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Combination Vermicompost and Nano-Fertilizer Applications and Its Impact on Growth Performance of Strawberry

[1]Mustafa N.S., [2]Moustafa Y.T.A., [3]El-Dahshouri M.F., [4]EL-Sawy S.M.M., Eman S. El-Hady[1], Laila F. Haggag[1], [5]Zhang L. and [6] Zuhair Raghda M.

[1]Pomology Department, National Research Centre (NRC), Egypt.
[2]Central Lab for Aquaculture Research, Agricultural Research Centre (ARC), Egypt.
[3]Fertilization Technology Department, Agricultural and Biological Institute (NRC), Egypt
[4] Vegetable Research Department, National Research Centre, 33 El Buhouth St, Dokki, Giza, P.O. Box 12622, Egypt.
[5]College of Life Sciences, Northwest A and F University, Yangling 712100, Shaanxi, China.
[6] Zoology Department, Faculty of Science, Tanta University, Egypt.

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ABSTRACT
Background and objective: Strawberry is one the economic crops in Egypt. There is a potentiality to improve growth and quality of this crop by applying vermicompost combined with nano-fertilizer. **Material and Methods:** Current work carried out in National Research Centers Farm, Northern Egypt, under greenhouse condition to estimate the impact of two types of vermicompost at different doses combined with nano-fertilizers on strawberry plants (2019/2020), as well as soil health. Strawberry seedlings were divided into 9 groups according to treatments. At the end of each growth season, different parameters were measured in this context concern plant growth performance, nutrient content, fruit quality and soil health. **Results:** Obtained results showed that there a positive impact of combining vermicompost and nano-fertilizer on fresh and dry weight of leaves; nutrient contents, fruit quality, soil health and (T_8) surpassed all studied treatments in its impact on the most of studied parameters. However, T_4 resulted in the highest leaf N content without markedly differences with T_8. Also, T_6 was recorded the highest value of fruit acidity and T_1 produced the highest value sugar content and vitamin C (VC.). Besides, T_4 led to an increment in fruit anthocyanin comparing to the other treatments. Also, T_5 produced the highest value of P and K content in soil than other treatments. Meanwhile, T_4 surpassed all treatments in its impact on microbial activity. **Conclusion:** This study came in a chain of several evidences that support the positive role of both vermicompost and nano-fertilizers on plant growth and soil health. Also, through vermicompost and nano-fertilizers application, the excessive amount of mineral fertilizers that used by farmers may be reduced to safe levels for environment and consumer health.

Keywords: fruit quality, nano-fertilizer, soil heath, strawberry, vermicompost.

1. Introduction

Egypt is occupies the fourth rank as the largest strawberry producer in the world with 435.3 thousand tons in 2016. Besides, Egypt exported about 23.6 thousand tons of strawberry in 2017(Hamdia *et al.,* 2019).

With the fact of the strawberry importance as economic crop, Egypt has a great opportunity to increase its production and its export share of strawberry if adopted organic production approaches in strawberry orchards. Besides, this approach comes to be compatible with all procedures that had been taken by Egypt during the past period to ensure the safety of Egypt's fresh strawberry exports in order to be in harmony with imported countries rules.

Corresponding Author: Mustafa N. S., Pomology Dept., National Research Center, Dokki, Cairo, Egypt
E-mail:- nabilhotline@yahoo.com

In this context, vermicompost as organic fertilizers gains an intensive attention recently due to its high content of nutrients, amino acids and growth promoters (Moustafa *et al*., 2020 &2021). In addition, Applying vermicompost as soil amendment resulted in improving soil porosity, aeration, drainage, water holding capacity and microbial activity (Arancon *et al*., 2006; Singh *et al*., 2008).

Several studies have demonstrated that vermicompost can improve strawberry growth, including leaf area, shoot biomass, number of flowers and runners (Arancon *et al*., 2004), as well as yield (Arancon *et al*., 2004; Singh *et al*., 2008).

Also, with all procedures that had been taken by Egyptian government to ensure safety of strawberry, reducing chemical (mineral fertilizers and pesticides) doses is considered the core of these procedures to increase export of crops. This target may be achieved through applying both of organic fertilizers (i.e. vermicompost) and nano-fertilizers due to its high efficiency when applied at low doses (Mustafa *et al*., 2018).

Nano-fertilizers emerged in the recent decade as a new revolution in agriculture sector (Chhipa, 2017) and have a bright future. Several fertilizes had been converted into nano-forms and subjected to study (Taha *et al*., 2016; Taran *et al.,* 2014; Pradhan *et al*., 2013; Ghafariyan *et al*., 2013; Mahajan *et al*., 2011). Their results indicated a promising future and positive impact for these new forms on levels (seed germination, growth rate and nutrients content in treated plants) as compared with conventional forms.

Current work carried out in a chain of studies to discover part of mystery about employment nanotechnology (as nano-fertilizers) in reinforcing production of strawberry in combination with vermicompost.

2. Material and Methods

2.1. Plant material

Strawberry seedlings (var. Festival) were subjected of current work in National Research Center Farm, Northern Egypt, under greenhouse conditions during growth seasons (2019/2020) in 189 pots (diameters 25cm).

2.2. Vermicompost production

Mixing three species of earthworm (*Eisenia fetida, Lumbricus rubellus* and *Perionyx excavatus*) were raised on cow dung (CD) and fish sludge (FS) to produce vermicompost.

2.3. Preparation of different feeding materials

I. **Cow dung (CD) processing**

Fresh cow dung (CD) was obtained a cow farm adjacent the Central Lab for Aquaculture Research (CLAR) and subjected directly to the vermicomposting process, assuming the moisture is about 50% of the wet weight.

II. Fish sludge (FS) collection and preparation

Fish sludge (FS) was collected from the concrete ponds of Nile tilapia *Oreochromisniloticus* brood stock and fry, at Nile tilapia hatchery belonging to CLAR; during fry harvesting from the brood stock ponds as well as from fry rearing ponds. The produced FS, with a moisture content of 96.5% and solid content of 3.5%, was collected in barrels and then spread out in a thin layer on a cement floor for air drying over fourteen days, so it can be stored safely until being used.

2.4. Earthworm inoculation and Vermicompost production

Both of fresh cow dung and dried fish sludge were used for feeding three species of earthworm (*Esiena fetida*; *Perionyx excavatus* and *Lumbricus rubellus*) at a rate of 1000g of either cow dung or fish sludge for each 50 g worm. For eight weeks the boxes were checked weekly and re-moistened and mixed until the vermicompost matured. All boxes were kept indoor and the temperature maintained between 18-25°C during the vermicompost maturation. At harvest time, vermicompost was checked manually on white plastic surface and the adult as well as pre-adult earthworms were collected then the vermicompost was returned to the boxes again for one more month. Later, the vermicompost was re-checked again and all hatched earthworms were collected. The harvested vermicompost was packed in plastic bags and samples of these two vermicompost types (CD &FS) delivered to laboratories to be analyzed. Tables 1-2 showed results of physiochemical parameters (CD and FS), Microbiological activity as Colony Forming Units (CFU) of vermicompost samples analysis.

Table 1: Show physiochemical parameters of two types of vermicompost.

Parameters	Cow dung vermicompost (CD)	Fish sludge vermicompost (FS)
O.M (%)	46.6	21.06
Humidity (%)	33	27.33
Ash	20.4	54.94
C/N ratio	20.4	11.58
N(%)	1.33	1.09
P(%)	0.35	0.4
K(%)	1.08	1.88
Amino acids (mg/g DW)	0.27	0.44
ABA *(g/100 g)	0.33	0.01
GA3 *(g/100 g)	1.08	0.16
IAA *(g/100 g)	0.04	0.03

* Abscisic Acid: ABA , Gibberellic acid : GA3 and Indole Acetic Acid: IAA.

2.5. Microbiological measurements in vermicompost

Table 2: Total bacteria counts in different vermicompost samples (CD and FS)

Samples	CFU counts/g vermicompost	Samples	CFU counts/g vermicompost
Cow Dung	9.62±0.28	FS alone	3.48±0.18

Total bacteria count was determined as Colony Forming Units (CFU)

2.6. The treatments

This experiment was included different types of vermicompost, fish sludge and cow dung. Each type was applied individual with two levels (1 or 1.5kg/ pot). In the same time nano-fertilizer (NPK) was applied at two levels (200 and 400 ppm). Treatments in this experiment were eight treatments in addition to control treatment that doesn't receive neither vermicompost nor sprayed with nano-fertilizer as shown in table 3:

Table 3: Shows all treatments that included in this work

TRT	Nano-fertilizer	Vermicompost (FS)	Vermicompost (CD)
T_0 (control)	0	0	0
T_1	200ppm	1kg/plant	0
T_2	200ppm	1.5kg/plant	
T_3	400ppm	1kg/plant	0
T_4	400ppm	1.5kg/plant	0
T_5	200ppm	0	1Kg/plant
T_6	200ppm	0	1.5kg/plant
T_7	400ppm	0	1 kg/plant
T_8	400ppm	0	1.5Kg/plant

2.7. Measurements

I. Vegetative Growth parameters

Average leaf areas (cm^2), fresh and dry weight of leaves (g) were measured. Chlorophyll reading (SPAD) was recorded by using Minolta chlorophyll meter (Spad – 501).

II. Leaf nutrient content analysis

Leaves samples were dried in a ventilated oven at 70°C to constant weight. Samples were grinded in stainless steel mill with 0.5 mm sieve and kept in plastic containers for chemical analysis. The samples (1 g of each sample) were dry-ashed in a muffle furnace at 450 °C for 6 hours. The ash was dissolved in HCl (2N).

Macronutrients were extracted using the dry ashing digestion method according to Chapman and Pratt, (1979). Nitrogen was determined by using the Kjeldahl method, and phosphorus was photometrical determined in the digested solution using vanado-molybdate color reaction according to the method described by Jackson, (1973). Potassium was measured in the digested suspension using the Flamephotometer, (Eppendorof, DR Lang).

2.8. Fruit quality parameters

I. Average fruit weight (g)

Average fruit weight of ten fruits from each treatment was recorded at harvest time after 20 weeks of transplanting.

II. Total soluble solids (TSS)

Also, TSS was measured in the fruits using hand refractometer at harvest time after 20 weeks of transplanting.

III. Titratable acidity in fruit juice (%)

It was measured in the fruit juice after 20 weeks of transplanting by titration with 0.1 N NaOH (sodium hydroxide solution) using phenolphthalein indicators, according to A.O.A.C. (1990).

IV. Total sugar percentage (%)

Total sugar was measured in the fruits after 20 weeks after transplanting according to Ramachandran and Gupta, (1992).

V. Ascorbic acid content (V.C)

Vitamin (C) was determined in fruit juice using 2,6 dichloro- phenol indophenol for titration according to A.O.A.C. (1990) in harvested fruits (20 weeks after transplanting).

VI. Anthocyanin determination

The anthocyanin pigment was determined calorimetrically to Vieira *et al*. (2019).

2.9. Soil health analysis (chemical & microbial activity)

All soil samples were analyzed using the standard procedures in the laboratory at National research Centre and Faculty of Science, Tanta University.

2.10. Soil chemical analysis

Physical parameters of soil, water retention in soil and soil fertility. Soil samples were analyzed for texture, pH and electric conductivity (EC) using water extract (1: 2.5) method, total calcium carbonate ($CaCO_3$ %) determined with Calcimeter method and for organic matter (O.M %) was determined with using potassium dichromate (Chapman and Pratt (1979). Phosphorus was extracted using sodium bicarbonate (Olsen, *et al*., 1954). Potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) were extracted using ammonium acetate (Jackson (1973). Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA (Lindsay and Norvell, 1978).

2.11. Measurement of total microbial activity of soil

The total microbial enzyme activities of soils were estimated based on the rate of fluorescein diacetate hydrolytec activity. In this method, the enzymes produced by microbial populations in soil (such as proteases, lipases and esterases) are capable to cleavage the colorless fluorescein diacetate and into fluorescein (with a measurable fluorescent color). According to the methods described by Patle *et al*., (2018), 2g soil samples and FDA in potassium phosphate buffer (pH 7.6) was incubated (at 30°C) for 20 min and the developed fluorescent color of fluorescein was measured spectrophotometrically at 490 nm against fluorescein standers.

2.12. Data Statistical analysis

Means were represented as the average of replicates of two seasons (as combined analysis of two seasons. The least significant difference (LSD5%) test was used to compare among the means of treatments according to (Snedecor and Cochran, 1989).

3. Results and Discussion

3.1. Effect of combination vermicompost and nano-fertilizer on growth performance

Data in table (4) showed that most of treatments improved both of fresh and dry weight of leaves whereas the highest fresh wight (39.98gm) and dry weight (22.05gm) were recorded with T_8 meanwhile the lowest fresh and dry weight of leaves (14.75 and 7.53gm respectively) were recorded in the control treatment (T_0). In respect to leaf area, data revealed that all FS vermocompost treatments (produced leaf area ranged from 7239.17 to 10457.76 cm^2) surpassed CD vermicompost teatments (produced leaf area ranged from 6172.93 to 8386.08 cm^2) and control treatment. The highes leaf area was achieved with T_4.

Also for chlorophyll data , T_1 recoreded the highest value of chlorophyll content (55.9 SPAD) followed by T_8 that recorded (54.75 spad) whithout any markedly differences between these tw treatments.

Table 4: The effect of vermicompsts types (CD or FS) at different doses incombination with Nanofertilizer at different doses on vegative parameters and chlorophyll conten of starwberry (festival cv.)

TRT	Leaf Fresh Weight (gm)	Leaf Dry Weight (gm)	Leaf area (Cm^2)	Chlorophyll SPAD
Control (T_0)	14.75E	7.53f	5763.79e	51.04b
FS 1kg+Nano-fertilizer 200ppm (T_1)	18.15d	9.26e	7239.17d	55.90a
FS 1.5kg+ Nano-fertilizer 200ppm (T_2)	17.38d	9.99ed	9826.77a	51.03b
FS 1kg+ Nano-fertilizer 400ppm (T_3)	18.65d	10.96dc	8634.85b	51.19b
FS 1.5kg+ Nano-fertilizer 400ppm (T_4)	23.33b	11.60c	10457.76a	51.13b
CD 1kg+ Nano-fertilizer 200ppm (T_5)	12.10F	10.80dc	6172.93e	47.25c
CD 1.5kg+ Nano-fertilizer 200ppm (T_6)	20.64C	11.21dc	8386.08bc	51.13b
CD 1kg+ Nano-fertilizer 400ppm (T_7)	21.28C	15.64b	6263.87e	52.90b
CD 1.5kg+ Nano-fertilizer 400ppm (T_8)	39.98a	22.05a	7777.97cd	54.75a

Means were represented as the average of replicates of two seasons. Different letters within column are express for significant differences at LSD $P<0.05$, CD: Cow dung, FS: Fish sludge.

3.2. Effect of combination vermicompost and nano-fertilizer on nutrients content

Table (5) reveales that all treatments increased N level in treated plants as compared to the contorl and the highest N content (2.6%) was achieved with T_4 followed by T_8 (2.57%) . In respect to P, data shows that all treatments improved of P status in leaves however, all CD treatments surpassed other treatments and the highest P content (0.715%) was obtained with T_8. The trend of P was obtained for (K) content, whereas all treatments (T_1 to T_8) resluted in markedly increaments in K content comparing with the control (T_0).

Table 5: The Effect of vermicompsts types (CD or FS) at different doses incombination with Nanofertilizer at different doses nutreints conten of starwberry (festival cv.)

TRT	N	P	K	Ca	Mg
Control (T_0)	2.00d	0.32d	1.85e	0.58c	0.26a
FS 1kg+ Nano-fertilizer 200ppm (T_1)	2.13cd	0.34d	1.97De	0.67bc	0.28a
FS 1.5kg+ Nano-fertilizer 200ppm (T_2)	2.30bc	0.43c	2.00De	0.71Bc	0.28a
FS 1kg+ Nano-fertilizer 400ppm (T_3)	2.40abc	0.43c	2.12Cd	0.71bc	0.32a
FS 1.5kg+ Nano-fertilizer 400ppm (T_4)	2.60a	0.58b	2.22C	0.76b	0.32a
CD 1kg+ Nano-fertilizer 200ppm (T_5)	2.13cd	0.61b	2.28C	0.61c	0.27a
CD 1.5kg+ Nano-fertilizer 200ppm (T_6)	2.33abc	0.64ab	2.48B	0.66bc	0.28a
CD 1kg+ Nano-fertilizer 400ppm (T_7)	2.33abc	0.65ab	2.58B	0.92a	0.29a
CD 1.5kg+ Nano-fertilizer 400ppm (T_8)	2.57ab	0.71a	2.98a	0.95a	0.29a

Means were represented as the average of replicates of two seasons. Different letters within column are express for significant differences at LSD P<0.05, CD: Cow dung, FS: Fish sludge.

Also, it can be noticed that all CD treatmens surpassed FS treatments in increments of K content and the highest value (2.98%) was achieved with (T_8). For (Ca) status, data in table (5) indicats that all treatments (T_1 to T_8) improved Ca status in comparison with T_0 which resulted in the lowest Ca content (0.58%), meanwhile the highest values of Ca content were produced fromT_8 & T_7 (0.95 and 0.92 respectively). In regard to impact of studied treatments on Mg status, they didn't produced noticable differences. However, ingeneral it inceased with the increased level of nanofertilizer.

3.3. Effect of combination vermicompost and nano-fertilizer on fruit quality

Generally, Table 6 shows that most measured fruit quality parameters were improved with applied treatments comparing to the control except for pH paratmeter that didn't affect by applying vermicompost treatments combined with nano-fertilizers doses. For instance, average fruit weight was improved by applying studied treatments compared to the control treatment (12.57gm). Also, most CD treatments surpassed FS treatments in its positive impact on average fruit fresh weight whereas the aveage fruit fresh weight ranged from (15.43gm) for T_5 to (19.9 gm) for T_8. Meanwhile, FS vermicompost treatments recodered average fruit weight ranged from (12.57g) for T_2 to 17.23 for T_3. Also, increasing FS vermicompost doses resulted in decreasing fruit weight at the same level of nano-fertlizers. For instances, at 200 ppm level of nanofertilizer, it can be nticed that raised FS vermicmpost from 1kg/plant to 1.5gm/plant led to decreasing average fruit fresh weight from (14.8 to 12.57gm). Also this decreament of average fruit fresh weight was descended from 17.23 to 13.83gm when FS vermicompost raised from 1kg/plant to 1.5kg/plant at nan-fertilizers at 400 ppm. Meanwhile the trend of impact of vermicompost doses on fruit fresh weight was reversed with CD vermicompost whereas the fruit fresh weight increased with increasing CD vreicompost doses at the same of nao-fertilizer.

Table 6: The effect of vermicompsts types (CD or FS) at different doses incombination with nanofertlizers at two levels on fruit quality of strawberry

TRT	Fruit Weight (g)	pH	TSS (%)	Acidity (%)	Sugar mg/100g F.W	VC mg/100g F.W	Anthocyanin
Control (T_0)	12.57**d**	3.30**a**	6.00**b**	0.54**c**	3.84**c**	47.85**h**	43.97**f**
FS 1kg+ Nano-fertilizer 200ppm (T_1)	14.80**c**	3.48**a**	8.00**a**	0.58**c**	5.02**a**	54.34**a**	66.61**c**
FS 1.5kg+ Nano-fertilizer 200ppm (T_2)	12.57**d**	3.30**a**	7.67**a**	0.54**c**	4.61**b**	49.20**g**	57.51**d**
FS 1kg+ Nano-fertilizer 400ppm (T_3)	17.23**b**	3.32**a**	8.00**a**	0.77**b**	4.81**a**	50.15**f**	51.63**e**
FS 1.5kg+ Nano-fertilizer 400ppm (T_4)	13.83**cd**	3.42**a**	7.00**ab**	0.64**cb**	3.84**c**	47.85**h**	78.38**a**
CD 1kg+ Nano-fertilizer 200ppm (T_5)	15.43**c**	3.45**a**	6.00**b**	0.71**cb**	4.94**a**	52.22**b**	71.16**b**
CD 1.5kg+ Nano-fertilizer 200ppm (T_6)	19.47**a**	3.53**a**	6.00**b**	1.10**a**	4.86**a**	52.00**c**	43.71**f**
CD 1kg+ Nano-fertilizer 400ppm (T_7)	17.00**b**	3.36**a**	7.33**ab**	0.70**cb**	4.85**a**	51.58**d**	43.97**f**
CD 1.5kg+ Nano-fertilizer 400ppm (T_8)	19.90**a**	3.52**a**	8.00**a**	0.67**cb**	4.84**a**	51.08**e**	71.69**b**

Means were represented as the average of replicates of two seasons. Different letters within column are express for significant differences at LSD P<0.05, CD: Cow dung, FS: Fish sludge.

In regard to total soluble solid (TSS) parameter, we can notice that control treatment (T_0) produced the lowest value of TSS (6%) meanwhile the most other treatments produced higher values of TSS that ranged from 7 to 8. Besides, it may notice that all FS vermicompost treatments surpassed CD vermicompost treatments in their positive impact on increasing TSS. Moreover, increasing vermicompost doses from 1kg to 1.5kg/plant FS vermicompost led to decline TSS values at the same level of nanofertilizer. On the other hand, increasing level of nano-fertilizer from 200 to 400ppm resulted in raising TSS level particular with CD vermicompost.

For acidity Parameter, control treatment (T_0) produced the lowest value of acidity (0.54%). Also, Most stutied treatments resulted in raising values of acidity from 0.54 to 1.15 and the highest acidity was achieved wih T_6 (1.1%). In addition, it may notice that raising level of vermicompost from 1 - 1.5kg/plant led to decline degree of fruit acidity at the same level of nano-fertilizer. On the other hand, increasing level of nano-fertilizer from 200 to 400ppm resulted in raising acidiy level particular with FS vermicompost.

Concern Sugar content in fruits, most applied treatments have a positive impact on fruit sugar content comparing to T_0. With close view, data indicats that the highest sugar (5.02 mg/100g FW) was achevied with T_2. Decreasing FS vermicompost level from 1.5 to 1.0 kg/plant led to decline sugar content in fruits at the same level of nanofertilize. Besides, there was reverse relation between nano-fertilizer level and sugar content in fruit particular in FS vermicompost treatments.

For VC, data shows that studied treatments (T_1 to T_8) have a positive impact on VC(mg/100g FW) in fruits comparing to the control (T_0). Through the present data , it may be obseverd that CD vermicompost treatments surpassed FS vermicompost except for (T_1) which recorded the highest content of VC in fruits. Also, with the same type of vermicompost, increasing vermicompost from 1 to 1.5kg has a ngative impact on VC content in fruit. Also, increasing nano-fertilizer from 200ppm to 400ppm with the same type of vermicompost resulted in a reduction in VC content.

For Anthocyanin, data revealed that most studied treamtents improved anthocyanin content in fruits and the highest value was achieved with T_4 comparing to the control treatment (T_0).

3.4. Effect of combination vermicompost and nano-fertilizer on soil health

In table (7) data revealed that generally, studied treaments led to markedly decrement in pH. Also, data indicated that increasing FS vermicompost doses resuted in decresing in pH at the same level of nano-fetrilizer.Moreover, treatments of CD vermicompost combined with nanofertilizer resulted in decreasing pH more than FS treaments.

For organic matter, data showed that CD vermicompost treatments led to markedy increase in organic matter specially with increasing CD vermicompost levels. Meanwhile, the trend changed in FS vemicompost treatments whereas organic metter decreased with increasing FS vermicompost levels. The lowest organic matter (0.6%) was recorded with treatment (T_5)

For P, generally most treatments enhanced P status in soil comparing to the (T_0). Also, for FS vermmicompost treatments , data showed that at same level of nanofertilizer (whether 200 or 400ppm) P level increased (from 2.19 to 2,42 %) and from (from 1.04 to 1.38%) with increasing FS vermocompost levels from 1 o 1.5kg respectively. The trend was reveresed in CD vermicompost treatments whereas at the same level of nanofertilizer , raising CD vermicompost from 1 to 1.5kg/plant produced decreament in P level from 2.76 to 1.54% at 200ppm of nanofertilizer level and from 1.71 to 0.93% at 400ppm of nanofertilizer.

For K status, there was no clear trend. The highest values of K was achieved with T_8 (6.92%) and T_5 (6.91%) meanwhile the lowest level of K was produced with treatment T_6 (4.45%) and T3 (4.74%).

Table 7: The Effect of vermicompsts types (CD or FS) at different doses incombination with Nanofertilizer at different doses on some soil physico-chemical of starwberry (festival cv.)

TRT	pH	O.M	P	K
Control (T_0)	8.35a	0.65c	0.71i	6.21b
FS 1kg+ 200 ppm nano-fertilizer (T_1)	8.04ba	0.72b	2.19c	5.90c
FS 1.5kg+ 200ppm nano-fertilizer (T_2)	7.96ba	0.70b	2.42b	6.13b
FS 1kg+ 400ppm nano-fertilizer (T_3)	8.38a	0.65c	1.04g	4.74f
FS 1.5kg+ 400ppm nano-fertilizer (T_4)	8.05ba	0.58d	1.38f	5.43d
CD 1kg+ 200ppm nano-fertilizer (T_5)	7.87b	0.60d	2.76a	6.91a
CD 1.5kg+ 200ppm nano-fertilizer (T_6)	7.66b	0.65c	1.54e	4.45g
CD 1kg+ 400ppm nano-fertilizer (T_7)	7.77b	0.70b	1.71d	5.01e
CD 1.5kg+ 400ppm nano-fertilizer (T_8)	7.64b	0.77a	0.93h	6.92a

Means were represented as the average of replicates of two seasons. Different letters within column are express for significant differences at LSD $P<0.05$, CD: Cow dung, FS: Fish sludge.

3.5. Effect of combination vermicompost and nano-fertilizer on microbial activity in treated soil

The obtained results in table 8 indicated that all applied treatments enhaced microbial activity in soil whereas this activity was raised from (1.9 to 5.1 µg Fluorescein/g) in the control treatment to T4 respectively, the other treaments resulted in values wihin this range. Also, data indicated that most FS vermicompost treatments surpassed CD vermicompost treatments and T4 recorded the highest level (5.1 µg fluorscein /g soil). Besides, main positive impact for these treatment may be attributed to vermicompost rather than nanofertilizer and this may be reffered to nature of vermicompost as organic fertilizer.

Table 8: The effect of vermicompsts types (CD or FS) at different doses incombination with Nanofertilizer at different doses on Total Microbial Activity of soil (µg Fluorescein/g)

TRT	Average total microbial activity (µg Fluorescein/g)
Control T_0	1.9 c
FS1k+ Nano- fertilize (200ppm) T_1	2.95 bc
FS1.5k+ Nano-fertilize (200ppm) T_2	3.50 bc
FS1k+ Nano-fertilize (400ppm) T_3	4.28 ab
FS1.5k+ Nano-fertilize (400ppm) T_4	5.1 a
CD 1k+Nano-fertilize (200ppm) T_5	1.95 c
CD 1.5k+ Nano-fertilize (200ppm) T_6	2.9 bc
CD 1k+ Nano-fertilize (400ppm) T_7	3.08 bc
CD 1.5k+ Nano-fertilize (400ppm) T_8	3.5 bc

Means were represented as the average of replicates of two seasons. Different letters within column are express for significant differences at LSD $P<0.05$, CD: Cow dung, FS: Fish sludge.

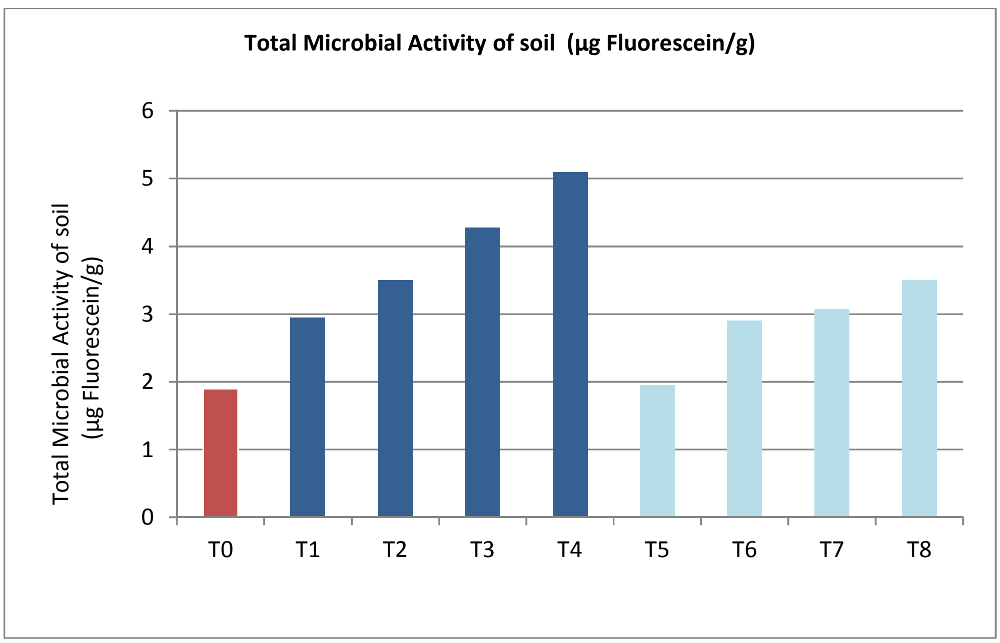

Fig. 1: Shows that all studied treatments improved microbial activity in soil that ranged from (1.9 µg Fluorescein/g) with T_0 to T_5 (5.1 µg Fluorescein/g) and other treatments came within this range.

4. Discussion

These positive results may be due to several points: a) for promoting effects of vermicompost on crop growth and productivity whereas several studies indicate vermicompost doesn't only rich in nutrients but also, it contains amino acids, hormone-like compounds (auxin, cytoknini and humus acids). All these compounds encourage growth performance plants and that will reflect on it productivity and quality, b) vermicompost considered as amendment for soil structure which lead to enhance growth of root system and uptake nutrients, c) vermicompost has a positive effect on beneficial soil microorganisms that improve nutrients absorption from soil by plant roots and d) vermicompost plays an effective role in improving water retention in soil these explanation agree with findings of (Moustafa *et al.,* 2021).

These results agree with the findings of Arancon *et al.,* (2004) and Avetisyan *et al*., (2021) who reported that there were positive effects of vermicompost on the growth of strawberry plants, especially the increase of leaf area and vegetative dry weight in field conditions. Besides, Bejbaruah *et al.,* (2013) showed that vermicompost had beneficial effects on the growth and yield of rice, caused a significant increase of many growth parameters, seeds germination, chlorophyll content and yield production.

In regard to nano-fertilizer application that resulted in enhancing fertilizer efficiency at low doses that will be reflected on metabolic processes in plants, plant growth performance, productivity, fruit quality and protecting environment (ground water and soil from accumulation minerals to toxic levels). These explanation is agree with what was reported by (Astaneh *et al*., 2021) who stated nano-fertilizers offer benefits in nutrition management through their strong potential to increase nutrient use efficiency. Besides, Cvelbar *et al*., (2021) reported that nano-Ca fertilization especially improved the strawberry fruit quality. Also, Naderi *et al.,* (2013) reported that nano-fertilizers could enhance nutrient use efficiency and decrease the costs of environmental protection. Moreover, Jubeir *et al.,* (2019) concluded that using nano-fertilizer and NPK enhances the vegetable and fruit characteristics of date palm.

5. Conclusion

This study came in a chain of several evidences that support the positive role of both vermicompost and nano-fertilizers on plant growth and soil health. Also, through vermicompost and nano-fertilizers application, the excessive amount of mineral fertilizers that used by farmers may be reduced to safe level for environment and consumer health.

Significance Statements

This study emphasized that vermicompost is an effective organic fertilizer to maintain soil health due to its content of several beneficial compounds such as nutrients, amino acids, growth promoters, humus compounds and microorganisms, which improved the vegetative growth and fruit quality of plants. Moreover, combining vermicompost and nano-fertilizer application may lead to improve fruit quality and decrease mineral fertilizers doses which reflect on consumer and soil health.

Author contributions

Mustafa N. S.: setting up the experiment, Monitoring all stages of experiment, revision data and writing the article.
Moustafa Y. T. A.: vermicompost production and monitoring all stages of experiment
El-Dahshouri M. F.: carrying out all analysis processing needed for study
EL-Sawy S. M.M.: conducting the experiment and collecting data
El-Hady Eman, S.: determining fruits quality parameters and data analysis
Haggag Laila F.; supervision on carrying out the experiment and revision the article
Zhang L. participating in setting up the experiment and revision the article
Zuhair Raghda M. conducting all microbial analysis and writing the microbial activity part

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References

Hamdia, M. Moussa, Fatima A. Shafiq and Nagwa M. El-Agroudy, 2019. An Economic Study of the Egyptian Exports of Strawberry Crop. Middle East Journal of Agriculture Research,8(02): 438-444. https://curresweb.com/mejar/mejar/2019/438-444.pdf

Moustafa, Y.T.A., T.R. Elsayed, M.F. El-Dahshouri, S.A.A. Gomah, L. Zhang and N.S.A. Mustafa, 2020. Effect of aquatic plants (Duck Weed and Water Hyacinth) on physico-chemical and microbial activities of vermicompost. Bioscience Research, 17(2): 1511-1520. https://www.isisn.org/BR17(2)2020/1511-1520-17(2)2020BR20-140.pdf.

Moustafa, Y.T.A., E.S. El-Hady, M.F. El-Dahshouri, R., Zuhair, L. Zhang and N.S.A. Mustafa, 2021. Impact of different agro-wastes on quality of vermicompost made of either fish sludge or cow dung. Asian Journal of Plant science, 20(3): 370-379. https://doi.org/10.3923/ajps.2021.370.379

Arancon, N., C.A. Edwards, and P. Bierman, 2006. Influences of vermicomposts on field strawberries: Part 2. Effects on soil microbiological and chemical properties. Bioresour. Technol., 97:831–840.

Singh, R., R.K. Gupta, R.T. Patil, R.R. Sharma, and S. Kumar, 2008. Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch.). Bioresour. Technol., 99:8507– 8511.

Arancon, N., C. Edwards, P. Bierman, C. Welch, and J. Metzger, 2004. Influences of vermicomposts on field strawberries: 1. Effects on growth and yields. Bioresour. Technol., 93:145–153.

Mustafa, N.S., H.H. sharawy, M.F. El-Dahshouri, and Sherin A. Mahfouze, 2018. Impact of nano-fertilizer on different aspects of growth performance, nutrient status and some enzymes activities of (Sultani) fig cultivar. Bioscience Research, 15(4):3249-3436.

Chhipa, H.E.C.L., 2017. Nano-fertilizers and nano-pesticides for agriculture. Environmental Chemistry Letters, 15(1):15–22.

Taha, R.A., M.M. Hassan, E.A. Ibrahim, N.H.A. Baker, and E.A. Shaaban, 2016. Carbon nanotubes impact on date palm in vitro cultures. Plant Cell Tissue Organ Cult., 127(2):525–534.

Taran, N.Y., O.M. Gonchar, K.G. Lopatko, L.M. Batsmanova, M.V. Patyka, and M.V. Volkogon, 2014. The effect of colloidal solution of molybdenum nanoparticles on the microbial composition in rhizosphere of *Cicer arietinum* L. Nanoscale Res. Lett., 9:289.

Pradhan, S., P. Patra, S. Das, S. Chandra, S. Mitra, K.K. Dey, S. Akbar, P. Palit, and A. Goswami, 2013. Photochemical modulation of biosafe manganese nanoparticles on Vignaradiata: a detailed molecular, biochemical, and biophysical study. Environ. Sci. Technol., 47:9.

Ghafariyan, M.H., M.J. Malakouti, M.R. Dadpour, P. Stroeve, and M. Mahmoudi, 2013. Effects of magnetite nanoparticles on soybean chlorophyll. Environ. Sci. Technol., 47:10645– 10652.

Mahajan, P., S.K. Dhoke, and A.S. Khanna, 2011. Effect of nano-ZnO particle suspension on growth of mung (*Vigna radiata*) and gram (*Cicer arietinum*) seedlings using plant agar method. J. Nanotechnol., 7.

Chapman, H.D. and P.F. Pratt, 1979. Methods of Analysis for Soils, Plants and Waters. 2^{nd} Edn., University of California Press, Berkeley, CA., USA PP: 12-19.

Jackson, M.L., 1973. Soil Chemical Analysis. 1^{st} Edn., Prentice Hall Ltd., New Delhi, India, Pages: 498.

A.O.A.C. 1990. Official Methods of Analysis of Association of Official Agricultural Chemists. 15th: 1045-1106.

Ramachandran K.N. and V.K. Gupta, 1992. Determination of Total Sugar in Food and Environmental Samples using 3,4-Dimethylphenol as a Reagent. Microchemical Journal, 45: 361-3.

Vieira, L.M., M.G.M. Letícia, G.R. Juliana De Cássia, A.R.B. Frederico, and C.S. Paulo, 2019. Chromatic analysis for predicting anthocyanin content in fruits and vegetables. Food Sci. Technol., Campinas, 39(2): 415-422, Apr.-June 2019. https://doi.org/10.1590/fst.32517.

Olsen, S.R., C.V. Cole, F.S. Watamable and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. US Department Agric. Circ., 939: 1-19.

Lindsay, W.L. and W.A. Norvell, 1978. Development of DTPA micronutrient soil tests for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J. 42(3): 421-428. https://doi.org/10.2136/sssaj1978.03615995004200030009x

Patle, P.N., N.P. Navnage, and P.K. Barange, 2018. Fluorescein diacetate (FDA): measure of total microbial activity and as indicator of soil quality. Int. J. Curr. Microbiol. Appl. Sci., 7: 2103-2107.

Snedecor, G.W., and W.G. Cochran, 1989. Statistical Methods, 8th Ed. Iowa State University Press Ames: 158-160.

Moustafa, Y.T.A., N.S.A. Mustafa, M.F. El-Dahshouri, S.M.M. EL-Sawy, L.F. Haggag, L. Zhang and R. Zuhair, 2021. Role of Vermicompost Types (Fish Sludge and Cow Dung) in Improving Agronomic Behavior and Soil Health of Tomato Crop (In press).

Avetisyan, A., M. Hokhanyan, K. Herdt, L. Lund, A.L. Hykkerud, L. Jaakola, and I. Martinussen, 2021. Effect of organic fertilizer on growth of strawberry cultivar 'Sonata'. Acta Hortic. 1309: 629-634. https://doi.org/10.17660/ActaHortic.2021.1309.90

Bejbaruah, R., R.C. Sharma and P. Banik, 2013. Split application of vermicompost to rice (Oryza sativa L.): Its effect on productivity, yield components and N dynamics. Org. Agr., 3: 123-128.

Astaneh, N., F. Bazrafshan, M. Zare, B. Amiri, and A. Bahrani, 2021. Nano-fertilizer prevents environmental pollution and improves physiological traits of wheat grown under drought stress conditions. Scientia Agropecuaria, *12*(1): 41-47.
https://doi.org/10.17268/sci.agropecu.2021.005

Cvelbar, W.N., D. Koron, J. Jakopiˇc, R. Veberiˇc, M. Hudina, and H. Baša Cesnik, 2021. Influence of Nitrogen, ˇ Calcium and Nano-Fertilizer on Strawberry (Fragaria × ananassa Duch.) Fruit Inner and Outer Quality. Agronomy 2021, 11, 997.
https://doi.org/10.3390/agronomy11050997

Naderi, M.R., and A.D. Shahkari, 2013. Nanofertilizers and their roles in sustainable agriculture. Int. J. Agric. Crops Sci., 19: 2229–2232.

Jubeir, S.M., W.A. Ahmed and Shaimaa Mohammed, 2019. Effect of nano-fertilizers and application methods to yield characteristics of date palm. Plant Archives, 19(1): 1881-1886.