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Effect of Cattle Manure, Active Dry Yeast and Humic Substances on Growth, Seed Yield and Oil Productivity of Evening Primrose (*Oenothera biennis*) Plants

[1]S. H. El-Hanafy, [1]H. A. Mansour, [2]E. O. El-Ghawwas and [2]S. N. Abd El-Khalek

[1]Ornamental Horticulture Department, Faculty of Agriculture, Cairo University
[2]Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt

Abstract : This study was conducted at the farm of the Medicinal and Aromatic Plant Research Department in El-Kanater El-Khaireya, Kalyubeia Governorate, Horticulture Research Institute during the two successive years of 2012/2013 and 2013/2014. A field experiment was carried out to study the effect of cattle manure at the rates of 15 or 30 m^3/fed., active dry yeast at 4 or 8 g/l water, humic substances at 1 l/fed., or combinations of these treatments, on the growth, seed yield and oil productivity of evening primrose (*Oenothera biennis*), compared to those obtained with the recommended dose of inorganic NPK fertilization [150 kg $fed.^{-1}$ ammonium nitrate (33%), 60 kg $fed.^{-1}$ calcium superphosphate (15.5%) and 60 kg $fed.^{-1}$ potassium sulphate (48%)]. The obtained results indicate that the highest values of plant growth and yield parameters (viz. plant height, number of branches/plant, fresh and dry weights/plant, number of capsules/plant, seed yield/plant, seed yield/fed., oil percentage, oil yield per plant and oil yield per fed.) were obtained with using the triple combination of cattle manure at 15 m^3/fed., yeast at 4 g/L water and humic substances at 1 L/fed.
Key words: evening primrose (*Oenothera biennis*), cattle manure, active dry yeast, humic substances.

Introduction

Evening primrose (*Oenothera biennis* L.) belongs to the *Onagraceae* family, and is a biennial plant which is cultivated as an annual crop [1]**.** It is an oil seed crop due to the presence of gamma linolenic acid (GLA), an unsaturated fatty acid, which has noticeable pharmaceutical and nutritional values[2,3,4]**.** Rheumatic arthritis, breast pain and skin disorders (like eczema) are positively influenced by evening primrose seed oi1[5]**.** The increased marketing for this plant has given producer the opportunity to replace food crops by non-food crops[6]**.** Despite the presence of higher levels of gamma linolenic acid (GLA) in seeds of plants such as black currant (*Ribes nigrum*), borage (*Borago officinalis*) and the oil produced by some species of the fungus *Mucor* genus[7,8], evening primrose oil appears to have the most biologically active form of GLA[9]**.** The special composition of fatty acids in triacylglycerol molecules makes the GLA of evening primrose oil easily accessible to hydrolysis by pancreatic lipase in the small intestine[10]**.**

Organic fertilization is the main source of nutrients and energy for soil microorganisms, providing macronutrients and most micronutrients for the plants. Organic fertilizers also benefit agriculture by keeping costs low and returns high[11,12]**.**

Active dry yeast is a natural safe biofertilizer which causes various promotive effects on plants [13]. It is considered as a natural source of cytokinins which stimulate cell division and enlargement, as well as the synthesis of protein, nucleic acid and B-vitamin[14]**.** It also releases CO_2, which is reflected in improving net photosynthesis[15,16]**.**

The use of humic substances (HS) to improve crop growth has been the subject of a substantial body of research over decades. HS refers to a complex, heterogeneous mixture of organic materials arising from the decay of plant and animal residues[17,18]**.** HS can be characterized as humic acid, fulvic acid, and humin on the basis of solubility in water as a function of pH. [19] reported effects of HS on soil physiochemical properties include stabilization of soil structure and increased cation exchange[20,21]. Root growth enhancement has been attributed to improved soil structure, stimulation of soil microflora, and auxin-like effects[22]**.**

The aim of the study is to investigate the effect of cattle manure, dry yeast and humic acid on growth, yield and chemical constituents of Evening Primrose (*Oenothera biennis* L.) plants, and to assess the possibility of reaching the highest seed and oil productivity by applying organic fertilizer treatments, compared to mineral fertilizers.

Materials and Methods

This study was conducted at the farm of the Medicinal and Aromatic Plant Research Department in El-Kanater El-Khaireya, Kalyubeia Governorate, Horticulture Research Institute (one of the research institutes of the Agricultural Research Center, Dokki, Giza), during the two successive years of 2012/2013 and 2013/2014.

Oenothera biennis L. seeds were obtained from the Medicinal and Aromatic Plant Research Department, Horticulture Research Institute, (Agricultural Research Center, Dokki, Giza) and were sown on 20th October 2012 and 2013 (in the two seasons, respectively) in rows in nursery beds inside a greenhouse (in a peat moss medium), where they germinated within 10-15 days. Two months after sowing the seeds (on 20th December, 2012 and 2013 in the two seasons), when the seedlings were 15-20 cm in height, they were transplanted to the prepared plots in the experimental field.

The experimental field was divided into plots, with each plot (2.5×3 m) containing three rows. The rows within each plot were 60 cm apart and 2.50 meters in length. Each plot contained 12 seedlings (4 seedlings per row), with a distance of 60 cm between rows, and a spacing of 60 cm between seedlings in each row.

The chemical analysis of the soil of the experimental field showed that it contained 25.6 ppm N, 106 ppm P_2O_5, 174 ppm K_2O, 5.13 ppm Zn, 2.20 ppm Fe, 1.10 ppm B, 0.64 ppm Mn and 0.47 ppm Cu.

The layout of the experiment was a complete randomized blocks design, with three blocks (replicates) and sixteen treatments, including the control (the recommended dose of NPK).

The tested treatments included:

1. Control (the recommended NPK fertilization)
2. Cattle manure at 15 m^3/fed. (CM1)
3. Cattle manure at 30 m^3/fed. (CM2)
4. Active dry yeast at 4 g/l water (Y1)
5. Active dry yeast at 8 g/l water (Y2)
6. Humic substances at 1 l/fed. (HS)
7. CM1 + HS
8. CM2 + HS
9. CM1 + Y1
10. CM2 + Y1
11. CM1 + Y2
12. CM2 + Y2
13. CM1 + Y1 + HS
14. CM2 + Y1 + HS
15. CM1 + Y2 + HS

16. CM2 + Y2 + HS

The recommended NPK fertilization as described by[23] consisted of:

a. Ammonium nitrate (33%) at the rate of 150 kg/fed., divided into two equal doses, one applied 2 weeks after planting, while the other was applied 4 weeks later.
b. Calcium super phosphate (15.5%) and potassium sulphate (48%), each at the rate of 60 kg/fed., mixed with the soil one day before planting.

The cattle manure was obtained from the Animal Production Department, Agricultural Research Center, El-Kanater El-Khaireya, and was incorporated into the soil to a depth of 15 cm, at the rates of 15 or 30 m^3/fed., 15 days before transplantation (on the 5th of December of each season). (Table 1) shows the physical and chemical characteristics of the used cattle manure in the two seasons.

Table (1): Physical and chemical characteristics of the cattle manure used for fertilization of Evening Primrose (*Oenothera biennis* L.) plants during the 2012/2013 and 2013/2014 seasons.

Cattle manure Characteristics	**1st season**	**2nd season**
Weight of 1 m^3 (kg)	460	472
Moisture content (%)	7.65	8.78
Organic matter (%)	65.24	63.55
Organic carbon (%)	37.80	35.63
Total N (%)	1.73	1.74
C:N ratio	22 : 1	20 : 1
NH_3 - N (ppm)	60.5	58.7
NO_3 – N (ppm)	184.31	195.23
Total P (%)	0.47	0.51
Total K (%)	1.36	1.24
Fe (ppm)	1775.6	1680.4
Mn (ppm)	235.8	210.3
Zn (ppm)	142.5	121.8
Cu (ppm)	42.73	41.74

Table (2): Chemical composition of the humic substances used for fertilization of Evening Primrose (*Oenothera biennis* L.) plants during the 2012/2013 and 2013/2014 seasons

Chemical components	**Concentration (%)**
Humic acid	4.6
Fulvic acid	15
Carbon (C)	2.7
Total Nitrogen (N)	0.5
Phosphorus (P)	0.06
Potassium (K)	0.8
Calcium (Ca)	1.0
Magnesium (Mg)	0.1
Sulfur (S)	1.3
Iron (Fe)	0.32
Boron (B)	0.01

The humic substances solution was applied on the day of transplantation at the rate of 1 litre/feddan. The dilution was 1 litre of humic substances in 30 litres of water and divided on the number of plants and, in each season, the treatment was repeated after 30 and 60 days from the first application. The chemical composition of the humic substances is represented in (Table 2).

Plants receiving the active dry yeast treatments were supplied with the first yeast application (at 4 or 8 g/l water) spraying on plants until the dripping point (the first spray after thirty days from planting), and the treatments were repeated every three weeks throughout the season. All agricultural practices were adopted during both seasons as recommended by [24]**.**

Recorded data:

The data on plant growth characteristics were recorded after three and a half months from planting (at 50% flowering). The recorded data included plant height (cm), number of branches/plant, as well as the plant fresh and dry weights (g). Also, the seeds were collected manually at the ripening stage (after six months from planting), and data were recorded on the number of capsules/plant, seed yield/plant (g) and seed yield/fed. (kg). Also, the oil was extracted from the ripe seeds using the method described by [25] and the oil percentage, as well as the oil yield/plant (g) and the oil yield/fed. (kg) were calculated. The recorded data were subjected to an analysis of variance, and the means were compared using the Least Significant Difference (L.S.D.) test at the 5% level, as described by [26].

Results and Discussion

1. Growth parameters

a. Plant height

Results recorded in the two seasons (Table 3) show that chemical NPK fertilization had a better effect on increasing the height of *Oenothera biennis* plants, in comparison to the addition of cattle manure, yeast or humic substances separately. Moreover, NPK fertilization also gave superior results in comparison to the addition of the combinations of cattle manure and yeast, or cattle manure and humic substances, regardless of the concentrations used.

On the other hand, combining cattle manure, yeast and humic substances gave better results than those caused by NPK fertilization, regardless of concentration used. In both seasons, using the triple combination of CM1, Y2 and HS was associated with the production of the tallest plants (with mean heights of 100 cm in the first season and 111 cm in the second season). These results are in harmony with those obtained by [27]**,** who found that application of active dry yeast increased height and stem diameter of *Oenothera biennis*, compared to the control (without yeast). Also, [28] on *Oenothera biennis* stated that application of organic fertilizers resulted in an increase in plant height, compared to that of control plants. In addition, [29]**,** on *Brassica rapa,* stated that application of humic acids, either as a foliar spray or via irrigation, stimulated shoot growth and gave taller plants than the control.

b. Number of branches/plant

The results presented in (Table 3) show that in both seasons, *Oenothera biennis* plants fertilized with NPK had more branches than those supplied with cattle manure, yeast or humic substances (when added separately), regardless of the concentration used.

On the other hand, the combinations of cattle manure and yeast, or cattle manure and humic substances, caused increases in the number of branches, compared to those obtained when these substances were added separately. In most cases, the difference between the number of branches formed on plants receiving these treatment combinations and plants receiving the NPK treatment was insignificant, especially in the second season.

Table (3): Effect of cattle manure, active dry yeast and humic substances on plant height, number of branches/plant, fresh and dry weight/plant of evening primrose (*Oenothera biennis* L.) plants during the 2012/2013 and 2013/2014 seasons.

*Treatments	Plant height (cm)		Number of branches/plant		Fresh weight/plant (g)		Dry weight/plant (g)	
	F.S.	S.S.	F.S.	S.S.	F.S.	S.S.	F.S.	S.S.
NPK	91.00	102.00	18.00	20.00	705.00	1043.67	190.31	273.09
CM1	80.00	90.67	10.00	11.67	561.00	781.33	158.97	218.69
CM2	84.00	93.67	13.66	17.00	613.66	828.67	172.42	240.05
Y1	76.00	80.33	6.00	8.67	224.00	422.33	60.09	111.81
Y2	79.00	86.33	9.00	13.33	317.33	551.00	85.05	151.90
HS	81.66	88.00	12.33	14.67	405.33	685.00	104.45	180.67
CM1+HS	86.00	97.33	19.00	20.33	706.00	1215.00	196.05	328.44
CM2+HS	90.00	100.00	21.00	22.67	803.00	1333.67	240.89	410.67
CM1+Y1	81.00	90.67	15.00	17.33	525.33	824.00	151.43	231.00
CM2+Y1	86.00	95.67	17.66	19.00	695.00	1000.00	204.35	291.65
CM1+Y2	82.33	93.00	16.67	19.67	634.33	1162.00	195.20	352.46
CM2+Y2	88.00	99.67	19.00	20.33	713.66	1242.67	216.43	391.45
CM1+Y1+HS	93.00	106.33	22.00	25.33	905.33	1384.00	300.27	467.42
CM2+Y1+HS	96.67	110.33	24.00	26.00	1026.00	1554.00	340.23	503.61
CM1+Y2+HS	100.00	111.00	25.00	27.00	1053.66	1591.66	355.50	533.66
CM2+Y2+HS	94.67	107.67	23.00	24.00	979.00	1523.00	319.77	484.34
L.S.D. at 0.05	**4.047**	**4.362**	**2.009**	**3.621**	**20.045**	**16.980**	**6.334**	**11.477**

* NPK= (2.5:1:1), CM1= Cattle manure (15 m^3/ fed.), CM2= Cattle manure (30 m^3/fed.), Y1= Active dry yeast (4 g/l), Y2= Active dry yeast (8 g/l), HS= Humic substances 1l/ fed., F.S.= First season, S.S.= Second season

The addition of the triple combination of cattle manure, yeast and humic substances gave better results, regardless of the levels used, in comparison to fertilization with NPK. In both seasons, using the triple combination of CM1, Y2 and HS gave the highest number of branches (25 and 27 branches/plant in the first and second seasons, respectively). Results recorded on the number of branches are in agreement with those obtained by [30]**,** on *Nigella Sativa*, found that manure treatments markedly increased the number of branches. In addition, [31]**,** on *Borago officinalis*, showed that adding dry yeast had the greatest effect on the growth parameters, including the number of branches. Also, [29] showed that humic acid increased all growth characteristics of *Brassica rapa* plants.

c. Plant fresh weight

The results presented in (Table 3) show that the plant fresh weight was higher with the NPK treatment, in comparison to the addition of CM, yeast or humic substances separately.

On the other hand, plants receiving the combination of CM2 and HS had a significantly heavier fresh weight (with mean values of 803 and 1333.67 g/plant in the first and second seasons, respectively), compared to plants fertilized with NPK.

Moreover, the addition of the triple combination of cattle manure, yeast and humic substances gave heavier fresh plants (regardless of the levels used), in comparison to fertilization with NPK. The triple combination of CM1, Y2 and HS gave significantly heaver fresh plants (with mean weights of 1053.66 and 1591.66 g/plant in the first and second seasons, respectively) than the NPK treatment. Similar results had been reported by [28] on *Oenothera biennis*, who showed that the application of cattle manure increased fresh weight/ plant and stem fresh weight/plant. Moreover, [31]showed that adding dry yeast had the greatest effect on growth parameters of *Borago officinalis*, including fresh weight of aerial parts. Also, [29]showed that humic acid increased all growth characteristics of *Brassica rapa* plants.

d. **Plant dry weight**

The results presented in (Table 3) show that plants fertilized with NPK had a higher mean dry weight, in comparison to plants that were supplied with CM, yeast or humic substances (added separately), regardless of the level used.

On the other hand, using the combination of CM2 and HS significantly increased plant dry weight (giving values of 240.89 and 410.67 g/plant in the first and second seasons, respectively), compared to NPK treatment.

The superior effect of using combinations of cattle manure, yeast and humic substances (compared to using NPK fertilization) was even more evident when the plants were supplied with combinations of all three substances, regardless of the levels used. The triple combination of CM1, Y2 and HS gave significantly higher plant dry weights (with means of 355.50 and 533.66 g/plant in the first and second seasons, respectively) than NPK treatment. The obtained results are in agreement with those reported by [28] who found that the application of cattle manure increased dry weight/ plant and stem dry weight/plant of *Oenothera biennis*. Moreover, [31] on *Borago officinalis*, showed that adding dry yeast was the most effective treatment on growth parameters, including dry weight of aerial parts. In addition, [29] showed that humic acid increased all growth characteristics of *Brassica rapa*.

2. Seed production

a. Number of capsules per plant

It is noticed from the data presented in (Table 4) that the number of capsules per plant was higher with NPK treatment in comparison to the addition of CM, Y or HS separately, regardless of the concentration used.

On other hand, the combination of CM2 and HS gave a significantly higher number of capsules (600.67 and 588.33 capsules/plant in the first and second seasons, respectively) than that produced by plants receiving the NPK treatment.

Also, the addition of the triple combinations of CM, Y and HS (at the different tested concentrations) gave better results in comparison to fertilization with NPK, or with the double treatment combinations. In addition, it could be noticed that the triple combination of CM1, Y2 and HS gave a significantly higher number of capsules per plant, in comparison to NPK and other treatments. These results are in agreement with those obtained by [32] who showed that treating *Nigella sativa* plants with dry yeast at 1 or 2 g/l increased the number of capsules. In addition, [30] on *Nigella Sativa*, mentioned that the manure treatments markedly increased number of fruits/plant. Furthermore, [33] found that application of humic acid to *Brassica compestris* resulted in the maximum number of pods plant^{-1}.

b. Weight of seeds per plant

It is clear from the data shown in (Table 4) that the weight of seeds per plant was higher with NPK treatment in comparison to the addition of CM, Y or HS separately, regardless of the concentration used.

On other hand, the combination of CM2 and HS gave a significant increase in weight of seeds per plant (with values of 114.18 and 121.63 g in the first and second seasons, respectively), in comparison to the NPK treatment.

The favourable effect of using combinations of CM, Y and HS treatments was even more evident when the plants were treated with all the three substances (i.e. a triple combination of the three substances), regardless of the concentrations that were used. In both seasons, addition of any triple combination of CM, Y and HS increased the production of seeds/plant, compared to the application of the NPK treatment.

The triple combination of CM1, Y2 and HS gave a significantly heavier weight of seeds per plant (with values of 170.85 g/plant in the first season, and 194.22 g/plant in the second season), compared to the application of NPK. Similar results were obtained by [34], who showed that spraying *Ricinus communis* plants with yeast at 3 gm/l resulted in a gradual increase in fruiting characteristics (weight of 100 seeds and seed yield/plant). Moreover, [35] found that foliar application of humic acid on sesame cultivar Giza 32 significantly

increased seed yield per plant. In addition, [28] found that the application of cattle manure at 10 m^3/fed. to *Oenothera biennis* plants significantly increased seed yield/plant.

Table (4): Effect of cattle manure, active dry yeast and humic substances on the number of capsules, weight of seeds/plant and seed yield/fed. of evening primrose (*Oenothera biennis* L.) plant during 2012/2013 and 2013/2014 seasons.

*Treatments	Number of Capsules		Weight of seeds per plant (g)		Seed yield/fed. (kg)	
	F.S.	S.S.	F.S.	S.S.	F.S.	S.S.
NPK	550.33	561.67	99.01	112.31	1100.10	1247.95
CM1	350.00	358.33	52.48	60.91	583.17	676.80
CM2	390.66	441.00	62.48	73.50	694.28	816.65
Y1	188.00	198.33	18.81	23.12	209.03	256.96
Y2	260.00	267.00	28.62	32.89	318.07	365.47
HS	290.33	300.00	37.75	44.98	419.47	499.84
CM1+HS	540.33	510.33	91.86	98.62	1020.73	1095.80
CM2+HS	600.67	588.33	114.18	121.63	1268.65	1351.43
CM1+Y1	355.00	414.00	56.82	70.40	631.32	782.25
CM2+Y1	420.33	450.00	77.01	73.42	855.73	815.80
CM1+Y2	406.00	468.66	73.08	89.09	812.06	989.91
CM2+Y2	445.33	540.33	89.04	99.12	989.32	1101.35
CM1+Y1+HS	615.00	652.00	122.98	143.45	1366.46	1593.91
CM2+Y1+HS	718.33	754.67	158.04	173.54	1756.05	1928.27
CM1+Y2+HS	776.66	809.33	170.85	194.22	1898.35	2157.97
CM2+Y2+HS	689.33	744.00	142.44	168.60	1582.65	1873.31
L.S.D. at 0.05	11.542	16.212	2.851	5.146	18.215	23.066

* NPK= (2.5:1:1), CM1= Cattle manure (15 m^3/ fed.), CM2= Cattle manure (30 m^3/fed.), Y1= Active dry yeast (4 g/l), Y2= Active dry yeast (8 g/l), HS= Humic substances 1 l/ fed., F.S.= First season, S.S.= Second season

c. Seed yield per fed.

Data presented in (Table 4) revealed that fertilization of *Oenothera biennis* plants with NPK had a better effect in increasing the seed yield per fed., in comparison to the addition of CM, Y or HS separately.

On other hand, combining of CM2 and HS significantly increased the seed yield per fed., in comparison to the NPK treatment. Also, the addition of the triple combinations of CM, Y and HS gave better results than those obtained with the NPK treatment. In this regards, the best results were recorded in plants receiving the triple combination of CM1, Y2 and HS, which gave a significantly higher seed yield per fed. (with values of 1898.35 and 2157.97 kg/fed. in the first and second seasons, respectively), compared to plants receiving any of the other tested treatments. Similar results were found by [34] who showed that spraying *Ricinus communis* plants with yeast at 3 gm/l resulted in a gradual increase in fruiting characteristics (weight of 100 seeds and seed yield/plant). In addition, [35] found that foliar application of humic acid on sesame cultivar Giza 32 significantly increased seed yield per plant. Moreover, [28] showed that the application of cattle manure at 10 m^3/fed. to *Oenothera biennis* plants significantly increased seed yield/plant.

3. Oil production

a. Fixed oil percentage

Table 5 shows the concentration (%) of fixed oil in *Oenothera biennis* seeds. The recorded results indicate that oil percentage in plants fertilized with NPK was higher than that recorded in plants supplied with CM, Y or HS, when added separately, regardless of the concentrations used.

Regarding the effect of the double treatment combinations, it can be seen from the data in (Table 5) that combining CM2 and HS significantly increased the oil percentage, compared to the NPK treatment (in both

season). Moreover, the addition of the triple combinations of CM, Y and HS gave better results in comparison to the NPK treatment, regardless of the concentrations used. In both seasons, the triple combination of CM1, Y2 and HS gave the highest oil percentage (with values of 24.44% and 26.34% in the first and second seasons, respectively), compared to any of the other tested treatments. Similar results were obtained by [36] who reported that application of humic acids (HA) to *Arachis hypogaea* increased its oil content. In addition, [37] found that the highest oil content in *Helianthus annuus* was recorded with the treatment of farmyard manure. On the other hand, [27] showed that spraying *Oenothera biennis* plants with yeast diminished the accumulation of fixed oil in seeds.

Table (5): Effect of cattle manure, active dry yeast and humic substances on oil percentage, oil yield/plant and oil yield/fed. of evening primrose (*Oenothera biennis* L.) plant during 2012/2013 and 2013/2014 seasons.

*Treatments	Oil percentage		Oil yield/plant (g)		Oil yield/fed. (kg)	
	F.S	S.S	F.S	S.S	F.S	S.S
NPK	18.29	20.20	18.13	22.75	201.52	252.84
CM1	16.56	18.37	8.69	11.19	96.63	124.43
CM2	17.65	17.56	11.03	12.86	122.60	142.89
Y1	13.54	14.31	2.54	3.31	28.26	36.83
Y2	14.56	15.10	4.14	4.95	46.09	55.08
HS	15.22	16.61	5.73	7.01	63.74	77.96
CM1+HS	20.22	21.19	18.60	20.82	206.70	231.40
CM2+HS	21.53	22.64	24.55	27.57	272.79	306.40
CM1+Y1	18.50	19.61	10.55	13.79	117.26	153.31
CM2+Y1	19.36	20.54	14.94	15.12	166.04	168.09
CM1+Y2	19.08	20.38	13.93	18.14	154.79	201.63
CM2+Y2	20.64	21.46	18.39	21.29	204.41	236.65
CM1+Y1+HS	22.13	24.46	27.16	35.02	301.85	389.16
CM2+Y1+HS	23.45	25.45	37.08	44.20	412.09	491.19
CM1+Y2+HS	24.44	26.34	41.75	51.13	463.97	568.19
CM2+Y2+HS	22.46	23.39	32.00	39.37	355.64	437.54
L.S.D. at 0.05	**1.550**	**1.824**	**3.228**	**5.307**	**7.406**	**10.147**

* NPK= (2.5:1:1), CM1= Cattle manure (15 m^3/ fed.), CM2= Cattle manure (30 m^3/fed.), Y1= Active dry yeast (4 g/l), Y2= Active dry yeast (8 g/l), HS= Humic substances 1 l/fed., F.S.= First season, S.S.= Second season.

b. Oil yield /plant

Data presented in (Table 5) revealed that the oil yield of *Oenothera biennis* plants was higher with NPK treatment, in comparison to the addition of CM, Y or HS separately, regardless of the concentrations used.

The results recorded in the two seasons (Table 5) also show that, among the different double combination treatments, combining CM2 and HS gave a higher oil yield per plant than the NPK treatment.

Regarding the effect of the triple treatment combinations, it can be seen that the combination of CM1, Y2 and HS gave highest oil yield per plant (with values of 41.75 and 51.13 g/plant in the first and second seasons, respectively), in comparison to any of the other tested treatments. These results are in agreement with the findings of [38] who reported that treating *Arachis hypogaea* plants with humic acid increased the oil yield / plant. Moreover, [27] found that spraying *Oenothera biennis* plants with yeast gave higher oil yields (per plant and per fed.). Also, [39] on sunflower (*Helianthus annuus*), found that the highest seed oil yield/plant was produced from plants which received organic fertilizer.

c. Oil yield/fed.

It is clear from data presented in (Table 5) that a higher oil yield per fed. was produced from plants treated with the NPK treatment, in comparison to plants receiving CM, Y or HS separately, regardless of the concentrations used.

On the other hand, plants treated with a combination of CM2 and HS gave a higher oil yield per fed. (272.79 and 306.40 kg/fed. in the first and second seasons, respectively), compared to plants receiving the NPK treatment.

It is also clear from the results recorded in the two seasons (Table 5) that the different triple treatment combinations were generally more effective that the NPK treatment or the double treatment combinations, and that the combination of CM1, Y2 and HS gave the highest oil yield per fed. (with values of 463.97 and 568.19 kg/fed. in the first and second seasons, respectively), in comparison to any of the tested treatments, including the NPK treatment. Similar results were reported by [27] who found that spraying *Oenothera biennis* plants with yeast increased the oil yields (per plant and per fed.). Also, [35] on sesame cultivars Giza 32, found that, humic acid significantly increased seed yield per fed. Moreover, [37] on *Helianthus annuus*, found that the highest oil yield per ha was recorded when the plants were treated with farmyard manure.

Discussion

These results provide a plausible evidence that combining the three tested substances (CM, Y and HS) had a generally better effect on the growth, seed yield and oil production in *Oenothera biennis* plants. Among the tested treatment combinations, using a combination of CM1, Y2 and HS gave the best results in terms of plant height, number of branches, plant fresh and dry weights, number of capsules/plant, seed yield/plant, seed yield/fed., oil percentage, oil yield/plant and oil yield/fed. These beneficial effects on plant growth may be attributed to the release of nutrients to the soil as well as improving the soil physical properties [11]**.** In addition, active dry yeast has a promotive effect on plants; it has been reported to be an enriched source for cytokinines, vitamins, enzymes, amino acid and minerals [40]. It also releases CO_2, which improves net photosynthesis in illuminated plants, and improves plant growth and oil content. Moreover, humic substances increase nutrient uptake, serving as a source of mineral plant nutrients and regulator of their release. They also influence the respiration process, the amount of sugars, amino acids and nitrate accumulation, and stimulate soil microflora and auxin-like effects [22]**.**

Conclusion

Generally, it can be concluded that the triple combination of CM1, Y2 and HS had the most favorable effect on *Oenothera biennis* plant. Accordingly, it can be recommended to treat *Oenothera biennis* plant with CM1, Y2 and HS during the growing season to obtain the best vegetative growth, as well as the highest seed and oil yields.

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