Sunflower for Forage and Seed Production Under Different Levels of Crop Management

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ABSTRACT

Malabar, Vedok and Hysun sunflower cultivars were sown as recommended (4kg/fad) and thinned after 21 days (P_1). That was compared to sowing at the rate of 12 kg seed/fad and thinned after 31 (P_2), 41 (P_3), 51 (P_4) and 61 (P_5) days from sowing during 2002 and 2003 summer seasons.

Significant variations among cultivars were found for plant height, number of leaves/plant, seed yield/plant and seed yield/fad in both seasons. Malabar produced the shortest plants and gave the maximum records of number of leaves plant, seed yield/plant and seed yield/fad in both seasons.

P_1 thinning treatment gave the highest 100-seed weight, seed yield/plant, seed yield/fad and cereal units (Cu_s). P_2, that was equal to P_1 in seed yield and Cu_s, gave additional fodder yield/fad as a profit of such procedure. Results obtained encourage thinning 10 days later than recommended to produce seed and forage yields from sunflower.

The two-factor interaction showed significant effects for plant height, 100-seed weight and seed yield/fad. Malabar had the shortest plants and greatest values of 100-seed weight and seed yield/fad under P_1 thinning treatment. However, Hysun produced the tallest plants, lowest 100-seed weight and seed yield/fad with P_5 application.

Regression analysis indicated an increase of 0.42 and 0.49 t/fad in forage yield, corresponding to a decrease of 19.5 and 21.5 kg in seed yield, for a delay in thinning of one day in the first and second seasons, respectively.

Stepwise regression analysis indicated that 100-seed weight was the best variable to explain the variations in seed yield/plant (in both seasons) and seed yield/fad (in the second season).

Keywords: Sunflower, thinning interval, forage yield, cereal units.

INTRODUCTION

Sunflower is a major oil seed crop in the world. Several considerations that encourage the cultivation of sunflower as a forage crop include rapid growth and high yielding potential of fodder that is high in nutritional value (Seiler, 1984 and 1986 and Miterva, 1989).

Plant growth can be expressed by the genotype and or genotype x environment interaction. In modern crop production, choice of high yielding cultivar, accommodating to the surrounding conditions, along with optimization of application of cultural practices for the purpose of growing that cultivar, are indispensable to obtain maximum yield. Beside genetical structure of sunflower, stand density and date of thinning are some of the necessary factors affecting sunflower yield potentiality.

Several investigations were conducted to examine the variations among sunflower cultivars with regard to plant height, number of leaves/plant, head seed weight and 100-seed weight (Nawar, 1994 and Basha, 2000) as well as seed yield (Parmar and Kharwar, 1992 and Pal *et al*, 1997).

Number of plants/m^2 is closely related to sunflower agronomic traits, yield and yield attributes. Increasing plant density increased plant height (Nawar, 1994 and AbdAllah, 2003), but reduced head diameter and head seed weight, 100 seed weight and seed yield (Narwal and Malik, 1985; Pal *et al*, 1997 and Basha, 2000).

In Egypt, where green fodder is presents a problem in the summer seasons along with the inability of small farmers to grow a sole forage summer crop, farmers are to delay thinning and use the removed plants in livestock feeding. Gelilah (1983) and Fisal *et al* (1993) found, in maize, that a delay in thinning to a period more than 21 days after sowing increased fodder yield of removed plants. El-Nakhlawy (1993) concluded that sunflower could be grown as a dual crop, i.e. green leaves as a fodder and seeds for oil production. Leushin and Mangutov (1990) reported that late cutting, or removal, of sunflower plant increased fresh fodder and dry matter yields.

The present investigation aimed to study sunflower varietal response to delay in thinning time, in addition to determining the delay period of thinning which gives a suitable forage yield without significant reduction in seed yield.

MATERIALS AND METHODS

A two summer season field study (2002 and 2003) was conducted at the Agricultural Research Station, Alexandria University, Egypt to investigate the response of three sunflower cultivars (Malabar, Vedok and Hysun) to five thinning treatments. Soil chemical properties in the experimental site were 7.9 for pH, 1.46% for organic matter, 16.68 ppm for available N and 9.39 ppm for inorganic phosphorus, as an average of the two seasons.

A split plot design with three replicates was used in both seasons. Cultivars occupied the main plots, whereas, the sub plots were allocated to the five thinning treatments. Each experimental unit (10.8 m^2 in area) comprised six ridges, 3.0 m long and 0.6 m wide. Sunflower was sown, at the rate of 4 kg/fad, in hills spaced at 20 cm apart and thinned after 21 days after sowing (DAS), at one plant/ hill for the control treatment or standard population (P_1). Drilling of sunflower at 12 kg/fad rate and thinning to the standard population at 31 (P_2), 41 (P_3), 51 (P_4) and 61 (P_5) DAS were conducted during the two seasons. Weights of removed plants (on plot basis) from treatment P_2 to P_5 were converted to ton/fad representing the forage yields. Sowing dates were May 10^{th} and 5^{th} during the two successive seasons. All other cultural practices were uniformly applied according to the recommendation for sunflower production in the region.

At harvest, ten random plants were taken, from each subplot, to determine the following characters on average basis: plant height (cm), number of leaves/plant, head diameter (cm) and seed yield/plant (g). Seed yield per plot was determined from the inner 4 ridges of each subplot then converted to kg/fad. The average of three random sample, from each subplot, was used to determine 100-seed weight. Cereal units were estimated according to Brackhaus (1962), who denoted that each 100 kg of seed or straw yields of sunflower was equivalent 1.5 and 0.15 Cu_s, respectively.

All statistical procedures (analysis of variance, regression and stepwise regression analysis) were conducted according to Gommez and Gommez (1984).

RESULTS AND DISCUSSIONS

Analysis of variance (Table 1) showed significant differences between cultivars for plant height, number of leaves/plant, seed yield/plant and seed yield/fad in both seasons. Responses to thinning treatments were significant for all the studied characters except number of leaves/plant and head diameter during the two seasons. Meanwhile, sunflower varietal response to thinning (first order interaction) was significant for plant height, 100-seed weight and seed yield/fad during the two successive seasons of the study.

Mean values for the studied characters are presented in Table (2). Malabar gave significantly shorter plants than those of Vedok and Hysun cultivars in both seasons. Reductions in plant height, as an average of the two seasons, for Malabar plants were 14.11 and 18.96 cm, compared to plant height of Vedok and Hysun, respectively. These results may be attributed to, genetically, shorter internodes (less expansion of internodes cells)of Malabar plants compared to those of Vedok and Hysun (Gardner *et al*, 1985).

Concerning number of leaves/plant, cultivars were arranged in a reverse order of plant height character. Variations in that trait was significant in both seasons, where both Malabar and Vedok significantly exceeded Hysun in that trait. Gardner *et al* (1985) indicated that leaf number is genotype- dependent and the increase in the interval time between the appearance of successive leaves is responsible for reduction in number of leaves/plant and vice versa.

Variations in seed yield/plant between the three cultivars were significant in both seasons. Increases in such trait for Malabar plants were 2.59 and 5.17g in 2002, corresponding to 3.16 and 6.99 g in 2003 season, compared to those of Vedok and Hysun plants, respectively.

Differences between the three cultivars, regarding seed yield/fad, were significant in both seasons. Yields of Malabar were 1026.00 and 1081.75, corresponding to 952.73 and 1003.13 for Vedok and 933.33 and 985.07 kg/fad for Hysun in 2002 and 2003 seasons, respectively. Reduction in plant height, and greater photosynthetic leaf area of Malabar (Table 2) with rapid translocation of nutrients into heads (Hassan, 1995) may be responsible for increases in photosynthesis, photoassimilates partitioning into seeds, seed fertility and individual seed weight, (Loomis and Coonor, 1992) hence seed yield/plant and seed yield/fad for that cultivar.

Similar findings were reported by (Mundstock and Zagonel, 1994), concerning plant height, number of leaves/plant and head seed weight. Similar results for seed yield were reported by Parmar and Kharwar (1992) and Sarmah *et al* (1994).

Responses of sunflower to thinning treatments for all the studied characters are shown in Table (2). There were significant and gradual increases in fodder yields with the delay of thinning time of sunflower. Increases in forage yield for P_3, P_4 and P_5, compared to P_2 treatment, were 4.10, 9.00 and 11.10 t/fad in 2002, corresponding to 4.90, 11.60 and 13.50 t/fad in 2003 season, respectively. Longer growth duration before thinning (P_5 treatment) was associated with greater nutrients uptake and larger investment of accumulated dry matter into the vegetative parts leading to increases in forage yield, compared to the remaining thinning treatments. These results could be explained by the production of vigorous plants, in terms of plant height, that increased forage yield obtained from P_5. Leushin and Mangutov (1990) reported an increase in fresh fodder and dry matter yields with late cutting, or late removal, of sunflower plants.

Plant height of sunflower plants under P_1 treatment was significantly shorter, compared to the other thinning treatments. More stand, with intracompetition for a longer period of time, may be a reason for increasing plant height. However, sowing sunflower at seeding rate of 12 kg seed/fad with a gradual increase in time to thinning up to 61 DAS, was associated with significant and progressive increases in plant height. Percentage of increases in plant height was 9.0, 14.9 and 18.3% in 2002 and 8.7, 13.7 and 17.1% in 2003 for P_3, P_4 and P_5, compared to P_2, respectively. Increasing the period of light intracompetition and increased auxin concentration inside sunflower plant due to mutual shading for a longer period increased plant etiolation (Gardner *et al*, 1985; Tetoskagho and Gardner, 1988 and Loomis and Coonor, 1992) of P_5, compared to the other thinning treatments.

The P_1 was statistically equal to P_2 treatment, but superior to the other thinning treatments in 100-seed weight and seed yield/plant in both seasons. Compared to P_1, relative reductions in 100-seed weight averaged 2.20, 39.22, 47.47 and 60.52%, whereas, in seed yield/plant, as an average of the two seasons, reductions were, 2.90, 30.94, 41.10 and 56.09% for P_2, P_3, P_4 and P_5, respectively. As reported, reductions in both traits were increased by increasing the interval between sowing and thinning, hence the lowest records of both 100-seed weight and seed yield/plant were obtained from P_5 (thinning at 61 DAS).

The trend of seed yield/fad, as affected by thinning application, was similar to that of 100-seed weight and seed yield/plant in both seasons. P_1 and P_2 were equal in seed yield/fad, but greater than yields of P_3, P_4 and P_5. Consequently, data reported a reduction in seed yield by a percentage of 1.80, 30.95, 41.08 and 56.12% (averaged over the two seasons)for P_2, P_3, P_4 and P_5 compared to P_1, respectively. As aforementioned, the longest interval from sowing to thinning (61 DAS) was responsible for the lowest seed yield, which may be explained by the occurrence of one of the following events: 1- greatest plant nutrients uptake and assimilation, investment of photoassimilates in favor of vegetative at the expense of reproductive parts in association with lower number and fertility of seeds, and/or reductions of individual seed weight and seed yield/fad (Miterva, 1989).

Cereal units (Cu_s) showed that P_1 and P_2 were equal, but economically greater compared to Cu_s of P_3, P_4 and P_5. This estimate gave an indication that greater fodder yield did not compensate for reductions in seed yield of that occurred when thinning was delayed beyond 31 DAS.

Several studies reported that increases in sunflower population density increased plant height, 100-seed weight and head-seed weight (Narwal and Malik, 1985; Sharmah *et al*, 1994; Basha, 2000 and AbdAllah, 2003).

In conclusion, reported data suggested that thinning 31 DAS for sunflower plants, sown at the rate of 12 kg seed/fad, could be followed by the small farmer, who can not afford to grow a sole summer forage crop, to produce a reasonable amount of fodder without any deleterious effects on sunflower seed yield.

Results of plant height, 100-seed weight and seed yield/fad, as affected by the combined effects of cultivars and the thinning treatments, are presented in Table (3). Plant height of the three cultivars was proportionally related to the period of delay of thinning. Longer period to thinning produced taller plants compared to shorter ones (21 DAS). Differences between cultivars for plant height were significant under each of thinning treatments. Hysun, grown under P_5 conditions, gave the tallest plants while the shortest plants were obtained from Malabar under P_1 application. Within each cultivar, P_1 was equal to P_2 in both 100-seed weight and seed yield/fad, but greater than those obtained from the remaining thinning treatments. These findings further showed that delay of thinning by 10 days, compared to 21 DAS, might not be enough to impose a drastic reduction in those traits. Malabar, in contrast with Hysun, produced the heaviest 100-seed weight and greatest seed yield/fad under P_1 and P_2 treatments. Superiority of Malabar under P_1 and P_2, thinning treatments, compared to Vedok and Hysun, might be due to greater nutrients uptake of Malabar plants in P_1 and P_2 plots and higher photosynthetic rate and photoassimilates translocation to heads followed by increases in seed number, fertility and size, and finally greater individual seed weight and seed yield/fad (Loomis and and Coonor, 1992).

Data in Table (4) indicated that forage yield was significantly and positively affected by increasing the period to thinning beyond 21 DAS. An increase of 0.42 and 0.49 t/fad was estimated with delay of thinning by one day, in the first and second seasons, respectively. On the other hand, a significant decrease of 19.5 and 21.5 kg in seed yield were estimated with one day increase in period to thinning in the two successive seasons, respectively. These findings revealed that delaying thinning increased plant intracompetition and shading, leading to lower photoassimilates production and hence decreased seed yields. On the other hand, forage yield increased due to higher plant growth with delayed thinning.

Stepwise regression analysis for seed yield (Table 5) indicated that plant height, in the first season, and seed yield per plant, in the second season, were the most important traits that affected seed yield. Adding of variables resulted in small gradual increases in values of coefficient of determination (R^2) indicating better interpretation of variation in seed yield. Regarding stepwise regression of 100-seed weight (Table 6), analysis indicated that seed yield per plant, in both seasons, was the best variable to explain the variations in that trait. However, in the second season, both plant height and number of leaves per plant contributed significantly to the interpretation of variation in 100-seed weight.

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Table (1): Mean squares for the studied characters in 2002 and 2003 seasons.

S.O.V	d.f	Green forage		Plant height		Number of leaves/plant		Head diameter		100-seed weight		Seed yield/ plant		Seed yield/ fad		Cereal units	
		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Cultivars (C)	2 (2)!	n.s.	n.s.	*	*	*	*	n.s.	n.s.	n.s.	n.s.	*	*	*	*	n.s.	n.s.
Error (a)	2 (2)	1.29	1.29	5.55	1.01	1.01	1.84	1.86	1.27	0.10	0.10	4.10	6.27	920.5	958.68	0.97	1.63
Thinning patterns (P)	4 (3)	*	*	*	*	n.s.	n.s.	n.s.	n.s.	*	*	*	*	*	*	*	*
C x P	8 (6)	n.s.	n.s.	*	*	n.s.	n.s.	n.s.	n.s.	*	*	n.s.	n.s.	*	*	n.s.	n.s.
Error (b)	24 (18)	2.81	2.81	6.34	2.07	2.07	2.11	1.56	0.55	0.015	0.012	3.15	5.50	242.90	240.36	4.21	1.67

*** Significantly different at 0.05 probability level.** **n.s. not significant.**

! Degrees of freedom for the green forage are given between parentheses.

Table (2): Means of studied characters as influenced by cultivars and thinning patterns in 2002 and 2003 seasons.

Treatments	Green forage yield (ton/fad)		Plant height (cm)		Number of leaves/plant		Head diameter		100-seed weight (g)		Seed yield/ plant (g)		Seed yield / fad (kg)		Cereal units CU,	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Cultivars :																
Malabar	11.30	12.83	138.32	152.70	23.19	28.71	14.05	14.77	7.73	7.99	31.98	35.68	1026.0	1081.75	21.98	2[illegible]2.15
Vedok	10.66	12.19	145.11	174.13	22.67	27.47	14.24	14.96	7.80	7.97	29.39	32.52	952.73	1003.13	22.10	2[illegible]2.23
Hysun	11.80	13.00	146.19	182.75	21.09	24.07	13.45	14.20	7.76	7.90	26.81	28.69	933.33	985.07	21.77	2[illegible]1.68
L.S.D. 0.05	n.s.	n.s.	2.06	2.39	1.02	1.37	n.s.	n.s.	n.s.	n.s.	2.05	2.54	30.76	35.14	n.s.	n.s.
Thinning pattern																
21 DAS (P_1)	0.00	0.00	130.97	155.30	22.03	26.80	14.53	14.67	8.04	8.69	43.30	45.87	1310.78	1395.22	21.96	2[illegible]6.79
31 DAS (P_2)	5.20	5.12	132.27	158.10	22.02	26.80	14.28	14.56	7.95	8.42	42.23	43.70	1296.78	1359.33	20.88	2[illegible]5.62
41 DAS (P_3)	9.30	10.02	144.18	170.93	21.82	26.78	14.18	14.39	7.80	7.89	23.78	30.49	918.56	956.78	16.55	2[illegible]0.55
51 DAS (P_4)	14.20	16.72	151.98	179.77	21.84	26.68	14.17	14.39	7.52	7.06	20.82	26.00	788.22	806.22	15.90	1[illegible]8.98
61 DAS (P_5)	16.30	18.62	156.48	185.20	21.84	26.72	14.07	14.00	7.50	7.01	16.82	18.40	588.44	598.98	15.31	1[illegible]8.20
L.S.D. 0.05	1.26	1.66	1.96	2.49	n.s.	n.s.	n.s.	n.s.	0.12	0.72	1.73	2.28	15.15	43.95	2.0	[illegible].26

* DAS = days after sowing.

Table (3): Two factor interaction for plant height, 100-seed weight and seed yield/fad during 2002 and 2003 seasons.

Cultivar	Thinning treatment	Plant height		100-seed weight		Seed yield/fad	
		2002	2003	2002	2003	2002	2003
Malabar	P_1	125.10	137.60	8.10	8.40	1388.1	1418.2
	P_2	126.47	139.13	7.98	8.29	1361.3	1401.8
	P_3	136.43	150.07	7.69	7.95	956.6	976.6
	P_4	151.67	166.83	7.53	7.73	852.4	872.4
	P_5	154.43	169.87	7.50	7.61	654.0	691.0
Vedok	P1	128.90	154.67	8.00	8.00	1315.0	1334.5
	P2	132.00	156.00	7.86	7.90	1302.4	1323.5
	P3	138.47	178.67	7.60	7.67	916.6	935.5
	P4	156.67	186.00	7.56	7.60	780.3	801.5
	P5	158.10	190.33	7.54	7.51	598.7	608.0
Hysun	P1	131.90	174.37	7.84	7.97	1251.08	1320.5
	P2	140.33	178.19	7.73	7.79	1222.92	1291.5
	P3	149.23	184.07	7.52	7.55	891.0	960.0
	P4	159.63	189.47	7.50	7.50	728.4	788.5
	P5	160.90	192.40	7.41	7.40	496.6	564.5
L.S.D.		3.34	4.24	0.21	0.18	26.27	76.12

Table (4): Regression analysis for both forage and seed yields on number of days to thinning in 2002 and 2003 seasons.

Season	Forage yield			Seed yield		
	a	b	R^2	a	b	R^2
2002	-8.06	0.42**	0.98	1779.98	-19.51**	0.94
2003	-9.93	0.49**	0.98	1903.00	-21.51**	0.95

** Highly significant at 0.01 level.
a = the intercept
b = regression coefficient for yields on number of days to thinning.

Table (5): Best equations for stepwise regression analysis for seed yield in 2002 and 2003 seasons.

Equation	2002		2003	
	Variables	R^2	Variables	R^2
1 variable	X_2	0.974	X_6	0.980
2 variables	X_1, X_2	0.975	X_2, X_3	0.992
3 variables	X_2, X_3, X_4	0.976	X_2, X_3, X_6	0.996
4 variables	X_2, X_3, X_4, X_6	0.977	X_1, X_2, X_3, X_6	0.997
5 variables	X_1, X_2, X_3, X_4, X_6	0.978	X_1, X_2, X_3, X_5, X_6	0.999
All variables	-	0.978	-	0.999

Table (6): Best equations for stepwise regression analysis for 100-seed weight in 2002 and 2003 seasons.

Equation	2002		2003	
	Variables	R^2	Variables	R^2
1 variable	X_6	0.93	X_6	0.87
2 variables	X_1, X_6	0.96	X_2, X_3	0.94
3 variables	X_1, X_2, X_6	0.97	X_2, X_3, X_6	0.95
4 variables	X_1, X_2, X_4, X_6	0.97	X_1, X_2, X_3, X_6	0.97
5 variables	X_1, X_2, X_3, X_4, X_6	0.97	X_1, X_2, X_3, X_4, X_6	0.97

Where: X_1 = forage yield

X_2 = plant height

X_3 = number of leaves/ plant

X_4 = head diameter

X_5 = 100-seed weight

X_6 = seed yield/ plant

الملخص العربى

زراعة محصول عباد الشمس للإنتاج البذرى والعلف الأخضر تحت مستويات مختلفة لخدمة وإدارة المحصول

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الملخص

تمت دراسة استجابة ثلاثة أصناف من عباد الشمس (مالابار ، فيدوك ، هاى صن) لخمسة مستويات من مواعيد الخف بمزرعة محطة التجارب بكلية الزراعة – جامعة الإسكندرية وذلك فى الموسم الصيفى لعامى 2002 و 2003. وكانت معاملات الخف هى :

P_1 : الخف بعد 21 من الزراعة (استخدام 4 كيلوجرام بذرة/فدان).

P_2 ، P_3 ، P_4 ، P_5 الخف بعد 31 ، 41 ، 51 ، 61 يوم من الزراعة (استخدام 12 كيلوجرام بذرة/فدان).

ويمكن إيجاز أهم النتائج المتحصل عليها كما يلى :-

- وجدت اختلافات معنوية بين الأصناف لصفات ارتفاع النبات ، عدد أوراق النبات ، المحصول البذرى للنبات والفدان خلال الموسمين حيث أعطى الصنف مالابار اقصر النباتات وأعلى قيمة لصفات عدد الأوراق/نبات ومحصول البذور للفدان.
- تساوت استجابة أصناف عباد الشمس للمعاملتين P_1 , P_2 مع التفوق المعنوى لتلك المعاملتين عن بقية معاملات الخف (P_3 ، P_4 ، P_5) لصفات وزن 100 بذرة ووزن البذرة للنبات والمحصول البذرى ووحدات الحبوب للفدان.
- أعطى الصنف مالابار اقل النباتات ارتفاعا مع أعلى القيم لصفات وزن 100 بذرة ومحصول البذور/فدان مع P_1 بينما انعكست قيم هذه الصفات مع الصنف هاىصن تحت تأثير معاملة الخف.
- أظهر تحليل الارتداد زيادة مقدارها 0.42 ، 0.49 طن/فدان لمحصول العلف يقابلها نقصا مقداره 19.5 و 21.5 كيلوجرام/فدان لصفة محصول البذور/فدان لكل تأخير فى الخف مقداره يوم واحد عن الخف بعد 21 يوم من الزراعة فى الموسم الأول والثانى على التوالى.
- أوضحت بيانات تحليل الارتداد المتدرج ان وزن 100 بذرة كان افضل المتغيرات التى تفسر الاختلافات فى المحصول البذرى/نبات (خلال الموسمين) ومحصول البذور/فدان (خلال الموسم الثانى).