Minufiya J. Agric. Res. Vol. 34 No.2: 641 - 659 (2009) "http://www.mujar.net"

RESPONSE OF SOME SUNFLOWER HYBRIDS TO DIFFERENT HILL SPACINGS AND N-FERTILIZATION LEVELS

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(Received: Mar. 8 , 2009)

ABSTRACT: ***The investigation was carried out during 2003, 2004 and 2005 summer seasons to study the effect of three nitrogen levels (71, 107 and 143 kg/ ha , three hill spacing of 10, 20 and 30 cm (corresponding to plant populations of 166667 , 83333 and 55555 plants/ ha, respectively), on the performance of two sunflower hybrids (Vidok and Malabar).***

Increasing the level of nitrogen fertilization from 71 to 107 kg/ ha significantly increased plant height, stem diameter, leaf area/ plant, head diameter, 100-seed weight, seed weight per plant and seed yield per hectare in the three seasons, but significantly decreased oil percent in 2003 and 2004 seasons. Further increase in nitrogen level (143 kg/ ha) insignificantly differed from 107 kg N/ ha for all the studied traits.

Increasing the distance between hills from 10 to 30 cm significantly increased stem and head diameter, 100- seed weight, seed weight/ head and oil percent, and decreased plant height. The difference between both 20 and 30 cm between hills did not reach significance level for leaf area/ plant, head diameter, seed yield/ ha and oil percent. Vidok hybrid surpassed Malabar in all studied traits except plant height and stem diameter in the three seasons. Interaction between 143 kg N/ ha and the wide hill spacing (30 cm) produced the largest heads, heaviest seeds and highest seed weight/ head.

Conversely, application of 107 or 143 kg N/ ha to the lax or medium populations well spacing of 30 and 20 cm , respectively produced the highest seed yield/ ha. The highest oil percent resulted from wide hill spacing (30 cm) with the lowest nitrogen fertilizer level (71 kg/ ha). Vidok fertilized with 143 kg N/ ha produced the highest leaf area/ plant and seed weight/ ha, however, the highest seed yield/ ha was produced from Vidok hybrid fertilized with 107 or 143 kg N/ ha. Vidok sown at 30 cm between hills produced the highest leaf area/ plant, while both Vidok and Malabar sown at 30 cm between hills produced the highest seed weight/ head.

Key words: ***sunflower, hill spacing, N-fertilization, seed yield, oil content*****.**

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is becoming an increasingly important source of edible vegetable oil through the world due to its no cholesterol and high unsaturated fatty acids content (Leland, 1996 and Khalifa, and awad 1997). In addition, due to its short growing season and the much need to fill

the gap between the vegetable oils production and consumption, it receives considerable attention in Egypt especially, in the reclaimed areas.

Seed yield of sunflower is affected by many factors, of which variety, nitrogen fertilization and plant densities play an important role in determining productivity of sunflower.

Several researches indicated that application of nitrogen fertilizer increased seed yield (El- Tabbakh, 1994; Nawar, 1994 and El-Tabbakh, 2000), head diameter and weight (Kandil *et al*, 1983), stem diameter (Kandil *et al*, 1983 and Narwal and Malik, 1985), leaf area (Narwal and Malik, 1985), plant height (Singh *et al*, 1987), however oil percent significantly decreased with increasing nitrogen fertilization levels from 107 to 179 kg/ ha (El-Tabbakh, 1994).

Increasing distance between plants within row from 10 to 40 cm, increased head diameter, 100- seed weight and oil yield/ fad. (Moursi *et al*, 1983 and El-Tabbakh, 2000). However, El-Tabbakh (1994) reported that increasing within row spacing up to 20 cm increased all the studied characters and decreased plant height and oil percentage in one season.

With regard to sunflower varieties, it is of interest to grow high yielding varieties that are responsive to cultural practices. Plant height, head diameter, 100- seed weight and seed yield/ ha were significantly affected (Nawar, 1994, Rehab, 1994 and El-Tabbakh, 2000) by sunflower varieties.

The present investigation was conducted to study the response of two sunflower varieties to three nitrogen fertilization levels and three hill spacing with regard to growth, seed yield, its attributes and oil percent.

MATERIALS AND METHODS

The present investigation was conducted in the summer seasons of 2003, 2004 and 2005 at the Agricultural Research Station, Faculty of Agriculture, Alexandria University. Soil chemical analysis of the experimental site are given in (Table 1).

Table(1): Soil chemical analysis of the experimental site in the three seasons.

Soil character	Summer seasons		
	2003	2004	2005
pH	8.02	7.88	7.92
Ec (dS/m)	1.96	1.70	1.67
Organic matter %	1.48	1.40	1.51
Available N, ppm	16.07	17.10	16.88
Available P, ppm	8.17	9.91	10.09
Available K, ppm	99.72	103.06	105.26

The experimental design was a split-split plot with three replications in the three seasons. The main plots were occupied by three nitrogen fertilization levels (71, 107 and 143 kg N/ ha.). The sub-plots were allocated to three hill spacings 10, 20 and 30 cm between hills corresponding to plant population of 166667, 83333 and 55555 plant/ ha, respectively. The sub-sub plots were assigned to two sunflower hybrids, i.e., Vidok and Malabar. Sowing date was June 12, May 20 and 28 in the three successive seasons and the preceding crop was wheat in the three seasons.

Experimental sub-sub plots consisted of five ridges, each 4m in length and 0.6 m width. Sunflower seeds were sown in hills in the regular hand planting at the denoted hill spacing and thinned to one plant/ hill after 21 days. Nitrogen fertilization levels, in the form of ammonium nitrate (33.5%N), were applied in two equal split- doses at the first and second irrigations after sowing irrigation. All other cultural practices were carried out as recommended for sunflower production.

At harvest, five guarded plants were taken from each experimental unit to measure plant height (cm), stem diameter (cm) measured above the fourth node directly, leaf area/ plant (m^2) using K_p- 90 N model planimeter, head diameter (cm), 100- seed weight and weight of seeds/ head (g). Seed yield was determined (in Kilograms) from the three inner ridges per plot and was converted to tons per hectare. Oil content in sunflower seeds was determined using Soxhlet apparatus with hexane (60^oc) as a solvent according to A.O.A.C. (1980). Data were statistically analyzed according to Steel and Torrie (1984).

RESULTS AND DISCUSSION

The analysis of variance presented in (Table 2) indicated significant effects for nitrogen fertilization levels and hill spacings on plant height and stem diameter in the three seasons. Significant differences were found between hybrids with regard to leaf area/ plant in the three seasons.

Moreover, partitioning of the effect of N level into linear and quadratic indicated the significance of the linear component in all studied traits, in the three seasons, with contribution of the quadratic effect on plant height in 2003 season, 100-seed weight and seed weight/ head in 2004 and 2005 seasons, seed yield/ ha in 2003 and 2005 seasons, and oil percentage in the three seasons. The significance of the linear effect implies the possibility of obtaining positive response from adding N-fertilizer rates higher than those used in this study.

However, the significance of quadratic component, in some characters and seasons, indicate the presence of environmental seasonal effects that may limit the efficiency of increasing nitrogen application. That may be observed from the response of 100-seed weight, seed weight/ head and seed yield/ ha (Figures 1,2 and 3, respectively) in the three seasons.

Fig 1

Fig 2

Fig 3

Nitrogen level × hill spacing interaction and sunflower hybrids interactions with each of nitrogen levels or hill spacing had significant effects on leaf area/ plant in the three seasons. On the other hand, all the other first and second order interactions did not indicate any significant effects on the three growth characters in the three seasons.

Increasing nitrogen fertilization levels from 71 to 143 kg N/ ha significantly increased the three studied characters in the three seasons. The highest nitrogen level (143 kg N/ ha) produced the tallest plants (174.87, 153.70 and 198.49 cm), thicker stems (2.32, 2.87 and 2.67 cm) and highest leaf area/ plant (1.17, 0.97 and 1.37 m^2) in the three successive seasons. Since the soil analysis of the experimental sites (Table 1) and the preceding crop was wheat in the three seasons, nitrogen application positively stimulated vegetative growth. Similar results were obtained by Akhtar *et al*, (1992) , Zeiton (1992) El-Nakhlawy (1993) and El-Tabbakh (2000).

Table (2): Mean Squares for plant height, stem diameter and leaf area/ plant of sunflower plants during 2003, 2004 and 2005 seasons:

S.O.V.	d.f.	Plant height (cm)			Stem diameter (cm)			Leaf area/ plant (m^2)		
		2003	2004	2005	2003	2004	2005	2003	2004	2005
Replication	2	91.25	756.02	400.47	1.15	0.05	0.36	0.83	0.51	0.73
Fertilizer (N)	2	854.29**	1384.13*	1703.54*	1.05*	0.73*	1.00*	1.10*	0.71*	2.04*
Linear	1	**	*	*	*	*	*	*	*	*
Quadratic	1	*	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Error a	4	121.78	198.11	243.71	0.13	0.09	0.12	0.15	0.09	0.29
Hill spacing (S)	2	568.28*	330.77*	588.32*	0.60*	0.66*	0.42*	0.71**	0.41*	0.83*
N × S	4	126.19 n.s	192.60 n.s	496.39*	0.01 n.s	0.16 n.s	0.08	0.56**	0.30*	0.72*
Error b	12	143.09	179.83	190.21	0.13	0.07	0.10	0.10	0.08	0.20
Hybrid (H)	1	2.76 n.s	257.24 n.s	439.43 n.s	0.004 n.s	0.03 n.s	0.12 n.s	0.65**	0.16*	0.85*
N × H	2	71.36 n.s	26.20 n.s	385.28 n.s	0.02 n.s	0.04 n.s	0.04 n.s	0.33*	0.20**	0.69*
S× H	2	26.61 n.s	145.76 n.s	513.24 n.s	0.04 n.s	0.06 n.s	0.13 n.s	0.40*	0.13*	0.70*
N × S × H	4	18.52 n.s	166.24 n.s	302.37 n.s	0.08 n.s	0.03 n.s	0.03 n.s	0.10 n.s	0.06 n.s	0.33 n.s
Error c	18	81.68	170.62	206.88	0.11	0.04	0.06	0.07	0.03	0.18

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**
Ns: not significant at 0.05 level of probability.

Increasing within row spacings from 10 to 30 cm significantly decreased and increased plant height and stem diameter, respectively, in the three seasons (Table 3).

The wider hill spacings produced the shortest sunflower plants (133.64, 140.68 and 185.51 cm) in the three successive seasons. These findings may be explained on the basis of gibberellin content in plant tissues that cause cell elongation (Makram *et al*, 1994). However, Esechie *et al*, (1996) referred plant height increases under narrow hill spacings to high competition between plants for sunlight.

On the contrary, wider spacings between hills (30 cm) produced thicker sunflower stems (2.40, 2.82 and 2.76 cm) in the three seasons, respectively. That might be due to high competition level in high plant density (10 cm between hills) for sunlight, hence plants will be taller and thinner than those grown in lax populations. These results agreed with those obtained by Sharief (1998), Basha (2000) and Allam *et al*, (2002).

Increasing within hill spacings from 10 to 20 cm significantly increased leaf area/ plant in the three seasons (Table 4). Further increase in hill spacings (30 cm) in the three seasons insignificantly increased that trait.

Sunflower varieties exhibited significant differences for leaf area/ plant, only in the three seasons. Vidok variety had higher leaf area/ plant (0.97, 0.84 and 1.13 m^2) than Malabar in the three successive seasons.

Table (3): Mean of plant height (cm), stem diameter (cm) and leaf area/ plant of sunflower plants under effects of nitrogen fertilizer levels, hill spacings and hybrids during 2003, 2004 and 2005 seasons:

Treatment	Plant height (cm)			Stem diameter (cm)			Leaf area/ plant (m^2)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Nitrogen levels (k/ha)									
- 71	131.97 b	137.87 b	175.50 b	1.86 b	2.11 c	2.2 b	0.63 b	0.57 b	0.71 b
- 107	139.56ab	142.62ab	187.40ab	2.09ab	2.43b	2.55ab	0.84ab	0.77ab	0.94ab
- 143	148.87 a	153.70 a	198.49 a	2.32 a	2.87 a	2.67 a	1.17 a	0.97 a	1.37 a
Hill spacings (cm)									
- 10	143.56 a	147.43 a	190.81 a	1.84 b	2.10 c	2.21 c	0.67 b	0.54 b	0.72 b
- 20	143.19 a	146.08ab	185.07ab	2.03 b	2.49b	2.49 b	0.91 a	0.85 a	1.11 a
- 30	133.64 b	140.68 b	185.51 b	2.40 a	2.82 a	2.82 a	1.06 a	0.92 a	1.14 a
Hybrids									
- Vidok	139.90 a	142.54 a	185.30 a	2.08 a	2.40 a	2.43 a	0.97 a	0.84 a	1.13 a
- Malabar	140.36 a	146.92 a	188.96 a	2.10 a	2.45 a	2.52 a	0.79 b	0.70 b	0.85 b

- **Means followed by same letter(s) are not significantly different according L.S.D. (0.05) level of probability.**

Table 4

Nitrogen fertilization level × hill spacing interaction effect on leaf area/ plant (Table 5) indicated that the highest values (1.60, 1.41 and 1.76 m^2) in the three successive seasons resulted from the 30 cm hill spacing fertilized by the highest nitrogen level (143 kg N/ ha). Since the soil analysis in the experimental sites was deficient in nitrogen (Table 1), application of nitrogen fertilizer up to 143 kg/ ha positively stimulated vegetative growth and leaf area/ plant especially under wider hill spacings (30 cm) where optimum orientation of plants at lax population enable plants to utilize growth factors more efficiently and consequently produce higer leaf area.

Data in (Table 6) showed that leaf area/ plant for the two sunflower hybrids were statistically similar under both low and intermediate nitrogen fertilizer levels in the three seasons. However, under the highest nitrogen level (143 kg/ ha), Vidok plants had the highest leaf area/ plant (1.46, 1.14 and 1.46 m^2) in the three seasons, respectively. That might be due to the differences in genetical structure of both hybrids (Abou-Kresha *et al*, 1996).

With regard to sunflower hybrids × hill spacing interaction effects on leaf area/ plant (Table 7), increasing within row spacing increased leaf area in both sunflower hybrids plants, but Vidok plants surpassed Malabar plant especially under the widest space between hills (30 cm) in the three seasons of study. That could be attributed to genetical differences between the two sunflower varieties (Abou-Kresha *et al*, 1996).

Mean squares of the analysis of variance (Table 4) showed that nitrogen levels, hill spacings and sunflower hybrids had significant effects on head diameter, 100 seed weight, seed weight per head and seed yield per hectare in the three seasons and oil percent in 2003 and 2004 seasons, only.

Nitrogen × within row spacing interaction had significant effects on 100-seed weight and seed weight/ ha in the three seasons, head diameter and oil percentage in the first and third seasons and seed weight/ head in the second and third seasons, only. However, nitrogen fertilization levels × sunflower hybrid interaction exhibited significant effects on seed yield/ ha in 2003 and 2005 seasons and both seed weight/ head oil percentage in the third season.

On the other hand, seed weight/ head and oil percent were significantly affected by interaction between hill spacings and sunflower hybrids in the three seasons and the third one, respectively.

Means of the previous traits (Table 5) indicated that increasing nitrogen levels up to 107 kg N/ ha increased head diameter, 100- seed weight, seed weight per head and seed yield per hectare in the three seasons and decreased oil percent only in 2003 and 2004 seasons. Further increase in nitrogen levels (143 kg N/ ha) insignificantly increased the preceding characters in the three seasons or decreased oil percent in the first two seasons.

Table 5

Table 6

Table 7

The largest head diameter (20.48, 20.54 and 21.58 cm), heaviest seeds (6.22, 5.88 and 6.34 g/ 100 seeds), heaviest seed weight/ head (41.81, 43.76 and 45.47 g) and highest oil percent (40.37, 41.22 and 38.81%) in the three seasons, respectively, were obtained from the lowest plant density 30 cm between hills. Also, that spacing increased seed yield/ ha by 27.0, 25.6 and 22.4% compared with the highest plant population 10 cm between hills in the three successive seasons. The intermediate plant density 20 cm between hills did not significantly differ from the lowest density for seed yield/ ha, its attributes and oil percent during the three seasons. These findings might be due to the decrease in competition between sunflower plants for water, light and nutrients in 20 and 30 cm between hills compared with 10 cm. Also, in the wider spacings 20 and 30 cm between plants, there was a greater translocation of metabolites from different parts of plant to heads as a result of leaf area increasing which significantly increased each of head diameter, 100- seed weight and seed weight/ head. That indicates the ability of sunflower plants to compensate for lower plant populations, at wider hill spacings, with higher seed weight/ head resulting in an increase of seed yield/ha. Foeli *et al*, (1993) reported that the narrow hill spacings produced the lowest seed yield/ha.

With regard to the studied sunflower hybrids, Vidok significantly surpassed Malabar in head diameter, 100- seed weight, seed weight per head and seed yield per hectare and oil percent in the three seasons of study (Table 5). Differences between the two studied hybrids might be attributed to the higher leaf area in Vidok plants compared to Malabar besides the genetically structure for both hybrids (Abou- Kresha *et al*, 1996).

Data in (Table 6) showed nitrogen level × hill spacing interaction effects on head diameter, 100-seed weight, seed weight per head and hectare and oil percent during the three seasons. Generally, the narrowest distance between hills (10 cm) with any of the three studied nitrogen levels (71, 107 and 143 kg/ ha) produced the smallest sunflower heads, lightest seeds, lowest seed weight per head and seed yield per hectare. The lowest nitrogen level (71 kg/ ha) with any of the three distances between hills (10, 20 and 30 am) showed the same trend. The wider hill spacings (30 cm) with the highest nitrogen level (143 kg/ ha) produced the largest heads (22.64 and 23.03 cm) in 2003 and 2005 seasons and heaviest seeds (7.08, 6.54 and 7.25 g) in the three seasons. The highest seed weight/ head in the second and third seasons (47.82 and 46.84 g) resulted from the wider hill spacing (30 cm) with 143 and 107 kg N/ ha, respectively. However, the highest nitrogen level (143 kg/ ha) produced the highest seed yield/ ha (2.51 and 2.72 ton) at 20 and 30 cm between hills in the first and second seasons, respectively. Also, 20 and 30 cm between sunflower plants fertilized with 107 kg N/ ha produced the highest seed yield/ ha (2.62 and 2.58 ton), respectively, in the third season.

Since the experimental site is considered poor in nitrogen content, increasing nitrogen fertilization level to 107 or 143 kg/ ha increased leaf area/ plant and consequently increased the amount of light energy intercepted by leaves especially under intermediate and wider hill spacings. In addition, the amounts of the metabolites translocated from different parts of the plant to the head increased (Kasem and El-Mesilhy, 1992 and Geweifel *et al*, 1997).

As for oil percent, the lowest oil percentages during the first and third seasons resulted from the highest plant density (10 cm between hills) fertilized by any of the three nitrogen levels (71, 107 and 143 kg N/ ha). On the contrary, the wider spacing between plants (30 cm) fertilized by the lowest nitrogen level (71 kg/ ha) produced the highest oil percentages (42.09 and 39.92%) in 2003 and 2005 seasons, respectively.

Nitrogen fertilization level × sunflower hybrids interactions (Table 7) indicated that both hybrids produced the highest seed weight/ head at both 107 and 143 kg N/ ha without significant differences between them, but under the lowest nitrogen level (71 kg/ ha), Vidok hybrid surpassed Malabar in 2005 season. On the other hand, in 2003 and 2004 seasons, Vidok hybrid produced the highest seed yield/ ha under 107 and 143 kg N/ ha in 2003 and 143 kg N/ ha in 2004 seasons, respectively.

These findings showed that both hybrids differently interacted especially with N levels, with higher nitrogen application levels (Abou- Kresha *et al*, 1996). On the contrary, Vidok sunflower hybrid produced the highest oil percent (39.75%) when it was fertilized by the lowest nitrogen (71 kg/ ha) in the third season.

Sunflower hybrids × within row spacings interaction effects on seed weight/ head in the three seasons and oil percent in the third season (Table 8) showed that the wider spacing between hills (30 cm) generally, produced the highest seed weight/ head for both sunflower hybrids in the three seasons. Conversely, the narrower hill spacing (10 cm) produced the lowest seed weight/ head for both hybrids in the three successive seasons.

On the other hand, in the third season, oil percent in Malabar hybrid insignificantly responded to spacings between hills, but Vidok oil percent was significantly increased from 37.12% at 10 cm between hills to 40.35% at 30 cm between hills.

Table 8

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استجابة بعض هجن عباد الشمس تحت مستويات مختلفة من المسافات بين الجور والتسميد النيتروجينى

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الملخص العربي

أجريت هذه الدراسة فى محطة البحوث الزراعية لكلية الزراعة- جامعة الإسكندرية بأبيس خلال عام ٢٠٠٣، ٢٠٠٤، ٢٠٠٥ بهدف دراسة ثلاثة مستويات من السماد الآزوتى (٧١، ١٠٧، ١٤٣ كجم/ هكتار) وثلاثة مسافات بين الجور ١٠، ٢٠، ٣٠ سم والتى نتج عنها ثلاثة كثافات نباتية هى (55555) , (83333) ,(166667) نبات/ هكتار بالزراعة على (١٠، ٢٠، ٣٠ سم) بين الجور على الترتيب، على الهجنين فيودك ومالابار.

أدت زيادة مستويات الآزوت من ٧١ إلى ١٤٣ كجم/ هكتار إلى زيادة معنوية فى صفات ارتفاع النبات، قطر الساق، المساحة الورقية للنبات وقطر القرص ووزن المائة بذرة ومحصول البذور/ النبات، ومحصول البذور/ الهكتار فى الثلاث مواسم ولكن أنخفضت نسبة الزيت معنوياً فى كلا موسمى ٢٠٠٣، ٢٠٠٤.

وأدت زيادة مستوى النيتروجين من ١٠٧ كجم/ هكتار إلى ١٤٣ كجم/ هكتار إلى اختلافات غير معنوية فى كل الصفات المدروسة.

أدت زيادة المسافة بين الجور من ١٠ إلى ٣٠ سم إلى زيادة معنوية فى كل من قطر الساق والقرص ووزن المائة بذرة ومحصول البذرة/ نبات ونسبة الزيت بينما أنخفض ارتفاع النبات وكانت الاختلافات بين كل من ٢٠، ٣٠ سم بين الجور لم ترقى إلى مستوى المعنوية فى كل من المساحة الورقية/ نبات، قطر الساق ومحصول البذرة/ هكتار، ونسبة الزيت.

أختلف الهجين فيودك عن الهجين مالابار فى كل الصفات المدروسة ماعدا ارتفاع النبات وقطر الساق فى الثلاث مواسم.

أدى التفاعل بين مستويات الآزوت ١٤٣ كجم/ هكتار × الكثافة العالية (٣٠ سم بين الجور) إلى الحصول على قطر أكبر للقرص وبذور أثقل فى الوزن ومحصول بذرة/ القرص أعلى.

أوضحت النتائج المتحصل عليها من الدراسة أن المستوى المتوسط من السماد (١٠٧ كجم/ هكتار) ومسافة الزراعة المتوسطة (٢٠ سم بين الجور) هى المعاملة التى أعطت أعلى محصول بذرة/ هكتار من كلا الهجنين المستخدمين وكان فيودك متفوقاً على مالابار فى صفات المحصول ومكوناته ونسبة الزيت كانت أعلا نسبة للزيت تم الحصول عليها من الكثافة النباتية العالية (الزراعة ٣٠ سم بين الجور) مع المستوى المنخفض من التسميد الآزوتى (٧١ كجم/ هكتار). كان الهجين فيودك مع مستوى التسميد المرتفع أعلى معنوياً فى المساحة الورقية/ نبات ومحصول البذرة/ هكتار.

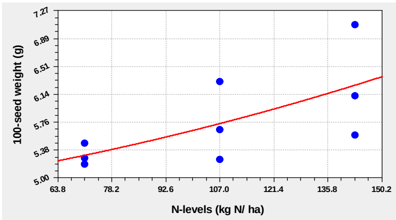
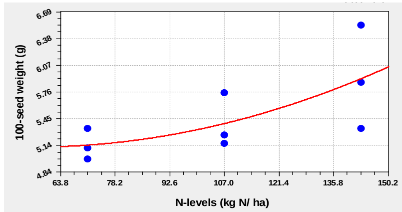
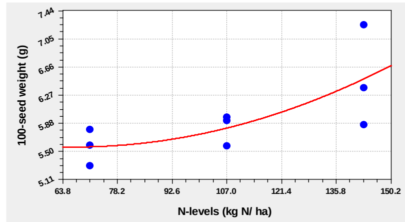
Season / Trait	2003	2004	2005
100-seed weight (g)	S.E. = 0.542 r = 0.659 $y = 4.725 + 0.0057X_1^* + 3.472X_2^2$ 	S.E. = 0.405 r = 0.696 $y = 5.45 - 0.0116X_1^* + 0.0001X_2^{2*}$ 	S.E. = 0.4461 r = 0.736 $y = 6.28 - 0.0216X_1^* + 0.0001X_2^{2*}$ 

Figure (1): Relationship between N-Levels and 100-seed weight (g) in 2003, 2004 and 2005 seasons

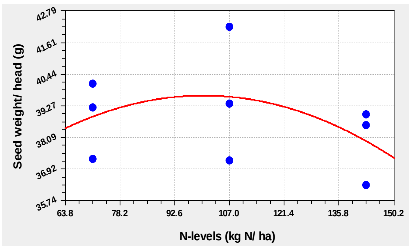
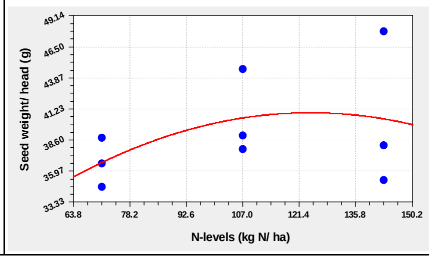
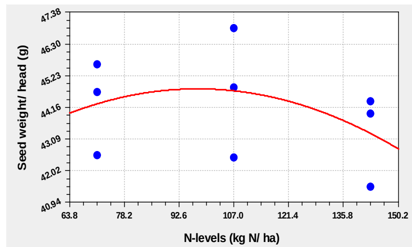
Seed weight/ head(g)	S.E. = 1.84 r = 0.41 $y = 30.399 + 0.184X_1^* - 0.0009X_2^{2*}$ 	S.E. = 4.52 r = 0.430 $y = 17.9 + 0.37X_1^* - 0.0014X_2^{2*}$ 	S.E. = 1.796 r = 0.382 $y = 37.87 + 0.142X_1^* - 0.0007X_2^{2*}$ 

Figure (2): Relationship between N-Levels and Seed weight/ head (g) in 2003, 2004 and 2005 seasons

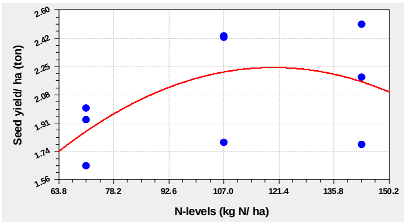
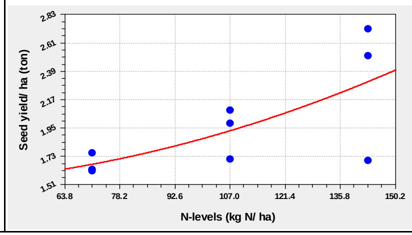
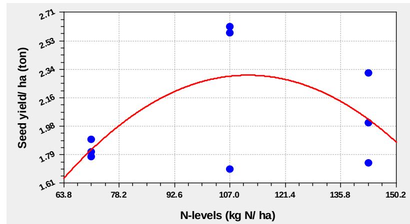
Season / Trait	2003	2004	2005
Seed yield/ ha (ton)	S.E. = 0.3198 r = 0.516 $y = -0.081+ 0.0388X_1{}^* - 0.0002X_2{}^{2*}$	S.E. = 0.334 r = 0.694 $y = 1.51- 0.001X_1{}^* + 4.625X_2{}^2$	S.E. = 0.345 r = 0.567 $y = -1.314+0.0649X_1{}^* -0.0003X_2{}^{2*}$
			

Figure (3): Relationship between N-Levels and Seed yield/ ha (ton) in 2003, 2004 and 2005 seasons

Table (4): Means squares for head diameter, 100-seed weight, seed weight/ head, seed yield/ ha and oil percentage (%) of sunflower seeds during 2003, 2004 and 2005 seasons.

S.O.V.	d.f.	Head diameter (cm)			100-seed weight (g)			Seed weight/ head (g)			Seed yield/ ha (ton)			Oil percentage (%)		
		2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Replication	2	0.01	1.48	3.58	0.01	0.03	0.13	0.49	3.30	48.34	0.20	0.26	0.43	0.05	3.91	0.68
Fertilization(N)	2	22.91*	60.83*	42.65*	14.06**	4.62*	6.83*	27.74*	47.29*	62.57*	0.91*	1.55*	1.12*	32.47*	71.83*	21.20$^{n.s}$
Linear	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Quadratic	1	n.s	n.s	n.s	n.s	*	*	n.s	*	*	*	n.s	*	*	*	*
Error (a)	4	3.23	8.66	5.99	0.73	0.49	0.90	3.82	6.50	0.86	0.10	0.22	0.16	4.51	10.27	6.49
Hill spacing(S)	2	12.28**	23.11*	14.61*	2.57**	1.09*	2.06*	22.86**	67.12**	81.75**	0.81*	0.79*	1.34*	12.58*	37.21*	16.02*
N × S	4	721*	10.21$^{n.s}$	12.32*	1.87*	0.91*	1.77*	8.06$^{n.s}$	88.82**	130.62**	0.67*	0.71*	1.91*	2.66*	10.58$^{n.s}$	12.23*
Error (b)	12	1.91	5.74	3.59	0.35	6.26	0.45	3.40	4.44	4.84	0.19	0.20	0.31	2.32	6.15	3.20
Hybrid (H)	1	8.39*	12.76*	8.52*	0.80*	6.50*	0.93*	12.43**	26.49**	99.77**	0.33*	0.78*	0.98*	17.11**	18.33*	34.56**
N × H	2	3.25$^{n.s}$	0.56$^{n.s}$	3.31$^{n.s}$	0.08$^{n.s}$	0.07$^{n.s}$	0.44$^{n.s}$	3.31$^{n.s}$	17.41$^{n.s}$	77.17**	0.30*	0.34$^{n.s}$	1.00*	0.25$^{n.s}$	0.10$^{n.s}$	87.12**
S × H	2	2.09$^{n.s}$	2.04$^{n.s}$	2.97$^{n.s}$	0.32$^{n.s}$	0.20$^{n.s}$	0.53$^{n.s}$	49.26**	39.74**	48.04**	0.14$^{n.s}$	0.28$^{n.s}$	0.49$^{n.s}$	0.63$^{n.s}$	0.12$^{n.s}$	74.58**
N × S × H	4	1.22$^{n.s}$	1.48$^{n.s}$	2.31$^{n.s}$	0.22$^{n.s}$	0.14$^{n.s}$	0.10$^{n.s}$	3.18$^{n.s}$	26.69**	17.70**	0.13$^{n.s}$	0.30$^{n.s}$	0.37$^{n.s}$	0.51$^{n.s}$	0.08$^{n.s}$	2.52$^{n.s}$
Error (c)	18	0.86	3.71	1.72	0.17	0.09	0.32	1.01	3.02	3.34	0.08	0.16	0.25	1.98	4.06	1.10

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.
N.S: not significant at 0.05 level of probability.

Table (5): Means of head diameter, 100-seed weight, seed weight/ head, seed yield/ ha and oil percentage (%) of sunflower as affected by nitrogen fertilization levels, hill spacings and hybrids during 1999, 2000 and 2001 seasons.

Treatments	Head diameter (cm)			100-seed weight (g)			Seed weight/ head (g)			Seed yield/ ha (ton)			Oil percentage (%)		
	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
Nitrogen levels (kg/ ha)															
71	17.88b	18.01b	18.98b	5.31b	5.15b	5.56b	38.35b	36.70b	41.28b	1.86b	1.67b	1.80b	41.04a	41.90a	38.36a
107	19.89a	19.60ab	21.53a	5.74a	5.40ab	5.82ab	41.16a	40.48a	45.72a	2.22a	2.31a	2.30a	39.77ab	40.34ab	37.67a
143	21.09a	21.70a	22.00a	6.26a	5.92a	6.50a	40.08ab	40.39a	45.27a	2.16a	1.93ab	2.02ab	38.08b	38.82b	37.88a
Hill spacings (cm)															
10	18.67b	18.79b	20.18b	5.34b	5.20b	5.58b	38.66b	35.89c	42.17b	1.74b	1.68b	1.74b	38.69b	39.29b	37.17b
20	19.71a	19.98ab	20.76ab	5.75b	5.39b	5.96ab	39.11b	37.92b	44.63a	2.29a	2.12a	2.25a	39.83a	40.54ab	37.93ab
30	20.48a	20.54a	21.58a	6.22a	5.88a	6.34a	41.81a	43.76a	45.47a	2.21a	2.11a	2.13ab	40.37a	41.22a	38.81a
Hybrids															
Vidok	20.08a	20.39a	21.32a	5.92a	5.65a	6.33a	40.20a	39.72a	44.68a	2.20a	2.11a	2.23a	40.91a	41.64a	38.72a
Malabar	19.16b	19.15b	20.36b	5.62b	5.33b	5.59b	39.52b	38.66b	43.50b	1.96b	1.83b	1.85b	38.35b	39.06b	37.22b

Means followed by the same letter(s) are not significantly different according to L.S.D. at 0.05 level of probability.

Table (6): Means of Leaf area/ plant (m^2), head diameter (cm), 100-seed weight (g), seed weight/ head (g), seed yield/ ha (ton) and oil percentage (%) as affected by nitrogen level × hill spacing interaction overall sunflower hybrid during 2003, 2004 and 2005 seasons.

N-levels (kg N/ha)	Hill spacing (cm)	Leaf area (m^2)			Head diameter (cm)			100-seed weight (g)			Seed weight/ head (g)			Seed yield/ ha (ton)			Oil percentage (%)		
		2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
71	10	0.51c	0.49c	0.58b	17.74c	18.60c	18.47b	5.19c	4.99c	5.30b	37.3b	34.65d	42.55b	1.65b	1.63b	1.78b	40.10ab	35.09ab	37.26b
	20	0.78bc	0.73bc	0.84b	17.95c	18.80c	19.05b	5.47bc	5.12bc	5.58b	39.20ab	36.63cd	44.67ab	1.93b	1.76b	1.81b	40.39ab	35.33ab	37.90ab
	30	0.60c	0.49c	0.71b	17.95c	18.75c	19.42b	5.27bc	5.34bc	5.80b	40.1ab	38.82c	45.62ab	2.00b	1.62b	1.89b	42.09a	37.77a	39.92a
107	10	0.64bc	0.56c	0.84b	18.90bc	19.85bc	20.21b	5.25c	5.27bc	5.57b	37.25b	37.82cd	42.48b	1.79b	1.71b	1.70b	38.97b	34.45b	37.20b
	20	0.90bc	0.89bc	1.03b	19.92b	20.95b	22.12ab	5.66bc	5.17bc	5.92b	39.36ab	38.98c	44.84ab	2.43ab	2.09b	2.62a	39.34b	34.43b	37.77ab
	30	0.98bc	0.86bc	0.95b	20.85ab	21.95ab	22.26ab	6.31ab	5.76b	5.97b	42.2a	44.64b	46.84a	2.44ab	1.99b	2.58a	41.10ab	35.99ab	38.04ab
143	10	0.86bc	0.57c	0.74b	19.37bc	20.38ab	21.86ab	5.58bc	5.34bc	5.87b	36.33b	35.20d	41.48b	1.78b	1.70b	1.74b	37.00b	31.44c	37.05b
	20	1.05b	0.93b	1.46ab	21.26ab	21.80ab	21.11ab	6.12b	5.88ab	6.38ab	38.95ab	38.15c	44.38ab	2.51a	2.51ab	2.32ab	39.22b	34.55b	38.12ab
	30	1.60a	1.41a	1.76a	22.64a	23.0a	23.03a	7.08a	6.54a	7.25a	38.56ab	47.82a	43.95ab	2.19ab	2.72a	2.00ab	38.02b	34.10b	38.47ab

Means followed by the same letter(s) are not significantly different according to L.S.D. at 0.05 level of probability.

Table (7): Means of Leaf area/ plant (m^2), seed weight/ head (g), seed yield/ ha (ton) and oil percentage (%) as affected by hill spacing × hybrid interaction overall nitrogen level during 2003, 2004 and 2005 seasons

N-levels kg (N/ha)	Hybrids	Leaf area			Seed weight/ head (g)			Seed yield/ ha (ton)			Oil percentage (%)		
		2003	2004	2005	2003	2004	2005	2003	2004	2005	2003	2004	2005
71	Vidok	0.59b	0.57b	0.86b	43.50c	40.40b	42.60b	1.98b	1.84b	2.25b	37.95a	38.50a	39.75a
	Malabar	0.67b	0.57b	0.56b	40.25d	38.9c	39.76c	1.74b	1.52b	1.55c	34.75b	34.90c	36.97b
107	Vidok	0.86b	0.81b	1.07ab	45.90a	44.20a	46.08a	2.32a	2.19ab	2.38ab	35.33b	36.30b	37.68b
	Malabar	0.82b	0.73b	0.81b	45.25a	43.85a	45.36a	2.12ab	2.05ab	2.40a	35.55b	38.20a	37.66b
143	Vidok	1.46a	1.14a	1.46a	45.55a	43.67a	45.36a	2.30a	2.30a	2.45a	35.44b	36.70b	38.73ab
	Malabar	0.88b	0.80b	1.18ab	44.60b	43.45a	45.18a	2.02ab	1.92ab	2.36ab	35.35b	36.95b	37.03b

Means followed by the same letter(s) are not significantly different according to L.S.D. at 0.05 level of probability.

Table (8): Means of Leaf area/ sunflower plant (m^2), seed weight/ head (g) and oil percentage (%) as affected by hill by nitrogen level × hybrid interaction during 2003, 2004 and 2005 seasons.

Hybrids	Hill spacing	Leaf area (m^2)			Seed weight/ head (g)			Oil percentage (%)		
		2003	2004	2005	2003	2004	2005	2003	2004	2005
Vidok	10	0.71bc	0.60c	0.78b	39.82b	36.31c	43.12b	37.0d	38.25c	37.12c
	20	0.92b	0.86ab	1.27a	39.12b	39.31b	44.22ab	40.60a	40.25b	38.69b
	30	1.28a	1.06a	1.34a	41.66a	43.54a	46.10a	40.85a	41.45a	40.35a
Malabar	10	0.63c	0.48c	0.66b	37.50c	35.47c	41.22b	37.9c	38.50c	37.22c
	20	0.90bc	0.84b	0.95ab	39.10b	36.53c	44.44ab	38.30c	38.10c	37.17c
	30	0.84bc	0.78bc	0.94ab	41.96a	43.98a	44.84ab	38.66c	38.30c	37.27bc

Means followed by the same letter(s) are not significantly different according to L.S.D. at 0.05 level of probability.