

## Effect of nitrogen on seed yield and content and quality of oil of winter grown sunflower (*Helianthus annuus* L.)

○○○○Ahmed E. Daffalla<sup>1</sup>, M.E. Lazim<sup>2</sup>, S.M. Farah<sup>2</sup> and E.A.Ahmed<sup>1</sup>

<sup>1</sup>Faculty of Agriculture and Natural Resources, Abu Haraz, Wad Medani, Sudan.

<sup>2</sup>Agricultural Research Corporation, Gezira Research Station, Wad Medani, Sudan.

### ABSTRACT

Field trials were carried out at Wad Medani and Sennar locations during season 2008 / 09 to investigate the effects of nitrogen levels on growth, seed yield, oil content and quality of two sunflower cultivars. The treatments consisted of three nitrogen levels (86.7, 108 and 129 kg N/ha, applied as urea) and two cultivars (Damazin and Hysun33). Nitrogen at the higher rate (129 kg N/ha) gave higher seed yield. The oil content ranged from 36.3 to 42.9 %. Nitrogen, cultivar and location had no significant effects on oil content. Oleic and linoleic acids were the most dominant fatty acids in the oil. It is recommended to apply 129 kg N/ha to winter grown sunflower to obtain high seed yield.

## INTRODUCTION

Sunflower (*Helianthus annuus* L.) is currently the world's fourth largest oil seed crop (De Rodriguez *et al.*, 2002). The world production of sunflower seeds increased from 26 to 31 million metric tons between 2004 and 2006 (FAO, 2007). Sunflower oil is high in linoleic acid content with low cholesterol values and it is considered good for human consumption.

Osman *et al.* (2003) reported that increasing N levels up to 86.6 kg/ha, irrespective of source, increased seed yield and 100 - seed weight and decreased percentage of empty seeds/head. Moreover, Abdalla and Hago (1996) reported that nitrogen application at a rate of 50kg/ha increased seed protein content by 10.8 % to 26.7%, but its effect on oil content was inconsistent. Information is meager about the effects of nitrogen fertilization on sunflower production, particularly, on oil content and quality. Therefore, this study was conducted to investigate the effects of nitrogen on growth, yield, oil content and quality of two winter grown sunflower cultivars in Sudan.

## MATERIALS AND METHODS

A field experiment was conducted at two locations (Wad Medani and Sinnar) during 2008/2009 to investigate the effects of nitrogen (N) levels on growth, seed yield, oil content and oil quality of sunflower. The treatments consisted of three N levels: 86.7, 107.6 and 129.2 kg N/ha and two cultivars: Damazin (V1) and Hysun33 (V2). The treatments were arranged in a randomized complete block design with four replicates. The first location, Wad Medani, lies at latitude 14° 6' N and longitude 33° 38' E" and 400 masl). Its a characterized by heavy cracking clay vertisols, it has 0.5 % organic matter, 0.03 nitrogen and 6 mg/ kg of phosphorus ( Dr. Mowia El Badwi Hamad, University of Gezira, personal communication, 2009). The second location, Sinnar lies at latitude 13° 12' E N and longitude. 33° 32' E and 417 masl. It has a heavy cracking clay soil, with a pH of 7.5 and is poor in nitrogen and organic matter (Mohamed *et al.*, 2005). The soil of the two experimental sites were disc ploughed, harrowed, leveled and ridged into 80 cm ridges. Plot size was 5.6 m X 6 m. Seeds were sown by hand on 15<sup>th</sup> of February 2008, at both locations, at 20 cm apart along the ridge. Three seeds were placed per hole and the seedlings were thinned to one plant/hole. Irrigation was applied adequately at 12-day intervals.

Nitrogen was applied as urea in split dose at 12 and 30 days after planting. A single herbicide spray of Stomp at the rate of 1.0 L/ ha was applied before emergence to control weeds.

Plant height (cm) and dry weight of whole plants (g) were determined for five plants at random, one month after sowing, and then every 15 days using the second inner rows.

Six mature heads were harvested at random, from 1m<sup>2</sup> of each plot, and the following parameters were determined: Seed yield (kg/ha), head diameter (cm), 1000 - seed weight (g), number of seeds per unit area (m<sup>2</sup>) and percentage of empty seeds .

The data were subjected to the analysis of variance procedure and the treatment means were separated using Duncan's Multiple Range Test .

The oil content and quality were determined according to the standard international methods used by A.O.A.C.S.(1990).

## RESULTS AND DISCUSSION

Nitrogen had significant effects on plant height (Table 1) and dry matter accumulation (Fig 1a and 1b). These parameters increased with increasing N up to 129 kg/ha. These findings were in line with those of Kasem and El Mesilhy (1992), who reported that the greatest plant height was obtained with 112 kg N/ha and 120 kg N/ha. Tenebe *et al.* (1996), Also reported that shoot dry weight of sunflower increased significantly with increasing rate of nitrogen from 0 to 100 kg/ha. However, these results were not in agreement with those of Osman *et al.* (2003), who reported that N had no significant effects on plant height of sunflower.

Hysun 33 plants were significantly (P=0.05) taller (188.7 and 157.8 cm) than Damazin (167.5 and 126.4 cm) at Wad Medani and Sinnar locations , respectively,

Table1. Effect of nitrogen rate on plant height (cm) of two sunflower cultivars, grown at the two locations when they attained their maximum values during season 2008/09.

Treatment	Wad Medani	Sinnar
N rate (kg/ha)		
86	178.5 a	135.8 b
108	176.5 a	144.9 a
129	179.4 a	145.7 a
Cultivars		
Damazin	167.5 b	126.4 b
Hysun33	188.7 a	157.8 a
Mean	178.1	142.1
C.V%	2.54	6.19

Means followed by the same letter (s) in each column were not significantly different according to Duncan's Multiple Range Test.

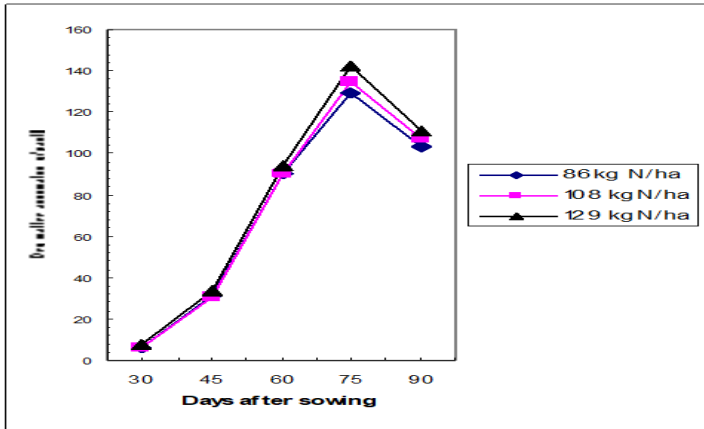


Fig. 1a. Effect of N rate on dry matter (g/plant) of sunflower grown at Wad Medani during 2008/09.

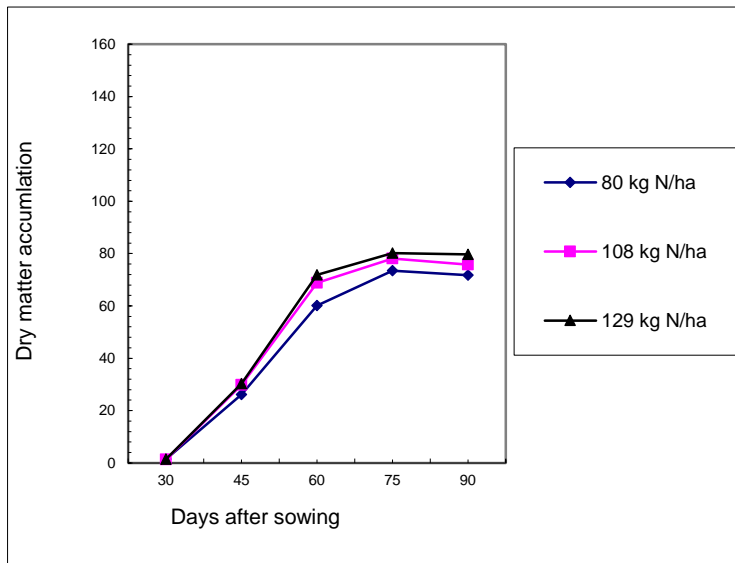


Fig. 1b. Effect of N rate on dry matter (g/plant) of sunflower grown at Sinnar during 2008/09

and had greater number of leaves / plant (31.3 and 29.8 ) than Damazin (28.6 and 27.6 cm) at both locations, respectively.

Nitrogen had significant effects on yield and yield components (Table 2). Seed yield and number of seeds/m<sup>2</sup> were significantly increased with increasing N up to 129kg/ha level at both locations. Moreover, the percentage of unfilled seeds/head was significantly (P=0.05) reduced with increasing nitrogen application particularly at Wad Medani. The increase in yield was mainly attributed to increase in number of seeds/m<sup>2</sup> and 1000 – seed weight. Similar findings were reported by Ali (2003), who

reported that seed yield of sunflower increased with addition of nitrogen (130 kg N/ha). However, our findings disagree with those of Osman (1995), who reported that N application at different rates (0, 44, 88 and 132 kg N/ha) had no significant effects on seed yield of sunflower under rain in Kordofan State.

Nitrogen applied in this study had no significant effect on head diameter at both locations. These findings were in line with those of Hassan and Mukhtar (2003), but were in contrary to those of Estrada *et al.* (2007) who reported that applied N at a rate of 120 kg/ha significantly ( $P=0.05\%$ ) increased head diameter.

Table. 2. Effect of nitrogen rate on yield and yield components of sunflower grown at two locations during 2008/09.

Treatment	Seed yield(kg/h)	No. of seeds/m <sup>2</sup>	Head diameter(cm)	1000 seed wt (g)	Unfilled seeds (%)
<u>Wad Medani</u>					
N rate (kg/ha)					
86	2826 b	5855 b	15.9 a	48.7 b	8.3 a
108	2993 b	6001 b	15.9 a	50.0 ab	8.2 a
129	3287 a	6503 a	16.1 a	50.6 a	8.1 a
Mean	3035	6120	16.0	49.8	8.2
C.V%	5.75	5.38	4.68	2.62	18.59
<u>Sinnar</u>					
86	2012 c	4842 c	12.9 b	44.6 b	14.6 a
108	2354 b	5163 b	14.2 a	48.0 a	13.7 ab
129	2655 a	5622 a	14.6 a	49.2 a	13.0 b
Mean	2340	5209	13.9	47.3	13.8
C.V%	7.28	5.14	3.12	3.63	7.31

Means followed by the same letter (s) in column were not significantly different according to Duncan's Multiple Range Test.

Nitrogen had significant effects on 1000 – seed weight which increased at both locations up to 129kg/a. Similar findings were reported by Ali (2003) but Babiker (1988), reported that N application at different rates (0, 21.61, 43.22 and 86.43Kg/ha) had no significant effects on 1000- seed weight.

The percentage of unfilled seeds/head was negatively associated with N application. Hence, application of N at 129 kg/a had lower percentage of unfilled seeds. Hassan and Mukhtar (2003), reported that the lowest percentages of empty seeds/head were obtained with the higher levels of N.

Location had significant effects on yield and its components. Seed yield was from 2340 to 3035 kg/ha, number of seeds/m<sup>2</sup> from 5209 to 6120, head diameter from 14 to 16 cm and 1000- seed weight from 47.3 to 50g. Mohammed and Abdella (2007) reported that seed yield was 5.14 t/ha at New Halfa and 3.35 t/ha at El Rahad Schemes.

Hysun 33, at Wad Medani, produced significantly ( $P =0.05$ ) higher seed yield, great number of seeds/m<sup>2</sup>, heavier 1000 seed weights and lower percentage of unfilled seeds /head (%) than Damazin cultivar (table 3).

Table 3. Effect of cultivar on yield and yield components of sunflower grown at two locations during 2008/09.

Treatment	Seed yield (kg/ha)	No. of seeds/m <sup>2</sup>	Head dia (cm)	1000 seed wt (g)	Unfilled seeds (%)
Cultivar			<u>Wad Medani</u>		
V1	2750 b	6063 b	15.9 a	45.6 b	8.8 a
V2	3320 a	6176 a	16.0 a	53.9 a	7.6 b
Mean	3035	6120	16.0	49.8	8.2
C.V%	5.75	5.38	4.68	2.62	18.59
			<u>Sinnar</u>		
V1	2256 b	5166 a	13.4 b	45.8 b	14.9 a
V2	2425 a	5253 a	14.4 a	48.7 a	12.5 b
Mean	2340	5209	13.9	47.3	13.8
C.V%	7.28	5.14	3.12	3.63	7.31
			<u>The combined of the two locations</u>		
V1	2503 b	5615 a	14.6 b	45.7 b	11.9 a
V2	2873 a	5714 a	15.2 a	51.3 a	10.0 b
Mean	2688	5664	14.9	48.5	11.0

Means followed by the same letter (s) within each column were not significantly different from each other according to Duncan's Multiple Range Test.

#### Oil and protein content (%)

Oil content decreased slightly with increasing N (Table 4). Application of N at 129 kg/ha gave an oil content (38.5% and 36.3 %) compared with other N levels (42.9% and 42.2 %) and (39.1% and 37.4 %) for Wad Medani and Sinnar locations, respectively. These findings agree with those of Osman *et al.* (2003) who showed that oil % decreased gradually from 42.3 to 39.9% with increasing N level up to 85.6 kg/ha but disagree with those of Naveed and Malik (2005) who reported that higher sunflower oil content (44.79%) was obtained by increasing rates of N up to 150 kg/ha,

N application had no significant effect on protein content when the crop was grown at Wad medani, and an inconsistent effect at Sinnar. These findings were not in line with those of Abdalla and Hago (1996), who reported that nitrogen application at 50 kg/ha increased protein content by 10.8 % - 26.7%.

Table 4. Effect of nitrogen rate on oil content and protein (%) of two sunflower cultivars, Damazin (V1) and Hysun 33 (V2) at the two locations during 2008/09.

Treatment	Oil content (%)		Protein (%)	
	Wad Medani	Sinnar	Wad Medani	Sinnar
N rate (kg/ha)				
86	42.9 a	39.1 a	24.3 a	30.1 b
108	42.2 ab	37.4 ab	24.2 a	36.8 a
129	38.5 b	36.3 b	24.6 a	33.0 ab
SE±	1.37	0.81	0.12	1.94
Cultivar				
V1	41.2 a	39.3 a	24.8 a	33.2 a
V2	41.1 a	36.2 a	23.8 a	33.0 a
SE±	0.05	1.55	0.5	0.1
Mean	41.2	37.8	24.3	33.1

Means followed by the same letter (s) within each column were not significantly different from each other according to Duncan's Multiple Range Test .

#### Fatty acid composition of oil

Fatty composition of sunflower oil is presented in Fig 2a and 2b. Linoleic and oleic acids were the most dominant fatty acids. Fatty acids content arranged in a decreasing order were as follows:

- 1- Linoleic acid (18:2) = 47.9 – 65.4 %.
- 2- Oleic acid (18: 1) = 20.1–38.3 %.
- 3- Palmitic acid (16:0) = 5.43 – 7.73 %.
- 4- Stearic acid (18:0) = 3.14 – 5.47 %.
- 5- Arachidic acid (20:0).= 0.03 –1.92 % .
- 6- Gadolic acid (20:1) = 0.18 –1.27 % .
- 7- linolenic acid (18:3) = 0.22 – 0.74 %.
- 8- Behenic acid (22:0) = 0.63 – 1.52%.
- 9- Palmitoleic (16:1) = 0.03 – 0.24 % .

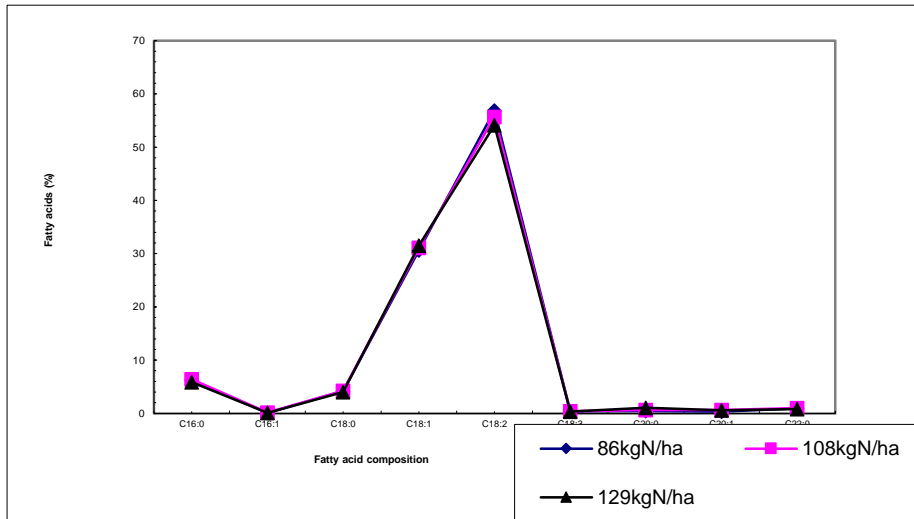


Fig. 2 a. Effect of N rate on fatty acid composition (%) of sunflower grown at Wad Medani (2008/09).

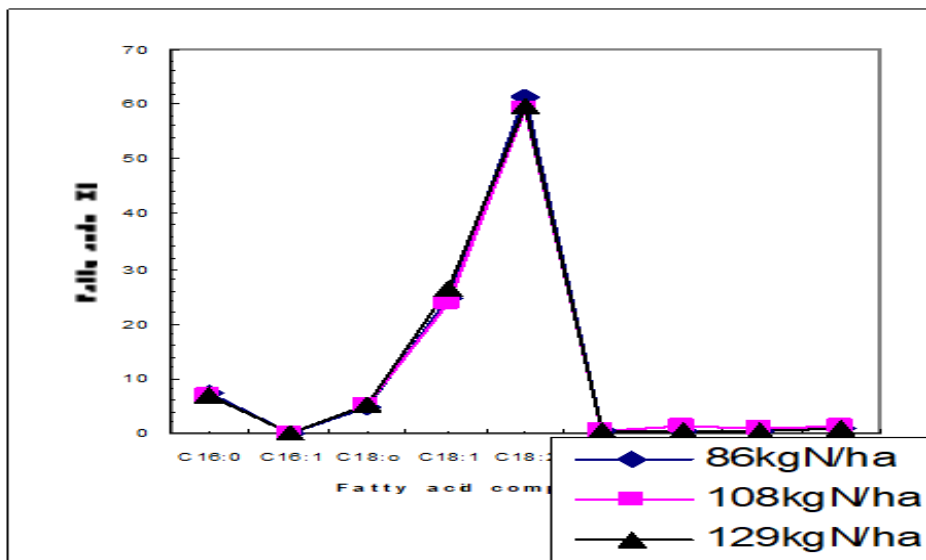


Fig 2b. Effect of N rate on fatty acid composition (%) of sunflower grown at Sinnar (2008/09)

N application had very little effect on linoleic acid at Wad medani, though a very slight decrease with increasing N was observed at the two locations. Moreover, the N treatments had no effect on oleic acid at Wad medani. The highest N rate (129kg/ha) produced significantly ( $P=0.05$ ) higher value than 108 kg N/ha at Sinnar ( Fig. 2a ). These findings agreed with those of Steer and Seiler (1990) who



**reported** that genotype and temperature during oil formation are the major factors determining the proportions of oleic and linoleic acids, whereas, N supply has a small effect and depends on the timing of application. They also reported **that the percentage of palmitic and linoleic acids responded positively to increase in N rate before florets initiation, whereas, stearic and oleic acids responded negatively. Only linoleic acid responded negatively to high N supply after anthesis.** Zheljaskov *et al.* (2009), **demonstrated** that agricultural factors such as planting date, hybrid, and N rate may significantly modify fatty acid composition and oil content of sunflower grown in Mississippi. Moreover, they reported that the three minor saturated fatty acids (SFA); arachidic (20:0), behenic (22:0), and lignoceric acid (24:0) followed a similar pattern.

### **CONCLUSIONS AND RECOMMENDATIONS**

Nitrogen applied at 129 Kg/ha gave taller plants with greater number of leaves and heavier dry weights than the other doses. It also gave higher seed yield at both locations. Oil content slightly decreased with nitrogen level, unlike protein content. Cultivar and location had no significant effects on oil content. Linoleic and oleic acid were the most dominant fatty acids in the oil. Nitrogen, location or cultivar had no effect on fatty acid composition. In order to obtain high seed yield of sunflower application of 129kg N/ha is recommended.

## REFERENCES

- A.O.A.C. 1990. Official Methods of Analysis. 15<sup>th</sup> edition. Published Association Of Analytical Chemists, Suite 400, 2200 Wilson Boulevard. Arligton, Virginia, 22201 USA.
- Abdalla, A. M. A. and T.E.M. Hago. 1996. The effect of nitrogen and phosphorus on some seed characteristic of sunflower. University of Khartoum Journal of Agricultural Sciences 4(2): 69-77.
- Ali, A. A. 2003. Effect of Nitrogen and Phosphorus on Growth Characters and Seed Yield of Irrigated Sunflower. M.Sc. Thesis. University of Gezira, Sudan.
- Babiker, E. A. 1988. Effect of Nitrogen rate and time of nitrogen application on yield and yield components of sunflower (Hybrid Hysun 33). Annual Report of Rahad Research Station, Sudan, 48 -52.
- De Rodriguez, D. J.,J. Remero-Garela, R.Rodriguez-Garcia and J.L. Angulo-Sanchez. 2002. Characterization of proteins from sunflower leaves and seeds : Relationship of biomass and seed yield, pp 143-149. In : J. Janick and A. Whipkey (ed). Trends in New Crops and New Uses. Purdu University, USA.
- Estrada, L. E., Y. L. Estrada and C. L. Elizalde. 2007. Effect of nitrogen fertilization on the yield of sunflower in Mexico. Agronomia-Costarricense 31(2): 95-100.
- FAO.2007. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Hassan. M. and O.N. Mukhtar. 2003. Respones of sunflower to nitrogen and phosphorus. Annual Report of Oil Seed Crops Research Programme. Wad Medani Research Station , Sudan 48 –49.
- Kasem, M. M. and M. A. El Mesilhy. 1992. Effect of rates and application treatment of nitrogen fertilizer on sunflower. Annual Report of Agricultural Sciences of Moshtohor 30 (2):653-663.
- Mohamed, S. B. and A. H. Abdella. 2007 . Performance of locally developed sunflower hybrids under irrigation. Gezira Journal of Agricultural Science 5 (2): 167-180.
- Mohamed, I. E., G. A. El Khalifa, I.A.M. Khier and A. S. Gangi. 2005. Effect of plant spacing and seasonality on growth and seed yield of sunflower. Gezira Journal of Agricultural Science 3 (2): 222-232.
- Naveed, K. and M.A. Malik. 2005. Yield response of diverse sunflower hybrids to varying levels of nitrogen. Journal of Agricultural Research. Lahore 43(2): 135 -144.
- Osman, K. A. 1995. Response of sunflower varieties to nitrogen and phosphorus application . Annual Report of El Obied Research Station, Sudan.
- Osman, R. A. A., A. E. Nour and A. N. Ali. 2003. Effect of Different Nitrogen Sources on Sunflower. Annual Report of Land and Water Research Center. Agricultural Research Coperation, Wad Medani, Sudan.
- Steer, B. T. and G. J. Seilier. 1990. Changes in fatty acids composition of sunflower seeds in response to time of nitrogen application, supply rates and defoliation. Journal of Science of Food and Agriculture 51(91): 11 - 26.
- Tenebe, V. A. , U. R. Pai, C. A. Okonkwo and B. M Auwalu. 1996. Response of rainfed sunflower (*Helianthus annuus* L.) to nitrogen rates and plant population in semi- arid savanna region of Nigeria. Journal of Agronomy and Crop Science 177(3): 205-207.
- Zheljazkov, V.D., B. S. Vick, B. S. Baldwin, N. Buchring, T. Astatkie and B. Johnson. 2009. Oil content and saturated fatty acids in sunflower as a function of planting date, nitrogen rate and hybrid. Agricultural Journal 101: 1003 – 1011.

أثر النتروجين علي إنتاجية البذور ونسبة ونوعية الزيت لصنفين من زهرة الشمس المزروعة في الشتاء  
أحمد الطيب دفع الله الطيب<sup>1</sup> ، مقبول الهادي لازم<sup>2</sup> ، سعيد محمد فرح<sup>2</sup> و الامين علي احمد<sup>1</sup>  
<sup>1</sup>كلية الزراعة والموارد الطبيعية ، أبو حراز ، وادمدني ، السودان.  
<sup>2</sup>هئية البحوث الزراعية ، محطة بحوث الجزيرة ، واد مدني ، السودان.

### الخلاصة

أجريت التجارب الحقلية لهذه الدراسة في كل من المزرعة التجريبية لكلية العلوم الزراعية ، جامعة الجزيرة و مزرعة محطة بحوث سنار موسم 2008 / 2009 لدراسة تأثير السماد النتروجيني علي إنتاجية البذور و نسبه وخصائص الزيت لصنفين من زهره الشمس (*Helianthus annuus L*). اشتملت الدراسة علي : أ/ ثلاث مستويات للنتروجين (86.7 و 108.3 و 129 كجم / هكتار) ب/ صنفين : Hysun 33 (هجين) و دما زين (مفتوح التلقيح). سجل التسميد النتروجيني عند المستوي 129 كجم /هكتار اطول النباتات وذات إنتاجية أعلى من الحبوب في الموقعين و تعزى تلك للزيادة المعنوية في عدد الحبوب/م<sup>2</sup> ووزن ال1000 حبه. تراوحت نسبة الزيت ما بين 36.8 إلي 42.9 % . الأصناف والموقع لم يكن لهما أي تأثير علي نسبة الزيت. الأحماض الدهنية الاوليك واللينوليك هما الأحماض الدهنية السائدة بالزيت. معدل النتروجين والموقع والأصناف ليس لها تأثير معنوي علي الأحماض الدهنية. توصي الدراسة بإضافة 129 كجم من النتروجين للهكتار للحصول علي اعلي إنتاج لمحصول زهرة الشمس المزروع شتاءا.