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Using Vermicompost as a Complementary to Mineral Fertilization in Cotton

Shaimaa O. El-Sayed[1*] and A. M. Abd El All [2]

[1]Cotton Agronomy Dep., Cotton Res. Institute, Agric. Res. Center, Giza, Egypt.
[2]Agric. Botany Dep., Faculty of Agric. Shebin El-Kom, Menoufia University.

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ABSTRACT

Two field experiments were carried out at the Research Farm of El-Gemmeiza Agric. Res. Station, El– Gharbia Governorate during 2018 and 2019 seasons, to study the effect of four NPK fertilizer rates (the recommended NPK rate (100%) serving as a control, 75%, 50% and 25% of the recommended NPK rate), foliar spraying with vermicompost extract at three levels (0, 5 cm^3 /L and 7.5 cm^3 /L) at three times (at 30, 45 and 60 days from sowing) and their interaction. The experimental design was a strip plot with four replicates in both seasons. The important results indicated that increasing NPK rate from 25% to 100% significantly increased leaves chemical composition and resulted in a significant increase in growth traits, earliness traits, yield and its components in both seasons and significantly increased fiber length and strength in one season. Fiber uniformity and fineness did not affect.Foliar application with 7.5 cm^3/L vermicompost extract significantly increased leaves chemical composition and recorded a significant increase in growth traits, earliness traits, yield and its components in both seasons, except number of total flowers $plant^{-1}$ and fiber strength which significantly increased in one season. Fiber length, uniformity index and fineness did not affect in both seasons.Regarding the interaction effect, data show that the best results were obtained from the high level of vermicompost extract (7.5 cm^3/L) combined with 100% NPK. It could be concluded this combination under El-Gemmeiza condition, to increase cotton productivity through soil fertility especially in vigor's cultivar like Giza 86.

Keywords: Vermicompost, extract, NPK, rate, foliar.

INTRODUCTION

Cotton is the most important commercial crop playing an outstanding role in the Egyptian economy and social affairs. It is backbone of our textile industry in addition, to its important for the production of oil for human consumption and cottonseed meal for livestock.

There are many serious problems related to nutritional factors such as over NPK fertilization and due to insufficient uptake of these chemical fertilizers by plants, where they reach into water bodies, cause eutrophication in water bodies and affect living beings including growth inhabiting microorganism. The excess uses of nitrogen fertilizers in agriculture are costly and also have various adverse effects on soils as depletion of water holding capacity, soil fertility and disparity in soil nutrients. In addition to this adverse effect and losses of N, air pollution caused by N volatilization cannot be neglected in this respect. Losses of nitrogen fertilizers are not only impacts to the environment, but also are great economic losses. Under such a condition, there is a great urgency to explore an alternate source, which can serve as a good supplement partially or wholly the use of chemical fertilizers and eco-friendly fertilizers which work without disturbing nature to reduce the environmental pollution related to excess use of chemical fertilizer costly input, protect the fragile ecosystem and to maintain high productivity and sustainability of soil and crop. Integrated use of chemical fertilizer and organic manures in suitable amount and balanced proportion is indispensable and can play an important role to increase cotton productivity through soil fertility. The requirement of cotton for nutrients is much higher during early growth stages, because of greater assimilatory and accumulation capacity of roots and shoots to accommodate the future needs (Ahmed *et al.*, 2016). The new varieties of cotton had highly response to NPK fertilizer, where by increasing these nutrients increased yield and its components. Hamoda *et al.* (2014) reported that the growth traits and seed cotton yield increased with increasing rates of NPK applied, Emara *et al.* (2015) found that the fiber properties did not affect by NPK fertilizer levels. Elhamamsey *et al.* (2016) reported that among fertilization rates, maximum boll weight, number of bolls $plant^{-1}$ and yield fed^{-1} were recorded with using the high fertilizer rate.

Nitrogen (N) is a major nutrient element limiting cotton production. Deficiency of nitrogen from seedling emergence to flowering initiation leads to inadequate vegetative growth, resulting in reduced fruiting (Sattar *et al.*, 2017). Thus, N nutrition is known to be the major pivotal facets of cotton production (Iren and Aminu, 2017). Soil fertility is a crucial factor in reducing cotton production risks and increasing its productivity. N deficiency causes premature senescence of the plants and reduces their productivity (Dong *et al.*, 2012). However, Luo *et al.* (2018) found that reducing N by 30% of the recommended dose did not affect cotton yield.

Phosphorus is one of the major nutrients necessary for cotton growth and development. Soil phosphorus

* **Corresponding author.**
E-mail address: shimaa4elsayed@gmail.com
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availability for crop uptake is pH dependent and alkalinity can adversely affect its uptake. Phosphorus is quite immobile in soils with neutral or high pH and appears in more or less stable calcium phosphates. Phosphorus is a nutrient related to the energy supply used in the photo assimilates production (Fahad *et al*., 2016).

In photosynthesis, K has the role of maintaining the balance of electrical charges at the site of ATP production. Also, K promotes the translocation of photosynthates (sugars) for plant growth or storage in fruits or roots (Hearn, 1981). Potassium is involved in protein synthesis (Uchida, 2000).

Vermicomposting is a simple biotechnological process of composting, in which earthworms of certain species are used to enhance the waste conversion process and produce a better end product (Lazcano and Domínguez, 2011). Vermicompost has higher nutritional value and direct effects on plant growth than traditional composts, where earthworms increased mineralization rate and humification degree (Albanell *et al*., 1988). Vermicompost provides plants with nutrients such as phosphates, nitrates and exchangeable calcium and soluble potassium in available forms (Orozco *et al.,* 1996). Vermicompost contains plant growth regulators and other plant growth influencing materials produced by microorganisms (Grappelli *et al.,* 1987). Production of cytokinins and auxins from organic wastes were processed by earthworms (Krishnamoorthy and Vajrabhiah, 1986). Certain metabolites, such as vitamin B, vitamin D and similar substances were released by earthworms (Nielson, 1965). In contrast to mineral fertilizers, the amount of nutrients provided by vermicompost depends on the original feedstock, processing time and its maturity (Campitelli and Ceppi, 2008). Vermicompost may influence plant growth directly *via* the supply of plant growth regulating substances (PGRs) and indirectly *via* the suppression or mitigation of plant diseases. The presence of biological suppressive agents in vermicompost can suppress a wide range of microbial diseases; plant parasitic nematodes and insect pests.

On the way of clean agriculture, this work aimed to study the effect of using vermicompost extract as ideal organic manure, safe for use, less expensive and as an alternative or complementary to NPK mineral fertilization in cotton

MATERIAL AND METHODS

Two field experiments were carried out at the Research Farm of El-Gemmeiza Agric. Res. Station, El–Gharbia Governorate during 2018 and 2019 seasons, to study the effect of four NPK fertilizer rates (the recommended NPK rate (100%) serving as a control, 75%, 50% and 25% of the recommended NPK rate), foliar spraying with vermicompost extract at three levels (0, 5 cm^3 /L and 7.5 cm^3 /L) at three times (at 30, 45 and 60 days from sowing) and their interaction on leaves chemical composition, growth traits, earliness traits, seed cotton yield and its components and fiber quality of the Egyptian cotton cultivar Giza 86 (*Gossypium barbadense* L.). The experimental design was a strip plot with four replicates, where the horizontal plots were assigned to the following four rates of NPK:

a_1- The recommended NPK rate (100%) serving as a control.
a_2- 75 % of the recommended NPK rate.
a_3- 50 % of the recommended NPK rate.
a_4- 25 % of the recommended NPK rate.

While, the vertical plots contained the following three levels of vermicompost extract:

b_1- Without vermicompost extract application (sprayed with tap water) as a control.
b_2- Foliar spraying with 5 cm^3 vermicompost extract /L.
b_3- Foliar spraying with 7.5 cm^3 vermicompost extract /L.

Mineral NPK fertilizers application:

The recommended rate of NPK fed^{-1} was 45 kg N +22.5 kg P_2O_5 + 24 kg K_2O. Nitrogen was applied as urea (46% N) at the tested rates in two equal doses. The first dose application was done 21 days after sowing and the second dose at 36 days after sowing. Phosphorus fertilizer was added at the tested rates as calcium superphosphate (15.5% P_2O_5) before sowing. Potassium fertilizer was soil added at the tested rates as potassium sulphate (48 % K_2O) in one dose after thinning.

Preceding crop was sugar beets (*Beta vulgaris* L.) in 2018 season and Egyptian clover (*Trifolium alexandrinum* L.) "berseem" only one cut in 2019 season.

Vermicompost extract treatments were foliar spraying three times (after 30, 45 and 60 days from sowing) on cotton leaves using hand operated sprayer compressed at a low volume of 200 liter per feddan. The lower leaf surface was sprayed until wetted as well as the upper surface using Tween 20 as a non-ionic surfactant at a concentration of 0.01%.

Preparation and application of vermicompost extract:

Vermicompost was extracted by the weighting 1 kg of raw material of vermicompost and dissolved in 100 liters of water. Vermicompost extract at the tested levels was three foliar applications (at 30, 45 and 60 days old). The main characteristics of raw material of vermicompost are depicted in Table 1.

Table 1.*The main characteristics of raw material of vermicompost used in the study

Components	Value	Components	Value
pH (1: 10)	8.3	Total chloride %	0.50
E.C. (1: 10) (ds/m^2)	1.97	Total iron %	1.0
Total nitrogen %	1	Total zinc %	0.022
Weight of m^3 kg	810	Moisture %	16
Total phosphorus(P_2O_5) %	1.63	Total manganese %	0.02
Total potassium (K_2O) %	0.66	Total copper ppm	46.2
Nitrate ppm	309	Nitrogen amonumy ppm	52
Total magnesium %	0.60	Total boron ppm	31.3
Total calcium %	6.20	C : N ratio	13:1
Moisture %	16	Ash %	77.71
**Organic matter %	22.29	Organic carbon %	12.93
Weed seeds, fungi sp and Nematoda	Not found	Nitrogen nitraty ppm	309

***Optimizing of Soil, Water and Environment Res. Inst. (SWERT). Analysis was done for vermicompost powder on the basis of dry weight except moisture content.**

**** Organic matter (OM) = Organic carbon x1.724 (Waksman, 1952).**

Before sowing, the soil samples represented layer from 0-30 cm depth from five spots across, were collected in a zigzag pattern, composited and analyzed according to (Estefan *et al*., 2013) and the results are depicted in Table 2.

Table 2. The particulars of the experimental soil sites in the two seasons of study

Particulars	Optimal Value (Ankerman and Large, 1974)	Season 2018	Season 2019
Mechanical analysis			
Clay%		38.0	44.2
Silt%		38.0	33.0
Sand%		24.0	22.8
Texture		Clay loam	Clayey
Chemical analysis			
pH (1 soil: 2.5 distilled water suspension using an automated pH analyzer)	6.7-7.3	8.0	8.1
EC ds/m^2 (1 soil: 2.5 distilled water extract at 25 ˚C using electrical conductivity meter)	1.5	0.37	0.99
Organic matter %	2.6-3	1.23	1.40
Total N(mg/100g)	30-60	43.05	49.00
Available P (mg/100g)	1.2-2.7	1.19	1.28
Available K (mg/100g)	21-30	21.5	31.0
Available Mg (mg/100g)	30-180	19	23
Available Fe (ppm)	10-16	6.0	12.4
Available Mn (ppm)	8-12	2.1	3.9
Available Zn (ppm)	1.5-3.0	0.70	1.12
Available Cu (ppm)	0.8-1.2	0.9	1.7

Sowing date was on 10 April in both seasons and the seedlings were thinned to two vigorous seedlings hill^{-1} at 21 days after sowing. The sub-plot area was 14 m^2 included 5 ridges 70 cm wide and 4 m long with hills 25 cm apart in both seasons. The other cultural practices were done as recommended for cotton production.

Studied characters: -

In 2019 season, twenty leaves (4th upper leaf) were randomly taken from plants of each sub-plot after 15 days from the last spraying of vermicompost extract (at 75 days old) to determine the following traits:

1- Mineral nutrients: Concentrations of Fe, Mn, Zn and Cu in ppm were determined with an atomic absorption spectrophotometer and percentages of total N, P, K, Mg and Ca were determined according to Chapman and Pratt (1978) and Ma and Zauzage (1942).

2- Photosynthetic pigments and total carbohydrate: Chlorophyll a, chlorophyll b, total chlorophyll and carotenoids were calculated using Wettestein's, 1957 formula as described by A.O.A.C. (1995) and were expressed as (mg/g dry weight). Total carbohydrate was determined according to the method of Dubois *et al*. (1956) and was expressed as (ug/g dry weight).

3- Growth parameters: Six guarded plants were randomly taken from each sub-plot after 15 days from the last spraying of vermicompost extract (at 75 days old). Roots of sample plants were removed at the cotyledonary nodes, then the different plant fractions were washed and oven dried to a constant weight at 70 °C and their total dry weights (g plant^{-1}) were obtained. Leaf area (dm^2 plant^{-1}) was determined by using disc method according to Johnson (1967). At harvest, data were taken from ten random representative guarded plants from each sub-plot to determine final plant height (cm) at harvesting and its number of fruiting branches

4- Earliness measurements: Numbers of total flowers and total bolls set plant^{-1}, boll setting percentage as percentage of total number of bolls set plant^{-1} to total number of flowers set plant^{-1} and first picking percentage.

5- Seed cotton yield and yield contributory characters: Number of open bolls plant^{-1}, boll weight (g), seed cotton yield plant^{-1} (g), lint % and seed index **(g).** The seed cotton yield (kentar fed^{-1}) was estimated as the weight of seed cotton in kilograms picked twice from each plot and transformed to kentars feddan^{-1} (one kentar =157.5 kg seed cotton and one feddan = 4200.83 m^{-2}).

6- Fiber quality: Samples of lint cotton were taken from each sub-plot after ginning seed cotton yield on a laboratory gin stand. All fiber tests for the samples were made at the laboratories of the Cotton Technology Research Division, Cotton Research Institute, Fiber upper half mean length (2.5% span length in mm.) and uniformity index (%) were determined on digital fibrograph instrument 630 according to A.S.T.M. (2012), D1447-07. Fiber fineness (micronaire reading) was determined on micronaire instrument 675 according to A.S.T.M. (2012) D1448-97. Fiber strength (Pressley index) was determined on Pressley instrument according to A.S.T.M. (2012), D1445-67.

Statistical analysis

All data were statistically analyzed with a strip plot design according to Snedecor and Cochran (1981). Whenever, the results were found to be significant, the treatments means were compared using LSD at 0.05 level of probability according to Waller and Duncan (1969).

RESULTS AND DISCUSSION

1-Leaves mineral nutrients:

A-Effect of NPK rates:

Different rates of NPK fertilizer significantly affected concentrations of macro and micronutrients studied in cotton leaves (Table 3), where the higher percentages of macronutrients and higher concentration of micronutrients in cotton leaves were recorded under higher fertility rate (100% RDF) followed by 75 % RDF, medium rate (50% RDF) and at last by low rate (25% RDF). The increase of nutrients concentration in leaves with the increase in NPK fertilizers rate could be attributed to the better availability of nutrients and their transport to the plant from the soil and the increase of plant requirements for nutrients resulting in a higher uptake of the nutrients. In this concern, it was found that potassium application significantly increased the NPK uptake by cotton plant (Dev et al., 2007). Raza et al. (2007) evaluated three levels of NPK fertilizers (half recommended, recommended and double recommended dose) on nutrient uptake by cotton plant. Nutrient use efficiency, in case of recommended dose of NPK fertilizers was increased by 12 and 90% in the year 2004 and 23 and 94% in the year 2005 over half dose of recommended fertilizers and two fold of recommended dose of fertilizers, respectively. The effect of fertilizers was significant on plant leaf NPK concentration during both years except phosphorus concentration during 2005. The absorption of N, K and Zn reduced under phosphorus deficiency (Duggan et al., 2009). Ghodpage et al. (2009) found that total uptake of N, P and K was increased by 47.47%, 54.51% and 40.09%, respectively with the application of 100% RDF over absolute control. The uptake of NPK by cotton plant was increased with increasing level of NPK (Bhalerao et al., 2011). Iqbal et al. (2020) found that

phosphorus application significantly affected N, P and K uptake..

B-Effect of vermicompost extract levels:

levels of vermicompost extract significantly affected concentrations of macro and micronutrients studied in cotton leaves (Table 3), where the higher values of these nutrients were recorded under higher vermicompost extract level (7.5 cm^3/L) as foliar spraying three times (at 30, 45 and 60 days from sowing) followed by the low level of vermicompost extract (5 cm^3/L) and at last by without vermicompost application. The positive effect due to higher vermicompost extract level is mainly referred to the high content of nutrients reserve in vermicompost (Table 1) and provides plant with these nutrients in available forms and thus, increasing accumulation of N, P, K, Ca, Mg, Fe, Zn, Mn and Cu uptake in cotton leaves as shown in Table 3. Moreover, it was found that vermicompost containing boron which increases nitrogen uptake, translocation and metabolism, directly by enhancing the enzymes activation and/or indirectly by promoting and regulating the substrate input through cellular membranes to the interior of cells. Boron has a positive effect on assimilation of phosphorous (Ahmed et al., 2011). Boron enhances the potassium accumulation in cells (Schon et al., 1990). Primarily boron leads to maintain membrane permeability that decreases nutrients leakage from the cells and thus, increasing their concentrations in the plant organs (Cakmak et al., 1995).

Table 3. Effect of NPK rates, vermicompost extract levels and their interaction on macro and micro-nutrients content in leaves of cotton during 2019 season.

Traits / Treatments		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
A-NPK rates:										
a_1-100%		4.24	0.548	3.56	1.58	0.371	179.50	24.35	44.45	8.17
a_2-75%		3.71	0.526	3.51	1.47	0.357	178.11	21.97	42.75	8.02
a_3-50%		3.55	0.493	3.41	1.20	0.344	177.00	21.17	40.40	7.90
a_4-25%		3.25	0.454	3.31	0.85	0.323	163.83	19.87	39.90	7.73
LSD at 5%		0.06	0.007	0.02	0.04	0.008	5.29	0.65	0.90	0.07
B-Vermicompost extract levels:										
b_1- Without		3.43	0.465	3.39	1.08	0.275	112.00	18.64	33.59	7.16
b_2- 5 cm^3/L		3.74	0.512	3.46	1.31	0.375	203.21	23.21	43.84	8.16
b_3-7.5 cm^3/L		3.90	0.538	3.49	1.44	0.397	208.63	23.67	48.20	8.54
LSD at 5%		0.03	0.019	0.02	0.04	0.009	6.22	0.93	1.46	0.04
AxB interaction:										
	b_1	4.01	0.510	3.51	1.35	0.290	113.00	19.10	33.70	7.35
a_1	b_2	4.25	0.553	3.57	1.65	0.400	210.50	26.70	46.40	8.40
	b_3	4.45	0.580	3.59	1.75	0.423	215.00	27.25	53.25	8.75
	b_1	3.50	0.490	3.47	1.25	0.280	112.00	18.85	33.35	7.30
a_2	b_2	3.75	0.523	3.51	1.50	0.380	208.33	23.45	45.55	8.15
	b_3	3.88	0.563	3.55	1.65	0.410	214.00	23.60	49.35	8.60
	b_1	3.35	0.450	3.35	1.05	0.270	110.00	18.40	33.80	7.10
a_3	b_2	3.60	0.500	3.41	1.20	0.370	207.00	22.05	42.15	8.10
	b_3	3.70	0.530	3.46	1.35	0.393	214.00	23.05	45.25	8.50
	b_1	2.85	0.410	3.22	0.65	0.260	113.00	18.20	33.50	6.90
a_4	b_2	3.35	0.473	3.35	0.90	0.350	187.00	20.65	41.25	8.00
	b_3	3.55	0.480	3.37	1.00	0.360	191.50	20.77	44.95	8.30
LSD at 5%		0.11	0.010	0.03	0.06	0.010	10.63	0.66	1.19	NS

C-Effect of the interaction:

Concentrations of macronutrients (nitrogen, phosphorus, potassium, calcium and magnesium) and micronutrients (iron, zinc and manganese) in cotton leaves were significantly influenced by the interaction between NPK rates and vermicompost extract levels (Table 3). Higher values of these nutrients in cotton leaves were recorded under 100% NPK combined with the high level of vermicompost extract (7.5 cm^3/L). Also, the high level of vermicompost extract (7.5 cm^3/L) when combined with NPK at any rate significantly increased these nutrients as compared with the interaction of the low level of vermicompost (5 cm^3/L) or without vermicompost application in combination with NPK at any rate. Leaves concentration of copper did not affect by the interaction. Integrated application of vermicompost and inorganic fertilizer showed increased nutrients content in cotton leaves (Table 3).

2- Photosynthetic pigments and total carbohydrate:

A-Effect of NPK rates:

NPK rates had a substantial effect on photosynthetic pigments and total carbohydrate concentrations in the leaves (Table 4). Soil application of 100% NPK (the recommended rate) resulted in a significant increase in leaves concentrations of carotenoids, chlorophyll a, chlorophyll b and total chlorophyll as well as total carbohydrate. The rate of 100% NPK (the recommended rate) recorded the highest values, while the lowest rate of NPK application recorded the lowest ones. Also, application of 100% and 75% NPK, being significant, exceeded application of 50% and 25% NPK.

The positive effect in photosynthesis pigments and total carbohydrate in cotton leaves due to 100% NPK application as compared with other rates is mainly referred to increase in minerals absorption (Table 3). Nitrogen and magnesium are the most important nutrients for the chlorophyll biosynthesis (Rajasekar *et al*., 2017). Mg is needed for photosynthetic fixation of carbon dioxide (Gerendás and Führs, 2013). Moreover, it was found that Fe, Zn, Mn and Cu increase formation of chlorophyll and increase sugar content (Broadley *et al*., 2012).

B-Effect of vermicompost extract levels:

Regarding the effect of vermicompost extract levels on the concentrations of chlorophyll a, chlorophyll b, total

chlorophylls and carotenoids as well as total carbohydrate in the leaves, the data in Table 4 show significant differences among the different vermicompost extract levels, in favor of higher vermicompost extract level (7.5 cm^3/L) as foliar spraying, followed by low level of vermicompost extract (5 cm^3/L) and at last by without vermicompost application. The significant increase in pigments of photosynthesis and total carbohydrate due to foliar spraying with vermicompost extract may be due to that: (1) Vermicompost is being contains magnesium, nitrogen, potassium, phosphorous, calcium, iron, zinc, manganese and copper (Table 1) and these nutrients increased the efficiency of photosynthesis process and enhanced formation of more carbohydrates and (2) Increase in minerals absorption (Table 3). The chlorophyll biosynthesis required nitrogen and magnesium (Rajasekar *et al.*, 2017). A reference to Table 3 shows that magnesium, nitrogen, potassium, phosphorous and calcium percentages and iron, zinc, manganese and copper concentrations in leaves were significantly increased due to foliar application with vermicompost extract especially at the high level (7 cm^3/L) and these nutrients were effective to produce more photosynthates through increasing pigments of photosynthesis and photosynthesis rate, (3) The experimental soil sites had clay loam and clayey in texture in the first and second seasons, respectively with high pH (Table 2). These conditions reduced the availability of Mn, Fe and Zn to plants, the foliar application of vermicompost extract enriched the leaves with these elements, where Fe is a catalyst to chlorophyll biosynthesis and manganese aids in chlorophyll synthesis. Zn-activated enzymes, *e.g*., carbonic anhydrase, which is localized in the cytoplasm and chloroplasts and plays a role in photosynthesis through facilitate the transfer of CO_2/HCO_3^- for photosynthetic CO_2 fixation (Sharma *et al.*, 1982) and (4) The superiority of using vermicompost extract on increasing leaves carotenoids content gave positive effect in reducing stress effect by protect chlorophyll and cell enzymes against light rays of short waves (blue and violet rays) and light oxidation by absorbing these rays.

C-Effect of the interaction:

Concentrations of total carbohydrate and pigments of photosynthesis in leaves of cotton were significantly affected by the interaction between NPK rates and vermicompost extract levels (Table 4). Plants received 100% NPK and foliar spraying with the high level of vermicompost extract (7.5 cm^3/L) produced the highest values than those received 25% NPK when combined with control (without vermicompost application) in both seasons. Leaves concentration of chlorophyll b did not affect by the interaction.

Table 4. Effect of NPK rates, vermicompost extract levels and their interaction on photosynthesis pigments and total carbohydrate concentration in leaves of cotton during 2019 season.

Traits / Treatments		Chlorophyll a (mg /g dry weight)	Chlorophyll b (mg /g dry weight)	Total chlorophyll (mg /g dry weight)	Carotenoids (mg /g dry weight)	Total carbohydtate (ug /g dry weight)
A-NPK rates:						
a_1-100%		4.59	1.91	6.51	1.95	952.33
a_2-75%		4.44	1.89	6.33	1.93	944.22
a_3-50%		4.32	1.85	6.17	1.86	938.67
a_4-25%		4.04	1.81	5.84	1.83	934.00
LSD at 5%		0.05	0.05	0.08	0.03	5.36
B-Vermicompost extract levels:						
b_1- Without		3.99	1.49	5.48	1.52	909.67
b_2- 5 cm^3/L		4.46	2.02	6.48	2.06	954.25
b_3-7.5 cm^3/L		4.60	2.09	6.69	2.10	963.00
LSD at 5%		0.04	0.04	0.01	0.03	7.60
AxB interaction:						
	b_1	4.39	1.52	5.91	1.57	924.00
a_1	b_2	4.64	2.08	6.72	2.13	964.00
	b_3	4.75	2.14	6.89	2.16	969.00
	b_1	4.10	1.50	5.60	1.54	911.67
a_2	b_2	4.50	2.07	6.57	2.10	955.00
	b_3	4.72	2.11	6.83	2.14	966.00
	b_1	3.98	1.49	5.47	1.50	909.00
a_3	b_2	4.43	1.99	6.42	2.02	946.00
	b_3	4.55	2.08	6.63	2.06	961.00
	b_1	3.48	1.45	4.93	1.46	894.00
a_4	b_2	4.26	1.93	6.19	2.00	952.00
	b_3	4.37	2.04	6.41	2.04	956.00
LSD at 5%		0.11	NS	0.17	0.03	3.60

3- Growth parameters:

A-Effect of NPK rates:

NPK rates had a substantial effect on total dry weight (g $plant^{-1}$), leaf area (dm^2 $plant^{-1}$) at 75 days old, final plant height (cm) and number of fruiting branches $plant^{-1}$ at harvesting in both seasons. Soil application of 100% (the recommended rate) resulted in a significant increase in these traits in consideration in both seasons. The rate of 100% NPK (the recommended rate) recorded the highest values, while 25% NPK application recorded the lowest ones in both seasons. Also, soil application of 100% and 75 % of the recommended NPK rate, being significant, exceeded application of 50% and 25 % NPK in both seasons (Tables 5 and 6).

The positive effect on growth traits due to 100% NPK (the recommended rate) may be due to that the high rate of NPK gave cotton plants their requirements from these nutrients and enabled them to produce taller plants

with higher number of fruiting branches and total dry weight, where this rate increased cell division and elongation in the meristematic tissues which led to significant increase in the final plant height. The adequate supply of nutrients level at 100% NPK (the recommended rate) exhibited significant increase in formation of chlorophyll which enhanced rapid rate of photosynthetic efficiency and high rate of synthesis of protoplasmic proteins and consequently produced higher dry weight plant^{-1} in comparison to 75%, 50% and 25% of RDF. Fruiting branches resulting from the expansion of axillary buds, which is closely associated with the nutritional application, particularly nitrogen which enhanced protoplasm content of the plant and acceleration of metabolic processes which led to increase the number of fruiting branches/plant. The plant supplied adequately NPK rates significantly increased leaf area which is being photosynthetic surface plays a vital role in significant increase in assimilates production and consequently significant increase in plant dry weigh, final plant height and its number of fruiting branches.

In this concern, Saleem *et al*. (2008) found that increasing rate of integrated plant nutrition levels significantly enhanced total dry matter production over control and lower rates of integrated plant nutrition, Kaur *et al*. (2010) conducted a field experiment to study the effect of three fertility levels (75% of recommended dose of fertilizer (RDF), RDF and 125% of RDF on the growth of cotton. The application of different fertilizer levels did not exert any significant effect on growth. Reduction of fertilizer doses by 25% reduced the growth (Kumar *et al*., 2011) B-Effect of vermicompost extract levels:

The growth parameters *viz*. final plant height, number of fruiting branches plant^{-1} at harvesting, dry matter accumulation and LA plant^{-1} at 75 days old were significantly influenced by applying vermicompost extract levels in both seasons (Tables 5 and 6). Foliar application of vermicompost extract at high level (7.5 cm^3/L) as foliar spraying three times (at 30, 45 and 60 days from sowing) was superior to low level of vermicompost extract (5 cm^3/L) or without vermicompost application in total dry weight plant^{-1} (g) and leaf area (dm^2 plant^{-1}) at 75 days old, final plant height (cm) and number of fruiting branches plant^{-1} at harvesting in both seasons. The positive effect of vermicompost application on plant growth characters is mainly due to: Vermicompost contains some plant growth promoters which significantly increased plant growth characters (Tomati and Galli, 1995). Vermicompost extract is rich in organic carbon and contains more supply of both macro and micro nutrients in available forms (Table 1), in addition to the significant increase of macronutrients (nitrogen, phosphorus, potassium, calcium and magnesium) and micronutrients (iron, zinc, manganese and copper) concentrations in cotton leaves (Table 3), where these nutrients provide cotton plants with their requirements and play a vital role in physiological processes such as formation of chlorophyll, photosynthetic fixation of carbon dioxide, the reduction of nitrite and hydroxylamine to ammonia, cell division and enlargement, transformation of solar energy into ATP, required for assimilation of photosynthate and activator of enzymes involved in respiration and enzyme synthesis as reported by (Nicol (1934), Marschner (1995), Valadabadi and Farahani (2010), Broadley *et al*. (2012) Gerendás and Führs (2013) and Rajasekar *et al*.(2017). Boron increases protein synthesis, formation of plant hormones, promotes maturity, increases flowering set, affects nitrogen and carbohydrate metabolism and water relation in plant. B deficiency reduced the leaf chlorophyll concentration (Ahmed *et al*., 2014).

Table 5. Effect of NPK rates, vermicompost extract levels and their interaction on cotton growth and earliness parameters in 2018 season

Traits / Treatments		Leaf area plant^{-1} (dm^2)	Total dry weight plant^{-1} (g)	No. of fruiting branches plant^{-1}	Final plant height (cm)	No. of total flowers plant^{-1}	No. of total bolls plant^{-1}	Boll setting %	Earliness %
A-NPK rates:									
a_1-100%		21.38	53.18	14.75	172.48	24.63	16.07	65.25	69.65
a_2-75%		19.71	50.24	14.31	169.62	24.23	15.66	64.63	64.78
a_3-50%		18.21	45.05	13.82	167.63	24.50	15.54	63.43	61.24
a_4-25%		17.37	41.21	13.29	166.13	24.19	14.45	59.73	59.54
LSD at 5%		0.32	1.39	0.17	0.47	0.38	0.25	0.36	0.29
B-Vermicompost extract levels:									
b_1- Without		18.70	45.51	13.30	167.73	24.21	15.04	62.13	62.49
b_2- 5 cm^3/L		19.28	47.12	13.96	168.89	24.27	15.35	63.21	63.74
b_3-7.5 cm^3/L		19.52	49.63	14.87	170.27	24.68	15.91	64.45	65.18
LSD at 5%		0.38	0.70	0.21	0.32	NS	0.30	0.40	0.52
AxB interaction:									
	b_1	21.83	50.79	13.98	169.70	24.39	15.71	64.41	68.50
a_1	b_2	21.54	52.59	14.65	172.65	24.43	15.99	65.45	69.66
	b_3	20.77	56.16	15.63	175.08	25.06	16.51	65.88	70.78
	b_1	19.47	48.68	13.55	168.50	23.83	15.17	63.66	63.65
a_2	b_2	19.69	50.38	14.25	169.13	24.40	15.61	63.98	64.20
	b_3	19.97	51.67	15.13	171.23	24.45	16.20	66.26	66.50
	b_1	17.25	43.22	13.10	167.13	24.62	15.27	62.02	59.72
a_3	b_2	18.23	44.85	13.75	167.68	24.31	15.43	63.47	61.30
	b_3	19.17	47.06	14.60	168.10	24.57	15.92	64.79	62.70
	b_1	16.24	39.34	12.58	165.60	24.00	14.02	58.42	58.10
a_4	b_2	17.68	40.65	13.18	166.10	23.95	14.35	59.92	59.80
	b_3	18.20	43.63	14.13	166.68	24.63	14.99	60.86	60.73
LSD at 5%		0.54	NS	NS	0.54	NS	NS	0.42	NS

C-Effect of the interaction:

NPK rates interaction with vermicompost levels was significant with regard to total dry weight (g plant^{-1}), leaf area (dm^2 plant^{-1}) at 75 days old, final plant height (cm) and number of fruiting branches plant^{-1} at harvesting in one season only, where the high level of vermicompost (7.5 cm^3/L) combined with NPK at any rate resulted in the tallest plants with higher number of fruiting branches, while the shortest plants with lower number of fruiting branches produced due to without vermicompost application in combination with 25% NPK. Also, the high level of vermicompost (7.5 cm^3/L) when combined with NPK at any rate significantly increased these traits as compared with the interaction of the low level of vermicompost (5 cm^3/L) or without vermicompost application in combination with NPK at any rate.

Table 6. Effect of NPK rates, vermicompost extract levels and their interaction on cotton growth and earliness parameters in 2019 season.

Traits / Treatments		Leaf area plant^{-1} (dm^2)	Total dry weight plant^{-1} (g)	No. of fruiting branches plant^{-1}	Final plant height (cm)	No. of total flowers plant^{-1}	No. of total bolls plant^{-1}	Boll setting %	Earliness %
A-NPK rates:									
a_1- 100%		24.49	57.19	15.98	171.27	24.44	16.73	68.46	72.38
a_2- 75%		22.16	54.18	15.35	169.53	24.11	16.01	66.40	69.00
a_3- 50%		20.55	45.96	14.41	164.20	24.40	15.62	63.99	65.52
a_4- 25%		18.40	42.72	13.67	161.81	24.14	14.95	61.93	62.13
LSD at 5%		0.31	0.54	0.28	1.11	0.27	0.18	0.29	0.37
B-Vermicompost extract levels:									
b_1- Without		20.54	48.54	14.04	164.86	23.71	15.35	64.74	65.97
b_2- 5 cm^3/L		21.20	49.36	14.79	166.50	24.20	15.74	65.03	67.59
b_3- 7.5 cm^3/L		22.46	52.14	15.73	168.75	24.91	16.39	65.80	68.22
LSD at 5%		0.27	0.88	0.23	1.14	0.37	0.22	0.32	0.53
AxB Interaction:									
	b_1	23.67	56.93	15.38	170.53	23.82	16.06	67.42	71.05
a_1	b_2	24.02	54.84	15.83	171.38	24.39	16.65	68.27	72.40
	b_3	25.78	59.81	16.73	171.90	25.10	17.49	69.68	73.70
	b_1	21.21	52.58	14.35	166.98	23.48	15.40	65.59	67.85
a_2	b_2	21.95	53.71	15.28	168.80	23.81	15.86	66.61	69.33
	b_3	23.33	56.24	16.43	172.83	25.04	16.78	67.01	69.83
	b_1	19.71	44.25	13.60	162.13	23.92	15.19	63.50	64.55
a_3	b_2	20.36	45.73	14.10	163.83	24.38	15.60	63.99	65.95
	b_3	21.60	47.90	15.53	166.65	24.91	16.06	64.47	66.05
	b_1	17.58	40.41	12.83	159.80	23.60	14.76	62.54	60.43
a_4	b_2	18.50	43.16	13.95	162.00	24.23	14.84	61.25	62.68
	b_3	19.13	56.93	14.23	163.63	24.58	15.24	62.00	63.30
LSD at 5%		NS	1.38	0.39	NS	NS	NS	0.56	0.67

This might be associated with: 1- The positive effect of N on gibberellins biosynthesis and activities of other phytohormonal which have direct effect on total dry weight, leaf area at 75 days old, final plant height and its number of fruiting branches at harvesting, 2-The enhanced photosynthetic pigments, total carbohydrate, the photosynthetic rate, the leaf area and the total plant dry matter weight, and 3-Organic manure and inorganic fertilizer provide cotton plants with sufficient micro and macro nutrients which in turn enhancing the metabolic activity and increasing the growth variables including plant height. In this concern, Hussain *et al.* (1988) reported that the use of organic manures increased the efficiency of chemical fertilizers applied.

4- Earliness measurements:

A-Effect of NPK rates:

The differences in total flowers number plant^{-1}, total bolls number plant^{-1}, boll setting percentage and earliness percentage at various NPK rates were significant in both seasons (Tables 5 and 6). Increasing NPK level from 25% up to 100% RDF significantly increased these traits in consideration in 2018 and 2019 seasons.

B-Effect of vermicompost extract levels:

Total bolls number plant^{-1}, boll setting and earliness percentages in both seasons and total flowers number plant^{-1} in the second season were significantly affected by the application of vermicompost extract levels (Tables 5 and 6), where the superiority was found in favor of foliar spraying with vermicompost extract at the high level (7.5 cm^3/L) as compared to the low level of vermicompost extract (5 cm^3/L) or without vermicompost application.

Good earliness traits at the two levels of vermicompost extract as compared to the control (without application) might be due to: 1-The high concentrations of macro and micronutrients in cotton leaves (Table 3). In addition to promote effect of their macro and micro nutrients contents (Table 1) in increasing leaf nutrients concentrations. These nutrients are directly linked to increase boll retention, either by themselves or as activators for many basic physiological processes in cotton plants, 2-The presence of sufficient leaf area (source) to provide enough photosynthates and enough adequate supplies of mineral nutrition and water which increased fruiting organs., 3-Quickly provide the necessary N uptake, application of 7.5 cm^3/L vermicompost extract increased nitrogen content in cotton leaves at 75 days after sowing which increased photosynthates production and above ground total dry weight (Hearn, 1981), 4- Phosphorus is involved in photosynthesis, respiration, phosphoglecric compounds, phosphoglycric acid, CO_2 conversion to sugar,

RNA and DNA structures, where it plays a major role in energy storage and transfer as ADP, ATP, DPN and TPN. Cells can't divide unless there is adequate phosphorus to form the new nuclei. A large portion of phosphorus is found as ions in plant cells which organizing pH and keeping the hydrogen ion concentration at a level which makes the cell more active in (Uchida, 2000) and 5-The synthesis of tryptophan, a precursor of IAA synthesis, which is the major hormone that inhibits abscission of squares and bolls required zinc. Thus, the retained bolls number plant^{-1} would be increased (Sawan *et al*., 2008).

C-Effect of the interaction:

The highest values of boll setting % in both seasons and earliness% in the second season throw the interaction were recorded when the high level of vermicompost extract (7.5 cm^3/L) combined with NPK at any rate as compared with the interaction of the low level of vermicompost extract (5 cm^3/L) or without vermicompost application in combination with NPK at any rate. Total flowers number plant^{-1} and total bolls number set plant^{-1} did not affect by the interaction in both seasons.

The obtained results may be due to:1-The significant increase of growth parameters and storing of sufficient reserved food materials required for differentiation of buds into flower buds and recorded higher boll setting % and as a result higher number of retained bolls plant^{-1} and 2-integrated mineral fertilizer and organic manure application fertilizer leads to significant increase in leaf area which increases the amount of solar radiation intercepted thereby increasing photosynthates and the plants over all ability to produce fruiting organs.

5- Seed cotton yield and yield contributory characters:

A-Effect of NPK rates:

The effect of NPK fertilization rates was significant on open bolls number plant^{-1}, boll weight, yield of seed cotton plant^{-1}, lint% and seed index in the two seasons of study (Tables 7 and 8). The highest values of open bolls number plant^{-1}, yield of seed cotton plant^{-1},, lint% and seed index were recorded with 100% NPK (the recommended rate), while the lowest values were recorded from 25% of the recommended NPK rate. Applying 100% NPK (recommended dose of fertilizers) gave the heaviest bolls. However, the lightest bolls were recorded from 25% of the recommended NPK rate. The significant increase in both lint percentage and seed index from the high rate of NPK (Tables 7 and 8) produced the heaviest bolls. Also, the high rate of nitrogen, phosphorus and potassium contributes to the size of cotton boll and this resulted in lint yield increase as the boll becomes larger at every additional dose of NPK applied.

Seed cotton yield fed^{-1} was highest at NPK rate of 100 % NPK (recommended dose of fertilizers) with yield of 10.71 kentar, followed by the yield of 10.19 kentar from 75% NPK of RDF and 9.62 kentar from 50% NPK of RDF and at last by 25% NPK of RDF with yield of 9.22 kentar in the first season. The respective seed cotton yield fed^{-1} values due to these rates were 11.13, 10.50, 9.83 and 9.20 kentar in the second season.

The efficiency of cotton plant to produce economic yield and give its capacity depends on the efficiency of photosynthetic system (its size, and duration) and translocation of photosynthates to the economic sink (seeds and lint) under different environmental conditions. Attainment of maximum cotton yield from the unit area is greatly dependent upon the two main yield components namely, open bolls number plant^{-1} and boll weight. Boll weight is a product of the seeds number and weight of lint. Physiological and metabolic processes are modified by environmental conditions and various cultural practices to affect the plant vegetative growth and development and consequently contribute indirectly to a component responsible for yield. Increasing NPK rate significantly increased seed cotton yield (Tables 7 and 8). The improvement in yield from 25% to 100% NPK as recommended dose (RD) might be due to: 1- Plants which received 100% NPK significantly increased boll setting % and produced heavier bolls and more open bolls number plant^{-1} and as a result higher seed cotton yield was obtained and 2- Under adequate and balanced between N, P and K in soil applied fertilizer, there would have been greater photosynthetic activity and photosynthates translocation from leaves *via* stem to sink site *i.e.* seeds and bolls and in turn increases formation of fully mature seed and thus increases seed weight and lint percentage (Tables 7 and 8). In this regard, similar results were obtained by other researchers included Raskar (2004), where he studied the effect of fertilizer levels on cotton yield. Application of 100% recommended dose of fertilizer (RDF) recorded 31.71 and 10.16% higher seed cotton yield than 50% and 75% RDF, respectively, Raza *et al.* (2007) evaluated three levels of NPK fertilizers (half recommended, recommended and double recommended dose) on yield of seed cotton. The results revealed that the maximum seed cotton yield during 2004 was obtained with two fold of recommended dose of NPK fertilizers that was not significant over yield with recommended dose of fertilizers. While during 2005, maximum cotton yield was obtained with recommended dose of fertilizers, Reddy *et al.* (2007) found that number of bolls per plant, boll weight and seed cotton yield not responded to the increase in fertilizer levels, Bhalerao *et al.* (2008) found that application of 100% RDF recorded significantly higher seed cotton yield over control and application of 50% RDF whereas differences with 150% RDF was not found significant, Hulihalli and Patil (2008) studied the effect of fertilizer levels on yield of cotton cv. Jayadhar. Application of 100 percent RDF recorded 6.4 and 15.4 per cent higher seed cotton yield than 50 and no fertilizers respectively. The quality parameters like ginning out turn did not influence by fertilizer levels whereas, 100% RDF resulted in significantly higher lint index. Munirathnam and Sawadhkar (2008) found that application of 100% recommended dose of fertilizer (RDF) registered significantly higher seed cotton yield than other levels of fertilizers (50 and 75% RDF), Reddy and Gopinath (2008) found that the boll number per plant was not significantly influenced by the nutritional levels. Application of 50% more than RDF numerically recorded lower seed cotton yield (3080 kg/ha) than the RDF (3365 kg/ha). Reduction of fertilizer doses by 25 per cent reduced the yield significantly (Kumar *et al.*, 2011). Rochester *et al*. (2012) inquired that this quality of cotton is gradually changed with introducing new and improved varieties for cultivation. So, the modern high yielding varieties change the concept of requirement of nutrients of cotton. So, the new varieties of cotton had highly response to NPK fertilizer, where by increasing these nutrients increased yield and its components of cotton, Hamoda *et al.* (2014) reported that the yield increased with

increasing rates of NPK applied, Elhamamsey *et al.* (2016) found that among fertilization rates, maximum bolls number plant^{-1}, boll weight and yield fed^{-1} were recorded with using high fertilizer rates, El Sayed (2016) found that adding 100% kg NPK fed^{-1} (the recommended dose) significantly increased open bolls number plant^{-1} and yield of seed cotton plant^{-1}as compared to 75 and 125 % kg NPK fed^{-} in both seasons and Echer *et al.* (2019) found that reduced the fertilization by 50% of the recommended dose showed decreased yield by a 42%..

Table 7. Effect of NPK rates, vermicompost extract levels and their interaction on seed cotton yield and yield contributory characters in 2018 season.

Traits / Treatments		No. of open bolls plant^{-1}	Boll weight (g)	Seed cotton yield plant^{-1}(g)	Lint %	Seed index (g)	Seed cotton yield fed^{-1}(kentar)
A-NPK rates:							
a_1-100%		15.60	2.78	43.41	40.73	10.20	10.71
a_2-75%		15.20	2.70	41.04	40.15	9.83	10.19
a_3-50%		15.09	2.55	38.48	39.59	9.69	9.62
a_4-25%		14.50	2.42	35.12	39.42	9.38	9.22
LSD at 5%		0.24	0.04	0.32	0.22	0.10	0.09
B-Vermicompost extract levels:							
b_1- Without		14.72	2.54	37.39	39.38	9.62	9.39
b_2- 5 cm^3/L		15.02	2.62	39.39	39.91	9.74	9.91
b_3- 7.5 cm^3/L		15.56	2.68	41.76	40.63	9.97	10.50
LSD at 5%		0.29	0.02	0.37	0.54	0.08	0.12
AxB interaction:							
	b_1	15.25	2.71	41.26	40.33	9.87	10.17
a_1	b_2	15.53	2.79	43.27	40.46	10.04	10.68
	b_3	16.03	2.85	45.69	41.39	10.71	11.28
	b_1	14.73	2.65	39.04	39.32	9.76	9.69
a_2	b_2	15.15	2.70	40.92	40.67	9.84	10.16
	b_3	15.73	2.75	43.16	40.47	9.91	10.72
	b_1	14.83	2.46	36.47	39.19	9.65	9.11
a_3	b_2	14.98	2.55	38.21	39.39	9.65	9.55
	b_3	15.45	2.64	40.75	40.20	9.75	10.19
	b_1	14.08	2.33	32.80	38.67	9.22	8.61
a_4	b_2	14.40	2.44	35.14	39.12	9.41	9.23
	b_3	15.03	2.49	37.43	40.46	9.50	9.83
LSD at 5%		NS	0.05	NS	0.55	0.17	NS

Table 8. Effect of NPK rates, vermicompost extract levels and their interaction on seed cotton yield and yield contributory characters in 2019 season.

Traits / Treatments		No. of open bolls plant^{-1}	Boll weight (g)	Seed cotton yield plant^{-1}(g)	Lint %	Seed index (g)	Seed cotton yield fed^{-1}(kentar)
A-NPK rates:							
a_1-100%		16.53	2.72	44.99	41.14	11.37	11.13
a_2-75%		15.81	2.64	41.81	40.78	11.24	10.50
a_3-50%		15.32	2.52	38.69	39.47	10.69	9.83
a_4-25%		14.65	2.46	35.99	38.84	10.32	9.20
LSD at 5%		0.18	0.03	0.61	0.31	0.10	0.10
B-Vermicompost extract levels:							
b_1- Without		15.10	2.52	38.03	39.52	10.69	9.50
b_2- 5 cm^3/L		15.48	2.59	40.10	40.07	10.91	10.18
b_3-7.5 cm^3/L		16.14	2.66	42.98	40.59	11.12	10.81
LSD at 5%		0.22	0.03	0.74	0.40	0.12	0.09
AxB interaction:							
	b_1	15.86	2.64	41.79	40.21	11.08	10.48
a_1	b_2	16.45	2.72	44.74	41.33	11.38	11.09
	b_3	17.29	2.80	48.46	41.89	11.65	11.81
	b_1	15.20	2.60	39.55	40.40	11.07	9.78
a_2	b_2	15.66	2.64	41.26	40.69	11.17	10.51
	b_3	16.58	2.69	44.63	41.27	11.48	11.22
	b_1	14.89	2.43	36.23	39.32	10.40	9.18
a_3	b_2	15.30	2.52	38.48	39.40	10.73	9.81
	b_3	15.76	2.63	41.37	39.69	10.93	10.51
	b_1	14.46	2.39	34.55	38.16	10.22	8.58
a_4	b_2	14.54	2.47	35.94	38.86	10.34	9.32
	b_3	14.94	2.51	37.47	39.50	10.41	9.72
LSD at 5%		0.47	0.05	1.02	0.48	0.14	0.12

B-Effect of vermicompost extract levels:

Significant differences were exhibited on open bolls number plant^{-1} , boll weight and yield of seed cotton plant^{-1} as influenced by various vermicompost levels in both seasons, where foliar spraying with vermicompost extract at the high level (7.5 cm^3/L) significantly increased these traits as compared with foliar spraying with vermicompost extract at the low level and the control treatment. The positive effect

of applying vermicompost extract as foliar spraying at the high level is mainly due to enhance uptake of nutrients (Table 3), thereby increasing their availability to plants and consequently increase boll setting percentage and produce a greater number of bolls and heaviest bolls. Higher boll weight from the high level of vermicompost extract is mainly due to the significant increase in both seed index and lint% (Tables 7 and 8). Significant differences in lint percentage and seed index were found due to various vermicompost levels in both seasons (Tables 7 and 8), where the highest values were obtained from foliar spraying with vermicompost extract at the high level (7.5 cm^3/L), followed in ranking by applying the low level of vermicompost extract and at last by the control. Heavier seeds as a result of the high level of vermicompost extract may be due to increase activity of photosynthetic process, which enhances plant dry weight (Tables 5 and 6) and in turn increases fully mature seeds formation and thus increases seed index (weight of 100 cotton seed in grams).

Seed cotton yield fed^{-1} was significant at various vermicompost levels in both seasons. In the first season, application of vermicompost level at 7.5 cm^3/L produced the highest yield of 10.50 kentar fed^{-1} compared with 9.91 kentar fed^{-1} for 5 cm^3/L and 9.39 kentar fed^{-1} for control plots. In the second season, foliar spraying with vermicompost level at 7.5 cm^3/L produced the highest yield of 10.81 kentar fed^{-1} compared with 10.18 kentar fed^{-1} for 5 cm^3/L and 9.50 kentar fed^{-1} for control plots.

The significant increase in yield by the application of 7.5 cm^3/L vermicompost extract might be due to: 1- Continuous supply of balanced and adequate nutrients in available forms throughout foliar spraying with vermicompost extract level at 7.5 cm^3/L three times at the various growth stages (after 30, 45 and 60 days from sowing) enables the plants to assimilate sufficient photosynthetic product and consequently increased their total dry weigh, leaf area, final height and number of fruiting branches (Tables 5 and 6) and this coupled with higher yield attributing characters, 2- Increased boll setting % due to higher level of vermicompost extract as shown in Tables 5 and 6 increases boll formation and improves the efficiency of photosynthetic, which in turn resulted in an increase in bolls number and their weights, 3-This treatment significantly increased leaves potassium percentage (Table 3), Wang *et al.*(2014) mentioned that boll weight and bolls number are related with appropriate increase in potassium, 4-Application of vermicompost extract produced maximum LA $plant^{-1}$ and thus plants may become photo-synthetically more active, which would contribute to improvement in yield attributes and 5-Vermicompost is rich in macro- and micro-nutrients and provides plant with these nutrients in available forms, where these nutrients increased plant nutrition status, leaves photosynthetic pigments, growth and boll setting percentage which in turn increased yield.

C-Effect of the interaction:

Interactively, boll weight, lint% and seed index were significantly influenced by the interaction between NPK rates and levels of vermicompost extract in the two seasons of study (Tables 7 and 8). Plants received 100% NPK and received foliar spraying with the high level of vermicompost extract (7.5 cm^3/L) produced higher boll weight, lint% and seed index than those received 25% NPK when combined with control (without vermicompost application) in both seasons. This is because boll size increased as the rate of application was increased which allowed for better accumulation of metabolite in the seeds hence larger bolls.

Concerning open bolls number $plant^{-1}$, yield of seed cotton $plant^{-1}$and yield of seed cotton fed^{-1}, NPK rates interaction with vermicompost levels effect was significant ($p < 0.05$) in 2019 season only, where the high level of vermicompost (7.5 cm^3/L) when combined with NPK at any rate significantly increased open bolls number $plant^{-1}$, yield of seed cotton $plant^{-1}$and yield of seed cotton fed^{-1} as compared with the interaction of the low level of vermicompost (5 cm^3/L) or without vermicompost application in combination with NPK at any rate. In the first season, the same trend was obtained without significant effect. It could be inferred that optimum seed cotton yield/fed could be achieved with the interaction of higher NPK rate in combination with the high level of vermicompost (7.5 cm^3/L) as foliar spraying three times (at 30, 45 and 60 days from sowing).

Integration of inorganic NPK and vermicompost increased yield of seed cotton fed^{-1} and its components due to balanced C/N ratio of vermicompost (Table 1) and the presence of more organic matter build up, higher nutrients concentration, sustainable availability and accelerated transport. All these increased accelerated metabolically activities, leading to maximize efficiency of photosynthesis and translocation of photosynthates from sink to sources. A synergistic effect of the combined application of N, K, P and organic carbon in promoting meristematic activity, cell division, expansion of cell wall, photosynthetic efficiency, regulation of water intake into the cells and proliferation of leaves and axillary branches, resulting in the enhancement of yield contributory characters. The positive action of applying 100% NPK when combined with foliar spraying with the high level of vermicompost extract (7.5 cm^3/L) on increasing number of fruiting branches $plant^{-1}$ which surely reflected on increasing total bolls set and improving plant metabolism which enhances boll retention/plant by reducing abscission and mobilizing nutrients to fruiting organs.

6- Fiber quality traits:

A-Effect of NPK rates:

Concerning the effect of the studied NPK rates on fiber quality traits, the data in Table 9 show that, fiber length was significantly affected by the tested NPK rates in the second season only, where the longest fibers (34.30, 34.32 and 33.99 mm) were obtained from 100%, 75% and 50% of the recommended NPK rate, respectively without significant differences among these three rates. However, the shortest fibers (33.31 mm) were recorded by 25% of the recommended NPK rate. Fiber strength was significantly affected by the tested NPK rates in the first season (Table 9), where applying 100% and 75% of the recommended NPK rate significantly increased fiber strength as compared with 50% and 25% of the recommended NPK rate. Length uniformity index and fiber fineness (micronaire reading) did not affect by the studied NPK rates in both seasons. Increased soil application of NPK has a positive effect on fiber traits. This may be directly related to the K supply, since this nutrient plays a crucial role on the fiber quality (Mullins and Burmester 1990). Lokhande and Reddy (2015) reported that the reduction of K fertilization from100% (the

recommended dose) to nil (without K application) decreases the production of cotton biomass by 28%. Furthermore, it linearly reduces fiber lengths, micronaire values, and yields. In contrast, Emara *et al.* (2015) revealed that fiber properties did not affect by the high NPK fertilizer level and Echer *et al.* (2019) found that applying 50% of the recommended fertilization dose recorded higher values of micronaire in 92% of the evaluated cultivars. Some cultivars did not tolerate the reduction of fertilization. According to Heitholt (1997), this occurs due to the reduction of fruiting an area of the plant, which reduces the internal competition of the plant by assimilates. This leads to higher cellulose deposition in the fiber secondary wall and increases the micronaire. Vieira *et al*. (2018) found that nutrient absorption per ton of fibers produced did not differ among cotton cultivars that received 100% of the recommended dose. Increased soil application of NPK has a direct effect on fiber traits. Prajapati and Modi (2012) revealed that potassium enhances cotton fiber quality, where during the first twelve to fourteen days of flowering cotton takes up about 30% of its potassium and during boll fill 66% of the total potassium is rapidly translocated from the leaves and stems to the boll bur. In this respect, Girma *et al.* (2007) indicated that N rates greater than 90 kg/ha significantly reduce lint, while potassium fertilizer application is the key to long fibres, Hulihalli and Patil (2008) determined the influence of different fertilizer levels (control, 50 and 100% RDF) on the quality of cotton. Results indicated that, except for fibre strength, none of the quality parameters were influenced due to the fertilizer levels and Munirathnam and Sawadhkar (2008) found that application of 100% recommended dose of fertilizer (RDF) recorded the highest values for fibre strength than other levels of fertilizers (50 and 75% RDF).

Table 9. Effect of NPK rates, vermicompost extract levels and their interaction on fiber quality in 2018 and 2019 seasons.

Traits	Micronaire reading		Pressley index		2.5% Span length (mm)		Uniformity Index (%)	
Treatments	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
A-NPK rates:								
a_1- 100%	4.23	4.60	10.84	10.29	33.27	34.30	84.81	86.82
a_2- 75%	4.34	4.51	10.68	10.35	33.06	34.32	85.46	86.70
a_3- 50%	4.46	4.47	10.38	10.40	32.89	33.99	85.35	86.69
a_4- 25%	4.53	4.67	10.33	10.14	32.97	33.31	84.73	86.59
LSD at 5%	NS	NS	0.05	NS	NS	0.41	NS	NS
B-Vermicompost extract levels:								
b_1- Without	4.48	4.57	10.39	10.24	32.69	33.91	84.76	86.70
b_2- 5 cm^3/L	4.38	4.57	10.58	10.28	33.05	33.98	85.18	86.93
b_3- 7.5 cm^3/L	4.31	4.55	10.69	10.42	33.40	34.05	85.32	86.47
LSD at 5%	NS	NS	0.05	NS	NS	NS	NS	NS
AxB interaction:								
	b_1	4.30	4.63	10.63	10.13	32.95	34.17	84.40	86.97
a_1	b_2	4.18	4.57	10.90	10.23	33.25	34.33	85.10	86.80
	b_3	4.20	4.60	11.00	10.50	33.61	34.40	84.93	86.70
	b_1	4.48	4.47	10.45	10.27	32.70	34.30	85.50	86.40
a_2	b_2	4.38	4.57	10.73	10.37	32.93	34.30	85.40	87.00
	b_3	4.18	4.50	10.83	10.40	33.55	34.37	85.48	86.70
	b_1	4.60	4.43	10.20	10.33	32.88	33.87	85.28	86.73
a_3	b_2	4.48	4.47	10.38	10.47	32.88	33.83	85.38	86.73
	b_3	4.30	4.50	10.55	10.40	32.90	34.27	85.40	86.60
	b_1	4.55	4.73	10.30	10.03	32.23	33.30	83.88	86.70
a_4	b_2	4.50	4.67	10.30	10.03	33.15	33.47	84.85	87.20
	b_3	4.55	4.60	10.38	10.37	33.53	33.17	85.48	85.87
LSD at 5%		NS	NS	0.20	NS	NS	NS	NS	NS

B-Effect of vermicompost extract levels:

Concerning the effect of the examined vermicompost extract levels on fiber traits under study, the results in Table 9 show that, fiber strength was significantly affected by the tested vermicompost levels in the first season only, where applying vermicompost extract as foliar spraying at the high level (7.5 cm^3/L) significantly increased fiber strength. Uniformity index, micronaire reading and fiber length did not affect by the tested vermicompost levels in both seasons.

C-Effect of the interaction:

The interaction gave a significant effect on fiber strength in the first season. Where, the high level of vermicompost extract (7.5 cm^3/L) combined with 100% NPK significantly increased this trait as compared with the other combinations (Table 9). However, micronaire reading, fiber length and uniformity index were insignificantly affected by the interaction in both seasons.

CONCLUSION

It could be concluded that under El-Gemmeiza condition, the combined use of vermicompost and mineral fertilizers maintains soil quality and sustains productivity in vigor's cultivar Giza 86. Cotton treated with 100% of the recommended NPK rate which was (45 kg N +22.50 kg P_2O_5 + 24.0 kg K_2O)/fed accompanied with 7.5 cm^3/L vermicompost extract proved to the most remunerative dose and vermicompost extract can be used as a complementary to mineral NPK fertilization at any rate.

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استخدام الفيرمى كمبوست كمكمل للتسميد المعدنى فى القطن

شيماء أسامه السيد[1] وأحمد محمد عبد العال[2]

[1] **قسم بحوث المعاملات الزراعية للقطن - معهد بحوث القطن- مركز البحوث الزراعية-الجيزة.**

[2] **قسم النبات الزراعى - كلية زراعة شبين الكوم – جامعة المنوفية.**

أجريت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بالجميزة بمحافظة الغربية خلال الموسمين المتتاليين 2019،2018 م لدراسة تأثير أربعة معدلات من NPK [100 % (المعدل الموصى به) ، 75% ، 50% ، 25%] والرش الورقى بمستخلص الفيرمى كمبوست بثلاث مستويات (بدون رش ،5 سم^3 / لتر ، 7.5 سم^3 / لتر) ثلاث مرات وكذلك تفاعلهما على الانتاجيه والجودة ، تم استخدام تصميم الشرائح المتعامدة فى أربعة مكررات. ويمكن تلخيص أهم النتائج فى: أدت زيادة معدل التسميد من 25% إلى 100% (المعدل الموصى به) إلى زيادة معنوية في التركيب الكيماوى في ورقة القطن ، وفى صفات النمو والتبكير والمحصول ومكوناته في الموسمين وزيادة معنوية فى طول التيلة ومتانة الألياف فى موسم واحد بينما الانتظام والنعومة لم يتاثرا بمعدلات التسميد. أدى استخدام مستخلص الفيرمى كمبوست كرش ورقي بمستوى عالى (7.5 سم^3 / لتر) إلى زيادة معنوية في التركيب الكيماوى في ورقة القطن ، وفى صفات النمو والتبكير والمحصول ومكوناته في الموسمين باستثناء عدد الازهارالكلية/النبات والتى زادت معنويا فى الموسم الثانى ولم تتأثرطول التيلة والانتظام والنعومة فى حين زادت المتانة معنويا فى الموسم الاول. أعطى التفاعل بين معدلات التسميد ومستويات مستخلص الفيرمى كمبوست أفضل النتائج لصالح استخدام مستخلص الفيرمى كمبوست كرش ورقي بمستوى عالى (7.5 سم^3 / لتر) ثلاث مرات (بعد 30، 45 ، 60 يوم من الزراعة) مع التسميد بمعدل 100% (المعدل الموصى به من التسميد) وتوصى الدراسة باستخدام هذا التفاعل تحت ظروف مماثلة لمنطقة الجميزة ويفضل استخدام مستخلص الفيرمى كمبوست كمكمل وليس كبديل للتسميد وذلك للحصول على أفضل تركيب كيماوى بالورقة ونمو قوى لتحقيق أقصى انتاجية مع جودة عالية.