

Effect of Leaves Defoliation and Plant Density on Growth, Yield and Quality of Some Sunflower Genotypes (*Helianthus annuus L.*, *Compositae*)

Dr. Saad A. M. Al-Doori

Dr. Moaid Y. Hasan

Department of Science

College of Basic Education / University of Mosul

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Abstract:

For maximization the productivity, quality of sunflower crop, two field experiments were conducted during two successive spring growing seasons of 2007, 2008-2008, 2009 to determine growth, yield and quality of sunflower genotypes (*Helianthus annuus L.*) to plant density and leaves defoliation. Each experiment comprised of three sunflower genotypes (Morden, Flame and Manon), four levels of plant density (22222, 29629, 44444 and 88888 plants.hector⁻¹) and three levels of upper leaves defoliation (0, 4 and 8 leaves). It was conducted according to Randomized Completely Block Design with split- split plot with three replications. The results could be summarized as:

Increasing plant density to 88888 plant.hector⁻¹ led to significant increases in plant high, hollow percentage and oil percentage. The plant density at 22222 plant.hector⁻¹ cause a significant increase in stem diameter, leaf area, head diameter, number of seed per head and weight of thousand seed, while increasing plant density from 22222 to 44444 plant.hector⁻¹ cause a significant increase in total yield, oil, protein yield in the two growing seasons of 2007, 2008-2008, 2009, respectively.

Non defoliation treatment recorded a significant increases in characters plant high, stem diameter, leaf area, head diameter, number of seed per head and weight of thousand seed, total yield and oil percentage, while increasing defoliation treatment to 8 leaves cause a significant increase in protein percentage of the seeds in both seasons 2007, 2008-2008, 2009, respectively.

The Flame genotype gave a high mean for characters stem diameter, leaf area, head diameter, number of seed per head and weight of thousand seed, total yield and oil yield (ton.hector⁻¹) and oil percentage, while Manon genotype gave a high percentage of protein in the seeds in both seasons 2007,2008-2008,2009, respectively.

The interaction between plant density with defoliation treatment was significant in some of growth, yield and quality characteristics, the plant

density 22222 plant.hector⁻¹ with the non defoliation treatment gave a high means of the head diameter, number of seed per head and weight of thousand seed, while the plant density at 44444 plant.hector⁻¹ with non defoliation treatment gave a high rate of the total seed yield (ton.hector⁻¹) in both seasons 2007, 2008-2008, 2009, respectively. The plant density 44444 plant.hector⁻¹ with the Flame genotype gave a high rate of total seed yield (ton.hector⁻¹) and oil yield for the tow seasons 2007, 2008-2008, 2009, respectively.

The effect of the interaction between leaves defoliation treatments and genotype was significant on some growth characters, yield and quality. Non defoliation treatment with Flame genotype gave the highest means for head diameter, weight of thousand seed and total seed yield in the two growing seasons. The interaction between plant density 44444 plant.hector⁻¹ with non defoliation treatment with Flame genotype gave a high rate for head diameter, weight of thousand seed and total seed yield in the two growing seasons.

تأثير خف الأوراق والكثافة النباتية في نمو وحاصل ونوعية بعض التراكيب الوراثية من زهرة الشمس (*Helianthus annuus L., Compositae*)

د. مؤيد يونس حسن الدليمي

د. سعد احمد محمد الدوري

قسم العلوم

كلية التربية الأساسية/ جامعة الموصل

ملخص البحث:

لزيادة إنتاجية محصول زهرة الشمس ونوعيته، نفذت تجربتين حقليتين خلال موسم النمو الربيعي من العامين المتعاقبين 2007, 2008-2008, 2009 لتحديد نمو وحاصل ونوعية تراكيب وراثية من زهرة الشمس (*Helianthus annuus L.*) للكثافة النباتية وخف الأوراق. تألفت كل تجربة من ثلاثة تراكيب وراثية من زهرة الشمس (موردن، فلامبي ومانون) وأربعة مستويات للكثافة النباتية (22222 و 29629 و 44444 و 88888 نبات/هكتار) وثلاث مستويات لخف الأوراق العلوية (0،4،8 أوراق). نفذت التجربة وفق نظام القطع المنشقة- المنشقة بتصميم القطاعات العشوائية الكاملة بثلاثة مكررات. وتم التوصل إلى النتائج الآتية : أدت زيادة الكثافة النباتية إلى 88888 نبات/هكتار إلى زيادة معنوية في صفات ارتفاع النبات/سم، نسبة البذور الفارغة ونسبة الزيت في البذور. سببت الكثافة النباتية 22222 نبات/هكتار زيادة معنوية في قطر الساق، المساحة الورقية، قطر القرص، عدد البذور/قرص ووزن الألف بذرة/غم، في حين سببت زيادة الكثافة النباتية من 22222 إلى 44444

نبات/هكتار زيادة معنوية في حاصل البذور الكلي وحاصل الزيت والبروتين في موسمي النمو 2007 و 2008-2008 و 2009 على التوالي.

سجلت معاملة عدم خف الأوراق زيادة معنوية في صفات ارتفاع النبات/سم، قطر الساق، المساحة الورقية، قطر القرص، عدد البذور/قرص ووزن الألف بذرة/غم، حاصل البذور الكلي ونسبة الزيت. في حين سببت معاملة خف 8 أوراق زيادة معنوية في نسبة البروتين في البذور في كلا الموسمين 2007 و 2008-2008 و 2009 على التوالي.

أعطى التركيب الوراثي فلامبي أعلى معدل لصفات قطر الساق، المساحة الورقية، قطر القرص، عدد البذور/قرص ووزن الألف بذرة/غم، حاصل البذور الكلي (طن /هكتار) ونسبة وحاصل الزيت (طن /هكتار)، في حين أعطى التركيب الوراثي مانون أعلى نسبة بروتين في البذور في كلا موسمي النمو 2007 و 2008-2008 و 2009 على التوالي. كان تأثير التداخل بين الكثافة النباتية ومعاملات خف الأوراق معنوياً في البعض من صفات النمو والحاصل والنوعية، أعطت الكثافة النباتية 22222 نبات/هكتار مع معاملة عدم الخف أعلى معدل لصفات قطر القرص، عدد البذور/قرص ووزن الألف بذرة/غم، بينما أعطت الكثافة النباتية 44444 نبات/هكتار مع معاملة عدم الخف أعلى معدل لحاصل البذور الكلي (طن /هكتار) في كلا موسمي النمو 2007 و 2008-2008 و 2009 على التوالي. أعطت الكثافة النباتية 44444 نبات/هكتار والتركيب الوراثي فلامبي أعلى معدل لحاصل البذور الكلي والزيت (طن /هكتار) في كلا موسمي النمو 2007 و 2008-2008 و 2009 على التوالي. كان تأثير التداخل بين معاملات خف الأوراق والتركيب الوراثية معنوياً في بعض صفات النمو والحاصل والنوعية، أعطت معاملة عدم الخف والتركيب الوراثي فلامبي أعلى متوسط لصفات قطر القرص، وزن الألف بذرة/غم وحاصل البذور الكلي (طن /هكتار) في كلا موسمي النمو. أعطى التداخل بين الكثافة النباتية 44444 نبات/هكتار مع معاملة عدم الخف والتركيب الوراثي فلامبي أعلى معدل لقطر القرص، وزن الألف بذرة/غم وحاصل البذور الكلي (طن /هكتار) في كلا موسمي النمو.

Introduction:

Sunflower (*Helianthus annuus L., Compositae*) currently cultivated for its seed and oil, is the worlds forth largest oilseed crop. Sunflower oil is primarily comprised of palmitic, stearic, oleic and linoleic acid. It contains more unsaturated fatty acids than other oil seeds such as soybean, peanut and cotton seed(Seiler, 1997).

Results of studies on the effect of plant density on seed composition are contradictory. Power and Zimmerman (1977), McWilliam and English (1978), Miller and Fick (1978), Steer, *et al.* (1986) and Rodriguez and Al-Asmi (1996) all found no effect of plant density on the

seed oil and protein content. Thompson and Fenton (1979) and Mathers and Stewart (1982) found a small response of seed composition to plant density (ranging from 25.000 to 150.000 plants.hector⁻¹). Stoyanova (1974), Jones (1978), Gubbels and Dedio (1986), Majid and Schneiter (1987) and Zaffaroni and Schneiter (1991) on the other hand, all found that oil content increased with increased plant density. Robinson, *et al.* (1980) found that the mean oil content of both low and high oil content genotypes produced at six localities increased from 37.5 to 42.2% when plant density was increased from 17.000 to 62.000 plants.hector⁻¹. Jones (1984) also found a small increase in seed oil content by increasing the density from 25.000 to 45.000 plants.hector⁻¹. Seed oil contents of 40.3 and 42.1% were measured by Ortegon and Diaz (1997) for densities of 31.000 and 63.000 plants.hector⁻¹. This difference in oil content was mainly due to different hull contents. Villalobos, *et al.* (1992) also found that oil content increased while the single seed weight decreased with increased plant density. The absolute amount of oil per seed showed a relatively small decrease compared to the decrease of the single seed weight. A decrease in oil content due to an increase in plant density has also been observed. Esendal and Kandemir (1996) increased the plant population by decreasing the row width to change the plant density from 35.000 to 66.000 plants.hector⁻¹ and found that the seed oil content decreased from 41.8 to 37.6%. The protein content also decreased from 17.4 to 15.3% whilst the kernel content decreased from 73.1 to 72.1%. After analyzing various trials on the response of seed composition to plant density, Connor and Hall (1997) stated that one interpretation of the results is that there is a ceiling to the absolute amount of oil that can be stored in a seed. The changes of physiological in plants, which occur in response to leaves defoliation decrease photosynthesis and respiration (Rodrgues, 1978 and Steer, *et al.* 1988) and as a result overall production of the crop is decreased. The general finding of researchers is that higher seed oil content is associated with smaller seed (Denis and Vear, 1996). One of the aims of sunflower breeding programmers is to increase the seed oil content of genotypes. If the negative relationship between oil content and seed stays valid in future and the oil content increases above the current level, seed will decline, resulting in declining oil quality. Baldini and Vannozzi (1996), however, found that this negative relationship is not universal since the cultivar Euroflor, in contrast with other genotypes, has high oil content and a big seed.

According to Merrien, *et al.* (1992) genotype is the main source of the variation in seed. In their investigation on the seed of different genotypes, Baldini and Vannozzi (1996) found that some genotypic traits, such as the length of the period from emergence to flowering and from flowering to physiological maturity, correlate negatively with seed size.

The objective of the present study was to investigate the effect of plant density and leaves defoliation on growth, seed yield, yield components, the chemical seed characteristics and the potentially recoverable oil of some genotypes of sunflower (*Helianthus annuus L.*).

Materials and Methods:

Tow filed experiments were carried out during 2007,2008-2008,2009 seasons at AL-Rashidia location which is far about (20km) to investigate the effect of four levels of plant density (22222, 29629, 44444 and 88888 plants.hector⁻¹) with three levels of upper leaves defoliation (0 , 4 and 8 defoliation during the start of flowering stage) on the growth, yield and quality of three sunflower genotypes (Morden, Flame and Manon). The mean number of leaves for three genotype was 20 to attain a defoliation percentage (0, 20 and 40 % leaves per plant, respectively). AL-Rashidia is located in the west north region of Mosul city at Nineveh province. Climatically, the region placed in the semiarid temperature zone cold winter and hot summer. Average rainfall is about 375 mm that most rainfall concentrated between winter and spring. Each experiment included (108) treatments comprising the combinations of four levels of plant density, three leaves defoliation treatments and three sunflower genotypes with three replications.

The experimental design was split-split plot in a Randomized Completely Block Design with arrangement keeping with plant density as main plots, the sub plots were assigned to leaves defoliation, while genotypes as sub-sub plots with three replications according to Steel and Torrie, 1980. Then Duncan's multiple range test (Duncan, 1955) was used to compare among means (SAS, 2001). A representative soil sample (0 to 30 cm depth) was taken before planting (table1) with the mean properties as pH (9.30 ,9.68), organic matter (1.38,1.36 gm.kg⁻¹), available N (45.23,38.68) , CaCO₃ (2.93 ,2.84 ml.kg⁻¹), available P (18.23,22.14) and available K (182.00 ,189.00) using the methods description by Black, 1965, Jackson, 1973, Page, *et al.* 1982 and Tandon, 1999.

The seeds were sown by putting three seeds to hills by hand in April 1st ,5th and harvested in August 8th,5th for 2007,2008-2008,2009seasons, respectively. Super phosphate 150kg/hector (45%P₂O₅) and potassium (48%K₂O) were applied (60 kg/hector) to the soil during the sowing period. Nitrogen were applied to the soil surface in two equal doses, half with sowing and the remaining half at immediately after one of month after sowing at a rate of 100 kg/hector as form of urea (46%N).

Table -1- :The physical and chemical characters of soil filed experiments in both seasons.

Seasons	2007,2008	2008,2009
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physical characters		
Sand (%)	61.00	57.00
Silt (%)	22.00	34.00
Clay (%)	17.00	9.00
Texture	Sandy loom	Sandy loom
chemical characters		
O.M. (gm.kg ⁻¹)	1.38	1.36
Available N (ppm)	45.23	38.68
Available P (ppm)	18.23	22.14
Available K (ppm)	182.00	189.00
Total CaCO ₃ (ml.kg ⁻¹)	2.93	2.84
pH	9.30	9.68
E.C. mmhos/ cm	2.43	2.92

Each plot 22.5 M² included six ridges 75 cm apart and five meters long and the distance between hills were 60, 45, 30 and 15 cm apart to attain a plant density of 22222, 29629, 44444 and 88888 plants.hector⁻¹ respectively. Plants were thinned to one plant per hill 25 days after sowing. The external two ridges were left as porder. Two of the remaining ridges were devoted for estimating plant growth and some characteristics. The first irrigation was applied immediately after sowing and after wards irrigation was scheduled at about four day's intervals. Normal cultural practices, control of insects and weeds of growing sunflower were conducted in the usual manner followed by the farmers of the district. At heading period, the heads of the two inner ridges were bagged early seed development to avoid bird's damage until maturity.

The studied characters were:

1- Growth characters: Sample of ten guarded plants each was taken from each treatment at 98 days after sowing. The following data were record: Plant height (cm), stem diameter (cm), leaf area (cm².plant), and head diameter (cm).

2- Yield, yield components and quality: At harvest, ten guarded plants were taken randomly from the two inner ridges of each experimental plot and left for two weeks until fully air dried, then the following data were measured, number of seeds/head, weight of thousand seed (g.), hollow (%), yield and oil, protein yield (ton.hector⁻¹). oil seed content was determined using Soxhlet method (A.O.A.C.,1984), Nitrogen estimated after digesting seeds samples using Microkjeldahl method, then, Protein percentage was calculated by multiplying the nitrogen percentage by the converting factor 6.25 (Agrawal, *et al.* 1980).

Results and Discussion:

1- Effect of plant density:

A- Growth characters and yield components:

Effect of plant density on growth characters were contradictory (table2). All investigated characteristics were significantly affected by plant density (table18). These results are true in the two growing seasons, although the low density (22222 plant.hector⁻¹) produced the highest stem diameter (3.02, 3.14cm), leaf area (4477.84, 4369.51cm².plant), the high density (88888 plant.hector⁻¹) gave the highest plant height (177.04, 172.00 cm). head diameter, no. of seeds/head and weight of thousand seed are an important yield components in sunflower. The crop planted at the lowest density (22222 plant.hector⁻¹) had the largest head diameter (22.96, 22.36cm) and stem diameter (3.02,3.14cm), but the highest density (88888 plant.hector⁻¹) produced the smallest head diameter (21.39,20.41cm) and stem diameter (2.35,2.65 cm). Density at 44444 and 88888, 29629 and 44444 plant. hector⁻¹ did not show statistically difference for stem diameter and head diameter in the two growing season's, respectively. Taller plants at high density may be duo to inter plant competition for light and aerial resources. With increasing plant density, the number of total seeds head⁻¹ reductions in confection sunflower at high density can be explained by lower head diameter. This reduction in number of total seeds with increasing plant density has been verified in early field studies (Gunel, 1971). Robinson, *et al.* (1980) working with sunflower, also founded that high plant density produced taller plants and smaller heads. Although head diameter, number of total seeds head⁻¹ and 1000 seeds weight reduced with increasing plant density, the plant increased. Narwal and Malik (1985) reported that as plant density was increased head diameter, number of seeds head⁻¹ and 1000 seeds weight decreased, while seed yield (ton. ha⁻¹) increased. Similar observations were made by Killi and Ozdemir (2001) and Sedghi, *et al.* (2008) who reported that increased plant density resulted in a significant increase in head diameter.

Table -2- : Effect of plant density on some growth characters and yield components of sunflower in both seasons.

seasons	plant density.	Plant height (cm)	stem diameter	leaf area (cm ² .plant)	head diameter	no. of seeds/head	weight of thousand
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	hector ⁻¹		(cm)		(cm)		seed (g.)
2007,2008	22222	163.19d	3.02a	4477.84a	22.96a	1186.20a	78.05a
	29629	168.47c	2.67b	3538.79b	21.76b	1029.78c	74.86b
	44444	170.53b	2.42c	3097.88c	21.83b	1093.03b	70.53c
	88888	177.04a	2.35c	2961.95d	21.39c	994.78d	63.31d
2008,2009	22222	154.25d	3.14a	4369.51a	22.36a	1146.71a	76.30a
	29629	157.48c	2.82b	3357.82b	21.38b	993.82c	71.86b
	44444	162.88b	2.65c	3006.81c	21.34b	1050.33b	69.11c
	88888	172.00a	2.65c	2968.78d	20.41c	964.98d	61.74d

* The means values within column followed by the different letter are significant at 5% level.

B-Yield and quality: Data pertaining to plant density are presented in table (3). All investigated characteristics were significantly affected by plant density in the two growing seasons except protein (%) in only 2008 season, with increasing plant density to 88888 plant.hector⁻¹, hallow percentage and oil percentage generally tended to increase, while increasing plant density from 22222 to 44444 plant.hector⁻¹ cause a significant increase in total yield (3.72,3.63 ton.hector⁻¹), oil, protein yield (1.668,1.641 and 0.537,0.501 ton.hector⁻¹) in the two growing seasons, respectively. The increase in seed yield may be due to the increase in the dry matter accumulated in plants with wide spacing which is may be increase the yield represented in head and weight of 1000 seeds and also because of sufficient of environmental elements as light, Co₂, nutrients, water, which increase plant ability to build metabolites. This reduction in total seed yield head by decreasing plant density has been verified in some studies (Killi and Ozdemir, 2001). Numerous research studies for different climates have shown that plant density or row spacing influences the growth, seed yield and quality of sunflower (Narwal and Malik,1985). The present results were in a good agreement with the finding of Sedghi, *et al.* 2008, who reported that increased plant density or row spacing resulted in a significant increase in seed oil content and oil yield. If availability of organic mater in the soil during seed filling exceeds the capacity for oil deposition, carbon is allocated to other seed components and the seed oil concentration is diluted. At typical commercial densities, the various effects of density on seed oil content may be hard to establish (Steer, *et al.* 1986).

Table -3- : Effect of plant density on yield and quality of sunflower in both seasons.

seasons	plant density.hector ⁻¹	hallow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
	22222	31.67d	2.76d	42.71d	1.178d	17.05a	0.470c

2007,2008	29629	34.97c	3.10c	43.70c	1.354c	15.68b	0.486b
	44444	35.98b	3.72a	44.85b	1.668a	14.45c	0.537a
	88888	38.69a	3.33b	45.07a	1.500b	13.80d	0.459d
2008,2009	22222	32.96c	2.70d	43.02d	1.161d	16.12a	0.435d
	29629	35.89b	3.03c	43.96c	1.331c	14.91b	0.451b
	44444	35.65b	3.63a	45.22b	1.641a	13.82c	0.501a
	88888	40.56a	3.23b	45.56a	1.471b	13.23d	0.439c

* The means values within column followed by the different letter are significant at 5% level.

2- Effect of Leaves Defoliation:

A- Growth characters and yield components: All investigated growth characteristics were significantly affected by defoliation treatments (table 4). When leaves defoliation was increased from 0 to 8, plant height were decreased approximately 2.28 and 1.81 %, these results are true in the two growing seasons, respectively. Schneiter and Johnson, 1994 and Julio, *et al.* 2001 reported that the non defoliation treatment was increased leaf area, while hollow percentage decreased. Similar observations were made by Cardinali, *et al.* 1978; Patil and Coswaml, 1979; Beer 1984; Silva, *et al.* 1985; Potdar and Pawar 1989; Agropol, 1998; Muro, *et al.* 2001 and Erbap and Baydar, 2007, who reported that leaves defoliation resulted in a significant decreased plant height, stem diameter, leaf area and head diameter.

Table -4- : Effect of leaves defoliation on some growth characters and yield components of sunflower in both seasons.

seasons	leaves defoliation	plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
2007,2008	0	171.32a	2.64	3561.95a	22.54a	1117.38a	76.96a
	4	170.70a	2.60	3516.80b	21.94b	1081.07b	72.13b
	8	167.40b	2.61	3478.59c	21.48c	1029.40c	65.96c
2008,2009	0	162.58a	2.84a	3475.76a	21.90a	1082.67a	75.11a
	4	162.75a	2.83a	3440.57b	21.42b	1044.60b	69.49b
	8	159.63b	2.77b	3360.85c	20.81c	989.61c	64.66c

* The means values within column followed by the different letter are significant at 5% level.

B- Yield and quality: Data pertaining to leaves defoliation are presented in table (5). In two growing seasons, the attributes of sunflower exhibited significant differences for the different defoliation treatments. With defoliation at 8 leaves, hollow percentage generally tended to increase. The total seed yield reductions in confection sunflower at high defoliation can be explained by lower head diameter, number of total seeds head⁻¹ (table 4). When leaves defoliation was increased from 0 to 8, total seed yield were decreased approximately 6.62 and 7.09%, these results are true in the two growing seasons, respectively. Although the 4 defoliation

treatment produced the lowest hollow (34.49,35.37%), the treatment of 8 leaves defoliation gave the highest protein (15.90, 15.12%), this reduction in seed yield with leaves defoliation has been verified in some studies (Urie, *et al.* 1968; Cardinali, *et al.* 1978; Rajan, 1982; Beer 1984; Silva, *et al.* 1985; Steer, *et al.* 1988; Potdar and Pawar 1989; Schneiter and Johnson, 1994; Agropol, 1998; Muro, *et al.*, 2001; and Erbap and Baydar, 2007) working with sunflower, also founded that leaves defoliation produced small seeds and oil yield. The increase in weight of thousand seed may be due to the increase in the dry matter accumulated in plants with non leaves defoliation which is may be increase the yield represented in head and weight of thousand seed, therefore non leaves defoliation may help the sunflower crop to compete better with other plants and give a more uniform stand which matures earlier, which increase plant ability to build metabolites. The yield reductions in sunflower at leaves defoliation can be explained by lower number of total seeds head⁻¹ and weight of thousand seed (table 2). This reduction in seed yield by leaves defoliation has been verified in some studies (Beer, 1984; Silva, *et al.* 1985; Schneiter and Johnson, 1994; Agropol, 1998; Julio, *et al.* 2001 and Erbap and Baydar, 2007). Numerous research studies for different climates have shown that leaves defoliation influences the growth, seed yield and quality of sunflower (Rodrgues, 1978; Patil and Coswaml, 1979; Beer 1984; Silva, *et al.* 1985; Steer, *et al.* 1988 and Erbap and Baydar, 2007). The present results were in a good agreement with the finding of Julio, *et al.* 2001, who reported that leaves defoliation resulted in a significant decrease in seed oil content and oil yield.

Table -5- : Effect of leaves defoliation on yield and quality of sunflower in both seasons.

seasons	leaves defoliation	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
2007,2008	0	35.14b	3.32a	45.03a	1.491a	14.50c	0.481c
	4	34.49c	3.27b	43.99b	1.438b	15.34b	0.501a
	8	36.36a	3.10c	43.23c	1.340b	15.90a	0.492b
2008,2009	0	36.15b	3.24a	45.41a	1.471a	13.80c	0.447c
	4	35.37c	3.19b	44.39b	1.416b	14.64b	0.467a
	8	37.28a	3.01c	43.52c	1.309c	15.12a	0.455b

* The means values within column followed by the different letter are significant at 5% level.

3- Effect of genotypes:

A- Growth characters and yield components: Flame genotype surpassed significantly Morden, Manon genotypes in a descending compared to the other three tested genotypes in the two seasons (table 6).

Flame genotype gave a high mean for characters stem diameter (2.92,3.19cm), leaf area (3819.20, 3664.93cm².plant), head diameter (22.96, 22.51cm), number of seed per head (1125.04,1086.31) and weight of thousand seed(76.80,75.38g) in both seasons 2008-2009, respectively. Moreover, the differences among the three genotypes in the leaf area (cm².plant) may be attributed to the general varietals differences in the number of leaves per plant. In this concern, Killi, 1997; Ortegon and Diaz, 1997 showed that taller genotypes had more number of leaves per plant and leaf primordial that the others sunflower genotypes. The superiority of Flame genotype in the seed yield production may be attributed to having more number of leaves per plant, and as well the highest area of photosynthetic number of leaves per plant and this in turn increased the capacity of dry matter accumulation in the different plant parts. In this report, Mould and Chapman, 1979; Blamey and Chapman, 1982; Gimenez and Fereres, 1987; Vannozzi, *et al.* 1988; Attene and Porru, 1990; Faizani, *et al.* 1990; Prasad, 1991; Kene, *et al.* 1992; Sarmah, *et al.* 1992; Villalobos, *et al.* 1992; Killi, 1997; Ortegon and Diaz 1997; Herdem, 1999; Nel, 2001; Ozer, 2003 reported that Vidoc genotype had highest seed yield and dry weight per plant than the Miak and Euroflor genotypes.

Table -6- : Effect of genotypes on some growth characters and yield components of sunflower in both seasons.

seasons	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
2007,2008	Morden	157.72c	2.63b	3434.61b	22.08b	1078.12b	70.35b
	Flame	168.54b	2.92a	3819.20a	22.96a	1125.04a	76.80a
	Manon	183.15a	2.30c	3303.53c	20.92c	1024.68c	67.91c
2008,2009	Morden	152.90c	2.69b	3365.84b	21.61b	1044.93b	68.52b
	Flame	158.46b	3.19a	3664.93a	22.51a	1086.31a	75.38a
	Manon	173.60a	2.56c	3246.42c	20.00c	985.64c	65.36c

* The means values within column followed by the different letter are significant at 5% level.

B- Yield and quality: Mean values of seed yield and some related traits for the three tested genotypes are presented in table (7). The data revealed that Flame genotype surpassed Morden, Manon genotypes in the yield components (weight of thousand seed (g.), 1000 seeds weight), Moreover, Morden surpassed Manon in those traits in both seasons. This means that Flame plants were more efficient to accumulate dry mater in their head. Regarding to the seed characters studied i.e., weight of thousand seed and oil percentage, data show that there were significant variations among the three tested sunflower genotypes in both seasons.

Flame genotype surpassed significantly Morden, Manon genotypes in weight of thousand seed, yield (3.56, 3.49 ton.hector⁻¹) and oil yield (1.62, 1.61 ton.hector⁻¹) in both seasons, respectively. However, the differences in oil percent of seeds may be attributed to genetic factors and their interaction with the prevailing environmental conditions. This increase in oil yield (ton.hector⁻¹) from Flame genotype may be due to their high seed yield per hectare (table 7) rather than differences in seed oil content. Similar conclusion were reported by Mould and Chapman, 1979; Blamey and Chapman, 1982; Gimenez and Fereres, 1987; Vannozzi, *et al.* 1988; Attene and Porru, 1990; Faizani, *et al.* 1990; Prasad, 1991; Kene, *et al.* 1992; Sarmah, *et al.* 1992; Villalobos, *et al.* 1992; Killi, 1997; Ortegon and Diaz, 1997; Herdem, 1999; Nel, 2001; Ozer, 2003. The superiority of Flame genotype in the most seed characters may be due to that Flame genotype had better vegetative growth and hence photosynthetic area which led to more carbohydrates which was translocated from the source (leaves and stem) to the sink (seeds) (Mengel and Kirkby, 1982). The results showed that weight of thousand seed, oil percentage (45.75, 46.25%), oil yield (ton.hector⁻¹) were always significantly higher for Flame than that for Morden, Manon genotypes. This indicates that Morden genotype was more efficient to translocation enough photoassimilates to developing seeds.

Table -7- : Effect of genotypes on yield and quality of sunflower in both seasons.

seasons	genotypes	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
2007,2008	Morden	34.97b	3.11b	43.43b	1.350b	15.34b	0.477c
	Flame	40.81a	3.56a	45.75a	1.628a	14.43c	0.513a
	Manon	30.20c	3.02c	43.07c	1.300c	15.97a	0.482b
2008,2009	Morden	35.96b	3.02b	43.78b	1.322b	14.65b	0.442c
	Flame	42.28a	3.49a	46.25a	1.614a	13.75c	0.479a
	Manon	30.55c	2.93c	43.30c	1.268c	15.16a	0.444b

* The means values within column followed by the different letter are significant at 5% level.

4-Effect of interaction between plant density and leaves defoliation on growth characters, yield, yield components and quality:

The interaction between plant density and defoliation treatment was significant in head diameter, no. of seeds/head, weight of thousand seed, hollow (%), total seed yield (ton.hector⁻¹), oil, protein (%) in both seasons, plant height in only 2009 season (tables 8, 9). The plant density 22222 plant.hector⁻¹ with the non defoliation treatment gave a high means of the head diameter (23.62, 22.81cm), number of seed per head

(1219.72, 1183.48) and weight of thousand seed (81.16, 79.63g), while the plant density at 44444 plant.hector⁻¹ with non defoliation treatment gave a high rate of the total seed yield (3.96, 3.89 ton.hector⁻¹) in both seasons 2008-2009, respectively. The increase in seed yield may be due to the increase in the dry matter accumulated in heads with wide spacing and non defoliation which is may be increase the total seed yield.

Table -8- : Effect of interaction between plant density.hector⁻¹ and defoliation on some growth characters and yield components of sunflower in both seasons.

plant density.hector ⁻¹	leaves defoliation	plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
2007,2008 season							
22222	0	164.69	3.05	4516.84	23.62a	1219.72a	81.16a
	4	164.24	3.04	4491.63	22.51b	1170.96b	78.94bc
	8	160.64	2.98	4425.05	22.73b	1167.92b	74.05e
29629	0	170.35	2.65	3579.9	22.13c	1060.56d	79.94b
	4	169.98	2.63	3541.33	21.73de	1032.61e	75.60d
	8	165.07	2.72	3495.15	21.42e	996.16g	69.05g
44444	0	171.84	2.49	3149.77	22.53b	1163.78b	78.05c
	4	170.53	2.32	3098.81	22.05cd	1113.92c	70.38f
	8	169.22	2.46	3045.07	20.91f	1001.38g	63.16h
88888	0	178.38	2.36	3001.31	21.87cd	1025.45ef	68.71g
	4	178.04	2.39	2935.44	21.47e	1006.78fg	63.60h
	8	174.69	2.3	2949.11	20.85f	952.12h	57.60i
2008,2009 season							
22222	0	154.51g	3.16	4419.53	22.81a	1183.48a	79.63a
	4	156.87fg	3.16	4374.47	22.23b	1136.71b	76.52b
	8	151.36h	3.10	4314.52	22.05b	1119.93bc	72.74c
29629	0	158.27ef	2.84	3408.86	21.76c	1024.72e	76.30b
	4	159.54de	2.82	3372.30	21.47c	992.75f	71.74c
	8	154.62g	2.79	3292.30	20.92d	964.00g	67.52d
44444	0	164.56b	2.69	3052.47	22.12b	1113.31c	76.63b
	4	163.18bc	2.67	3037.58	21.65c	1079.97d	68.74d
	8	160.91cd	2.60	2930.38	20.25ef	957.71g	61.97e
88888	0	172.98a	2.69	3022.20	20.90d	1009.17ef	67.86d
	4	171.40a	2.67	2977.92	20.34e	968.97g	60.97e
	8	171.62a	2.58	2906.22	20.01f	916.80h	56.41f

* The means values within column followed by the different letter are significant at 5% level.

Table -9- : Effect of interaction between plant density.hector⁻¹ and defoliation on yield and quality of sunflower in both seasons.

plant density.hector ⁻¹	leaves defoliation	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
2007,2008 season							
22222	0	31.66d	2.78i	43.53e	1.210	16.42c	0.456
	4	31.12d	2.76ij	42.53g	1.173	17.13b	0.472
	8	32.24d	2.74j	42.07h	1.152	17.60a	0.482
29629	0	34.86c	3.14f	44.42c	1.394	15.13f	0.475
	4	34.52c	3.11g	43.64e	1.357	15.71e	0.488
	8	35.52c	3.06h	43.02f	1.316	16.20d	0.495
44444	0	35.39c	3.96a	45.98a	1.820	13.60i	0.538
	4	34.28c	3.87b	44.82b	1.734	14.55g	0.563
	8	38.26ab	3.34d	43.76de	1.461	15.20f	0.507
88888	0	38.64ab	3.40c	46.18a	1.570	12.84j	0.436
	4	38.01b	3.35d	44.98b	1.506	13.95h	0.467
	8	39.41a	3.25e	44.07d	1.432	14.62g	0.475
2008,2009 season							
22222	0	32.92h	2.72h	43.80d	1.191	15.68c	0.426
	4	32.16i	2.70hi	42.91e	1.158	16.12b	0.435
	8	33.79g	2.67i	42.36f	1.131	16.55a	0.441
29629	0	35.90e	3.06f	44.62c	1.365	14.59f	0.446
	4	35.21f	3.04fg	43.98d	1.336	14.90e	0.452
	8	36.56d	3.00g	43.27e	1.298	15.24d	0.457
44444	0	35.45f	3.89a	46.54a	1.810	12.86i	0.500
	4	34.16g	3.78b	45.18b	1.707	14.01g	0.529
	8	37.34c	3.22d	43.94d	1.414	14.59f	0.469
88888	0	40.32b	3.29c	46.69a	1.536	12.08j	0.397
	4	39.94b	3.26cd	45.49b	1.482	13.50h	0.440
	8	41.41a	3.13e	44.51c	1.393	14.10g	0.441

* The means values within column followed by the different letter are significant at 5% level.

5-Effect of interaction between plant density and genotypes on Growth characters, yield, yield components and quality:

Data reported in tables (10,11) indicate the significant effect of interaction between plant density and genotypes on sunflower attributes i.e. plant height, stem diameter, leaf area, head diameter, 1000 seeds weight, yield (ton/hector) and oil percent in two seasons, oil yield in only 2008 season, no. of seeds/head in only 2009 season. The plant density 44444 plant.hector⁻¹ with the Flame genotype gave a high rate of total seed yield (4.09, 4.00 ton.hector⁻¹) and oil percentage (46.98, 47.60%). Maximum protein percentage (18.22, 17.26%) was observed at 22222 plant.hector⁻¹ and Manon genotypes for the tow seasons 2008-2009,

respectively. Similar conclusion were reported by Gimenez and Fereres, 1987; Faizani, *et al.* 1990; Prasad; Nel, 2001 and Ozer, 2003.

Table -10- : Effect of interaction between plant density.hector⁻¹ and genotypes on some growth characters and yield components of sunflower in both seasons.

plant density.hector ⁻¹	genotypes	Plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
2007,2008 season							
22222	Morden	152.69h	3.05ab	4315.50b	23.22b	1197.10	77.71c
	Flame	162.69f	3.20a	4971.66a	23.91a	1239.63	83.05a
	Manon	174.20d	2.82cd	4146.36c	21.73e	1121.87	73.38e
29629	Morden	155.95g	2.83cd	3520.13e	21.60e	1032.10	73.05e
	Flame	166.73e	2.95bc	3726.53d	22.69c	1073.70	79.71b
	Manon	182.71c	2.22f	3369.72f	21.00f	983.54	71.82f
44444	Morden	157.78g	2.41e	3012.60h	22.09d	1096.05	68.38g
	Flame	168.71e	2.73d	3329.66f	23.07b	1145.58	76.38d
	Manon	185.11b	2.13fg	2951.39i	20.33g	1037.45	66.82h
88888	Morden	164.47f	2.23f	2890.22j	21.42e	987.23	62.27i
	Flame	176.04d	2.80cd	3248.97g	22.16d	1041.25	68.05g
	Manon	190.60a	2.02g	2746.66k	20.60g	955.87	59.60j
2008,2009 season							
22222	Morden	147.27h	3.19b	4191.19b	22.87b	1154.88b	76.19bc
	Flame	152.47f	3.32a	4800.30a	23.32a	1198.64a	81.52a
	Manon	163.00d	2.90d	4117.02c	20.90f	1086.60d	71.19d
29629	Morden	149.74g	2.64e	3340.44e	21.30e	995.48g	70.41d
	Flame	154.69f	3.19b	3524.55d	22.32c	1043.37f	77.19b
	Manon	168.00c	2.62e	3208.46f	20.54g	942.61i	67.97e
44444	Morden	153.71f	2.48f	2982.49g	21.87d	1063.11e	66.52f
	Flame	160.09e	3.05c	3159.21f	22.58c	1105.20c	75.74c
	Manon	174.85b	2.43f	2878.73h	19.56h	982.68gh	65.08g
88888	Morden	160.87de	2.44f	2949.25g	20.41g	966.26h	60.97h
	Flame	166.60c	3.21b	3175.65f	21.83d	998.02g	67.08ef
	Manon	188.54a	2.30g	2781.45i	19.01i	930.66i	57.19i

* The means values within column followed by the different letter are significant at 5% level.

Table -11- : Effect of interaction between plant density.hector⁻¹ and genotypes on yield and quality of sunflower in both seasons.

plant density.hector ⁻¹	genotypes	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
2007,2008 season							
22222	Morden	31.55	2.74k	42.09f	1.153j	17.13b	0.469
	Flame	37.37	2.87j	44.16c	1.267i	15.80d	0.453
	Manon	26.10	2.68l	41.89f	1.122k	18.22a	0.488
29629	Morden	34.70	3.03g	43.13e	1.306g	15.84d	0.479
	Flame	40.48	3.31e	44.78b	1.482e	14.75f	0.488
	Manon	29.72	2.97h	43.18e	1.282gh	16.44c	0.488
44444	Morden	35.39	3.58c	44.18c	1.581c	14.55g	0.520
	Flame	41.68	4.09a	46.98a	1.921a	13.78i	0.563
	Manon	30.86	3.50d	43.40e	1.519d	15.02e	0.525
88888	Morden	38.24	3.11f	44.31c	1.378f	13.84i	0.430
	Flame	43.70	3.96b	47.09a	1.864b	13.38j	0.529
	Manon	34.12	2.92i	43.82d	1.279h	14.20h	0.414
2008,2009 season							
22222	Morden	32.72g	2.64j	42.40f	1.119	16.08b	0.424
	Flame	39.01d	2.85hi	44.36cd	1.264	15.01e	0.427
	Manon	27.14i	2.59k	42.31f	1.095	17.26a	0.447
29629	Morden	35.79e	2.95g	43.42e	1.280	15.26d	0.450
	Flame	41.90b	3.26e	45.22b	1.474	13.90g	0.453
	Manon	29.99h	2.90h	43.22e	1.253	15.57c	0.451
44444	Morden	35.32f	3.48c	44.47cd	1.547	13.99fg	0.486
	Flame	41.81b	4.00a	47.60a	1.904	13.28i	0.531
	Manon	29.83h	3.41d	43.58e	1.486	14.19f	0.483
88888	Morden	40.01c	3.02f	44.82bc	1.353	13.26i	0.400
	Flame	46.41a	3.85b	47.80a	1.840	12.79j	0.492
	Manon	35.25f	2.82i	44.07d	1.242	13.64h	0.384

* The means values within column followed by the different letter are significant at 5% level.

6-Effect of interaction between leaves defoliation and genotypes on growth characters, yield, yield components and quality:

The interaction effect between leaves defoliation and genotypes reached the 5% level of significant for plant height (cm), yield (ton. hector⁻¹) and oil percentage, protein yield in only 2008 season, head diameter, weight of thousand seed (g.) in both seasons (tables 12,13). Non defoliation treatment with Flame genotype gave the highest means for head diameter (23.55, 22.98cm), weight of thousand seed and total seed yield (3.67, 3.60 ton.hector⁻¹) in the two growing seasons. Such increase may be due to increasing the dry weight per plant when non leaves defoliation, and increase in the photosynthetic and transporting

efficiency of the plant (Cardinali, *et al.* 1978; Patil and Coswaml, 1979; Rajan, 1982; Beer, 1984; Silva, *et al.* 1985). This result clearly indicated the importance of non leaves defoliation to hormonal chinchies in plant tissues. Similar conclusion was reported by Muro, *et al.* 2001; Julio, *et al.* 2001 and Erbap and Baydar, 2007 found that thicker genotypes had more number of leaf primordial that the others sunflower genotypes. The insignificant effect between leaves defoliation and genotypes on other characteristic showed that each of these two factors acted independently on these traits.

Table -12- : Effect of interaction between defoliation and genotypes on some growth characters and yield components of sunflower in both seasons.

leaves defoliation	genotypes	Plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
2007,2008 season							
0	Morden	159.20d	2.64	3479.97	22.65bc	1117.35	75.19c
	Flame	170.38b	2.98	3872.72	23.55a	1166.55	83.69a
	Manon	184.37a	2.29	3333.18	21.43e	1068.25	72.02d
4	Morden	159.42d	2.62	3443.42	22.21d	1088.93	71.27d
	Flame	169.92b	2.87	3802.54	22.86b	1125.81	76.77b
	Manon	182.77a	2.30	3304.45	20.75f	1028.46	68.35f
8	Morden	154.55e	2.63	3380.45	21.40e	1028.08	64.60g
	Flame	165.33c	2.90	3782.35	22.46cd	1082.76	69.94e
	Manon	182.33a	2.31	3272.97	20.58f	977.35	63.35h
2008,2009 season							
0	Morden	153.94	2.71	3420.09	22.16c	1088.86	73.19c
	Flame	159.34	3.23	3706.42	22.98a	1125.13	82.36a
	Manon	174.47	2.59	3300.79	20.55f	1034.02	69.77d
4	Morden	154.55	2.69	3396.54	21.80d	1053.16	68.61d
	Flame	159.27	3.22	3653.06	22.50b	1087.40	75.19b
	Manon	174.42	2.58	3272.10	19.98g	993.25	64.69e
8	Morden	150.20	2.66	3280.90	20.88e	992.78	63.77f
	Flame	156.79	3.14	3635.30	22.06c	1046.40	68.61d
	Manon	171.90	2.51	3166.36	19.48h	929.65	61.61g

* The means values within column followed by the different letter are significant at 5% level.

Table -13- : Effect of interaction between defoliation and genotypes on yield and quality of sunflower in both seasons.

leaves defoliation	genotypes	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
2007,2008 season							
0	Morden	34.75	3.20d	44.16d	1.413	14.59	0.465
	Flame	40.79	3.67a	46.81a	1.717	13.73	0.503
	Manon	29.87	3.09f	44.12d	1.363	15.18	0.469
4	Morden	34.32	2.97e	43.21e	1.283	15.36	0.456
	Flame	40.02	3.61b	45.84b	1.654	14.51	0.523
	Manon	29.12	3.05g	42.94e	1.309	16.14	0.492
8	Morden	35.84	2.99h	42.92e	1.283	16.08	0.480
	Flame	41.62	3.39c	44.61c	1.512	15.04	0.509
	Manon	31.62	2.91i	42.16f	1.226	16.64	0.484
2008,2009 season							
0	Morden	35.79	3.12	44.65	1.393	13.87	0.432
	Flame	42.14	3.60	47.27	1.701	13.02	0.468
	Manon	30.51	3.01	44.32	1.334	14.52	0.437
4	Morden	35.06	3.07	43.65	1.340	14.79	0.454
	Flame	41.36	3.55	46.39	1.646	13.85	0.491
	Manon	29.69	2.97	43.14	1.281	15.27	0.453
8	Morden	37.03	2.89	43.04	1.243	15.29	0.441
	Flame	43.34	3.33	45.09	1.501	14.37	0.478
	Manon	31.46	2.81	42.44	1.192	15.70	0.441

* The means values within column followed by the different letter are significant at 5% level.

7-Effect of interaction among plant density, leaves defoliation and genotypes on growth characters, yield, yield components and quality:

The interaction among the three studying factors (plant density, leaves defoliation and genotypes) showed significant effects on head diameter, no. of seeds/head, weight of thousand seed (g.) yield (ton.hector⁻¹), oil, protein percentage, in only 2008 season as illustrated in tables (14-17). The interaction between the plant density, leaves defoliation and genotypes for the other investigated traits were not statistically significant in both seasons, therefore the data were excluded. Flame genotypes with non defoliation at plant density 44444 gave highest means for total seed yield (4.36, 4.26 ton.hector⁻¹) in both growing seasons. On the other hand, non defoliation reflected the greatest response to plant density levels up to 44444 plant.ha⁻¹ and Flame genotypes. For these traits, with this regard, Chavan, *et al.* 1990; Getmanets, *et al.* 1991 Sarmah, *et al.* 1992; Villalobos, *et al.* 1992; Ortegon and Diaz 1997; Herdem, 1999; Nel, 2001; Ozer, 2003 also found that total seed yield and oil content in sunflower genotypes increased, while the single seed weight decreased with increased plant density.

Table -14- : Effect of interaction between plant density.hector⁻¹, leaves

defoliation and genotypes on some growth characters and yield components of sunflower in 2007,2008 season.

plant density	leaves defoliation	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
22222	0	Morden	153.53	3.08	4362.51	23.78b	1224.57b	80.94k
		Flame	163.73	3.24	5017.90	24.58a	1268.77a	86.94c
		Manon	176.80	2.83	4170.10	22.51eh	1165.83ce	75.60a
	4	Morden	155.47	3.06	4329.49	23.05cf	1167.30cd	79.60eg
		Flame	164.60	3.22	4990.23	23.65bc	1216.83b	83.27c
		Manon	172.67	2.85	4155.18	20.85nq	1128.77eg	73.94b
	8	Morden	149.07	3.02	4256.50	22.85df	1199.43bc	72.60
		Flame	159.73	3.13	4906.84	23.51bc	1233.30b	78.94ik
		Manon	173.13	2.78	4113.81	21.85ik	1071.03hi	70.60cd
29629	0	Morden	157.13	2.84	3567.32	21.85ik	1069.70hi	77.27lm
		Flame	169.67	2.96	3770.50	23.11ce	1101.70gh	86.27de
		Manon	184.27	2.15	3401.88	21.45kn	1010.30kn	76.27a
	4	Morden	158.47	2.86	3527.84	21.65jm	1041.23il	74.27ef
		Flame	168.27	2.93	3717.54	22.45fi	1072.83ih	79.94fj
		Manon	183.20	2.12	3378.60	21.11lp	983.77no	72.60c
	8	Morden	152.27	2.80	3465.23	21.31ko	985.37mo	67.60gi
		Flame	162.27	2.96	3691.56	22.51eh	1046.57ik	72.94lm
		Manon	180.67	2.39	3328.67	20.45qs	956.57pq	66.60hj
44444	0	Morden	159.87	2.42	3061.50	23.05cf	1151.90df	74.94p
		Flame	169.00	2.86	3378.63	23.85b	1229.50b	86.94fh
		Manon	186.67	2.19	3009.17	20.71or	1109.97fg	72.27jk
	4	Morden	158.00	2.36	3020.47	22.45fi	1141.83df	68.27l
		Flame	169.67	2.50	3327.83	23.25bd	1163.77ce	76.27ef
		Manon	183.93	2.10	2948.15	20.45qs	1036.17il	66.60lm
	8	Morden	155.47	2.44	2955.83	20.78or	994.43mo	61.94k
		Flame	167.47	2.83	3282.51	22.11gj	1043.50il	65.94np
		Manon	184.73	2.10	2896.86	19.85s	966.23op	61.60m
88888	0	Morden	166.27	2.23	2928.54	21.91hk	1023.23jm	67.60lm
		Flame	179.13	2.87	3323.84	22.65dg	1066.23hi	74.60fh
		Manon	189.73	1.98	2751.55	21.05mq	986.90mo	63.94n
	4	Morden	165.73	2.20	2895.87	21.71jl	1005.37ln	62.94no
		Flame	177.13	2.85	3174.57	22.11gj	1049.83ij	67.60lm
		Manon	191.27	2.12	2735.88	20.58pr	965.17op	60.27p
	8	Morden	161.40	2.26	2846.26	20.65pr	933.10pq	56.27q
		Flame	171.87	2.68	3248.51	21.71jl	1007.70ln	61.94np
		Manon	191.00	1.97	2752.56	20.18rs	915.57q	54.60q

* The means values within column followed by the different letter are significant at 5% level.

Table -15- : Effect of interaction between plant density.hector⁻¹, leaves

defoliation and genotypes on some growth characters and yield components of sunflower in 2008,2009 season.

plant density	leaves defoliation	genotypes	plant height (cm)	stem diameter (cm)	leaf area (cm ² .plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)
22222	0	Morden	147.34	3.21	4198.97	23.36	1175.87	79.52
		Flame	152.74	3.34	4870.28	23.63	1238.40	85.52
		Manon	163.47	2.93	4189.33	21.43	1136.20	73.86
	4	Morden	150.07	3.20	4232.64	22.76	1160.27	77.52
		Flame	155.07	3.34	4769.99	23.30	1181.40	80.86
		Manon	165.47	2.94	4120.78	20.63	1068.47	71.19
	8	Morden	144.40	3.17	4141.96	22.50	1128.53	71.52
		Flame	149.60	3.29	4760.64	23.03	1176.13	78.19
		Manon	160.07	2.84	4040.95	20.63	1055.13	68.52
29629	0	Morden	150.34	2.66	3389.75	21.70	1036.67	74.52
		Flame	155.07	3.24	3557.43	22.56	1062.40	82.52
		Manon	169.40	2.63	3279.40	21.03	975.10	71.86
	4	Morden	151.87	2.64	3362.93	21.50	985.33	70.19
		Flame	156.27	3.22	3521.64	22.30	1041.33	77.52
		Manon	170.47	2.62	3232.32	20.63	951.60	67.52
	8	Morden	147.00	2.64	3268.65	20.70	964.47	66.52
		Flame	152.74	3.12	3494.59	22.10	1026.40	71.52
		Manon	164.14	2.62	3113.67	19.96	901.13	64.52
44444	0	Morden	156.14	2.51	3039.66	22.83	1134.47	72.19
		Flame	161.94	3.10	3170.65	23.30	1156.53	86.19
		Manon	175.60	2.46	2947.10	20.23	1048.93	71.52
	4	Morden	154.20	2.47	3025.82	22.43	1099.87	66.19
		Flame	160.07	3.11	3161.29	22.76	1135.13	76.52
		Manon	175.27	2.44	2925.63	19.76	1004.93	63.52
	8	Morden	150.80	2.45	2882.00	20.36	955.00	61.19
		Flame	158.27	2.96	3145.68	21.70	1023.93	64.52
		Manon	173.67	2.40	2763.45	18.70	894.20	60.19
88888	0	Morden	161.94	2.48	3051.98	20.76	1008.47	66.52
		Flame	167.60	3.24	3227.30	22.43	1043.20	75.19
		Manon	189.40	2.36	2787.31	19.50	975.87	61.86
	4	Morden	162.07	2.47	2964.78	20.50	967.20	60.52
		Flame	165.67	3.22	3159.33	21.63	964.73	65.86
		Manon	186.47	2.33	2809.66	18.90	948.00	56.52
	8	Morden	158.60	2.37	2830.99	19.96	923.13	55.86
		Flame	166.54	3.18	3140.30	21.43	959.13	60.19
		Manon	189.74	2.20	2747.38	18.63	868.13	53.19

* The means values within column followed by the different letter are significant at 5% level.

Table -16- : Effect of interaction between plant density.hector⁻¹, Leaves

defoliation and genotypes on yield and quality of sunflower in 2007,2008 season.

plant density	leaves defoliation	genotypes	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
22222	0	Morden	31.50	2.77u	42.76l	1.184	16.44ef	0.455
		Flame	37.37	2.89qr	45.16ef	1.305	15.24ij	0.440
		Manon	26.10	2.69wx	42.69l	1.148	17.58c	0.472
	4	Morden	31.17	2.74uv	41.76mn	1.144	17.11d	0.468
		Flame	36.64	2.87st	44.16gh	1.267	15.91g	0.456
		Manon	25.57	2.68x	41.69mn	1.117	18.38b	0.492
	8	Morden	31.97	2.72vw	41.76mn	1.135	17.84c	0.485
		Flame	38.10	2.84t	43.16jl	1.225	16.24f	0.461
		Manon	26.64	2.67x	41.29n	1.102	18.71a	0.499
29629	0	Morden	34.50	3.05mn	43.56hk	1.328	15.44nj	0.470
		Flame	40.44	3.37i	45.82d	1.544	14.38mo	0.484
		Manon	29.64	3.00op	43.89ij	1.316	15.58gi	0.467
	4	Morden	34.10	3.03no	43.16jl	1.307	15.78gh	0.478
		Flame	40.04	3.34i	44.76fg	1.494	14.71lm	0.491
		Manon	29.44	2.97pq	43.02kl	1.277	16.64e	0.494
	8	Morden	35.50	3.01o	42.69l	1.284	16.31ef	0.490
		Flame	40.97	3.21j	43.76hj	1.404	15.18j	0.487
		Manon	30.10	2.95q	42.62l	1.257	17.11d	0.504
44444	0	Morden	34.84	3.83e	45.22df	1.731	13.71qr	0.525
		Flame	41.70	4.36a	47.76b	2.08	12.91s	0.562
		Manon	29.64	3.71g	44.96f	1.668	14.18op	0.526
	4	Morden	34.37	3.74g	43.76hj	1.636	14.58ln	0.545
		Flame	40.64	4.20b	47.42bc	1.991	13.98pq	0.587
		Manon	27.84	3.66h	43.29hl	1.584	15.11jk	0.553
	8	Morden	36.97	3.17k	43.56hk	1.380	15.38ij	0.487
		Flame	42.70	3.71g	45.76de	1.697	14.44lo	0.535
		Manon	35.10	3.13kl	41.96m	1.313	15.78gh	0.493
88888	0	Morden	38.17	3.16k	45.09f	1.424	12.78s	0.403
		Flame	43.64	4.08c	48.49a	1.978	12.38t	0.505
		Manon	34.10	2.97pq	44.96f	1.335	13.38r	0.397
	4	Morden	37.64	3.11l	44.16gh	1.373	13.98pq	0.434
		Flame	42.77	4.02d	47.02c	1.890	13.44r	0.540
		Manon	33.64	2.92r	43.76hj	1.277	14.44lo	0.421
	8	Morden	38.90	3.07m	43.69hk	1.341	14.78kl	0.453
		Flame	44.70	3.78f	45.76de	1.729	14.31np	0.540
		Manon	34.64	2.89rs	42.76l	1.235	14.78kl	0.427

* The means values within column followed by the different letter are significant at 5% level.

Table -17- : Effect of interaction between plant density.hector⁻¹, leaves defoliation and genotypes on yield and quality of sunflower in 2008,2009 season.

plant density	leaves defoliation	genotypes	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
22222	0	Morden	32.68	2.67	43.00	1.148	15.64	0.417
		Flame	39.01	2.86	45.07	1.289	14.50	0.414
		Manon	27.08	2.62	43.34	1.135	16.90	0.442
	4	Morden	32.01	2.66	42.40	1.127	16.04	0.426
		Flame	37.81	2.85	44.27	1.261	15.10	0.430
		Manon	26.68	2.60	42.07	1.093	17.24	0.448
	8	Morden	33.48	2.60	41.80	1.086	16.57	0.430
		Flame	40.21	2.84	43.74	1.242	15.44	0.438
		Manon	27.68	2.56	41.54	1.063	17.64	0.451
29629	0	Morden	35.81	2.97	43.94	1.305	14.84	0.440
		Flame	41.81	3.29	45.87	1.509	13.64	0.448
		Manon	30.08	2.92	44.07	1.286	15.30	0.446
	4	Morden	35.08	2.95	43.54	1.284	15.30	0.451
		Flame	41.08	3.27	45.47	1.486	13.84	0.452
		Manon	29.48	2.89	42.94	1.240	15.57	0.449
	8	Morden	36.48	2.92	42.80	1.249	15.64	0.456
		Flame	42.81	3.22	44.34	1.427	14.24	0.458
		Manon	30.41	2.88	42.67	1.228	15.84	0.456
44444	0	Morden	34.88	3.76	45.80	1.722	13.04	0.490
		Flame	41.68	4.26	48.94	2.084	12.30	0.523
		Manon	29.81	3.64	44.87	1.633	13.24	0.481
	4	Morden	33.94	3.64	43.94	1.599	14.17	0.515
		Flame	40.61	4.13	47.94	1.979	13.44	0.555
		Manon	27.94	3.57	43.67	1.559	14.44	0.515
	8	Morden	37.14	3.05	43.67	1.331	14.77	0.450
		Flame	43.14	3.62	45.94	1.663	14.10	0.510
		Manon	31.74	3.00	42.20	1.266	14.90	0.447
88888	0	Morden	39.81	3.06	45.87	1.403	11.97	0.366
		Flame	46.08	3.97	49.20	1.953	11.64	0.462
		Manon	35.08	2.85	45.00	1.282	12.64	0.360
	4	Morden	39.21	3.03	44.74	1.355	13.64	0.413
		Flame	45.94	3.94	47.87	1.886	13.04	0.513
		Manon	34.68	2.81	43.87	1.232	13.84	0.388
	8	Morden	41.01	2.98	43.87	1.307	14.17	0.422
		Flame	47.21	3.63	47.34	1.718	13.70	0.497
		Manon	36.01	2.80	43.34	1.213	14.44	0.404

* The means values within column followed by the different letter are significant at 5% level.

Table-18:- Analysis of variance F values for some growth characters, yield and yield components and quality in 2007-2008 and 2008-2009 seasons.

M.S. for 2007-2008 season													
S.O.V	D.f	plant height (cm)	stem diameter (cm)	leaf area (cm ² /plant)	head diameter (cm)	no. of seeds/head	weight of thousand seed (g.)	hollow (%)	yield (ton/ha.)	oil (%)	oil yield (ton/ha.)	protein (%)	protein yield (ton/ha.)
Replications	2	5899.148	3.18943	2645850.21	34.68307	87034.80	748.063	3540.26	3.7806	175032	63.78	93449.3	1026.161
a	3	18.400*	0.03448**	4672.32*	0.11769**	197.46**	1.2963**	41.5136*	0.0215**	73.24**	0.008**	178.84**	7.821**
Error a	6	3.37037	0.00861	4151.70	0.0370	49.5648	0.3703	39.1111	0.0054	5462.04	0.159	89.8056	2.814
b	2	860.89**	0.2571 ^{ns}	1280.27 ^{ns}	12.5055*	191913.57**	1119.154*	1297.169**	1.49672**	1193509**	20.83**	175634.8**	986.590**
a × b	6	2.08 ^{ns}	0.011 ^{ns}	4209.37**	0.04629**	66.00**	0.4722**	39.3580**	0.0071**	4863.27**	0.142 ^{ns}	99.682**	3.3703 ^{ns}
Error ab	16	6.57	0.07583	45750.63	0.53651	598.45	3.3606	34.4870	0.0829	37500.1	0.647	541.55	5.813
c	2	168.727**	0.03925**	76632.10**	9.84812*	69953.90*	1120.726**	237.783**	0.05202*	185222.8**	13.96**	79269.7**	940.58**
a × c	6	1.925*	0.0086**	4151.70**	0.0370*	49.56**	0.3703**	39.11 ^{ns}	0.0054*	5462.04**	0.159**	89.80**	2.8148 ^{ns}
b × c	4	5.564**	0.0416 ^{ns}	1122.16 ^{ns}	1.06530**	7350.86 ^{ns}	20.2188*	12.91 ^{ns}	0.0053**	3996.16**	0.768 ^{ns}	6796.07 ^{ns}	47.075 ^{ns}
a × b × c	12	2.5679 ^{ns}	0.0199 ^{ns}	4382.38 ^{ns}	0.07407*	115.30*	0.7777**	40.09 ^{ns}	0.0123**	3066.9**	0.091 ^{ns}	129.311**	5.0370 ^{ns}
Error abc	48	4.645	0.022	3506.90	0.17467	429.02	3.3930	32.1006	0.0099	4272.84	0.166	523.923	7.822
Total	107												
S.O.V	D.f	M.S. for 2008-2009 season											
Replications	2	1080.29	3.05368	8440509715	1.1658	20.7048	0.01509	1264.23670	3.55664	97.5515	4.27768	561.38	10.6833
a	3	12.117*	0.00439**	0.9872*	0.00081**	0.0062**	0.00130**	0.5179**	0.0087**	0.1566**	387.152*	247.899**	226.121**
Error a	6	0.611	0.00123	0.6951299	0.00011	0.0226	0.000282	0.21729	0.00557	0.0470	8.48737	492.54	11.0624
b	2	215.770**	4.4592**	38.14112**	1.21420**	58.1147**	0.03693**	261.7006**	4.22380**	41.2562**	30.00881**	539.94**	21.8215**
a × b	6	0.777**	0.00173 ^{ns}	0.7223 ^{ns}	0.000147**	0.0205**	0.00035**	0.25097**	0.00566*	0.0436**	33.83 ^{ns}	468.17**	20.3409 ^{ns}
Error ab	16	1.0610	0.12642	1.73663	0.03656	0.4364	0.00466	0.29668	0.12499	1.1131	159.95	625.86	28.4954
c	2	22.212**	0.5906**	22.4506**	0.24848**	16.2027**	0.00541**	29.2370**	0.64629**	27.453**	13.591**	889.83**	18.6446**
a × c	6	0.611*	0.00116*	0.6951**	0.000113**	0.0226**	0.000282**	0.21729**	0.00557*	0.0515**	10.94 ^{ns}	719.90**	18.2736 ^{ns}
b × c	4	7.7288 ^{ns}	0.2101 ^{ns}	2.277 ^{ns}	0.05075*	0.254 ^{ns}	0.00287*	2.121 ^{ns}	0.23 ^{ns}	0.83 ^{ns}	143.46 ^{ns}	425.516 ^{ns}	9.6079 ^{ns}
a × b × c	12	1.277 ^{ns}	0.0022 ^{ns}	0.817 ^{ns}	0.00025 ^{ns}	0.014 ^{ns}	0.00057 ^{ns}	0.3519 ^{ns}	0.005 ^{ns}	0.033 ^{ns}	143.16 ^{ns}	438.589 ^{ns}	9.75155 ^{ns}
Error abc	48	2.023	0.00069	1.1412060	0.00090	0.06459	0.000596	0.37765	0.00733	0.1441	109.52737	570.36	10.8818
Total	107												

* ** Significant at the 0.05 and 0.01 probability levels, respectively.

*, ** Significant at the 0.05 and 0.01 probability levels, respectively, and n.s. not Significant.

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