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EFFECT OF ORGANIC MANURING, PLANTING DENSITY AND N FERTILIZATION LEVELS ON YIELD AND ITS RELATION TO PHOTOSYNTHATE PARTITIONING PARAMETERS OF SUNFLOWER USING DRIP IRRIGATION SYSTEM UNDER SANDY SOIL CONDITIONS

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ABSTRACT: Two field experiments were conducted at an administration field in Ramsis Agriculture Farm, Abo-Hammad Distinct, Sharkia Governorate, Egypt under Agronomy Department supervision, Faculty of Agriculture, Zagazig University, during 2004 and 2005 seasons to study the effect of organic manuring (check and 3 ton compost/fad.), two planting densities (one plant/hill giving 23000 plant/fad. and two plants/hill giving 46000 plant/fad.) and four N levels (30, 60, 90 and 120 kgN/fad.) on photosynthate partitioning parameters and yield of sunflower grown under sandy soil conditions using drip irrigation system.

Data of combined analysis revealed that addition of 3 ton compost/fad. brought a significant increase in each of plant height, head diameter, head dry weight/plant, 100-seed weight, seed weight/plant, leaf area index (LAI), relative photosynthetic potential (RPP of seed and biological yields/plant), seed, straw and biological yields/fad., harvest index (H I), crop index (C I) and oil yield/fad. Whereas RPP straw, migration coefficient (MC) and seed oil content were not significantly affected by compost application.

Decreasing plant population from 46000 to 23000 plants/fad. significantly increased head diameter, head dry weight/plant, 100-seed weight, seed weight/plant, LAI, seed, straw, biological and oil yields/fad., but significantly decreased plant height, RPP seed, straw

and biological yields/plant, HI and CI. However, MC and seed oil content were not significantly affected by varying plant population according to combined analysis.

Data of combined analysis revealed that increasing N application level up to 120 kgN/fad. significantly increased each of plant height, head diameter, head dry weight/plant, 100 seed weight, seed weight/plant, LAI, RPP seed, MC, seed, straw, biological and oil yields/fad., but decreased RPP straw, HI and CI. Meantime, seed oil content responded to N addition up to 90 kgN/fad. Also, plants received 120 kgN/fad. had higher RPP-biological than those received 30 kgN/fad.

Significant interactions between the studied factors indicated that the addition of compost increased the response of sunflower to the increase of N level particularly when planted at 23000 plants/fad.

Results of the interactions between compost and planting density and between planting density and N levels recommended that sunflower should be fertilized with 3 ton compost/fad. and 120 kgN/fad. and planted by 23000 plant/fad. and this N level should be increased in the future, as the response of seed yield/fad. was linear when compost was added.

Oil yield/fad. was positively correlated with each of plant dry weight, seed yield/plant, 100-seed weight, straw yield/fad., seed yield/fad. and seed oil percentage where correlation coefficients were 0.954, 0.948, 0.932, 0.961, 0.992 and 0.625 in respective order.

Key words : Sunflower, nitrogen levels, compost, planting density.

INTRODUCTION

In Egypt, cotton seed is the main source of edibe oil followed by soybean. The production from this commodity (10%) is still far below the actual needs (El-Zaher *et al.*, 2001). Sunflower may play an important role to partially narrow the gap between actual consumption and national production of the edible oil as it has been successfully grown at widely scattered geographical areas. This wide adaptability led to the fact that sunflower can be

grown under low productivity soils, particularly in the newly reclaimed areas in Egypt.

Sandy soil is poor not only in essential plant nutrients but also in organic matter content where under such conditions, the productivity of different crops trends to decrease. In addition, the high leaching losses of mineral fertilizers particularly N, from these soils are frequent. The use of indigenous resources such as organic materials as fertilizers is recommended (Makary, 2002). Organic manures play a direct role in sustaining soil fertility through their ameliorating effect on the soil physical, chemical and biological properties, as well as their positive effect on the increment of available nutrients to the growing plants (Hashem *et al.*, 1997 and El-Fakhrani, 1999). In this connection, Sugawa *et al.* (1997) noticed that the highest seed yield and almost all of its components were obtained with application of FYM + 60: 40: 30 NPK kg/ha. Also, Devi-Dayal *et al.* (1998) observed that sunflower hybrid Badshsh gave a higher yield and some of its components with a combination of organic manures + 80 kg N + 40 kg P_2O_5/ha. El-Zaher and El-Kafoury (1999) reported that increasing FYM rates from zero to 20 m^3/fad. significantly increased sunflower yield and its components. Molewar *et al.* (1999) found that sunflower seed yield and almost of its components were significantly increased due to combined application of 10 ton FYM/ha + full recommended dose of 60:30:30 kg NPK/ha. Meantime, Gorttappeh *et al.* (2000) showed that increasing organic manure from 6 to 30 ton/ha. and N level from 40 to 200 kg/ha. increased seed and biological yields, seed number, 100-seed weight, plant height, head diameter, seed oil content, oil yield and use efficiency of mineral fertilizers. Moreover, Jeyabal *et al.* (2000) noticed that integrated application of organic sources and a biofertilizer gave the highest seed yield and its components (29% higher yield than the recommended NPK). Furthermore, Thind *et al.* (2001) observed that the residual effect of FYM significantly increased the seed yield at all N level, where, N uptake by sunflower at 30 and 60 kg N/ha. was higher than the control by 67.2% and 86.7%, respectively. Mahavishnan *et al.* (2005) indicated that favorable effects of FYM application either alone or in

combination with other nutrient sources could be attributed to the better nutrient availability in these treatments.

Planting density is one of the major factors determining the ability of the crop plant to capture resources. Modifying crop density and plant arrangement may be seen as a way of changing crop spatial and temporal structure and, by this means, the use of crop resources. In this connection, Sarhan (1995) observed that narrowing plant spacing from 40 to 30 and 20 cm apart (35000 plants/fad.) caused a constant and significant decrease in head diameter and weight, seed weight/plant and 100-seed weight, but this narrowing resulted in a constant and significant increase in seed, oil and straw yields/fad. Similar results were obtained by Geweifel *et al.* (1997) and Mohamed (1997). Also, Sharief (1998) noticed that increasing plant population density from 20000 to 28000, 40000 and 56000 plant/fad. significantly increased plant height, LAI, oil content and seed and oil yields/fad., but, head diameter, 1000-seed weight and seed yield/plant were decreased. Basha, (2000) noticed that widening hill spacing from 20 to 30 and 40 cm apart caused a significant increase in plant height, head weight, seed weight/head, 100-seed weight and seed yield/fad. He added that increasing hill spacing from 20 to 30 cm apart caused a significant increase in oil percentage and oil yield/fad. However, Nawar (2002) found that increasing hill spacing from 20 to 30 cm significantly decreased seed yield. Whereas, Bassal (2003) observed that increasing hill spacing from 15 to 25 and 35 significantly increased head diameter, seed weight/plant, 1000-seed weight and seed oil content, where, the highest seed and oil yields/fad. were obtained with hill spacing of 25 cm. Moreover, Belal *et al.* (2003) found that widening row spacing from 50 to 70 cm increased head diameter, seed yield/plant, 100-seed weight, while the narrowest row width (50 cm) gave the highest seed and oil yields/fad. and seed oil content. Furthermore, Zarea *et al.* (2005) noticed that twin zigzag rows of 8 plants/m^2 and conventional rows of 8 plants/m^2 produced the highest yield/fad.

Historically, nitrogen has been received much attention from researchers in sunflower. Due to low N availability under sandy soil conditions, several researchers got

significant response to its fertilizers application up to 35 kg N/fad. (Salehi and Bahrani, 2000 and Sarmah *et al.,* 2000). Also, others got similar response when they added 45 kg N/fad. (Tomar *et al.,* 1999; Ali *et al.,* 2000; Singh *et al.,* 2000; Angelova, 2001; Mohamed, 2003 and Khalil, 2003). Moreover, Mohamed, (1997), Abou Khadrah *et al.* (2000), Nel *et al.* (2000), Reddy *et al.* (2000) and El-Zaher *et al.* (2001) found that this response reaching 75 kg N/fad. In all these responses, the significant increase of yield was attributed to the significant increase of yield attributes. Basha, (2000) observed that increasing N level up to 90 kg N/fad. caused a highly significant increase in each of plant height, head diameter, head weight, seed weight/head, 100-seed weight and seed and oil yields/fad. but seed oil percentage decreased. Belal *et al.* (2003) got similar response, but, to N addition of 60 kg N/fad.

The present study, therefore, aimed to study the effect of organic manuring and planting density as well as N level on sunflower productivity when grown in sandy soil using drip irrigation system.

MATERIALS AND METHODS

Two field experiments were conducted at an administration field at Ramsis Agriculture Farm, Abo-Hammad District, Sharkia Governorate, Egypt under Agronomy Department supervision, Faculty of Agriculture, Zagazig University, during 2004 and 2005 seasons to study the effect of organic manuring (compost), planting density and N level on yield of sunflower using drip irrigation system in sandy soil. The soil of the experimental site is sandy in texture and has a particle size distribution of 77.45, 2.10 and 20.45% for sand, silt and clay, respectively. The soil had an average pH value of 7.98 and organic matter content of 0.19%. The available N, P and K contents were 20.1, 4.0 and 97.1 ppm, respectively (averaged over the two seasons for the upper 30 cm of soil depth). Each experiment included 16 treatments which were the combinations of two planting density (one plant/hill giving 23000 plant/fad. and two plant/hill giving 46000 plant/fad.) and four N levels (30, 60, 90 and 120 kg N/fad.) without or with application of $3m^3$ organic manuring (compost).

A split split plot design with three replicates was used where the main plots were occupied by the organic fertilizer (compost) whereas planting density and levels of N were allotted in the 1st and 2nd sub-plots, respectively. The irrigation lines (rows) spaced at 60 cm apart, thus, the area of the experimental plot was 10.8 m^2 (3m in length and 3.60m in width) included 6 rows (lines). Five seeds of Vedoc sunflower CV were sown per each hill. Sowing was on May 20th in both seasons, where the drippers spaced 30cm apart. Sunflower was drip irrigated and preceding by Egyptian clover in the two seasons. After 21 days from sowing (DAS) the seedlings were thinned to one plant/hill (23000 plants/fad.) and two plants/hill (46000 plants/fad.).

Compost as an organic manuring was delivered from the Egyptian Company for Agriculture Residuals Utilization. It contains 1.6-2.0% of total N, 460 ppm ammonium N, 125 ppm nitrate N, 26.2-31.8% organic carbon, 13% Humic acid, 0.6-0.8% total P, 1.2-1.6% total K, 1025 ppm Mn, 180 ppm Cu, and 28 ppm Zn, with a pH of 8-8.5 and EC of 3-4. Compost was incorporated at 10 cm soil depth before sowing. Nitrogen fertilizer in the form of ammonium sulphate (20.6% N) was soil added around the driper line beside the plants in three equal doses applied at thinning and ten days intervals. Calcium superphosphate (15.5% P_2O_5) at level of 15.5 kg P_2O_5/fad. was applied at seedbed preparation whereas potassium sulphate (48-52% K_2O) at level of 50 kg K_2O/fad. was added in two equal doses as soil application around the dripper line beside the plants at thinning and 30 DAS. Sunflower was drip irrigated using ground water since, each dripper discharge was 4 L/hr. Irrigation schedule started with one hour every 2 days at early growth stages up to 4 hours at critical periods of plant development. Weeds were controlled manually and all other cultural practices were kept the same as usually practiced in farmer's fields. Harvest date was on August 20th in the two seasons.

At heading, the heads of two central rows were bagged at early seed development (ten days after complete flowering) to avoid birds damage until maturity. The following characters were recorded:

Growth Characters

Sample of five guarded plants was taken from each treatment at 55 DAS. The following data were recorded: number of leaves/plant, leaf area (cm^2) i.e., leaf area was determined according to the formula outlined by Schneiter, (1978), then divided by the occupied land area by the plants to obtain leaf area index (LAI).

Photosynthate Partitioning Parameters

1- Relative photosynthetic potential for seed yield/plant

RPP (seed) = Seed yield per plant (gm) / LAI.

2- Relative photosynthetic potential for straw yield/plant.

RPP (straw) = Straw yield per plant (gm) / LAI.

3- Relative photosynthetic potential for biological yield/plant.

RPP(biological) = Biological yield per plant (gm) / LAI.

The RPP of seed, straw and biological yields/plant at harvest were calculated according to the procedure documented by Vidovic and Pokorny, (1973).

4- Migration coefficient (MC):
MC = Head dry weight per plant recorded at harvest (gm)/Biological yield per plant at harvest (gm). Such parameter was estimated as mentioned by MC Graw, (1977).

Yield and Yield Components

At harvest, five guarded plants were taken at random from 2^{nd} or 5^{th} row for each sub-sub plot and left two weeks until fully air dried by sun and the following data were recorded: 1- Plant height 2- Head diameter 3- Head dry weight/plant 4- Stem dry weight/plant 5- Plant dry weight 6- Seed weight/plant 7- 100-seed weight. Thereafter, in order to determine the yield characters, the following traits were recorded from two central rows i.e. 3.6 m^2, and then transformed to the final yield/fad. 1- Seed yield and straw yield (kg/fad.) corrected to 14% moisture content. 2- Biological yield/fad. (kg/fad.) 3- Harvest index (seed yield/biological yield ×100). 4- Crop index (seed yield / straw yield ×100). 5- Seed oil content (%) was determined according to A.O.A.C (1980) using Soxhelt apparatus and diethyl ether as a solvent. 6- Oil yield (kg/fad.) was calculated for each plot by multiplying the seed yield per fad. by seed oil content and dividing by 100.

Data of both seasons and combined were subjected to the proper analysis according to Snedecor and Cochran (1981) as a split split plot design. Treatments means were compared using LSD.

The response equations were calculated according to Snedecor and Cochran (1981) using the orthogonal polynomial tables for significant interactions between factors under study. The significancy of the linear and quadratic components of each of these equations was tested, then the response could be described as linear (first order) or quadratic (second order). The expected maximum seed yield (Y_{max}) and the expected maximum N level kgN/fad. (X_{max}) were calculated according to Neter *et al.* (1990) and Abdul Galil *et al.* (2003).

In interaction tables, capital and small letters were used to compare rows and columns means, respectively. *, ** and N.S denote the significant and highly significant and the insignificant differences, orderly. The combined data of oil yield and yield attributes were subjected to simple correlation, it was calculated according to Svab, (1973).

RESULTS AND DISCUSSION

Seed Weight/plant and its Attributes

Organic manuring effect

It is quite clear from Table 1 that addition of organic manure (compost) affected significantly each of plant height, head diameter, head dry weight/plant, 100-seed weight and seed weight/plant, but was without significant effect on plant height in the first season only. As shown from the combined data, addition of organic manure increased plant height by 6.9cm, head diameter by 2.6, head dry weight by 31.9 gm, 100-seed weight by 1.4 gm and seed weight/plant by 22.2 gm. These results refer to the beneficial effect of organic manure under sandy soil conditions due to a possible increase in the availability of macro and micronutrients (Hashem *et al.*, 1997; El-Fakhrani, 1999 and Makary, 2002). In this connection Sugawa *et al.* (1997) observed that the highest seed yield and almost all of its components were obtained with application of FYM+ 60:40:30 NPK kg/ha.

Table 1. Seed weight per sunflower plant and its attributes as affected by organic manuring, planting density and N levels and their interactions in the two seasons and their combined

Main effects and interactions	Plant height (cm)			Head diameter (cm)			Head dry weight/plant (gm)			100- seed weight (gm)			Seed weight/plant (gm)		
	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.
Organic manure (Compost) (O)															
Check	156.5	156.3	156.3	16.3	15.9	16.1	79.0	85.4	82.2	6.30	6.08	6.19	43.7	45.3	44.5
3 ton / fad.	162.8	163.6	163.2	18.9	18.6	18.7	114.0	114.1	114.1	7.58	7.59	7.59	64.6	68.7	66.7
F. test	N.S	**	**	*	*	**	**	**	**	**	*	**	**	*	**
Planting density (P)															
23000 plants/fad.	157.0	158.4	157.7	18.3	17.9	18.1	106.1	105.9	106.0	7.40	7.35	7.38	59.8	63.2	61.5
46000 plants/fad.	162.0	161.4	161.7	16.9	16.6	16.8	86.9	93.6	90.3	6.48	6.33	6.40	48.4	50.8	49.6
F. test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
N levels (kgN/fad) (N)															
30	153.0 d	152.2 d	152.6 d	13.8 d	13.8 d	13.8 d	59.2 d	59.9 d	59.6 d	5.46 d	5.13 d	5.29 d	28.1 d	29.9 d	29.0 d
60	158.0 c	158.3 c	158.1 c	16.3 c	15.9 c	16.1 c	82.2 c	87.8 c	85.0 c	6.70 c	6.16 c	6.43 c	42.5 c	45.2 c	43.9 c
90	161.7 b	162.7 b	162.2 b	18.6 b	18.2 b	18.4 b	105.9 b	112.7 b	109.3 b	7.29 b	7.15 b	7.22 b	61.8 b	64.6 b	63.2 b
120	165.5 a	166.6 a	166.0 a	21.6 a	21.1 a	21.4 a	138.6 a	138.7 a	138.6 a	8.31 a	8.91 a	8.61 a	84.1 a	88.4 a	86.3 a
F. test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interactions															
O × P	N.S	N.S	N.S	N.S	N.S	N.S	**	**	**	*	N.S	*	*	N.S	**
O × N	N.S	N.S	*	N.S	N.S	N.S	**	**	**	N.S	N.S	N.S	**	**	**
P × N	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S	*	N.S	N.S	N.S	**	**	**
O × P × N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

Planting density effect

In both seasons and their combined, decreasing planting density from 46000 plant/fad. (two plants/hill) to 23000 plant/fad. (one plant/hill) appeared to be significant increase in each of head diameter, head dry weight/plant, 100-seed weight and seed weight/plant. On the other hand, plant height was significantly decreased Table 1. These results clearly indicate that dense sown plants at 46000 plants/fad. suffered from an intensive mutual shading. Crowded sown plants are known to be forced for elongation due to the elongation effect of invisible solar radiation which are predominant under these conditions (Chang, 1974). The competition for light could be served to explain the higher height reached by those plants due to internode elongation. The phenomenon of plant elongation due to dense planting is attributed to matual shading and is known as "cooperative interaction" where longer plants enhance elongation of shorter ones and as a result more height is reached by the whole population (Duncan, 1978). In the literature, Sarhan (1995) noticed that narrowing plant spacing from 40 to 30 and 20 cm apart (35000 plants/fad.) caused a constant and significant decrease in head diameter and weight, seed weight/plant and 100-seed weight. Similar results were obtained by Geweifel *et al.* (1997) and Mohamed (1997). Moreover, Sharief, (1998) observed that increasing plant population from 20000 to 28000, 40000 and 56000 plant/fad. significantly increased plant height but, head diameter, 100-seed weight and seed yield/plant were increased as density decreased. Furthermore, Basha, (2000) noticed that widening the space from 20 to 30 and 40 cm apart caused a significant increase in plant height, head weight, seed weight/head and 100-seed weight.

Nitrogen level effect

Data in Table 1 show that increasing N level from 30 to 60, 90 and 120 kg N/fad. gradually increased plant height, head diameter and its dry weight/plant, hundred seed weight and seed weight/plant as indicated from the two seasons and their combined. The increase in plant height may be attributed to stem elongation caused by the addition of N (Peltonen *et al.*, 1995). It is evident that N enhanced vegetative growth of sunflower and hence improved yield contributing characters.

These improvements were rather expected as the soil of the experimental site was sandy and a very poor soil fertility level from nitrogen (20.1 ppm). These results are in general accordance with those reported by Salehi and Bahrani (2000), Tomar *et al.* (1999) and Abou-Khadrah *et al.* (2000) when they increased N level to sunflower up to 35, 45 and 75 kg N/fad. respectively.

Interaction effect

It is evident from Table 1-a that organic manuring for the light sown plants (23 thousand plants/fad.) heavier heads and heavier seed index and hence heavier seed weight/plant than organic manuring for the dense sown ones (46 thousand plants/fad.). These results clearly indicate that light sown plants were more benefited from organic manuring than dense sown ones.

Results in table 1-b clearly indicate that organic manured plants were more efficient and responsive to added N than those without organic manuring. Response equation of plant height, head dry weight/plant and seed weight/plant indicated diminishing returns to the increase of N level. However higher maximums values could have been reached from plant height, head dry weight/plant and seed weight/plant if the N level was maximized to 175.9, 302.1 and 222.9 kgN/fad. in respective order. These data clearly indicate that added compost increased the efficiency of added N. This as aforementioned could be attributed to the direct and indirect roles of compost on sunflower growth and development. Therefore the highest values of plant height, head dry weight and seed weight/plant (168.8 cm, 153.0 and 102.6 gm) could be obtained when sunflowers plants were fertilized with 120 kg N/fad. and three ton compost was added.

Results in table 1-c are in harmony with those in table 1-b when high N levels could have been added to maximize seed weight/plant for the thin sown plants. It is evident that decreasing plant density from 46000 to 23000 plant/fad. produced the highest head dry weight and seed weight/plant under any level of N fertilizer. On the other hand, under the two planting densities increasing N fertilizer level produced the highest values for two characters. Similar conclusions were reported by *El*-Karamity and El-Serogy (1997) and Basha (2000).

Table 1-a. Head dry weight/plant, 100-seed weight and seed weight/plant as affected by organic manuring × planting density interaction (combined)

Planting density	Head dry weight / plant (gm)		100 – seed weight (gm)		Seed weight / plant (gm)	
Organic manure	23000 plants/fad	46000 plants/fad	23000 plants/fad	46000 plant/fad	23000 plants/fad	46000 plants/fad
Check	A 87.0 b	B 77.4 b	A 6.6 b	B 5.8 b	A 49.6 b	B 39.4 b
3 ton / fad.	A 125.0 a	B 103.2 a	A 8.2 a	B 7.0 a	A 73.4 a	B 59.9 a

Table 1-b: Plant height, head dry weight and seed weight / plant as affected by oraganic manuring × N level interaction (combined)

Organic manure \ N level	30	60	90	120	Response equation	$Y_{max.}$	X_{max} (kgN/fad.)
			Plant height (cm)				
Check	D 148.8 b	C 154.0 b	B 159.0 b	A 163.3 b	$149.3 + 5.5X$	-	-
3 ton / fad.	D 156.4 a	C 162.2 a	B 165.4 a	A 168.8 a	$156.5 + 5.84X - 0.6X^2$	170.7	175.9
			Head dry weight / plant (gm)				
Check	D 47.5 b	C 64.7 b	B 92.3 b	A 124.3 b	$39.8 + 36.9X - 3.7X^2$	131.8	179.6
3 ton / fad.	D 71.6 a	C 105.3 a	B 126.3 a	A 153.0 a	$72.6 + 31.75X - 1.75X^2$	216.6	302.1
			Seed weight / plant (gm)				
Check	D 22.7 b	C 33.1 b	B 52.2 b	A 69.9 b	$18.6 + 21.6X - 1.83X^2$	82.2	207.1
3 ton / fad.	D 35.2 a	C 54.6 a	B 74.2 a	A 102.6 a	$31.13 + 28.9X - 2.3X^2$	124.1	222.9

Table 1-c: Head dry weight / plant and seed weight / plant as affected by planting density × N level interaction (combined)

Planting density \ N level	30	60	90	120	Response equation	$Y_{max.}$	X_{max} (kgN/fad.)
			Head dry weight / plant (gm)				
23000 plants/fad	D 66.2 a	C 92.7 a	B 118.7 a	A 146.4 a	$65.65 + 27.6X$	-	-
46000 plants/fad	D 53.0 b	C 77.3 b	B 99.9 b	A 130.9 b	$50.16 + 30.7X$	-	-
			Seed weight / plant (gm)				
23000 plants/fad	D 31.9 a	C 50.1 a	B 67.7 a	A 96.5 a	$27.2 + 29.1X - 2.65X^2$	111.5	194.7
46000 plants/fad	D 26.1 b	C 37.7 b	B 58.7 b	A 76.0 b	$22.6 + 21.34X - 1.425X^2$	102.5	254.6

Sunflower Photosynthetic Attributes

Organic manuring effect

The results in Table 2 show that organic manure addition significantly increased LAI, relative photosynthetic potential (RPP) of seed and biological yields/plant as indicated from the combined analysis. But, this addition was without significant effect on RPP straw and migration coefficient (MC) in the two seasons and their combined. The effect of compost (organic manure) on rising the activity of root system to absorb more necessary nutrients for producing more assimilates is responsible much for in boosting these characters. In addition these effects of compost its importance in raising photosynthetic activity of sunflower leaves which might account much for high accumulation of metabolites in sunflower plant tissues. Thus, the beneficial effect of organic manuring on growth and yield potentiality was, also, reported by Devi-Dayal *et al.* (1998) and Mahavishnan *et al.* (2005).

Planting density effect

It is obvious from the recorded data in Table 2 that increasing planting density from 23 to 46 thousand plants/fad. appeared to be increased RPPseed, straw and biological yields/plant, whereas LAI showed an opposite trend as indicated from the combined analysis. But, MC followed two different trends in the two seasons and hence was not significantly affected as observed from the combined analysis. In the literature, Nawar (2002) noticed that increasing hill spacing from 20 to 30cm significantly decreased seed yield. Whereas, Bassal (2003) observed that increasing hill spacing from 15 to 25 and 35 significantly increased seed weight/plant.

Nitrogen level effect

Applying N fertilizer up to 120 kgN/fad. reflected significant effect on LAI, RPP seed and MC, the opposite was completely true for RPP straw, whereas two opposite trends could be observed in RPP biological as indicated from the two seasons and their combined (Table 2). On the average of the two seasons, the RPP seed was increased from 16.1 to 21.3 to 26.6 and then to 31.2 gm/LAI when the N level was increased from 30 to 60 to 90 and then to 120 kg N/fad. Also, the migration coefficient was increased

Table 2. Leaf area index (LAI), relative photosynthetic potential of both seed and straw as well as biological yields / plant ($RPP_{seed,\ straw\ and\ biological}$) and migration coefficient (MC) as affected by the different treatments in the two seasons and their combined

Main effects and interactions	LAI			RPP_{seed} (gm/LAI)			RPP_{straw}(gm/LAI)			$RPP_{biological}$(gm/LAI)			Migration coefficient (MC)		
	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.
Organic manure (Compost) (O)															
Check	1.90	2.15	2.03	22.5	20.4	21.5	64.8	53.7	59.2	87.3	74.1	80.7	0.470	0.519	0.495
3 ton / fad.	2.39	2.76	2.58	27.8	24.4	26.1	70.0	54.0	62.0	97.7	78.4	88.1	0.521	0.520	0.520
F. test	N.S	*	**	*	N.S	*	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S
Planting density (P)															
23000 plants/fad.	2.68	2.62	2.65	21.6	23.5	22.5	55.7	54.4	55.0	77.2	77.9	77.6	0.501	0.506	0.504
46000 plants/fad.	1.62	2.29	1.96	28.8	21.4	25.1	79.1	53.2	66.1	107.8	77.6	91.2	0.490	0.533	0.511
F. test	**	**	**	**	*	**	**	N.S	**	**	N.S	**	N.S	*	N.S
N levels (kgN/fad) (N)															
30	1.57 d	2.17 d	1.87 d	18.5 d	13.7 d	16.1 d	78.1 a	54.2	66.2 a	96.7 a	67.9 d	82.3 b	0.401 c	0.410c	0.405 d
60	1.90 c	2.34 c	1.12 c	23.6 c	19.1 c	21.3 c	72.6 b	52.7	62.7 b	96.1 a	71.8 c	84.0 ab	0.481 b	0.516b	0.498 c
90	2.36 b	2.51 b	2.44 b	27.5 b	25.6 b	26.6 b	61.8 c	54.2	58.0 c	89.3 b	79.8 b	84.5 ab	0.531 a	0.565a	0.548 b
120	2.75 a	2.80 a	2.78 a	31.1 a	31.4 a	31.2 a	56.9 d	54.1	55.5 c	88.0 b	85.5 a	86.7 a	0.569 a	0.587a	0.578 a
F. test	**	**	**	**	**	**	**	N.S	**	*	**	*	**	**	**
Interactions															
O × P	*	N.S	N.S	*	N.S	*	*	N.S	**	*	N.S	N.S	N.S	*	**
O × N	N.S	**	N.S	*	N.S	**	**	**	**	*	**	**	N.S	**	**
P × N	N.S	N.S	N.S	N.S	N.S	*	**	*	**	**	N.S	**	*	N.S	*
O × P × N	N.S	N.S	N.S	*	N.S	N.S	*	N.S	N.S	N.S	**	N.S	N.S	**	N.S

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

from 0.405 to 0.498 to 0.548 and then to 0.578 due to these three N increments. The favourable effects of N fertilization on such characters may be due to the activation and excess of photosynthates and other metabolic processes being responsible for such increment in LAI and the final yields/plant and their photosynthate distribution parameters. Analogous findings were documented by Ali *et al.* (2000), Sarmah *et al.* (2000) *and* Singh *et al* (2000).

Interaction effect

Data of combined analysis presented in Table 2-a reveal that RPP seed and straw yields and migration coefficient were significantly affected by the interaction between compost and planting density. Results indicated that RPP seed and straw yields had greater mean records when the sunflower plants were sown at 46000 plant/fad. and received three ton of compost/fad. At the same time, the 23000 plant stand together with 3 ton compost/fad. produced greater mean averages of MC.

It is quite clear from table 2-b that the increase of N level at both organic manuring rates, was followed by a significant increase in each of RPP seed and biological yields and MC, but with different magnitudes. The opposite was true for both RPP straw and biological yields particularly when three ton compost was added. The linear component of response equation, indicated higher response to the increase of N level when compost was added compared to the without compost addition. Meantime, higher maximums could have been reached from RPP seed, straw and biological yields/plant if the N level was maximized to 357, 145.4 and 88.61 kgN/fad. in respective order.

Data in table 2-c show the effect of the interaction between planting density ×N levels on tabulated characters. It is evident that increasing planting density from 23000 plants/fad. to 46000 plants/fad. produced the highest RPP seed, straw and biological yields and MC under any level of N fertilizer. Also, higher maximums values could have been reached from RPP seed, straw and biological yields and MC if the N level was maximized to 205.7, 85.15, 85.2 and 197.7 kgN/fad. under dense sown plants in respective order.

Table 2-a. Relative photosynthetic potential (RPP) of seed and straw yields/plant and migration coefficient as affected by organic manuring × planting density interaction (combined)

Planting density / Organic manuring	RPP (seed yield) (gm/LAI)		RPP (Straw yield)(gm/LAI)		Migration coefficient	
	23000 plants/fad.	46000 plants/fad.	23000 plants/fad.	46000 plants/fad.	23000 plants/fad.	46000 plants/fad.
(check)	A 21.2 b	A 21.8 b	B 55.9 a	A 62.5 b	B 0.477 b	A 0.512 a
3 ton / fad.	B 23.8 a	A 28.4 a	B 54.2 b	A 69.8 a	A 0.530 a	B 0.510 a

Table 2-b. Relative photosynthetic potential (RPP) of seed, straw and biological yields/plant and migration coefficient as affected by organic manuring × N level interaction, as well as, response equations (combined)

N level (KgN/fad.) / Organic manuring	30	60	90	120	Response equation	$Y_{max.}$	X_{max} (kgN/fad.)
				RPP (Seed yield)(gm/LAI)			
Check	D 14.4 b	C 18.0 b	B 25.0 b	A 28.6 b	$14.06 + 4.9X$	-	-
3 ton / fad.	D 17.8 a	C 24.7 a	B 28.1 a	A 33.9 a	$18.10 + 5.995X - 0.275X^2$	50.77	357
				RPP(straw yield)(gm/LAI)			
Check	B 60.0 b	A 61.3 b	C 58.7 a	D 56.8 a	$60.23 + 1.18X - 0.8X^2$	60.66	52.13
3 ton / fad.	A 72.3 a	B 64.0 a	C 57.3 b	D 54.2 b	$72.4 - 10X + 1.3X^2$	91.63	145.4
				RPP(biological yield)(gm/LAI)			
Check	D 74.4 b	C 79.3 b	B 83.7 b	A 85.4 b	$74.29 + 6.14X - 0.8X^2$	86.07	145.12
3 ton / fad.	A 90.1 a	B 88.7 a	C 85.4 a	B 88.1 a	$90.5 - 4.01X + 1.025X^2$	94.4	88.61
				Migration coefficient			
Check	D 0.407 a	C 0.460 b	B 0.537 b	A 0.574 a	$0.412 + 0.07X$	-	-
3 ton / fad.	D 0.404 a	C 0.536 a	B 0.559 a	A 0.582 a	$0.41 + 0.64X$	-	-

Table 2-c. Relative photosynthetic potential (RPP) of seed, straw and biological yields/plant and migration coefficient as affected by planting density × N level interaction, as well as, response equations (combined)

N level / Planting density	30		60		90		120		Response equation	$Y_{max.}$	X_{max} (kgN/fad.)
						RPP(seed yield)(gm/LAI)					
23000 plants/fad.	D 14.2	b	C 20.2	b	B 24.3	b	A 30.6	b	14.41 + 5.11X	-	-
46000 plants/fad.	D 17.2	a	C 22.5	a	B 28.8	a	A 31.8	a	$16.99 + 6.74X - 0.575X^2$	36.7	205.7
						RPP(straw yield)(gm/LAI)					
23000 plants/fad.	A 61.5	b	C 52.7	b	B 55.0	b	D 50.9	b	$60.63 - 0.575X - 1.175X^2$	-	-
46000 plants/fad.	B 70.8	a	A 72.6	a	C 61.0	a	D 60.2	a	$72.01 - 2.39X - 0.65X^2$	74.21	85.15
						RPP(biological yield)(gm/LAI)					
23000 plants/fad.	C 76.5	b	D 72.9	b	B 79.3	b	A 81.5	b	$75.49 - 2.21X + 1.45X^2$	-	-
46000 plants/fad.	D 88.0	a	A 95.1	a	C 89.8	a	B 92.0	a	$89 + 0.67X - 1.225X^2$	92.85	85.2
						Migration coefficient					
23000 plants/fad	C 0.405	a	B 0.505	a	A 0.550	a	A 0.555	b	$0.406 + 0.121X - 0.024X^2$	0.559	105.6
46000 plants/fad	D 0.406	a	C 0.492	a	B 0.546	a	A 0.601	a	$0.407 + 0.0872X - 0.0078X^2$	0.651	197.7

Seed, Straw and Biological Yields/fad. and Harvest Index

Organic manuring effect

The results in table 3 reveal that, application of three ton/fad. of compost significantly increased seed, straw and biological yields/fad. and HI. The increase observed in seed and straw yields is rather expected as most of seed and straw yields attributes as well as LAI and photosynthetic potentials were increased due to this addition Tables 1 and 2. It is evident that the increase in sunflower yield due to the addition of the compost could be explained through its favourable effect on water retention and hence on applied nutrients against leaching (Asker *et al.*, 1994 and Fageria *et al.*, 1997). Thus, the beneficial effects of organic manure on yield potentiality for sunflower plants was, also, reported by El-Zaher and El-Kafoury (1999), Molewar *et al.* (1999), Gorttappeh *et al.* (2000), Jeyabal *et al.* (2000) and Thind *et al.* (2001).

Planting density effect

The results in Table 3 reveal that, as shown in the two seasons and their combined analysis, decreasing plant density from two plants/hill (46000 plant/fad.) to one plant/hill (23000 plant/fad.) caused a significant increase in seed yield/fad., straw yield/fad. and biological yield/fad, but HI was decreased. This trend was true in both seasons and their combined. The increase in seed, straw and biological yields/fad. caused by the decreasing number of plant/hill may be attributed to the increase in each of head diameter and its dry weight, 100-seed weight, seed weight/plant and LAI (Tables 1 and 2). The decrease of HI in thin planting, could be attributed to the increase of plant height indicating more increase in source than in sink. Belal *et al.* (2003) noticed that widening row spacing from 50 to 70 cm increased seed yield/plant, while the narrowest row width (50 cm) gave the highest seed yield/fad. Moreover, Zarea *et al.* (2005) found that twin zigzag rows of 8 plants/m^2 and conventional rows of 8 plants/m^2 produced the highest yield/fad.

Nitrogen level effect

Data in Table 3 show that increasing N level from 30 to 60 and to 90 and then 120 kgN/fad. caused a gradually increase in each of seed yield/fad., straw yield/fad. and biological yield / fad., but HI

Table 3. Seed, straw and biological yields/fad. and harvest index as affected by organic manuring, planting density and N levels and their interactions in the two seasons and their combined

Main effects and interactions	Seed yield / fad.(kg)			Straw yield / fad.(kg)			Biological yield / fad.(kg)			Harvest index		
	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.
Organic manure (O)												
Check	495.2	501.9	498.5	1053.5	1035.7	1044.6	1548.7	1537.6	1543.1	32.67	33.13	32.90
3 ton / fad.	745.9	767.5	756.7	1559.5	1557.1	1558.3	2305.4	2324.7	2315.0	33.00	33.45	33.22
F. test	**	**	**	**	**	**	**	**	**	**	N.S	**
Planting density (P)												
23000 plants/fad.	681.2	695.3	688.3	1538.6	1491.6	1515.1	2219.9	2186.8	2203.3	31.10	32.06	31.58
46000 plants/fad.	559.9	574.2	567.0	1074.4	1101.3	1087.8	1634.2	1675.4	1654.8	34.56	34.52	34.54
F. test	**	**	**	**	**	**	**	**	**	**	**	**
N levels (kgN/fad) (N)												
30	388.9 d	389.8 d	389.4 d	746.6 d	745.6 d	746.1 d	1135.6 d	1135.4 d	1135.5 d	34.44 a	33.43 a	34.43 a
60	533.9 c	551.9 c	542.9 c	1089.5c	1088.6c	1089.1c	1623.4 c	1640.5 c	1631.9 c	33.18 b	33.75 b	33.46 b
90	703.7 b	703.5 b	703.6 b	1475.0b	1437.5b	1456.3b	2178.8 b	2140.9 b	2159.8 b	32.57 c	32.94 c	32.76 c
120	855.6 a	893.8 a	874.7 a	1914.8a	1913.9a	1914.3a	2770.4 a	2807.6 a	2789.1 a	31.13 d	32.04 d	31.59 d
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interactions												
O × P	N.S	**	**	**	**	**	**	**	**	N.S	**	N.S
O × N	N.S	**	**	**	**	**	**	**	**	N.S	N.S	N.S
P × N	*	*	*	**	**	**	**	**	*	**	*	N.S
O × P × N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

was decreased. Regarding seed yield/fad. and according to the combined analysis, the first N increment produced a significant increase of 39.42%, whereas the second N increment gave an increase of 29.60% and, the third N increment secured an increase of 24.32% only. It is clear that the response of seed yield to N fertilization, generally is in correspondence with the response of most yield attributes to increments of N fertilizer level, too (Tables 1 and 2) the decrease of HI by the high N fertilized plants was also observed in thin planting indicating that the increase of plant height played a role in this respect. In the literature, some authors reported significant increase in yield of sunflower due to the increase of N level up to 45 kgN/fad. (Angelova, 2001; Mohamed, 2003 and Khalil, 2003). Other authors reported that sunflower responded to more additions of N reaching 75 kgN/fad. (Mohamed, 1997; Nel *et al.*, 2000; Reddy *et al.*, 2000 and El-Zaher *et al.*, 2001) and 90 kgN/fad. (Basha, 2000).

Interaction effect

It is quite clear from Table 3-a that the decrease of planting density was more effective on seed, straw and biological yields/fad. when organic manure was added. The highest yields of seed, straw and biological (839.5, 1825.8 and 2665.3 kg/fad., respectively) were obtained when sunflower plants were grown at 23000 plants/fad. coupled with the addition of 3 ton compost.

It is evident from Table 3-b that the increase of N level at both the check and organic manure treatments, was followed by a significant increase in seed, straw and biological yields/fad. but with different magnitudes. The response equations, clearly, show that the response to the increase of N level was qudratic when compost was not added whereas it was linear or qudratic when compost was added. In both cases, the linear component of these equations, indicated higher response to the increase N level when compost was added compared to the check treatment. These data clearly indicate that added compost increased the efficiency of added N. This, as mentioned earlier, could be attributed to the direct and indirect roles of compost on sunflower yield. Therefore, the highest values of seed, straw and biological yields/fad. (1022.2, 2229.5 and 3251.7 kg) were obtained when

Table 3-a. Seed, straw and biological yields/fad. as affected by organic manure × planting density interaction (combined)

Planting density	Seed yield / fad.(kg)		Straw yield / fad.(kg)		Biological yield / fad.(kg)	
Organic manuring	23000 plant/fad	46000 plant/fad	23000 plant/fad	46000 plant/fad	23000 plant/fad	46000 plant/fad
Check	A 537.1 b	B 460.0 b	A 1204.3 b	B 884.9 b	A 1741.4 b	B 1344.9 b
3 ton / fad.	A 839.5 a	B 674.0 a	A 1825.8 a	B 1290.8 a	A 2665.3 a	B 1964.8 a

Table 3-b. Seed, straw and biological yields/fad. as well as harvest index as affected by organic manuring × N level interaction (combined)

N level (kgN/fad.)							
Organic manuring	30	60	90	120	Response equation	$Y_{max.}$	X_{max} (kgN/fad.)
				Seed yield / fad.(kg)			
Check	D 297.6 b	C 395.5 b	B 573.9 b	A 727.2 b	$264.6+188.3X-13.9X^2$	904.4	233.9
3 ton / fad.	D 481.1 a	C 690.4 a	B 833.3 a	A 1022.2 a	486.7+191.9X	-	-
				Straw yield / fad.(kg)			
Check	D 576.2 b	C 802.4 b	B 1200.7 b	A 1599.1 b	$493.2+460.6X-38.6X^2$	1868.7	209.2
3 ton / fad.	D 916.1 a	C 1375.8 a	B 1711.8 a	A 2229.5 a	902.4+471.1X	-	-
				Biological yield / fad.(kg)			
Check	D 873.8 b	C 1197.8 b	B 1774.6 b	A 2326.3 b	$746.02+664.2X-56.93X^2$	2683.3	204.9
3 ton / fad.	D 1397.2 a	C 2066.2 a	B 2545.1 a	A 3251.7 a	1398.8+632.8X	-	-

sunflower plants were fertilized with 120 kgN/fad. and three ton of compost. In addition, the increase in seed yield due to applying 120 kgN compared with 30 kgN/fad. was 144% when no compost was applied, while it was 112% when 3 ton of compost was added. These two figures were 177% and 143% for straw yield and 166% and 133% for biological yield. This indicate that some N was contributed by the compost. In addition, the 120 kgN is not adequate for sunflower growth on sandy soil. This also can be observed from table (3-b) where the maximum N level shown from the response equations for the three yields exceeds the 120 kgN.

Data in Table 3-c show the effect of the interaction between planting density × N level on seed, straw and biological yields/fad. It is evident that, decreasing plant density from 46000to 23000 plant/fad. produced higher seed, straw and biological yields/fad. under any level of N fertilizer. On the other hand, under the two planting densities increasing N fertilizer level produced the highest values for seed, straw and biological yields. In similar way, the 46000 plants/fad. needed more N compared with 23000 plants/fad. This could be seen as the seed yield was increased by 105% when N level was increased from 30 to 120 kgN/fad. under 23000 plants/fad. density while this figure was 152% for 46000 plants/fad. indicating the need for more applied N under dense planting. These two figures were 143% and 177% for straw yield and were 130% and 169% for the biological yield, respectively.

Crop Index, Seed Oil Content and Oil Yield/fad.

Organic manuring effect

It is obvious from the recorded data in Table 4 that the application of three ton of compost/fad. significantly increased CI and oil yield/fad., however, compost had no significant effect on seed oil content (%) as indicated from combined analysis. These results suggest that the application of compost improved soil organic matter content of the experimental site, which in turn improve soil physical and chemical properties through providing the soil with macro and micronutrients as well as improving soil structure. Organic substances are considered as a main source of nutrients and energy for most soil microorganisms.

Table 3-c. Seed, straw and biological yields / fad.(kg) as well as harvest index as affected by planting density × N level interaction (combined)

N level	(kgN/fad.)							
Planting density	30		60		90		120	
	Seed yield / fad.(kg)							
23000 plants/fad.	D		C		B		A	
	455.9	a	608.8	a	753.9	a	934.4	a
46000 plants/fad.	D		C		B		A	
	322.8	b	477.1	b	653.2	b	815.0	b
	Straw yield / fad.(kg)							
23000 plants/fad.	D		C		B		A	
	905.1	a	1288.7	a	1666.1	a	2200.5	a
46000 plants/fad.	D		C		B		A	
	587.2	b	889.5	b	1246.5	b	1628.1	b
	Biological yield / fad.(kg)							
23000 plants/fad.	D		C		B		A	
	1360.9	a	1897.5	a	2419.9	a	3134.9	a
46000 plants/fad.	D		C		B		A	
	909.9	b	1366.5	b	1899.7	b	2443.1	b

Table 4. Crop index, seed oil content (%) and oil yield / fad. as affected by the different treatments in the two seasons and their combined

Main effects and interactions	Crop index			Seed oil content(%)			Oil yield / fad (kg)		
	2004	2005	Comb.	2004	2005	Comb.	2004	2005	Comb.
Organic manuring (O)									
Check	48.7	49.6	49.2	43.3	42.9	43.1	217.6	217.9	217.7
3 ton / fad.	49.4	50.3	49.9	43.6	43.6	43.6	327.6	336.9	332.3
F. test	**	N.S	**	N.S	N.S	N.S	**	**	**
Planting density (P)									
23000 plants/fad.	45.2	47.2	46.2	43.7	43.4	43.5	299.2	303.4	301.3
46000 plants/fad.	52.9	52.7	52.8	43.3	43.1	43.2	245.9	251.4	248.7
F. test	**	**	**	N.S	N.S	N.S	**	**	**
N levels (kgN/fad) (N)									
30	52.6 a	52.6 a	52.6 a	40.3 c	40.7 d	40.5 d	156.5 d	159.6 d	158.1 d
60	49.8 b	51.0 b	50.4 b	43.9 b	43.4 c	43.6 c	236.6 c	242.1 c	239.4 c
90	48.5 b	49.2 c	48.8 c	45.3 a	44.9 a	45.1 a	319.1 b	316.2 b	317.6 b
120	45.4 c	47.3 d	46.3 d	44.4 b	43.9 b	44.2 b	378.1 a	391.6 a	384.9 a
F. test	**	**	**	**	**	**	**	**	**
Interactions									
O × P	N.S	**	**	N.S	N.S	N.S	*	**	**
O × N	*	N.S	N.S	**	**	**	**	**	**
P × N	N.S	**	**	**	**	**	*	**	**
O × P × N	N.S	*	N.S	**	N.S	N.S	N.S	**	N.S

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

Martin and Carter (2002) reported that, organic matter input the dynamics of the sand-sized marco-organic matter and the soil aggregation process are important factors in maintaining and regulating organic matter function in soil. Mahavishnan *et al.* (2005) observed that favorable effects of farmyard manure (FYM) application either alone or in combination with other nutrient sources could be attributed to the better nutrient availability in these treatments.

Planting density effect

The results in Table 4 show that the increase in the number of plants/hill from one plant/hill (23 thousand plants/fad.) to two plants/hill (46 thousand plants/fad.) was accompanied by significant increase in CI and significant decrease in oil yield/fad. But, planting density had no significant effect on seed oil content. This was true in the two seasons with more clear trend in the combined analysis. In this connection, Basha (2000) noticed that increasing hill spacing from 20 to 30 cm apart caused a significant increase in oil percentage and oil yield/fad. Moreover, Bassal (2003) found that increasing hill spacing from 15 to 25 and 35 significantly increased seed oil content, but the highest oil yield/fad. was obtained with hill spacing of 25 cm.

Nitrogen level effect

Applying N fertilizer up to 120 kgN/fad. to sunflower reflected a significant decrease on crop index with more consistent trend in the second season and significantly increased each of seed oil content and oil yield/fad. Regarding oil yield/fad. and according to the combined analysis the first N increment produced a significant increase of 51.4%, the second N increment gave an increase of 32.7% whereas the third N increment achieved an increase of 21.2% only. The increase in oil yield/fad. caused by the increase of N level may be attributed to the role of N in increasing seed oil content and seed yield/fad. In the literature Reddy *et al.* (2000) and El-Zaher *et al.* (2001) got significant response to N fertilizer application up to 75 kgN/fad.

Interaction effect

It is evident from data in Table 4-a that compost application increased CI for lighter plants. However, dense planting had higher CI values either with or

Table 4-a. Crop index and oil yield/fad. as affected by organic manuring × planting density interaction (combined)

Planting density	Crop index		Oil yield/fad.	
Organic manuring	23000 plant/fad	46000 plant/fad	23000 plant/fad	46000 plant/fad
Check	B 45.6 b	A 52.8 a	A 233.8 b	B 201.6 b
3 ton / fad.	B 46.9 a	A 52.3 a	B 368.8 a	A 295.7 a

Table (4-b). Seed oil percentage and oil yield / fad. as affected by organic manuring ×N level interaction (combined)

N level	(kg N/fad.)			
Organic manuring	30	60	90	120
	Seed oil content			
Check	C 40.4 a	B 42.6 b	A 44.5 b	A 44.9 a
3 ton / fad.	C 40.6 a	A 44.7 a	A 45.6 a	B 43.5 b
	Oil yield / fad.			
Check	D 120.6 b	C 168.6 b	B 256.0 b	A 325.7 b
3 ton / fad.	D 195.6 a	C 310.1 a	B 379.3 a	A 444.0 a

without compost furnishing. Moreover compost had favourable effect on oil yield/fad. under both densities. Meantime dense planting attain higher values of this character with compost furnishing but, the reverse was the case for this character without compost. These findings generally indicate that dense sown plants suffer from severe competition when received no compost.

It is evident from Table 4-b, the highest seed oil content was obtained when plants were fertilized by 3 ton compost and 90kgN/fad. Moreover, the increase of N level at both organic manure treatments, was followed by a significant increase in oil yield/fad., therefore, the highest oil yield/fad. (444 kg) was obtained when sunflower plants were fertilized with 120 kgN/fad. and 3 ton compost was added.

It is quite clear from Table 4-c that under all N levels, dense planting of 46 thousand plant/fad. had greater value of CI compared to 23 thousand plant density. On the other side, any increase in N level was followed by a respective significant decrease in that index, this was the case under both densities. The opposite was completely true for oil yield (kg/fad.). Since, the highest oil yield could be obtained by planting 23 thousand plant/fad. fertilized with 120 kgN/fad. (403.2 kg oil/fad.)

Correlation Studies

Data of simple correlation between oil yield/fad. and some seed yield contributing characters of sunflower are presented in Table 5. Oil yield/fad. showed positive and significant correlation with each of plant dry weight, seed yield/plant, 100-seed weight, straw yield/fad., seed yield/fad. and seed oil content but, negative and significant correlation with HI. Also, plant dry weight showed positive and significant associations with seed yield/plant, 100-seed weight, straw yield/fad., seed yield/fad. and seed oil content but, negatively and significantly correlated with HI. Likewise, seed yield/plant was positively correlated with 100-seed weight, straw yield/fad, seed yield/fad. and seed oil content but, negative and significant correlation with HI. Moreover, 100-seed weight had positive and significant associations with straw yield/fad., seed yield/fad. and seed oil content but, negative and significant correlation with HI. Meanwhile, straw yield/fad. indicated positive

Table 4-c. Crop index, seed oil percentage and oil yield / fad. as affected by planting density ×N level interaction (combined)

Planting density \ N level (kg N/fad.)	30	60	90	120
		Crop index		
23000 plants/fad.	A 50.2 b	B 47.1 b	C 45.2 b	D 42.5 b
46000 plants/fad.	A 55.0 a	B 53.7 a	C 52.4 a	D 50.1 a
		Seed oil content (%)		
23000 plants/fad.	C 41.1 a	A 44.9 a	A 45.0 a	B 43.2 b
46000 plants/fad.	C 40.0 b	A 42.4 b	A 45.1 a	B 45.2 a
		Oil yield (kg / fad.)		
23000 plants/fad.	D 186.8 a	C 276.2 a	B 339.0 a	A 403.2 a
46000 plants/fad.	D 129.3 b	C 202.6 b	B 296.3 b	A 366.5 b

Table 5. Simple correlation coefficients between oil yield (kg/fad.) and some seed yield attributes of sunflower (combined)

Characters	1	2	3	4	5	6	7
Y-Oil yield/fad.	0.954**	0.948**	0.932**	0.961**	0.992**	-0.388**	0.625**
1- Plant dry weight	-	0.945**	0.939**	0.961**	0.971**	-0.409**	0.459**
2- Seed yield/plant		-	0.928**	0.961**	0.962**	-0.402**	0.476**
3- 100-seed weight			-	0.945**	0.942**	-0.464**	0.522**
4- Straw yield/fad.				-	0.974**	-0.515**	0.485**
5- Seed yield/fad.					-	-0.378**	0.526**
6- Harvest index						-	-0.367*
7-Seed oil content (%)							-

and significant relationships with seed yield/fad. and seed oil content but, negative and significant correlated with HI. Similarly, seed yield/fad. gave positive and significant relations with seed oil content but, negative and significant correlated with HI. Furthermore, HI indicated negative significant relationships with seed oil content. The present results indicate that oil yield/fad. and its contributing characters were positively and significantly associated except HI. Thus, it semi evident that all these characters contributed to the final seed yield of sunflower.

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تأثير التسميد العضوى، كثافة الزراعة ومستويات التسميد النيتروجينى على محصول دوار الشمس وعلاقة ذلك بمقاييس توظيف ناتجات التمثيل الضوئى بإستخدام نظام الرى بالتنقيط تحت ظروف الأراضى الرملية

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أقيمت تجربتان حقليتان بحقل إرشادى بمنطقة رمسيس الزراعية – مركز أبو حماد – محافظة الشرقية خلال موسمى ٢٠٠٤، ٢٠٠٥تحت إشراف قسم المحاصيل لدراسة تأثير إضافة ٣ طن سماد عضوى (كومبوست) مقارنة بعدم الإضافة، كثافتين للزراعة (نبات واحد بالجورة ليعطى ٢٣٠٠٠ نبات للفدان أ، نباتين بالجورة لتعطى ٤٦٠٠٠ نبات بالفدان) وأربعة مستويات من النيتروجين (٣٠ – ٦٠ – ٩٠ – ١٢٠ كجم ن/فدان) على محصول دوار الشمس وعلاقة ذلك بمقاييس توظيف (توزيع) ناتجات التمثيل الضوئى تحت نظام الرى بالتنقيط بالأراضى الرملية ويمكن إيجاز أهم النتائج المتحصل عليها كما يلى:

أوضح التحليل التجميعى للموسمين أن إضافة ٣ طن سماد عضوى compost (كومبوست) أدى لزيادة معنوية فى كل من إرتفاع النبات، قطر القرص، الوزن الجاف للقرص/للنبات، وزن ١٠٠ بذرة، وزن البذور/النبات، دليل مساحة الأوراق، الجهد التمثيلى النسبى لكل من محصول البذور والمحصول البيولوجى/للنبات، محصول البذور/فدان، محصول القش/فدان، المحصول البيولوجى/فدان، دليل الحصاد، دليل المحصول، ومحصول الزيت/فدان فى حين لم تؤثر هذه الإضافة على الجهد التمثيلى النسبى لمحصول القش ، معامل الهجرة ونسبة الزيت ببذور دوار الشمس.

أدى خفض الكثافة النباتية من ٤٦٠٠٠ نبات بالفدان إلى ٢٣٠٠٠ نبات بالفدان لزيادة معنوية فى كل من قطر القرص، الوزن الجاف للقرص/نبات، وزن ١٠٠ بذرة، وزن بذور النبات، دليل مساحة الأوراق، محصول البذور/فدان، محصول القش/فدان، المحصول

البيولوجى/فدان ومحصول الزيت للفدان ولكن كان هناك إنخفاضاً معنوياً فى كل من إرتفاع النبات، الجهد التمثيلى النسبى لمحصول البذور ، محصول القش والبيولوجى/نبات، دليل الحصاد ودليل المحصول فى حين لم يتأثر كل من معامل الهجرة، ونسبة الزيت بالبذور وذلك طبقاً للتحليل التجميعى للموسمين.

أوضح التحليل التجميعى للموسمين أن زيادة مستوى إضافة السماد النيتروجينى حتى ١٢٠ كجم ن/فدان أدى لزيادة معنوية فى كل من إرتفاع النبات – قطر القرص – الوزن الجاف للقرص/النبات، وزن ١٠٠ بذرة، وزن بذور النبات، دليل مساحة الأوراق، الجهد التمثيلى النسبى لمحصول البذور، معامل الهجرة، محصولى البذور والقش/فدان، المحصول البيولوجى/فدان ومحصول الزيت/فدان وإنخفض كل من الجهد التمثيلى النسبى لمحصول القش ودليلى الحصاد والمحصول فى حين تأثر الجهد التمثيلى النسبى للمحصول البيولوجى حتى ٣٠ كجم.ن/ف ونسبة الزيت بالبذور حتى ٩٠ كجم ن/فدان.

لوحظ تداخل فعل معنوى بين عوامل الدراسة حيث كانت إستجابة دوار الشمس لزيادة مستوى التسميد النيتروجينى أعلى عند إضافة الكومبوست أو الزراعة بكثافة ٢٣ ألف نبات/فدان هذا وقد أوضحت معادلات الإستجابة إمكانية تعظيم محصول البذور والقش للفدان بزيادة مستوى التسميد عن ١٢٠ كجم ن/ف.

أظهرت البيانات وجود إرتباط موجب ومعنوى بين محصول الزيت/فدان وكل من الوزن الجاف للنبات، محصول البذور/النبات، وزن ١٠٠ بذرة، محصول القش/فدان، محصول البذور/فدان ونسبة الزيت بالبذور حيث كان معامل الارتباط: ٠.٩٥٤ ، ٠.٩٤٨ ، ٠.٩٣٢ ، ٠.٩٦١ ، ٠.٩٩٢ ، ٠.٦٢٥على الترتيب.

توصى هذه الدراسة بإضافة ٣ طن كومبوست عند إعداد الأرض لزراعة محصول دوار الشمس تحت نظام الرى بالتنقيط والزراعة بكثافة نباتية ٢٣ ألف نبات/فدان (نبات واحد بالجورة) كما يوصى فى الدراسات المستقبلية بزيادة مستوى التسميد النتيروجينى عن ١٢٠ كجم ن/ف حيث كانت إستجابة محصول البذور طردية عند إضافة الكومبوست.