ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Maximizing the performance, productivity and quality traits of two flax cultivars by using some bio-fertilizers under newly reclaimed sandy soil.

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ABSTRACT

Two field experiments were carried out at the Research and Production Station, National Research Centre, Al-Nubaria district, El-Behaira Governorate, Egypt, during the two successive winter seasons 2013/2014 and 2014/2015.The aim of this study was to investigate the effect of whey, chicken and farmyard manures as biofertilizer and their combination effects on yield, yield components, some biochemical constituents and quality traits of two flax cultivars (Letwania-1 and Opal) grown under sandy soil conditions**.** The obtained results indicated that Opal and Letwania-1 varieties differed significantly in all studied traits in combined analysis. Letwania-1 variety surpassed significantly Opal in seed and oil yields/feddan. Results indicated that the highest seed yield (607.81 kg/fed.), straw yield (2.32 tons/fed.) and oil yield (223.81 kg/fed.) were obtained with treatment of organic fertilizer at (5 ton /fed.) with whey foliar treatment of (50 l/fed). Data recorded that there was a significant increase in all growth parameters and photosynthetic pigments in term of (shoot length (cm), fresh, dry weight of shoot/plant, chlorophyll a and b, carotenoids and total pigments content**.** the interaction between treatment of chicken manure + Whey with Letwania-1 variety caused a significant increase in total carbohydrates, polysaccharides, total IAA and total phenol content. The interaction of FYM + Whey with Opal variety gave the highest value of the total phenol content, while the same variety with the treatment of chicken manure + Whey gave the highest value of the total carbohydrates contents in seeds**.** The application of FYM + Whey increased the biological yield by about 115.79 % for Letwania-1 and 95.09 % for Opal, this was due to the straw yield/feddan increase by 104.67% and 128.97 % for the two flax cultivars in the same order. However, seed yield/ feddan increased due to Whey, FYM, FYM + Whey, chicken manure and chicken manure + Whey over to control treatment by 30.91, 18.52, 66.0, 17.79 and 33.68 % for Opal variety and by 12.72, 19.35, 58.27, 16.44 and 37.95 % for Letwania-1 variety.

Keywords: flax, varieties, whey, biofertilizers, seed, straw and oil yields.

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INTRODUCTION

Flax (*Linum usitatissimum* L.) is old economic crop grown as oil, fiber and dual purpose crop. Because of quick air drying oil, it's utilized for making of paints, varnishes, printing ink, oil cloth and soap. In Egypt, flax assumes an important role in the national economy attributable to export beside local industry. Flax is considering the second fiber crop after cotton in Egypt with regard to the cultivated area and economic importance [1]. Nowadays, the advantages of flax have passed all expectations. Regardless the well-known conventional uses, the crop has more advantages in producing feeding animals and poultry. Also, in producing few sorts of compact wood, popular in name particle board. The crop is also common in few fine industries in which making electric insulations and non-textile medical materials are the most important. More important is that identified to producing bank note papers. Flax varieties differed in seed yield and its components and also seed oil content [2].

Linseed is widely used medicinally due to a high ratio of α-linolenic (omega-3) to linoleic (omega-6) unsaturated fatty acids, and it is one of the richest sources of omega-3 fatty acid. Treatment with 1 g per day of Omega-3 fatty acid decreased occurrence the diseases of cardio-vascular and sudden cardiac death [3]. In many arid and semiarid regions of the world, drought is considered probably the most vital factor limiting crop productivity. It minimizes plant growth by affecting various physiological and biochemical processes, [4].

Increasing the production of flax could be achieved through vertical expansion (growing high yielding genotypes) and/or by horizontal expansion (sowing the newly reclaimed lands) which desert area represented about 95% from the area of Egypt. The soil of Nubaria District, Egypt like sandy soils are Sdescribe very low organic matter, low water availability and nutrients deprivation. Such soil factors are known to limit mobility and availability of soil fertilizers therefore organic fertilization, as a particular way to supply macro and micro-nutrients.

Chemical fertilizers caused environmental pollution. Recently, under Egyptian conditions a great interest is being devoted to minimize, high rates of chemical fertilizers, the cost of production and environmental pollution to minimizing rates of nitrogen and phosphorus fertilization. Organic fertilization can be viewed as viable to supply nutritional plant requirements. The effect of organic fertilizers on the soil characteristics, such as physical, chemical, and biological ones has been well known for a long time. Soil organic matter contains residues of plants and animals and primary & high polymer organic compounds formed by their decomposition. [5] They found that, treatments of organic fertilizer levels of (6.0 tons/fed), led to cause significant increases in all yield and yield components in both cultivars compared to control.

In most food production, byproducts are inescapable. Such products have been taken into consideration as waste and dumped as sewage. Nowadays, with more consideration to environmental issues, such sewage is being put a multiplicity of uses [6, 7 and 8]. Whey, is the byproduct of cheese production, compares to cheese making as buttermilk compares to butter manufacture. Whey might be characterized as the serum or water part of milk staying after separation of the curd from the coagulation of milk by acid or proteolytic enzymes [9]. Whey has low economic value and is composed of 93% water and 7% solids; it is rich in minerals, the use of whey being important for nutrition and microbiological growth is another strategy to enhance nutrient outflow to plants. It has been used as fertilizer to encourage plant growth and also increase microorganism population in the soil (10-11]. The use of whey as manure for fields is another strategy to enhance nutrient outflow to plants. The milk whey consists of several minerals such as N, P, K, S, Ca, Na, Mg, lactose and proteins [12]. So, the use of milk whey as biofertilizer is being important for plant nutrition and growth, also it has been used to enhance microorganism population in the soil [11and 13]. Applied Whey on the soil as for fertilization to improve soil structure, and increases water aviability of the soil and for increasing plants productivity [14].

Organic material is used to decrease soil salinity and increase the organic matter, improve soil structure and increase water and air permeability by root developing in soil which improved plant growth, development. It is the best one of fertilizers used [15-16]. Among the organic fertilizers available in large quantities is chicken manure. [17] reported that fresh poultry contain twice as much as farmyard manure. They are much richer in phosphorus and contain as much potassium as farmyard manure. Compost of droppings and straw are richer in NPK than farmyard manure. Recently, organic substrates as chicken manure have been used to improve soil structure. In seedling production in vegetables, obtaining suitable growth medium is essential. The addition of organic residues could improve physical conditions of growth [18-19]. Little research work on whey and chicken manure as a biofertilizer in agriculture has been carried in Egypt desert. Therefore the objectives of this research were to investigate whey, chicken and farmyard manures as biofertilizer and their combination effects on yield, yield components, some biochemical constituents and quality traits of two flax cultivars grown under sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out at the experimental Station of National Research Centre, Nubaria district El-Behrea Governorate–Egypt, during two successive winter seasons of 2013/2014 and 2014/2015. Soil of the experimental site was sandy soil where mechanical and chemical analysis is reported in Table (1) according to [20].

Table 1: Soil physio-chemical characters

Sand %	88	K	10.18
Silt %	4	Ca mg/100g	92.0
Clay %	7.2	Mg	18.4
Texture	Sandy	Na	12.36
pH (1: 2.5 water)	8.83	Fe	8.92
E.C(mmhos/cm)(1:2.5)	0.12	Mn mg/kg	8.34
CaCO3 %	4.8	Zn	0.13
O.M %	0.24	Cu	0.10
P	0.22		

The experimental design was split plot design with three replication, where flax seed varieties (Letwania-1 and Opal) occupied the main plots, while the fertilizers treatments were allocated at random in sub plots as follow:

1- Control
2- Organic fertilizer of farm yard manure (FYM) at rate of (5.0 ton/fed).
3- Chicken manure fertilizer at rate of (2 ton/fed).
4- Whey foliar application at rate of (50 l/fed).
5- Organic fertilizer (FYM) at rate of (5.0 ton/fed) + Whey foliar application at rate of (50 l/fed).
6- Chicken manure at rate of (2 ton/fed). + Whey foliar application at rate of (50 l/fed).

Flax seed cultivars were sown on the 15th November in both season in rows 3.5 meters long, and the distance between rows was 20 cm apart, Plot area was 10.5 m^2 (3.0 m in width and 3.5 m in Length). The recommended agricultural practices for growing flax seed were applied and the seeding rate was 2000 seeds/m^2). Pre-sowing, 150 kg/fed. of calcium super-phosphate (15.5 % P_2 O_5). Nitrogen was applied after emergence in the form of ammonium nitrate 33.5% at rate of 75 Kg/fed., were split to five equal doses. Potassium sulfate (48.52 % K_2O) was added at two equal doses of 50 kg/fed,. Irrigation was carried out using the new sprinkler irrigation system where water was added every 5 days. Foliar application of whey was carried out twice; where plants were sprayed after 30 and 50 days from sowing and skipping the irrigation at 45 and 60 days after sowing after application of treatments.. Plant samples were taken after 75 days from sowing for measurements growth characters were measured in terms of, plant height shoots (cm) fresh and dry weight g/plant, roots length(cm), root fresh and dry weight(g). Plant samples were dried in an electric oven with drift fan at 70°C for 48 hr. till constant dry weight. Plant samples were taken for chemical analysis after 75 days from sowing for chemical analysis of total soluble sugars, polysaccharides, total carbohydrates, total IAA, total phenol content, proline, free amino acids contents and lipid peroxidation.

Flax plants were pulled when signs of full maturity were appeared, then left on ground to suitable complete drying. Capsules were removed carefully. At harvest the characters were recorded on random samples of ten guarded plants in each plot to estimate the following characters:

Total Plant height (cm), Technical stem length (cm), Fruiting zone length (cm), Number of fruiting branches / plant , Number of capsules / plant, Seed yield / plant (g), Biological yield/ plant (g), Seed yield (kg / fed), Straw yield/ (ton/fed), Seed oil %, Oil yield (kg/fed) was calculated by Seed yield (kg / fed) * Seed oil (%) and fatty acid profile.

ISSN: 0975-8585

Chemical analysis:

Photosynthetic Pigments:

Total chlorophyll a and b and carotenoids contents in fresh leaves were estimated using the method of [21]. The fresh tissue was ground in a mortar and pestles using 80% acetone. The optical density (OD) of the solution was recorded at 662 and 645 nm (for chlorophyll a and b, respectively) and 470 nm (for carotenoids) using a spectrophotometer (Shimadzu UV-1700, Tokyo, Japan). The values of photosynthetic pigments were expressed in mg/100g FW.

Total soluble sugars (TSS):

Total soluble carbohydrates (TSS) were extracted by overnight submersion of dry tissue in 10 ml of 80% (v/v) ethanol at 25°C with periodic shaking, and centrifuged at 600g. The supernatant was evaporated till completely dried then dissolved in a known volume of distilled water to be ready for determination of soluble carbohydrates (Homme et al. 1992). TSS were analyzed by reacting of 0.1 ml of ethanolic extract with 3.0 ml freshly prepared anthrone (150 mg anthrone + 100 ml 72% H_2SO_4) in boiling water bath for ten minutes and reading the cooled samples at 625 nm using Spekol SpectrocololourimeterVEB Carl Zeiss [22].

Total carbohydrate:

Determination of total carbohydrates was carried out according to [23]. A known mass (0.2-0.5 g) of dried tissue was placed in a test tube, and then 10 ml of sulphuric acid (1N) was added. The tube was sealed and placed overnight in an oven at 100ºC. The solution was then filtered into a measuring flask (100ml) and completed to the mark with distilled water. The total sugars were determined Colorimeterically according to the method of [24] as follows: An aliquot of 1ml of sugar solution was transferred into test tube and treated with 1ml of 5% aqueous phenol solution followed by 5.0 ml of concentrated sulphuric acid. The tubes were thoroughly shaken for ten minutes then placed in a water bath at 23-30ºC for 20 minutes. The optical density of the developed color was measured at 490 nm using Shimadzu spectrophotometer model UV 1201.

Indole acetic acid content:

A known weight of the fresh samples was taken and extracted with 85% cold methanol (v/v) for three times at 0OC. The combined extracts were collected and made up to a known volume with cold methanol. Then take 1ml of the methanolic extract and 4ml of PDAB reagent (para-dimethylamino benzoic acid 1g dissolve in 50 ml HCl, 50 ml of ethanol 95%) and left for 60 min in 30-400C. The developing colour was spectophotometrically measured at wave length of 530 nm. As described by [25].

Total phenol content:

The extract was extracted as IAA extraction, and then 0.5 ml of the extraction was added to 0.5 ml Folin, shaked and allowed to stand for 3 min. Then one ml of saturated sodium carbonate was added to each tube followed by distilled water shaken and allowed to stand for 60min. The optical density was determined at wave length of 725 nm using spectrophotometer as described by [26].

Oil determination:

The oil of flax seeds were extracted according to [27], the powdered seeds is shaken overnight with isopropanol: chloroform (1:1). The solvent were evaporated under reduced pressure of CO_2 atmosphere. The lipid residue is taken up in a chloroform: methanol (2:1 v/v) and given a folch wash, the dissolved total oils were purified by washing with 1% aqueous saline solution. The aqueous phases were washed
With chloroform that was combined with the pure oil solution. Chloroform was evaporated and the total pure oil was weighed.

ISSN: 0975-8585

Statistical analysis:

The obtained results were subjected to statistical analysis of variance according to method described by [28], since the trend was similar in both seasons the homogeneity test Bartlet's equation was applied and the combined analysis of the two seasons was calculated according to the method of [29]. Means were compared by using least significant difference (LSD) at 5% levels of probability.

RESULTS AND DISCUSSION

Cultivars differences:

Table (2) indicated that Opal and Letwania-1 varieties differed significantly in all studied traits in combined analysis. Letwania-1 variety surpassed significantly Opal in seed and oil yields/feddan due to its great number of capsules, fruiting branches and seed yield/plant, 1000-seeds weight, fresh and dry weight/plant, chlorophyll a, total pigments, total carbohydrates, polysaccharides, Indol acetic acid and total phenol contents, In addition, Opal variety surpassed significantly Letwania-1 in high straw yield/feddan was due its superiority in plant height, technical stem length, biological yield/ plant and per fed., chlorophyll b, carotenoids, total soluble sugar and flavenoids contents than Opal. These results are confirmed with those obtained by other investigators [1], [30], [31-33], [5] and [34]. They found that the flax varieties differed in seed productivity, Moreover, the variability among flax varieties which may be expected because of the differences of these varieties in origin and growth habit, where, these flax varieties are grown for double purpose crop oil and fibers under the conditions of this trail.

Table (2): Effect of varieties on some morphological characters, chemical contents, yield and its components of flax under newly reclaimed sandy soil (Combined analysis of two growing seasons 2013/2014 and 2014/2015).

Characters	Varieties		LSD 0.05
	Opal	Letwania-1	
shoot length (cm)	50.84	52.31	1.05
fresh wt/plant (g)	6.16	10.73	2.15
dry wt/ plant (g)	0.66	1.25	0.33
chlorophyll a (mg/100g fresh wt)	12.711	13.367	1.03
chlorophyll b (mg/100g fresh wt)	4.622	4.576	0.10
Carotenoids (mg/100g fresh wt)	4.164	4.114	0.023
Total pigments (mg/100g fresh wt)	21.497	22.056	1.010
Total carbohydrates (Mg/100g dry wt.)	18.08	23.01	2.01
Total soluble sugar (Mg/100g dry wt.)	2.89	2.69	0.06
Polysaccharides (Mg/100g dry wt.)	15.19	20.32	2.02
IAA (Mg/100g fresh wt.)	35.67	40.27	0.42
Phenol (Mg/100g fresh wt.)	36.02	43.42	0.53
flavenoids (Mg/100g dry wt.)	36.82	18.56	0.41
Total carbohydrates (Mg/100g dry wt.) in seed	30.28	28.19	0.22
Phenol (Mg/100g dry wt.) in seed	234.99	223.19	3.79
Plant height (cm)	71.79	62.77	3.25
fruiting zone length (cm)	12.20	13.10	0.33
Technical stem length (cm)	59.59	49.67	2.39
Biological yield /plant (g)	4.13	3.77	0.44
No of fruiting branches/ plant	3.44	3.63	0.16
No. of capsules/ plant	19.26	20.17	0.45
Seed yield/ plant (g)	1.39	1.63	0.18
1000 seeds weight (g)	4.84	5.09	0.26
seed yield (kg/fed)	454.40	490. 51	12.17
Biological yield (ton/fed)	2.259	2.152	12.17
straw yield (ton/fed)	1.804	1.678	0.077
Oil%	37.40	36.21	1.01
oil yield (kg/fed)	168.25	171.17	1.12

ISSN: 0975-8585

Effect of treatments:

Data presented in Table 3 showed that there were significant differences among all treatments of all studied characters under this trail. Results indicated that the highest seed yield (607.81 kg/fed.), straw yield (2.32 tons/fed.) and oil yield (223.81 kg/fed.) were obtained with treatment of organic fertilizer at (5 ton /fed.) + whey foliar treatment of (50 l/fed). This may be due to the highest shoot length, shoot fresh and dry weight per plant, as well as the significant increase in photosynthetic pigment (chlorophyll a, carotenoids and total pigments), total soluble sugar and flavenoids contents of flax shoots. In addition, the same treatment increased seed yield/fed by 61.9 %, straw yield/fed by 107.1 % and oil yield by 68.3 % over the control. These increase due to its great plant height (76.23 cm), technical stem length (59.91 cm), fruiting zone length (16.32 cm), number of fruiting branches/plant (5.41), number of capsules per plant (27.19), seed yield per plant (2.21 g), biological yield per plant (5.41g), 1000 seed weight (5.60 g) and oil seed percentage (36.94 %) compared with the other treatments. These results are in agreement with those obtained by several investigators. Organic manure plays a direct effect in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improves physical and chemical properties of soils [35-36] pointed that organic matter plays an important role in the chemical behavior of several metals in soils throughout its active groups (Flavonic and humic acids) which have the ability to retain the metals in complex and chelate forms fertilizers by using organic farming system [37]. [5] they found that, treatment of organic fertilizer levels of (6.0 tons/fed), tended to cause significant gradual increases in all yield and yield components (plant height, technical length, fruiting zone length (cm), number of fruiting branches/plant, number of capsules/plant, biological yield/plant (g), seed yield/plant (g), straw yield (ton/fed) and seed yield (kg/fed) in both cultivars compared to control.

Table (3): Effect of organic, chicken, whey fertilizers and their interaction on some morphological characters, chemical contents and yield and its components of flax under newly reclaimed sandy soil(Combined analysis of two growing seasons 2013/2014 and 2014/2015)

Characters	control	Whey (50 l/fed)	FYM (5 ton/fed)	FYM + whey	Chicken manure (2 ton/fed)	Chicken manure + whey	LSD $_{0.05}$
shoot length (cm)	46.00	51.50	51.34	60.09	49.84	50.67	2.25
fresh wt/plant (g)	4.12	6.98	9.51	13.72	8.89	7.45	1.53
dry wt/ plant (g)	0.57	0.81	1.00	1.46	1.10	0.81	0.13
chlorophyll a (mg/100g fresh wt)	11.18	12.958	13.876	14.892	11.971	13.358	1.013
chlorophyll b (mg/100g fresh wt)	3.477	4.338	4.015	5.478	5.930	4.358	0.217
Carotenoids (mg/100g fresh wt)	3.756	4.201	4.121	4.751	3.715	4.290	0.110
Total pigments (mg/100g fresh wt)	18.412	21.496	22.012	25.12	21.616	22.005	1.050
Total carbohydrates (Mg/100g dry wt.)	16.62	18.78	18.14	21.89	19.31	28.52	3.47
Total soluble sugar (Mg/100g dry wt.)	2.46	2.54	2.79	3.15	2.6	3.19	0.11
Polysaccharides (Mg/100g dry wt.)	14.17	16.24	15.35	18.74	16.71	25.33	3.49
IAA (Mg/100g fresh wt.)	24.91	31.21	38.46	45.43	37.97	49.84	0.72
Phenol (Mg/100g fresh wt.)	24.63	33.2	36.55	45.07	43.7	55.19	0.91
flavenoids (Mg/100g dry wt.)	23.14	25.95	26.08	31.9	28.48	30.57	0.69
Total carbohydrates (Mg/100g dry wt.) in seed	27.19	28.21	28.98	29.13	30.76	31.15	0.38
Phenol (Mg/100g dry wt.) in seed	194.14	207.85	201.89	279.26	215.68	275.73	6.56
Plant height (cm)	60.96	65.95	64.41	76.23	67.45	68.69	3.06
fruiting zone length (cm)	9.12	10.39	11.69	16.32	13.68	14.71	1.17
technical length	51.84	55.56	52.72	59.91	53.78	53.99	1.03
Biological yield /plant(g)	1.91	4.26	4.11	5.06	4.36	4.01	0.41
no. of fruiting branches/ plant	1.96	3.54	3.18	5.41	3.24	3.87	0.35
no. of capsules/ plant	9.76	18.70	21.61	27.19	19.59	21.44	1.15
Seed yield/ plant (g)	1.00	1.55	1.56	2.21	1.29	1.44	0.22
1000 seeds weight (g)	4.32	5.03	4.79	5.60	4.83	5.22	0.16
seed yield kg/fed	375.34	455.43	446.50	607.81	439.44	510.21	18.45
Biological yield (ton/fed)	1.50	2.05	2.15	2.93	2.07	2.54	0.17
Straw yield (ton/fed.)	1.12	1.59	1.76	2.32	1.63	2.03	0.22
Oil%	35.74	37.53	38.22	36.94	36.01	36.39	0.11
Oil yield (kg/fed.)	133.00	172.31	151.51	223.81	152.69	184.92	2.13

Effect of interaction:

Statistical analysis revealed that interactions had significant effects on all studied traits in the combined analysis (tables 4, 5 and 6)

1- Changes in growth parameters and Photosynthetic pigments:

The results reported in Table (4) showed the effect of organic, chicken and whey fertilizers in two flax varieties in response to drought stress. Data recorded that there was a significant increase in all growth parameters and photosynthetic pigments in term of (shoot length (cm), fresh, dry weight of shoot/plant, chlorophyll a and b, carotenoids and total pigments content. due to organic, chicken with whey fertilizers application compared with untreated control plants. This promoting effect reached maximum with treatment of interaction between organic fertilizers at level of (5 ton /fed) + whey fertilizers at level of (50 l/fed) with Letwania-1 variety for fresh and dry weight/plant, chlorophyll a and carotenoids characters, while the same treatments with Opal variety gave the highest values of shoot length and total pigments, These results are in agreement with those obtained by [38] they found that whey treatment at 50% level induced a marked increase in shoot length, shoot fresh and dry weight and leaf area of wheat plants, whey appeared to enhance hill activity and photosynthetic pigments, which only 50% level of whey increased total 14C photoassimilates. [39] Concluded that the purpose of adding Whey to the soil as fertilizer was improving soil structure, increasing water holding capacity and porosity of the soil besides increasing crops productivity. Because of its qualities, whey is active as plant nutrition as well as nutrient of microorganisms existing in soil micro flora. [40] Studied the effects of whey on the colonization and sporulation of AMF in lentil particularly with the application of low doses of whey. These researchers also stated that nutrition status inside plant increment because of utilize of whey also influenced the development of AM fungus which is an obligate microorganism. [41] Reported that poultry manure or chicken manure mixed with fertilizer sheep provides the plant greatly advantage from the nutrients leading to improved production and quality.

Table (4): Effect of interaction between organic, chicken, whey fertilizers and their interaction on morphological characters and chlorophyll contents of two flax varieties under newly reclaimed sandy soil (Combined analysis of two growing seasons 2013/2014 and 2014/2015)

Cultivars	Treatments	shoot length (cm)	fresh wt/plant (g)	dry wt/ plant (g)	chlorophyll a	chlorophyll b	Carotenoids	Total pigments
					(mg/100g fresh wt)			
Opal	control	43.00	2.17	0.35	11.546	3.724	3.879	19.149
	whey	52.00	5.13	0.46	12.918	4.658	4.296	21.872
	FYM	51.00	5.82	0.64	12.868	4.205	4.202	21.275
	FYM + whey	62.67	10.78	1.12	14.528	6.541	4.667	25.736
	chicken manure	46.67	8.05	0.87	11.669	4.558	4.009	20.236
	Chicken + whey	49.67	5.00	0.54	12.737	4.045	3.930	20.712
Letwania-1	control	49.00	6.07	0.79	10.813	3.229	3.632	17.674
	whey	51.00	8.83	1.16	12.997	4.017	4.106	21.120
	FYM	51.67	13.20	1.35	14.883	3.825	4.040	22.748
	FYM + whey	57.50	16.65	1.80	15.256	4.414	4.834	24.504
	chicken manure	53.00	9.73	1.32	12.273	7.302	3.420	22.995
	Chicken + whey	51.67	9.90	1.08	13.978	4.670	4.649	23.297
LSD 0.05		2.15	1.03	0.13	0.335	0.123	0.151	1.45

2- Changes in chemical constituents.

Data presented in Table 5 indicated that all of chemical studied characters were respond positively to fertilizers application but with different magnitude for the two flax cultivars. For example, TSS and flavenoids characters of Opal variety increased significantly due to application of chicken manure + Whey. While, such increase did not reach to significance level for the treatment of FYM + Whey with the same variety. On the other hand, the data in same Table indicated that the interaction between treatment of chicken manure +

ISSN: 0975-8585

Whey with Letwania-1 variety caused a significant increase in total carbohydrates, polysaccharides, total IAA and total phenol content. The interaction of FYM + Whey with Opal variety gave the highest value of the total phenol content, while the same variety with the treatment of chicken manure + Whey gave the highest value of the total carbohydrates contents in seeds. These results are in confirmed with those obtained by [38] they found that whey treatment at 50% level increased total 14C photo assimilates and consequently soluble and insoluble carbohydrate of wheat plants. Moreover, this treatment induced increase in total carbohydrates and total nitrogen content of wheat seedlings.

Table (5): Effect of interaction between organic, chicken, whey fertilizers and their interaction on chemical contents of flax varieties under newly reclaimed sandy soil (Combined analysis of two growing seasons 2013/2014 and 2014/2015).

Treatments		Total carbohydrates (Mg/100g dry wt.)	Total soluble sugar (Mg/100g dry wt.)	Polysaccharides (Mg/100g dry wt.)	IAA (Mg/100g fresh wt.)	Phenol (Mg/100g fresh wt.)	flavenoids (Mg/100g dry wt.)	Total carbohydrates (Mg/100g dry wt.) in seed	Phenol (Mg/100g dry wt.) in seed
Opal	control	14.72	2.49	12.24	20.41	19.63	33.20	28.47	202.80
	whey	16.77	2.67	14.11	25.61	29.47	37.10	29.34	220.23
	FYM	15.82	2.80	13.02	38.52	34.75	35.13	30.52	202.35
	FYM + whey	20.81	3.29	17.52	45.15	44.30	39.17	29.69	310.40
	chicken manure	17.82	2.69	15.14	36.20	38.95	37.03	31.70	213.57
	Chicken + whey	22.53	3.42	19.11	48.17	49.02	39.27	31.95	260.61
Letwania-1	control	18.52	2.43	16.10	29.41	29.64	13.08	25.91	185.48
	whey	20.78	2.42	18.37	36.81	36.93	14.80	27.09	195.47
	FYM	20.46	2.78	17.69	38.41	38.35	17.03	27.44	201.43
	FYM + whey	22.98	3.02	19.96	45.71	45.83	24.63	28.56	248.13
	chicken manure	20.80	2.52	18.28	39.74	48.45	19.94	29.82	217.78
	Chicken + whey	34.52	2.96	31.56	51.52	61.36	21.88	30.34	290.86
LSD 5%		2.01	0.19	1.37	1.27	1.60	1.22	0.67	11.51

3- **Changes in yield and yield components.**

Data in Table (6) showed that there were significant differences in all studied characters due to the interaction between the two flax cultivars and the treatments of fertilizers application.

Data presented in Table 6 indicated that all of studied characters were respond positively to fertilizers application but with different magnitude for the two flax cultivars. For example, fruiting zone length, number of capsules/plant and oil yield/feddan of Letwania-1 variety increased significantly due to application of FYM + Whey. While, such increase did not reach to significance level for Opal variety. Table 6 also, indicated that application of FYM + Whey increased the biological yield by about 115.79 % for Letwania-1 and 95.09 % for Opal; this was due to the straw yield/feddan increase by 104.67% and 128.97 % for the two flax cultivars in the same order. However, seed yield/ feddan increased due to Whey, FYM, FYM + Whey, chicken manure and chicken manure + Whey over to control treatment by 30.91, 18.52, 66.0, 17.79 and 33.68 % for Opal variety and by 12.72, 19.35, 58.27, 16.44 and 37.95 % for Letwania-1 variety. In addition there were significant differences in all studied characters due to the interaction between the two flax cultivars and all treatments of fertilizers. Opal x FYM + Whey produced the tallest plants (87.18 cm); tallest fruiting zone and technical stem length (15.96 and 71.22 cm), while, Letwania-1 with the same treatment gave the highest values of seed yield /plant (2.48 g) and heaviest 1000 seeds weight (5.82 g).

ISSN: 0975-8585

Table (6): Effect of interaction between organic, chicken, whey fertilizers and their interaction on seed, Straw and oil yields and there components of flax varieties under newly reclaimed sandy soil (Combined analysis of two growing seasons 2013/2014 and 2014/2015).

cultivars	Treatment	Plant height (cm)	fruiting zone length (cm)	technical length (cm)	Bio. yield /plant (g)	No of fruiting branches/ plant	No. of capsules/ plant	Seed yield/ plant (g)	1000 seeds weight (g)	seed yield kg/fed	Bio. yield (ton/fed)	straw yield (ton/fed)	Oil%	oil yield kg/fed
Opal	control	61.6	9.13	52.47	2.43	1.66	11.33	1.07	4.35	355.5	1.425	1.070	36.42	128.49
	whey	69.25	11.15	58.1	5.96	3.35	22.15	1.22	4.75	465.4	2.375	1.910	38.44	179.59
	FYM	66.69	10.22	56.47	3.61	3.03	20.21	1.55	4.5	421.35	2.25	1.829	38.78	164.43
	FYM + whey	87.18	15.96	71.22	4.55	5.66	26.19	1.93	5.38	590.15	2.78	2.190	37.85	222.56
	Chicken manure	72.35	13.1	59.25	4.69	2.37	18.02	1.19	4.97	418.75	2.233	1.814	36.37	143.15
	Chicken manure + whey	73.69	13.66	60.03	3.55	4.55	17.63	1.35	5.06	475.25	2.489	2.014	36.53	171.25
Letania-1	control	60.31	9.11	51.2	1.39	2.25	8.19	0.92	4.28	395.18	1.565	1.170	35.05	137.52
	whey	62.65	9.63	53.02	2.55	3.73	15.25	1.88	5.3	445.45	1.715	1.270	36.62	165.03
	FYM	62.13	13.16	48.97	4.6	3.32	23.01	1.56	5.07	471.65	2.055	1.683	37.66	138.59
	FYM + whey	65.27	16.67	48.6	5.57	5.15	28.19	2.48	5.82	625.47	3.075	2.450	36.02	225.05
	Chicken manure	62.55	14.25	48.3	4.03	4.11	21.15	1.39	4.69	460.13	1.915	1.455	35.64	162.23
	Chicken manure + whey	63.69	15.75	47.94	4.46	3.19	25.25	1.52	5.37	545.17	2.589	2.044	36.24	198.60
LSD 0.05		2.77	2.13	3.47	0.35	0.17	3.04	0.16	0.17	15.33	0.225	0.108	0.52	4.17

4- Changes in Fatty acid profile of the oil yield.

Data presented in Table (7) showed that the predominant saturated fatty acids were palmitic acid and stearic acid While, Linolneic, Linoleic and Oleic acids were the predominant as unsaturated fatty in the two flax cultivars. Linoleic acid and linolenic acid are essential for humans because our bodies cannot manufacture them and we must consume them in our diets (Morris, 2003). The oil quality is usually valued according to the content of essential fatty acids (Johnson et al., 2008).

Exposure of the two flax cultivars plants to all different treatments (Table 7) induced marked increases in total unsaturated fatty acids which the maximum increased reached with treatment of chekin manure + whey with Opal variety and the treatment of FYM + whey with letwania-1 variety compared with control. The maximum of Oleic acid was recorded by treatment of chekin manure + whey with the two flax varieties compare with control. As well as, the same treatment and FYM + whey gave the best values of Linoleic acid recorded with the two flax varieties compared with control. While, the maximum of Linolenic acid was noted by the two treatments of whey and chekin manure gave the same value with Letwania-1 variety compare with control. On the other hand, saturated fatty acids markedly decreased by all treatments compared with control, which the maximum decreased 26 % reached by whey treatment with Opal variety compared with control. [42] Stated that using organic and bio-fertilizers lead to a change in the composition of essential oil in the different plant species. The increase in total unsaturated fatty acid accompanied by decrease in total saturated fatty acid of three flax cultivars by yeast extract treatment was confirmed by [43] on soybean.

The increase in unsaturated fatty acid with decreasing of saturated fatty acids and consequently, increasing in total unsaturated/saturated fatty acids (TUS/TS). Thus the oil yield becomes safer for human consumption. Poly unsaturated fatty acid (PUFA) from flax oil are essential for human diet and lower the risk of diseases related to cholesterol oxidation. Consumption of oleic, linoleic and linolenic acids lowers the level of LDL in human blood. Unfortunately, flax oil with high PUFA content is readily oxidized and thus has a minor role in human diet. Moreover, diets high in saturated fats are correlated with an increased incidence of atherosclerosis and coronary heart disease [44].

Table (7): Mean Effect of interaction between organic, chicken, whey fertilizers and their interaction on oil fatty acids composition of two flax varieties (Combined analysis of two growing seasons 2013/2014 and 2014/2015)

Cultivars	Opal						Lethuania-1					
Treatment	Control	whey	FYM	FYM + whey	Chicken manure	Chicken manure + whey	Control	whey	FYM	FYM + whey	Chicken manure	Chicken manure + whey
Myristic (C14:0)	0.65	0.31	0.60	0.13	0.54	0.65	0.72	0.98	0.65	0.41	0.00	0.14
Palmitic (C16:0)	5.32	5.10	4.28	5.58	4.37	4.25	4.76	5.47	4.41	4.54	4.42	3.41
Stearic (C18:0)	4.52	3.28	4.25	3.36	4.35	3.26	4.81	3.09	3.42	2.01	3.61	2.61
Oleic (C18:1)	22.45	23.46	23.33	24.37	23.26	24.46	21.24	22.41	22.14	22.54	22.46	22.68
Linoleic (C18:2)	15.31	16.26	15.56	18.45	16.26	18.52	18.52	20.15	20.36	21.42	19.42	20.15
Linolenic (C18:3)	42.21	45.99	45.85	45.12	46.36	46.41	46.41	47.21	45.23	46.01	47.21	46.27
Beheric (C22:0)	0.48	0.00	0.19	0.02	1.25	0.26	0.25	0.13	0.02	2.13	0.27	1.12
Lignocenic(C24:0)	0.00	0.02	0.11	0.00	0.00	0.59	0.00	0.26	0.46	0.34	0.00	1.41
Total unsaturated	79.97	85.71	84.74	87.94	85.88	89.39	86.17	89.77	87.73	89.98	89.09	89.09
Total saturated	10.97	8.70	9.43	9.08	10.51	9.01	10.54	9.93	8.97	9.44	8.30	8.69
Total identified	90.94	94.41	94.16	97.03	96.39	98.40	96.71	99.70	96.70	99.42	97.39	97.79
T Uns./TS	7.29	9.85	8.99	9.68	8.17	9.92	8.17	9.04	9.78	9.53	10.73	10.25

Acknowledgement

This work was sported and funded by National Research Centre through the project entitled: (Increasing performance and Productivity of Flax and Sesame Crops under Newly Reclaimed sandy Soil). Project No. (10120201), during in-house projects strategy 2013-2016.

ISSN: 0975-8585

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