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Original Article

Response of lettuce (*Lactuca sativa L.*) plants to replacement of mineral fertilizers to substituted for compost tea

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ABSTRACT

Background: Lettuce (*Lactuca sativa* L.) is a widely cultivated leafy vegetable belonging to the Asteraceae family Growth, productivity and quality of lettuce plants **Objectives:** (*Lactuca sativa* L.) were evaluated under circumstances of depending on "compost tea", "compost tea + molasses" and "compost tea + bacterial inoculation" as sources for fertilization compared to mineral fertilizers. **Methods:** The experiment was conducted at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Dokki, Giza. Seedlings of lettuce (*Lactuca sativa* L. c.v Iceberg) were transplanted at the 15th of October through 2019/2020 and 2020/2021 seasons. **Results:** Obtained results confirmed the ability of "compost tea + bacterial inoculation" followed by "compost tea + molasses" and then chemical fertilizer ranked in the third order as a sole fertilizer for lettuce to enhance plant height, number of leaves per head, head length, head diameter, SPAD reading, head volume, average head weight, total heads yield/m^2 and content of nitrogen, phosphorus, potassium, calcium and magnesium and ascorbic acid (Vitamin C) in leaves. While, reduced nitrate content in leaves. **Conclusion:** Applied "compost tea + bacterial inoculation" and "compost tea + molasses" can considered as one of ways to replacement of mineral fertilizers

INTRODUCTION

Basically human consumed leafy vegetable crops for obtain fiber and other nutritional components. Lettuce is the clear example for the popular and nutritive leafy vegetable, that's consumed worldwide however as a salad or in fast food. Lettuce is a good source for vitamin A and C, minerals like calcium, phosphorus and iron.

Lettuce (*Lactuca sativa* L.) is a widely cultivated leafy vegetable belonging to the Asteraceae family [1]. Vegetables leafy crops like lettuce voracious for nitrogen fertilizers throughout short life cycle. Consequently, Nitrogen quickly supply organic fertilizers are very expensive but, it is very important to produce a competitive crop yield [2].

Nearby all farms fertilize lettuce as well as, other vegetables using chemical (mineral) fertilizers for its quick results in nitrate cultivated crops. In spite of the known harmful effect of such mineral fertilizers on environment and both of human and animal. Through replace the organic fertilizers substitute of mineral fertilizers, the harmful and toxic elements resulted from mineral fertilizers are reduced [3]. Now a days, awareness of consumers directed to prefer vegetable produce using organic fertilizers. Such vegetables is less in toxic compounds compared to those mineral fertilized. As well as, improve tasty and quality of leafy crops. This awareness considered as a part of the global consideration for saving and improving the environment [4].

Through the organic commercial agriculture compost extract; that's called 'compost tea" is used to fertilize wide range of vegetables [5]. The compost tea guarantee many advanced such like (1) contain nutrients in soluble solution that is easy to absorb by plants or soak seeds and seedlings, (2) ability to add through irrigation system or as foliar application, (3) high contents of phytohormones and plant growth regulators and (4) rich in microorganisms which have the ability to enhance the rhizosphere of the plants [6]. "Compost tea" is the compost water extract, which retains all the beneficial bioactive soluble components, making it an effective source of stimulating and protective compounds for plants [7]. Earlier on 2012, Zaccardelli *et al*., reported that compost tea enhanced the physiological process inside plants as a results of humic and hormone-like substances that produced by microbes [8]. Listed advanced qualify compost tea for reducing both of chemical pesticides and chemical fertilizers.

Moreover, compost tea increase number of microorganisms in soil [9]. Such microorganisms contain growth promoter's bacteria. Addition to, nitrogen fixation and phosphor solubilization that increase available minerals for the plants [10]. From another point of view, compost tea enhance levels of carbon and organic matter in soil, this reflected in better soil aggregates, structure and water holding capacity [11]. Quality of compost tea depending on the quality of using compost as the first important factor. As well as, method of production [12]. When using organic fertilizers, soil fertility is enhanced through improving both of biological, chemical and physical properties [13].

Furthermore, compost tea considered as a valuable organic fertilizers because of its nutritional and bio stimulation. Through add some additive to the compost tea such nutritional value is elevated. During producing the compost tea some additive are add to achieve high number of different variety of microorganisms. One of the most famous and cheap available additive is molasses [6]. By adding molasses or other additives for the compost tae the C:N ratio, carbohydrates types and source of nitrogen are all affected [14]. Whilst, in liquid molasses contains lots of complex sugars that is considered as a basic food for bacteria [15].

This study aims to evaluate lettuce crop yield and quality under solo organic fertilizers circumstances together with molasses and bacterial inoculation as additive for the compost tea.

MATERIAL & METHODS

For testing effectiveness of replacements chemical fertilizers by enhanced-compost tea through add "compost tea + Molasses" or "compost tea + bacterial inoculation" on growth, productivity and quality of lettuce plants, an experiments was conducted at CLAC, ARC, Dokki, Giza. The experiment was replicated through winter seasons of 2019 and 2020.

Preparing the experimental area

A 60 m long, eight meters width and 4.25 m height unheated white-net house was used for held the investigation. Five ridges (1 m width and 60 m long) separated by 0.60 m wide pathway were made inside the shade-house. Recommended fertilizers were add to the soil before planting. Drip irrigation system was used, where the dripping lines were placed about 10 cm apart from the center of seed hole.

Treatments

Two types of enhanced compost tea were tested compared to chemical fertilizers to create the followed treatments:

1- Pure compost tea.
2- Compost tea (50L) + molasses (500ml).
3- Compost tea (50L) + bacterial mix (*Azotobacter chroococcum* and *Bacillus megaterium*)/ 250ml from both types of bacteria.
4- Chemical fertilizers as a control.

Compost tea was prepared by soaking 250 g of compost (plant compost) in 50 liters of tap water for 24 hours. Application of treatments starts after two weeks from transplanting (Table 1). Also, EC and pH of fertilizer solutions were measured prior to application. Whereas, pH and Ec were evaluated in the range of 6.9 – 7 and 1-1.2 µm, respectively. All treatment of organic liquid fertilizer was measured, as well as, molasses and bacterial inoculation mix (Table 1).

Table (1): Used Nile compost chemical analysis, extract compost tea, molasses and bacterial mix.

Items	pH	EC	Org. matter %	Org. carbon %	Humate %	C/N ratio	N %	P %	K %	Fe ppm	Cu ppm	Mn ppm	Zn ppm
Nile compost	8.2	5.5	44	25.5	-	16.5:1	1.6	0.60	1.6	1750	200	125	60
Compost tea	6.7	0.96	-	-	5.8	-	2.2	0.12	2.8	-	-	-	-
Molasses	6.9	1.2	-	-	-	-	0.9	0.112	1.79	-	-	-	-
Bacterial mix	7.0	1.1	-	-	-	-	1.3	0.14	1.84	-	-	-	-

Recorded data

Parameters including plant height, number of leaves/head, head length, head diameter, fresh and dry weights of leaves, head volume, average head weight and total heads yield/m^2 were recorded.

Experimental design and data analysis

With three repetitions, the study was conducted in randomized complete block design. Duncan's multiple range tests were used to compare mean values at a 5% level of probability (SAS, 2005).

RESULTS & DISCUSSION

Vegetative growth:

Illustrated data in Table (2): indicated a significant effect for the tested fertilizers on both of lettuce plant height and number of leaves. However, a non-significant effect for such fertilizers was obtained in characteristics of head length and head diameter.

Concerning the significant effect, it's noticeable that, using "compost tea + bacterial inoculation" recorded a superiority in plant height and number of leaves per head, followed by "compost tea + molasses" as second highest significant values. Moreover, chemical fertilizers recorded the third highest significant value. The lowest significant values of plant height and number of leaves/head obtained in plants fertilized with compost tea. The mentioned trend of results was confirmed in both studied seasons.

Contrary, none of the tested fertilizers cause a significant effect on lettuce heads length or diameters during both studied seasons.

Table (2): effect of using each of compost tea, compost tea plus bacterial inoculation, compost tea plus molasses and chemical fertilizers as a sole fertilizer on lettuce plant height (cm), number of leaves per head, head length (cm) and head diameter (cm) during seasons of 2019/2020 and 2020/2021.

Treatments	First season			
	Plant height	Number of leaves/head	Head length	Head diameter
Compost tea	20.08C	19.00C	14.00A	12.63A

Compost tea + Bacteria	24.33A	36.00A	14.70A	13.73A
Compost tea + Molasses	22.67B	35.33A	14.00A	13.33A
Chemical (control)	22.00B	26.00B	14.33A	13.10A
	Second season			
Compost tea	19.55C	19.00C	13.68A	12.43A
Compost tea + Bacteria	23.85A	35.67A	14.40A	13.41A
Compost tea + Molasses	22.34B	34.83A	14.00A	13.05A
Chemical (control)	21.82B	25.83B	13.92A	12.65A

Vegetative growth such as (plant height, number of leaves per head, head length and head diameter) in this study were enhanced by using compost tea with bacterial mix (*Azotobacter chroococcum* for fixed nitrogen and *Bacillus megaterium* for absorbed phosphor) followed by plants fertilized with compost tea + molasses. Such enhancement attributed to the beneficial effects of bacterial mix that help in increasing nitrogen fixation in rhizosphere, increase supply of phosphorus, as well as, produce plant hormones [16], plus to the available nutrients, vitamins and hormone in compost tea [17]. In other hand, Shahein *et al.* confirmed that on studied at vegetative characteristics of lettuce (plant height, No. of leaves, head length and head diameter) were enhanced significantly when fertilized using compost tea [18] . Obtained enhancement in lettuce vegetative growth that obviously found when increasing available nitrogen by N-fixing bacteria (*Azotobacter chroococcum*) in presence of compost tea, attributed to both of soil physical and chemical properties improvement through using compost tea [19]. Also, this improvements is because of increasing soil fertility together with biological activity in roots rhizosphere [20]. In addition, add *Azotobacter chroococcum* to the compost tea present fixed nitrogen, hormones, signal molecules, vitamins, iron, etc which enhance root growth of plants [21]. All that, play an important role in increasing nutrient availability for uptake which reflected in better root distribution and vegetative growth. Rather than, Hernández *et al.* explained that, this enhancement on basis of elevating level of phytohormones that already exist in compost tea as a direct effect for the fixing bacteria and molasses [22]

Chlorophyll reading (SPAD):

Chlorophyll reading (SPAD reading) in outer lettuce leaves (Table 3) recorded the highest significant value in plants fertilized with compost tea supported with bacterial inoculation followed by compost tea supported with molasses in second order and chemical fertilizer in third order. The lowest significant SPAD reading was found in plants fertilized with single compost tea. This trend was found in second season.

Results obtained a significant enhancement in SPADE reading in organically fertilized treatments compared to chemical fertilizer treatment. Similar results was obtained in lettuce and kohlrabi by Pane *et al.* [6]. This enhancement is attribute to impact of compost tea on the physiological status of the plants. Such impact appear in higher content of chlorophyll in lettuce leaf of organically treated plants. Additional, confirmation was found by Siddiqui *et al.* reported a positive relation fertilizing using compost tea and final chlorophyll content, as well as, enhanced rate of photosynthesis [23].

Table (3): effect of using each of compost tea, compost tea plus bacterial inoculation, compost tea plus molasses and chemical fertilizers as a sole fertilizer on lettuce leaves content of chlorophyll reading (SPAD reading), nitrogen, phosphorus, potassium, calcium and magnesium (%) during seasons of 2019/2020 and 2020/2021.

Treatments	First season					
	Chlorophyll reading	N	P	K	Ca	Mg
Compost tea	30.51C	1.995C	0.346C	2.932B	1.706D	0.471C
Compost tea +	47.09A	3.023A	0.418A	3.914A	1.944A	0.585A

Bacteria						
Compost tea + Molasses	43.31B	2.974B	0.395B	3.183B	1.839B	0.534B
Chemical (control)	43.26B	2.016C	0.363C	3.126B	1.778C	0.481C
	Second season					
Compost tea	30.06C	1.941C	0.339C	2.752B	1.820D	0.462B
Compost tea + Bacteria	46.34A	2.997A	0.416A	3.823A	2.119A	0.561A
Compost tea + Molasses	43.40B	2.701B	0.376B	3.164B	2.044B	0.528A
Chemical (control)	42.62B	1.968C	0.341C	3.118B	1.885C	0.478B

Chemical component

Chemical components in lettuce leaves were affected significantly by different tested organic fertilizers and control treatments (chemical fertilizer), as shown in (Table 3). It is clear from data in (Table 3) that fertilize lettuce plants using compost tea supported with bacterial inoculation lead to obtain the highest significant values of nitrogen, phosphorus, potassium, calcium and magnesium in lettuce leaves. In addition, using compost tea supported with molasses recorded significantly second highest values of all studied chemical contents in leaves.

Results confirmed a significant increment in macro elements in plants that fertilized with compost tea supported with additives like molasses and bacterial inoculation compared to plants that fertilized with chemical fertilizer. Masarirambi *et al*. obtained similar results in organic fertilized lettuce plants compared to conventional fertilizers [24].

Table (4): effect of using each of compost tea, compost tea plus bacterial inoculation, compost tea plus molasses and chemical fertilizers as a sole fertilizer on lettuce total head yield (g/m^2), average head weight (g), head volume (m^3), vitamin C (%) and nitrate accumulation (mg/kg fresh matter) during seasons of 2019/2020 and 2020/2021.

Treatments	First season				
	Total yield	Average head	Head volume	Vitamin C	(NO_3^-)
Compost tea	3154.150D	630.830D	1000B	20.867D	4473B
Compost tea + Bacteria	4366.167A	873.233A	1500A	23.720A	4456B
Compost tea + Molasses	4290.300B	858.060B	1000B	23.418B	4462B
Chemical (control)	3333.350C	666.670C	1000B	22.914C	5954A
	Second season				
Compost tea	3133.367D	626.673D	966.67C	20.973D	4384B
Compost tea + Bacteria	4357.150A	871.430A	1483.33A	23.853A	4367B
Compost tea + Molasses	4279.133B	855.826B	1000.00B	23.502B	4373B
Chemical (control)	3321.433C	664.286C	1000.00B	23.175C	5835A

This study indicated that, using of compost tea supported with molasses and/or bacterial inoculation lead to positively enhanced yield quantity and produce heavier heads compared to solo compost tea and chemical fertilizers. They explained the mentioned enhancement on basis of compost tea together with the additives containing number of available images of nutrient elements (both macro and micro), cytokines, vitamins and antioxidants. These components are able to enhance plant growth and improve quantity and quality of the yield [3, 25].

Accumulation of NO_3^-:

Concerning, nitrate (NO_3^-) accumulation in leaves of lettuce, lowest significant accumulated NO_3^- was found in plants fertilized with "compost tea + bacterial inoculation" followed by those receive "compost tea + molasses" in second lowest accumulated No_3^-. In contrary; highest significant accumulated NO_3^- was obtained in plants fertilized with chemical fertilizer (Table 4). The same results was found in the second season.

In general, all treatments that received compost tea however together with or without additive represent less values of accumulated NO_3^- [26].

CONCLUSION

Applied "compost tea + bacterial inoculation" and "compost tea + molasses" can considered as one of ways to replacement of mineral fertilizers. Both of them achieved an enhance at all tested parameters of lettuce plants i.e., plant height, number of leaves per head, head length, head diameter, head volume, average head weight, total heads yield/m^2 and content of chlorophyll (SPAD reading), nitrogen, phosphorus, potassium, calcium, magnesium and ascorbic acid (Vitamin C) in leaves. Additionally, reduced nitrate accumulation in leaves.

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