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RELATIONSHIP OF HEAT UNITS ACCUMULATION AND FATTY ACID COMPOSITION IN SUNFLOWER

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Two field experiments were conducted at the University of Arid Agriculture, Rawalpindi, Pakistan during autumn, 2003 and spring, 2004 to document relationship of heat units accumulation and fatty acid composition in sunflower hybrids. Five sunflower hybrids (Super-25, Parsun-1, SMH-9706, Award and Hysun-33) were sown on ten planting dates both in autumn and spring. Experiments were laid out in randomized complete block design with split plot arrangements replicated four times. Planting dates were kept in main plots and hybrids in subplots. Sunflower hybrids exhibited significant differences for heat units accumulation and fatty acid composition. During autumn, amongst hybrids Hysun-33 accumulated the maximum heat units which was statistically significant from rest of the hybrids. During autumn, amongst hybrids Hysun-33 performed better for oleic acid while Award remained at the top for palmatic and linoleic acid. However, during spring, Super-25 accumulated the highest linoleic acid while Hysun-33 was the best for stearic and oleic acid. Planting dates also influenced fatty acid composition significantly. Overall, spring plantation accumulated higher oleic acid in comparison with autumn planting. However, autumn planting accumulated higher linoleic acid which depicted an inverse relationship of oleic and linoleic acid. During autumn, late August planting accumulated the maximum linoleic and the minimum oleic acid. During spring, late April planting exhibited the highest oleic and least linoleic acid.
Keywords: Heat units, accumulation, composition, oleic acid, linoleic acid

INTRODUCTION

Environmental variables such as temperature, sunshine and rainfall affect plant growth and development differently. It has been concluded that temperature regulates plant growth and development processes. The rate of plant development is mainly temperature driven (Ritche and Ne Smith 1991). Temperature is major environmental factor that determine the rate of plant development as well as fatty acid accumulation in sunflower. Genotypes behave differently under different environmental conditions. Sunflower is a temperate zone crop but it can perform well under various climatic and soil conditions. It can withstand early frost in autumn that usually kills maize and soybean. Khalifa *et al.* (2000) concluded that wide geographic, morphological and habitat wise diversity of sunflower, extending from very hot areas in the south west of US to very cold areas in eastern Canada, might have developed the unique characteristics of sunflower tolerance to both low and high temperatures and accounted for wide adaptation of the crop.

Having wider adaptability, different sunflower hybrids require different total number of cumulative degree-days or heat units for growth, development and maturity. All physiological and morphological developments occurring in plant are markedly influenced by temperature. Different sowing times might result in different environmental conditions during grain filling and oil synthesis. In particular, the fatty acid composition is known to differ with cultivars and environmental conditions (Connor and Sadras 1992). The growing degree days (GDD), or heat unit (HU) is the most common index used to estimate plant development. The accumulation of these heat units determines the maturity of crop as well as performance and quality of produce. Ahmad and Hassan (2000) found higher oil contents in sunflower hybrids matured and harvested at higher temperature of June as compared to those matured and harvested in April. Similarly, Skoric (1992) indicated that oil concentration in the seed depends upon the daily mean temperature in addition to the availability of water during seed filling period. Oleic acid content is essentially influenced by temperature during seed development. Each 1°C increase in temperature leads to about 2% increase in oleic acid. A strong negative correlation exists between oleic and linoleic acid. A low oleic phenotype would essentially be high linoleic one (Demurin *et al.*, 2000).

Growing degree days or heat units variations in the field can be created by planting crops at different dates

during a particular season, thus crop will grow at different temperature, sunshine and relative humidity. The present study was contemplated to investigate relationship of heat unit accumulation and fatty acid composition in different sunflower hybrids. Difference in temperature for growth, development and maturity was created by planting sunflower hybrids at different dates during both the seasons i.e. spring and autumn thus giving a wide range of temperature from germination till maturity.

MATERIALS AND METHODS

Field experiments were conducted during autumn, 2003 and spring, 2004 at the University of Arid Agriculture, Rawalpindi, Pakistan. Five sunflower hybrids (Super 25, Parsun-1, SMH 9706, Award and Hysun 33), five planting dates in autumn (11th, 23rd July, 6th, 16th and 26th August), five planting dates in spring (16th February, 3rd, 15th March, 9th and 27th April) were arranged in a randomized complete block design in split plot arrangements with four replications. The planting dates were in main plots and genotypes in subplots. Nitrogen and phosphorus fertilizers were applied and incorporated in the soil during seedbed preparation @ 80 kg N ha^{-1} and 50 kg ha^{-1} P_2O_5. The row-to-row distance was maintained at 75 cm and plant-to-plant distance at 25 cm in net plot size of 5 m x 3 m. The seeds were sown with the help of dibbler putting two seeds per hill. After emergence one plant per hill was maintained. Weeds were kept under control by hand weeding throughout crop life cycle. The cumulative heat units for different growth stages were calculated by the equation of Dwyer and Stewart (1986).

$$CHU = \sum_{t_2}^{t_1} [(Tmax + Tmin)/2 - 8]$$

Where $[(Tmax+Tmin)/2-8]>0$

Tmax and Tmin were daily maximum and minimum air temperatures in degree centigrade and T_1 and T_2 were the time intervals. Base temperature for sunflower development is 8°C (Sadras and Hali 1988). At maturity central two rows were harvested on 15th, 21st, 29th ,of October, 4th , 15th of November for autumn and 10th, 15th, 25th of June, 20th , 25th of July for spring crops respectively. Harvested plants were sun dried for seven days. Heads were thrashed manually and grains cleaned with small blower. Fatty acids (stearic, palmatic, oleic and linoleic acids) composition were determined by gas liquid chromatograph (GLC). The data thus recorded during study were subjected to Fisher's analysis of variance technique. Treatment means were compared for significance using Duncan's Multiple Range Test at 5 percent level of probability (Steel and Torrie 1980).

RESULTS

Hybrids under evaluation exhibited significant differences for heat unit accumulation during both the seasons. During autumn, Hysun-33 accumulated the maximum (1598) heat units while Super-25 had the minimum (1469). Similarly, planting dates had statistically significant differences for heat units accumulation. The 11th July planting had accumulated the maximum (1626) those progressively decreased to minimum (1380) with late planting 26thAugust (Table 1). During spring, again Hysun-33 accumulated the maximum (1900) heat units. Planting dates also affected the heat units accumulation significantly with maximum (1948) from early-planted crop and least (1575) from late planted (Table 2). Overall spring crop accumulated more heat units than that of autumn planted crop.

Hybrids exhibited significant differences for palmatic acid during autumn. The highest (7.49 %) of palmatic acid was recorded in Award. The lowest (6.42%) palmatic acid was recorded in Hysun-33. Significant differences were observed among planting dates for palmatic acid during autumn. Crop planted on 6th of August gained the highest palmatic acid (7.58%) which was statistically at par with the crop planted on 16th (7.36%) and 26th of August (7.00 %) but different from rest of planting dates. The least palmatic acid (6.23%) was gained by the crop planted on 11th of July, which was statistically at par with the crop planted on 23rd of July (Table 1). During spring, hybrids exhibited significant differences for palmatic acid. The highest palmatic acid (7.10%) was recorded in SMH-9706 which was statistically at par with Super-25 (6.87%) and Hysun-33 (6.32%), while Award accumulated the lowest (5.93%). During spring, significant differences among the planting dates were also observed for palmatic acid. Crop planted on 16th of February gave the highest palmatic acid (7.05%) which was statistically at par with other planting dates except that of 27th April, which exhibited the least value (6.05%). Interaction between the planting date and sunflower hybrids was also significant (Table 2).

Hybrids differed significantly for stearic acid planted in autumn. The highest stearic acid (4.54%) was found in Hysun-33, which was statistically at par with rest of the hybrids except Award (3.75%). During autumn, planting dates exhibited significant differences for stearic acid (Table 1). The highest stearic acid (4.86%)

Table 1. Heat units accumulation and fatty acid composition in sunflower during autumn.

Hybrids	Heat units	Palmatic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)
Super-25	1469e	6.81 ab	3.84 ab	24.54 a	61.68 cd
Parsun-1	1514d	7.43 a	4.11 ab	22.31 b	60.48 d
SMH-9706	1561c	6.48 b	4.45 ab	22.09 b	63.62 b
Award	1578b	7.49 a	3.75 b	16.95 c	70.07 a
Hysun-33	1598a	6.42 b	4.54 a	24.69 a	62.17 c
SEM	4.38	0.272	0.241	0.381	0.461
Planting dates					
11th July	1626a	6.23 b	3.63 c	35.55 a	51.21 d
23rd July	1610b	6.44 b	3.80 bc	31.35 b	53.52 c
6th Aug.	1606b	7.58 a	4.47 ab	16.20 c	70.26 b
16th Aug.	1498c	7.36 a	3.92 bc	14.62 d	69.88 b
26th Aug.	1380d	7.00 ab	4.86 a	12.87 e	73.15 a
SEM	4.38	0.272	0.241	0.381	0.461

Any two means not sharing a letter common in a column differ significantly at 5% probability level.

Table 2. Heat units accumulation and fatty acid composition in sunflower during spring.

Hybrids	Heat units	Palmatic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)
Super-25	1656c	6.87 ab	2.49 b	46.41 e	41.82 a
Parsun-1	1800b	6.24 bc	2.94 ab	50.19 c	37.44 c
SMH-9706	1782b	7.10 a	2.79 ab	48.95 d	39.89 b
Award	1890a	5.93 c	2.86 ab	56.88 b	32.22 d
Hysun-33	1900a	6.32 abc	3.11 a	59.35 a	30.32 e
SEM	11.24	0.261	0.160	0.400	0.390
Planting dates					
16th February	1948a	7.05 a	3.01	42.13 e	45.98 a
3rd March	1810b	6.47 ab	2.68	49.24 d	39.03 b
15th March	1849c	6.39 ab	2.68	54.33 c	35.32 c
9th April	1746d	6.49 ab	2.71	55.98 b	32.99 d
27th April	1575e	6.05 b	3.09NS	60.12 a	28.37 e
SEM	11.24	0.261	0.160	0.400	0.390

Any two means not sharing a letter common in a column differ significantly at 5% probability level.

was recorded for the crop planted on 26th of August, which was statistically at par with the crop planted on 6th of August (4.47%). The lowest (3.63%) stearic acid was recorded from the crop planted on 11th of July, which was statistically at par with the crops planted on 23rd of July (3.80 %) and 16th of August (3.92%) (Table 1). During spring, hybrids exhibited significant differences for stearic acid. The highest stearic acid (3.11%) was accumulated by Hysun-33, while super-25 had the lowest (2.49 %). However, during spring planting dates exhibited non-significant differences for stearic acid (Table 2).

Hybrids differed significantly from each other for oleic acid during autumn. Hybrid Hysun-33 accumulated significantly higher oleic acid (24.69%) than other hybrids except Super-25 (24.5%) while Award gave the lowest (16.95%) oleic acid. During autumn, planting dates significantly affected oleic acid. The crop planted on 11th of July exhibited the highest (35.55%) oleic acid. The lowest (12.87%) oleic acid was observed from the crop planted on 26th of August (Table 1). Hybrids differed significantly from each other for oleic acid accumulation of crop planted during spring. The sunflower hybrid Hysun-33 accumulated significantly higher (59.35%) oleic acid, while hybrid Super-25 gave

the lowest (46.4 %) oleic acid. Planting dates during spring significantly affected oleic acid. The crop planted on 27th of April gave the highest (60.12%) oleic acid, which was significantly different from all other planting dates. The lowest (42.13%) oleic acid concentration was observed in the crop planted on 16th of February (Table 2).

Sunflower hybrids accumulated significantly different linoleic acid during autumn. The highest (70.07%) linoleic acid was recorded in Award, which was significantly different from rest of the hybrids. The lowest (60.48%) value of linoleic acid was recorded in Parsun-1, which was statistically at par with the Super-25 (61.68%). Planting dates exhibited significant differences for linoleic acid during autumn (Table 1). The highest linoleic acid (73.15%) was recorded from crop planted on 26th of August and the minimum linoleic acid (51.21 %) from crop planted on 11th of July. Sunflower hybrids significantly differed from each other for linoleic acid during spring. The hybrid Super-25 contained significantly higher linoleic acid (41.82%) than rest of the hybrids, while hybrid Hysun-33 gave the lowest (30.32%) linoleic acid. During spring, planting dates significantly affected linoleic acid. All the planting dates differed significantly from each other. The crop planted on 16th of February produced the highest (45.98%) linoleic acid. The lowest (28.37%) linoleic acid concentration was observed in the crop planted on 27th of April. The interaction between the planting date and sunflower hybrids was also significant (Table 2).

DISCUSSION

Environmental factors, especially temperature is the key factor which influences plant growth and development. Significant differences among different hybrids for heat units depicted that different hybrids have varying maturity periods. However, higher heat units accumulated by early planted crop during both the seasons reflected that the optimum sowing time of a particular crop is early planting to have good output. According to Aggrarwal and Sinha (1993) most of the simulation studies have shown a decrease in duration and yield of crops as temperature increased. However, effects of delayed sowing in present study on fatty acid accumulation has been noticed to be wide and different during both the seasons.

Sunflower oil consists of different types of saturated and unsaturated fatty acids (palmitic acid, stearic acid, oleic acid, linoleic acid etc.). The palmatic acid and stearic acid are the major saturated fatty acids, whereas oleic and linoleic acids are unsaturated. The quality of sunflower oil is generally associated with the relative concentration of oleic and linoleic acid. A probable reason for low and high palmatic acid concentration in oil of different sunflower hybrids may be the effect of temperature during the physiological maturity stage. The results showed that when the temperature increased towards the maturity of the crop the palmatic acid decreased. Inverse relationship of heat unit and palmatic acid (Fig. 1) is in line with finding of Ahmad *et al.* (2001a) who found significant variations among sunflower hybrid for palmatic acid. Stearic acid content in oil varied from 2.7% to 3.1%. The minor differences for stearic acid among the hybrids showed the genetic homogeneity for particular character that is not influenced by environments, as reported by Ahmad and Hassan (2000). However, Khalil *et al.* (2000) observed significant differences for stearic acid. Ahmad and Hassan (2000) also depicted that lower temperature and lesser growing degree days favor the higher stearic acid accumulation. Significant relationship (Fig 1) between heat units and steric acid are supportive to above findings.

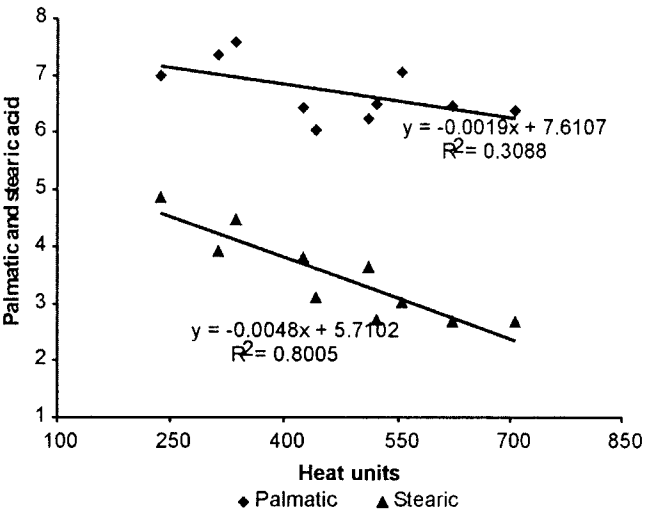

Fig. 1. Relationship between heat units, palmatic and stearic acid

Fatty acid composition of sunflower in particular and other oil seed crops in general, are influenced by temperature, mainly regulating the ratio of oleic and linoleic acid (Garaces *et al.* 1989). The results showed that overall oleic acid was more during the spring planting as compared to the autumn plantings, this is in confirmation with Ahmad and Hassan (2000) who reported that oleic acid increased with increasing maturity temperature. The probable reason for the increase and decrease of oleic and linoleic acid of different sunflower hybrids may be the effect of temperature and moisture during the growing season (Fig.2 & 3). Such variations among hybrids have also been observed by Ahmad *et al.* (1999). The differences for oleic and linoleic acid among planting dates might be due to the differences in environmental conditions prevailing during the crop growing season. The findings of present study are similar to the conclusion of Flagella *et al.* (2002) who reported that sunflower maturation under different environmental conditions

would accumulate different concentration of oleic acid. Similarly, variations in linoleic acid content have also been observed by Ahmad *et al.* (2001b) in autumn planted sunflower hybrids. However, Roberston (1981) reported that linoleic acid content varied inversely with the oleic acid content. Significant but opposite response of oleic acid and linoleic acid to heat units (Fig 2 & 3) is supportive to earlier findings. Thus, an inverse relationship existed between two essential fatty acids which also depicted that percentage of

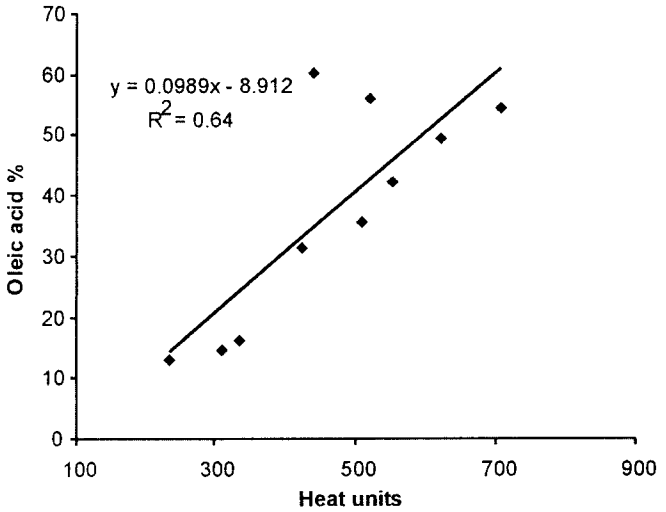

Fig. 2. Relationship between heat units and oleic acid

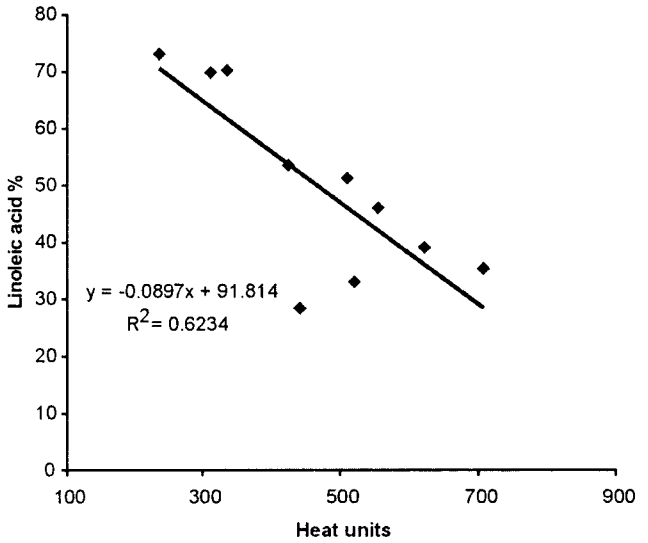

Fig. 3. Relationship between heat units and

polyunsaturated fatty acid will be higher in autumn planted crop. Autumn crop matures at relatively low temperature of October and November. The spring crop which matures at high temperature of May and June would accumulate the higher percentage of mono unsaturated fatty acid. Thus it can be concluded that oil obtained from autumn planting sunflower would be better nutritionally having higher percentage of ploy unsaturated fatty acid.

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