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Effect of Some Soil Additives and Mineral Nitrogen Fertilizer at Different Rates on Vegetative Growth, Tuber Yield and Fixed Oil of Tiger Nut (*Cyperus esculentus* L.) Plants .

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ABSTRACT

A pot experiment was carried out in the Experimental Station of Horticulture and Medicinal and Aromatic Plants, Fac. Agric., Mansoura Univ., during the two summer seasons of 2014 and 2015 to study the effect of different soil additives(rice straw compost (R.S.C.), town refuse compost (T.R.C.) and bio-fertilizer nitrobien) and different rates of mineral nitrogen fertilizer (ammonium sulfate (20.6% N) at 0, 50, 100 and 150 kg/fed) on vegetative growth, tuber yield , fixed oil percentage and compositionof tiger nut (*Cyperus esculentus* L.) plants. The results indicated that (R.S.C.or T.R.C.) fertilizer at the rate (15 m^3/fed) plus nitrobien at the rate of(4 kg/fed) had a positive effect on vegetative growth of tiger nut plant; expressed as plant height (cm), number of tillers/pot, herb dry weight (g/pot) and harvesting characters including number of tubers/pot, tuber yield (g/pot), fixed oil percentage and oil yield (ml/pot), compared with other soil additive treatments.In addition,R.S.C. fertilizer was more effective on all studied characters in both seasons than either T.R.C. or nitrobien treatment. The highest level of nitrogen fertilizer (150 kg/fed) significantly enhanced all vegetative growth characters and some harvesting characters including tuber yield (g/pot) and fixed oil yield (ml/pot), but the maximum number of tubers per pot, fixed oil % were obtained from plants treated with nitrogen fertilizer at rate of 100 kg/fed compared with the other levels of nitrogen fertilizer. The combined treatment of 150 kg/fed nitrogen fertilizer with R.S.C. plus nitrobien was the most effective treatment to improve vegetative growth and harvest characters including tuber yield (g/pot), fixed oil yield (ml/pot), followed by the same combination using 100 kg/fed nitrogen fertilizer instead of 150 kg/fed nitrogen fertilizer with non-significant differences between the two treatments. The combined treatment of 100 kg/fed nitrogen fertilizer with R.S.C. plus nitrobien was more effective on number of tubers per pot, fixed oil % than any individual or combination treatments in both seasons. The gas liquid chromatography (G.L.C.) analysis identified twelve fatty acids in tiger nut fixed oil: six unsaturated fatty acids (oleic, linolinc, gondoic , palmitoleic , α-linolenic and heptadecenoic acids),as ranged from 78.50 to 79.21% of the oil and six saturated fatty acids (palmatic , stearic, myristic, arachidic, behenic and margaric acids),as ranged from 20.80 to 21.81%. The main components of the unsaturated fatty acids in tiger nut fixed oil were oleic acid (67.42-69.19 %), linolenic acid (9.42 – 10.27%), while the main saturated fatty acids in the fixed oil were palmatic acid (12.29 – 13.26 %) and stearic acid (6.60 – 8.13%).

INTRODCTION

Tiger nut or yellow nutsedge (*Cyperus esculentus* L.) has many names in English i.e. tiger nut, yellow sedge, earth almond, ground almond, and yellow nutgrass(Wills, 1987). It is also named Habelaziz in Arabic, Chufa in Spanish, and Ayaya and Zulu nuts in Africa (El-Shenawy*et al*, 2012). Tiger nut is an erect, grass-like perennial, with shiny yellowish green leaves, triangular stem, golden-brown flower head, shallow rhizomes that produce many nut-like tubers, and belongs to the sedge family (Cyperaceae).The stems are un-branched, yellowish green and about 20 to 60 cm tall. The leaves are approximately 8 cm wide with a distinctive mid-vein, a waxy surface, gradually pointed tip, arranged in 3's and form a sheath around the stem. The plant forms a complex, shallow underground system composed of fine fibrous roots, thin scaly rhizomes and spherical tubers. Tubers are about 0.6 cm to 1 cm long, borne singly at the ends of rhizomes, whitish and succulent at first and turn dark brown as they mature (Mitchell and Martin, 1986 and Wills, 1987).

Tubers of yellow nut sedge are true tubers matching the American definition most of the tubers present in the top 20 cm of the soil (Peters and Afton, 1993).Tubers are the economical part used of the plant since they contains about 50 % digestible carbohydrates, 4-8 % proteins and 9 % crude fibers, and about 20-36 % oil.In addition,many products can be obtained from it like tiger nut oil, flour and milk(Zhang *et al*., 1996).He also reported that the oil of the tiger nut tuber contains 18% saturated fatty acids (palmitic and stearic) and 82% unsaturated fatty acids (mainly olieic and linoleic acids) and therefore, have excellent nutritional qualities with a fat composition similar to olives and can be used as food oil as well as for industrial and medicinal purposes (Coskuner*et al*., 2002).

Tiger nut tubers were used as an important food, medicine and perfumes for ancient Egyptians since the fourth millennium, and for several centuries in south of Europe (De vries, 1991 and Negbi 1992). The plant had been reported to be a “health” food, since its consumption can help to prevent heart disease and thrombosis, to activate blood circulation, to assist in reducing the risk of colon cancer and is suitable for diabetics (Borges *et al*. 2008 andAdejuyitan*et al*. 2009). Nowadays, lands cultivated with tiger nut in Egypt do not exceed 80 feddans which are not enough to have a role in bridging the gap of oil (www.kenanaonline. net/blog/42577/page/1022).

Information regarding tiger nut fertilization is little in published literature (Irvine, 1969)and fertilization requirements of tiger nut were variable (Pascual and Maroto,1982,Yarrow and Yarrow, 2005 and Harper, 2008).

Due to the intensive farming, Egypt is a heavy consumer of chemical fertilizers. The application of bio-fertilizers and organic manures is recommended in order to improve biological, physical and chemical properties of the soil as well as to obtain clean agricultural products free from undesirable high doses of heavy metals and pollutants. (Subrahmaniyan *et al.*, 2000). Nitrogen is the most important nutrient for plants (Irvine. 1969).

Azotobacter, a free living bacteria, acts as plant growth promoting rhizobacteria in the rhizosphere of almost all crops. Azotobacter fix nitrogen for non-legume crops like wheat, cotton, maize and sorghum, sustain themselves by root exudates and produce growth hormones (Ritenour *et al*., 1996). Compost improves nutrient supply to plants and reduce the input of mineral fertilizer and increases nitrogen content of the soil during long-term compost fertilization (Erhart *et al*., 2005).

The objective of the present work was to study the effect of different soil additives(rice straw compost (R.S.C.), town refuse compost (T.R.C.) and bio-fertilizer nitrobien) and different rates of mineral nitrogen fertilizer (ammonium sulfate (20.6% N) at 0, 50, 100 and 150 kg/fed) on vegetative growth, tuber yield and fixed oil percentage and composition of tiger nut (*Cyperus esculentus* L.) plants in order to investigate its growth performance and to improve its production.

MATERIALS AND METHODS

The present study was conducted during the two successive summer seasons of 2014 and 2015 at the Experimental Station of Horticulture and Medicinal and Aromatic Plants, Fac. of Agric., Mansoura Univ.

Tiger nut tubers were obtained from the local market at Tanta city, Egypt. Before planting, the nuts were soaked in a tap water for 4 days to facilitate germination, and the water was changed every day. After soaking, tubers were taken out of water and kept in a basket until they began to sprout within 7 to 12 days after soaking. Tiger nut tubers were planted on mid-April in both seasons in pots of 40 cm diameter. Each pot was filled with 15 kg sandy soil, and tubers were planted at a rate of 4 tubers /pot.

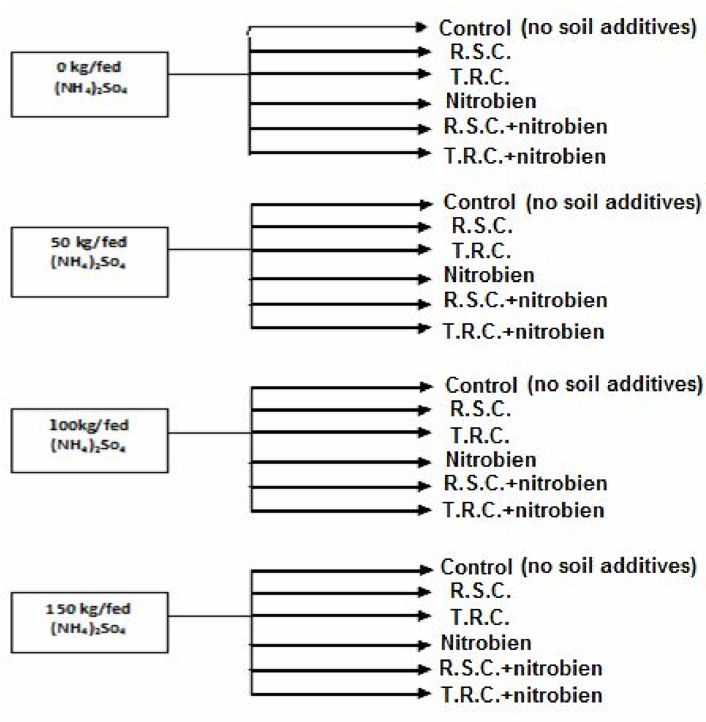
The soil is sandy in texture and its physical and chemical properties are shown in Table (A).

Table A. Physical and chemical properties of the experimental soil before the application of any fertilizers in both seasons (2014 and 2015).

Physical properties	1st season	2nd season	Chemical properties	1st season	2nd season
Coarse sand (%)	6.7	5.9	$CaCO_3$	1.93	1.91
Fine sand (%)	85.9	84.3	Organic matter (%)	0.19	0.23
Silt (%)	3.8	3.2	Nitrogen (ppm)	34.6	35.5
Clay (%)	3.6	6.6	Phosphorus (ppm)	5.36	5.32
			Potassium (ppm)	185	187
			Iron (ppm)	3.95	3.98
Textural class	Sandy soil	Sandy soil	Manganese (ppm)	1.42	1.44
			Zinc (ppm)	0.53	0.54
			E.C. ds/m	0.79	0.75
			pH	8.07	8.05

The layout of the experiment was factorial experiment in randomized complete block design with (24 treatments) each treatment contains three replicates (pots) with a total of 72 pots.

Pots were arranged in 24 treatments as follows:



Fertilizers material:

A) Mineral fertilizers:

1) **Basic application:** Calcium superphosphate(15.5 % P_2O_5) at the rate of 50 kg /fed [1.58g/pot] was added during preparation of soil. Potassium sulphate (48 % k_2O) at the rate of 50 kg /fed [1.58g/pot] was added in two split doses; the first dose during soil preparation and the second after emergence and seedlings growth reached 5 cm above soil surface. Micronutrients were applied as a foliar spray to all pots at the rate of 3 kg/fed (concentration of 3g / l of water) using Commercial Dsper Complex G.S produced from Eden Modern Agriculture – Spain. It contained 5% Fe, 4% Mn, 2% Mgo, 0.5% Zn, 0.4% Cu, 0.6% B, 0.2% Mo. Micronutrients were split into two equal doses; the first dose after emergence and seedlings growth reached 5 cm above soil surface, and the second one month later.
2) **Nitrogen fertilizer treatments:** plants were provided with ammonium sulfate (20.6% N) as a source of mineral nitrogen fertilizer at 0,50,100 and150 kg/fed (0, 1.58, 3.15 and 4.73 g/pot).Ammonium sulfate was split to two equal doses; the first dose after emergence and when seedlings height reached 5 cm above soil surface, and the second was added one month later.

B) Soil additives treatment included:

1) Compost: rice straw compost (R.S.C.) and town refuse compost (T.R.C.) were added during soil preparation at the rate of:

- 0 m^3 / fed organic compost
- 15 m^3/ fed rice straw compost (153.6 g / pot per season).
- 15 m^3/ fed town refuse compost (273.4 g / pot per season).

Rice straw compost was obtained from Res. Dept., Gemiza, Gharbia Governorate, and its chemical properties are presented in Table (B). Town refuse compost was provided from Garbage recycling plant, Sandoub, Mansoura Dakahlia, and its chemical properties are presented in Table (C).

2) Biofertilizer: bio-fertilizer used was nitrobien (commercial name), which contains live cells of efficient bacteria strains for N-fixing bacteria (*Azotobacter sp*.and *Azospirillum sp.*) was provided by the Ministry of Agriculture, Egypt General Organization for the Agriculture Equalization fund (G.O.A.E.F). Nitrobien was used at a rate of 4 kg/fed.,which was mixed with wet soft soil and incorporated into the root absorption zone of the plant for 10 minutes before planting, covered with afine soil and was irrigated immediately according to the methods described by El-Zeiny *et al.* (2001).

Table B. Chemical analysis of the used rice straw compost (R.S.C.) in both seasons (2014) and (2015).

Seasons	PH (1:5)	E.C (1:10) ds/m^{-1}	O.M %	O. C %	C / N	Weight (m^3.kg^{-1})	Available nutrients N %	P %	K %	Fe ppm	Zn ppm
1st	6.14	3.71	35.1	20.4	13.9	325	1.46	0.49	0.88	54.8	10.7
2nd	6.36	3.81	35.8	21.7	13.8	312	1.57	0.48	0.90	55.0	10.6

Table C. Chemical analysis of the used town refuse compost (T.R.C.) in both seasons (2014) and (2015).

Seasons	PH (1:5)	E.C (1:10) ds/m^{-1}	O.M %	O. C %	C / N	Weight (m^3.kg^{-1})	Available nutrients N %	P %	K %	Fe ppm	Zn ppm
1st	7.72	4.25	19.8	11.5	20.8	580	0.55	0.36	0.72	60.3	1.98
2nd	7.80	4.28	20.0	11.9	20.7	573	0.57	0.34	0.73	60.7	2.05

Maturity and harvesting:

The crop matured within 2.5 - 3 months after planting, when leaves color turned yellow and cessation of new inflorescenceoccurred (Tetteh and Ofori, 1998). Plants were, gently, removed from the soil, and tubers were separated from the root system, thoroughly washed and dried at 70° C until a constant weight, then the fibrous appendages were removed and stored at room temperature in a perforated paper bags.

Data recorded: At harvesting after 125 days from sowing (mid of August), the following data were recorded:

1) **Vegetative growth characters:** plant height (cm), number of tillers/pot and herb dry weight (g/pot).
2) **Tuber measurements:** number of tubers per pot and tuber yield (g/pot)
3) **Fixed oil% in tubers dry weight:** The tubers were further dried to aconstant weight in an oven at 70 °C and milled using mechanical grinder. One hundred grams of each of the dried milled tubers sample was subjected to solvent extraction method to extract the oil with soxhlet extractor using chloroform: methanol (2:1 v/v) solvent according to the method described by Adebayo *et al.* (2012). Each extraction occurred over a period of 8 hours. The filtrate was kept in desiccators and allowed to cool at room temperature and the extracted oil was re-heated to remove the solvent from the oil through evaporation.

The fixed oil percentage was calculated using the following equation (Warra, 2013).

$$\text{Oil percentage} = \frac{\text{Extracted oil (ml)}}{\text{Weight of sample (g)}} \times 100$$

Fixed oil yield (ml /pot): was calculated as follows:

$$\text{Fixed oil yield (ml /pot)} = \frac{\text{Oil percentage} \times \text{tubers dry weight (g/pot)}}{100}$$

Gas liquid chromatography (GLC) was used to separate and identify the components of the fixed oil constituents according to the method of IUPAC (2000) at the Central Laboratory of oils and fats Food Industry Research Center in Cairo.

Statistical analysis:

Data of the present study was subjected to analysis of variance (ANOVA) by the general linear models (GLMS) procedure using (SAS) statistical analysis system. Mean comparisons were performed using the least significant differences (L.S.D) method at significance level of 5% according to Gomez and Gomez (1984). All Statistical analysis was performed using analysis of variance technique by means of Gen-STAT computer software package.

RESULTS AND DISCUSSION

1. Vegetative growth characteristics

Effect of mineral nitrogen fertilizer

Results presented in Table (1) showed that increasing nitrogen fertilizer level resulted in significant effect on growth parameters (plant height, number of tillers/pot and herb dry weight g/pot) recording the highest values with nitrogen fertilizer at 150 kg/fed. Nitrogen fertilizer at the rate of 100 kg/fed. ranked second, while the least values of these parameters were recorded in the control plants.This increment in vegetative growth characters of tiger nut plants by increasing nitrogen levels may be due to the increase in nitrogen uptake which enhanced physiological activities of plants including cell division, cell elongation and thereby increased the growth and yield. These results are in harmony with those obtained by Iqbal *et al.* (2012) on tiger nut and Kandil *et al.* (2007) on groundnut plants.

Table 1. Vegetative growth characters of tiger nut plants as affected by nitrogen fertilizer levels, soil additives, and their interaction during the two seasons of (2014) and (2015).

Treatments		Plant height (cm)		Number of tillers		Dry weight of herb (g/pot)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
		Effect of $(NH_4)_2SO_4$ kg/fed (A)					
0		33.67	34.84	34.17	36.78	11.52	12.08
50		44.44	45.37	56.61	59.00	23.95	24.98
100		49.65	52.06	65.89	69.22	28.99	30.20
150		52.75	55.87	70.72	73.33	33.03	33.93
L.S.D at 5%		1.08	1.24	3.55	2.91	1.15	1.25
		Effect of soil additives (B)					
Control (untreated plants)		38.83	40.30	44.42	47.17	18.10	18.93
R.S.C. $15m^3$/fed		46.08	48.38	60.08	62.42	25.50	26.40
T.R.C. $15m^3$/fed		44.08	45.88	53.67	56.50	22.95	23.79
Nitro.		42.57	44.43	49.42	52.92	21.49	21.97
R.S.C. $15m^3$/fed plus Nitro.		51.00	53.07	70.75	72.75	30.52	31.71
T.R.C. $15m^3$/fed plus Nitro.		48.21	50.14	62.75	65.75	27.69	28.98
L.S.D at 5%		1.87	1.73	2.03	2.03	1.04	1.07
		Effect of the interaction (A× B)					
0 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	28.53	29.68	22.67	24.67	5.99	6.15
	R.S.C. $15m^3$/fed	34.54	36.60	37.67	40.33	12.69	13.11
	T.R.C. $15m^3$/fed	32.65	33.45	32.00	34.33	10.43	10.74
	Nitro.	30.64	31.43	24.00	27.33	7.15	7.51
	R.S.C. $15m^3$/fed plus Nitro.	38.82	40.43	47.67	49.33	17.66	18.73
	T.R.C. $15m^3$/fed plus Nitro.	36.82	37.43	41.00	44.67	15.18	16.25
50 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	37.42	39.10	45.00	48.00	17.46	18.61
	R.S.C. $15m^3$/fed	45.71	46.27	59.67	62.00	25.80	27.10
	T.R.C. $15m^3$/fed	43.85	44.33	54.00	56.00	22.64	23.54
	Nitro.	42.51	43.13	51.67	53.67	20.74	21.12
	R.S.C. $15m^3$/fed plus Nitro.	49.61	50.93	69.00	71.33	30.11	31.43
	T.R.C. $15m^3$/fed plus Nitro.	47.52	48.47	60.33	63.00	26.96	28.10
100 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	43.52	45.10	53.00	56.00	21.74	22.93
	R.S.C. $15m^3$/fed	50.63	53.60	68.67	71.33	29.00	30.15
	T.R.C. $15m^3$/fed	48.46	50.70	61.67	65.33	27.61	28.96
	Nitro.	47.61	49.96	59.00	63.33	27.92	28.11
	R.S.C. $15m^3$/fed plus Nitro.	55.36	57.33	80.33	83.00	35.30	36.83
	T.R.C. $15m^3$/fed plus Nitro.	52.34	55.67	72.67	76.33	32.39	34.24
150 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	45.85	47.33	57.00	60.00	27.21	28.02
	R.S.C. $15m^3$/fed	53.42	57.04	74.33	76.00	34.52	35.26
	T.R.C. $15m^3$/fed	51.36	55.03	67.00	70.33	31.10	31.94
	Nitro.	49.51	53.20	63.00	67.33	30.15	31.15
	R.S.C. $15m^3$/fed plus Nitro.	60.21	63.60	86.00	87.33	39.00	39.87
	T.R.C. $15m^3$/fed plus Nitro.	56.14	59.00	77.00	79.00	36.21	37.33
	L.S.D at 5%	3.52	3.30	4.78	4.42	2.11	2.21

(R.S.C.) rice straw compost (T.R.C.) town refuse compost (Nitro.) nitrobien

Effect of soil additives

As for soil additive treatments, the results showed also that both composts were more effective on tiger nut growth parameters (plant height, number of tillers/pot and herb dry weight g/pot) than nitrobien and the control, The increases in the vegetative growth of tiger nut plant after applying compost might be referred to the compost role in enhancing soil physical properties as soil texture, aeration, and water holding capacity, providing energy for microorganisms activity, increasing nutrients supply and its ability to meet microelements requirements(El-Afifi *et al*., 2013 on eggplant). In addition, the results showed that R.S.C. was more effective in this concern than T.R.C. in both seasons, which could be attributed to the fact that R.S.C. contains higher levels of nutritional elements, especially N, which is required for plant growth than T.R.C., as shown in their chemical analyses (Tables B & C). On the other hand, data showed that tiger nut plants treated with R.S.C. at the rate of 15 m^3/fed plus nitrobien at the rate of 4 kg/fed produced the highest values of growth parameters compared with other soil additive treatments and the control (without soil additives) in both seasons. Nitrobien includes *Azotobacter* and *Azospirillum* bacteria that produce some hormones which induce the proliferation of roots and root hairs, and thus increase nutrient absorption as well as produce organic acids, which solubilize inorganic and organic forms of mineral elements resulting in better plant growth and yield (Aly,2003).The combination of compost plus biofertilizer would result in better growth of the plant than when any of them used separately. These results are supported by the findings of Abou-Hussein *et al.* (2002) on potato and EL-Naggar (2010) on *Narcissus tazetta*, L.

Effect of the interaction

The interaction between treatments shown in Table (1) indicated that in both seasons, the highest values of plant height (60.21 and 63.60 cm), number of tillers/pot (86.00 and 87.33) and dry weight of herb g/pot (39.00 and 39.87 g) respectively, were recorded using 150 kg/fed nitrogen fertilizer with R.S.C. plus nitrobien in both seasons, followed by the same treatment using T.R.C. instead of R.S.C. and 100 kg/fed nitrogen fertilizer combined with R.S.C. plus nitrobien. It is worthy to mention that there was no significant differences in plant vegetative growth parameters between 100 kg/fed nitrogen fertilizer combined with R.S.C. plus nitrobein application and other treatment using 150 kg/fed nitrogen fertilizer combined with T.R.C. plus nitrobein. This indicated that the use of R.S.C. as a soil additive instead of T.R.C. would reduce the amount of nitrogen fertilizer used to achieve similar or even better effect on plant growth.The significant Increase in growth as a result of increasing nitrogen fertilizer level plus compost and bio-fertilizer application is a result of improving soil characteristics and increasing N concentration and availability in the root zone. These results are in agreement with those of Abou-Zeid and Bakry(2011) on potato and Said-Al Ahl *et al*. (2015) on dill plant.

2. Tuber measurements

Effect of mineral nitrogen fertilizer

The results presented in Table (2) showed that increasing nitrogen fertilizer level led to increased number of tiger nut tubers. However, when nitrogen fertilizer exceeded 100 kg/fed, number of tubers/pot started to decrease probably because excess nitrogen level would encourage vegetative growth at the expense of the underground organs. The aforementioned results of nitrogen fertilizer are in accordance with those of Garg*et al.* (1967) on tiger nut plant. On the other hand, tuber yield expressed as weight of tubers (g/pot) was highest when plants were fertilized with 150 kg/fed. The increase in tuber yield per pot for plants fertilized with the maximum dose (150 kg/fed) of nitrogen fertilizer might be attributed to the adequate and balanced nitrogen requirements, which favored optimum growth and, in turn achieved more tubers yield as mentioned by Khalifa (1987) on soybean plant.

Effect of soil additives

Presented data in Table (2) showed also that R.S.C. was more effective on yield parameters than either T.R.C. or nitrobien treatments in both seasons. Moreover, R.S.C. plus nitrobien produced the highest values of yield parameters followed by T.R.C. plus nitrobien treatment than other individual soil additive treatments or the control in both seasons. The increase in number of tubers of tiger nut plants may be due to increased nutrients availability as a result of compost treatment. These results coincide with those published by Klasman *et al*. (2002) on lilium plants. The effect of bio-fertilizers on yield may be attributed to changes in growth or morphology of roots as found by Bottini *et al.* (2004) on potato plant. The results are also in conformity with the findings of El-Sayed *et al.* (2014) on potato plant.

Effect of the interaction

As for the interaction among treatments, data of the same Table showed that the highest number of tubers of tiger nut per plant (151.67 and 154.33 tubers/pot) was that of plants treated with 100 kg/fed nitrogen fertilizer combined with R.S.C. plus nitrobien, followed by the similar treatment using 150 kg/fed nitrogen fertilizer(143.00 and 146.33 tubers/pot), while the lowest (58.67 and 61.33 tubers/pot) was of the control plants, respectively in the both seasons.On the other hand, data showed also that, the highest tuber yield per pot (58.86 and 60.48 g/pot) were from the plants treated with 150 kg/fed nitrogen fertilizer combined with R.S.C. plus nitrobien .The significant increase in tuber yield in tiger nut plants as affected by bio-nitrogen plus organic compost and mineral fertilizer may be related to increasing the availability of minerals especially N fixation that may led to an increase of photosynthesing surface. Therefore, an increase in accumulation of carbohydrates in bulbs occurred and subsequently resulted in an enhancement in bulb characteristics as found by EL-Naggar (2010) on *Narcissus tazetta* L. plants. These results are in agreement with those of El- Kramany *et al*. (2007) and Rizwan *et al*. (2008) who reported that integrated application of chemical, organic and biological fertilizer produced higher yield of maize plant compared with application of any treatment alone.

Table 2. Tuber measurements of tiger nut plants as affected by nitrogen fertilizer levels, soil additives, and their interaction during the two seasons of (2014) and (2015).

Treatments		Number of tubers		Tuber yield (g/pot)	
		1stseason	2nd season	1st season	2nd season
Effect of $(NH_4)_2SO_4$ kg/fed (A)					
0		77.39	80.11	20.98	21.92
50		113.56	115.39	37.26	38.00
100		125.72	128.83	43.98	45.32
150		119.72	121.83	46.43	47.96
L.S.D at 5%		2.58	3.11	1.28	1.41
Effect of soil additives (B)					
Control (untreated plants)		91.58	93.83	28.87	29.71
R.S.C. 15m^3/fed		108.25	110.83	37.62	38.68
T.R.C. 15m^3/fed		100.58	104.00	34.27	35.63
Nitro.		99.33	101.50	31.82	32.71
R.S.C. 15m^3/fed plus Nitro.		132.83	135.17	48.49	49.50
T.R.C. 15m3/fed plus Nitro.		122.00	123.91	41.91	43.57
L.S.D at 5%		2.59	2.32	1.39	1.30
Effect of the interaction (A× B)					
0 kg/fed $(NH_4)2SO_4$	Control (untreated plants)	58.67	61.33	13.49	14.38
	R.S.C. 15m^3/fed	80.00	83.00	22.58	23.85
	T.R.C. 15m^3/fed	71.33	73.00	18.59	19.40
	Nitro.	69.67	74.67	16.51	17.73
	R.S.C. 15m^3/fedplus Nitro.	97.67	100.00	29.40	30.21
	T.R.C. 15m^3/fedplus Nitro.	87.00	88.67	25.28	25.94
50 kg/fed $(NH_4)2SO_4$	Control (untreated plants)	95.00	96.67	28.90	29.61
	R.S.C. 15m^3/fed	113.67	115.67	37.16	37.87
	T.R.C. 15m^3/fed	104.00	107.67	33.83	35.18
	Nitro.	102.33	103.00	32.10	32.41
	R.S.C. 15m^3/fedplus Nitro.	139.00	140.00	48.86	49.38
	T.R.C. 15m^3/fedplus Nitro.	127.33	129.33	42.73	43.57
100 kg/fed $(NH_4)2SO_4$	Control (untreated plants)	107.33	111.00	35.71	35.97
	R.S.C. 15m^3/fed	122.00	125.67	43.56	45.01
	T.R.C. 15m^3/fed	115.67	121.67	40.37	42.56
	Nitro.	117.33	118.33	38.42	39.34
	R.S.C. 15m^3/fedplus Nitro.	151.67	154.33	56.83	57.92
	T.R.C. 15m^3/fedplus Nitro.	140.33	142.00	48.97	50.03
150 kg/fed $(NH_4)2SO_4$	Control (untreated plants)	105.33	106.33	37.36	37.81
	R.S.C. 15m^3/fed	117.33	119.00	47.18	48.00
	T.R.C. 15m^3/fed	111.33	113.67	44.30	45.37
	Nitro.	108.00	110.00	40.23	41.37
	R.S.C. 15m^3/fedplus Nitro.	143.00	146.33	58.86	60.48
	T.R.C. 15m^3/fedplus Nitro.	133.33	135.67	50.67	54.74
L.S.D at 5%		5.17	4.95	2.73	2.63

(R.S.C.) rice straw compost (T.R.C.) town refuse compost (Nitro.) nitrobien

3- Fixed oil determinations

Effect of mineral nitrogen fertilizer

Data recorded in Table (3) clearly demonstrated that,plants which received nitrogen fertilizer had significantly higher fixed oil percentage in the tubers compared with plants, which did not receive nitrogen fertilizer (control). However, there were non-significant differences between any nitrogen fertilizer levels. On the other hand, the fixed oil yield (ml/pot) of tiger nut tubers increased as the nitrogen fertilizer level increased from 50 to 150 kg/fed. Plants which received 100 and 150 kg/fed. did not significantly differ in their oil yields, but both had significantly higher yields than plants which received 50 kg/fed and the control. Oil yield is a result of both oil percentage and tuber yield thus, it is very likely that the increase in fixed oil yield due to nitrogen fertilizer treatments is related mainly to their effects on tuber yield rather than on oil percentage.The results agree with those documented by Fismes *et al.* (2000) and Ahmed *et al.* (2007) who reported that increasing N rate decreased oil concentration but the overall oil yields increased because of the higher seed yield in canola plant.

Effect of soil additives

The two types of compost (R.S.C. and T.R.C.) were more effective than nitrobien treatment for increasing the fixed oil % (Table, 3), The maximum fixed oil (%) resulted from plants treated with R.S.C. (21.34 and 21.40 %) or / and T.R.C. (21.27 and 21.31 %) compared with nitrobien which gave (20.12 and 20.16 %) respectively, in both seasons. Oil percentages produced by plants treated with nitrobien plus R.S.C. (21.84 and 21.86 %) and plants treated with nitrobien plus T.R.C. (21.71 and 21.74 %) were higher than those produced by any other individual soil additive treatments and the control, in both seasons.Similarly, the highest values of fixed oil yield resulted from plants treated with nitrobien plus R.S.C. (10.73 and 10.96 ml / pot) followed by plants treated with nitrobien plus T.R.C. (9.24 and 9.61 ml/pot) respectively. Applying compost plus biofertilizer treatments promoted the fixed oil percentages through Increasing the uptake of nutrients by roots of plant especially phosphorus. The energy of photosynthesis or respiration is utilized in the synthesis of the pyrophosphate bounds in ATP, through which the energy activates uptake and synthesis of various organic compounds such as volatile and fixed oils(El-Ghadban *et al.*, 2003 on marjoram plant). These results are also in agreement with those of Abdelaziz *et al.* (2007) on rosemary, Saeed *et al.* (2002) and Akbari *et al.* (2011) on sunflower.

Effect of the interaction

In general, data presented in Table (3) showed that the triple integration between either compost

(R.S.C. or T.R.C.) combined with nitrobein plus any nitrogen fertilizer rate of 50, 100, or 150 kg/fed. resulted in higher values of the fixed oil percentage than any other interaction treatments, in both seasons. In addition, there was non-significant difference in fixed oil % among any of the previously mentioned triple integration treatments. On the other hand, the highest values of fixed oil yield of tiger nut plant resulted from plants treated with R.S.C. combined with nitrobien plus either 150 kg/fed. (13.27 and 13.63 ml/pot) or 100 kg/fed. (12.86 and 13.12 ml/pot) with non-significant difference between these two interaction treatments in both seasons respectively.

Table 3. Fixed oil (%) and oil content (ml / pot) of tiger nut plants as affected by nitrogen fertilizer levels, soil additives, and their interaction during the two seasons of (2014) and (2015).

Treatments		Fixed oil (%)		Oil content (ml/pot)	
		1st season	2nd season	1st season	2nd season
Effect of $(NH4)_2SO_4$ kg/fed (A)					
0		19.37	19.39	4.08	4.27
50		21.38	21.42	8.04	8.21
100		21.74	21.78	9.62	9.89
150		21.66	21.69	10.11	10.46
L.S.D at 5%		0.65	1.06	0.50	0.70
Effect of soil additives (B)					
Control (untreated plants)		19.94	19.97	5.82	5.94
R.S.C. $15m^3$/fed		21.34	21.40	8.12	8.37
T.R.C. $15m^3$/fed		21.27	21.31	7.39	7.70
Nitro.		20.12	20.16	6.47	6.66
R.S.C. $15m^3$/fed plus Nitro.		21.84	21.86	10.73	10.96
T.R.C. $15m^3$/fed plus Nitro.		21.71	21.74	9.24	9.61
L.S.D at 5%		0.70	0.60	0.45	0.39
Effect of the interaction (A× B)					
0 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	19.05	19.07	2.57	2.74
	R.S.C. $15m^3$/fed	19.50	19.53	4.41	4.67
	T.R.C. $15m^3$/fed	19.37	19.38	3.60	3.76
	Nitro.	19.11	19.14	3.16	3.40
	R.S.C. $15m^3$/fedplus Nitro.	19.76	19.78	5.82	5.98
	T.R.C. $15m^3$/fedplus Nitro.	19.43	19.45	4.91	5.05
50 kg/fed (($(NH_4)_2SO_4$	Control (untreated plants)	19.66	19.69	5.70	5.85
	R.S.C. $15m^3$/fed	21.90	21.96	8.15	8.32
	T.R.C. $15m^3$/fed	21.86	21.92	7.40	7.72
	Nitro.	19.93	19.97	6.41	6.48
	R.S.C. $15m^3$/fedplus Nitro.	22.48	22.49	11.00	11.11
	T.R.C. $15m^3$/fedplus Nitro.	22.44	22.46	9.60	9.80
100 kg/fed $(NH_4)_2SO_4$	Control (untreated plants)	20.59	20.60	7.35	7.41
	R.S.C. $15m^3$/fed	22.00	22.10	9.58	9.95
	T.R.C. $15m^3$/fed	21.95	21.98	8.88	9.37
	Nitro.	20.76	20.81	7.98	8.18
	R.S.C. $15m^3$/fedplus Nitro.	22.60	22.63	12.86	13.12
	T.R.C. $15m^3$/fedplus Nitro.	22.54	22.56	11.04	11.29
150 kg/fed (($(NH_4)_2SO_4$	Control (untreated plants)	20.46	20.51	7.65	7.75
	R.S.C. $15m^3$/fed	21.95	21.99	10.35	10.55
	T.R.C. $15m^3$/fed	21.88	21.94	9.69	9.95
	Nitro.	20.68	20.72	8.32	8.57
	R.S.C. $15m^3$/fedplus Nitro.	22.52	22.53	13.27	13.63
	T.R.C. $15m^3$/fedplus Nitro.	22.45	22.47	11.39	12.29
L.S.D at 5%		1.38	1.42	0.92	0.93

(R.S.C.) rice straw compost (T.R.C.) town refuse compost (Nitro.) nitrobien

The effect of these treatments on enhancing fixed oil yield in tiger nut plants might be due to the combined effect of fertilizers and bio-fertilizer through their direct and indirect roles in plant metabolism processes such as photosynthesis, enzymatic system resulting in more plant metabolism. These promotive effects of different fertilizer sources on fixed oil yield were reported on some medicinal and aromatic plants such as Hendawy *et al.* (2015) on *Lallemantia iberica* L., and Saeed *et al.*(2002) and Akbari *et al.* (2011) on sunflower plant.

4- Fixed oil components%:

The presented results in Table (4) and illustrated in Fig. (1) showed that twelve fatty acids were identified in tiger nut fixed oil which were divided into two groups; six unsaturated fatty acids (oleic,lnolinc, gondoic, palmitoleic , α-linolenic and heptadecenoic acids) ranged from 78.50 to 79.21% of the oil and six saturated fatty acids (palmatic , stearic, myristic, arachidic, behenic and margaric acids) ranged from 20.80 to 21.81% of the oil. These results agree with those of El-Anany and Ali (2012)who indicated that tiger nut oil is a mono unsaturated oil similar to olive oil (both contain high levels of oleic acid). Saturated fats tend to increase blood cholestrol levels, while unsaturated ones show the reverse direction; they are mostly from plant sources. The most common saturated fatty acids found in plant lipids that contain 16 or 18 carbon atoms. Low content of saturated fatty acids is desirable for edible uses Anderson (1999).

The main components of the unsaturated fatty acids in tiger nut fixed oil were oleic acid (67.42-69.19 %) and linolenic acid (9.42 – 10.27%), while the main saturated fatty acids were palmatic acid (12.29 –

13.26%) and stearic acid (6.60 – 8.13%). These results agree with those of Zhang *et al*. (1996)who reported that the nut was found to be rich in oleic, linoleic and myristic acids. Muhammad *et al*. (2011) reported that tiger nut oil has a similar fatty acids composition to olive oil, and it consists predominantly of oleic acid with values ranging from 65.5 to 76.1% compared to values for olive oil which ranges from 56 to 85%. Also, Fomuso and Akoh (2002) reported that other major fatty acids in tiger nut oil are palmitic ,llinoleic and stearic acids.

Table 4. Fxed oil components (%) of *Cyperus esculentus* L. tubers as affected by some interaction treatments, during the second season (2015).

Treatments	Fixed oil components (%)													
	Unsaturated fatty acids							Saturated fatty acids						
	C16:1 Palmitoleic	C17:1 Heptadecenoic	C18:1 oleic	C18:2 linolinc	C18:3n3 Alpha-linolenic	C20:1 Gondoic	Total	C14:0 Myristic	C16:0 Palmatic	C17:0 Margaric	C18:0 Stearic	C20:0 Arachidic	C22:0 Behenic	Total
Without soil additives														
$(NH_4)_2SO_4$ 100kg/fed	0.15	0.03	68.14	9.86	0.13	0.19	78.50	0.18	12.29	0.06	8.03	0.82	0.15	21.51
$(NH_4)_2SO_4$ 150kg/fed	0.16	0.03	67.42	10.27	0.13	0.19	78.19	0.18	12.49	0.07	8.13	0.81	0.14	21.81
Plus R.S.C. and nitrobien														
$(NH_4)_2SO_4$ 100kg/fed	0.19	0.03	69.19	9.46	0.14	0.19	79.21	0.13	13.26	0.07	6.60	0.64	0.10	20.80
$(NH_4)_2SO_4$ 150kg/fed	0.18	0.03	68.93	9.42	0.14	0.19	78.89	0.14	13.18	0.07	6.95	0.68	0.10	21.11

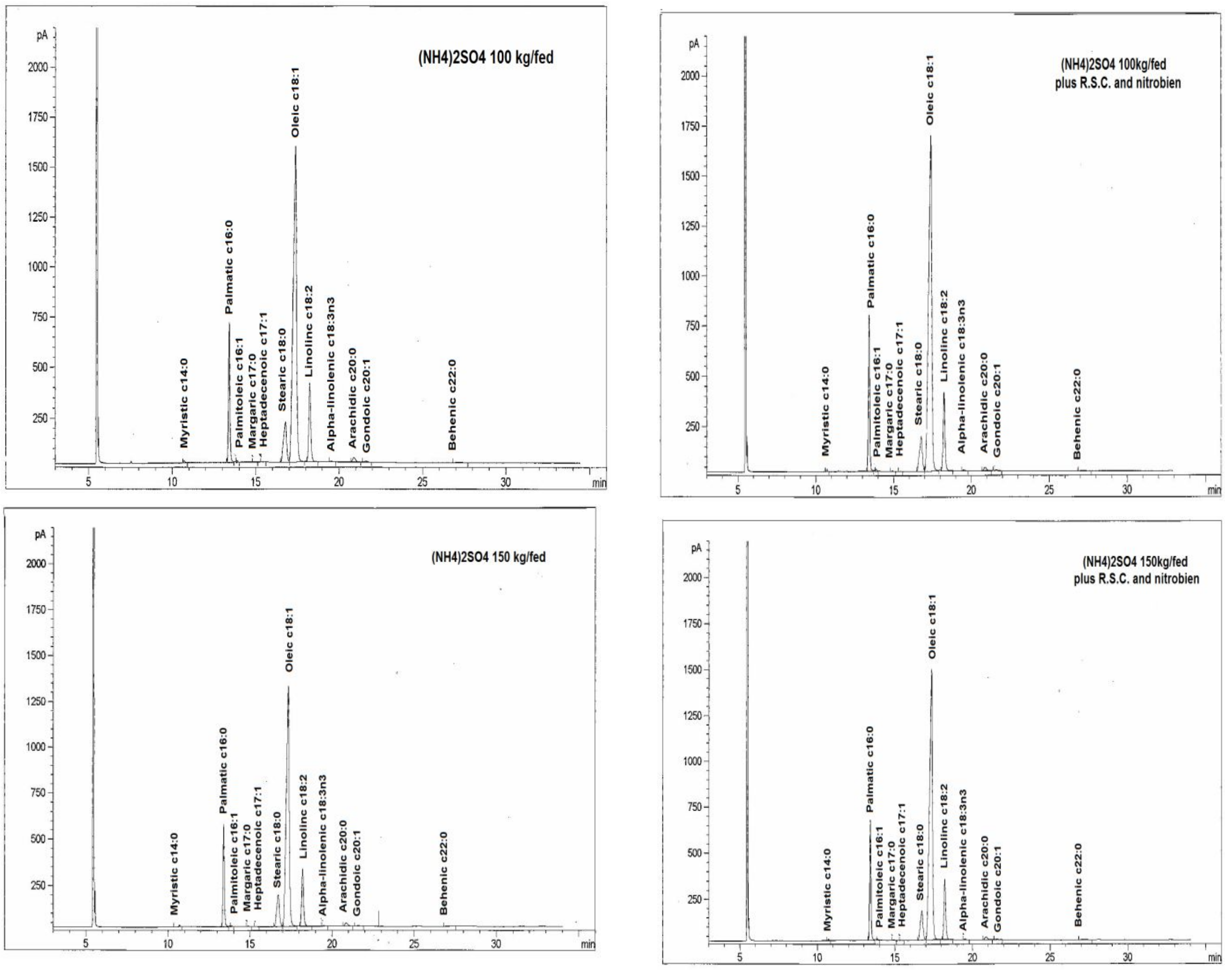


Fig. 1. G.L.C. chromatographic analysis of tiger nut oil components % from mineral nitrogen fertilizer $(NH_4)_2SO_4$ at (100 and 150 kg/fed) without soil additives or plus R.S.C. and nitrobien application

Data presented in Table (4) also showed that, using 100 or 150 kg/fed nitrogen fertilizer combined with R.S.C. plus nitrobien had a positive effect on increasing the values of unsaturated fatty acids compared with using these rates of nitrogen fertilizer alone. The highest value of unsaturated fatty acids

(79.21%) was obtained from plants fertilized with 100 kg/fed nitrogen fertilizer with R.S.C. plus nitrobien fertilizer. In this respect, Ahmed and Abdin (2000) stated that, nitrogen probably promotes elongation of the carbon chain of rape seed oil and that fatty acid composition changes by nitrogen. Nitrogen is the most recognized element in plant for its presence in the structure of proteins molecules.Accordingly, N plays an important role in synthesis of the plant constituents through the action of different enzymes(Jones *et al*., 1991).

CONCLUSION

On the basis of results, it can be concluded that the crop was fertilized at 100 kg/fed nitrogen fertilizer with 15m^3/fed R.S.C. plus bio-fertilizer nitrobien at 4 kg/fed appeared to be most appropriate and suitable for harvesting a good crop of tiger nut tubers, fixed oil quality and maximum value of un saturated fatty acid under the conditions of this experiment. It is further noted that the nitrogen fertilizer should not be applied alone, rather in combination with compost or bio-fertilizer.

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تأثير بعض إضافات التربة ومستويات مختلفة من السماد النتروجيني على النمو الخضري ومحصول الدرنات والزيت الثابت لنبات حب العزيز.

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تم تنفيذ تجربتين أصص خلال موسمين صيفين ٢٠١٤م و ٢٠١٥م على نبات حب العزيز في مزرعة نباتات الزينة والنباتات الطبية والعطرية بكلية الزراعة - جامعة المنصورة ، لدراسة تأثير إضافات مختلفة للتربة (كومبست قمامة المدن و السماد الحيوي النتروبين)و مستويات مختلفة من السماد النتروجيني (سلفات النشادر (٢٠.٦ % نتروجين) بمعدل ٠-٥٠-١٠٠-١٥٠ كجم/للفدان) وتأثير ذلك على النمو الخضرى ومحصول الدرنات وكذلك النسة المئوية للزيت الثابت ومكوناته في نباتات حب العزيز. و تشير النتائج المتحصل عليها أن سماد كومبست قش الارز او سماد قمامة المدن بمعدل ١٥م٣/للفدان مع النتروبين بمعدل ٤ كجم/ للفدان كان له تاثير ايجابي علي النمو الخضري الذي يتمثل في ارتفاع النبات ، عدد الخلفات/للاصيص ، الوزن الجاف للعشب (جم/للاصيص) و صفات الحصاد المشتملة علي عدد الدرنات/للاصيص ، محصول الدرنات (جم/للاصيص) ، النسبة المئوية للزيت الثابت و محصول الزيت (مل /للاصيص) عند المقارنة بباقي معاملات إضافات التربة . بالاضافة إلي أن سماد كومبست قش الارز كان له تاثير إيجابي علي كل الصفات المدروسة في كلا الموسمين بالمقارنة بـ معاملة قمامة المدن او النتروبين . أدي أعلي مستوي من السماد النتروجيني (١٥٠كجم/للفدان) إلي زيادة معنوية في جميع الصفات الخضرية ، بعض صفات الحصاد المشتملة علي محصول الدرنات (جم/للاصيص) ، محصول الزيت (مل /للاصيص)،لكن أعلي القيم في عدد الدرنات للاصيص ، النسبة المئوية للزيت الثابت كانت من النباتات المعاملة بالسماد النتروجيني عند مستوي ١٠٠ كجم/للفدان عند مقارنتها بالمستويات الاخري من السماد النتروجيني . معاملة التفاعل بين ١٥٠ كجم/للفدان سماد نتروجيني مع كومبست قش الارز و النتروبين كانت أكثر فاعلية في تحسين صفات النمو الخضري ، صفات الحصاد المشتملة علي محصول الدرنات (جم / للاصيص) ، محصول الزيت الثابت (مل /للاصيص) يتبعها نفس المعاملة المجمعة لكن باستخدام ١٠٠ كجم/للفدان سماد نتروجيني بدلا" من ١٥٠ كجم/ للفدان سماد نتروجيني بدون إختلافات معنوية بين المعاملتين. كانت معاملة التفاعل بين ١٠٠ كجم/للفدان سماد نتروجيني مع كومبست قش الارز و النتروبين أكثر فاعلية علي عدد الدنات للاصيص،النسبة المئوية للزيت الثابت عند المقارنة بالمعاملات الفردية او معاملات التفاعل في كلا الموسمين. تم التعرف علي ١٢ مركب من الاحماض الدهنية من التحليل الكروماتوجرافي للزيت الثابت لحب العزيز و التي قسمت الي مجموعتين ٦ أحماض دهنية غير مشبعة و هي (الاوليك ، لينولينك ،جوندوك ، البالمت اوليك ، الفا لينولينك و حمض هيبتاديكينوك) و تراوحت قيمهم من ٧٨.٥٠- ٧٩.٢١% و ٦ أحماض دهنية مشبعة و هي (البالمتيك ، الاستياريك ، ميرستيك ، اركيديك ، بهنيك وحمض المارجيك) و تراوحت قيمهم من ٢٠.٨٠- ٢١.٨١%.المركبات الاساسية في الاحماض الدهنية غير المشبعة في الزيت الثابت لحب العزيز هي حمض الاوليك التي تراوحت قيمتة من (٦٧.٤٢-٦٩.١٩%) و حمض لينولينك التي تراوحت قيمتة من (٩.٤٢-١٠.٢٧%) بينما الاحماض الدهنية غير المشبعة في الزيت الثابت كانت حمض البالمتيك التي تراوحت قيمتة من(١٢.٢٩-١٣.٢٦%) و حمض الستريك التي تراوحت قيمتة من(٦.٦٠-٨.١٣%) . التوصيـة تبعا" للنتائج الاساسية ، يمكن إستنتاج أن المحصول المسمد بـ ١٠٠ كجم /للفدان سماد نتروجيني مع ١٥م٣/ للفدان سماد كومبست قش الارز و السماد الحيوي النتروبين بمعدل ٤كجم/ للفدان أظهر أنه الاكثر ملائمة و مناسبة لمحصول جيد من درنات حب العزيز ، كمية الزيت الثابت و أعلي قيمة من الاحماض الدهنية غير المشبعة تحت ظروف التجربة. ويلاحظ كذلك أن السماد النتروجيني لا ينبغي أن يضاف بمفردة ، بل بالاشتراك مع الاسمدة العضوية أو الحيوية .