Comparing Four Different Squash Hybrids on Growing Degree Days (GDD) Bases

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Abstract: This investigation was conducted during two seasons (2012 and 2013) at the Central Laboratory for Agricultural Climate (CLAC) Dokki, Agricultural Research Center (ARC), Giza, Egypt. The experiment aimed to study the effect of four different sowing date (March 23rd, April 2nd, April 12th and April 22nd) and four Squash hybrids (*Cucurbita pepo* L. Eskandarany, Marzouka, Revera and Rosina). The experimental design was a split-plot with four replications. Squash plants (*Cucurbita pepo* L.) were planted in clay soil. Number of leaves and plant fresh and dry weights were measured after 90 days from each sowing date. Mineral nutrient contents (nitrogen, phosphor and potassium) were analyzed in the mature leaves after 60 days from each sowing date. In addition, total yield (kg/plant) and fruits (number/plant) were measured for each hybrid in each sowing date. The accumulative growing degree days (GDD) for each hybrid was calculated for different phenological stages depending on planting date and both maximum and minimum air temperature at Dokki site. Results confirmed that, using different sowing dates for the four squash hybrids had an effect on vegetative growth parameters (Number of leaves, Plant fresh weight and Plant dry weight), nutrients content on leaves (N, P and K) and yield. In addition, highest values of vegetative growth parameters, nutrient contents and total yield and accumulated GDD were obtained from the second sowing date and Eskandarany hybrid. Economic evaluation indicated that the second sowing date and Eskandarany hybrid had highest net return (L.E)/feddan. Finally, a polynomial relationship between the total accumulative GDD and the total yield for four the hybrids were found (determination of coefficient) R^2.

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1. Introduction:

Environmental variables are the key factor affecting plant growth, crop growth, development and yield through agronomic, physiological and qualitative functions of the crop plant (Kaleem *et al*., 2009; Kaleem*et al*., 2010a; Kaleem *et al*., 2011).

Air temperature is among the most important environmental factors that control plant development, growth and yield. It is a major environmental factor that determines the rate of plant growth and development. All biological processes respond to temperature, and all responses can be summarized in terms of three cardinal temperatures, namely the base or minimum (T_{min}), the optimum (T_{opt}), and the maximum (T_{max}) temperatures. The nature of the response to temperature between these cardinal points, which is important for calculating the phenology, adaptation and yield of various crops (Shaykewich, 1995). The most common temperature index used to estimate plant development is growing degree days (GDD), or heat unit (HU). The accumulation of GDD determines time of developmental events, maturity of the crop and yield.

A linear relationship between GDD and the rate of plant development was found and reported by Lu *et al*., 2001.

Crop display and yield characteristics are influenced by environmental disparity (Kaleem *et al*., 2010b). Combined effects of environmental factors not only modify plant phenology, but also cause many physiological and qualitative changes. Differences of yield attributes in varying seasons might be due to the different climatic conditions that are based on temperature prevailing during the crop life cycle (Kll and Altunbay, 2005).

Genotypes behave differently under different environmental conditions (Qadir *et al*., 2007). Most crop species are adapted to particular set of temperature, as temperature is a major environmental factor influencing their distribution (Atkinson and Porter, 1996). Temperature variations in the field can be created by planting crops at different dates in the season, thus crop will grow at different temperature, sunshine and relative humidity. Cucurbits play a significant role in human nutrition. Cucurbits crops constitute a major portion of vegetable production and are grown in different regions in Egypt. Squash ranked the second among the popular cucurbits preceded by watermelon (Yousef *et al*, 2013). In Cucurbitaceae, temperature is the major factor in determining the time of pollen shed, flower opening and pollination and growth rate, which in turn could influence yield and quality (Bielinski *et al*., 2008).

Different squash hybrids require different total number of cumulative degree-days or growing degree days for growth, development and maturity.

All physiological and morphological developments occurring in plant are markedly influenced by temperature. Different planting dates might cause different environmental conditions from emergence to harvest.

This study mainly aimed to:

1- Investigate the relationship between growing degree days and different phenological stages and yield of squash hybrids.
2- Determin the adaptation ability of the four tested squash hybrids.
3- Calculate the necessary demands of growing degree days for each of studied squash hybrids.

2. Material & Method

The investigation was carried out in seasons 2012 and 2013 at the Central Laboratory for Agricultural Climate (CLAC), Dokki, Giza. Seeds of squash hybrids were sown in four beds (forty meters each). Each bed was sown at one sowing date. Moreover, each bed was divided into four parts every part contain one squash hybrid. Therefor, each experimental plot was 10 meter long and 1 meter wide and contain twenty plants.

Studied factors:

Two factors were studied; first factor was the four sowing dates whereas; seeds were sown in (March 23rd, April 2nd, April 12 and April 22nd). The second factor was the four squash hybrids (*Cucurbita pepo* L., Eskandarany, Marzouka, Rosina and Revera).

Measurements:

Growth parameters

Plant samples from each experimental plot were taken after 90 days from every sowing date to determine growth parameters as follows:

1- Number of leaves: total number of complete mature leaves per plant was counted.

2- Fresh and dry weights per plant: plant fresh weight was taken after 90 days from each sowing date. Plants were air dried and then put into the oven at 105 ^{o}C for 10 hours and weighted for dry weight.

Chemical analysis:

Three plants from each hybrid, at different sowing date were randomly taken for the mineral nutrients (nitrogen, phosphor and potassium) analysis in the mature leaves after 60 days from each sowing date according to ADAS/MAFF (1987). For mineral analysis, wet distraction was performed according to FAO SOILS BULLETIN.

1- Nitrogen: total nitrogen was determined using Kjeldahl method according to the procedure described by FAO (1980).

2- Phosphorous%: phosphorous concentration in acid digested was determined by colorimeter method (ammonium molybdate) using spectrophotometer according to Watanabe and Olsen (1965) and the data was calculated as percentage.

3- Potassium%: potassium content was determined photo-metrically using Flame photometer as described by Chapman and Pratt, (1961) and the data was calculated as percentage.

Yield measurements:

Total yield: cumulative total fruit weight (kg/plant) and fruits number/plant were recorded and calculated for each hybrid in each sowing date.

Climatic measurements:

Daily maximum and minimum air temperatures were collected from Dokki weather station during the period from March to June during 2012 and 2013 seasons.

Growing degree days (GDD) calculation:

Phenological stages as well as number of days between each phenological stage were recorded and GDD was also calculated for every stage using climatology data with the following equation.

$$GDD = \frac{\sum (T_{max} + T_{min})}{2} - T_b$$

Where

T_{max} = daily maximum air temperature

T_{min} = daily minimum air temperature

T_b = base temperature

Maximum air temperatures were adjusted to upper temperature (32 ^{o}C). In case of T_{max} exceed upper threshold temperature (T_{ut}) then T_{max} equal T_{ut}. The Base temperature for squash development is 8°C according to (Maynard and Hochmuth, 2007).

Experimental design & statistical analysis

The experiment was designed using split plot design with four replicates. The main plots and subplots were assigned to squash hybrids (A) and sowing dates (B), respectively.

The obtained data were statistically analyzed using the analysis of variance method according to Snedicor and Cochran (1980). Duncan's multiple range test at 5% level of probability was used to compare means of the treatments.

Squash plants were irrigated by using drippers of 4 l/hr capacity. The chemical fertilizers were injected within irrigation water system. The row-to-row distance was maintained at 75 cm and plant-to-plant distance at 50 cm.

Economic evaluation

Finally, economic indicators were used to provide economic evaluation for this experiment.

3. Results:

1- Climatic circumstances

The field experiment was conducted during the period from March 23rd to July 16th 2012 and from March 23rd to July 10th 2013. Both growing seasons were characterized by the high daily air temperatures through the period of the two studied seasons (Figures

1 and 2). The highest recorded maximum and minimum air temperature were "42 and 26.2°C" and "43.8 and 26°C during seasons 2012 and 2013, respectively. However, the lowest recorded maximum and minimum air temperature were "22 and 9.8°C" and "18 and 11.5°C" during 2012 and 2013, respectively.

The averages maximum and minimum air temperatures for the four tested sowing dates growing period in season 2012 were "32.6 and 18.9 °C", "34 and 20.4 °C", "34.5 and 20.9 °C" and "35 and 21.5 °C" during the first, second, third and fourth sowing dates, respectively. While through 2013 season they were "32.4 and 18.4 °C", "33.6 and 19.8 °C", "34.1 and 20.2 °C" and "35.1 and 21 °C", respectively.

From the overall illustrated climatic circumstances, it's clear that such conditions will reflect directly on the calculated GDD, whereas, the highest calculated GDD (21 GDD/day) was found at the same day with the highest maximum and minimum air temperature during both studied seasons. The same conclusion was found regarding the lowest calculated GDD "8 and 9.7 GDD/day", which were observed at the days characterized by the lowest recorded maximum and minimum air temperatures at 2012 and 2013 seasons, respectively.

Averages calculated GDD/day during the period of the four sowing dates were 16.6, 17.8, 18.2 and 18.6, respectively during 2012. And it recorded 16.2, 17.2, 17.6 and 18.2, during season 2013, respectively.

2-Vegetative growth:

2-1 GDD& days to emergence

It's concluded from data in Table (1) that, different sowing dates and hybrids as well as the interaction between them significantly affected both number of days and accumulative heat units from sowing to emergence.

Focusing on effect of different sowing dates, first sowing date (March 23rd) had the longest period to emergence in both studied seasons. While, the third and fourth sowing dates (April 12 and April 22nd) recorded the shortest period to emergence during the 2012 and 2013 season. In addition, accumulated growing degree days (GDD) from sowing date to the complete emergence presented a significant difference because of the different sowing dates. The highest significant GDD was found in the third sowing date (April 12) during the first season and was found in the first sowing date (March 23rd) during the second season. Contrary, the lowest significant GDD was obtained in first (March 23rd) and fourth (April 22nd) sowing dates during seasons 2012 and 2013, respectively. The mentioned differences in GDD during those period were a direct results for the different in air temperature existed during this times.

Regarding the effect of squash hybrids, Marzouka significantly recorded the longest period to emergence in both studied seasons. However, Revera and Rozena recorded the shortest periods to emergence in both studied seasons. Also, the same trend of results was found in GDD. The highest GDD from sowing to emergence was required for Marzouka compared to Revera and Rozena, whereas they required a less GDD from sowing to emergence.

Interaction between studied squash hybrids and tested sowing dates reflect a clear significant difference in both number of days. Interaction between Marzouka and first sowing date recorded the longest period to emergence during seasons 2012 and 2013. While the interaction between Marzouka and first sowing date and interaction between Marzouka and second sowing dates significantly recorded the highest GDD in seasons 2012 and 2013, respectively, due to different climatic circumstances in the first and second seasons according to Kll and Altunbay, 2005.

Table (1): Effect of different sowing dates and squash hybrids on number of days and accumulative GDD to emergence.

	Days to Emergence									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	6.0 ab	4.0 b	4.0 b	4.0 b	**4.5 B**	5.0 ab	4.0 bc	4.0 bc	3.0 c	**4.0 A**
Marzoka	7.0 a	6.0 ab	5.0 ab	5.0 ab	**5.8 A**	6.0 a	5.0 ab	5.0 ab	4.0 bc	**5.0 A**
Revera	5.0 ab	4.0 b	4.0 b	4.0 b	**4.3 B**	5.0 ab	4.0 bc	4.0 bc	3.0 c	**4.0 A**
Rozina	5.0 ab	4.0 b	4.0 b	4.0 b	**4.3 B**	5.0 ab	4.0 bc	4.0 bc	3.0 c	**4.0 A**
Mean	**5.8 A**	**4.5 AB**	**4.3 B**	**4.3 B**		**5.3 A**	**4.3AB**	**4.3AB**	**3.3 B**	
	GDD to Emergence									
Eskandarane	55.0 d	55.0 d	67.0bc	56.5 d	**58.4 B**	56.0cd	49.5de	48.5 e	35.0 f	**47.3 B**
Marzoka	64.0 c	89.5 a	84.5 a	73.5 b	**77.9 A**	70.5 a	66.5ab	59.5bc	44.0 e	**60.1A**
Revera	46.0 e	55.0 d	67.0bc	56.5 d	**56.1 B**	56.0cd	49.5de	48.5 e	35.0 f	**47.3 B**
Rozina	46.0 e	55.0 d	67.0bc	56.5 d	**56.1 B**	56.0cd	49.5de	48.5 e	35.0 f	**47.3 B**
Mean	**52.8C**	**63.6B**	**71.4A**	**60.8B**		**59.6 A**	**53.8 B**	**51.3 B**	**37.3C**	

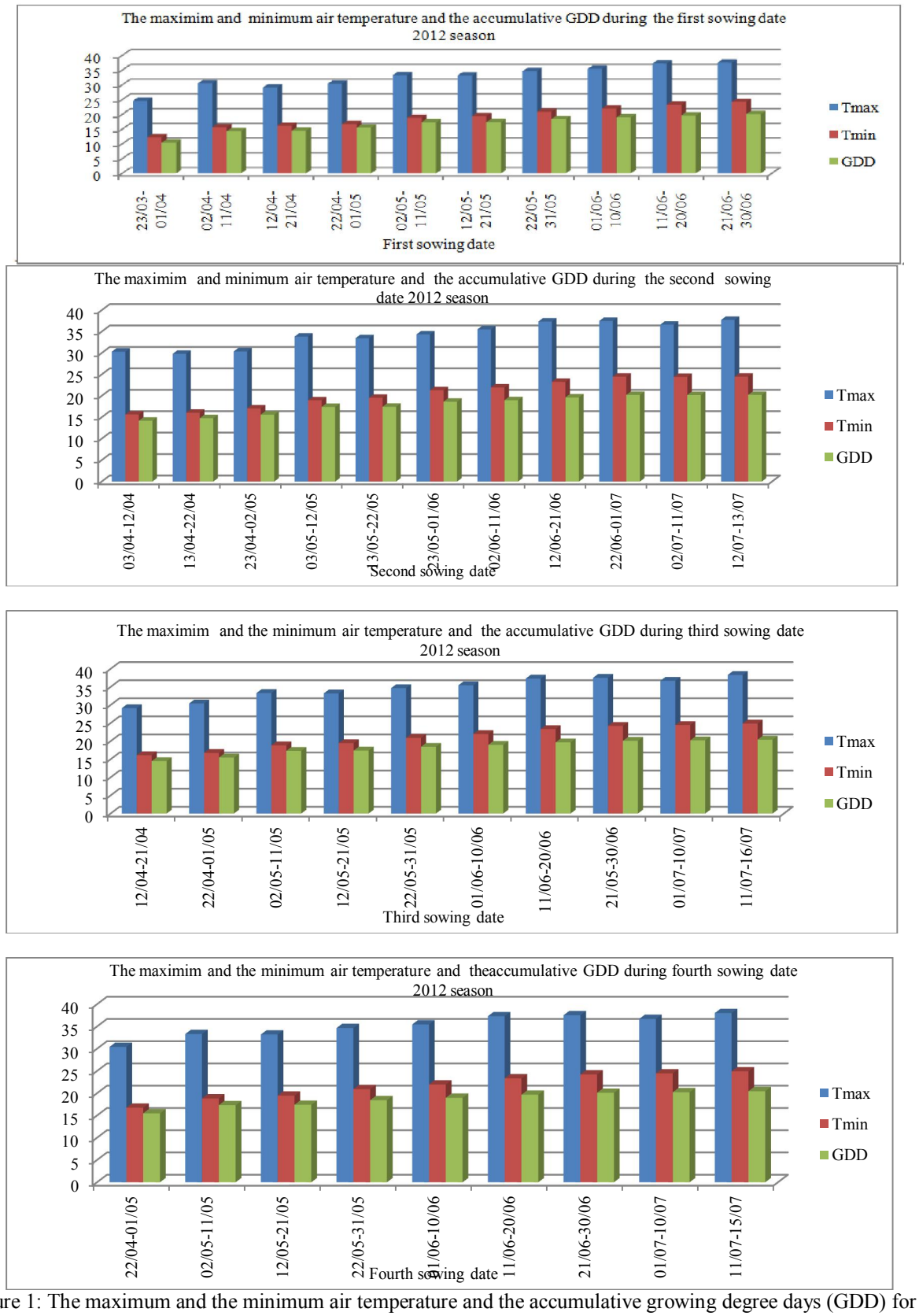

Figure 1: The maximum and the minimum air temperature and the accumulative growing degree days (GDD) for the four sowing dates growing seasons (2012).

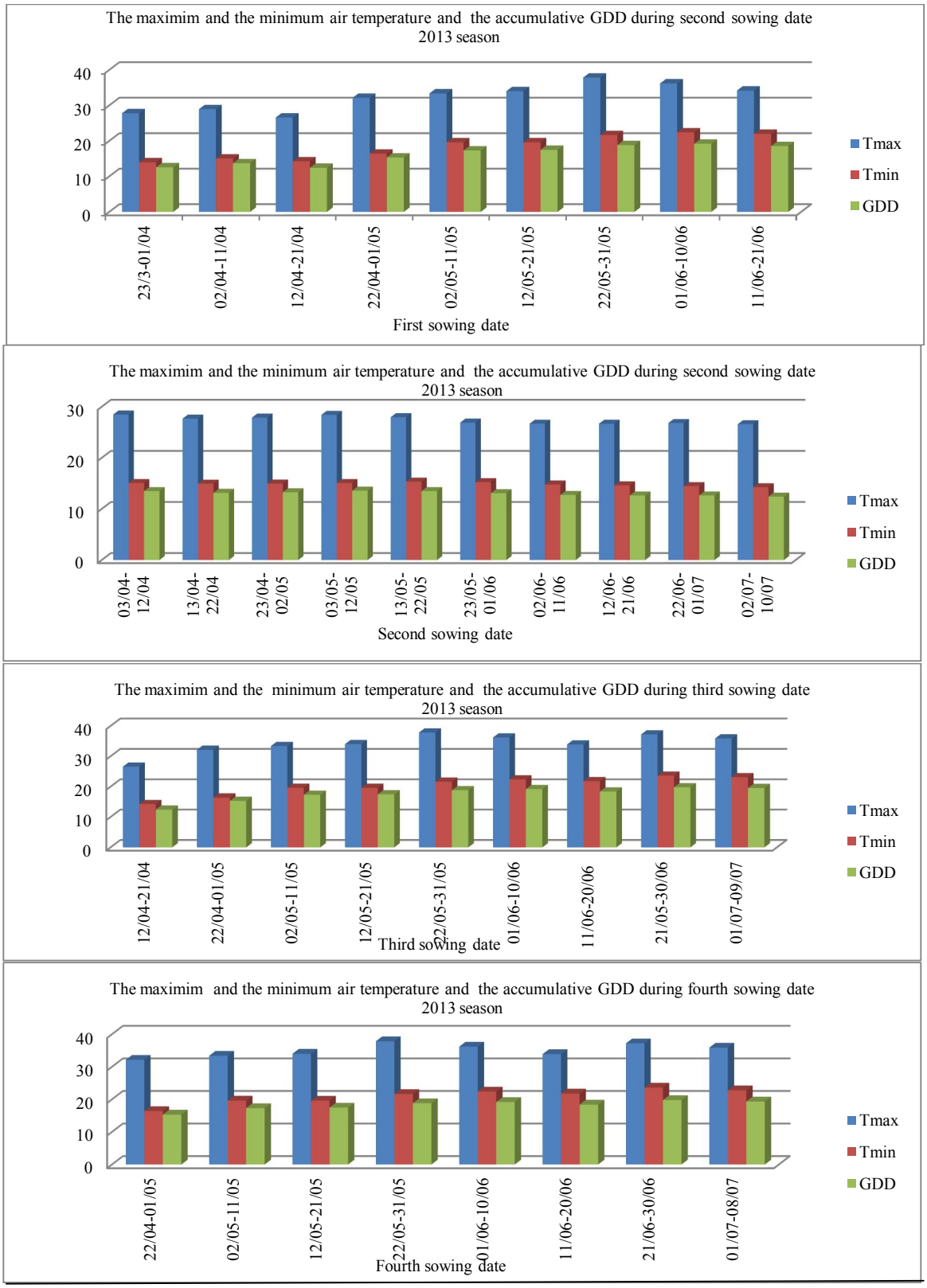

Figure 2: The maximum and the minimum air temperature and the accumulative growing degree days (GDD) for the four sowing dates growing seasons (2013).

2-2 GDD& days to first leaf

Data in Table (2) showed that, necessary days and accumulative GDD from the complete emergence to the complete appearance of the first true leaf were affected significantly by the four tested sowing dates, squash hybrids and the interaction between them.

The longest significant period to first leaf complete appearance was recorded for the first and second sowing dates in both seasons without significant different between them. Moreover, the shortest significant period to first leaf appearance was recorded for fourth sowing date in both studied seasons and without significant different between fourth and third sowing date. In addition, the highest significant GDD was recorded for the second and first sowing date in seasons 2012 and 2013, respectively. However, lowest significant GDD was observed for the fourth and third sowing dates in seasons 2012 and 2013, respectively.

Regarding the effect of squash hybrids, Marzouka recorded the longest significant period to first leaf appearance and the highest accumulated GDD in both studied seasons. Where the less in both time and accumulated GDD were obtained with Revera and Rozena and without significant different between them in both growing seasons.

Focusing on interaction between studied squash hybrids and tested sowing dates, a clear significant difference in both number of days and GDD were obtained. Interaction between Marzouka and both first and second sowing dates were recorded with the highest number of days to first leaf appearance during 2012 and 2013 growing seasons. The highest accumulated GDD was obtained when Marzouka interacted with the second sowing date in season 2012 and when the same hybrid interacted with the first sowing date in season 2013. On the other hand, both of Revera and Rozena recorded the lowest GDD when interacted with third and fourth sowing dates in seasons of 2012 and 2013, respectively.

Table (2): Effect of different sowing dates and squash hybrids on number of days and accumulative GDD to first leaf appearance.

	Days to first leaf									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	6.0 a:c	6.0 a:c	5.0 c:e	4.0 d:f	**5.3 B**	5.0 ab	4.0 ab	4.0 ab	4.0 ab	**4.3 B**
Marzoka	7.0 a	7.0 a	6.0 a:c	5.0 c:e	**6.3 A**	6.0 a	6.0 a	5.0 ab	5.0 ab	**5.5 A**
Revera	6.0 a:c	5.0 c:e	3.0 f	3.0 f	**4.3 B**	4.0 ab	3.0 b	3.0 b	3.0 b	**3.3 C**
Rozina	5.0 c:e	5.0 c:e	4.0 d:f	3.0 f	**4.3 B**	4.0 ab	3.0 b	3.0 b	3.0 b	**3.3 C**
Mean	**6.0 A**	**5.8 A**	**4.5B**	**3.8B**		**4.8 A**	**4.0 A**	**3.8 A**	**3.8 A**	
	GDD to first leaf									
Eskandarane	65.0 e	84.5bc	79.5c	57.5 fg	**71.6 B**	79.0 b	50.5 e	39.0 g	58.0 d	**56.6B**
Marzoka	85.0bc	104.5a	89.5b	81.0 c	**90.0 A**	91.5 a	66.0 c	46.0ef	84.5 b	**72.0A**
Revera	63.0 ef	72.0 d	53.5gh	50.5 h	**59.8 C**	62.0cd	40.5fg	29.0 h	41.5 fg	**43.3C**
Rozina	51.5 h	72.0 d	67.0de	50.5 h	**60.3 C**	62.0cd	40.5fg	29.0 h	41.5 fg	**43.3C**
Mean	**66.1 C**	**83.3 A**	**72.4 B**	**59.9 D**		**73.6 A**	**49.4 C**	**35.8 D**	**56.4 B**	

2-3 Number of leaves

It's obvious from data illustrated in Table (3) that, total number of squash leaves affected significantly by the four tested sowing dates, tested squash hybrids and their interaction.

The highest significant number of leaves was detected in plants planted during the second sowing date followed by those planted at the first sowing date. Moreover, the lowest significant number of leaves was found for plants planted at the fourth sowing date.

Regarding the effect of hybrids, both of Eskandarane and Revera recorded the highest significant number of leaves without significant different between them. Contrary, both of Marzouka and Rozina were significantly the lowest in number of leaves without significant different between them.

Moreover, the interaction between Eskandarane and the second sowing date were significantly gave the highest number of leaves. While, Marzoka and Rozina with the fourth sowing date gave the lowest number of leaves. The discussed results were confirmed for both studied seasons of 2012 and 2013.

Table (3): Effect of different sowing dates and squash hybrids on number of leaves after 90 days from transplanting.

	Number of leaves									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	20.2 d	24.4 a	19.3 e	17.3 g	**20.2A**	19.3 c	21.0 a	18.1 d	16.3 f	**18.6A**
Marzoka	21.4 c	22.3 b	18.0 f	16.0 h	**19.4B**	16.4 f	19.2 c	17.1 e	15.4 g	**17.0B**
Revera	21.1 c	22.3 b	19.3 e	17.3 g	**20.0A**	19.3 c	19.3 c	17.2 e	16.6 f	**18.1A**
Rozina	21.4 c	22.3 b	18.0 f	16.0 h	**19.4B**	19.1 c	20.6 a	17.1 e	13.5 g	**17.5B**
Mean	**21.0 B**	**22.8A**	**18.7C**	**16.7D**		**18.6 B**	**20.3A**	**17.4C**	**15.5D**	

2-4 Fresh weight

It's notable from data in Table (4) that, plant fresh weight was affected significantly by the different sowing dates, the four hybrids and their interaction.

Regarding the effect of sowing dates, the highest significant plant fresh weight was observed for the second sowing date followed by those planted in the first sowing date. In addition, the lowest significant plant fresh weight was found for the fourth sowing date. The same trend of results was found in both studied seasons.

Focusing on the effect of hybrids, Eskandarane hybrid was significantly the highest significant plant fresh weight followed by Revera. On the other hand, both hybrids Marzouka and Rozina were significantly the lowest fresh weight without significant different between them.

Regarding the effect of the interaction between hybrids and sowing dates, Eskandarane and second sowing dates were significantly the highest in fresh weight. While, the lowest interaction obtained with Marzoka and fourth sowing date. Results were confirmed for both studied seasons 2012 and 2013.

2-5 Dry weight

Data in Table (5) shown the effect of different sowing dates, squash hybrids and them interaction on plant dry weight.

Four tested sowing dates affected significantly plant dry weight. The highest significant plant dry weight was found in second sowing date followed by both first and third sowing dates. Moreover, the lowest significant plant dry weight was recorded in the fourth sowing date. The mentioned results were confirmed in both growing seasons.

Table (4): Effect of different sowing dates and squash hybrids on plant fresh weight after 90 days from sowing date.

	Plant fresh weight (g/plant)									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	2342 c	3264 a	3062 b	1147 hi	**2453 A**	3859 b	4306 a	3253 c	2244 e	**3415A**
Marzoka	1084 i	1435 f	953 j	748 k	**1055 C**	849 i	1649 f	1138 h	813 i	**1112C**
Revera	2343 c	2206 d	1280 gh	1192 gh	**1755 B**	2180 e	2552 d	2494 d	1409 g	**2159B**
Rozina	965 j	1874 e	1294 g	924 j	**1264 C**	1663 f	2085 e	1142 h	1061 h	**1487C**
Mean	**1684 B**	**2195 A**	**1647 B**	**1002 C**		**2138 B**	**2648 A**	**2007 B**	**1381C**	

Regarding to the effect of hybrids, Eskandarane recorded the highest significant plant dry weight followed by Revera. The two hybrids Marzouka and Rozina had significantly the lowest dry weight without significant different between them in both seasons 2012 and 2013.

Highlighting effect of the interaction between hybrids and sowing dates, interaction between Eskandarane and second sowing date had significantly the highest dry weight. While, interaction between Marzoka and fourth sowing date had significantly the lowest dry weight. The results were confirmed for both studied seasons 2012 and 2013.

Table (5): Effect of different sowing dates, squash hybrid and them interaction on Days and GDD on plant fresh weight after 90 days from sowing date.

	Plant dry weight (g/plant)									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	420 c	588 a	551 b	206 hi	**441 A**	695 b	775 a	586 c	404 e	**614 A**
Marzoka	210 j	273 f	181 j	142 k	**201 C**	161i	313 f	216 h	154 i	**211 C**
Revera	395 c	375 d	218 gh	203 gh	**297 B**	371e	434 d	424 d	240 g	**367 B**
Rozina	174 j	337 e	233 g	166 j	**227 C**	299f	375 e	206 h	191 h	**267 C**
Mean	**299 B**	**393 A**	**295 B**	**179 C**		**381 B**	**474 A**	**357 B**	**247 C**	

3- GDD& days to flowering

It's concluded from the above mentioned data in Table (6) that, earlier sowing dates had significantly longest period to flowering compared to late sowing dates. Giving more details, first sowing date was significantly the longest period to flowering followed by second, third and fourth sowing dates, in descending order during the two seasons 2012 and 2013. Moreover, same trend of result was found regarding GDD accumulated to flowering. Only one exception was found in season 2013, no significant different was found between accumulated GDD in first and second sowing dates.

A significant reflection was appeared in period and GDD to flowering because of using squash hybrids. Rozina plants were significantly the first flowering followed by Revera and Eskandarane during seasons 2012 and 2013. It's clear from the data in Table (6) that Marzouka plants was significantly the last flowering during both studied seasons 2012 and 2013.

A clear significant different, in both time from sowing to flowering and accumulated GDD during this period, was found because of the interaction between different sowing dates and the four tested squash hybrids as shown in Table (6). Interaction between Marzouka and first sowing date were recorded significantly as the longest period to flowering in both studied seasons. The same trend of results was confirmed for accumulated GDD. Hence, interactions between Rozina and Revera and the last sowing date recorded significantly lowest period to flowering and accumulated GDD in both studied seasons.

Table (6): Effect of different sowing dates and squash hybrids on number of days and accumulative GDD to flowering.

	Days to flowering									
	First season				**Mean**	Second season				**Mean**
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	24 ab	23 a:c	20 d:f	16 g	**20.8 B**	21 ab	21 ab	19 b:d	15 ef	**19.0 B**
Marzoka	25 a	24 ab	21 c:e	18 fg	**22.0 A**	22 a	22 a	20 a:c	17 de	**20.3 A**
Revera	23 a:c	22 b:d	19 ef	16 g	**20.0 B**	20 a:c	19 b:d	18 cd	14 f	**17.8 C**
Rozina	23 a:c	20 d:f	19 ef	16 g	**19.5 C**	19 b:d	17 de	18 cd	14 f	**17.0 C**
Mean	**23.8 A**	**22.3 A**	**19.8 B**	**16.5 C**		**20.5 A**	**19.8 A**	**18.8 A**	**15.0 B**	
GDD to flowering										
Eskandarane	367.5b	366.5b	320.5d	274.0g	**332.1B**	239.5fg	257.5d	279.0c	253.5d	**257.4B**
Marzoka	387.0a	361.5b	346.5c	313.5e	**352.1A**	246.5e	291.5b	313.0a	280.0c	**282.8A**
Revera	344.5c	342.0c	295.5f	273.0g	**313.8C**	237.5g	218.5i	254.0d	236.5g	**236.6C**
Rozina	341.5c	309.5e	298.5f	273.0g	**305.6D**	228.5h	186.5j	245.0ef	236.5g	**224.1D**
Mean	**360.1A**	**344.9B**	**315.3C**	**283.4D**		**238.0C**	**238.5C**	**272.8A**	**251.6B**	

4-Yield and its component

4-1 GDD& days to first harvest (start generative stage)

First harvest (start of generative stage) clearly affected significantly by different sowing date, squash hybrids and there interaction as shown in Table (7).

It is noticeable that, the response for all tested sowing dates was not similar for both studied seasons concerning the time to start generative stage

or the accumulated GDD during this time. Concerning to time, first sowing date in the first season 2012 recorded a significant highest number of days compared to the other tested sowing dates. However, during the second season no significant different were detected between the four tested sowing dates. Regarding the accumulated GDD from flowering to first harvest, the highest significant GDD was found in first sowing date in season 2012 and was observed in both second and third sowing dates in season 2013.

Discussing the effect of squash hybrids, it's clear that Rozena was significantly the earliest to start the generative stage (first harvest) followed by Revera with significant different between them in number of days and without significant different in accumulated GDD. While, Marzouka was significantly the last hybrid transfered to generative stage. Trend of results were true in both studied seasons.

Focusing on the interaction between different sowing dates and squash hybrids, it's concluded that interaction between Rozina and the last sowing date reflected significantly the shortest period to transfer to generative stage (first harvest) as well as the lowest accumulated GDD. However, interaction between first sowing date and Marzouka cause significant increment in the period to transfer to generative stage (first harvest) and accumulated GDD. Such trend of results was true during both studied seasons.

Table (7): Effect of different sowing dates and squash hybrids on number of days and accumulative GDD to start generative stage (first harvest).

	Days to first harvest (start generative stage)									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	10 b	9 bc	9 bc	8 cd	**8.8 AB**	9 ab	9 ab	9 ab	8 ab	**8.8AB**
Marzoka	12 a	10 b	10 b	9 bc	**10.3 A**	10 a	10 a	9 ab	9 ab	**9.5A**
Revera	8 cd	7 de	7 de	7 de	**7.3 BC**	8 ab	8 ab	7 bc	7 bc	**7.5BC**
Rozina	8 cd	7 de	7 de	6 e	**7.0 C**	8 ab	7 bc	7 bc	5 c	**6.8C**
Mean	**9.5 A**	**8.3 B**	**8.3 B**	**7.5 B**		**8.8 A**	**8.5 A**	**8.0 A**	**7.3 A**	
GDD to first harvest (start generative stage)										
Eskandarane	166.5cd	156.0f	160.0ef	122.0ij	**151.1B**	132.0e	155.0bc	147.5cd	140.0de	**143.6B**
Marzoka	205.5a	161.5de	178.5b	167.0c	**178.1A**	164.5ab	167.5a	154.5c	174.0a	**165.1A**
Revera	130.5g	121.0ij	123.0h:j	121.0ij	**123.9C**	102.0gh	133.0e	120.5f	114.5f	**117.5C**
Rozina	127.5gh	119.0j	124.5hi	104.5k	**118.9C**	94.5h	111.5fg	120.5e	78.0i	**104.5D**
Mean	**157.5 A**	**135.4C**	**146.5 B**	**128.6D**		**123.3 B**	**141.8A**	**135.8A**	**126.6 B**	

4-2 GDD& days to last harvest (total generative stage)

Both times from first to last harvest and accumulated GDD during this time were affected significantly by all studied factors and their interactions, as shown in Table (8). Longest generative stage and highest GDD significantly obtained from second sowing date in both studied seasons 2012 and 2013. Shortest generative stage and lowest GDD were recorded in fourth sowing date during seasons 2012 and 2013.

Moreover, role of tested squash hybrids were significantly clear; Eskandarane significantly was the longest generative stage and the highest recorded GDD in both studied seasons 2012 and 2013. But, no significant different was detected between any of the tested hybrids regarding number of generative days in season 2012. On the other hand, Revera significantly was the shortest generative stage and the lowest obtained GDD during both studied seasons.

Interaction between second sowing date and Marzouka gave the longest generative stage and the highest GDD in both studied seasons with one exception for GDD in first season 2012, where interaction between Eskandarane and the third sowing date gave the highest significant GDD. While, shortest generative stage and lowest recorded GDD were found when fourth sowing date interacted with Revera and Rozina in seasons 2012 and 2013.

Table (8): Effect of different sowing dates and squash hybrids on number of days and accumulative GDD to ending generative stage (last harvest).

	Days to end generative stage									Mean
	First season				**Mean**	Second season				
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	50 c:e	57 ab	57 ab	50 c:e	**53.5A**	49 d:f	54 ab	53 a:c	47 ef	**50.8 A**
Marzoka	48 ef	59 a	52 b:e	48 ef	**51.8A**	47 ef	56 a	50 c:e	43 g	**49.0AB**
Revera	55 a:c	53 b:e	49 d:f	40 g	**49.3A**	50 c:e	50 c:e	46 fg	37 h	**45.8 B**
Rozina	54 a:d	55 a:c	51 c:e	44 fg	**51.0A**	49 d:f	51 b:d	47 ef	37 h	**46.0 B**
Mean	**51.8B**	**56.0A**	**52.3AB**	**45.5C**		**48.8B**	**52.8A**	**49.0B**	**41.0C**	
	GDD to end generative stage									
Eskandarane	951.5 h	1084 bc	1122 a	962.5g	**1030A**	893.5 f	1015.0b	1021.0b	903.5e	**958.3A**
Marzoka	923.5 i	1092.5b	1001.5 f	926.0 i	**985.9B**	867.0h	1072.5a	962.0c	827.0i	**932.1B**
Revera	1022.0e	1083.0 c	929.0 i	767.0k	**950.3D**	904.5 e	929.5d	887.0fg	708.0j	**857.3C**
Rozina	1000.5f	1033.5d	970.5 g	842.0 j	**961.6C**	885.0g	903.0e	887.0fg	704.0j	**844.8D**
Mean	**974.4C**	**1073.3A**	**1005.8B**	**874.4D**		**887.5A**	**980.0B**	**939.3C**	**785.6D**	

4-3 Total GDD & long of growing season

Total number of days from sowing to last harvest as well as total GDD significantly affected by different sowing dates, squash hybrids and their interaction as shown in Table 9.

Plants that were sown at first and second sowing dates recorded significantly the highest number of days for growing season without significant different between them. Such trend was confirmed for both studied seasons. Fourth sowing date was significantly the shortest season during both studied seasons. In addition, the highest total significant GDD was recorded in second sowing date and the lowest significant GDD was found in first sowing date during both seasons.

Regarding squash hybrids, the longest season and highest GDD were recorded in Marzouka plants. While, the shortest season was found in Revera plants and the lowest GDD was significantly found in Rozina plants during both studied seasons 2012 and 2013.

Interaction between second sowing date and Marzouka recorded significantly the longest season and the highest GDD in seasons 2012 and 2013. Contrary, the shortest season and lowest GDD were found in interaction between first sowing date and Rozina in seasons 2012 and 2013.

Table (9): Effect of different sowing dates and squash hybrids on total season number of days and accumulative GDD.

	Days to end generative stage									Mean
	First season				**Mean**	Second season				
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	96 bc	99 b	95 bc	82 e	**93A**	89 b:d	92 b	89 b:d	77 h	86.75A
Marzoka	99 b	106 a	94 bc	85 de	**96A**	91 bc	99 a	89 b:d	78 gh	89.25A
Revera	97 bc	91 cd	82 e	70 f	**85B**	87 c:e	84 ef	78 gh	64 i	78.25B
Rozina	95 bc	91cd	85 de	73 f	**86B**	85 d:f	82 fg	79 gh	62 i	77.0B
Mean	**96.8 A**	**96 A**	**89 B**	**77.5C**		**88.0A**	**89.3A**	**83.8B**	**70.3C**	
	GDD to end generative stage									
Eskandarane	1606 e	1746 b	1749 b	1473 i	**1610.8B**	1400 de	1528 b	1535 b	1390 e	1382 C
Marzoka	1665 d	1810 a	1701 c	1561 g	**1704.4A**	1440 c	1664 a	1535 b	1410 d	1463 A
Revera	1606 e	1673 d	1468 i	1268 k	**1611.2B**	1362 f	1371 f	1339 g	1136 i	1435 B
Rozina	1567 g	1589 f	1528 h	1327 j	**1407.0C**	1326 g	1291 h	1330 g	1095 j	1258 D
Mean	**1643 B**	**1684 A**	**1504 C**	**1503 C**		**1463 B**	**1512A**	**1302C**	**1261D**	

4-4 Total crop yield (kg/plant)

Total crop yield weight and fruits number are affected significantly by the different sowing dates, quash hybrids and interaction (Table 10).

It's obvious that the highest total yield (fruits weight) and fruits number/plant were significantly found in second sowing date followed by the first sowing date. Never the less, the lowest

significant total yield and fruits number /plant were obtained from fourth sowing date. The mentioned trend of results was true during both studied seasons.

On the other hand, Eskandarane recorded the highest significant total yield in both studied seasons. Where, Marzouka was significantly the lowest total yield during both studied seasons. Also, Eskandarane gave highest fruits number /plant compared to other hybrids in second season 2013. While, in first season, no significant differences between tested hybrids were found.

Interaction between second sowing date and Marzoka recorded highest significant total yield (fruits weight) and fruits number/plant in both studied seasons 2012 and 2013. Moreover, interaction between fourth sowing date and Revera had significantly the lowest significant total yield (fruits weight) and fruits number/plant in both studied season.

5- Chemical components

Clearly concluded from data in Table (11) that, mineral components (N, P and K) were significantly affected by different sowing dates, squash hybrids and their interaction. Moreover, it's concluded that performance of the three components of mineral (N, P and K) were almost the same.

Highlighting sowing dates and its effect on mineral contents, a significant effect was obviously recorded because of the four tested sowing dates. The highest significant mineral contents were found in plants that sown in second sowing date followed by those planted in first sowing date. In contrary, plants that were sown in the fourth sowing date reflected significantly the lowest values of mineral contents.

Table (10): Effect of different sowing dates and squash hybrids on total yield (kg/plant) and fruits number/plant.

	Total yield (kg/plant)									**Mean**
	First season				Mean	Second season				
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	1.476 f	2.989b	2.504c	0.778 i	**1939.0A**	1.268 i	2.720c	2.291d	0.866m	**1.786A**
Marzoka	1.309h	3.071 a	1.468 f	0.686 j	**1634.0C**	1.187 l	2.807b	1.335h	0.622 n	**1.487D**
Revera	3.001b	2.042 e	1.327 h	0.554 l	**1731.4B**	2.825a	1.943g	1.214k	0.506 p	**1.622B**
Rozina	2.494c	2.136d	1.356 g	0.588k	**1643.6C**	2.270e	2.056 f	1.230 j	0.535 o	**1.522C**
Mean	**2.070B**	**2.562A**	**1.664C**	**0.651D**		**1.887B**	**2.381A**	**1.517C**	**0.632D**	
	Fruits number/plant									
Eskandarane	13 ef	25 ab	21 b:d	6 g	**16.3 A**	11 d	25 a	20 b	7 e	**15.8 A**
Marzoka	11 f	27 a	12 f	6 g	**14.0 A**	10 d	26 a	11 d	5 e	**13.0 B**
Revera	25 ab	17 de	11 f	5 g	**14.5 A**	27 a	17 c	10 d	4 e	**14.5AB**
Rozina	22 bc	20 dc	11 f	5 g	**14.5 A**	21 b	19 bc	10 d	5 e	**13.8AB**
Mean	**17.8 B**	**22.3 A**	**13.8 C**	**5.5 D**		**17.3 B**	**21.8 A**	**12.8 C**	**5.3 D**	

Regarding the effect of squash hybrids, significant different were found due to such effect. Eskandarane hybrid was significantly the highest in mineral contents (N, P and K) during both studied seasons. Hence, Marzoka and Rozina had significantly the lowest mineral contents, and without significant different between them in seasons 2012 and 2013.

Interaction between second sowing date and Eskandarane recorded the highest significant values of nitrogen phosphorus and potassium. While, the lowest significant values were observed in Marzoka and fourth sowing date during the two studied seasons.

6- Economic evaluation

Results presented in Table (12) indicated the effect of different sowing dates and squash hybrids on net return/feddan. The data showed that second sowing date had highest net return/feddan (6960 and 6165 L.E), while lowest net return/feddan was obtained with fourth sowing date (-1558 and -1644 L.E) in both growing seasons 2012 and 2013, respectively.

Regarding hybrids, Eskandarane hybrid gave highest net return/feddan compared to other hybrids (4180 and 3508 L.E), while, Marzoka hybrid recorded lowest net return/feddan (2826 and 2175 L.E) in seasons 2012 and 2013, respectively.

In first season, Marzoka hybrid which sown at second sowing date showed the highest net return by 9243 L.E, while Revera hybrid with fourth sowing date had lowest net return (-1993) L.E. In second season, Revera hybrid at first and fourth sowing dates recorded highest net return (8145 L.E) and lowest net return (-2207 L.E), respectively. This could be attributed to the most favorable effect of air temperature and cumulative growing degree days (GDD) on plant growth as previously mentioned. Same results were found with total revenue (L.E)/feddan in both seasons.

Table (11): Effect of different sowing dates and squash hybrids on mineral components (N, P and K).

	Nitrogen (%)									
	First season				Mean	Second season				Mean
	March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	4.14 c	4.92 a	4.49 b	2.57 hi	**4.03 A**	4.85 b	4.90 a	4.60 c	3.89 e	**4.56 A**
Marzoka	2.62 i	2.67 f	2.83 j	2.51 k	**2.66 C**	2.61 i	3.32 f	2.54 h	2.72 i	**2.80 C**
Revera	3.80 c	3.81 d	2.36 gh	2.15gh	**3.03 B**	4.18 e	4.41 d	3.68 d	2.81 g	**3.77 B**
Rozina	2.68 j	3.45 e	2.47 g	2.83 j	**2.83 C**	2.62 f	4.05 e	2.99 h	2.98 h	**3.16 C**
Mean	**3.31 B**	**3.71 A**	**3.04 C**	**2.59D**		**3.57 B**	**4.17 A**	**3.45 C**	**3.10 D**	
	Phosphorus (%)									
Eskandarane	0.38 c	0.39 a	0.27 b	0.27 hi	**0.33 A**	0.38 b	0.39 a	0.35 c	0.25 e	**0.34 A**
Marzoka	0.25 i	0.26 f	0.25 j	0.25 k	**0.25 C**	0.28 i	0.29 f	0.26 h	0.25 i	**0.27 C**
Revera	0.36 c	0.36 d	0.26 gh	0.28gh	**0.32 B**	0.29 e	0.39 d	0.26 d	0.33 g	**0.32 B**
Rozina	0.26 j	0.37 e	0.28 g	0.25 j	**0.29 C**	0.33 f	0.28 e	0.27 h	0.26 h	**0.29 C**
Mean	**0.31 B**	**0.35 A**	**0.27 C**	**0.26 D**		**0.32 B**	**0.34 A**	**0.29 C**	**0.27 D**	
	Potassium (%)									
Eskandarane	2.92 c	2.81 a	2.67 b	2.67 hi	**2.77 A**	2.83 b	2.73 a	2.59 c	2.59 e	**2.68 A**
Marzoka	2.68 i	2.61 f	2.69 j	2.63 k	**2.65 C**	2.60 i	2.53 f	2.61 h	2.55 i	**2.57 C**
Revera	2.63 c	2.85 d	2.82 gh	2.73gh	**2.76 B**	2.55 e	2.76 d	2.74 d	2.65 g	**2.67 B**
Rozina	2.63 j	2.64 e	2.64 g	2.75 j	**2.67 C**	2.55 f	2.56 e	2.56 h	2.67 h	**2.59 C**
Mean	**2.72 B**	**2.73 A**	**2.71 C**	**2.70 D**		**2.63 B**	**2.65 A**	**2.62 C**	**2.61 D**	

Table (12): Effect of different sowing dates and squash hybrids on total revenue (L.E)/feddan and total net return (L.E/feddan) during growing seasons 2012 and 2013.

	Total costs with rent (L.E/feddan)*	**Average farm gate price (L.E/Ton)***	**First season**									
			Total revenue (L.E)/feddan				**Mean**	Total net return (L.E)/feddan				**Mean**
			March 23rd	April 3rd	April 12	April 22nd		March 23rd	April 3rd	April 12	April 22nd	
Eskandarane	4466	1395	6589	13343	11178	3473	**8646**	2123	8877	6712	-993	**4180**
Marzoka			5843	13709	6553	3062	**7292**	1377	9243	2087	-1404	**2826**
Revera			13396	9115	5924	2473	**7727**	8930	4649	1458	-1993	**3261**
Rozina			11133	9535	6053	262	**7337**	6667	5069	1587	-1841	**2871**
Mean			**9240B**	**1142**	**7427**	**2908**		**4774**	**6960**	**2961**	**-1558**	
			Second season									
Eskandarane			5660	12142	10227	3866	**7974**	1194	7676	5761	-600	**3508**
Marzoka			5299	12530	5959	2777	**6641**	833	8064	1493	-1689	**2175**
Revera			12611	8674	5419	2259	**7241**	8145	4208	953	-2207	**2775**
Rozina			10133	9178	5491	2388	**6798**	5667	4712	1025	-2078	**2332**
Mean			**8426**	**10631**	**6774**	**2822**		**3960**	**6165**	**2308**	**-1644**	

***** Source: Economic Affairs Sector bulletin 2012, Ministry of Agriculture and Land Reclamation.

7- Regression analysis

A positive linear relationship was observed between yield of squash hybrids (Eskandarane and Marzoka) per plant and accumulation growing degree days (GDD). While a negative linear relationship was observed between yield/plant of squash hybrids (Revera and Rozena) and accumulation growing degree days (GDD).

When the data was regression (Figure 3), it was obvious that the equations according to squash hybrids were as flowing:

$y = -0.031x^2 + 108.7x - 90959$ (1) for Eskandarane

$y = 0.012x^2 - 29.92x + 17478$ (2) for Marzoka

$y = -7E\text{-}05x^3 + 0.325x^2 - 499.4x + 26213$ (3) for Revera

$y = 8E\text{-}05x^3 - 0.379x^2 + 613.5x - 32194$ (4) for Rozena

A good fit to the data and the values of the co-efficient of determination ($R^2 = 0.8839$ for Eskandarane, $R^2 = 0.8805$ for Marzoka, $R^2 = 0.8211$ for Revera and $R^2 = 0.8215$ for Rozena) showed that the fitted regression line had a significant regression co-efficient. The increase in yield per plant occurred at more GDD for Eskandarane and Marzoka, while for Revera and Rozena the increase in yield per plant occurred at less GDD.

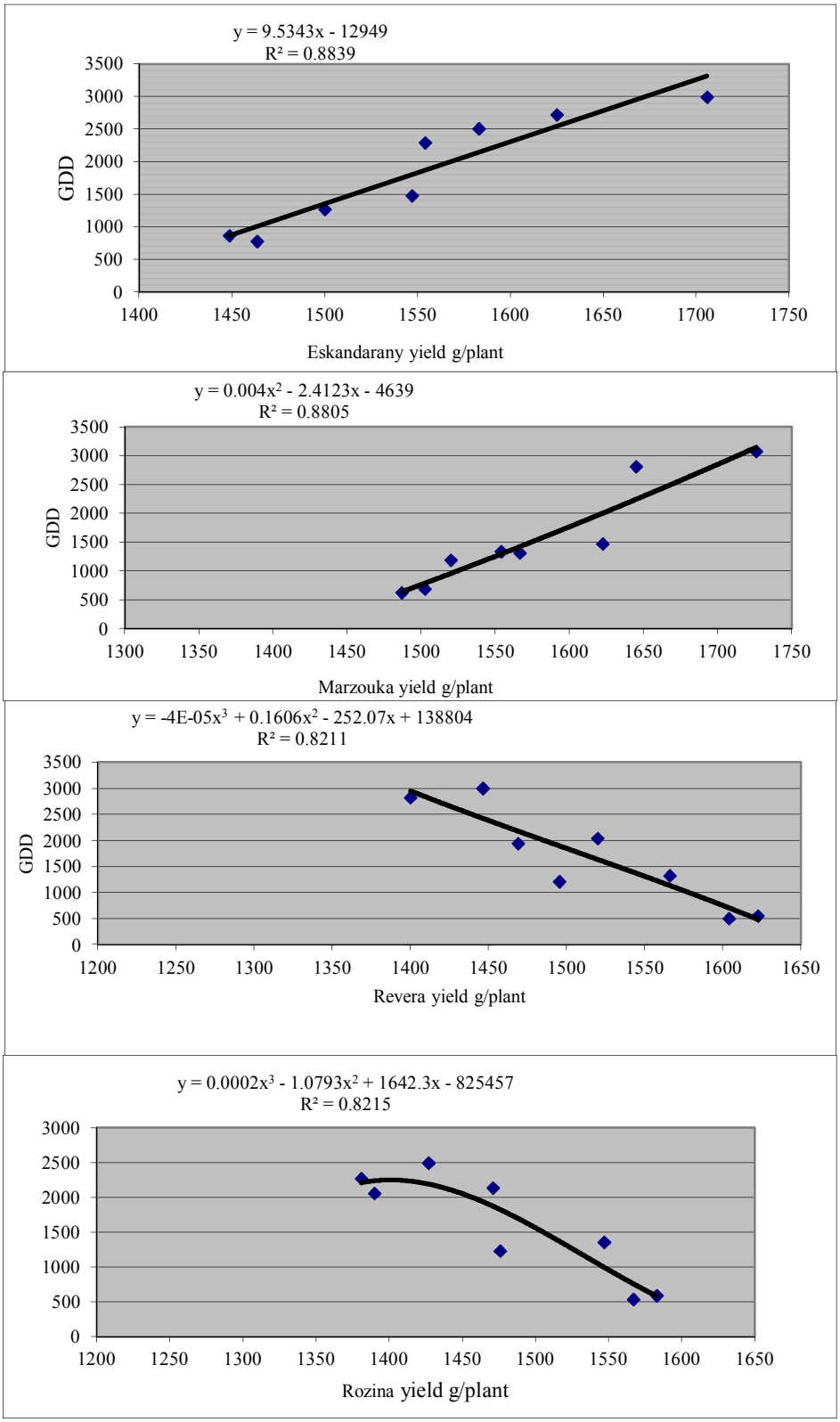

Figure (3): Relationship between squash hybrids and accumulated GDD.

4. Discussion:

From all previous results, it's noted that, first and second sowing dates were usually the latest to start any of the studied phenological stages or to move from stage to the next. Moreover, the recorded long period for those two sowing dates recorded the highest accumulative GDD. Looking deeply to these results drive directly to the role and the effect of the relatively low average air temperature during these two sowing dates. The mentioned low average air temperature reflected significantly on the recorded long days to accumulate the required GDD for emergence process.

This hypothesis is similar to that found by Hume and Lovell, 1983; van der Vlugt, 1983. They indicated that the number of flowers in cucurbits, including summer squash, is highly variable, depending on both environment (especially temperature) and cultivar. Flower sex is determined for cucurbit crops as early as the two true-leaf growth stage. Thus, the temperature of the first 2 weeks after seeding will likely influence early flowering.

Focusing on the significant differences between the four tested sowing dates, it's clear that the first sowing date was the latest to start any of the studied phenological stages compared to other sowing dates. In addition, first sowing date usually recorded the highest significant GDD to start or finish any of the studied phenological stages. On the other hand, third and fourth sowing dates were the earliest to start or finish any of the studied phenological stages and the lowest recorded GDD. The key of explanation for this trend of results is the average air temperature that was existed during the growing seasons.

Supporting this explanation regarding the germination stage, Mwale *et al.* (1994) and kamkar *et al.* (2006) reported that germination increased with temperature, at least within a well–defined range and declines sharply at higher temperatures. Moreover, the same explanation for flowering stage was found by NeSmith and Hoogenboom (1994). They reported that, number of days from sowing to the first flower of summer squash varied considerably depending on cultivar, and environment, and there was as much as a 20-day difference in the number of days from sowing to flowering.

Regarding to harvest, NeSmith and Hoogenboom, (1994) found that, harvest of this crop generally begins 5 to 7 days after flowering; thus, potential planting dates and flowering dates could be used in planning production and brokering strategies over diverse regions. Wien, 2002, found that, early cucurbit planting could expose young seedlings to unfavorable growing conditions. Temperature is a major factor in determining the time of pollen shed, flower opening and pollination, and growth rate in cucurbits, which in turn could influence yield and quality, if growing conditions were unfavorable.

The hybrids, (Marzouka and Eskandarane) are apparently required high temperatures and accumulative GDD to start and finish any of the studied phynological stages. Contrary, hybrids (Revera and Rozina) recorded lower days and GDD compared to other hybrids (Marzouka and Eskandarane). NeSmith and Hoogenboom, 1994, reported similar results, that the varying GDD requirements for squash cultivars suggest that cultivars can be categorized generally into two classes of GDD requirements for flowering. In addition, another experiment on squash germination in response to temperature has indicated that base temperatures are likely to be similar, but ceiling or optimum temperatures for development may differ through cultivars (NeSmith and Bridges, 1992).

Conclusion

The overall results revealed that the number of days is not the key factor for the plant to start or finish any of the studied phenological stages. The accumulative growing degree days (GDD) is the real key factor to move from phenological stage to another one.

Moreover, obtained results confirmed that, both Eskandarany and Marzoka hybrids needed highest air temperature and highest accumulative growing degree days to move from phenological stage to another in order to complete the life cycle. Contrary, both Revera and Rozina hybrids needed lowest air temperature and accumulative growing degree days compared to other tested hybrids Eskandarany and Marzoka. This means that, Eskandarany and Marzoka are suitable to be cultivated in season or areas with high air temperature. Whereas, both of Revera and Rozina hybrids are suitable to cultivated in areas with low air temperature.

On other hand, first and second sowing dates were late to start and finished all phenological stages compared with third and fourth sowing dates. This due to low air temperature through first and second sowing dates, which mean long period of days are needed to complete the needed growing degree days.

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