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

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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.
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

| MONTH   | Temperature (°C) |          |          | MONTH   | Temperature (°C) |          |          |
|---------|------------------|----------|----------|---------|------------------|----------|----------|
|         | 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. (Agilent 6890 GC, USA), in Central Laboratory of Food Technology Research Institute, ARC, Egypt, according to Zygarlo 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≤0.01) for chemical properties except total protein% (Table 5). Results showed that growing seasons were significant (p≤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 ** Significant at 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 (20.48 cm) 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 (46.07 g) and seed yield/fed. (1167.8 kg) than it in winter seasons. Sakha 53 had the highest oil percentage was shown by Sakha 53 (44.20%) which grow 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 L770 in winter season.

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%) when planted in winter season compared to L770 which had the lowest oil percentage (38.06%) when planted in summer season. The highest total protein was obtained by L770 when 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 L770 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  | 49.37| 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   | 6.31 | 43.02  | 46.07  | 43.56| 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  | Winter | Summer | Mean | Winter | Summer | Mean | Winter | Summer | Mean | Winter | Summer | Mean |
|-----------|--------|--------|------|--------|--------|------|--------|--------|------|--------|--------|------|
|           | Oil %  | Protein |     |        |        |     |        |        |     |        |        |     |
|           |        |         |     |        |        |     |        |        |     |        |        |     |
|           | TPUF % |          |     |        |        |     |        |        |     |        |        |     |
|           | TMUF % |          |     |        |        |     |        |        |     |        |        |     |
| Giza 102  | 44.20  | 40.60  | 42.40 | 19.53  | 17.42  | 18.48 | 9.41   | 14.63  | 12.02 | 17.54  | 13.83  | 15.69 |
| 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  | 40.72 | 20.58  | 18.52  | 18.14 | 8.42   | 13.70  | 17.60 | 13.99  | 13.00  | 13.99 |

**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 | Protein | Total Protein % | TPUF % | TMUF % | Oleic acid % | Linoleic acid % |
|------------------------|--------------|---------------|---------------|-----------------|--------------|----------------|----------------|---------|-----------------|--------|--------|-------------|---------------|
|                        | 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**        |
|                        | 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**      |                |
|                        | 1 0.109      | 0.439**       | -0.310        | -0.241          | -0.162       | 0.480**        | -0.024         | -0.038  | 0.327           | -0.398* | 0.380  | 0.480*       |                |
|                        | 1 0.439      | 0.471**       | 0.524**       | -0.411**        | 0.036        | -0.155         | -0.453**       | 0.035   | -0.321          |        |        |             |                |
|                        | 1 0.802**    | 0.750**       | -0.759**      | -0.221          | 0.755**      | -0.708**       | -0.410**       | -0.416  | -0.350          |        |        |             |                |
|                        | 1 0.806**    | 0.848**       | -0.102        | 0.676**         | -0.606**     | -0.408**       | -0.286         | -0.458  | -0.350          |        |        |             |                |
|                        | 1 -0.867**   | -0.244        | 0.839**       | -0.710**        | -0.566**     | -0.309         | -0.616**       |        |                |        |        |             |                |
|                        | 1 -0.073     | -0.630**      | 0.585**       | 0.351           | 0.363        | 0.366          |                |        |                |        |        |             |                |
|                        | 1 -0.565**   | 0.621**       | 0.176         | 0.108           | 0.173        |                |                |        |                |        |        |             |                |
|                        | 1 -0.854**   | -0.664**      | -0.376        | -0.643**        |            |                |                |        |                |        |        |             |                |
|                        | 1 0.178      | 0.712**       | 0.211         |                |            |                |                |        |                |        |        |             |                |
|                        | 1 -0.312     | 0.912**       |            |                |            |                |                |        |                |        |        |             |                |
|                        |                |                | -0.262-       |                |            |                |                |        |                |        |        |             |                |

* 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 stem 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.

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