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Research Article
Effect of Fertilizer Management on Growth, Yield and Quality of Pea (*Pisum sativum* L.)

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Abstract

Background and Objective: Sandy soils are characterized with low fertility and needs organic build up through organic fertilizers. This study aimed the contribution of organic fertilizer adding in improving growth and yield of pea plants and its comparison with chemical fertilizer under sandy soil conditions. **Materials and Methods:** Two field experiments were conducted at the experimental station of National Research Center, Nubaria region, Behira Governorate, Egypt during the two winter seasons of 2016/2017 and 2017/2018. The study was carried out to investigate the effect of nutrients mixture (Aqua Cool) at 0, 1 and 2 cm L^{-1} under two sources of nitrogen, i.e., compost fertilization (2.5 t/fed) and ammonium sulphate (243 K/fed) and their interaction on growth, yield and quality of pea plant cv. "Little Marvel". **Results:** The results showed that ammonium sulphate exceeded compost fertilizer in all studied characters (plant height, leaves number/plant, shoots fresh and dry weight, pods number/plant, pod length, pod weight, number of seeds/pod, average weight of 10 pods, average weight of 100 seeds, total yield (t/fed), leaves content of chlorophyll a, b and carotenoids and pods content of N, P, K and protein) in both seasons. Moreover, nutrients mixture (Aqua Cool) at 1 and 2 cm L^{-1} significantly increased the former characters compared with untreated plants. The highest values were recorded by 2 cm L^{-1} in both seasons of the study. **Conclusion:** It can be recommended to fertilize pea plants with ammonium sulphate at 243 K/fed and spray with Aqua Cool at 2 cm L^{-1} for producing high yield and quality under similar conditions of the study.

Key words: Organic fertilizer, nutrients, *Pisum sativum*, Little Marvel, ammonium sulphate

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important *Leguminous* vegetable crops grown during winter season in Egypt for local consumption and exportation. It is considered as one of the most important sources in human nutrition, being its pods contain a great amount of protein, carbohydrates, vitamins, phosphorus, iron, magnesium, calcium and amino acids. Besides, pea considered as a soil fertility building crop through biological nitrogen fixation in association with symbiotic *Rhizobium* prevalent in their root nodules[1].

Vegetable crops often have shallow rooting systems and short periods of high N demand, both of which favour NO_3 leaching[2], especially in sandy soil which is very poor in organic matter content and nutrients. Therefore, fertilizers application is required for improving the availability of soil nutrients to obtain optimum plant growth. It is a major element in crop nutrition and its availability is most important factor limiting plant growth than other nutrients. Nitrogen is a major essential element for all organisms and a constituent of proteins, nucleic acids and other indispensable organic compounds[3]. Nitrogen fertilizers come in two types, either as chemical or organic fertilizers. Most growers use chemical fertilizers for enhancing growth and production of crops due to its easy and rapid availability to plants[4]. One of the chemical fertilizers used by growers was ammonium sulphate $[(NH_4)_2\ SO_4]$ as a source of nitrogen (20.6% N) and sulphur (24% S). It was applied by growers primarily where they need supplemental N and S to meet the nutritional requirement of growing plants and decrease pH of the soil. In general, chemical fertilizers are the major factor to meet the nutrient requirement and increase crop yield, but the continuous dependence on chemical fertilizers increased the total costs of crop production, created pollution of agro-ecosystem and increased deterioration of soil fertility[5].

Using organic fertilizers such as animal manures, composts and bio fertilizer can serve as an alternative practice to use N mineral fertilizers, in particular, with increased attention to organic food in many countries. The advantages of using organic fertilizers over chemical fertilizers that they are cost effective and less leached into ground water[6] as well as the production of agricultural crops is safe for humans and animals. Compost and other organic fertilizers have been shown to enhance soil microbial activity, increase organic matter content of the soil, improve the exchange capacity of nutrients, improve soil structure, increase moisture retention capacity of the soil, promote formation of soil aggregates and promote nutrient mobilization. Also, they can improve the physical, chemical and biological properties of degraded or low fertility soil, decrease certain plant diseases and soil borne pathogens and encourage the growth of beneficial microorganisms and consequently support the maximum yield[7]. The availability of nutrients from organic fertilizers such as animal manure and compost is lower than the total in the short-term[8,9] and may not meet crop requirements at any growth stage and often occurs out of the crop growing cycle. In contrast, chemical fertilizers are immediately available to crops, thus they are intended to be directly recovered by the crop they are supplied to Tei *et al.*[10]. Nevertheless, nutrient availability and crop yields come out similar for organic and mineral fertilization when long-term effects are evaluated[11].

Likewise, the availability of nutrients such as phosphorus, potassium and most of the micronutrients is relatively low in soil solution, because they are mainly fixed on the soil complex as insoluble forms. Otherwise, the more soluble nutrients such as nitrogen (N) are easily leached down the soil profile[12]. Thus, foliar fertilization is most commonly used for supplying the needed nutrients to plants in adequate concentrations, improving nutritional status of plants and increasing the crop yield and its quality[13]. Foliar fertilization is better than soil fertilization in case of soil deficiencies in nutrients (where it is capable of quickly, cheaply and economically overcoming various deficiency symptoms), soil nutrient imbalance and in case of stress situations during growing stages[14]. In addition, the amounts of fertilizers used in foliar fertilizations are very small and the ground water pollution is less.

Therefore, this study aimed to evaluate the effect of nitrogen sources, spraying with nutrients mixture as well as their interaction on growth, yield and quality of pea cv. "Little Marvel".

MATERIALS AND METHODS

Two field experiments were carried out at the experimental station of National Research Center, Nubaria, Behira Governorate, Egypt during the two successive seasons of 2016/2017 and 2017/2018 to investigate the effects of two sources of nitrogen, i.e., compost application and ammonium sulfate and spraying with Aqua Cool (nutrients mixture) on growth, yield and pods quality of pea (*Pisum sativum* L.) cv. Little Marvel. The physical and chemical properties of soil are shown in Table 1.

Seeds were inoculated before sowing with root nodules bacteria (*Rhizobium leguminosarum*) and sown in 14th and 16th of October in the first and the second seasons, respectively on one side of the irrigation lines with 20 cm

Table 1: Physical and chemical properties of experimental soil

Physical properties	Values	Chemical analysis (Meq L^{-1})	Values
Sand	90.08	Ca	7.020
Clay	9.26	Mg	0.527
Silt	0.66	Na	0.982
Texture	Sandy	K	0.310
FC (%)	16.57	HCO_3	1.300
WP (%)	5.25	Cl	0.566
EC (M/moh)	1.70		
pH	8.20		

FC: Field capacity, WP: Wilting point, EC: Electrical conductivity

Table 2: Physical and chemical properties of Nile compost

Compost properties	Values
Density as wet basis (kg m^{-3})	600-750
Density as dry basis (kg m^{-3})	450-560
Moisture content (%)	25-30
pH in 1:10 extract	5.5-7.5
EC in 1:10 extract (dS m^{-1})	3.5-5.5
Water holding capacity (%)	200-300
Organic matter (%)	40-45
Organic carbon (%)	23.2-26.1
C/N ratio	14.5:1-16.5:1
Total nitrogen (%)	1.4-1.8
Phosphorus (%)	0.4-0.8
Potassium (%)	0.6-1.2
Iron (ppm)	1500-200
Copper (ppm)	160-240
Manganese (ppm)	100-150
Zinc (ppm)	40-80

spacing between lines and 15 cm between plants. The experimental design was split-plot in a randomized block design with 3 replicates. The main plots contain the two sources of nitrogen, i.e., compost at 2.5 t/fed and ammonium sulfate (20.6% N) at 243 kg/fed and the sub-plots contain the foliar spray of Aqua Cool at 1 and 2 cm L^{-1} in addition to control (sprayed with tap water).

The sub-plot area was 12.8 m^2 (4 dripper line, each 4 m long and 0.8 m width). Organic fertilizer (Nile compost) was added during preparing the soil for sowing and ammonium sulphate was added as two equal sub rates, after completing germination and at the beginning of the flowering. Aqua Cool compound (7% N, 5% P, 5% K, 1% Mg, 2.1% S, 0.05% B and 0.3% Fe) was sprayed three times, the first 15 days after sowing and repeated each 15 days. The physical and chemical properties of Nile compost are shown in Table 2. The normal agricultural practices of pea production in sandy soils were followed according to the recommendations of Egyptian Ministry of Agriculture.

At 55 days after sowing five plants from each sub plot were randomly chosen to record the following data: plant length (cm), leaves number/plant and shoots fresh and dry weight as g/plant. Total pigments (chlorophyll a, b and carotenoids) were determined in leaves as mg/100 g fresh weight according to Wellburn[15]. At the harvest stage, number of pods/plant, average weight of 10 pods (g) and total pod yield (t/fed) were determined. 20 pods from each unit were taken to record pod length (cm), pod weight (g), number of seeds/pod and average weight of 100 seeds (g). Contents of N, P and K in dry seeds were determined according to the methods of Faithfull[16]. Crude protein was determined according to AOAC[17].

Statistical analysis: Statistical analysis of the obtained data was carried out according to statistical analysis of variance according to Snedecor and Cochran[18]. The differences between the mean values of various treatments were compared by Duncan's multiple range test[19] using "CoStat" computer software package.

RESULTS

Vegetative growth

Effect of nitrogen sources: Table 3 shows the effect of nitrogen sources (compost and ammonium sulphate) on vegetative growth of pea. As in Table 2, the differences between the two studied sources of nitrogen were significant in the two seasons of the study. Ammonium sulphate fertilizer gave higher values of plant height, leaves number/plant and shoots fresh and dry weight than compost.

Effect of nutrients mixture: It can be said that Aqua Cool foliar treatment at (1 and 2 cm L^{-1}) significantly increased plant height, leaves number/plant and shoots fresh and dry weight of pea compared with untreated plants (control) in both seasons of the study (Table 3). The 2 cm L^{-1}concentration recorded the highest values of the former characters followed by 1 cm L^{-1} with significant differences between them.

Effect of the interaction: Concerning the interaction between nitrogen sources and Aqua Cool foliar spray, Table 3 shows that fertilized pea plants with ammonium sulphate (243 kg/fed) and sprayed with Aqua Cool (2 cm L^{-1}) gave the highest significant values of plant height, leaves number/plant and shoots fresh and dry weight compared other treatments. The lowest values in previous parameters were noticed in pea plants received compost application (2.5 t/fed) with tap water spraying.

Pod yield and its components

Effect of nitrogen sources: The response of pea pod yield and its component to nitrogen sources is presented in Table 4 and 5. Ammonium sulphate surpassed compost fertilizer in all

Table 3: Plant length, leaves number and shoots fresh and dry weight of pea were affected by nitrogen sources, foliar treatments and their interaction

	Plant length (cm)		Leaves number/plant		Shoots fresh weight (g)		Shoots dry weight (g)	
Treatments	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Nitrogen sources								
Compost (2.5 t/fed)	60.44^{b}	63.11^{b}	9.55^{b}	9.00^{b}	24.60^{b}	23.16^{b}	4.25^{b}	3.87^{b}
Ammonium sulphate (243 kg/fed)	71.00^{a}	75.22^{a}	11.88^{a}	11.55^{a}	27.59^{a}	26.52^{a}	4.71^{a}	4.77^{a}
Foliar application								
Control	57.83^{c}	61.66^{c}	9.83^{c}	8.33^{c}	23.03^{c}	21.94^{c}	4.18^{c}	3.84^{c}
Aqua Cool (1 cm L^{-1})	66.66^{b}	69.83^{b}	10.83^{b}	10.66^{b}	26.94^{b}	25.16^{b}	4.48^{b}	4.34^{b}
Aqua Cool (2 cm L^{-1})	72.66^{a}	76.00^{a}	11.50^{a}	11.83^{a}	28.31^{a}	27.41^{a}	4.78^{a}	4.79^{a}
A×B compost (2.5 t/fed)								
Control	52.66^{e}	55.33^{f}	8.33^{e}	7.33^{d}	22.20^{e}	20.82^{e}	3.91^{e}	3.26^{d}
Aqua Cool (1 cm L^{-1})	60.33^{d}	62.33^{e}	9.66^{d}	9.00^{c}	25.40^{c}	23.23^{d}	4.23^{d}	3.87^{c}
Aqua Cool (2 cm L^{-1})	68.33^{bc}	71.66^{c}	10.66^{c}	10.66^{b}	26.20^{c}	25.42^{c}	4.61^{bc}	4.48^{b}
Ammonium sulphate (243 kg/fed)								
Control	63.00^{cd}	68.00^{d}	11.33^{bc}	9.33^{c}	23.86^{d}	23.06^{d}	4.46^{cd}	4.41^{b}
Aqua Cool (1 cm L^{-1})	73.00^{ab}	77.33^{b}	12.00^{ab}	12.33^{a}	28.48^{b}	27.09^{b}	4.73^{ab}	4.81^{ab}
Aqua Cool (2 cm L^{-1})	77.00^{a}	80.33^{a}	12.33^{a}	13.00^{a}	30.43^{a}	29.40^{a}	4.95^{a}	5.11^{a}

Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan’s multiple range test

Table 4: Pods number, pod length, pod weight and number of seeds of pea were affected by nitrogen sources, foliar treatments and their interaction

	Pods number/plant		Pod length (cm)		Pod weight (g)		Number of seeds/pod	
Treatments	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Nitrogen sources								
Compost (2.5 t/fed)	8.88^{b}	6.33^{b}	8.11^{b}	9.44^{b}	5.31^{b}	4.94^{b}	6.20^{b}	6.33^{b}
Ammonium sulphate (243 kg/fed)	12.55^{a}	9.00^{a}	10.33^{a}	11.22^{a}	6.22^{a}	6.60^{a}	7.57^{a}	8.11^{a}
Foliar application								
Control	9.50^{c}	6.66^{c}	8.66^{c}	9.66^{b}	5.40^{b}	5.25^{c}	6.35^{c}	6.50^{c}
Aqua Cool (1 cm L^{-1})	10.66^{b}	7.66^{b}	9.19^{b}	10.50^{a}	5.82^{a}	5.81^{b}	6.87^{b}	7.16^{b}
Aqua Cool (2 cm L^{-1})	12.00^{a}	8.66^{a}	9.83^{a}	10.83^{a}	6.08^{a}	6.25^{a}	7.45^{a}	8.00^{a}
A×B compost (2.5 t/fed)								
Control	8.00^{e}	5.66^{e}	7.66^{d}	8.66^{e}	4.83^{e}	4.36^{f}	5.80^{d}	5.33^{e}
Aqua Cool (1 cm L^{-1})	8.66^{e}	6.33^{de}	8.00^{cd}	9.66^{d}	5.36^{d}	5.00^{e}	6.25^{cd}	6.33^{d}
Aqua Cool (2 cm L^{-1})	10.00^{d}	7.00^{cd}	8.66^{c}	10.00^{cd}	5.73^{cd}	5.46^{d}	6.56^{c}	7.33^{c}
Ammonium sulphate (243 kg/fed)								
Control	11.00^{c}	7.66^{c}	9.66^{b}	10.66^{bc}	5.96^{bc}	6.13^{c}	6.90^{bc}	7.66^{bc}
Aqua Cool (1 cm L^{-1})	12.66^{b}	9.00^{b}	10.33^{ab}	11.33^{ab}	6.28^{ab}	6.63^{b}	7.50^{b}	8.00^{b}
Aqua Cool (2 cm L^{-1})	14.00^{a}	10.33^{a}	11.00^{a}	11.66^{a}	6.43^{a}	7.03^{a}	8.33^{a}	8.66^{a}

Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan’s multiple range test

characters, i.e., pods number/plant, pod length, pod weight, number of seeds/pod, average weight of 10 pods, average weight of 100 seeds and total yield (t/fed) in both seasons with significant differences between them.

Effect of nutrients mixture: Spraying nutrients mixture (Aqua Cool) at different concentrations (1 and 2 cm L^{-1}) gave significant increases in pods number, pod length, pod weight, number of seeds/pod, average weight of 10 pods, average weight of 100 seeds and total yield (t/fed) compared with control treatment (Table 4 and 5). The 2 cm L^{-1} foliar treatment recorded the highest significant values in aforementioned characters in both seasons, except pod length in the second season, pod weight and average weight of 100 seeds in the first season.

Effect of the interaction: The different interactions between nitrogen sources and nutrients mixture (Aqua Cool) increased pods number/plant, pod length, pod diameter and number of seeds/pod (Table 4) and average weight of 10 pods, average weight of 100 seeds and total yield/fed (Table 5) compared with compost and tap water spray interaction (control) in both seasons. Fertilizing pea plants with ammonium sulphate and spraying with Aqua Cool (2 cm L^{-1}) gave the highest values of yield parameters compared with other interaction treatments.

Chemical contents

Effect of nitrogen sources: Analysis of variance revealed that ammonium sulphate fertilizer gave much content of chlorophyll a, b and carotenoids in leaves (Table 6) and N,

Table 5: Average weight of 10 pods, average weight of 100 seeds and total yield of pea were affected by nitrogen sources, foliar treatments and their interaction

	Average weight of 10 pods (g)		Average weight of 100 seeds (g)		Total yield (t/fed)	
Treatments	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Nitrogen sources						
Compost (2.5 t/fed)	48.67b	48.75b	21.76b	21.38b	2.826b	3.500b
Ammonium sulphate (243 kg/fed)	52.37a	51.59a	24.87a	24.20a	3.905a	4.300a
Foliar application						
Control	47.74c	48.36b	21.82b	21.53c	2.960c	3.650c
Aqua Cool (1 cm L^{-1})	50.48b	50.53ab	23.60a	22.99b	3.321b	3.850b
Aqua Cool (2 cm L^{-1})	53.34a	51.62a	24.51a	23.86a	3.816a	4.200a
A×B compost (2.5 t/fed)						
Control	45.54d	47.56c	19.73d	19.50e	2.520f	3.200f
Aqua Cool (1 cm L^{-1})	49.07c	49.58bc	22.26c	21.76d	2.843e	3.400e
Aqua Cool (2 cm L^{-1})	51.40bc	49.12bc	23.28bc	22.90c	3.116d	3.900d
Ammonium sulphate (243 kg/fed)						
Control	49.94bc	49.16bc	23.91abc	23.56bc	3.400c	4.100c
Aqua Cool (1 cm L^{-1})	51.89b	51.47ab	24.95ab	24.21ab	3.800b	4.300b
Aqua Cool (2 cm L^{-1})	55.29a	54.12a	25.75a	24.83a	4.516a	4.500a

Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan's multiple range test

Table 6: Chlorophyll a, chlorophyll b and carotenoids contents of pea leaves were affected by nitrogen sources, foliar treatments and their interaction

	Chlorophyll a (mg/100 g fw)		Chlorophyll b (mg/100 g fw)		Carotenoids (mg/100 g fw)	
Treatments	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Nitrogen sources						
Compost (2.5 t/fed)	0.308b	0.316b	0.261b	0.300b	0.240b	0.344a
Ammonium sulphate (243 kg/fed)	0.372a	0.415a	0.309a	0.318a	0.281a	0.377a
Foliar application						
Control	0.321c	0.346b	0.273c	0.300c	0.247c	0.351c
Aqua Cool (1 cm L^{-1})	0.338b	0.372a	0.286b	0.311b	0.260b	0.361b
Aqua Cool (2 cm L^{-1})	0.361a	0.380a	0.295a	0.316a	0.274a	0.369a
A×B compost (2.5 t/fed)						
Control	0.290f	0.312d	0.250e	0.287f	0.220e	0.335f
Aqua Cool (1 cm L^{-1})	0.312e	0.317d	0.262d	0.304e	0.238d	0.344e
Aqua Cool (2 cm L^{-1})	0.321d	0.320d	0.272c	0.310d	0.262c	0.352d
Ammonium sulphate (243 kg/fed)						
Control	0.353c	0.380c	0.297b	0.313c	0.275b	0.368c
Aqua Cool (1 cm L^{-1})	0.364b	0.426b	0.310a	0.319b	0.281ab	0.378b
Aqua Cool (2 cm L^{-1})	0.401a	0.439a	0.319a	0.323a	0.287a	0.385a

Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan's multiple range test, FW: Fresh weight

P, K and protein in seeds (Table 7) than compost fertilizer. The differences between them were significant in all previous parameters except, carotenoids in the second season.

Effect of nutrients mixture: In both seasons of the study, nutrients mixture (Aqua Cool) foliar treatment at (1 and 2 cm L^{-1}) recorded a significant increase in leaves content of chlorophyll a and b and carotenoids (Table 6) and pods content of N, P, K and protein compared with the control (Table 7). The highest values of previous contents were recorded in the plants sprayed with 2 cm L^{-1} followed by 1 cm L^{-1} concentration.

Effect of the interaction: As seen, all interactions between nitrogen sources and nutrients mixture (Aqua Cool) increased leaves content of chlorophyll a, b and carotenoids (Table 6) and pods content of N, P, K and protein (Table 7) in both seasons. Pea plants fertilized with ammonium sulphate and sprayed with Aqua Cool at 2 cm L^{-1} recorded the highest chemical content of leaves and pods.

DISCUSSION

The obtained results revealed that ammonium sulphate exceeded compost fertilizer in all vegetative growth characters. The superiority of chemical fertilizer (ammonium

Table 7: N, P, K and protein contents of pea pods were affected by nitrogen sources, foliar treatments and their interaction

	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Protein (%)	
Treatments	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Nitrogen sources								
Compost (2.5 t/fed)	1.463[b]	1.400[b]	1.206[b]	1.203[b]	1.475[b]	1.594[b]	9.14[b]	8.75[b]
Ammonium sulphate (243 kg/fed)	1.794[a]	1.671[a]	1.563[a]	1.462[a]	1.676[a]	1.774[a]	11.21[a]	10.45[a]
Foliar application								
Control	1.545[c]	1.438[c]	1.266[c]	1.233[b]	1.508[c]	1.595[c]	9.65[c]	8.98[c]
Aqua Cool (1 cm L^{-1})	1.603[b]	1.550[b]	1.403[b]	1.311[b]	1.573[b]	1.701[b]	10.02[b]	9.68[b]
Aqua Cool (2 cm L^{-1})	1.738[a]	1.618[a]	1.485[a]	1.453[a]	1.646[a]	1.756[a]	10.86[a]	10.13[a]
A×B compost (2.5 t/fed)								
Control	1.383[d]	1.310[e]	1.100[f]	1.140[d]	1.406[f]	1.503[d]	8.64[d]	8.18[e]
Aqua Cool (1 cm L^{-1})	1.433[d]	1.416[d]	1.216[e]	1.223[cd]	1.466[e]	1.606[c]	8.95[d]	8.85[d]
Aqua Cool (2 cm L^{-1})	1.573[c]	1.473[d]	1.303[d]	1.246[cd]	1.553[d]	1.673[b]	9.83[c]	9.21[d]
Ammonium sulphate (243 kg/fed)								
Control	1.706[b]	1.566[c]	1.433[c]	1.326[bc]	1.610[c]	1.686[b]	10.66[b]	9.79[c]
Aqua Cool (1 cm L^{-1})	1.773[b]	1.683[b]	1.590[b]	1.400[b]	1.680[b]	1.796[a]	11.08[b]	10.52[b]
Aqua Cool (2 cm L^{-1})	1.903[a]	1.763[a]	1.666[a]	1.660[a]	1.740[a]	1.840[a]	11.90[a]	11.05[a]

Values followed by the same letter within a column are not significantly different at the 0.05% level of probability according to Duncan's multiple range test

sulphate) may be attributed to faster release of nutrient contents than compost fertilizer, which needs more time to release the nutrients from it and may not meet pea requirements at any growth stage. Moreover, ammonium sulphate contains about 24% sulpher, which plays an important role in decreasing pH of the soil (pH of the experimental soil presented in Table 1) which increased nutrients absorption.

Similar results about the superiority of chemical fertilizer were obtained by Khan *et al.*[20], Abo-Basha[21] and Lalito *et al.*[22] they found that vegetative growth of pea affected by chemical fertilizer more than organic one. On the other hand, Abuo El-Kasem and Elkassas[23] found that compost fertilizing gave vegetative growth values higher than chemical fertilizer in pea. As seen, the response of pea plant to organic fertilizers, i.e., compost was variable and that depends on the type of compound.

Concerning compost addition, it had positive effect on pea growth due its role in improving soil structure, increasing soil organic matter content and soil moisture retention capacity, promoting formation of soil aggregates and encouraging the beneficial microorganisms growth[7]. Moreover, compost provides pea plants with essential nutrients, i.e., nitrogen, phosphorus, potassium as well as iron, copper, manganese and zinc (Table 2). The positive impact of compost on vegetative growth of pea was obtained by Mahmoud *et al.*[24], Jannoura *et al.*[25], Kumar *et al.*[26] and Shafeek *et al.*[27].

Nutrients mixture foliar spray positively affected pea growth due to its content of N, P, K, S, Mg, B and Fe elements. Nitrogen (N) is essential for the synthesis of proteins, nucleic acids, amino acids, cell division and elongation, protoplasm formation, phosphorus (P) is essential for the synthesis of nucleic acids, phospholipids, phospho-proteins, ATP, photosynthesis, the transfer of energy and root growth and potassium (K) is known to be an enzyme activator that promotes metabolism and facilitates cell division and growth by helping to move starches and sugars between plant parts[5,28]. Also, magnesium (Mg) is necessary in chlorophyll biosynthesis, activating Mg chelatase and an enzyme activator in the synthesis of nucleic acids (DNA and RNA) and sulphur (S) is an essential component in the synthesis of amino acids and required for chlorophyll production and nodule formation in legumes[28-30].

In addition, iron (Fe) has an essential role in the synthesis and maintenance of chlorophyll and activation of several biochemical processes in plant such as respiration, photosynthesis and symbiotic nitrogen fixation as well as boron (B) has a role in differentiation of meristem cells, the structure of the cell wall and promoting root growth[28,31].

Similar results were obtained by Milev[32], Zaghloul *et al.*[33] and Klimek-Kopyra *et al.*[34] they found that foliar application of nutrients mixture improved vegetative growth of pea compared with the control.

Pod yield showed great response to the integrated application of both organic and inorganic amendments. The impact of compost or ammonium sulphate on yield of pea is related to increase the availability of nutrients in soil and subsequent uptake by plants following the assimilation and translation in different plant parts further enhanced the metabolites[1]. Moreover, compost addition improves soil texture, microbial mass and soil properties and enhances root growth due to better soil structure which is reflected in the increased of pea yield. Kumar *et al.*[26], Shafeek *et al.*[27] and

Hirich *et al.*[35] reported that compost application increased yield and its components of pea. Compared with compost, the overbalance effect of chemical fertilizer (ammonium sulphate) on yield is a result of its positive effect on vegetative growth of pea (Table 3).

The superiority of chemical on organic fertilizer regarding pod yield and its components was noticed by Khan *et al.*[20] and Albayrak *et al.*[36] on pea and Joshi *et al.*[37] on cowpea. Compost effect on pea yield may be similar to the chemical effect when used for a long time. In this context, Warman[38] revealed that the long-term use of compost (12 years) in comparison with mineral fertilizers can produce similar yields for most vegetable crops in compost-amended and conventionally-fertilized soils. Similar results were obtained by El-Azab[39], Rahman *et al.*[40] and Hassan[41].

The positive impact of foliar applied nutrients through the treatment (Aqua Cool) on yield and its components of pea is attributed to the effect of macro and micronutrients. Nitrogen (N) promotes rapid growth and production of more photosynthesis, hastens crop maturity and promotes fruit and seed development, phosphorus (P) stimulates root and flower formation, fruit setting, seed formation, fruit development and accelerates maturity of crops and potassium (K) promotes enzyme activity, enhances the translocation of assimilates for plant growth or storage in fruits or roots and improves the size of seeds. Additionally, magnesium (Mg) has an important role in chlorophyll accumulation, photosynthesis, net assimilation and transpiration rates and sulphur (S) has a role in increasing the size and weight of seeds and enhancing the efficiency of nitrogen for protein synthesis[32,42].

Concerning micronutrients, Fe has a role in chlorophyll formation, photosynthesis activation, carbohydrates assimilation and activation of enzymes associated with energy transfer and B is essential for pollen germination and growth of the pollen tube and involved in seed and cell formation and development, nitrogen metabolism and photosynthesis[28,32].

The response of chemical contents of leaves and pods of pea to organic and inorganic fertilizers showed that ammonium sulphate gave much content of chlorophyll a, b and carotenoids in leaves and N, P, K and protein in seeds than compost fertilizer. In case of ammonium sulphate, the nutrients are immediately available to plants and that led to better root growth absorbs more nutrients followed by increasing translocation of nitrogen from the vegetative parts to the developing seeds and increment in protein synthesis. While compost may not provide the plants with all the necessary nutrients in adequate quantities and also might slow release of nutrients as compared to chemical fertilizers[10]. Similar results were recorded by Khan *et al.*[20] and Kumar *et al.*[43], they reported that chemical contents of pea were higher in plants received chemical fertilizer compared with those received organic addition. In this regard, Moghazy *et al.*[44] studied the effect of compost and ammonium sulphate on N, P, K and protein contents of pea seeds. They reported that chemical fertilizer (ammonium sulphate) resulted in the highest values compared with compost application.

The nutrients (N, P, K, S, Mg, Fe and B) existing in Aqua Cool mixture solution are responsible for improving the chemical contents of pea. Nitrogen is a major part of the chlorophyll molecule, necessary for photosynthesis and improves the quality and quantity of dry matter in vegetables and increases protein content in grain crops[28], phosphorus improves the quality of certain crops and also activates coenzymes for amino acid production used in protein synthesis[32] and potassium is involved in protein synthesis, improves the size of grains and seeds and improves the quality of fruits and vegetables. Concerning magnesium, it plays an important role in source-sink relationships and facilitating the translocation of carbohydrates (sugars and starches) as well as sulphur has a role in chlorophyll formation and stabilizing protein structure[45]. Regarding to iron, it has a role in synthesis and maintenance of chlorophyll and protein synthesis and degradation[28,31], furthermore boron is involved in active salt absorption, hormone, fat, phosphorus metabolism and photosynthesis and associated with lignin synthesis, activities of certain enzymes and sugar transport[28,32]. Similar results were reported by Eisa and Ali[46] and El-Azab[47].

The significance of this study is that the compost application could not be considered as a substitution of the inorganic N in such poor soils. Therefore, the integrated use of organic and inorganic fertilizers is favored and many studies must be carried out to raise the benefits of organic fertilizers and how to reach an effect similar to that of chemical fertilizers.

CONCLUSION

The obtained results clearly showed that compost and chemical fertilizers improved the growth and yield of pea plants, but the effect of chemical fertilizer was greater and more significant than compost. Also, foliar fertilization with nutrients mixture is important beside the basic fertilizer for increasing the yield of pea, especially under sandy soil conditions.

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