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

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**Received: 19/5/2011 ; Accepted: 20/10/2011**

## 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*)

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## 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، فلامي ومانون) وأربعة مستويات للكثافة النباتية (22222 و29629 و44444 و88888 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 2007و2008 -2008و2009 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 2007و2008 -2008و2009 على التوالي.

أعطى التركيب الوراثي فلامي 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 2007و2008 -2008و2009 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 2007و2008 -2008و2009 على التوالي. أعطت الكثافة النباتية 44444 نبات/هكتار والتركيب الوراثي فلامي أعلى معدل لحاصل البذور الكلي والزيت (طن /هكتار) في كلا موسمي النمو 2007و2008 -2008و2009 على التوالي. كان تأثير التداخل بين معاملات خف الأوراق والتراكيب الوراثية معنوياً في بعض صفات النمو والحاصل والنوعية، أعطت معاملة عدم الخف والتركيب الوراثي فلامي 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 فلامي 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) , $CaCO_3$ (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 1$^{st}$ ,5$^{th}$ and harvested in August 8$^{th}$,5$^{th}$ for 2007,2008-2008,2009seasons, respectively. Super phosphate 150kg/hector (45%$P_2O_5$) and potassium (48%$K_2O$) 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 |
|---|---|---|
| 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 $M^2$ 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 ($cm^2$.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, 4369.51cm$^{2}$ .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. hector$^{-1}$ | 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 | 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, $Co_2$, 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$^{-1}$ | hollow (%) | yield (ton/ha.) | oil (%) | oil yield (ton/ha.) | protein (%) | protein yield (ton/ha.) |
|---|---|---|---|---|---|---|---|
| 2007,2008 | 22222 | 31.67d | 2.76d | 42.71d | 1.178d | 17.05a | 0.470c |
| | 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*. 2001and 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, 3664.93cm$^2$ .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 (cm$^2$.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 hector (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 photoassinilates 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 chinches 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.

| S.O.V | D.f | M.S. for 2007 -2008 season | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 n.s | 1280.27 n.s | 12.5055* | 191913.57** | 1119.154* | 1297.169** | 1.49672** | 1193509** | 20.83** | 175634.8** | 986.590** |
| a × b | 6 | 2.08 n.s | 0.011 n.s | 4209.37** | 0.04629** | 66.00** | 0.4722** | 39.3580** | 0.0071** | 4863.27** | 0.142 n.s | 99.682** | 3.3703 n.s |
| 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 n.s | 0.0054** | 5462.04** | 0.159** | 89.80** | 2.8148 n.s |
| b×c | 4 | 5.564** | 0.0416 n.s | 1122.16 n.s | 1.06530** | 7350.86 n.s | 20.2188* | 12.91 n.s | 0.0053** | 3996.16** | 0.768 n.s | 6796.07 n.s | 47.075 n.s |
| a×b×c | 12 | 2.5679 n.s | 0.0199 n.s | 4382.38 n.s | 0.07407* | 115.30* | 0.7777** | 40.09 n.s | 0.0123** | 3066.9** | 0.091 n.s | 129.311** | 5.0370 n.s |
| 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 | 84.0509715 | 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 n.s | 0.7223 n.s | 0.000147** | 0.0205** | 0.00035** | 0.25097** | 0.00566* | 0.0436** | 33.83 n.s | 468.17** | 20.3409 n.s |
| 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 n.s | 719.90** | 18.2736 n.s |
| b×c | 4 | 7.7288 n.s | 0.2101 n.s | 2.277 n.s | 0.05075* | 0.254 n.s | 0.00287* | 2.121 n.s | 0.23 n.s | 0.83 n.s | 143.46 n.s | 425.516 n.s | 9.6079 n.s |
| a×b×c | 12 | 1.277 n.s | 0.0022 n.s | 0.817 n.s | 0.00025 n.s | 0.014 n.s | 0.00057 n.s | 0.3519 n.s | 0.005 n.s | 0.033 n.s | 143.16 n.s | 438.589 n.s | 9.75155 n.s |
| 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. and n.s. not Significant.

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