrients to plants, improve overall health of plants increase microbial population densities in the soil (Nosb, 2004; Scheuerell *et al.*, 2002; Griffin and Hutchinson, 2007; Scheuerell, 2003).

One of the most important benefits of compost tea is improving soil fertility by supplying essential nutrients that can remediation nutritional efficiencies during plants growth (Zaccardelli *et al.*, 2018). Application of vermicompost teas increase plant growth by improving the nutrient status of plants, enhancing beneficial microbial communities (Weltzein, 1991; Carpenter-Boggs, 2005).

Given the potential agronomic, economic, and environmental benefits of replacing or partial replacing of mineral fertilizers with solid and liquid organic fertilizers to intensive cropping cultivation under arid

conditions, it is critical for researchers to continue looking for methods to establish quantitative benchmarks for new strategies. This may be used to justify replacing chemical fertilizers that are relatively harmful to the environment with solid and liquid organic fertilizers in order to improve soil fertility and, as a result, boost crop yield. From this point, the purpose of the present study was to determine the effectiveness of compost, compost tea and vermicompost tea on some soil properties, growth and yield of onion (*Allium cepa* L.) plants.

Materials and Methods

Experimental site and soil analysis

Field experiments were conducted during two successive winter seasons 2019 and 2020 at the Experimental Research Farm, Faculty of Agriculture, South Valley University, Qena, Egypt. The site is located at (latitude 26° 11' 22.2" N to Longitude 32° 44' 25.5" E), and 81 m above sea level. The physical and chemical characteristics of the experimental soil were evaluated using a composite soil sample taken prior to the commencement of the experiment from a soil layer 0-30 cm¹ deep (Brady, 1990). These properties were shown in (Table 1). The physical and chemical soil characteristics were determined according the method described by (Okalebo *et al.*, 2002).

Table 1. Physical and chemical properties of the soil used in this experiment

Sand	Silt	Clay	Texture	pH (1:2.5)	EC (dS m)	Calcium Carbonate (%)	Organic Matter (%)	Total N (%)	Available P (mg/kg)	Available K (mg/kg)
70	25	5	Sandy loam	7.99	0.55	9.98	0.74	0.015	3.41	114

Experimental design and treatments

The field experiments were arranged in a randomized complete block design (RCBD) with three replications. The experimental field was divided into three main blocks with a size of 28 m × 4 m for each and one-meter buffer zone between them. Thereafter, each block was divided into eight plots with a size of 2.5 m × 4 m for each and one-meter buffer zone between them. The experiment included eight treatments representing different combinations of compost, compost tea and vermicompost tea, in addition to the control treatment (without additions). The different treatments that were used in these experiments are as follow: T0: C: control (without additions), T1: CN: compost (100% compost as recommended N), T2: CT: compost tea (100% compost tea as recommended N), T3: VCT: vermicompost tea (100% vermicompost tea as recommended N), T4: CN+CT: compost + compost tea (50% compost + 50% compost tea), T5: CN+VCT: compost + vermicompost tea (50% compost + 50% vermicompost tea), T6: CT+VCT: compost tea + vermicompost tea (50% compost tea + 50% vermicompost tea), T7: CN+CT+VCT: compost+ compost tea+ vermicompost tea (50% compost + 25% vermicompost tea+ 25% compost tea).

Cultural practices

The onion seeds were sown in the nursery on the 1st and 8th September in 2019 and 2020 seasons, respectively. Nursery bed was prepared and planted with onion seeds (cv. Improved Giza 6) and transplanting took place on 21st November in both seasons. The plot size was 2.5 m in length and 4 m in width including five ridges with 60 cm a part with total area of 10.5 m². Ridging direction was north-south (NS). Transplants were placed on both sides of the ridge at 7 cm between plants. The quantities of compost and two types of teas were calculated based on nitrogen recommended dose in sandy loam soil (240 kg ha.), that were about (CN: 5kg/m²; CT: 10l/m²; and VCT: 6l/m²) compost tea and vermicompost tea were applied at three stages: when seedlings were planted, two weeks later, and lastly after 60 days.

Preparing compost, compost tea and vermicompost teas

In this experiment, organic wastes from mixture of horticultural crops residuals, tree leaf and field crops wastes were collected from Experimental Research Farm, Faculty of Agriculture, South Valley University, Egypt. Poultry litter and cow dung were obtained from Animal Experimental Farm, Faculty of Agriculture, South Valley University.

The organic wastes used in the current experiment were digested, air dried for several days and then mechanically crushed into smaller size particles. Next, the crushed wastes were thoroughly mixed together, divided into piles, the composted was done using Passively Aerated Composting Technique in a pile (PACT). During the composting phase, the pile was mechanically flipped upside down and watered weekly for the first month to establish appropriate aeration conditions, then twice a month thereafter, as described by (Misra *et al.*, 2003). After 100 days of composting and for composting pile, several samples were taken from various locations, to create one composite sample. The compost properties are presented in (Table 2).

Vermicompost samples were collected from vermicompost Production unit, Faculty of Agriculture, South Valley University. Compost tea and vermicompost tea were prepared using aerated extraction method where compost or vermicompost and tap water were mixed at a ratio of 1:10 (w/v) and manually agitated for 7 days. The suspension was purified to remove unfavourable solid particles. as described with some modification by (Arumugam *et al.*, 2017). Then samples of compost tea and vermicompost tea were taken, to determine characteristics, the liquid organic fertilizer characteristics are presented in (Table 2).

Soil analysis

The particle-size distribution was carried out by the pipette method (Richards, 1954; Jackson, 1969). Bulk density was carried out by collecting a known volume of soil using a metal ring pressed into the soil (intact core) and determining the weight after drying (McKenzie *et al.*, 2004). Total calcium carbonate content (CaCO₃ %) was estimated by a Collins calcimeter according to (Jackson, 1973).

The soil organic carbon content was determined according to the modified Walkley and Black method (USDA, 1996). The soil pH in a 1:2.5 ratio of the soil to water suspension was measured using a digital pH meter. The electrical conductivity (EC) of the 1:5 ratio of soil to water extract was estimated using an electrical conductivity meter Jackson (1973). The available phosphorus was extracted by 0.5 M NaHCO₃ at pH 8.5 (Olsen *et al.*, 1954) and spectrophotometrically determined according to (Jackson, 1973). The available potassium was extracted with 1 N ammonium acetate at pH 7.0 and determined using the flame photometer (Jackson, 1973). The total soil nitrogen was determined using the micro Kjeldahl method as described by (Jackson, 1973).

Organic fertilizers analysis

After taken compost sample directly, pH and EC were measured in 1:10 (w/v) of water suspensions and extracts respectively after 1 h shaking (Teutscherova *et al.*, 2018). Compost tea and vermicompost tea pH and EC were measured directly in the prepared suspension. The organic matter content of the compost was analysed after drying at 105 °C for 24 h by weight loss on ignition at 550 °C for 4h as recommended by (Møller *et al.*, 2000).

The organic matter content of the compost tea and vermicompost tea was determined by Walkley-Black wet digestion. Total organic carbon (TOC): The organic carbon was determined based on the average organic matter's containment of 58% total carbon (Nelson and Sommers, 1996) according to the following procedure. (TOC) = O.M × (58/100). Moreover, C/N ratio: The ratio of total carbon to total nitrogen is calculated depending to the following equation: C/N ratio = (% total carbon / % total nitrogen). In addition, a sample of 0.5 g of compost was digested using a 20:5 mixture of sulfuric acid to hydrogen peroxide. In addition, 25 ml from compost tea or vermicompost tea was digested using same previous mixture. And then potassium, phosphorous and nitrogen were determined in digests using the methods as described for the soil analysis.

Table 2. Some properties of compost, compost tea and vermicompost tea used in this study

Parameters	Compost	Compost tea	Vermicompost tea
pH (1:10)	8.14	7.93	7.72
EC (1:10), (dS/m)	2.15	2.93	3.92
Organic matter (%)	43.06	5.55	4.36
Organic carbon (%)	24.97	3.22	2.53
Total N (%)	1.2	0.25	0.40
C/N ratio	20.81	12.88	6.35
Total P (%)	0.98	0.09	0.07
Total K (%)	0.44	0.06	0.08

Bulb growth, yield, quality and storability measurements

At the growth stage of onion, after 75 days from transplanting, five plants were chosen randomly from each plot to determine characteristics of vegetative growth and nutritional status of onion plants. Plant height (cm), number of leaves/plant and plant fresh weight (g), plant dry weight (g), were measured. Chlorophyll reading was measured in leaves samples of the inner mature leaf by using Minolta Chlorophyll Meter SPAD 501. At the harvesting stage (120 days from transplanting date), total bulbs yield/ha. was calculated from plot yield, and average bulb weight (g). Some bulb quality characteristics were measured by taking ten bulbs from each replicate, to measure bulb diameter using a digital calliper at widest part of the bulb. As well as, bulb length (cm), bulb shape index using formula: bulb length/bulb diameter. The protein percentage was measured by multiplying N% by 6.25, and dry matter percentage of bulb were determined by drying plants for four hours at 105 °C and then at 70 °C in a drying oven with ventilator, until the weight reaches to a constant value, according to the following formula: sample dry weight/sample fresh weight × 100. Total soluble solids (TSS) were measured immediately by using Digital Refractometer. At storage stage, a representative sample of 50 healthy onion bulbs from each sub plot was selected to store at natural atmosphere for 4 months from end-May to end-September, to determine some bulb storability characteristics. Data of dry matter percentage and total soluble solids were estimated monthly during storage period. The percentage of weight loss was calculated at the end storage period according to equation. Weight loss (%) = (Initial weight of bulb – Weight of bulb at observation after storage / Initial weight of bulb) × 100.

Plant uptake

Fresh bulbs were collected from each treatment during harvesting stage, they were air-dried and weighed. Then, plant tissues samples were oven-dried at 70 °C for 72 hrs., sample of 0.5 g of the dried plant material was digested using a 20:5 mixture of sulfuric acid to hydrogen peroxide. Total nitrogen (N) content was determined with Kjeldahl digestion method. Phosphorus (P) content was determined spectrophotometrically, and potassium concentration was determined using flame photometry method, according to (Jackson, 1973).

Statistical analysis

The data of the plant and soil analysis were subjected to one-way ANOVA to assess the effect of different compost, compost tea and vermicompost tea on onion (*Allium cepa* L. cv. improved 'Giza 6') growth, yield, quality and storability characteristics. The differences among the treatments were analysed with Tukey multiple range test followed by standard error (SE) and differences were considered significant when $P \leq 0.05$. The analysis was performed with Minitab Statistics v 18.0, Graph prism 5 for graph. Pearson moment correlations were also performed for all measured parameters, and a principal component analysis (PCA) was used to check the similarity between the responses to the different organic fertilizers.

Results

Impact of compost, compost tea, and vermicompost on soil properties

The results showed that positive significant changes in soil characteristic during both seasons as compared with the soil before cultivation and control treatment, these changes are as it follows:

Organic Matter (OM%) content

The results showed that, in most cases, the sole and combined application of organic fertilizers, significantly improved the soil organic matter content, in comparison with the control treatment (Table 3). The most pronounced increases after the first season, of the soil OM% (1.83, 1.71, and 1.56%) were obtained in onion plants treated with 100% CN, 50% CN+25% CT+25% VCT, and 50% CN+50% CT, respectively, as compared with the control treatment (0.91%). While, after the second season, the soil OM% increases reached in (2.08, 1.96, and 1.81%) for the same previous treatments respectively compared with the control treatment (0.72%).

Soil pH

The results in Table 3 clearly showed that, after both seasons, applying most treatments under current study, resulted in significant decreases in the soil pH compared to both control treatment and the original soil pH (Table 1). The soil pH was influenced significantly after the first growing season, the soil pH decreases gradually (7.53, 7.67, and 7.70) in plants treated with 50% CN+50% CT, 50% CT+50% VCT, and 50% CN+25% CT+25% VCT, respectively, compared to the original soil pH (8.19). In addition, after the second season, they were (7.61, 7.56, and 8.17), respectively. The reductions in the soil pH after the end of experiment were more evident under compost applications alone or combined with compost tea and vermicompost tea compared to the sole application of compost tea or vermicompost tea.

Table 3. Effects of compost, compost tea and vermicompost tea on organic matter, pH, and EC of soil in both seasons

Treatments	Organic Matter %		pH		EC dS/m	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
C	0.91±0.04 ^d	0.72±0.08 ^e	7.93±0.03 ^{ab}	7.89±0.16 ^b	0.94±0.09 ^{bc}	0.74±0.00 ^f
CN	1.83±0.04 ^a	2.08±0.04 ^a	7.74±0.04 ^{cd}	7.59±0.03 ^{dc}	1.00±0.05 ^{bc}	1.02±0.05 ^d
CT	1.21±0.13 ^{cd}	1.33±0.13 ^{cd}	7.81±0.03 ^{bc}	7.62±0.02 ^{cd}	1.13±0.04 ^a	1.17±0.07 ^c
VCT	1.04±0.11 ^{cd}	1.16±0.11 ^d	8.04±0.03 ^a	7.73±0.05 ^c	0.91±0.01 ^c	0.99±0.00 ^d
CN+CT	1.56±0.10 ^{ab}	1.81±0.10 ^{ab}	7.53±0.05 ^e	7.61±0.04 ^{cd}	1.04±0.05 ^{bc}	1.28±0.02 ^b
CN+VCT	1.35±0.17 ^{bc}	1.56±0.18 ^{bc}	7.74±0.04 ^{cd}	7.72±0.005 ^{cd}	0.98±0.03 ^{bc}	0.87±0.01 ^e
CT+VCT	1.10±0.15 ^{cd}	1.27±0.16 ^{cd}	7.67±0.08 ^d	7.56±0.04 ^e	0.99±0.00 ^b	1.56±0.08 ^a
CN+CT+VCT	1.71±0.13 ^a	1.96±0.13 ^a	7.70±0.01 ^{cd}	8.17±0.01 ^a	0.51±0.01 ^d	0.40±0.01 ^s

C: control; CN: 100% compost only; CT: 100% compost tea; 100% VCT: vermicompost tea; 50% CN+50% CT: compost+ compost tea; 50% CN+50% VCT: compost+ vermicompost tea; 50%CT+50% VCT: compost tea+ vermicompost tea; 50% CN+25% CT+25% VCT: compost+ compost tea+ vermicompost tea. Distinct letters in the same column indicate statistically significant differences among treatments as determined by Tukey's honest significant difference (HSD) ($p \leq 0.05$).

Soil salinity (EC)

Electrical conductivity (EC) is considered as an indication of the soil salinity. EC was increased (1.13, 1.04, 1, 0.99 and 0.98 dS/m) for 100% CT, 50% CN+50% CT, 100% CN, 50% CT+50% VCT and 50% CN+50% VCT, respectively, compared to both control treatment and the original soil EC, in the first growing season. While, the values of EC were (1.17, 1.28, 1.02, 1.56 and 0.87) respectively, in the second season.

Generally, in most cases, the soil EC was raised, compared to the control treatment and the original soil (Table 3).

Soil total calcium carbonate (CaCO₃)

In comparison with the control treatment, both individual and combined of organic fertilizer application significantly decreases CaCO₃ content in the soil at the end of the current study (Table 4). At the beginning of the experiment, CaCO₃ content in the soil was (9.98%). The most decreased (5.97, 6.71, and 7.65%) was noted when plants treated with 100% CN, 100% VCT, and 100% CT, respectively. After the second season, these decrease in calcium carbonate continued for those previous treatments. Exhibiting more CaCO₃ reduction of (5.38, 6.23, and 7.08%), respectively.

Soil bulk density

Soil bulk density is an indicator of soil compaction and soil health, the application of all the treatments under study led to decreases in the soil bulk density values compared to the control (Table 4). The values were (1.58, 1.78, and 1.82 g /cm³ for 100% CN, 50% CN+25% CT+25% VCT, and 50% CN+50% VCT treatments respectively, compared to the control (1.91 g/cm³), in the first season. In addition, these decreases continued for those previous treatments. Exhibiting reduction of (1.52, 1.70, and 1.77 g/cm³), respectively, in the second growing season. Different decreases in soil bulk density were observed, with different application rates and type of organic amendments. Moreover, application of 100% compost was reduced the volume weight more than application of other treatments.

Table 4. Effects of compost, compost tea and vermicompost tea on CaCO₃% and Bulk density of soil in both seasons

Treatments	CaCO ₃ %		Bulk density	
	1 st season	2 nd season	1 st season	2 nd season
C	9.66±0.62 ^a	9.2±0.45 ^a	1.90±0.01 ^{ab}	1.91±0.01 ^a
CN	5.97±0.19 ^c	5.38±0.51 ^d	1.58±0.04 ^d	1.52±0.02 ^c
CT	7.08±0.58 ^{cd}	7.65±0.04 ^b	1.75±0.03 ^c	1.86±0.00 ^{bc}
VCT	6.71±0.1d ^c	6.23±0.37 ^{bc}	1.91±0.02 ^a	1.89±0.03 ^{ab}
CN+CT	9.45±0.26 ^a	7.5±0.29 ^b	1.76±0.01 ^c	1.88±0.00 ^{ab}
CN+VCT	8.05±0.45 ^{bc}	7.34±0.27 ^b	1.77±0.05 ^{bc}	1.82±0.01 ^c
CT+VCT	9.09±0.37 ^{ab}	7.22±0.01 ^b	1.76±0.11 ^c	1.87±0.01 ^{ab}
CN+CT+VCT	8.85±0.12 ^{ab}	9.2±0.45 ^{cd}	1.78±0.03 ^{abc}	1.70±0.03 ^d

C: control; CN: 100% compost only; CT: 100% compost tea; 100% VCT: vermicompost tea; 50% CN+50% CT: compost+ compost tea; 50% CN+50% VCT: compost+ vermicompost tea; 50%CT+50% VCT: compost tea+ vermicompost tea; 50% CN+25% CT+25% VCT: compost+ compost tea+ vermicompost tea. Distinct letters in the same column indicate statistically significant differences among treatments as determined by Tukey's honest significant difference (HSD) ($p \leq 0.05$).

Total N, Available P and available K contents in soil.

Individual and combined application of organic fertilizers significantly increased the capability of nutrient absorption by the plant roots (Figures 1 and 2). The maximum nutrient content of N% (0.106 %), was obtained in those plants receiving 50% CN, 25% CT and 25% VCT as compared to the untreated plants, after the first season. (Figures 1 a and b). Moreover, applying such treatment in the second season resulted in respective total N% value (0.123%). On the other hand, available P content, significantly increased with applying compost, compost tea and vermicompost tea individual or combined as compared to the control treatment (Figure 2a). The available-P in the soil was increased (44.83, 42.67 mg/Kg) in plots treated with CN+VCT, and CT+VCT, as compared with the untreated plants (5.89 mg/Kg), in the first growing season.

While, in the second season the values were found slightly increased as compared with first season. The maximum P (58.31 and 57.02 mg/Kg) were observed in those plants treated with 100% CT and 100% solid compost CN, as compared with untreated treatment (Figure 2b). Data graphically in (Figure 2 c and d). Showed that the maximum available K content (263.33 and 240.32 mg/kg) was obtained when onion plants treated with 50% CN + 50% VCT followed by 50% CN + 25% CT + 25%VCT, as compared with the control treatment (135.97 mg/kg). While, after the second season, the highest values were obtained with 100% CN, and 50% CN + 50% VCT which recorded (303.75 and 249.94 mg/kg), respectively. Generally, the available K of the soil increased with compost alone or with compost tea and vermicompost tea.

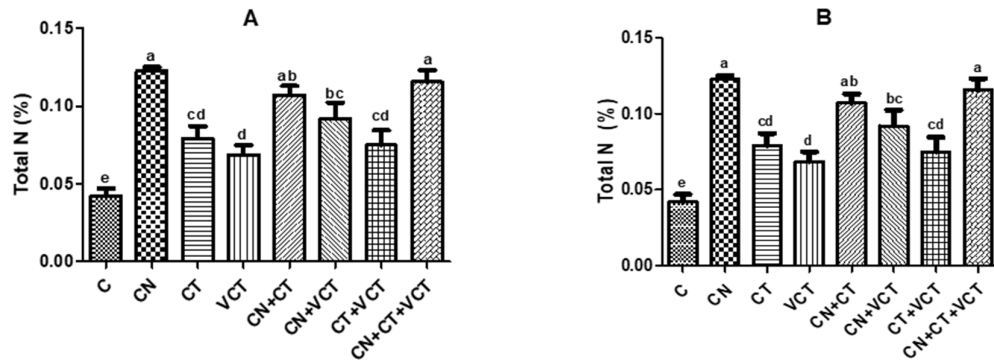


Figure 1. Effects of compost, compost tea and vermicompost tea on total nitrogen in soil (%), (a) the 1st season and (b) in the 2nd seasons respectively. Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

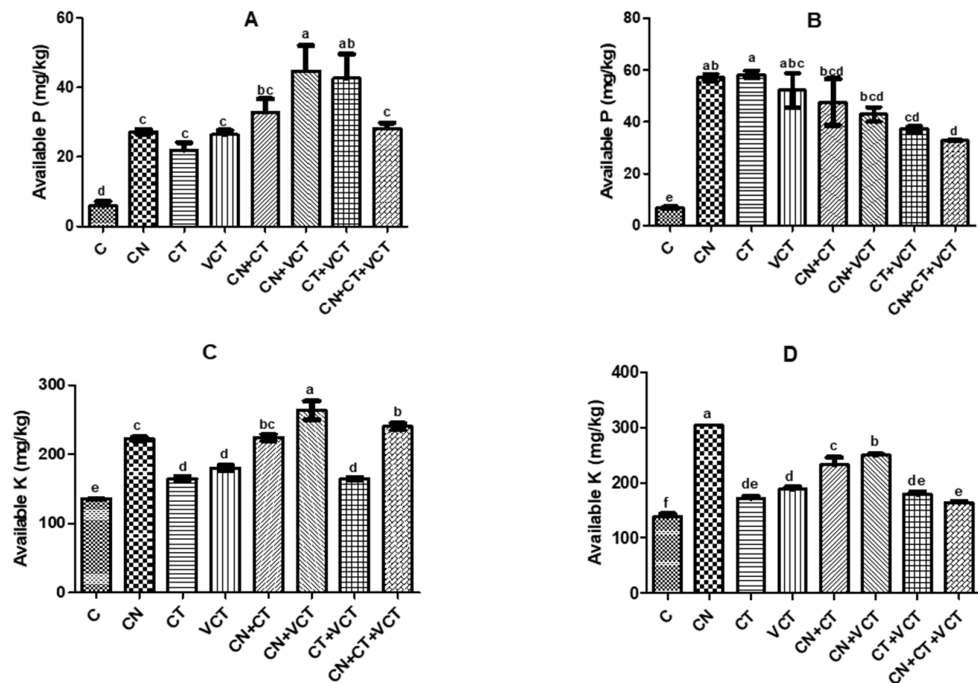


Figure 2. Effects of compost, compost tea and vermicompost tea on P mg/kg in soil (a and b) and K mg/kg in soil (c and d), in both seasons respectively. Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

Impact of compost, compost tea, and vermicompost on growth traits of onion plants.

The organic fertilizers, compost, compost tea, vermicompost tea and their interactions had a significant effect on the plant height, number of leaves/plants, plant fresh and dry weights and relative chlorophyll content ($P < 0.05$) data presented in (Tables 5 and 6). The tallest plants (69.50 and 61.85 cm) were obtained in those plots treated with a mixture of 50% CN+25% CT+25% VCT, followed by a mixture of 50% CT+50% VCT (69.08 and 61.20 cm), as compared to the control treatment (47.46 and 48.70 cm), in both seasons, respectively. The highest number of leaves per plant was observed in plants treated with a mixture of 50% CN+25% CT+25% VCT (9.90 and 8.14), followed by a mixture of 50% CT+50% VCT (9.69 and 7.87) and 50% CN+50% VCT (8.98 and 7.81) as compared to control treatment (6.84 and 6.73), in both seasons, respectively (Table 5). The results in (Table 5) reveal that a mixture of 50% CN+25% CT+25% VCT (115.84 and 121.00 g), gave the heaviest plants, followed by a mixture of CT+VCT (98.73 and 99.92 g) and 50% CN+50% VCT (92.94 and 96.88 g), as compared with control treatment (52.24 and 53.07 g), in both seasons, respectively. On the other hand, a mixture of 50% CN+25% CT+25% VCT, followed by 50% CN+50% VCT had a maximum value (33.97 and 29.62g) and (33.53 and 29.62 g) in both seasons, respectively.

The data regarding application a mixture of CN+CT+VCT (33.97 and 29.62 g) had a highest value of plant dry weight, followed by a mixture of CT+VCT (33.53 and 27.18 g) and CN+VCT (24.51 and 26.08 g) as compared. with control treatment (21.82 and 21.14 g), in both seasons, respectively. The treatment having 100% CT found to be less effective as compared to other treatment for plant height (63.63 and 55.48 Cm), number of leaves per plant (8.24 and 6.99), and (78.61 and 82.05 g) for plant fresh weight, in both seasons respectively (Table 5).

Table 5. plant height, number of leaves/plant and plant fresh weight of onion as affected by compost, compost tea and vermicompost, in both seasons 2018/2019- 2019/2020

Treatments	Plant height (cm)		Number of leaves/plant		Plant fresh weight (g)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
C	47.46±0.89 ^d	48.70±0.13 ^f	6.84±0.13 ^d	6.73±0.07 ^f	52.24±1.13 ^f	53.07±0.47 ^h
CN	66.34±0.49 ^b	57.48±0.26 ^d	8.51±0.20 ^{bc}	7.37±0.13 ^d	86.58±0.38 ^d	90.78±0.53 ^c
CT	63.63± 0.32 ^c	55.48±0.42 ^c	8.24±0.14 ^c	6.99±0.02 ^c	78.61±0.12 ^c	82.03±0.40 ^g
VCT	67.81± 1.01 ^{a,b}	58.96±0.32 ^c	8.71±0.24 ^{bc}	7.64±0.03 ^c	92.82±0.17 ^c	95.01±0.02 ^d
CN+CT	66.35± 1.02 ^b	57.26±0.26 ^d	8.65±0.26 ^{bc}	7.09±0.07 ^c	85.04±0.9 ^d	88.76±0.09 ^f
CN+VCT	68.86±0.12 ^a	60.56±0.49 ^b	8.98±0.03 ^b	7.81±0.04 ^b	92.94±0.07 ^c	96.88±0.15 ^c
CT+VCT	69.08±0.14 ^a	61.20±0.26 ^{a,b}	9.69±0.07 ^a	7.87±0.09 ^b	98.73±0.47 ^b	99.92±0.76 ^b
CN+CT+VCT	69.50±0.83 ^a	61.85±0.27 ^a	9.90±0.17 ^a	8.14±0.04 ^a	115.84±0.90 ^a	121.10±0.52 ^a

C: control; CN: 100% compost only; CT: 100% compost tea; 100% VCT: vermicompost tea; 50% CN+50% CT: compost+ compost tea; 50% CN+50% VCT: compost+ vermicompost tea; 50%CT+50% VCT: compost tea+ vermicompost tea; 50% CN+25% CT+25% VCT: compost+ compost tea+ vermicompost tea. Distinct letters in the same column indicate statistically significant differences among treatments as determined by Tukey's honest significant difference (HSD) ($p \leq 0.05$).

Maximum SPAD units reading for chlorophyll content were obtained in plants treated with VCT (61.63 and 60.63), followed by CT+VCT (60.67 and 59.63), and a mixture of 50% CN+25% CT+25% VCT (59.45 and 58.45), as compared with control treatment (52.03 and 51.03), in both seasons respectively.

Table 6. plant dry weight, and relative chlorophyll index SPAD of onion as affected by compost, compost tea and vermicompost, in both seasons 2018/2019- 2019/2020

Treatments	Plant dry weight (g)		Chlorophyll (SPAD)	
	1 st season	2 nd season	1 st season	2 nd season
C	21.82±0.07 ^d	21.14±0.24 ^f	52.03±0.06 ^c	51.03±0.06 ^f
CN	23.66±0.11 ^c	23.01±0.02 ^d	53.97±0.06 ^d	52.97±0.06 ^{de}
CT	22.10±0.05 ^d	22.06±0.11 ^c	53.55±0.05 ^d	52.55±0.05 ^c
VCT	23.85±0.07 ^c	23.07±0.12 ^d	61.63±0.64 ^a	60.63±0.64 ^a
CN+CT	23.45±0.41 ^c	22.68±0.28 ^d	54.17±0.29 ^d	53.00±0.00 ^{de}
CN+VCT	24.51±0.14 ^b	26.08±0.14 ^c	54.00±0.00 ^d	53.72±0.03 ^d
CT+VCT	33.53±0.19 ^a	27.18±0.31 ^b	60.67±0.58 ^b	59.63±0.55 ^b
CN+CT+VCT	33.97±0.05 ^a	29.62±0.31 ^a	59.45±0.05 ^c	58.45±0.05 ^c

C: control; CN: 100% compost only; CT: 100% compost tea; 100% VCT: vermicompost tea; 50% CN+50% CT: compost+ compost tea; 50% CN+50% VCT: compost+ vermicompost tea; 50%CT+50% VCT: compost tea+ vermicompost tea; 50% CN+25% CT+25% VCT: compost+ compost tea+ vermicompost tea. Distinct letters in the same column indicate statistically significant differences among treatments as determined by Tukey's honest significant difference (HSD) ($p \leq 0.05$).

Impact of compost, compost tea, and vermicompost on bulb yield parameters of onion plants.

Figure (3) shows the effect of different organic fertilizers treatments on yield and its components parameters of onion in each growing season. In general, a mixture of 50%CN+25%CT+25%VCT, and a mixture of 50% CT+50% VCT, had the highest values for average bulb weight, whereas the C treatment (control) and 100% CT had the lowest values, in both seasons, respectively. In addition, a mixture of 50% CT + 50% VCT, followed by a mixture of 50% CN+25% CT+25% VCT) had the highest values for total bulb yield (ton/ha), whilst C treatment (control), 100% CT and 50% CN+50% CT had the lowest values for the total bulb yield (ton/ha), in the first and second seasons, respectively. The values of average bulb weight and total bulb yield ton/ha treated with 100% VCT and 50% CN+50% VCT significantly increased by 61.09-51.12%, 29.43-35.56%, and 60.80-53.43%, 35.74-40.38%, in both seasons, respectively (Figure 3).

Impact of compost, compost tea, and vermicompost on bulb quality parameters of onion plants.

The results in (Table 7 and Figures 3 and 4) reveal that organic fertilizer treatments had a significant effect on bulb polar diameter, bulb equatorial diameter, bulb shape index, protein percentage, dry matter and total soluble solids percentage, in both seasons. The bulb polar diameter and bulb equatorial diameter were affected by fertilization treatment, both individual and combinations. Amending soil with a combination of 50% CT+50% VCT and 50% CN+25% CT+25% VCT resulted in the maximum values of the bulb polar and equatorial diameter 6.46-6.35 cm, 6.38-6.27cm and 6.94-7.01, 6.88-6.92 cm, in both seasons, respectively (Table 5). Interestingly, combine application of CN+VCT or CT resulted in the highest values of bulb shape index, in both seasons. whereas protein percentage was increased significantly in the first season, but insignificant in the second season, when compared with control treatment without fertilization. The highest protein percentage (18.37%) was observed in plots treated with CN+VCT, in the first season, while, 50% CN+50% CT treatment was the highest (15.78), in the second season. For the total soluble solids (T.S.S °Bx) trait, data clearly show that treatments of CT+VCT and 50% CN+25%CT+25%VCT gave the highest (T.S.S °Bx) (11.97 and 12.96 °Bx) and (11.87 and 12.88°Bx), in both seasons, respectively (Figure 3 a and b) on the contrary, treatments of C, and CT produced the lowest values of TSS % (11.42 and 12.43 °Bx) and (11.48 and 12.47°Bx), in the first and second seasons, respectively.

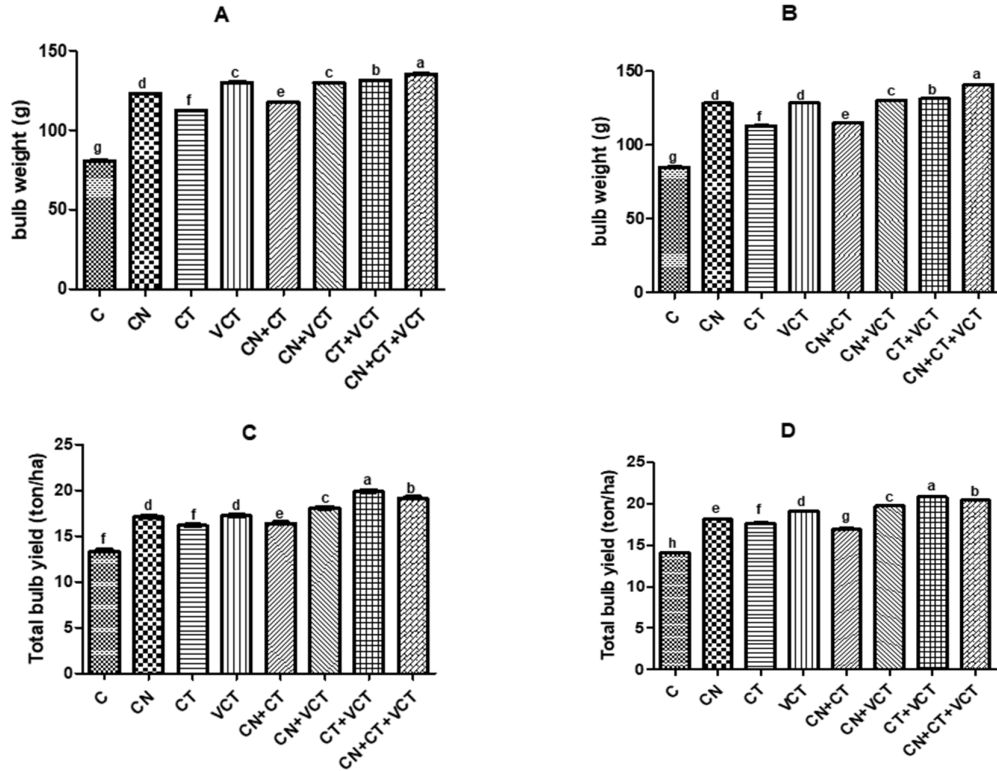


Figure 3. Effects of compost, compost tea and vermicompost tea on bulb weight (a and b) and total bulb weight (c and d), in both seasons respectively. Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

Table 7. Bulb quality effect of compost, compost tea and vermicompost on onion in both seasons 2018/2019- 2019/2020

Treatments	Polar diameter (cm)		Equatorial diameter (cm)		Bulb shape index		Protein (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
C	4.72 \pm 0.02 ^c	4.74 \pm 0.03 ^c	5.26 \pm 0.10 ^f	5.18 \pm 0.03 ^f	1.11 \pm 0.02 ^b	1.09 \pm 0.00 ^c	9.25 \pm 2.97 ^c	7.19 \pm 0.11 ^b
CN	5.88 \pm 0.03 ^c	5.92 \pm 0.03 ^c	6.56 \pm 0.06 ^d	6.66 \pm 0.01 ^d	1.11 \pm 0.01 ^b	1.12 \pm 0.01 ^{ab}	14.10 \pm 0.17 ^b	13.75 \pm 0.35 ^a
CT	5.47 \pm 0.02 ^d	5.67 \pm 0.02 ^d	6.40 \pm 0.05 ^c	6.48 \pm 0.03 ^c	1.17 \pm 0.01 ^a	1.14 \pm 0.00 ^a	14.51 \pm 1.37 ^b	14.45 \pm 0.57 ^a
VCT	6.16 \pm 0.12 ^b	6.16 \pm 0.12 ^b	6.72 \pm 0.03 ^c	6.69 \pm 0.01 ^d	1.09 \pm 0.02 ^b	1.09 \pm 0.02 ^c	13.80 \pm 0.62 ^b	14.75 \pm 1.50 ^a
CN+CT	5.63 \pm 0.05 ^{cd}	5.79 \pm 0.01 ^{cd}	6.56 \pm 0.01 ^d	6.65 \pm 0.02 ^d	1.17 \pm 0.01 ^a	1.15 \pm 0.00 ^a	14.91 \pm 0.91 ^{ab}	15.78 \pm 1.03 ^a
CN+VCT	6.25 \pm 0.18 ^{ab}	6.24 \pm 0.02 ^{ab}	6.80 \pm 0.02 ^{bc}	6.74 \pm 0.01 ^c	1.09 \pm 0.03 ^b	1.08 \pm 0.00 ^c	18.37 \pm 0.86 ^a	15.19 \pm 0.43 ^a
CT+VCT	6.46 \pm 0.12 ^a	6.35 \pm 0.03 ^a	6.94 \pm 0.01 ^a	7.01 \pm 0.01 ^a	1.08 \pm 0.02 ^b	1.10 \pm 0.01 ^{bc}	15.10 \pm 0.47 ^{ab}	14.15 \pm 0.63 ^a
CN+CT+VCT	6.38 \pm 0.07 ^{ab}	6.27 \pm 0.03 ^{ab}	6.88 \pm 0.03 ^{ab}	6.92 \pm 0.02 ^b	1.08 \pm 0.01 ^b	1.10 \pm 0.01 ^{bc}	14.72 \pm 0.44 ^b	14.76 \pm 0.21 ^a

C: control; CN: 100% compost only; CT: 100% compost tea; 100% VCT: vermicompost tea; 50% CN+50% CT: compost+ compost tea; 50% CN+50% VCT: compost+ vermicompost tea; 50%CT+50% VCT: compost tea+ vermicompost tea; 50% CN+25% CT+25% VCT: compost+ compost tea+ vermicompost tea. Distinct letters in the same column indicate statistically significant differences among treatments as determined by Tukey's honest significant difference (HSD) ($p \leq 0.05$).

Data have been presented graphically in (Figure 5 a and b) showed that the highest values of dry matter % (14.75 and 14.41%) were obtained from treatment of CT + VCT in the both seasons, respectively. While, the lowest values (13.63 and 13.28%) were obtained by the control, in the first and second seasons, respectively.

Impact of compost, compost tea, and vermicompost on bulb storability parameters of onion plants.

Data presented in (Figures 4 c and d, 5 c and d, and 6 a and b) showed the effect of different organic fertilizer treatments on some storability characters. TSS%, dry matter % and total weight loss % of onion during storage period. For dry matter trait, the results indicated that dry matter % at end of storage period were increased compared to the percentage of dry matter before storability. Generally, CT+VCT had a highest value (18.32- 16.37%) followed by CN+CT+VCT (16.37, 16.01%), in both seasons, respectively. While, control treatment was the lowest (17.19 and 15.24%) in both seasons, respectively (Figures 5 c and d). Plants treated with combine of CT+VCT had a highest value was observed of TSS% (17.63, 15.30%) followed by CN+CT+VCT (17.52, 15.20%), in both seasons, respectively. While, control treatment was the lowest (17.07 and 14.75%) in both seasons, respectively (Figures 4 c and d). Using of control treatment resulted in the greatest overall weight reduction at the end of the storage period, with values (16.21 and 17.21%), in both seasons, respectively. Meanwhile, the VCT had the lowest overall weight loss at the end of the storage period, with values (12.00 and 12.50%), in both seasons, respectively (Figure 6 a and b).

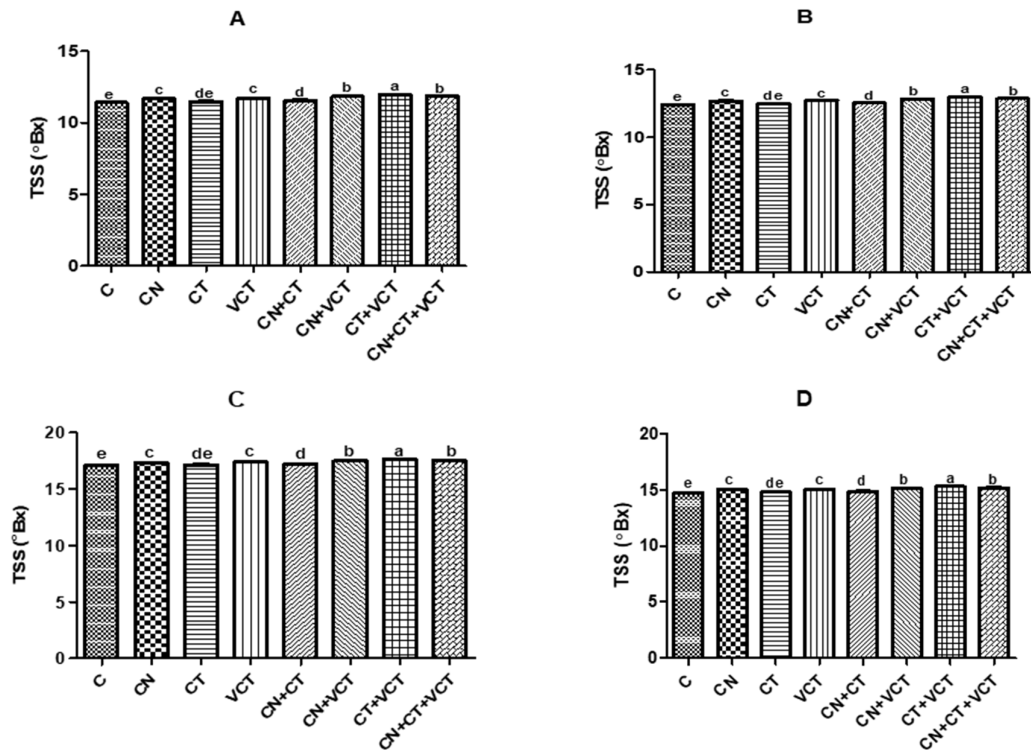


Figure 4. Effects of compost, compost tea and vermicompost tea on total soluble solids (a and b) before storability and (c and d) after storability, in both seasons respectively. Each value is mean (\pm SE) of three replicates and different letters in the same columns indicate statistically significant at ($p \leq 0.05$).

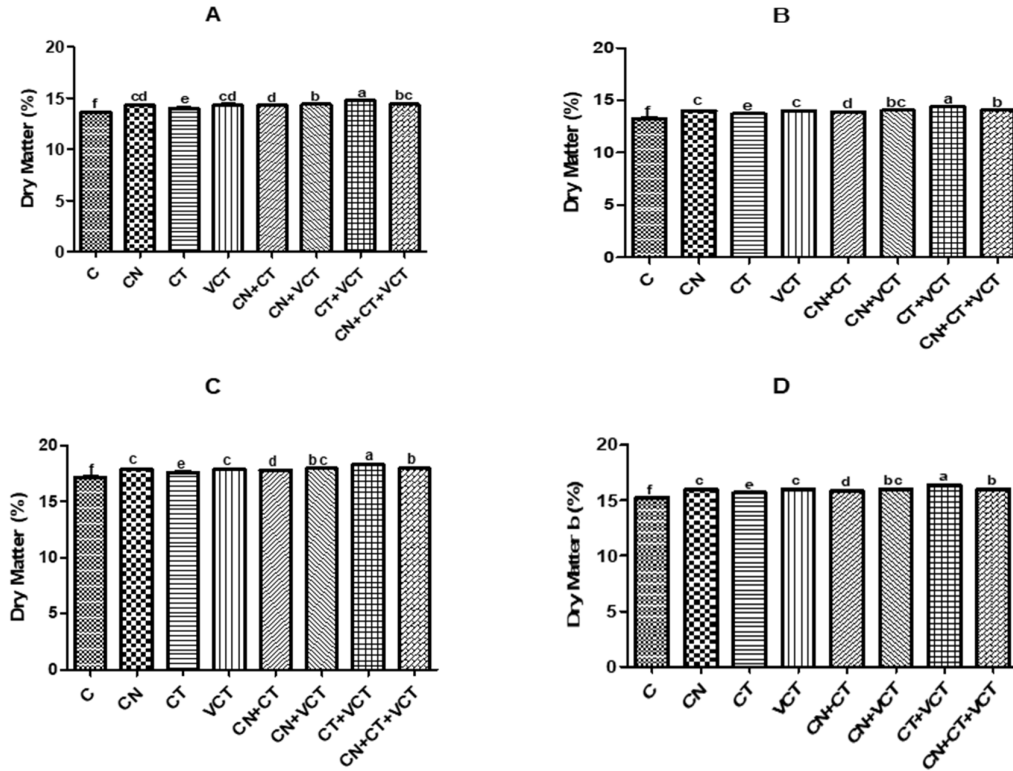


Figure 5. Effect of compost, compost tea and vermicompost tea on dry matter (a and b) before storability and (c and d) after storability, in both seasons respectively. Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

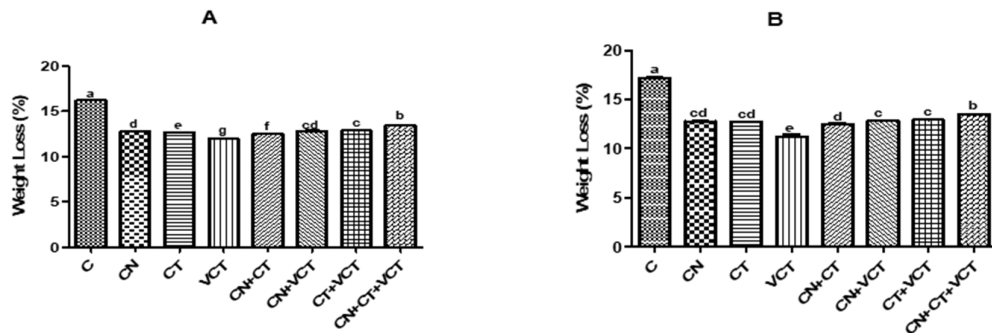


Figure 6. Effects of compost, compost tea and vermicompost tea on weight loss % (a and b) before storability and (c and d) after storability, in both seasons respectively. Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

Impact of compost, compost tea, and vermicompost tea on N%, P% and K% contents in onion plants:

The effect of organic amendments on mineral nutrient uptake per plant is presented in (Figures 7 and 8), All types of organic amendments applied consistently increased total N, P and K contents per plant compared to control plants. At the first season, the highest values of N % were obtained for CN+VCT, CT+VCT and CN+CT (2.94, 2.42 and 3.39%) respectively, while the highest values of P were for CN, CN+VCT, CN+CT (0.42, 0.40 and 0.37%) respectively, in addition, the highest values of K were treated by

CN, VCT and CN + VCT (0.58, 0.52 and 0.51%) respectively. On the other hand, after the second season the highest values of N% were recorded by CN+CT, CN+VCT and CN+CT+ VCT (2.53, 2.43 and 2.36%) respectively. the highest values of P were for CN+CT, CN+CT+VCT and VCT (0.40, 0.37 and 0.36%) respectively. While the highest values of K were observed in plots treated by CN, CT+VCT and CN+VCT (0.68, 0.57 and 0.54%), respectively.

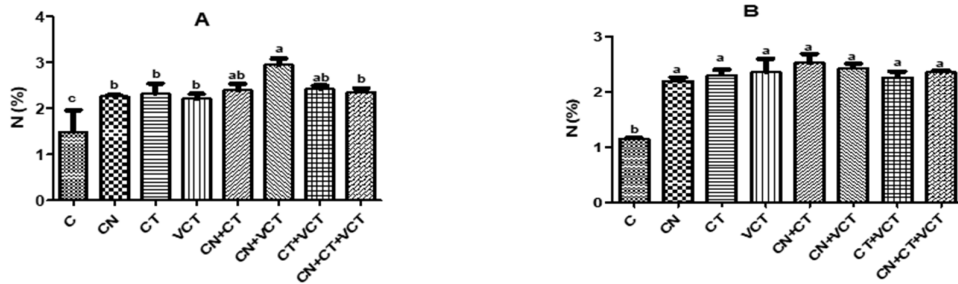


Figure 7. Effects of compost, compost tea and vermicompost tea on P% in plant (a and b) and K % in plant (c and d), in both seasons respectively
Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

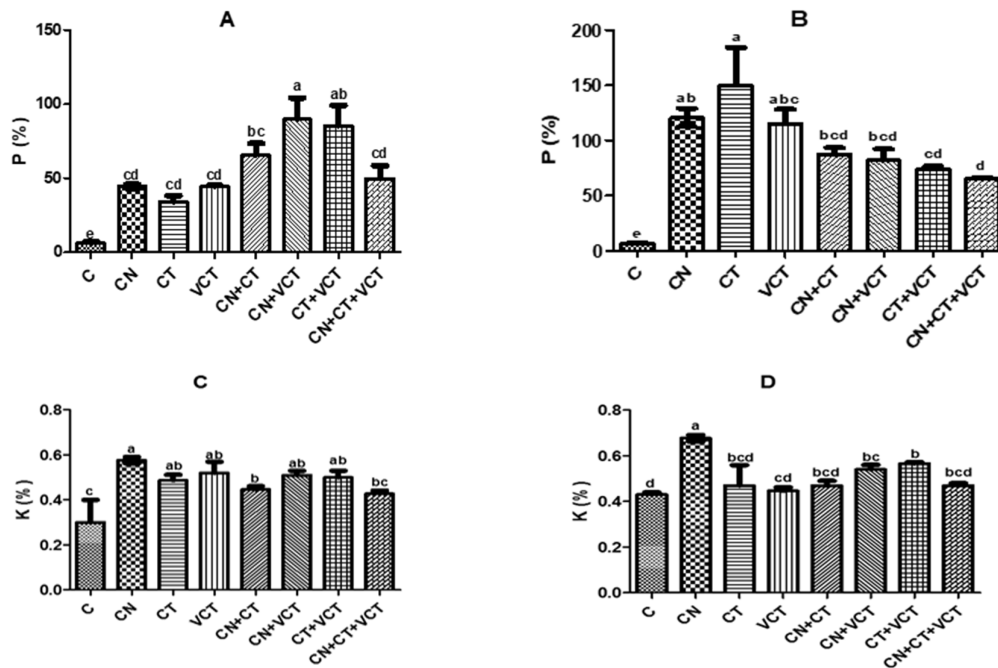


Figure 8. Effects of compost, compost tea and vermicompost tea on P% in plant (a and b) and K % in plant (c and d), in both seasons respectively
Each value is a mean (\pm SE) of three replicates and different letters in the same column indicate statistically significant at ($p \leq 0.05$).

Correlation analysis

Pearson correlations for organic fertilizers are shown individually on soil characteristics (Figure 9a), on growth, yield and quality of onion plants (Figure 9b) and treatments. Regarding correlations among soil properties traits, the results indicated that, positive significant correlation between OM and total soil N and available K in soil. While, it was found negative significant correlation between OM and bulk density. In

addition, high negative correlation but not significant founded between soil pH and soil EC, soil organic matter total N, available P, available K and N, P, K in plant. Also, significant positive correlation founded between available soil P and %P in plant. In addition, high negative correlation but not significant founded between % CaCO₃ in soil and available P, available K and N, P, K in plant Figure 9a. Furthermore, the correlations among all morphological characteristics were positive for organic fertilizers treatments, the greatest correlation (r 0.97) were identified between plant fresh weight (FW) and number of leaves (NL), followed by plant height (PH) and plant fresh weight (FW) (r 0.93) (Figure 9b). For onion yield characteristics, the strongest correlations were obtained between bulb diameter (PD), and average bulb weight (BW), or total bulb yield (TBY), in addition, bulb diameter (PD), and protein, plant height (PH) and protein, and bulb length (BL), and plant height (PH) were had the highest values of correlations for onion quality traits. While, the greatest correlation for storability traits was observed between bulb diameter (PD), and dry matter (DM a), number of leaves (NL), and total soluble solids (TSS a). on the contrary, bulb shape index (BSI) showed negative and insignificantly correlations with all traits studied (Figure 9b).

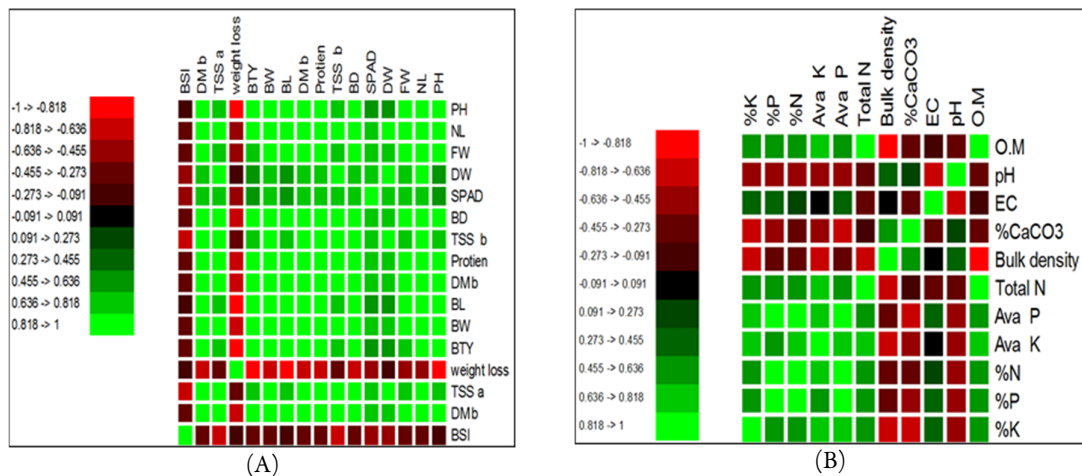


Figure 9. Pearson correlation matrix (r) between the analysed traits in onion plants treated with compost, compost tea, vermicompost tea and their combinations in combined seasons. (b) for onion growth, yield and quality, (a) for soil properties

Principal Component Analysis (PCA)

The principal component analysis (PCA) corresponding to the organic fertilizer treatments identified two components with Eigenvalues greater than one, which explained 91.70% of the total variability of data (79.70% and 12.00% for the first and second components, respectively), (Table 7 and Figure 10). All growth, yield and quality parameters were positively correlated with the PC 1, the most significantly was the bulb diameter (BD), number of leaves/plant (NL), protein %, and average bulb weight (BW). Whereas the weight loss, and bulb shape index (BSI) were negatively correlated. Regarding the PC 2, some of traits were positively correlated number of leaves/plants (NL), plant dry weight (DW), and total soluble solids before and after storability (TSS b and TSS a) while, plant height (PH), bulb shape index (BSI), and bulb length (BL) were negatively correlated (Table 6, Figure 10). On the other hand, organic fertilizers residing in PC 3 exhibited positive outcomes for some traits (plant dry weight (DW), weight loss, number of leaves/plants (NL), and bulb shape index (BSI). On contrary, some traits chlorophyll content (SPAD), total bulb yield (TBY) and bulb diameter (BD) were negatively correlated. Three components with an Eigenvalue > 1 was also observed to the soil properties, they are explaining 57.70, 19.50 and 10.80 % of the total variability.

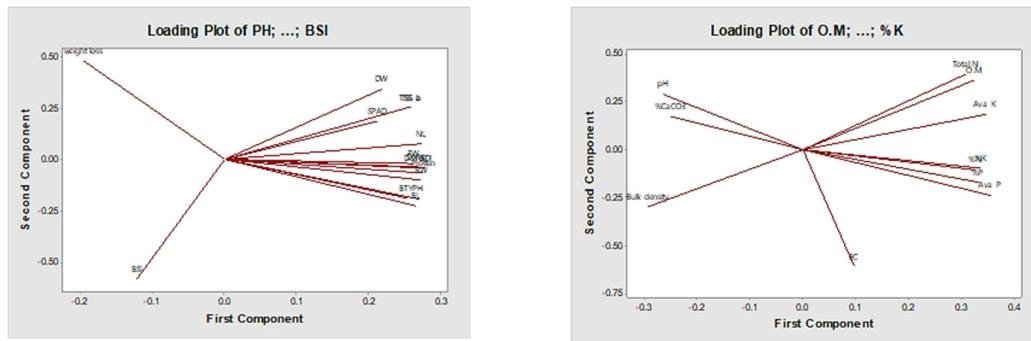


Figure 10. Loading plot of the principal component analysis (PCA) conducted with the analysed traits, in onion plants treated with compost, compost tea, vermicompost tea, and their combinations, in combined seasons. (a) for growth, yield and quality parameters, and (b) for soil properties

Correlations of the soil properties variables were positively correlated with PC 1 for all studied parameters, except pH, CaO₃% and bulk density (-.264, -.250 and -.0.293). with Available P and Available K high showing the highest values (0.354, and 0.345). Table 6, Figure 10b for PC 2 traits organic matter, pH, CaO₃%, total N, and available K were positively correlated, whereas EC, bulk density, available P in soil, and N %, P% and K% contents in plant were negatively correlated. Regarding for PC3, the parameters organic matter, CaO₃%, bulk density, total soil N, available soil P, and N%, and P%, in plants were negatively correlated, on contrary, pH, EC, available soil K, and K% in plants were positively correlated Table 8, Figure 10 b). While, plant height (PH), bulb shape index (BSI), and bulb length (BL) were negatively correlated Table 6, Figure 10. On the other hand, organic fertilizers residing in PC 3 exhibited positive outcomes for some traits (plant dry weight (DW), weight loss, number of leaves/plants (NL), and bulb shape index (BSI). On contrary, some traits chlorophyll content (SPAD), total bulb yield (TBY) and bulb diameter (BD) were negatively correlated. Three components with an Eigenvalue >1 was also observed to the soil properties, they are explaining 57.70, 19.50 and 10.80 % of the total variability. Correlations of the soil properties variables were positively correlated with PC 1 for all studied parameters, except pH, CaO₃% and bulk density (-.264, -.250 and -.0.293). with Available P and Available K high showing the highest values (0.354, and 0.345). Table 6, Figure 10b for PC 2 traits organic matter, pH, CaO₃ %, total N, and available K were positively correlated, whereas EC, bulk density, available P in soil, and N %, P% and K % contents in plant were negatively correlated. Regarding for PC3, the parameters organic matter, CaO₃ %, bulk density, total soil N, available soil P, and N%, and P%, in plants were negatively correlated, on contrary, pH, EC, available soil K, and K% in plants were positively correlated Table 8, Figure 10 b). While, plant height (PH), bulb shape index (BSI), and bulb length (BL) were negatively correlated Table 6, Figure 10. On the other hand, organic fertilizers residing in PC 3 exhibited positive outcomes for some traits (plant dry weight (DW), weight loss, number of leaves/plants (NL), and bulb shape index (BSI). On contrary, some traits chlorophyll content (SPAD), total

bulb yield (TBY) and bulb diameter (BD) were negatively correlated. Three components with an Eigenvalue >1 was also observed to the soil properties, they are explaining 57.70, 19.50 and 10.80% of the total variability. Correlations of the soil properties variables were positively correlated with PC 1 for all studied parameters, expect pH, CaO₃% and bulk density (-.264, -.250 and -.0.293). with Available P and Available K high showing the highest values (0.354, and 0.345). Table 6, Figure 10b for PC 2 traits organic matter, pH, CaO₃%, total N, and available K were positively correlated, whereas EC, bulk density, available P in soil, and N %, P% and K% contents in plant were negatively correlated. Regarding for PC3, the parameters organic matter, CaO₃%, bulk density, total soil N, available soil P, and N%, and P%, in plants were negatively correlated, on contrary, pH, EC, available soil K, and K% in plants were positively correlated (Table 8, Figure 10 b).

Table 8. Eigenvalue, percentage of variability and cumulative variability

Parameter	Bulb growth and yield			Parameter	Soil properties		
	PC I	PC II	PC III		PC I	PC II	PC III
Statistical variables				Statistical variables			
Eigenvalue	12.76	1.91	0.563	Eigenvalue	6.34	2.14	1.19
Percent variability	79.70	12.00	3.50	Percent variability	57.70	19.50	10.80
Cumulative percentage	79.70	91.70	95.20	Cumulative percentage	57.70	77.10	87.90
Traits				Traits			
PH	0.268	-0.191	0.053	O.M	0.324	0.362	-0.075
NL	0.273	0.076	0.216	pH	-0.264	0.290	0.123
FW	0.262	-0.019	0.267	EC	0.096	-0.609	0.123
DW	0.218	0.341	0.513	%CaCO ₃	-0.250	0.173	-0.536
SPAD	0.212	0.186	-0.404	BUD	-0.293	-0.298	-0.403
BD	0.278	-0.042	-0.071	Total N	0.307	0.393	-0.157
TSS b	0.258	0.255	-0.021	Ava P	0.354	-0.241	-0.135
Protein	0.276	-0.065	0.131	Ava K	0.345	0.182	0.013
DM b	0.267	-0.037	-0.006	%N	0.326	-0.108	-0.420
BL	0.266	-0.226	0.075	%P	0.331	-0.170	-0.355
BW	0.272	-0.101	0.000	%K	0.336	-0.097	0.411
BTY	0.253	-0.190	-0.244				
weight loss	-0.195	0.482	0.352				
TSS a	0.258	0.255	-0.021				
DM a	0.269	-0.042	-0.013				
BSI	-0.121	-0.581	0.490				

Discussion

Application of solid compost individual or combined with compost tea or vermicompost tea significantly increased the organic matter content of the soils compared to other treatments and the control treatment. Adding compost, in particular, increases the contents of soil organic matter compared to other treatments and the control; this may be due to the relative stability of compost materials in soils, as indicated by higher C contents in compost amended soils; compost also has a higher organic matter content than compost tea and vermicompost tea. These results in harmony with those of (Leifeld *et al.*, 2002; Mohammed *et al.*, 2004, Bouajila and Sanaa, 2011; Soheil *et al.*, 2012). The reductions in the soil pH in both seasons, were more evident under individual applications of compost or combined with teas. That reduction is depending on

increased of organic matter content in compost compared to other treatments. Also, during oxidation of organic compounds, the activity of microorganisms was increased resulted in increasing productivity of CO₂ and other organic acid, these led to decreased in the soil pH. These results are in accordance with those reported by (Kabirinejad *et al.*, 2014; Abo-baker, 2017; Barka *et al.*, 2018). After the second season when plants were treated with (CN+CT, CT+VCT and CN+CT+VCT), pH ascended in spite of reapplication of organic amendments. The increasing of pH in the second season, could be attributed to, during organic matter decomposition the organic acid and CO₂ were produced in considerable amounts, and its helps dissolve part of the calcium carbonate causing soil pH rise (Sigua *et al.*, 2005). Increased of soil EC with application of organic amendments either alone or mixed, this may be attributed to, high content of soluble salts in applied organic amendments. These results are identical with (Forster *et al.*, 2006; Lakhdar, 2009). In addition, during organic matter decomposition some organic acids was produced, this effected of increases the dissolution of the soil salts with time. This could be the reason for the increase in the soil EC in most treatments in the second season of cultivation. The negative effect of organic amendments on the soil CaCO₃ content is attributed mainly to the decomposing the organic matter and microbial activity, this helps produce CO₂ and organic acids that react and dissolve the calcium carbonate of the soil. These results are in agreement with (Abo-baker, 2017; Villarreal Sanchez *et al.*, 2018). The decrease in the soil CaCO₃ content varied according to the amount of compost, this may be due to increase of organic matter content in the compost compared to teas. Different decreases in soil bulk density were observed, with different application rates and type of organic amendments. Moreover, application of compost alone was found to reduce the volume weight more than application of other treatments. These results are in agreement with some studies that found, the application of compost as organic amendments significantly decreased soil bulk density compared to the uncomposed soil. In addition, the highest reduction of soil bulk density values was mostly correlated with the level of organic fertilizer application (Mohammadshirazi *et al.*, 2017; Sax *et al.*, 2017; Somerville *et al.*, 2018; Kranz, *et al.*, 2020).

In general, the increase in the total soil N content were associated with increasing compost addition level. A large portion of (N) in compost is in organic form, it is requiring more time for decomposition to make the organic N molecules accessible and, subsequently, to liberate N from those molecules, this reduces nitrogen loss by washing and uptake by plant. On the other hand, most nitrogen in compost and vermicompost teas in minerals form, greater losses occur when N is in these form by leaching or plant uptake. It leads to a decrease in the total nitrogen content of the soil.

In addition, in the both seasons, the maximum values of available soil P in most cases were found in the soil amended with compost tea and vermicompost tea either alone or with compost. It might be due to, compost and vermicompost teas were composed of water extractable components such as mineral supplements, organic acids, and active microorganisms, that can help to enhance the nutrient status and increase the availability of P by convert the insoluble forms of P into soluble ones (Carballo *et al.*, 2014; Abo-baker, 2017; Sujesh *et al.*, 2017). Moreover, in the second season the data showed that, the available phosphorus increased significantly with application of compost alone compared to the first season, these increased may be due to the accumulative effect of inorganic, organic acids and CO₂ and reduction of soil pH, these effects are responsible for increasing the soil P availability for plants. These results are in a close agreement with those found by (Abo-baker, 2017; Abou Hussien *et al.*, 2019). Generally, the available K of the soil increased with CN or with CT and VCT could be due to the release of K during the mineralization of organic materials (Abo-baker, 2017). In addition, applying CT and VCT with CN gave the highest values for available K, this may be attributed to compost and vermicompost teas have components such as mineral supplements, organic acids, active microorganisms help to enhances the release K from soil minerals (Mica and Feldspar). The agree with those obtained by (Zarjani *et al.*, 2013; Rashid *et al.*, 2016; Carballo *et al.*, 2014; Sujesh *et al.*, 2017).

In addition, organic fertilizer treatments resulted in statistically significant changes in vegetative growth parameters. Whereas the mixture of CN+CT+VCT treatments resulted in the greatest values of plant height, number of leaves per plant, plant fresh and dry weights and relative chlorophyll reading SPAD. While, the lowest values of these characters were resulted from control treatment. The plant height was increased by 31.71

and 21.26%, in both seasons, respectively in plants treated with a mixture of CN+CT+VCT compared to control treatment (Table 3). Hence finding that CN+CT+VCT treatments promotes vegetative development of onion plants might be related to the fact that vermicompost tea has more benefits than compost. The use of vermicompost tea aqueous extract has been found to increase plant health, crop production, and nutritional quality (Gamaley *et al.*, 2001; Pant *et al.*, 2009; Pant *et al.*, 2011). It is thought that the tea's, organic acids, and plant growth regulators have a favourable influence on early root formation and plant growth with both forms foliar spray and soil application (Keeling *et al.*, 2003; Edwards *et al.*, 2006; Arancon *et al.*, 2007; Pant *et al.*, 2011). Compost tea contains live microorganisms that may boost nutrient absorption and plant development. (Scheuerell and Mahaffee, 2002; Ingham, 2005; Hargreaves *et al.*, 2008). Vermicompost tea contains more nitrate, which is the more easily absorbed type of nitrogen for plants. Furthermore, as compared to compost, vermicompost releases nutrients in a shorter period (Manivannan *et al.*, 2009; Mupondi *et al.*, 2010). Along from that, adding compost and compost tea to vermicompost tea helps to fix atmospheric nitrogen and excrete certain growth stimulants (Saharan and Nehra, 2011). Similar findings were found by (Reddy and Reddy 2005; Pant *et al.*, 2011; Kaswan *et al.*, 2013; Shedeed *et al.*, 2014; Singh and Ram 2014; Singh *et al.*, 2015; Monira *et al.*, 2019). Across all organic fertilizer treatments, number of leaves per plant were increased significantly as compared with the control. The most raised (44.74 and 20.95%) was obtained in plots treated with CN+CT+VCT, in both seasons. Liquid organic fertilizers boost plant production, microbial communities in the soil, and mineral nutrient quality of the plants. Also, had a high concentration of beneficial bacteria, which have been shown to improve plant growth by increasing soil fertility and mineral concentration in plant tissue. (Fritz, 2012; Atiyeh *et al.*, 2002). Similar results were found by (Monira *et al.*, 2019). They indicated that increasing the amount of vermicompost boosted the number of leaves per plant substantially. and this is due to improved growth performance in terms of plant height, number of leaves per plant, and leaf area per plant. In current study, variation on plant fresh weight and plant dry weight were significantly affected by organic fertilizer treatments (Table 5 and 6). The maximum increase (115.84, 121.10 and 33.97, 29.62) was observed with CN+CT+VCT as compared to control, in both seasons, for plant fresh and dry weights, respectively. For instance, relative chlorophyll content index (SPAD) was achieved maximum reading with (18.45 and 18.81%) compared to control treatment, in both seasons, respectively. Besides the main nutrients, vermicompost is reported to include micronutrients. Also include a variety of plant growth stimulants, enzymes, useful bacteria, and mycorrhizae (Gupta, 2005). As a result, enhanced nutrient availability, improved soil physical characteristics, and increased activity of microorganisms with greater amounts of organics may have aided in raising plant height, number of leaves, leaf area, and leaf area index. (Reddy and Reddy, 2005). The analysis of this study showed that average bulb weight and total bulb yield were significantly influenced by the effect organic fertilizer treatments ($P < 0.05$). average bulb weight⁻¹ was increased by 32.14 and 34.18%, compared to control treatment, in plants treated with CN+CT+VCT, in both seasons, respectively. on the other hand, treated onions with CT+VCT increased total bulb yield ton/ha⁻¹ by 50.28 and 52.16%, compared to control treatment, in both seasons respectively. These results are in harmony with findings by (Arguella *et al.*, 2006; Coulibaly, 2020; Monira *et al.*, 2019; Singh *et al.*, 2013; El-Shatanofy, 2011; Yoldas *et al.*, 2011; Soleymani and Shahrajabian, 2012; Indira and Singh, 2014; Thanunathan *et al.*, 1997). The rise in average bulb weight and total bulb yield in response to a mixture of CT+ VCT with or without solid compost application might be attributed to the availability of optimal nutrients in manure, which could have resulted in a high leaf area index through better leaf development and photosynthesis. This finding is consistent with the findings of (Mehdi *et al.*, 2012). Bulb quality parameters, polar and equatorial diameter, bulb shape index, protein%, dry matte and TSS% (Table 5, Figures 2 a and b, 3 a and b). The results of this study reported that, polar and equatorial diameter increased significantly in plots treated with 50% CT+ 50% VCT, in both seasons, as compared to control treatment. While, the protein percentage was achieved maximum content in plants fertilized with 50% CN+ 50% VCT or 50% CT, in the first and second season, respectively. The highest amount of protein was approximately twice (18.37 and 15.78%), compared to control treatment (9.25 and 7.19%). Also, 50% CT+ 50% VCT was superior treatment for dry matter % and TSS %. The pervious findings were similar with the

results obtained by (Arguella *et al.*, 2006; Coulibaly, 2020; Abou-El-Hassan *et al.*, 2018; Monira *et al.*, 2019; Singh *et al.*, 2013). The build-up of non-structural carbohydrates whose distribution patterns alter, favouring the metabolism of fructi precursors and accumulating as scorodite, increased the bulb dry weight. It might be related to an increase in the build-up of reserve chemicals in the bulbs. This conclusion is corroborated by the findings of (Singh *et al.*, 2013), who indicating a greater fruit density and more TSS% in tomato as a result of vermicompost application as compared to a control treatment. In general, the values of TSS%, and dry matter% of onion bulbs rose progressively at the end of storage period, reaching their greatest values during the end of storage. This can be ascribed to the bulb's low moisture content that increasing with storage time, which raised the concentration of total soluble solids and dry matter in the bulb. Treated onion plants with a mixture of compost tea and vermicompost tea were superior in the total soluble solids content and dry matter % at the end of the storage period, in both seasons. The highest values of total weight loss at the end of storage period were resulted from using control treatment and the lowest was obtained in plants treated with vermicompost in both seasons. high amount of moisture in bulb in the initial storage period, is greatly decreased TSS% and dry matter%, which leads to high weight loss. Similar results were reported by (Abou El-Hassan, 2018; Shaheen *et al.*, 2010; Gerjes *et al.*, 2012; Singh and Ram 2014; Lasmini *et al.*, 2015; Singh *et al.*, 2015). Furthermore, total plant N, P and K contents was not significantly different across organic amendments application except in some cases, there was a significant positive effect of vermicompost tea and compost tea on plant N, P, K contents, especially when treated with compost compared to the other treatments. Liquid organic fertilizers consistently enhanced plant growth and mineral nutrient concentration in plant tissue. Also, it may be due to, soluble mineral nutrients and microbial by products in vermicompost tea can enhance nutrient uptake from the soil and increase foliar uptake of nutrients (Ingham, 2005; Sanwal *et al.*, 2006; Hargreaves *et al.*, 2008). Also, in other study nutrient analysis indicated that, compost tea and vermicompost tea supplied a considerable amount of soluble mineral nutrients to plants compared with the control (Pant *et al.*, 2009). In addition to (Arancon *et al.*, 2007) reported that humic, fulvic and other organic acids extracted or produced by microorganisms in vermicompost tea could induce plant growth and nutrient uptake.

regarding correlations among soil properties traits, the results indicated that, positive significant correlation between organic matter and total soil N and available K in soil. While, it was found negative significant correlation between organic matter and bulk density. In addition, high negative correlation but not significant founded between soil pH and soil EC, soil organic matter total N, available P, available K and N, P, K in plant. Also, significant positive correlation founded between available soil P and %P in plant. In addition, high negative correlation but not significant founded between % CaCO₃ in soil and available P, available K and N, P, K in plant (Figure 9a). These results indicated that, any increase in total soluble salts in soil was accompanied by decreases in pH values. The mean levels of available P increase with increasing organic matter content in soil. Similar results were obtained by (Staunton and Leprince, 1996), they found that rhizosphere acidification does not necessarily increase phosphate solubility. However, carboxylates, the conjugate bases of organic acids, may play an important role in improving the availability of soil phosphate. In addition, negative correlation but not significant was obtained between the available phosphorus in soil and soil pH values ($r = -0.628$) this results agree with the results was obtained by (Tisdale *et al.*, 1997) they found that the maximum P availability in most soils occurs between pH 5.5 and 6.5.

There was also a correlation study performed between the growth parameters and organic fertilizers of the onion. A highly significant connection was established between plant fresh weight (FW) and number of leaves (NL) ($r = 0.93$). Onion yield characteristics, the strongest correlations were obtained between bulb diameter (PD), and average bulb weight (BW), or total bulb yield (TBY), in addition to, bulb diameter (PD), and protein, plant height (PH) and protein, and bulb length (BL), and plant height (PH) were had the highest values of correlations for onion quality traits. While, the greatest correlation for storability traits was observed between bulb diameter (PD), and dry matter (DM a), on the contrary, bulb shape index (BSI) showed negative and insignificantly correlations with all traits studied. The different growth, yield, and quality parameters of

onion showed very strong and positive correlations with each other (r ranged from 0.71 *** to 0.98 ***, Figure 9 b). while, for soil properties was (r 0.81 to 0.98) (Figure 9a).

Additionally, the first factor of PCA, which explained 79.70% and 57.70 of the total variability of all parameters, had strong loadings for all parameters (loading values less than 0.79 and 0.57), (Table 6). All growth, yield and quality parameters were positively correlated with the PC 1, the most significantly was the bulb diameter (BD), number of leaves/plant (NL), protein %, and average bulb weight (BW). Regarding the PC 2, some of traits were positively correlated (number of leaves/plants (NL), plant dry weight (DW), and total soluble solids before and after storability (TSS b and TSS a). (Table 6, Figure 10). On the other hand, organic fertilizers residing in PC 3 exhibited positive outcomes for some traits (plant dry weight (DW), weight loss, number of leaves/plants (NL), and bulb shape index (BSI). On contrary, some traits (chlorophyll content (SPAD), total bulb yield (TBY) and bulb diameter (BD) were negatively correlated. Correlations of the soil properties variables were positively correlated with PC 1 for all studied parameters, except pH, CaO₃ % and bulk density (-0.264, -0.250 and -0.293). with Available P and Available K high showing the highest values (0.354, and 0.345). (Table 6, Figure 10 b). for PC 2 traits organic matter, pH, CaO₃%, total N, and available K were positively correlated, whereas EC, bulk density, available P, N %, P% and K % were negatively correlated. Regarding for PC3, the parameters organic matter, CaO₃%, bulk density, total N, available P, N%, and P%, were negatively correlated, on contrary, pH, EC, available K, and K% were positively correlated (Table 8, Figure 10 b).

These findings indicate that most of the parameters examined in this study were significantly affected by different organic fertilizer treatments and therefore, are good candidates to predict the optimal and effective fertilization scheme for adequate plant growth and the sustainable production of onion under similar agroecosystem conditions. These findings indicate that the majority of the parameters studied in this study were significantly affected by different organic fertilizer treatments, making them good candidates for predicting the optimal and effective fertilization scheme for adequate plant growth and sustainable onion production under similar agroecosystem conditions. In this study, the treatments CT+VCT and CN+CT+VCT had the highest values for all parameters of onion followed by treatments VCT. This confirms that the application a mixture of organic compost, compost tea and vermicompost tea seems to be better treatment for the optimal performance of onion. Under study conditions. The improvements in all onion parameters could be correlated with these treatments' ability to gradually provide sufficient nutrients for plants throughout their growth period, which ultimately improved several fundamental physiological activities in leaves, such as the chlorophyll biosynthesis process and photosynthetic capacity (Geng *et al.*, 2019; Hasnain, *et al.* 2020; Iqbal *et al.*, 2020).

Conclusions

Content and associated positive effects of different organic fertilizers on soil characteristics, including nutrient retention and availability. Overall, the results suggest that a mixture of 50% CN+25% CT+ 25% VCT is a lead treatment for most of the soil properties. Whereas, vermicompost tea was the superior for relative chlorophyll content (SPAD). Thus, the use of these fertilizers can boost onion production in line with current export trends, which prefer vegetable products grown using bio- and organic farming. However, when using manure to fertilize food crops, especially fruits and vegetables, food safety should be a top focus. Therefore, via application of 50% CT+ 50% VCT, it is possible to achieve an acceptable total bulb yield ton/ha, TSS%, dry matter % before and after storage period. while, 50% CN+ 25% CT+ 25% VCT is achieve a valuable average bulb weight, followed by application of 50% CT+ 50% VCT, and that is an essential feature, particularly in arid and semi-arid agriculture. On the other hand, for bulb quality parameters, via application of 100% VCT, it is possible to achieve a minimum weight loss %.

P% in plant tissue was raised when onion plants treated with teas (vermicompost and compost), sole or combined with sole compost 50%. N% in plants was increased significantly in both seasons. The maximum

increase was obtained with application 50% CT+50% VCT or 50% CT. While, K% in plant tissue was increased in plots treated with sole compost or 100% compost. Mineral fertilizer prices have lately skyrocketed, prompting farmers to seek out other sources of manure, which will also skyrocket in price. As a result, unless a local manure fertilizer business emerges, the economic appraisal of its application in vegetable cultivation will be unclear. So, using organic fertilizer is key of agriculture sustainability and food safety.

Authors' Contributions

Data curation; EAAH and FHM Formal analysis; EAAH Investigation; BAAA Methodology; AKG and EAAH Project administration; FHA and EAAH Resources; BAAA, and AKG Software; EAAH and AKG Supervision; EAAH Validation; FHM Visualization; BAAA Writing - original draft; AKG Writing - review and editing, EAAH and BAAA. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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