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Effect of intercropping agriculture and organic fertilization on yield quantitative and qualitative of carrot plant and production in the unit area with sustainable agriculture system

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Abstract: *In order to increase production and improve the quality of carrot, the research was carried out in the field of experiments of Horticulture Department - College of Agriculture- University of Baghdad during the autumn season of 2015 to study the effect of intercropping agriculture and organic fertilization in yield quantitative and qualitative of carrot plant and production in the unit area, The experiment included two factors : The first factor is to grow the carrot alone and cultivate it by interfering with the broad bean of the system 1: 1 and cultivate it by mixing onion with 1: 1 system, which symbolizes it (C, CF, CO) respectively, and the second factor included three levels of organic fertilizer Leonardite Extract (Humic Acid 80% + K2O 11%), extracted from natural Leonardite coal and in three concentrations (0,10,20 g.L^{-1}), which have a symbol (0,1,2) respectively, and the interaction between them to reach 9 transactions.The factorial experiment was carried out according to (RCBD) at three replicates.The results can be summarized as follows: The treatment of CO2 resulted in a significant increase in the leaves number of 10.3 leaf .plant $^{-1}$ and leaf dry weight of 3.00 g. plant $^{-1}$ and total chlorophyll in leaves was 448.50 mg .100 g $^{-1}$ and total yield of root 68.00 ton.h^{-1} . The yield index in the treatment of CF2 was 92.13% while the highest productivity of the unit of the area was at the treatment of CF1 and reached 158.04 tons ton.h^{-1}, and the factors of the study affected the characteristics of the roots and their quality as the treatment gave CO2 the highest weight and root length of 85.00 g and 17.35 cm respectively, and the root content of total carotenoids and total sugars in CO1 was 7.83 and 11.37 mg. $^{-1}$ compared to the control treatment.*

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I. Introduction

Vegetable crops are a major component of human food as they supply protein, carbohydrates, vitamins and minerals.The current production of vegetable crops suffers from the fact that it is necessary to meet the needs,Therefore, intercropping is of great benefit compared to monoculture, including the promotion of optimal and efficient use of environmental factors such as light, nutrients and humidity, in addition to reducing the effort and reducing the biological and non-biological stress,It also promotes food diversity and increases productivity within the unit area (Akanda and Quayyum, 1982 and Sarker. et al., 2013). Intercropping system is modern agricultural concepts and practical application of the principles of biodiversity of crops and vegetables living in nature,It means the growth of two or more crops in a limited area during the same growth season (Ouma and Jeruto, 2010). The intercropping system is capable of achieving the idea of a positive coexistence between crops that require nitrogen fertilization and crops that stabilize the atmospheric nitrogen more than their needs, such as legumes. Therefore, the main crop benefits from of the associated cropcompared to single cultivation without a bean crop (Xiao and Zhang, 2004). Because legume crops are low competition crops, they are treated as secondary crops (Hauggard-Nielsen and Jensen, 2001). Al-Obeidi (2003) found that the intercropping system had a significant effect on the traits of the crop and its components (early yield, total yield, plant yield, total number of fruits, fruit weight)when growing tomato plants intercropping with beans in open and protected agriculture,The cucumber plants, which were intercropping with the beans, gave the highest height of the plant, the fruits number and their weight, and the highest yield of one plant in protected agriculture, while the cucumber plants with the tomato gave the highest average fruit weight in open field,while Bean intercropped with cucumber gave the highest percentage of dry matter in open field.Sharaiha and Hadidi (2007) found that the combined okra with pea was significantly higher than that of the cultivated okra alone.Hadidi and et al (2011) in a study conducted in a private farm in the Madaba explained that the intercropping of beans with okra, lettuce and squash, the highest yield was recorded in bean intercropped with lettuce, When cultivating the okra intercropped with beans, lettuce and squash, the highest yield was the treatment of intercropping between okra and beans. Adeniyi (2011) received the highest yield of tomatoes when cultivar was planted with 1: 1 cowpea compared to each crop.

In recent years, organic fertilizers such as humic acids have been used with low concentrations to improve soil properties, plant nutrition, accelerate growth and increase production (Zidan and Samir, 2005). The use of humic acid (HA) is a promising natural resource to be utilized as an alternative for increasing crop production. Humic acids make important contributions to improve soil stability and fertility, which lead to exceptional plant growth and micronutrient uptake (Calvo et al, 2014). In the same respect, Rajpar et al (2011) found that the application of humic acid at 6.35 kg/acre positively affected almost all the growth and yield parameters of *Brassica campestris* plants. El-Sherbenyet al (2012) found that adding humic acid increased carbohydrate content of turnip roots.And in a study conducted by Bender et al (2015) to evaluate how the quality of carrots is affected by organic and conventional production systems. In organic cultivation system compost and humic acid solution Humistar were used for fertilization, they found the contents of total sugars, phosphorus, potassium, calcium and magnesium did not differ significantly between carrots from different cultivation systems.Whereas vitamin C and ß-carotene content was significantly lower in organically grown carrots. However,after 5-months of storage, the organic carrots had significantly higher total soluble solids (TSS) and β-carotene content compared to the conventional system.

The carrot (*Daucus carota* L.) is cold season crops of the Apiaceae family and one of the most important crops that are rooted worldwide (Welbaum, 2015).The roots of the carrot plant contain a high percentage of dry matter ranging from 12-14%, each of which gives about 100 g of about 40 calories, A high percentage of sugars, ranging from 5-7% (of dry matter), proteins of 1-1.5% and salts of 1-2%, is found in the composition of the dry matter. Potassium occupies the first position followed by phosphorus and sodium. And a small amount of vitamin C, Carrots (20% on α-carotene, 50% β-carotene, 10% $_{\gamma}$-carotene, 15% lycopene and 5% xanthophyll), which play an important role in the prevention of some Forms of cancer by improving the performance of antioxidants, which works to modify the effects of oxidation, which destroys cells and damage proteins and genetic material leading to the occurrence of cancers (Boras et al, 2011 and Welbaum, 2015). The roots of fresh carrots are used as vegetables in salad and soup as well as steamed with other vegetables(Amjad et al., 2005), As well as the use of different parts of carrot for pharmaceutical purposes (Rossi et al., 2007). The acreage of carrot and turnip in the world reached about 1368358 hectare, with production of 38835235 tons (FAO, 2014).Therefore, the aim of the research was to cultivate the plants of broad bean and onion (as accompanying crops, one of which is a bean crop and the other non-bean crop),intercropped with the carrot plant (the main crop) and the addition of organic fertilizers and the effect of this on the quantitative and qualitative yield of carrot plant and production in the unit area.

II. Material And Methods

This study was carried out in the vegetable field of the Department of Horticulture at the Faculty of Agriculture - University of Baghdad - Jadriya for the 2015-2016 autumn seasons. The soil was prepared and analyzed for soil analysis and the results were as shown in Table 1. And then divided into three meters each meter is a repeater where the length of the 18 m and width of 1 m and the distance between the meter and another 1 m and then extended drip irrigation pipes on the cutter and each was divided into 9 units each experimental unit of 1.5 m^2 (1.5 m × 1 m), The four lines of carrot cultivation (the main crop) have a distance of 30 cm between one line and another with a distance of 0.5 m between experimental units.The experiment included two factors, The first factor is to cultivate the carrot alone and cultivate them in combination with Faba bean of the system 1: 1 and cultivate them with onion in a system of 1: 1, which symbolizes them (C, CF, CO), respectively, The second factor consisted of three levels of natural Leonardite Extract (Humic Acid 80% + K2O 11%) extracted from natural leonardite coal and in three concentrations (0, 10, 20 $g.L^{-1}$) Respectively.The factorial experiment was carried out according to (RCBD) at three replicates.Baladis carrot cultivars were planted, produced by Top Harvest Dutch company on 16/9/2015 and a distance of 5cm between plant and another,The faba bean seeds (LUZ DE OTOOO) hybrid were also planted , and produced by the Spanish company SEMILLAS Fito on the same date and with 30 cm planting between plants, The onions were Texas Early Grano 502 and were transferred to the field on 26/10/2015 and 10 cm between one plant and another after the seeds were planted on 16/9/2015 for the purpose of intercropping system.The organic fertilizer was added to the soil three times during the season as of 1/11/2015 and a month between the addition and another note that the field was surrounded by onion plants as a method of sustainable farming methods to prevent insects.

Table 1: Chemical and physical properties of soil

Total Nitrogen N%	Inorganic Nitrogen extracted with 2*M* KCL		Extractable elements with DTPA (ppm)				Extractable elements with NH_4OAC (ppm)			
	NH_4^{1+} (ppm)	NO_3^{1} (ppm)	Zn	Cu	Fe	Mn	Na^{1+}	K^{1+}	Ca^{2+}	Mg^{2+}
0.56	2.52	47.60	0.5466	0.8733	2.205	5.958	25076.0	371.5	6650	234.1

Water soluble extracted elements at ratio (1:1) in (ppm)								Extractable phosphorus (ppm)	Organic Carbon %	Sodium Adsorption Ratio
Ec (mS cm^{-1})	pH	Na^{1+}	K^{1+}	Ca^{2+}	Mg^{2+}	SO_4^{2-}	Cl^{1-}	p	O.C.%	(SAR)
3	7.34	185.8	32.32	395.6	92.75	1199.6	753.48	12.88	1.03	2.18

Soil Texture Class	% Clay	% Silt	% Sand	% $CaCO_3$	Total Carbon %	Stable of Aggregates%
Clay soil	41.28	33.45	25.27	20.32	3.47	28.09

Ten plants were randomly selected from each experimental unit; the total number of leaves of the plant was calculated at the end of the season. The dry weight of the leaves was estimated after drying in an oven and at 70 ° C. For weight stability, the harvest index was calculated according to the following equation: Harvest index %= (root weight / total plant weight) × 100. Total leaves chlorophyll content was estimated according to the method (Goodwin, 1976) from the following equation:Total Chlorophyll ($mg.L^{-1}$) = 20.2 D(645) +8.02 D(663), then converted to 100 mg $.g^{-1}$ fresh weight,Total root yield and production per unit area was calculated at the end of the season, then calculate root weight (gm. $plant^{-1}$) and root length (cm), Root diameter (cm) was measured from the widest area of the root by digital vernier, and the ratio of wood to bark was calculated as follows:Wood / bark %= (wood diameter / bark diameter) × 100 .Root content of total carotenoids was estimated by (Abbas and Abbas, 1992); root β-Carotene content was calculated by (Nagata and Yamashita, 1992), the root content of total sugars was determined by Joslyn (1970).

The obtained results were subjected to analysis of variance according to (Elsahookie and Wuhaib, 1990) using L.S.D 0.05 for comparing differences between various treatment means.

III. Results And Discussion

Effect of intercropping and organic fertilizer on growth and yield of carrot

Different parameters of growth and yield were significantly affected due to intercropping between carrot, faba bean and onion (Table 2). At harvest the highest number of leaves (9.13 $leaf.plants^{-1}$), Dry weight of leaves (2.61g. $plants^{-1}$), total chlorophyll (440.53 mg.100g fresh wt^{-1}), total root yield (59.33 $t.h^{-1}$) was obtained when intercropping between carrots and onion except productivity per unit area gave the highest yield (136.79 $t.h^{-1}$) and harvest index (83.99%) when intercropping between carrots and faba bean compared to the cultivation of carrots alone , which gave lower results in all measured traits.

Table 2.Effect of intercropping on growth and yield of carrot

Effect of intercropping	Leaves. $plants^{-1}$	Leaves dry weight (g)	Harvest index %	total chlorophyll (mg.100g fresh $wt.^{-1)}$	Total root yield ($t\ h^{-1}$)	productivity per unit area($t\ h^{-1}$)
C	**8.30**	**2.43**	**80.00**	**416.50**	**51.93**	**51.93**
CF	**9.00**	**2.47**	**83.99**	**434.90**	**54.66**	**136.79**
CO	**9.13**	**2.61**	**82.92**	**440.53**	**59.33**	**112.02**
LSD 5%	**0.21**	**0.04**	**3.00**	**7.30**	**0.53**	**3.72**

The different levels of organic fertilizer significantly affected on growth and yield of carrot (Table 3), where fertilization treatment at 20 $g.L^{-1}$ gave a highest leaves number (9.70 $leaf.plants^{-1}$), leaves dry weight (2.78 $g.plants^{-1}$), harvest index (86.77%), total chlorophyll (443.33 mg.100g fresh $wt.^{-1}$), total root yield (62.53 $t.h^{-1}$) and higher productivity per unit area (110.66 $t.h^{-1}$) .

Table 3.Effect of organic fertilizer on growth and yield of carrot

Effect of organic fertilizer	Leaves. $plants^{-1}$	Leaves dry weight (g)	Harvest index %	total chlorophyll (mg.100g fresh $wt.^{-1)}$	Total root yield ($t\ h^{-1}$)	productivity per unit area ($t\ h^{-1}$)
0	**8.23**	**2.28**	**77.24**	**417.33**	**48.62**	**83.14**
1	**8.50**	**2.45**	**82.96**	**436.33**	**54.77**	**106.94**
2	**9.70**	**2.78**	**86.77**	**443.33**	**62.53**	**110.66**
LSD 5%	**0.21**	**0.04**	**3.00**	**7.30**	**0.53**	**3.72**

The interaction between intercropping and organic fertilizer was increased significantly compared to the control treatment (table 4) , interaction between intercropping of carrot and onion with organic fertilization at 20 $g.L^{-1}$ gave a highest leaves number of (10.3 $leaf.plants^{-1}$), leaves dry weight of (3.00$g.plants^{-1}$), total chlorophyll of (448.50mg.100g fresh $wt.^{-1}$), total root yield of (68.00 $t.h^{-1}$) , while the interaction between the carrots and faba bean with organic fertilization at 20 $g.L^{-1}$ gave a highest harvest index of (92.13%) , while the highest production per unit area was when intercropping carrots and faba bean with organic fertilization at 10$g.L^{-1}$ of (158.04$t.h^{-1}$). The effect of interference between the carrots, both onions and faba bean, plus organic fertilization at a concentration of 20 $g.L^{-1}$ in most of the studied traits (Table 4) may be due to the type of material produced by the associated crop

roots during their growth, It is one of the biological processes that are controlled by the plant and at the same time are influenced by different environmental factors, whether these factors, air or ground or vital factors and this is known as allelopathy (Travis et al., 2003), It is an environmental phenomenon that plays an important role in the ecosystems and agricultural systems through its effect on the production of various crops, as well as the biochemical interactions between crops between them and between plants and microorganisms, and between crops and weeds. Many studies have been conducted on this phenomenon and its role in the ecosystem. Allopathic effects result from the release of compounds called Allelochemicals, which are secondary metabolites produced in any part of the plant (Bertin et al., 2003), the leaves and roots are a major source of these compounds, The effects of allelopathic compounds depend on their nature and concentration, some of which have catalytic effects, while other compounds have inhibitory effects, and the information available about them is almost negligible due to the presence of a large number of these compounds, each of which has more than the physiological effect. Ali and Al-Mezori (2006) have shown that the secretions of carrot roots increase the growth of carrot and tomato plants over time.

Table 4. Effect of intercropping and organic fertilizers on growth and yield of carrot

Effect of organic fertilizer	Leaves. plants^{-1}	Leaves dry weight (g)	Harvest index %	total chlorophyll (mg.100g fresh wt.$^{-1)}$	Total root yield (t h^{-1})	productivity per unit area (t h^{-1})
C 0	**7.7**	**2.25**	**72.80**	**398.80**	**45.20**	**45.20**
CF 0	**8.5**	**2.29**	**77.76**	**427.80**	**46.67**	**107.75**
CO 0	**8.5**	**2.31**	**81.16**	**427.70**	**54.00**	**96.49**
C 1	**8.2**	**2.41**	**82.20**	**437.40**	**53.00**	**53.00**
CF 1	**8.7**	**2.41**	**82.10**	**434.80**	**55.33**	**158.04**
CO 1	**8.6**	**2.54**	**84.60**	**445.40**	**56.00**	**109.79**
C 2	**9.0**	**2.63**	**85.20**	**413.30**	**57.60**	**57.60**
CF 2	**9.8**	**2.73**	**92.13**	**442.20**	**62.00**	**144.60**
CO 2	**10.3**	**3.00**	**83.00**	**448.50**	**68.00**	**129.79**
LSD 5%	**0.37**	**0.06**	**5.20**	**12.64**	**0.93**	**6.44**

Or may be due to the humic acids role to form compounds that have a role similar to the role of plant hormones such as auxins and cytokine, causing an increase in plant height (Zhang and Ervin, 2004) ,Which is reflected in leaves number, as the addition of humic acid fertilizer containing potassium has an important role in increasing the leaves number may be due to the role of potassium in the physiological processes by promoting the work of enzymes and the transfer of products of carbon representation as well as its role in the division and elongation of cells (El-Desuki et al., 2006 and Fawzy et al ., 2007) . The humic acid has a role in increasing the levels of nitrogen released in the soil, which in turn increases the accumulation of nitrogen in the plant as well as improving the properties of physical and chemical soil, which leads to increased leaves chlorophyll content (Agehaea and Warncke , 2005) Which increases the photosynthesis and accumulated materials in the plant such as carbohydrates and proteins and then increases the dry weight of the vegetative part(Amujoyegbe et al ., 2007). Or may be due to the integration of the factors studied in the arrival of the plant to the food balance and then the positive effect in increasing the components of the total vegetation, which was reflected on the root and total yield.

Effect of intercropping and organic fertilizer on root characteristics:

The effect of intercropping carrot with faba bean and onion on the quality of carrot are listed in table (5) , The intercropping of carrot with onion in the root weight, height and diameter and root content of total carotenoids, β-carotene and total sugars was superior with 74.16 g, 16.12 cm, 3.17 cm, 7.51, 3.14, 10.59 mg.100g, fresh.Weight-1, respectively, compared with the control treatment that gave the lowest values in these traits. The interaction between carrot and faba bean was gave higher percentage of xylem to phloem, which gave 46.06% compared to the interaction between carrot and onion which gave 44.50%.

Table 5: Effect of intercropping on the characteristics and quality of roots

Effect of intercropping	Root weight. (g)	Root length (cm)	Root Diameter(cm)	Xylem /phloem (%)	Roots carotenoids content (mg.100g fresh wt^{-1})	β-carotene (mg.100g fresh wt^{-1})	Total sugar (mg.100g fresh wt^{-1})
C	**64.90**	**14.25**	**3.03**	**45.00**	**6.79**	**2.71**	**7.82**
CF	**68.30**	**14.97**	**3.13**	**46.06**	**6.83**	**2.66**	**9.13**
CO	**74.16**	**16.12**	**3.17**	**44.50**	**7.51**	**3.14**	**10.59**

LSD 5%	**2.14**	**0.23**	**0.27**	**0.84**	**0.33**	**0.15**	**0.51**

Based on Table 6, results of variance analysis(ANOVA) showed that different values of humic acid showed significant difference on most studied traits in 5% level.The humic acid at concentration 20 $g.L^{-1}$ gave the highest root weight and root length and xylem to phloem ratio, root carotenoids content and β- carotene, it was 78.16 g, 16.18 cm, 40.62%, 7.14 and 3.12 mg (100.100g fresh wt-1) respectively and humic acid at concentration 10 $g.L^{-1}$ gave the highest Total sugar of 9.75 mg.100g fresh wt-1) compared to the control treatment.

Table 6. Effect of organic fertilizer on the characteristics and quality of roots

Effect of organic fertilizer	Root weight. (g)	Root length (cm)	Root Diameter (cm)	Xylem /phloem (%)	Roots carotenoids content(mg.100g fresh wt^{-1})	β-carotene (mg.100g fresh wt^{-1})	Total sugar (mg.100g fresh wt^{-1})
0	**60.76**	**14.04**	**2.93**	**49.55**	**6.59**	**2.54**	**8.57**
1	**68.43**	**15.13**	**3.08**	**45.38**	**7.40**	**2.84**	**9.75**
2	**78.16**	**16.18**	**3.33**	**40.62**	**7.14**	**3.12**	**9.23**
LSD 5%	**2.14**	**0.23**	**N.S**	**0.84**	**0.33**	**0.15**	**0.29**

As well as the effect of interaction between intercropping system and humic acid ,The results are indicated in a table (7) The intercropping between carrot and onions with fertilization at a concentration of 20 g. L^{-1} gave the highest root weight, root length, Xylem/phloem and root β- carotene content, which gave 85.00 g, 17.35 cm, 39.00% and 3.52 (mg.100g fresh wt^{-1}) respectively. The interaction of carrot and onions with fertilization at 10 $g.L^{-1}$ in both roots carotenoids content and total sugars was 7.83 and 11.37 (mg.100g fresh wt^{-1}) compared with control treatment.

The superiority of interaction between intercropping and organic fertilization treatments giving the highest rate of root traits (root weight, root length, xylem-bark ratio), total carotenoids, β- carotene and total sugars (Table 7) may be due to the role of these factors in improving plant growth (Table 4), Thus, photosynthesis products increase and increase carbohydrate accumulation (Smit and Combrink, 2004). The increase in root content of total carotenoids, β- carotene and total sugars may also be attributed to increased vegetative growth (Table 4), which increases the efficiency of photosynthesis for the manufacture of compounds such as polysaccharides, which, when analyzed, produce acetyl COA, Lycopene and β- carotene dyes (Hussein, 2013). This is in line with the results of (Al-Obeidi, 2003; Mana and Kazem, 2014) that the intercropping system outweighs the qualities and quality of the product. The increases in these traits may be due to the superiority of vegetative growth parameters (table 4) of the treated plants, which could be attributed to the stimulatory effect of humic acid on rate of photosynthesis, as well as, transport of the photosynthetic product from the leaves to the storage root. Also, Humic acid caused increase of transfer of glucose from among cellular membranes in sunflower, sugarcane and onion plants and also increase of degree of carbohydrate in potato, sugarcane, carrot and tomato (Tan, 2003). These results are in harmony with those obtained by Abou El-Nasr and Ibrahim (2011) and Bender et al. (2015).

Table 7: Effect of intercropping and organic fertilizer on the characteristics and quality of roots

Effect of intercropping	Root weight. (g)	Root length (cm)	Root Diameter (cm)	Xylem /phloem (%)	Roots carotenoids content(mg.100g fresh wt^{-1})	β- carotene (mg.100g fresh wt^{-1})	Total sugar (mg.100g fresh wt^{-1})
C 0	**56.50**	**13.32**	**2.85**	**50.94**	**5.98**	**2.42**	**7.56**
CF 0	**58.30**	**13.72**	**2.88**	**49.86**	**6.52**	**2.60**	**8.56**
CO 0	**67.50**	**15.08**	**3.06**	**47.87**	**7.29**	**2.62**	**9.59**
C 1	**66.20**	**14.50**	**3.04**	**43.78**	**7.01**	**2.62**	**8.22**
CF 1	**69.10**	**14.95**	**3.09**	**46.63**	**7.36**	**2.63**	**9.66**
CO 1	**70.00**	**15.95**	**3.13**	**45.73**	**7.83**	**3.28**	**11.37**
C 2	**72.00**	**14.95**	**3.22**	**40.28**	**7.40**	**3.10**	**7.70**
CF 2	**77.50**	**16.25**	**3.44**	**41.70**	**6.61**	**2.75**	**9.19**
CO 2	**85.00**	**17.35**	**3.33**	**39.90**	**7.41**	**3.52**	**10.82**
LSD 5%	**3.71**	**0.41**	**N.S**	**1.47**	**0.58**	**0.27**	**0.55**

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