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Influence of Compost and Rock Amendments on Growth and Active Ingredients of Safflower (*Carthamus tinctorius* L.).

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Abstract: The effect of compost (0, 5, 10 and 20 ton/fed), rock amendments (0, 500, and 1000 kg/fed) and their combinations on some morphological parameters, yield and active ingredients of safflower (*Carthamus tinctorius* L.) was carried out in the field during 2006/2007 & 2007/2008 seasons. Two samples were taken after 150 and 190 day from planting. The obtained results indicated that all treatments achieved an increament in morphological parametres, carthamin of petals yield and oil content of seeds comparing with the control. As for the effect of single treatments on growth parameters and active ingredients, the compost 20 ton/fed and rock 1000 kg/fed revealed significant values than the control, except height with R1000 in both seasons. The combination of high concentration of compost (20 ton/fed) and rock phosphate (1000 kg/fed) recorded the highest values in this concern (except plant height and fatty acids charachters). Meanwhile, C20 led to obtain good quality of safflower oil by increasing unsaturated/saturated fatty acids ratio.

Key words: Safflower, *Carthamus tinctorius* L., Compost, Rock phosphate, Carthammin, Fatty acids.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a member of the family Compositae or Asteraceae, cultivated mainly for its seed, which is used as edible oil and dye production since ancient times. Traditionally, the crop was grown for its flowers, used for coloring and flavoring foods and making dyes, especially before cheaper aniline dyes became available and in medicine (Anonymous, 1996). Safflower is native to the Old World, and the genus occurs naturally in the Mediterranean region, northeastern Africa, and southwestern Asia to India. There are positively identified archaeological records of safflower from 4000-year-old Egyptian tombs, including a find of single safflower flowers wrapped in willow leaves that were placed with a mummy from the 18th Dynasty (ca. 1600 B.C.). The flowers of Carthamus are pale yellow to red-orange, tubular disk florets; there are no ray florets in this thistle-like head. Since ancient times, orange pigments have been obtained from safflower. In fact, the name safflower may be derived from another plant, saffron (Crocus sativus), which was a precious and very expensive yellowish dye obtained from the stigmas of freshly opened flowers. The name Carthamus is the latinized form of the Arabic word quartum or gurtum, which refers to the pigment color. The corolla as a water-soluble yellow dye (carthamidin, an anthocyanin) and a water-insoluble orange-red dye (carthamin), which is readily soluble in an alkaline solution.

Organic matter is not only necessary for plant nutrition but also essential for efficient plant production system (Cole *et al.*, 1987). The compost must be added to conventional NPK fertilizer to improve soil structure, making the soil easier to cultivate, encouraging root development, providing plant nutrients and enabling their increased uptake by plants. Moreover, compost aids water absorption and retention by soil, reducing erosion and run-off and thereby protecting surface waters from sedimentation, help binding agricultural chemicals, keeping them out of water ways and protecting ground water from contamination (leaMaster *et al.*, 1998).

Many researchers in India and other areas have used rock phosphate by composting it with different kinds of organic compounds to improve its agronomic effectiveness (Mishra *et al.*, 1982; Singh *et al.,* 1983; Singh, 1985; Singh and Amberger, 1991). Rock phosphates (RP) for direct application are effective in acid soils. However, a minimum processing is requried before application in non-acid soils. Some alternative methods for improving low-grade RP are by partial acidulation (Biswas and Narayanasamy, 1998); thermal alternation

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(Reddy *et al.*, 1996); blending with water-soluble ferilizers (Xiong *et al.*, 1996); dry compaction of RP with water-soluble P fertilizers (Menon and Chien, 1996) and preparation of RP-enriched compost (Biswas and Narayanasamy, 2006).

The main object of this work was to tilizers. Avoid the effect of chemical ferrecord the suitable compost and rock phosphate level to obtain the highest growth characters, oil and carthamin yield of safflower plant under the Egyptian environmental condition.

MATERIAL AND METHODS

A field experiment was laid out in the Experimental Farm Station of National Organization for Drug Control and Research, at Kafr-Algabal Governorate Giza, Egypt during two successive winter seasons of 2006/2007 and 2007/2008 in loamy sand soil. Mechanical and chemical analyses of the cultivation soil were determined as show in Table (1).

Table 1: Mechanical and chemical analyses of the cultivated soil.

Mechanical analysis			Chemical analysis					
Sand %	Silt %	Clay %	N mg/kg	Pmg/kg	Kmg/kg	Organic matter%	$CaCO_3$ %	pH
80.2	13.7	6.1	84.0	5.9	272.0	0.52	2.0	8.06

The experimental design was established as completley randomized design with three replicates. Four levels of compost amendment (C) 0, 5, 10 and 20 ton/fed were applied and distributed in the main-plots and three levels of rock amendment (R) 0, 500, and 1000 kg/fed and their combination were applied in the subplot. The area of subplot was 7.88m^2 (3.5 × 2.25 m), containing 3 rows (3.5 m length and 75 cm width), while plot area was 23.63 m^2. Mixture of bacteria include N-fixer (*Azotobacter chrooccum*), P-Solubilizer (*Bacillus megatherium*), and K-Availabilizer (*Bacillus cercileans*) which obtained from Microbiology Department, Faculty of Agriculture, Ain Shams University as solution. These types of bacteria were mixed with the organic compost and rock amendments and added to all experimental soil at equal before sowing. Seedbed preparation practices; plowing (chisel plow twice), leveling and ridging were achieved before sowing.

Seeds were sown at 15^{th} November for each season in hills at 25 cm distances on rows which has 75 cm in between and each sub-plot was 7.88 m^2. After germination completely, seedling were thinned to obtain 42 plant in each sub-plot and 21334 plant per fed. All agricultural practices; seedbed preparation, sowing, irrigation, thinning, weed control, harvesting and post harvest were applied as recommended. Safflower seeds (*Carthamus tenctorius L.*) varity Giza-1, obtained from Oil Crop Department, Agricultural Researches Centre, Giza, Egypt.

Compost Amendment Analysis:

Compost amendment was obtained from El-Arabia for Organic amendments Co., Egypt. Its chemical analysis is shown in Table (2).

Table 2: Chemical analysis of compost amendment.

Total N %	Total P %	Total K %	Fe %	Mn ppm	Cu ppm	Zn ppm	Organic matter%	C:N ratio	pH	Organic carbon %	Ash %
1.24	0.58	1.15	1.26	578.00	136.00	130.00	36.56	16.8:1	8.80	63.44	20.84

Rock Amendment Analysis:

Rock amendment was obtained from El-Ahram for natural amendments Co., Egypt. Its physical and chemical analyses are shown in Table (3).

Table 3: Physical and chemical analyses of rock amendment.

P_2O_5%	K_2O%	MgO%	Fe_2O_3%	MnO%	SiO_2%	CaO%	Na_2O%	SO_3%	Al_2O_3%	TiO_2%	L.O.I
9.56	3.93	3.03	4.13	1.02	28.51	20.46	0.28	7.22	5.70	1.22	13.42

L.O.I = Loss on ignition

Two samples were taken at 150 and 190 days from sowing date. In the first sample (150 days from sowing), ten plants were taken for each replicate to determinate growth parameters, petal yield and active ingredients in petals.

In the second sample (190 days from sowing), 10 plants were taken for each replicate to determinate dry weight, seed yield and active ingredients in seed.

Morphological Parameters and Growth:

The recorded morphological parameters included plant height (cm), leaf area (cm^2/plant) and number of branches/plant. Growth was measured by herb dry weight (g), petal and seed yield. Leaf area (LA) was calculated for main stem and branches according to (Çama *et al.* 2005). Petal yield was determined by g/plant and kg/fed.

Petal yield kg/fed = [petal yield (g/plant) × plant population (21334 per fed)] × 10^{-3}

Seed yield was estimated by g/plant and ton/fed.

Seed yield (ton/fed) = [Seed yield (g/plant) × plant population (21334)] × 10^{-6}

Chemical Analyses:

***Red Pigment (Carthamin)*:**

Red pigment (Carthamin) was extracted and estimated according to FAO, (1997) with some modification. A fifty mg dry petal was weighed accurately and removed yellow pigment from it by socking in 100 ml of citric acid/disodium hydrogen phosphate buffer solution (pH 5) for overnight and then filtered. After that, residual petals were socked in 100 ml of distilled water for 1 hour (it was repeated 3 times). The residual petals were air dried; then socked in 20 ml dimethylformamide (DMFA) for 3 hours and filtrated. A five ml of DMFA extracted was diluted to 10 ml using DMFA. Carthamin was determined at 530 nm using HP spectrophotometer (UV – VIS Double Bean PC, 8 scanning auto cells, UVD - 3000). The percent of coloring matter (P) was calculated using the following formula: $P = [A / 992] \times [40 / W]$

where:

W = Weight of the sample.

A = The absorbance of the sample.

992 = The specific absorbance of carthamin.

Total Lipid Extraction and Determination:

For extraction of total lipids (Coşge *et al.*, 2007), one gram of seeds was ground with sand, extracted with chloroform : methanol (2:1) in a Soxhlet apparatus (24h) and filtered. The solvent was removed by heating at 50ºC. Crude lipid exrtract was resuspended in chloroform and filtered (Wt. no.1). Chloroform was evaporated and the total sample lipid weight determined (Wright *et al.*, 1980).

Extraction and Determination of Fatty Acids:

Analysis of fatty acids was acheived with control and three treatments (C20, R1000 and C20R1000). The crude lipid was saponified with 1% KOH in 80% Et-OH (2h). The aqueous fraction was acidified by 6N HCl using only 1.5 ml and extracted with ether (3 times) to separate the fatty acids. After evaporating the solvent, the concentrated fatty acid was estarified with mixture of methanol : benzene : sulfuric acid (20:10:1) according to Mendhan *et al.* (2000). Some water was added to it, again extracted with ether (3 times) and evaporated to get the fatty acid methyl esters (FAME).

Finally, the FAME were dissolved in 2 ml hexan in order to run on GC. The samples were dehydrated over anhydrous sodium sulfate, and then analyzed by HP 7890A (Agilent Technologies) GC-system with equipped with HP5 capillary column (25 m x 0.12 μm). Nitrogen was used as carrier gas at a flow rate of 1 ml/min. Injector and detector temperature were 250 and 275 ºC, respectively. The column temperature was programmed from 150 to 240 ºC at the rate of 10 ºC/min. One μL of sample was injected by hand and in the split mode (1:20). Fatty acids were identified by comparison of their retention times with those of the reference standards. The content (percentage by weight) of fatty acids was calculated from their corresponding integration data.

The statistical analysis of data was done by SAS (Statistical Analysis System) 1996.

RESULTS AND DISCUSSION

Morphological Parameters and Growth:

Data illustrated in Table (4) showed the effect of compost, rock amendment treatments and their combinations on morphological parameters (plant height, branches number/plant, leaf area/plant) and growth (herb dry weight, petal and seed yields) of safflower. All treatments increased morphological parameters when compared to the control. The treatment C20R1000 mostly gave the highest value of morphological parameters except plant height in both seasons. In this respect, Khalil and El-Sherbeny (2003) indicated that compost additions markedly improved the productivity of the three mint species, where the increasing compost levels from 3.5 to 7.5 ton/fed caused gradual and significant increases of morphological parameters and growth. Ebadah *et al.* (2006) investigated the influence of several types of amendments. They found that, there are positive impact on snap bean (*Phaseolus vulgaris* L.) growth (plant height, no. of leaves/plant, No. of shoots/plant and yield/plant) compared with NPK as control.

Table 4: The effect of compost, rock amendment treatments and the interaction between both of them on growth charactars of safflower plant.

	First season						Second season					
Characters	Plant height, cm	No. of branches/ plant	Leaf area, m2/plant	Dry weight, g/plant	Petal yield, g/plant	seed yield, g/plant	Plant height, cm	No. of branches/ plant	Leaf area, cm2/plant	Dry weight, g/plant	Petal yield, g/plant	seed yield, g/plant
control	136.92 i	5.500 d	0.142 i	82.867 l	1.928 j	45.955 g	139.367 i	5.538 e	0.151 i	85.283 j	1.958 i	46.415 g
C5	157.77 ef	5.567 d	0.211 gh	133.900 j	2.635 h	61.527 f	159.833 f	5.662 de	0.222 g	138.450 hi	2.745 g	62.325 f
C10	166.90 d	5.833 cd	0.257 e	140.467 i	3.333 f	77.351 e	165.500 ef	5.933 bcde	0.269 f	142.750 h	3.557 e	78.355 e
C20	173.25 c	6.267 abcd	0.302 c	171.467 e	4.738 d	107.553 c	175.167 bc	6.377 abcd	0.308 c	172.250 e	4.992 c	108.721 c
R500	154.35 f	5.667 cd	0.203 h	129.233 k	2.363 i	58.360 f	153.667 g	5.767 cde	0.207 h	135.500 i	2.460 h	59.233 f
R1000	143.47 h	5.833 cd	0.223 g	149.800 h	2.793 h	61.737 f	146.957 h	5.907 bcde	0.230 g	153.450 g	2.920 g	62.353 f
C5 R500	161.00 e	5.733 cd	0.240 f	155.467 g	3.160 g	73.910 e	163.933 ef	5.833 cde	0.260 f	159.183 f	3.237 f	74.500 e
C5 R1000	148.10 g	5.900 bcd	0.270 de	160.617 f	3.360 f	75.027 e	149.820 gh	5.970 bcde	0.283 d	168.600 e	3.487 e	75.997 e
C10 R500	173.27 c	6.167 abcd	0.283 d	179.767 d	3.790 e	93.383 d	172.500 cd	6.213 abcde	0.287 d	184.967 d	4.197 d	94.593 d
C10 R1000	170.25 cd	6.667 ab	0.350 b	190.617 c	5.313 b	125.097 b	169.107 de	6.663 ab	0.367 b	193.383 c	5.443 b	126.723 b
C20 R500	189.38 a	6.400 abc	0.343 b	230.017 b	5.057 c	122.487 b	194.517 a	6.573 abc	0.360 b	231.000 b	5.277 b	123.207 b
C20 R1000	180.68 b	6.867 a	0.460 a	251.30 a	6.013 a	133.853 a	179.443 b	6.823 a	0. 490 a	263.533 a	6.187 a	135.307 a
LSD	4.2969	0.8212	0.0138	4.6085	0.1665	6.3481	5.9163	0.8298	0.015	5.2269	0.1955	6.4219

The addition of C20R500 gave the highest significant value of plant height (189.38 & 194.517) compared to the contol (136.92 & 139.367) and other treatments in both seasons, respectively. As for the effect of single treatments on plant height, C20 and R500 treatments showed higher significant value than the control in both seasons. In this respect, Hussein *et al.* (2006) observed that additing of compost (39.6 ton/ha) gave the highest value of plant height (66.23 and 77.22 cm) in both seasons, respectively. Also, Ibeawuchi *et al*. (2007) reported that there were significant differences in plant height with the treatments (NPK 0.0 + organic manure 8.0) and (NPK 0.1 + organic manure 6.0) ton/ha respectively being taller than the other maize plants.

Concerning the rest morphological parameters and growth, the maximum values of number of branches (6.88 & 6.82), leaf area (0.46 & 0.49 m^2/plant), herb dry weight (251.3 and 263.5 g/plant), petal yield (6.01and 6.19 g/plant) and seed yield (133.85 and 135.31 g/plant) were obtained as a result of the high level of compost and rock amendment (C20R1000) in both seasons, respectively. In this respect, Ramilison (2001) found that maize grain yield was increased with rock phosphate treatments at 150 and 300 kg/ha. Also, he reported that the interaction between rock phosphate and organic manure showed significant effect on grain yield especially with the high concentration of rock phosphate.

Also, Akanbi *et al*. (2007) suggested that *Telfairia occidentalis* showed significant differences with 75% cassava peel compost (CPC) treated plants which had the highest number of secondary branches. Taalab and Badr (2007) reported that dry matter yield of sorghum plants increased about two times with the addation of nitrogen forms combined with rock phosphate. Hegazy *et al.* (2007) showed that all flowering measurements (length of inflorescence, number of infloresences per shoot and total number of flower per each) were almost highly significant with organic fertilization (poultry manure) on olive trees, their improvement in flowering measures resulted from organic fertilization may be attributed to the stimulation effect of the absorbed nutrients on photosynthesis process which certainly reflected positively on both vegetative growth and flowering characteristics. Nishanth and Biswas (2007) reported that additions of diammonium phosphate (DAP) or ennriched composts resulted in highly significant of shoot, root and total yield with the growth stages of wheat as compared to control. Khalil *et al.* (2008) found that increasing compost level progressively and significantly increased the values of morphological parameters (plant height, number of branches/plant) and growth (herb fresh and dry weights) on bitter fennel and Egyptian sage plants in most cases, also yield of fennel seed and sage herb (g/plant). Cherif *et al.*(2009) reported that wheat grain yields showed a noticeable increase with treatments of solid waste compost as compared to the control.

Carthamin and Oil Yield:

Data illustrated in Table (5) showed the effect of compost, rock amendment treatments and their combination on carthamin and oil yield of safflower plant. All treatments increased carthamin and oil yield when compared to the control. The treatment C20R1000 gave the highest value of carthamin (32 mg/plant & 695.6 g/fed) and oil yield (50.2 ml/plant & 1069.8 l/fed). In this respect, Hussein *et al.* (2006) observed that the compost treatments produced rather high and constant oil content (%) on maize plants. The maximum value of oil concentration were obtained as a result of compost at 39.6 ton/ha. The same trend was observed for oil yield (ml/plant) by compost at 16.5 ton/fed. Gharib *et al.* (2008) found that application compost extract (15 and 30%) to the soil with bacterial suspension of three nitrogen-fixer strains had a positive impact on essential oil concentration compared with (NPK) on sweet marjoram plant. Khalil *et al.* (2008) revealed that compost at three levels (6, 12 and 18 m^3/fed) significantly increased oil (%) in fennel seeds and sage herb, as well as seed, herb and oil yield ml/plant and l/fed in fennel and sage, respectively, as compared to mineral fertilization. The highest compost level (18m^3/fed.) resulted significant increament in oil (%) over the lowest level (6m^3/fed.) only. They also reported that oil yield per plant (ml) and per feddan (l) attained a parallel trend to oil (%) and seed or herb yield.

Table 5: The effect of compost, rock amendment treatments and their combination on carthamin and oil yield of safflower plant.

Treatments	Carthamin yield, mg/plant	Carthamin yield, g/fed.	Oil yield, ml/plant	Oil yield, l/fed.
Control	8.41 i	179.38 i	15.123 g	322.61 g
C5	13.02 gh	277.68 gh	21.643 f	461.80 f
C10	19.87 e	423.94 e	27.917 e	595.56 e
C20	25.75 d	550.64 d	40.047 c	854.37 c
R500	12.00 h	256.06 h	19.967 f	426.00 f
R1000	13.47 g	287.32 g	20.690 f	441.41 f
C5 R500	18.22 f	388.77 f	26.757 e	570.78 e
C5 R1000	18.66 ef	398.08 ef	27.097 e	578.09 e
C10 R500	25.68 d	547.95 d	35.693 d	761.50 d
C10 R1000	30.28 b	626.07 b	45.333 b	967.15 b
C20 R500	28.00 c	597.32 c	46.940 b	1001.42 b
C20 R1000	32.60 a	695.59 a	50.147 a	1069.80 a
LSD	1.2175	26.623	2.2608	48.262

Data illustrated in Table (6) showed that treatment C20 led to an increase in C16:0, saturated and unsaturated fatty acids and unsaturated fatty acids/saturated fatty acids ratio. On the contrary, the rest treatments gave opposite trend in this respect. Meanwhile, C20 led to the obtain of good quality of safflower oil by increasing unsaturated/saturated fatty acids ratio. In this respect, Naguib (2003) concluded that in order to obtain the best yield of good quality chamomile oil, the plants would be fertilized with 80kg/fed. from both mineral nitrogen source and organic compost.

Table 6: Fatty acid characters.

Treatments	Area of fatty acids							
	C 16:0	C 18:0	C 18:1	C 18:2	Sat. FA	UnSat. FA	UnSat./Sat.	C18/C16
Control	856.7	280.5	1498.2	9634.7	1137.2	11132.9	9.8	13.3
C20	1222.3	167.7	2419.7	13682.4	1390.0	16102.2	11.6	13.3
R1000	756.5	262.0	1340.6	8318.4	1018.4	9659.0	9.5	13.1
C20R1000	778.5	249.1	1340.7	8637.5	1027.5	9978.3	9.7	13.1

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