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RESEARCH ARTICLE

Effect of growing seasons on yield and its components and oil quality of some Sunflower (*Helianthus annuus* L.) genotypes.

Aboelkassem, K.M.

Oil Crops Research Department, Field Crops Research Institute, Agriculture Research Center, Giza, Egypt

Abstract

The present investigation was carried out to determine the effect of growing season on four sunflower genotypes (Sakha 53, Giza 102, L120 and L770) at Shandaweel agricultural research station, Agricultural Research Center, Egypt during the two years 2019 and 2020 for yield, its components and oil quality sown during winter and summer seasons. A randomized complete block design with 3 replications. The combined analysis showed that growing season had significant effect on genotypes for yield components and chemical properties. The highest each of content of oil (44.20%), total protein (21.33%) in seeds and the best oil quality recognized the highest proportion from unsaturated fatty acids (TMUF % and (TPUF%) with high oleic acid and linolenic acid, low proportion saturated fatty acids were in winter season. The summer season produced the highest 100-seed weight, yield/plant and seed yield/fed. The genotype L120 had the heaviest 100-seed weight (6.88 g) and yield/plant (48.15 g) and seed yield/fed (1223.90 kg) in summer season. Giza 102 recorded the highest proportion in TMUF % (18.16) and oleic acid% (17.10), L770 recorded the highest proportion in TPUF % (75.50) and Linoleic acid % (73.40). Correlation coefficients among various studied characters and seed yield/fed in sunflower genotypes across the environments demonstrated that seed yield (kg/fed) were positively associated and highly significantly with head diameter, 100-seed weight and seed yield/ plant and between oil percentage with 50% flowering and steam diameter across the seasons and years.

Keywords: Linoleic acid; Oleic acid; Productivity; Quality; Seed yield; Sunflower

1. Introduction

Sunflower seeds are high in both oil (from 39 to 49%) and protein (from 39 to 49%), making them a healthy source of both. Because of its light color, high content of (unsaturated fatty acids and linolenic acid), and bland flavor, sunflower oil is often regarded as a premium oil Basheer HG *et al.* (2016). Sunflower was grown by Indians as a food source and in North America is a native plant. The leading sunflower-producing countries are Russia and the United States, it's the world's third-largest oil crop after soybeans and rapeseed and it's a potential source of high-quality edible oil. The total cultivated area in Egypt was 8000 ha produced 24000 tons (FAO 2019).

Oil quality is associated with fatty acid composition, mainly with percentage of oleic and linoleic acids. and oil concentration in the sunflower seed depends upon the daily mean temperature (Baydar and Erbas 2020). However, the quality and potential usage of vegetable oils are determined by their composition. Because of its nutritional and industrial properties, sunflower oil is one of the most extensively used vegetable oils (Marvey, 2008).

Mrdja *et al.* (2012) reported that the amount and distribution of temperature conditions during the growth season, as well as the time, duration, and severity of drought, have a substantial impact on yield levels, 1000-seed weight, and germinability. They came to the conclusion that the success of sunflower cultivation and production is determined not only by the genotype's genetic potential, but also by environmental factors.

***Corresponding author:** K.M. Aboelkassem
Email: khaled_aboelkassem@hotmail.com
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Genotype, environment, and their interplay all have a big impact on productivity and quality. Ahmad and Hassan (2000) discovered that sunflower hybrids grown and harvested at warmer temperatures in June have more oil content than those matured and harvested in April.

Kll and Altunbay (2005) observed that sunflower breeders have responded to market demand by developing a number of hybrids with high oleic acid content recently. Different climatic conditions based on temperature prevailing during the crop life cycle may explain differences in yield qualities across seasons. The fatty acid content of sunflower seed lipids is regulated by plant genotype and is changed more or less by external factors such as light and temperature, depending on its compassion (Bazina and He 2018).

Sunflower growth, productivity and oil quality is influenced by the current growing environment, and the crop is influenced by environmental variables such as the growth season, temperature and photoperiod. Therefore, our efforts in this research were limited to study the effect of growing season on growth, yield components characters and oil quality of sunflower crop sown during winter and summer seasons.

2. Materials and methods

Four sunflower genotypes were evaluated using entire randomized block design with three replications over the course of two years with four environment (winter and summer seasons of 2019 and 2020) at Shandaweel Agricultural Research Station ARC, Egypt. Names and pedigree of the four genotypes are shown in Table 1.

Table 1. Genotype's name and pedigree of the four sunflower genotypes studied

No	Genotypes	Pedigree
1	Sakha 53	Mayak × Bulgarian1
2	Giza 102	Indian line × Mayak
3	L120	Mayak × Bulgarian2
4	L770	Bulgarian 53 × Bulgarian 49

Planting date in winter season was 1st of November, and planting date in summer season was 15th of May in the two years, the experimental plots were made up of 3-ridges, 5 m length and 75 -cm width with 25-cm between plant. Sowing was done in hills on ridges, with three seeds per hill, to ensure a consistent stand, and then thinned to one plant per hill 15 days later, as recommended. Maximum and minimum temperature during the praid of the experiment were reported by meteorological data of Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (during winter and summer seasons of 2019 and 2020) at Shandaweel are shown in Table 2.

All other agricultural practiced was done as recommended by Oil Crops Research Department, Field Crops Research, Institute, Agricultural Research Center, Giza, Egypt. At maturity, to determine yield components and chemical qualities, ten sunflower plants were randomly chosen at maturity from each entry in each replication.

2.1. Date recorded

The following character could be divided in two main groups: -

2.1.1. Growth and yield components

number of days to 50% flowering as flowering date, plant height (cm), stem diameter (cm), Head diameter (cm), 100-seed weight (g), seed yield / plant (g) and seed yield / feddan (kg.)

Table 2. Meteorological data of mean of maximum and minimum temperature of the two years

	Winter					Summer			
	2019		2020			2019		2020	
MONTH	Temperature (ºC)		Temperature (ºC)		MONTH	Temperature (ºC)		Temperature (ºC)	
	Max (Mean)	Min. (Mean)	Max. (Mean)	Min. (Mean)		Max. (Mean)	Min. (Mean)	Max. (Mean)	Min. (Mean)
November	30.5	20.8	32.4	19.2	May	34.1	20.0	30.2	19.5
December	22.1	11.1	21.5	10.5	June	37.4	25.2	35.4	22.5
January	18.6	8.6	17.5	8.0	July	39.8	29.5	40.1	28.4
February	19.9	9.2	21.6	11.5	August	41.5	31.2	42.1	32.5
March	25.9	10.5	27.8	12.1	September	38.5	29.2	39.2	29.6

Table 3. shows the mechanical and chemical analyses of the soil at Shandaweel station. Saturation extracts conductivity (EC), pH, cations and anions of experimental sites were analyzed according to soil and water analysis Institute, Shandaweel Lab., Agriculture Research Center (ARC).

Table 3. Analysis of the experimental soil's mechanical and chemical at Shandaweel agricultural station.

1-Mechanical analysis:

Sand %	Silt %	Clay %	Soil texture
31.91	25.84	42.25	Clay loam

2- chemical analysis:

Organic matter %	Total nitrogen %	Available nutrients N ppm	Available nutrients P ppm	Available nutrients Zn ppm	Available nutrients Mn ppm	Available nutrients Fe ppm	EC m mhos/ cm at 25 C	pH
1.89	1.26	183	6.3	18.1	14.05	13.65	0.39	7.6

2.1.2. Chemical properties

which indicate to oil quality represented in oil percentage (%), total protein (%), total saturated fatty acids (TSF %), total monounsaturated fatty acids (TMUF %), total polyunsaturated fatty acids (TPUF %), oleic acid (C18:1), and Linolenic acid (C18:2).

Samples of seeds were oven dried, ground finely and stored in small bags for chemical analysis. Extraction of oils, was done according to (AOAC, 2005). According to AOAC (1990) oil percentage was determined, and the total protein in the seeds according to AOAC (2000). Using gas liquid chromatography, the content of fatty acids was measured and identified. (Aglent 6890 GC, USA)., in Central Laboratory of Food Technology Research Institute, ARC, Egypt, according to Zygadlo *et al.* (1994)

2.2. Statistical analysis

Standard statistical analysis of variance was run using randomized complete block design (RCBD) with three replications according to Gomez and Gomez (1984). Combined analysis was performed for all studied traits after confirmed from homogeneity of error variance for evaluated seasons using Bartlett test according to Snedecor and Cochran (1989).

The formula suggested by Al-jibouri *et al,* (1958) was used to calculate correlation coefficients for yield components and chemical properties.

3. Results and discussion

3.1. Analysis of variance

3.1.1. Growth and yield components characters.

The combined analysis of variance across years and environments revealed that highly significant differences among the genotypes for all yield traits (Table 4). A non-significant GYE (G x Y x E) interaction was observed for all yield traits except head diameter. This significant interaction indicated that the genotypes were inconsistent in their performance when tested across environments. The G x E interaction had also significant effect ($p<0.05$) on all traits. The greater the magnitude of mean squares attributable to environments, the more significant the variations between environments for all characters and the greater the influence of environments on these characters was observed. This indicates the large differences between environments along with greater part of genotypic response to be a linear function of environments i.e., the environments created by season, seasons across years was justified and had linear effects. These results are in agreement with Dencic *et al.* (2011)

Table 4. Combined analysis of variance for four sunflower genotypes to growth and yield components over two years**.**

S.O.V	d.f	Mean squares						
		Days to 50% flowering	Plant height (Cm)	Stem diameter (Cm)	Head diameter (Cm)	100-seed weight (g)	Yield /plant (g)	Seed yield/fed (kg)
Years (Y)	1	3.691*	3.630	0.0001	0.350	0.323	0.824	1253.6**
Env. (E)	1	670.1**	3.000	0.269**	2.539*	12.73**	111.8**	207204.7**
Y x E	1	1.095	106.8**	0.079**	0.576	0.663*	0.010	24.23
R/E/Y	8	1.526	44.73**	0.006	2.582**	0.314*	2.319	190.3
Genotypes (G)	3	3.611*	2501.1**	0.350**	5.062**	0.922**	26.42**	43891.1**
G x Y	3	1.122	11.06	0.003	0.132	0.008	0.144	182.5
G x E	3	3.887**	25.30	0.045**	5.282**	0.015	0.254	4385.3**
G x Y x E	3	1.083	25.85	0.020	1.474*	0.002	0.255	79.11
Error	24	0.870	13.21	0.007	0.438	0.112	2.585	167.8

*, ** Significant at 0.05 and 0.01 levels of probability, respectively

The GY interaction had no significant effect on all seven sunflower traits. This indicated that the genotypes were consistent in their performance when tested across years. These results are supported by Baghdadi *et al.* (2014)

3.1.2. Chemical properties

The analysis of variance of genotypes were significant ($p \leq 0.01$) for chemical properties except total protein% (Table 5). Results showed that growing seasons were significant ($p \leqslant 0.01$) for all chemical studied traits; oil percentage, total protein (%), (TSF%), (TMUF%), (TPUF%), oleic acid and Linolenic acid. These outcomes are consistent with Ahmad and Hassan (2000), Qadir *et al.* (2006) and Echarte *et al.* (2010). Bazina and He (2018) stated that temperature is the most important environmental element affecting fatty acid proportions, oil percentage and total protein in the oil of sunflower, and added that the temperature was raised, the amount of highly unsaturated acids decreased. This decrease was accompanied by increase in oleic acid and was significant with temperature.

Table 5. Combined analysis of variance for four sunflower genotypes to chemical properties over two years.

S.O.V	d.f	Mean squares						
		Oil%	Protein%	TSF%	TMUF%	TPUF%	Oleic acid%	Linoleic acid%
Years (Y)	1	1.184	0.015	0.090	2.567*	3.619	7.995**	0.032
Env. (E)	1	162.8**	50.78**	334.5**	157.0**	33.33**	39.30**	16.97**
Y x E	1	3.413	1.207*	0.513	0.880	2.736	15.52**	0.001
R/E/Y	8	1.160	0.147	0.533	0.729	1.695	0.659	1.664
Genotypes (G)	3	73.05**	6.994	5.606**	5.462**	11.39**	5.500**	12.96**
G x Y	3	10.69**	0.074	1.792*	0.112	2.510	0.074	3.223*
G x E	3	0.083	0.040	0.111	0.018	0.185	0.009	0.035
G x Y x E	3	0.083	0.040	0.129	0.005	0.168	0.0001	0.0001
Error	24	1.400	0.186	0.583	0.458	1.310	0.457	1.087

*, ** Significant at 0.05 and 0.01 levels of probability, respectively

3.2. *Mean performance of genotypes*

Mean performance of four sunflower genotypes is given in Table 6. The results showed that the mean performance of all genotypes in summer season were earlier (45.27 days), taller in plant height (152.3 cm), thickener in stem diameter (1.78 cm), larger in head diameter (19.88 cm), heavier in seed weight (6.65 g) and higher in yield/plant (46.07 g) and seed yield/fed. (1167.8 kg) than it in winter seasons. Sakha 53 had the highest value for stem diameter (1.95 cm) in summer season, and the lowest value was detected in L120 (1.47 cm) in winter season. The largest head diameter (20.48cm) was for Sakha 53 and the lowest (18.07 cm) was for L770. Line 120 was the heaviest in 100-seed weight (6.88 g) and highest in yield/plant (48.15g) and seed yield/fed (1223.90 kg) in summer season, while the lightest mean of 100-seed weight (5.23 g), lowest mean of yield/plant (41.68 g) and seed yield/fed (974.30 kg) in winter season for Giza 102 cultivar.

These results are consistent with those obtained by Ahmed *et al.* (2020) and Radic *et al.* (2009). Baghdadi *et al.* (2014) found that number of days to maturity, plant height, head diameter, 1000-seed weight, seed weight plant-^{1}, and seed yield ha-^{1} of sunflower crop change significantly by sowing season.

The presented data in Table 7. showed that growing season significantly affected all chemical properties of sunflower genotypes traits across two years. The highest values were in the winter season in all chemical properties except TSF%, as the highest values were in the summer season. The highest oil percentage was shown by Sakha 53 (44.20 %) which grown in winter season compared to L770 which had the lowest oil percentage (38.06 %) when grown in summer season. The highest total protein was obtained by L770 which grown in winter season, but the lowest value was shown by Sakha 53 when grown in summer season. However, the highest TSF% were detected in Sakha 53 (14.63%) in summer season, but the lowest value (7.85%) recorded by Giza102 and L 770 in winter season.

Giza 102 recorded the highest values of TMUF% (18.16) and Oleic acid % (17.10) when grown in winter season but L770 recorded the lowest values when grown in summer season 18.16% and 17.10% respectively. In summer season; Sakha 53 recorded the lowest value of TPUF% (71.55) and Linoleic acid% (69.93) but in winter season L770 recorded the highest value (75.50) and (73.40), respectively. These results are in confirmation with Seiler (2007), Radic *et* *al.* (2009) and Baydar and Erbas (2020). Echarte *et al.* (2010) depicted that lower temperature favor the higher total monounsaturated fatty acids %.

3.3. Simple correlation

The correlation coefficients between seed yield/fed. and the other studied traits in sunflower genotypes over environments (Two successive summer and two winter seasons) are presented in Table 8.

The results showed that seed yield (kg/fed) were associated positively and highly significant with head diameter, 100-seed weight and seed yield/plant. These results indicate that selection for high seed yield/plant, 100 seed weight and head diameter at the same time is selection for higher seed yield/fed in sunflower genotypes. Also, seed yield/plant and 100-seed weight and head diameter all had a positive and significant correlation, giving the evidence that indirect selection for higher seed yield /plant is at the same time selection to weight 100-seed yield and large head diameter. 100-seed weight was correlated significantly and positively with head diameter. These results are in accordance to Zheljazkov *et al.* (2011) and Baghdadi *et al.* (2014).

Table 6. Effect of growing season on growth and yield components of sunflower genotypes across two years

Genotype	Days to50% Flowering			Plant height (Cm)			Stem diameter (Cm)			Head diameter (Cm)		
	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean
Sakha 53	53.43	44.45	48.94	151.3	148.2	149.7	1.93	1.95	1.94	20.48	20.27	20.38
Giza 102	51.67	44.86	48.27	171.0	174.85	172.9	1.57	1.85	1.71	19.13	18.78	18.96
L120	53.32	45.62	49.47	144.4	145.7	145.1	1.47	1.69	1.58	20.03	19.98	20.01
L770	52.57	46.16	49.37	140.4	140.4	140.4	1.53	1.62	1.58	18.07	20.51	19.29
Mean	52.74	45.27		151.8	152.3		1.63	1.78		19.43	19.88	
F-test (L)	**			n.s			*			**		
LSD (G)			0.785			3.063			0.071			0.558
LSD (LxG)	1.113			n.s			0.100			0.788		

Genotype	100-seed weight (g)			yield/plant (g)			Seed yield/fed (Kg)		
	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean
Sakha 53	5.73	6.74	6.24	43.43	46.30	44.87	1078.5	1190.6	1134.6
Giza 102	5.23	6.29	5.76	41.68	44.43	43.06	974.3	1082.1	1028.2
L120	5.95	6.88	6.42	44.79	48.15	46.47	1106.7	1223.9	1165.3
L770	5.58	6.68	6.13	42.17	45.4	43.79	986.1	1174.5	1080.3
Mean	5.62	6.65		43.02	46.07		1036.4	1167.8	
F-test (L)	**			**			**		
LSD (G)			0.283			1.355			10.92
LSD (LxG)	n.s			n.s			15.44		

Table 7. Effect of growing season on chemical properties of sunflower genotypes across two years.

Genotype	Oil percentage			Total Protein (%)			TSF%			TMUF%		
	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean
Sakha 53	44.20	40.60	42.40	19.53	17.42	18.48	9.41	14.63	12.02	17.54	13.83	15.69
Giza 102	47.74	44.14	45.94	20.84	18.72	19.78	7.85	13.23	10.54	18.16	14.54	16.35
L120	43.72	40.12	41.92	20.63	18.74	19.69	8.57	13.62	11.10	18.08	14.46	16.27
L770	41.99	38.06	40.03	21.33	19.22	20.28	7.85	13.34	10.60	16.65	13.13	14.89
Mean	44.41	40.73		20.58	18.52		8.42	13.70		17.60	13.99	
F-test (L)	**			**			**			**		
LSD (G)			0.999			n.s			0.642			0.572
LSD (LxG)		n.s			n.s			n.s			n.s	

Genotype	TPUF%			Oleic acid%			Linoleic acid%		
	Winter	Summer	Mean	Winter	Summer	Mean	Winter	Summer	Mean
Sakha 53	73.06	71.55	72.31	16.39	14.55	15.47	71.17	69.93	70.55
Giza 102	73.99	72.23	73.11	17.10	15.27	16.19	72.10	70.86	71.48
L120	73.35	71.93	72.64	17.02	15.18	16.10	71.46	70.21	70.84
L770	75.50	73.53	74.52	15.59	13.86	14.73	73.40	72.37	72.89
Mean	73.97	72.31		16.52	14.71		72.03	70.84	
F-test (L)	**			**			**		
LSD (G)			0.964			0.569			0.879
LSD (LxG)		n.s			n.s			n.s	

TSF% Total saturated fatty acids, TMUF% Total monounsaturated fatty acids, TPUF% Total polyunsaturated fatty acids

Table 8. correlations for growth, yield components and chemical properties of sunflower genotypes across two years

	Days to 50% Flowering	Plant height	Stem diameter	Head diameter	100-seed weight	Yield /Plant	Seed yield/fed	Oil percentage	Total Protein %	TSF%	TMUF %	TPUF %	Oleic acid %	Linoleic acid%
Days to 50% Flowering	1	0.123	0.131	-0.138	-0.693**	-0.614**	-0.710**	0.515**	0.740**	-0.866**	0.894**	0.353	0.396	0.405*
Plant height		1	-0.255	-0.196	-0.075	-0.171	-0.106	-0.070	0.277	-0.142	-0.135	0.463*	-0.577**	0.430*
Stem diameter			1	0.109	-0.310	-0.241	-0.162	0.480*	-0.024	-0.038	0.327	-0.398*	0.380	-0.480*
Head diameter				1	0.439*	0.471*	0.524**	-0.411*	0.036	0.357	-0.155	-0.453*	0.035	-0.321
100-seed weight					1	0.802**	0.750**	-0.759**	-0.221	0.755**	-0.708**	-0.410*	-0.416*	-0.350
yield/plant						1	0.806**	-0.848**	-0.102	0.676**	-0.606**	-0.408*	-0.286	-0.458*
Seed yield/fed							1	-0.867**	-0.244	0.839**	-0.710**	-0.566**	-0.309	-0.616**
oil percentage								1	-0.073	-0.630**	0.585**	0.351	0.363	0.366
Total Protein %									1	-0.565**	0.621**	0.176	0.108	0.173
TSF%										1	-0.854**	-0.664**	-0.376	-0.643**
TMUF %											1	0.178	0.712**	0.211
TPUF %												1	-0.312	0.912**
Oleic acid %													1	-.262-
Linoleic acid%														1

*****. Correlation is significant at the 0.05 level (2-tailed). ******. Correlation is significant at the 0.01 level (2-tailed).

The results showed associated positively and significantly between oil percentage with 50% flowering and steam diameter, total protein % with 50% flowering, TSF% with 100-seed weight and seed yield/plant, TMUF% with 50% flowering, oil percentage and total protein, TPUF% with plant height, oleic acid percentage with TMUF%, and linoleic acid% 50% flowering, plant height and TPUF%.

4. Conclusion

It noticed that the average of all genotypes of sunflower grown in summer season were the earlier in flowering, taller in plant height, higher in stem diameter, larger in head diameter, heavier in seed weight, higher in yield/plant and seed yield/fed than their in winter season. While, the average of all sunflower genotypes which grown in winter season was the highest compared to grown in summer season for all chemical properties except TSF%.

The correlation between seed yield (kg/fed) and each of head diameter, 100-seed weight, seed yield/plant and TSF% was positive and highly significant over environments. But it was negative and highly significant with days to 50% flowering, oil percentage, TMUF%, TPUF% and linoleic acid over environment.

5. References

A.O.A.C (2000) '*Official methods of analysis*, 17th ed Gaithersburg, MD, USA: The Association of Official Analytical Chemists.' EUA.

A.O.A.C (2005) '*Official Methods of Analysis of the Association of Official Analytical Chemists'* 18 th Edition. Washington, D.C. USA.

A.O.A.C. (1990) '*Official Methods of Analysis of the Association of Official Analytical Chemists'* 15 th Edition. Washington, D.C. USA.

Ahmad, S. and Hassan, F.U., (2000) 'Oil yield and fatty acid composition of spring sunflower'. *Pakistan J. Biological Sciences* 3, 2063-2064.

Ahmed M.A., Abd-Elsaber A. and Abdelsatar M. A. (2020) 'Effect of sowing dates on yield and yield- attributes of some sunflower hybrids' *Agricultura, 113*(1-2):131-144.

Al-Jibouri HA, Miller PA and Robinson HF (1958) 'Genotypic and environment variances and co-variances in an upland cotton cross of interspecific origin' *Agron. J.*,50: 633-636.

Baghdadi A., R.A. Halim, A. Nasiri, I. Ahmad and F. Aslani (2014) 'Influence of plant spacing and sowing time on yield of sunflower (*Helianthus annuus* L.)' *J. Food Agric. Environ.*, 12(2): 688-691.

Basheer, H. G., Atif E. I., Badr E.and Abdelgadir M, A., (2016) 'Impact of Bio-Fertilizer on Growth and Yield of Two Sunflower (*Helianthus annuus* L.) Hybrids at Shambat, Sudan' *Sch J Agric Vet Sci*; 3(4):332-336

Baydar, H. and Erbas, S., (2020) 'Environmental effect on sunflower (*Helianthus annus L.*) oil quality' *Ind. Crop. Prod.* 29: 179-186.

Bazina, N, and He, J. (2018) 'Analysis of fatty acid profiles of free fatty acids generated in deep-frying process' *J. Food.Sci. Technol.* 55, 3085–3092.

Dencic, S., Mladenov, N. and Kobiljski, B., (2011) 'Effects of genotype and environment on breadmaking quality in sunflower'. *Int. J. Plant Prod.* 5(1): 71-82.

Echarte, M. M., Patricia, A., Florencia, J., Jorge, T., Natalia G., Valentinuz, O .and Luis, A.N. (2010) 'Night temperature and intercepted solar radiation additively contribute to oleic acid percentage in sunflower oil'. *Field Crops Research*, 119. 27–35.

FAO Food and Agriculture Organization (2019) ' Http://appsl.fao.org/servlet/xte.servlet.jrun'

Gomez K.A., and Gomez A.A. (1984) 'Statistical Procedures for Agricultural Research' 2nd

Edition, *John Wiley and sons Inc., USA Hoboken*, p.680.

Kll F, and Altunbay S.G., (2005) 'Seed yield, oil content and yield components of confection and oil seed sunflower cultivars (*Helianthus annus* L.) planted on different dates '*Int. J. Agric. Biol.* 7: 21-24.

Marvey, B.B., (2008) 'Sunflower-based feedstock in nonfood applications: perspectives from olefin metatheses' *Int. J. Mol. Sci.* 9, 1393–1406.

Mrdja, J., Crnobarac, J., Radic, V. and Miklic, V., (2012) 'Sunflower seed quality and yield in relation to environmental conditions of production region' *Hella*, 35, (57): 123-134.

Qadir, G., Ahmad, S., Hassan, F. U. and Cheema, M. A. (2006) 'Oil and fatty acid accumulation in sunflower as influenced by temperature variation' *Pakistan Journal of Botany*, 38(4), 1137-1147.

Radic, V., Vujakovic, M., Marjanovic-Jeromela, A., Mrdja, J., Miklic, V., Dušanic, N. and Balalic, I., (2009) 'Interdependence of sunflower seed quality parameters' *Helia 32(50):* 157-164.

Seiler, J., (2007). 'Wild annual *Helianthus anomalus* and *H. deserticola* for improving oil content and quality in sunflower' Industrial *Crops and Products* 25 95–100.

Snedecor, G.W., and Cochran, W.G. (1989) 'Statistical Methods'. *8th Edition, Iowa State University Press,* Ames.

Zheljazkov, V. D., Vick, B.A., Baldwin, B.S., Christine N. B., Astatkie, C. and Johnson, T., (2011) 'Oil productivity and composition of sunflower as a function of hybrid and planting date' Industrial *Crops and Products* 33, 537–543

Zygadlo J.A., Morere R.E., Abburra R.E. and Guzman C.A. (1994) 'Fatty acids composition in seed oils of some on' *J Am Oil Chem Soc.*, 71:915–6.