



## Effect of Bio and chemical Fertilizers on some physiological traits and yield of Arugula

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Article info	Abstract
Original: 17 June 2020 Revised: 10 October 2020 Accepted: 9 November 2020 Published online: 20 December 2020	A study was conducted in Erbil agricultural research directorate protected plastic tunnel to investigate the effect of five fertilization types; biofertilizer; locally prepared compost; manufactured compost; chemical fertilizer (DAP); and no fertilizer (control) on some physiological, yield traits of Arugula and some soil properties. Results indicated significant increase of green harvesting leaves dry weight in four cutting processes, leaf area, plant height, number of branches per plant, and chlorophyll content when arugula plants treated with different types of fertilizers compared to no fertilizer plots. Manufactured compost produced highest seed yield 1.98 (t. ha <sup>-1</sup> ) comparing to other fertilizer treated plots and the lowest seed yield was 1.04 (t. ha <sup>-1</sup> ) under no fertilization conditions. All yield component data revealed the positive effect of fertilization on arugula yield, straw and biological yield were at higher levels under local and manufactured compost as well as DAP fertilization treatments. The significant effect of fertilization enhanced chemical characteristics of arugula seeds data of nitrogen, phosphorus potassium, protein, oil percentage and poly phenol content comparing to no fertilizers treatment. Soil chemical characteristics were elevated after 45 days from finishing the study which insures the importance of organic fertilizers effect on soil and environment. Taste panel declare differences in leaf pungent taste, leaf texture and color according to fertilization type. Levels of positive effect of using fertilizers on fixed oil yield was from highest to lowest Manufactured compost, Local compost, DAP, Biofertilizer and no fertilizer (control).
<b>Key Words:</b> Biofertilizer, Chlorophyll, Fixed Oil Yield, Arugula.	

### INTRODUCTION

Arugula or rocket (*Eruca sativa* Mill) a plant that belongs to Brassicaceae family had been known since ancient times as medicinal herb and it was first documented by a greek physician Pedanius Dioscorides, (father of pharmacy) who published five volumes of (Materia medica) in 70 A.D [1]. It is consumed all over the world as green salad because of the pungent leaves taste or it is cultivated as oilseed crop [2]. Arugula is an important source for different vitamins especially C, antioxidants, polyphenol compounds, glucosinolates and mineral salts [3]. It is well known as a medicine for stomach-ache, as diuretic, eye infections, antiscorbutic, and as aphrodisiac [4]. Garden rocket seeds has high erucic acid content so it is used in industry as lubrication oil and illumination [5]. Arugula is a annual plant with deeply cut, dull green compound leaves, with distinct spicy pungent flavor, it is a long day flowering- winter season crop, that could be green harvested (pinched) each 20-25 day's till flowering with consideration of sequential harvesting will postponed flowering of the plant [6]. Arugula is cultivated in open field or plastic tunnels (protected area) when the goal is leaf production to keep plants growing during cold environments in late autumn and winter. Cultivation area of arugula is growing in recent years and fertilization is the second most important cultivation requirement after irrigation for arugula crop which enhances higher leaf producing due to its green leaf marketing for human consumption as green salad [7]. Nitrogen fertilization is the key factor for producing more leaves in rocket plant culture due

to its structural importance in amino acids, proteins, different enzymes, chlorophylls and energy transferring compounds, so it was reported that two nitrogen sources (normal and coated urea) influenced arugula culture productive characteristics and higher yield [8]. The chlorophyll content, glucosinolates content, oil yield and percentage was elevated by 150 kg.ha<sup>-1</sup> nitrogen fertilization [9]. The inequality and random use of chemical fertilizers causes soil pollution, fluctuation of soil organic matter content, minimizing soil fauna and flora biodiversity and finally fading soil health. Organic fertilizers which, contain composts from different materials such as animal manure, leaves, garden waste, and other components that contain some mineral nutrients for crop plants, it increases water holding capacity and improve soil texture. Also it was postulated that Organic fertilizer increased nitrate in leaves of arugula, minutiae, and lettuce, but decreased it in kale, similar to nitrate fertilizers, organic fertilizer increased significantly the concentrations of iron, zinc, and chloride, while it had no effect on manganese, and lowered copper and sulfate in leaves relative to nitrate based fertilizer [10]. Biofertilizers are organic effective microorganisms and ecofriendly substances that could minimize the use of chemical fertilizers and improve soil characteristics, it plays an important role in soil fertility maintenance, so biofertilizers would be the main option to increase productivity toward sustainable agriculture [11]. The use of Biofertilizers will increase levels of organic carbon, plant nutrients and enhances the diversity of soil microorganisms comparing to chemical and organic fertilizers, which, significantly reduced the use of chemical fertilizers to 35-50% [12]. Studies have been conducted to evaluate simultaneous use of organic manures and Biofertilizers, results indicated positive results, where the compost will act as long term reserve and a source for macro nutrients in a study for three agricultural seasons [13]. The objective of this study was investigating the effect of different fertilizers (chemical fertilizer; local and manufactured compost; an exported biofertilizer (Bactiva) and no fertilizers on growth, yield and some chemical contents of arugula plants under protected cultivation beside the effect on soil and some arugula leaves descriptive characteristics.

## **MATERIALS & METHODS**

### **A. Study Site**

The experiment was conducted on the fields of Erbil Agriculture Research Directorate- Ainkawa center (44.06 ° E, 36.11° N and 420m above sea level during 2016-2017 growing season in a plastic tunnel. The soil structure was silt clay with pH 7.70, organic matter 1.10%, Electrical conductivity 0.25ds.m<sup>-1</sup>, nitrogen 0.11%, phosphorus 8.3 ppm and potassium 280 ppm.

### **B. Experimental design**

The experiment consisted of five treatments; Rhizobacteria (PGPR) and Trichoderma bio fertilizer (Bactiva and Endodrip) (T1) local compost prepared in the field (T2), locally manufactured compost (Shamal) (T3), chemical fertilizer diammonium phosphate DAP (T4), No fertilization (control) (T5). Treatments were laid out in a completely randomized block design with three replicates and plot size (1×1 m) each consisting 10 rows, with distance 50 cm between plots.

### **C. Agronomical practices**

Experimental plots were prepared by two dry plowings, leveling, after that arugula seeds were sown in seed germination racks on 14<sup>th</sup> of September 2016, then seedlings were planted on the 5<sup>th</sup> of October 2016. Fertilizers were used as DAP (Diammonium phosphate) with the rate of 100 kg. ha<sup>-1</sup>, local and manufactured compost with the rate of 1000 kg. ha<sup>-1</sup>, bactiva biofertilizer with the rate of 1 kg. ha<sup>-1</sup> and no fertilizer application in control plots. Four cuttings were conducted first on the 20<sup>th</sup> of October 2016, second on 15<sup>th</sup> November 2016, third on the 17<sup>th</sup> of December 2016 and the fourth on the 11<sup>th</sup> of February 2017. After each cutting a taste panel was implemented to indicate the taste and texture of harvested leaves this process executed by 25 volunteer persons [14]. Biofertilizer plots have been treated with Endodrip each week with 35g. plot<sup>-1</sup> that was dissolved in irrigation water. irrigation and other agricultural practices was conducted triweekly or when it was needed, finally the experiment was terminated by harvesting the plants on the 10<sup>th</sup> of July 2017.

### D. Fertilizers Application

Diammonium phosphate DAP was added to soil, both organic composts (Shamal and Local) were soil incorporated, while the biofertilizer was mixed with irrigation water bio-fertigation, then the endo-drip was weekly added with irrigation water 35 gm for each plot (Table -1).

Table -1 the chemical content of different fertilizers used in this study

Fertilizer Name	Content	
Manufactured Organic Fertilizer (Shamal)	pH 6.90, organic matter 69.98 %, Nitrogen 54.4 %, Phosphorus 2.1%, Potassium 2.7%, Sulphur 0.75%, Calcium 1.43% Sodium 0.85%, Iron 3365.5ppm, Magnesium 0.27%, Manganese 2.7%, Zinc 291.5ppm, Boron 57.98ppm, Density 0.75 g.cm <sup>3</sup> , and Moisture less than 12%	
Bactiva	Beneficial bacteria: nitrogen fixation, solubilization of phosphorus, production of plant growth hormones	100,000,000 CFU/g (108 CFU/g) CFU = Colony Forming Units
	Beneficial fungi: Stimulation of root growth and resistance	Trichoderma harzianum, T. reesei, T. viride, Gliocladium virens: 100,000,000 CFU/g (108 CFU/g)
	Vitamins	Biotin, folic acid, B, B2, B3, B6, B7, B12, C and K
	Amino acids	Plant proteins
	Soluble yucca extracts	Yucca schidigera
	Soluble sea kelp extracts	Ascophyllum nodosum
Endo-drip	Endomycorrhizal fungus	Glomus intraradices: at least 200 spores/g
	Beneficial fungi	Trichoderma harzianum, T. reesei, T. viride, Gliocladium virens: 3,000,000 CFU/g (3x10 <sup>6</sup> CFU/g)
	Beneficial bacteria (PGPR): Nitrogen fixation, phosphorus solubilizing, production of plant growth hormones	2,000,000,000 CFU/g (2x10 <sup>9</sup> CFU/g) CFU = Colony Forming Units
	Vitamins	Biotin, folic acid, B, B2, B3, B6, B7, B12, C and K
	Amino acids	Protein hydrolysate
	Soluble yucca extracts	Yucca schidigera
	Soluble sea kelp extracts	Ascophyllum nodosum

Data Recording: arugula chlorophyll levels were documented twice during the season by atLEAF chlorophyll meter instrument [15]. Other parameters were arugula Plant Height (cm); leaf area (cm<sup>2</sup>) punching method [16]; branch number per plant; silique number per plant; seed yield (ton.ha<sup>-1</sup>); straw yield (ton.ha<sup>-1</sup>); biological yield (ton.ha<sup>-1</sup>) and harvest index (equation-1)[17]. Seed chemical content nitrogen; phosphorus; potassium; protein; oil percentage; polyphenols were estimated according to [18], while fixed oil yield estimated according to (equation-2)[19]. Soil samples were taken from experimental plots (45) days after completion the study to estimate soil characteristics.

$$\text{Harvest Index} = \left( \frac{\text{Seed Yield}}{\text{Biological Yield}} \right) \times 100 \quad \dots \dots \dots (1)$$

$$\text{Fixed Oil Yield (kg. ha}^{-1}\text{)} = \text{Oil Percentage \%} \times \text{Seed Yield (kg. ha}^{-1}\text{)} \quad \dots \dots \dots (2)$$

### E. Statistical analysis

All recorded data were subjected to standard analysis of variance and means were compared using Duncan Multiple Range Test (DMRT) at 5% of probability using SPSS computer analysis version 22 according to [20] and [21] while panel taste was analyzed according to rank analysis [14].

## RESULTS & DISCUSSION

Results of this study will be classified to different categories as explained below

### A. Effect of Fertilizers on Some Growth Characteristics of *Arugula Erucasativa* Mill. Plants

The effect of different types of fertilizers were significant on all recorded growth parameters (Table-2). In four plant cutting process, first and second cuttings the highest dry weight 197.56 and 252.13 kg.ha<sup>-1</sup> respectively were recorded in chemical fertilizer DAP plots, while the lowest data were 105.67 and 145.56 kg.ha<sup>-1</sup> respectively in biofertilizer plots. The highest value for third cutting process was 261.99 kg.ha<sup>-1</sup> documented with manufactured compost and the lowest value 155.32 kg.ha<sup>-1</sup> in no fertilizer (control) plots, in fourth cutting the maximum value was 456.53 kg.ha<sup>-1</sup> in chemical fertilizer DAP plots and the lowest 263.58 kg.ha<sup>-1</sup> was recorded with locally prepared compost. For the first, second, and fourth cuttings the higher dry weight in plots of chemical fertilizers may be due to the fact that chemical fertilizers contain nutrients in easily available chemical form to plants [22, 23]. Leaf area was affected significantly by different fertilizers and the highest leaf area was (91.48 cm<sup>2</sup>) in biofertilizers plots while the lowest data (65.11 cm<sup>2</sup>) was observed in locally prepared compost plots, this result may be because of the activation of plant growth processes by photosynthesis as a result of higher sugar production may elevate cell division and expansion, also the carbohydrate accumulation that produced higher leaf area to capture higher amounts of solar radiation which is required for photosynthesis [9]. Data of plant height indicated significant effect of used fertilizers in this study and the maximum height was 124.00 cm observed in manufactured compost and both local and DAP plots, while the minimum plant height was 109.00 cm recorded in the plots which was not treated with any type of fertilizers (control), it's worth mentioning that there were no significant differences between local compost, manufactured compost and DAP fertilizers. This result may indicate the importance of chemical, compost and biofertilizers that enhance plants height increasing comparing to no fertilization plots which may be due to the different compounds as shown in (table 1). Number of plant branches was in highest levels 6.67 with biofertilizer and bio-fertigation plots, while lowest levels was 4.67 in no-fertilizer (control) plots, this indicates the vital role of plant hormones in higher branches production due to the complex relationships between cytokines and auxins in plants that leads to higher branches comparing to other treatments [24]. Total chlorophyll was estimated twice during the study as shown in (figure-1) where the significant effects is obvious and in first estimation the highest chlorophyll level was 38.01 at LEAF in manufactured compost plots, while lowest level was 32.96 at LEAF in biofertilizer plots, data for second estimation the highest level was 40.77 at LEAF in biofertilizers plot and the lowest level was 35.27 at LEAF in the plots that wasn't treated with any fertilizers (control). This results of chlorophyll data indicates the importance of nitrogen supply for plants that is the key factor in chlorophyll synthesis also the composition of amino acids and different proteins, it is interesting to discover the role of weekly spraying of endo-drip which caused the difference between biofertilizers estimation in this study [25, 26].

Table -2 The Effect of Fertilizers on Some Arugula (*Eruca sativa* Mill.) Plants Growth Characteristics.

Treatments	1st cutting (kg.ha <sup>-1</sup> )	2nd cutting (kg.ha <sup>-1</sup> )	3rd cutting (kg.ha <sup>-1</sup> )	4th cutting (kg.ha <sup>-1</sup> )	leaf area (cm <sup>2</sup> )	Plant Height (cm)	No. of branches. Plant <sup>-1</sup>
Biofertilizer	105.67 c	145.56 d	161.37 c	271.93 c	91.48 a	115.00 ab	6.67 a
Local Compost	152.19 b	202.93 bc	191.34 bc	263.58 c	65.11 b	120.00 a	5.33 bc
Manufactured Compost	194.70 a	247.10 ab	261.99 a	428.17 a	67.80 b	124.00 a	5.33 bc
Diammonium Phosphate DAP	197.56 a	252.13 a	219.89 ab	456.53 a	86.09 a	120.67 a	6.00 ab
Control	116.54 bc	162.65 cd	155.32 c	320.64 b	67.67 b	109.00 b	4.67 c

**Note:** Means with the same symbols in one column are not significantly different from each other at alpha = 0.05 % based on multiple range test of Duncan

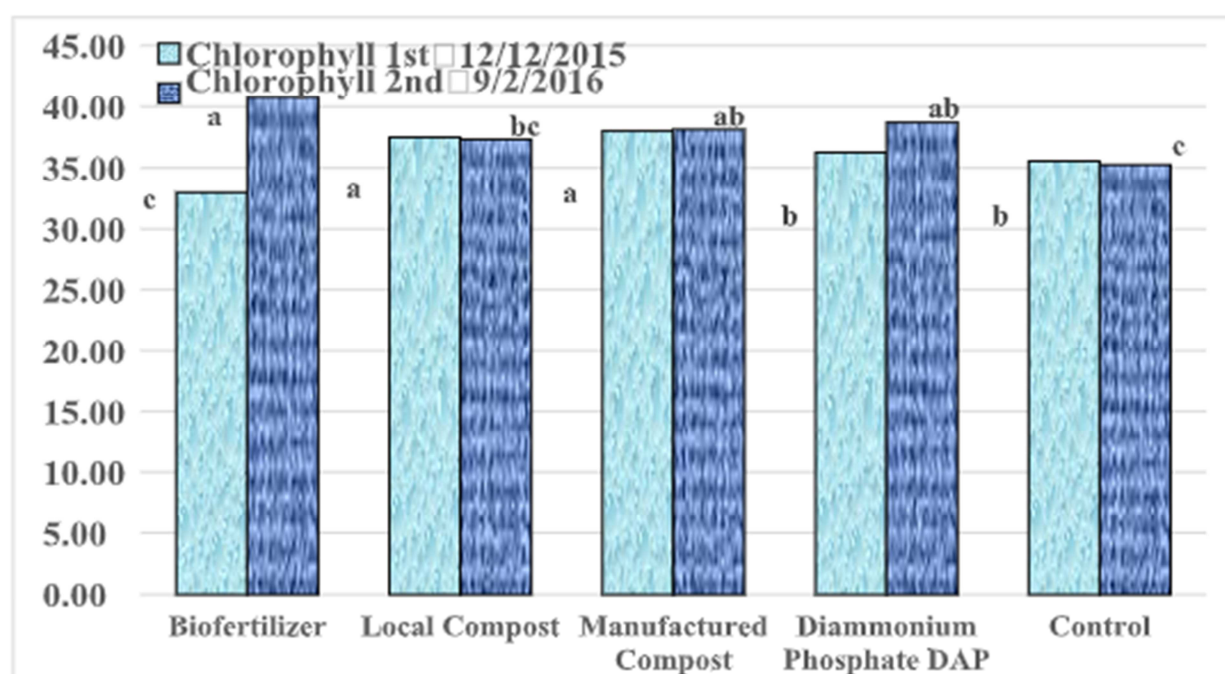


Figure 1 The effect of fertilizers on two measures of total Chlorophyll Content of Arugula (*Eruca sativa* Mill.) Plants.

**B. Effect of Fertilizers on Some Yield and Yield Components of Arugula (*Eruca sativa* Mill.)**

Plants (Table -3) indicates the significant effect of fertilizers on yield and yield components of arugula the higher number of silique per plant was 28.95 silique. Plant<sup>-1</sup> in plots that were treated with biofertilizer and the lowest data was 16.07 silique. Plant<sup>-1</sup> in control plots, adding biofertilizers, local and manufactured compost weren't significantly differ than each other, so perhaps the increase of silique number caused by the microbial content of the biofertilizer especially *Trichoderma sp.*[27]. In case of seed yield the sole application of manufactured compost provided highest seed yield 1.98 (t. ha<sup>-1</sup>), while the lowest seed yield was 1.04 (t. ha<sup>-1</sup>) when the plots wasn't treated with any type of fertilizers (control). The maximum data for straw yield was 10.20 (t. ha<sup>-1</sup>) when arugula plants treated with chemical fertilizer DAP compared to the lowest straw yield 6.53 (t. ha<sup>-1</sup>) in biofertilizer treated plots, although there weren't significant differences between all four treatments except biofertilizers treatment. Locally prepared compost performed highest data 11.70 (t. ha<sup>-1</sup>) of biological yield that weren't significantly differ than that of manufactured compost

and DAP fertilizers compared to lowest data when biofertilizers applied  $7.81(t. ha^{-1})$ . The greater harvest index was 16.95 % observed with manufactured compost plots meanwhile the lowest harvest index was 10.74 % reported in control treatments. Yield and yield components data declares the vital role of fertilizers in plant yield comparing to no fertilizers (control) plots, all that may be due to higher carbohydrate production as a result of higher chlorophyll levels that was the main requirement for building higher leaf area and maximum solar exposure [9, 28].

Table -3 The Effect of Fertilizers on Some Yield and Yield components of Arugula (*Eruca sativa* Mill.) Plants

Treatments	Number of Siliques. Plant <sup>-1</sup>	seed yield t. ha <sup>-1</sup>	straw yield t. ha <sup>-1</sup>	biological yield t. ha <sup>-1</sup>	Harvest index %
Biofertilizer	28.95 a	1.28 c	6.53 b	7.81 c	16.39 a
Local Compost	28.12 a	1.73 b	9.97 a	11.70 a	15.06 a
Manufactured Compost	26.25 a	1.98 a	9.70 a	11.68 a	16.95 a
Diammonium Phosphate DAP	18.93 b	1.36 c	10.20 a	11.56 a	11.75 b
Control	16.07 b	1.04 d	8.67 a	9.70 b	10.74 c

**Note:** Means with the same symbols in one column are not significantly different from each other at alpha = 0.05 % based on multiple range test of Duncan

### C. Effect of Fertilizer on Some Chemical Characteristics of Arugula *Eruca sativa* Mill. Seeds

The Effect of fertilizers types on chemical characteristics of arugula seeds was significant on all recorded data in this study (table- 4). It was observed that biofertilizers maximized the nitrogen levels in arugula seeds up to 4.93%, meanwhile in no fertilizer (control) plots it was minimized to 4.13 %. Phosphorus percentage in arugula seeds reaches highest level 0.15% when chemical fertilizers DAP was used but it was at lowest level 0.05% when biofertilizers were applied. Both treatments of manufactured compost and chemical fertilizers elevated the potassium percentage to 1.22% while it was at lowest level 0.88% in biofertilizer plots. Seeds protein percentage reached 30.79% in biofertilizer plots and get down to 25.79% in control treatments. Oil content was at highest percentage 35.00% in chemical fertilization plots but at lowest levels 23.67% when no fertilizers was applied (control) plots. Biofertilizers fertigation improved the polyphenolic content in arugula seeds to 9.40 (mg.g<sup>-1</sup>) dry weight but it recorded lowest data 8.23 (mg. g<sup>-1</sup>) dry weight in control treatments. The fertilization types in this research enhanced increasing of chemical seed content because fertilizers usually consist of different plant nutrients that utilized by plant roots especially nitrogen, phosphorus and potassium [29]. Nitrogen supply by different fertilizers compared to no fertilizer plots caused the elevation of seed nitrogen content, protein percentage and polyphenolic compounds content [30].

Table -4 The Effect of Fertilizers on Some Chemical Characteristics of Arugula (*Eruca sativa* Mill.) Seeds.

Treatments	Seed (N) content %	Seed (P) content %	Seed (K) content %	protein content %	Oil content %	polyphenol content (mg.g <sup>-1</sup> ) Dry weight
Biofertilizer	4.93 a	0.05 d	0.88 d	30.79 a	30.33 c	9.40 a
Local Compost	4.71 b	0.06 cd	0.98 c	29.46 b	32.67 b	9.33 a
Manufactured Compost	4.27 d	0.09 b	1.22 a	26.71 d	31.00 c	9.37 a
Diammonium Phosphate DAP	4.59 c	0.15 a	1.22 a	28.67 c	35.00 a	8.60 b
Control	4.13 e	0.07 c	1.08 b	25.79 e	23.67 d	8.23 c

**Note:** Means with the same symbols in one column are not significantly different from each other at alpha = 0.05 % based on multiple range test of Duncan

**D. Effect of Fertilizers on Some Chemical Characteristics of Experiment Soil**

Applying different fertilizers during the study caused significant differences on all recorded data except potassium content as shown in table (5). Soil nitrogen and phosphorus percentage were at highest values (0.20 % and 8.93ppm) respectively with diammonium phosphate plots, nitrogen percentage was (0.11%) in minimum level in no-fertilizer plots while for phosphorus content lowest data was 8.17ppm in biofertilizer plots. Data of electrical conductance explains the differences before and after conducting the study, it is obvious that EC was maximized by local compost to (0.41 ds.m<sup>-1</sup>) meanwhile it was lowered when no fertilizer was applied (0.19 ds.m<sup>-1</sup>), highest soil pH was 7.82 in local compost plots while lowest was 7.51 in plots which were treated with chemical fertilizers. Application of local compost increased the soil organic matter content to 1.41 meanwhile chemical fertilizers caused dropping the data of soil organic matter content to 0.98. These results indicated the importance of organic fertilizers to maintain soil chemical characteristics as shown in these data, so it is clear that all studied data were better than control treatments after a period from experiment application which reduced soil degradation [31, 32]. These results revealed the need for more studies regarding post-fertilizer use effects on agricultural soil to indicate best methods of soil health and fertility maintenance.

Table -5 The Effect of Fertilizers on Some Characteristics of the Experiment Soil after 45 days from finishing the study

Treatments	Nitrogen (N) %	Phosphorus (P) ppm	Potassium (K) ppm	Soil EC	Soil pH	Soil organic matter
Bactiva	0.15 c	8.17 c	206.00	0.31 b	7.54 d	1.32 b
local compost	0.17 b	8.67 b	217.67	0.41 a	7.82 a	1.41 a
Shamal compost	0.15 c	8.57 b	183.00	0.21 c	7.62 c	1.21 c
DAP	0.20 a	8.93 a	189.00	0.20 c	7.51 d	0.98 e
No fertilizers	0.11 d	8.27 c	198.33	0.19 c	7.70 b	1.10 d

Note: Means with the same symbols in one column are not significantly different from each other at alpha = 0.05 % based on multiple range test of Duncan

**E. Effect of Fertilizers on Taste and Leaf Texture of Arugula (Eruca sativa Mill.) Plants**

A panel taste was conducted for the four green leaf harvesting (cuttings) as shown in table (6) to indicate the effect of fertilizers on taste of arugula leaves, results indicated differences between treatments as resulted from the average of 25 volunteer persons who agreed to conduct the taste panel according to some indicated sensory attributes and to rank the descriptive characteristics. Results for taste may be due to the higher phenolic compounds content as shown in table (4), leaf texture may be result of using different fertilizers type, while leaf color was a result of producing higher amounts of chlorophyll as indicated in figure (1). It is worth mentioning that it was the first panel taste conducted in the governorate [14].

Table -6 Taste Panel Results of leaves green cutting of Arugula (Eruca sativa Mill.) Plants according to rank analysis.

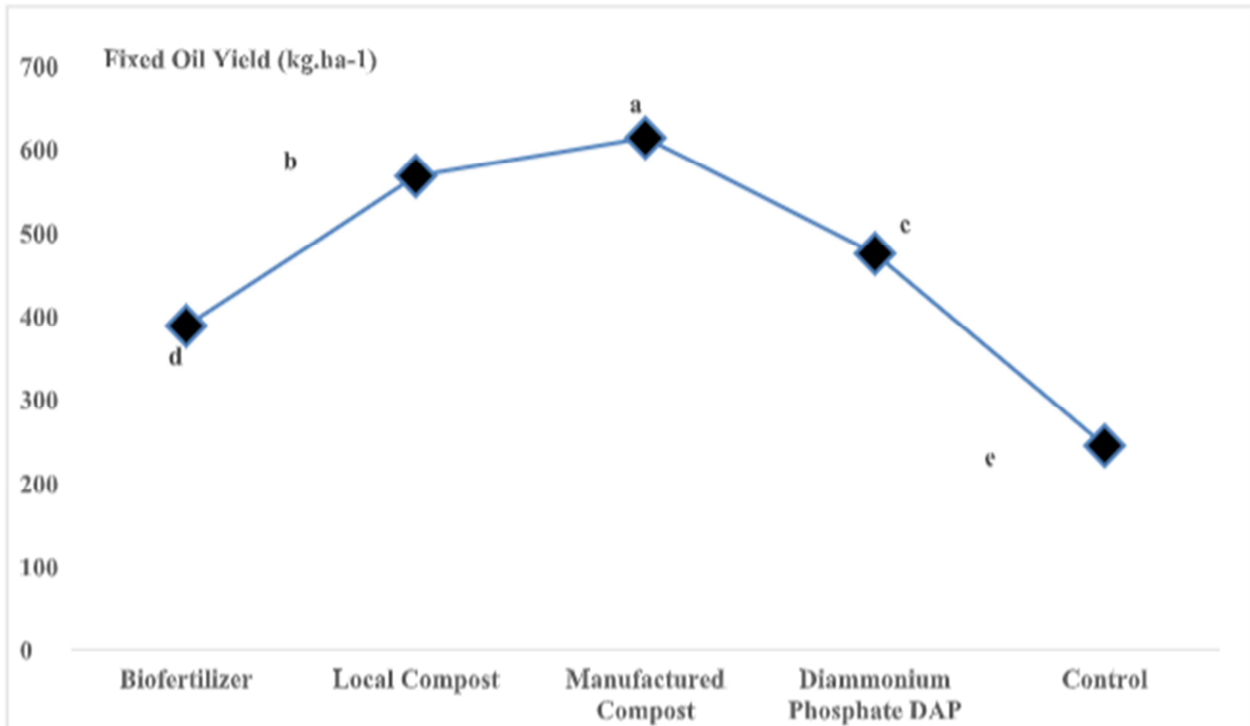
Treatment	Taste	Leaf texture	Leaf Color
Biofertilizer	4	3	5
Local Compost	5	3	3
Manufactured Compost	3	2	4
Diammonium Phosphate DAP	2	1	1
Control	1	4	2

Note : Rang from 1 - 2- 3- 4- 5 for each of

- 1- Taste From low to high pungent teats
- 2- Leaf texture from tender to coarse
- 3- Leaf color From Light to dark green.

### F. Effect of Fertilizers on Fixed Oil Yield of Arugula (*Eruca sativa* Mill.) Plants

From both tables (4 and 5) we can conclude the fixed oil yield according to equation (1) as shown in (figure-2). Where there were significant differences between studied fertilizers and it is obvious from the data that highest fixed oil yield was gained from manufactured fertilizers plots (613.00 kg. ha<sup>-1</sup>) and the lowest fixed oil yield was (244.80 kg. ha<sup>-1</sup>) in control treatments. Manufactured fertilizers contain different materials as shown in table (1) where it declares that beside high organic matter content there are macro and micro nutrients that is essential and important in plant growth, yield and seeds chemical contents [16].



(Figure- 2) The Effect of Fertilizers on Fixed Oil Yield of Arugula (*Eruca sativa* Mill.) Plants.

### CONCLUSION

This study concluded that arugula flowering could be delayed by successive green harvesting (punching), fertilization gives the arugula plants potentiality of higher growth compared to no fertilizer plots. Compost fertilizers were better to use comparing to other used fertilizers in this study, seed chemical content were positively responded to fertilizer application compared to control treatments. It is important to use compost or biofertilizer in maintaining soil health or fertility, where after finishing this experiment some soil chemical and physical properties were better compared to unfertilized plots. Organic compost elevated the oil yield in arugula compared to chemical, biofertilizer and no fertilizer plots.

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