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INTERNATIONAL JOURNAL OF
Agricultural Science and Food Technology

ISSN: 2455-815X DOI: https://dx.doi.org/10.17352/ijasft

Research Article

Role of Vermicompost and algae Extract in Improving Growth and Fruit Quality of Mango (Keitt)

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Received: 21 June, 2024
Accepted: 05 November, 2024
Published: 06 November, 2024

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Keywords: Mango; Vermicompost; Spirulina platensis; Algae extracts; Vegetative performance; Fruit characters

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Abstract

This research, spanning the 2021 and 2022 seasons, aimed to explore the impact of vermicomposting on the growth and productivity of Mango trees (cv. Keitt) cultivated in sandy soil at Ahmed Orabi Agricultural region, El-Obour City, Cairo Governorate, Egypt. The selected trees underwent various treatments, including water (control), vermicomposting at 1 or 2 Kg/tree, *Spirulina platensis* algae extract at (5 or 10ml/l), and their combinations. Optimal results in terms of leaf fresh and dry weight, leaf area, and chlorophyll content were observed with the treatment of 2kg vermicompost + 10ml/l algae extract. Furthermore, the addition of vermicompost along with algae extract improved the leaf status of N, P, K, and Ca. Application of both vermicompost and algae extract, whether individually or in combination, demonstrated positive effects on the physicochemical quality of the fruit. The findings suggest that the simultaneous use of vermicompost and algae extract holds promise as a supplementary material for enhancing the growth, productivity, and fruit quality of Mango trees.

Introduction

In Egypt, mango ranks the third economic crop after citrus and grapes. Mango cv. Keitt is widely cultivated in the newly reclaimed regions, where the soil is mostly sandy and characterized by its poor structure, low fertility, salinity, and low availability of water and nutrients [1]. In such lands, there is excessive usage of different agrochemicals in order to increase crop production which proved to be detrimental to the environment's health and the whole ecosystem. Nowadays, organic agriculture is known to be a promising culturing system that would increase crop productivity and protect the whole ecosystem. Accordingly, the technology of vermicomposting is recently paid a fast attention as an innovative ecotechnology for the conversion of various types of wastes into vermicompost. Vermicompost is rich in nutritional elements, various hormones, enzymes, and organic matter and several studies indicated its role in substituting chemical fertilizers [2,3]. These studies emphasized the positive impact of vermicompost on photosynthesis and leaf chlorophyll content, plant nutrition, and growth. Vermicompost contains a high percentage of humus substances i.e.; humin, fulvic acid, and humic acid which provide numerous sites for chemical reactions and microbial components known to enhance plant growth and promote the synthesis of phenolic compounds such as flavonoids and anthocyanins which may improve the crop quality [2]. Moreover, Lim, et al. [4] referred to the positive influence of vermicompost application to its role in

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increasing the ability of soil to retain water, soil minerals, and microorganisms as well as decrease plant pest populations thus improving the tree nutritional status and yield. Besides, some researchers went beyond more than the role of vermicompost as an organic fertilizer to its role as a bio-control agent. Raghda, et al. [5] indicated that vermicompost can serve as an effective bio-controlling treatment for root-knot nematodes without negative effects on the environment.

Green algae serve as popular bio-stimulants, with their extracts containing numerous bioactive compounds capable of positively influencing plant physiology. These compounds lead to beneficial outcomes, including enhanced biomass production, improved nutritional status, and increased resistance to stress, as demonstrated by Ertani, et al. in [6]. Algae are typically cultivated in open systems such as ponds, bubble columns, and stirred tanks, as highlighted by Satish in 2017 [7]. The application of algae extracts is recognized for its ability to enhance various aspects of plant development, including flowering, leaf and shoot growth, fruit set, yield, and overall fruit quality, as observed in studies by Abd-Allah in 2008, Ertani, et al. in 2018, and Ertani, et al. in 2014 [6,8,9].

In this respect, current work aims to investigate the potential of vermicompost to serve in enhancing the growth performance of Keitt mango grown in sandy soil.

Materials and methods

Plant material and treatments

Treatments of this study were conducted during the 2021 and 2022 seasons on 13-year-old mango trees (*Mangifera indica*) cv. Keitt, grown at Ahmed Orabi Agricultural region, El-Obour City, Cairo Governorate, Egypt, located at (30°12'25.2"N 31°31'57.0"E). Trees were spaced 5×5 m in sandy soil and irrigated by the drip irrigation system. Forty-five trees were selected uniformly in vigor as possible and were subjected to the same fertilization and other agricultural practices in the orchard. Nine treatments including control (water only), vermicompost (Vermi.) at 1 and 2kg/tree, and *Spirulina platensis* algae extract at 5 and 10ml/l were applied either alone or in combinations in a randomized complete block design (RCBD) with 5 replicates for each treatment. Both vermicompost and algae extract were produced in the national research centre and applied during two growth seasons starting from March to July (each season). Vermicompost was applied once per growth season in Feb., (2021/2022) while algae extract was added monthly (March to July) each growth season.

Measurements

Vegetative growth parameters: To assess the impact of studied treatments on mango vegetative growth, leaf fresh and dry weight (g) were measured. Also, the chlorophyll content of fresh leaves was recorded using a Minolta chlorophyll meter (SPAD – 501). Additionally, leaf area (mm^2) was measured using the intelligent leaf area meter (Android) software.

Leaf mineral content: Also, leaf nitrogen, phosphorus, potassium, calcium, and magnesium content (%) was determined at the end of the experiment in both seasons. Leaf samples were prepared to assess minerals content according to Chapman and Pratt [10] and methods of preparation and measurement are shown in Table 1.

Fruit physicochemical quality

Five ripened fruits were taken at commercial date harvest (September-October) from each treated tree and the following physical and chemical properties were assessed: fruit weight (g), pulp weight (g), seed weight (g), pulp/fruit and pulp/seed percentages. Total soluble solids (TSS) content was measured by a hand refractometer and the percentage of total acidity as g citric acid/100 g fresh weight, and vitamin C content as mg ascorbic acid/100 ml juice were determined according to A.O.A.C. [14]. Also, fruit peel carotenoid content was determined according to Nagata and Yamashita [15], and the values of β-Carotene were calculated by the following equation:

β-Carotene (mg/100 ml) = 0.216 A663 - 1.22 A645 - 0.304 A505 + 0.452 A453

Where, A is the absorbance at 663, 645, 505, and 453 nm.

Statistical analysis

The obtained data in the 2021 and 2022 seasons were subjected to a two-way analysis of variance (ANOVA) according to Clarke and Kempson [16]. Means were differentiated using the Range test at the 0.05 level of significance [17].

Results and discussion

Vegetative growth

Data presented in Table 2 showed that all treatments generally had a positive influence in increasing the vegetative growth parameters when compared with the control. Applying the vermicompost at 2kg/tree either alone or in combination with algae extract at 10ml/l resulted in significantly the highest values of leaf fresh weight compared to all other treatments. Also, applying Vermi at 2kg/tree either alone or combined with 5 or 10ml/l gave similar leaf dry weight values and were significantly higher than the rest of the treatments. Moreover, leaf area was increased by all treatments compared to the control with no significant difference in the values obtained among treatments. All treatments resulted in significantly higher leaf chlorophyll content than the control. Adding vermicompost at 2kg/tree either alone or combined with algae extract at 10ml/l indicated the highest values of chlorophyll content. Overall, the combination of algae extract with vermicompost demonstrated

Table 1: Methods used for leaf sample preparation and minerals measurement:

Leaf Minerals	Methods used for sample preparation and measurement
Nitrogen (N)	Micro–Kjeldahl method, using boric acid modification, and distillation was done using Gerhardt apparatus [11].
Phosphorus (P)	($NaHCO_3$-Extractable) and measured using Spectrophotometer (Perkin-Elmer Lambda-2) according to [12]
Potassium (K)	(NH_4OAC-Extractable) and measured using (Eppendorf Dr. Lang) Flame-photometer according to [10]
Calcium (Ca)	
Magnesium (Mg)	(DTPA-Extractable) and measured using Atomic absorption (Perkin-Elmer 1100 B) according to [13]

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superior growth performance compared to the application of algae extract alone at either concentration.

Leaf mineral content

The obtained results shown in Table 3 indicated that adding vermicompost as well as algae extract enhanced N, P, K, and Ca status in treated trees as compared with the control, while did not affect magnesium content. The treatments: vermicompost at 1kg/l alone or combined with 10ml/l algae extract, algae extract alone at 5 or 10ml/l, and the combination of 2kg/tree vermicompost + 10ml/l algae extract did not significantly differ among each other and resulted in the highest leaf nitrogen content compared to all other treatments. Leaf phosphorous was significantly increased by all treatments in comparison with the control. Applying vermicompost at 2kg/tree combined with 10ml/l algae extract resulted in the highest values of leaf P followed by applying the same concentration of vermicompost combined with the lower rate of the algae extract. In the meanwhile, applying both vermicompost rates alone surpassed the single applications of algae extract in improving leaf phosphorous content. Additionally, all treatments (except vermicompost alone at 2kg/tree) significantly increased leaf potassium content compared with the control treatment. The significantly highest values of leaf potassium were obtained when adding vermicompost at 1 kg/tree either alone or combined with 10ml/l algae extract. In the meantime, applying the algae extract at 5ml/l resulted in similar potassium content when adding 10ml/l algae extract combined with vermicompost at 1kg/tree. All treatments (except 1kg/tree Vermi. alone) improved leaf calcium content compared with the control, with no remarkable differences found among these treatments. On the other hand, leaf magnesium was not affected by any of the applied treatments.

Our results go in line with studies on strawberries which demonstrated improvement in strawberry plant growth, including leaf area, shoot biomass, number of flowers and runners [18], as well as yield [18,19] by vermicompost application. Obtained results may be attributed to the facts reported by [2] who stated that vermicompost is a promising organic manure for better vegetative growth, high rates of mineralization, and soil water holding capacity as well as soil microorganisms 'content. Similarly, Mustafa, et al. [20] indicated the role of vermicompost as soil amendment and mentioned that soil porosity, aeration, drainage, water holding capacity, and microbial activity were improved by its application. Also, our results are supported by the findings of [20,21] which cleared that vermicompost as an organic fertilizer has an intensive attention recently due to its high content of nutrients, amino acids, and growth promoters. Similar findings were stated in an earlier study by Lim, et al. [4] who prepared a report on the utilization of vermicompost in an organic farming approach and its beneficial effects on soil well-being. They indicated that vermicompost serves not only as a provider of nutrients and organic matter but also plays a role in augmenting the size, biodiversity, and activity of the microbial population within the soil. Furthermore, vermicompost has a positive impact on soil

Table 2: Effect of vermicompost and algae extract application on leaf fresh and dry weights, leaf area, and chlorophyll contents of mango trees cv. Keitt during the 2021 and 2022 seasons (a combined analysis).

Parameters / Treatments	Leaf fresh weight (g)	Leaf dry weight (g)	Leaf Area (mm²)	Chlorophyll (SPAD)
Control (water only)	14.60 d	7.12 d	8064.2 c	50.75 e
Vermicompost 1kg/tree	19.30 b	9.07 cb	11375.5 ab	58.47 cb
Vermicompost 2kg/tree	21.62 s	11.35 a	11830.8 ab	65.05 a
Algae extract 5ml/l	18.42 c	8.01 c	9223.9 bc	52.12 ed
Algae extract 10ml/l	14.41 d	8.89 xb	9803.1 bc	59.18 cb
Vermi.1kg/tree +Algae extract 5ml/l	18.22 c	8.75 c	10892.1 ab	56.12 dc
Vermi.1kg/tree +Algae extract 10ml/l	19.22 b	9.91 b	10941.0 ab	62.62 ba
Vermi.2kg/tree +Algae extract 5ml/l	19.39 b	10.80 a	11258.4 ab	62.08 ba
Vermi.2kg/tree +Algae extract 10ml/l	21.22 a	10.94 a	13432.7 a	66.75 a

Means were represented as the average of replicates, different letters are expressed for significant differences while the same letters are non-significant at LSD $p > 0.05$.

Table 3: Effect of vermicompost and algae extract application on leaf nitrogen, phosphorous, potassium, calcium, and magnesium content (%) of mango trees cv. Keitt during the 2021 and 2022 seasons (a combined analysis).

Parameters / Treatments	N	P	K	Ca	Mg
	(%)				
Control	2.00 dc	0.05 f	0.71 e	0.64 b	0.23 a
Vermicompost 1kg	2.30 cba	0.26 d	1.02 a	0.65 b	0.23 a
Vermicompost 2kg	1.95 d	0.38 c	0.63 e	0.90 a	0.22 a
Algae 5ml/l	2.35 bc	0.11 fe	0.94 b	0.90 a	0.23 a
Algae 10ml/l	2.60 da	0.16 e	0.75 d	0.85	0.24 a
Vermi.1kg+Algae 5ml/l	2.10 dcb	0.41 c	0.76 d	0.89 a	0.24 a
Vermi.1kg+Algae10ml/l	2.65 a	0.42 c	0.98 ba	0.91 a	0.25 a
Vermi.2kg+Algae 5ml/l	1.85 d	0.52 b	0.78 d	0.91 a	0.22 a
Vermi.2kg+Algae10ml/l	2.40 ba	0.66 a	0.87 c	0.91 a	0.22 a

Means were represented as the average of replicates, different letters are expressed for significant differences while the same letters are non-significant at LSD $p > 0.05$.

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structure, nutrient turnover, and various other soil properties. In the meanwhile, Moreover, Daniele, et al. [22] strongly suggested that the nitrogen metabolism process was impacted by algae extract application.

Generally, Rasool, et al. [23] highlighted that substituting inorganic fertilizers with farmyard manure (organic fertilizer) leads to improvements in soil properties, including increased total porosity and water-holding capacity, enhanced soil aggregation in deeper layers, and elevated grain and straw yields for both maize and wheat.

Vermicompost, recognized as an organic fertilizer, contains substantial quantities of humic acid and biologically active substances such as plant growth regulators [24,25]. Numerous studies indicate that incorporating 20–40% vermicompost into commercial growth media has positive effects on germination, plant growth, and yield. Roberts, et al. [26] demonstrated that vermicomposts, comprising a blend of humified earthworm faces and organic matter, possess the ability to stimulate plant growth.

The favorable impact of humic acids on plant growth and productivity is attributed to their hormone-like activities, influencing processes such as cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis, and various enzymatic reactions [27]. Humic acids, rapidly generated in vermicomposts, offer a complex structure capable of adsorbing plant growth hormones. The swift production of both plant growth hormones and humic acids in vermicomposts suggests a synergistic effect that enhances overall plant growth [27,28].

Considering the desired effects of vermicompost on plants and soil, Abdel-Salam and Roshdy [29] conducted a study investigating the impact of foliar application of vermicompost tea, its application to the soil, and its use either individually or in combination. Their findings demonstrated that treatments involving vermicompost tea could enhance the physical and chemical properties of pomegranates (Punica granatum Manfalouty). Additionally, the effects of vermicompost tea closely resembled those of inorganic fertilizers, suggesting its potential as a promising natural resource for crop development. The use of vermicompost tea as an alternative to synthetic fertilizers has the potential to reduce chemical fertilizer application, thereby mitigating environmental pollution and lowering fertilizer costs.

Also, Abobatta and El-Azazy [30] demonstrated the pivotal role of organic fertilizers, specifically vermicompost, in enhancing diverse soil characteristics and promoting stress tolerance in citrus plants. Their study established a robust connection between soil fertility and organic fertilizers by elevating soil organic matter in sandy and degraded soils. This increase in soil organic matter contributed to heightened citrus productivity, stimulated soil microbial growth and activities, improved water retention capacity, and enhanced buffering capacity.

With respect to *Spirulina platensis* algae extract positive effects, Hussein and El-Kareem [31] asserted that *Spirulina platensis* algae serves as a nutrient source and contains compounds that enhance plant growth parameters such as shoot length, leaf quantity per shoot, and leaf area. Additionally, it contributes to improved fruit quality, making it a subject of significant study due to its commercial importance for proteins, vitamins, essential amino acids, and fatty acids. The integration of enriched organic fertilizers, specifically vermicompost, with biofertilizers primarily *Spirulina platensis* algae proved more beneficial in enhancing both quantitative and qualitative yield compared to the application of organic fertilizers alone. Notably, treatments involving algae in conjunction with organic fertilizers demonstrated positive effects on the yield and fruit quality of Koroneiki olive trees.

Fruit quality

Recorded data i ws that applying vermicompost and algae extract individually or in combination resulted in enhancing these parameters in comparison to control treatment. Moreover, fruit weight and pulp weight in both seasons besides the seed weight in the 2022 season recorded the highest value with treatment (vermicompost 1kg + Algae 10ml/l). Also, treatments that contained algae extract individual at 5ml/l came in second rank in enhancing fruit weight and pulp weight. The lowest weights of fruit, pulp, and seed were recorded with control treatments.

Table 4: Effect of vermicompost and algae extract application on physical characteristics of mango trees cv. Keitt during the 2021 and 2022 seasons (a combined analysis).

Parameters / Treatments	Fruit weight (g)	Pulp weight (g)	Seed weight (g)	Pulp/seed ratio	Pulp/fruit ratio
Control	536.67 f	336.67 f	51.67 g	6.52 cd	0.63 f
Vermicompost 1 kg	691.67 c	458.33 d	86.67 b	5.29 f	0.66 e
Vermi. 2 kg	626.67 d	442.67 d	71.67 de	6.18 d	0.71 bc
Algae 5 ml/L	781.67 b	540.00 a	95.00 a	5.69 e	0.69 cd
Algae 10 ml/L	706.67 c	508.33 bc	75.00 d	6.79 bc	0.72 b
Vermi. 1 kg + Algae 5 ml/L	581.67 e	405.67 e	81.67 bc	4.97 f	0.66 e
Vermi. 1 kg + Algae10 ml/L	813.33 a	543.33 a	76.67 cd	7.09 b	0.67 de
Vermi. 2 kg + Algae 5 ml/L	77.6.67 b	490.00 c	63.33 f	7.74 a	0.63 f
Vermi. 2 kg + Algae 10 ml/L	611.67 d	513.33 b	66.67 ef	7.701 a	0.94 a

Means were represented as the average of replicates, different letters are expressed for significant differences while the same letters are non-significant at LSD $p > 0.05$.

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Also, Data in Table 4 shows that applying both vermicompost and algae extract individually or in combination resulted in improving ratios of both Pulp: seed and pulp: fruit weight. Moreover, applying high rates of algae and vermicompost in combinations produced the highest values of these ratios as compared with control in both seasons.

The positive effects of algae and vermicompost application on plant growth are due to the presence of a variety of beneficial substances in both of them, including: Like- hormones substances which can encourage growth and development. Also, amino acids which are needed form building blocks of proteins and other essential molecules. Finally, both of them are rich in nutrient elements that are needed for metabolic processes and growth. These results are supported by the findings of several studies. Whereas De Pascale, et al. [32] and Battacharyya, et al. [33] indicated that Algae Extracts (AE) are considered the most commonly used biostimulants in agriculture. It can play an essential role in increasing nutrient uptake, stress tolerance, and productivity in several crops Daniele, et al. [22]. Moreover, Khan, et al. [34] and Pohl, et al. [35] cleared that the use of AE improves promotes plant growth and yield.

In regard to vermicompost, Tahsina, et al. [36] reported that vermicompost is the best source of humus and plant nutrients and it has been used as organic manure in many parts of the world in order to increase crop production. Moreover, vermicompost application can be a promising organic matter to partially replace chemical fertilizers in the production of crops such as rice [37].

Applying vermicompost products resulted in an increment of 15% vegetative and reproductive growth in fruit trees and flowering plants which resulted in an increase of 40% to 80% yield, fruit size, and fruit test of the crops [38].

With respect to the results presented in Table 5, indicate that both vermicompost and algae treatments enhanced most chemical parameters of fruit quality. The data in Table 5 indicates that most studied parameters were increased by applying vermicompost and algae treatments compared with the control treatment. Moreover, TSS, Ratio of (TSS: acidity), ascorbic acid content, and carotene content were recorded the highest increment when gathering vermicompost and algae extract together.

The highest level of TSS was recorded when vermicompost and algae extract were at high levels (2kg/tree and 10ml/L respectively). Meanwhile, the highest level of ascorbic acid was recorded with a low level of both vermicompost and algae (vermicompost at 1kg/tree + algae extract at 5ml/l). Also, the carotene parameter was recorded at the highest level at a high level of vermicompost (2kg/tree) and a low level of algae extract (5ml/l). However, the acidity was recorded at the highest level with individual treatment of algae extract (5ml/l) in both seasons. With respect to (TSS: acidity) recorded, the highest level was recorded in the first season, the highest level with individual treatment of algae extract at 10m/l) and in the second season with gathering vermicompost and algae extract at a high level (2kg/ tree and 10ml/l respectively).

Generally, most parameters were enhanced in the second season when gathering vermicompost and algae extract at high levels for both of them.

All these positive effects of vermicompost and algae extract may be interpreted by the following facts:

Previous studies have mentioned that amending the soil using vermicompost promotes soil health (including structure and quality), increases microbial activity, and enhances the nutrients available to the plant, which in turn leads to improved plant production compared to traditional chemical fertilization [39].

Besides, vermicompost is an organic waste produced from earthworms that can enhance the soil condition and is rich with essential plant nutrients, growth promoters, and amino acids thus it may result in increasing growth performance, productivity, quality, and shelf life of pineapple [40]. Moreover, they suggested that vermicompost cannot completely replace chemical fertilizer for the production of fruits with a high content of phytoconstituents but could be used as an additional supplement to reduce environmental pollution and ensure agricultural sustainability. Also, Kaur, et al. [41] indicated that utilization of vermicompost has been found to be beneficial in improving germination, plant growth, yield, and content of bioactives with anolides of the Ashwagandha leaves. This is in line with the findings of the current study where the addition of vermicompost was found to significantly enhance growth performance, productivity, and quality of mango.

Table 5: Effect of vermicompost and algae extract application on chemical parameters of fruit quality of mango trees cv. Keitt during the 2021 and 2022 seasons (a combined analysis).

Treatments	TSS (Bix°)	Acidity %	TSS/Acidity ratio	Ascorbic acid g/ 100g fresh pulp	Carotene mg/g fresh pulp
Control	11.83 ab	1.34 e	8.83 d	0.36 a	3.12 f
Vermi. 1kg	11.33 ab	1.60 d	7.08 f	0.34 b	4.33 d
Vermi. 2kg	13.67 ab	1.73 c	7.90 e	0.33 b	6.89 b
Algae 5ml/L	15.50 ab	2.05 a	7.56 e	0.26 d	2.49 g
Algae 10ml/L	16.07 a	1.34 e	11.99 a	0.30 c	3.46 e
Vermi.1kg+Algae 5ml/L	15.17 ab	1.41 e	10.76 b	0.38 a	4.66 c
Vermi.1kg+Algae10ml/L	17.83 ab	1.73 c	10.31 c	0.32 bc	7.39 a
Vermi.2kg+Algae 5ml/L	10.50 b	1.54 d	6.82 f	0.30 c	7.64 a
Vermi.2kg+Algae10ml/L	16.33 a	1.92 b	8.51 d	0.25 d	6.99 b

Means were represented as the average of replicates, different letters are expressed for significant differences while the same letters are non-significant at LSD $p > 0.05$.

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Vermicompost as a soil amendment can enhance soil fertility; it works on increasing soil organic carbon, nitrates, phosphates, exchangeable calcium, and some other nutrients for plants [42]. Moreover, vermicompost improves entire soil health (pH, structure, aeration water retention, and soil microorganism activity) [43,44]. Whereas, vermicompost is highly porosity, aeration, drainage, water-holding capacity, and microbial activity that work on mineralization nutrients. Besides, several studies and reports demonstrated the positive impacts of vermicompost application on a wide range of crops including cereals and legumes, ornamental and flowering plants [45] vegetables [46-48] and field crops [49].

Also, Wang, et al. [44] indicated that vermicompost can also enhance the growth of nitrogen-fixing microorganisms in the rhizosphere, which enhances N availability by making biologically fixed N available through the intimate mixing of ingested particles with soil. They also draw the attention to that the positive impact of vermicompost may be due to a partial increment in soil microbial biomass after the application of vermicompost, leading to more amino acids, hormones, or humate content in the vermicompost treatment.

Moreover, Yang, et al. [50] reported that the positive impacts of vermicompost are closely related to a number of applications. In other words, these positive impacts significantly increased with the rising number times of applications. This may interpret why the positive impact of vermicompost in the current study varied from the first season to the second season and markedly related to both of dose and number of vermicompost applications (i.e. acidity and TSS acidity ratio) which means there is accumulated effects occurred with number and doses of vermicompost applications.

Current results were supported by the findings of Wang, et al. 2017 [44] who concluded that vermicompost can improve the biochemical properties of soil under different years of continuous growth, thereby increasing tomato growth, yield, and fruit quality compared with control.

In regard to the impact of algae extract, Rady, et al. [51] showed that algae extract (i.e. spirulina extract) is utilized in a wide range with a small amount of either inorganic or organic fertilizers to enhance crop growth and productivity. This may be due to that showed by El-Sharony, et al. [52] who reported that applying spirulina extract is very important because it is rich in macro and micro-nutrients (N, P, K, Ca, Mg, Zn, Fe, and Mo), as well as growth promoters, poly-amino acids, and vitamins that are required by most of plants to improve nutrient content, vegetative growth parameters and fruit quality in different fruits orchards. Also, Spirulina extract is abundant in osmoprotectants and antioxidants such as proline, salicylic acid, soluble sugars, and phytohormones (e.g., cytokinins, gibberellins, and auxins) Yanni, et al. [53].

Conclusion

The findings underscored vermicompost and *Spirulina platensis* algae extract as promising and substantial supplemental materials in improving the growth, productivity, and tolerance for adverse (particularly drought) of Mango (CV. Keitt) cultivated in sandy soil. Elevating the dosage of algae extract could potentially result in a notable positive effect. The combined application of these bio-stimulants may enhance their positive effects, but this outcome is contingent upon various factors such as dosage, frequency of application, plant and soil types, and the cumulative effects of these bio-stimulants.

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