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IMPACT OF GROWING DEGREE DAYS ON GROWTH AND YIELD OF BOTTLE GOURD (*LEGENARIA SICERARIA* (MOL.) STANDL) IN DIFFERENT PLANTING DATES

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ABSTRACT

The field experiment was carried out at Al-Bousaily farm which located at AL-Behaira governorate belong to the Central Laboratory for Agricultural Climate (CLAC), Egypt, during the growing summer seasons of 2012 and 2013. Al-Bousaily is situated at 30˚ 35′ N latitude, 30˚36′ E longitude to investigate the effect of different planting dates i.e., Mar., 15, Apr., 15 and May, 15 on growth and yield of bottle gourd plant, cv. Pusa Summer Prolific Long, as well as the effect of accumulated heat units, which calculated as growing degree days (GDDs) on the plant development from one stage to another. The correlation between vegetative growth parameters and number of days after cultivation was positive and strong. The correlation values (R^2) were ranged from 0.7 up to 0.98. The planting date on May, 15 gave the highest values of vine length, no. of leaves, vine diameter, leaf area and sex ratio of bottle gourd plant. The lowest values were recorded in planting on March, 15. The lowest no. of days from planting to male flower formation, female flower formation and edible fruit harvesting recorded in May, 15 planting date. Whereas, the highest edible fruits yield was 9 Ton per feddan were recorded in Mar., 15 planting date. In addition, growing degree days (GDDs) were estimated for bottle gourd plant (from transplanting to the end of the season) during both studied seasons, the recorded values were (1653, 1657), (1768, 1809) and (1798, 1836) in Mar., 15, Apr., 15 and May, 15 planting dates, respectively. Results obtained that growing degree days is not only the limiting factor of plant growth and production but the distribution of these growing degree days through the different stages of plant growth cycle.

Keywords: Bottle Gourd - *Lagenaria Siceraria* - Growing Degree Days - Planting Dates - Correlation.

1. INTRODUCTION

Bottle gourd (*Legenaria siceraria* (Mol.) Standl) belongs to the Cucurbitaceae family, which includes many important economic vegetables such as cucumber, watermelon, squash, and pumpkin.

Bottle gourd is one of the excellent fruits which gifted by nature to human beings because it consists of almost of the essential constituents that are required for good health and quality of human life **(Parle and Satbir, 2011)**.

Temperature is one of the most important factors influencing fruit and seed formation. The low or high temperature during the reproductive stage of many crops causes sterility of pollen grains and reduced yield **(Nasrabadi and Nemati, 2015)**.

The concept of using growing degree days (GDDs) for vegetable growth and production has been used for many years on the crops which have a limited growth life period.

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Plant development depends on temperature and requires a specific amount of heat to develop from one point in their lifecycle to another, such as from seeding to the harvest stage. Temperature is a key factor in the timing of biological processes, and hence the growth and development of plants **(Parthasarathi *et al.*, 2013).**

Baker and Reddy (2001) in their study on muskmelon, mentioned that the base temperature (10 ^{o}C) at which leaf appearance rate was zero; an optimum temperature (34 ^{o}C) at which the rate of leaf appearance was maximal; and an upper threshold temperature (45 ^{o}C) at which leaf appearance rate returned to zero.

Rudich and Peles (1976) studied the effect of environmental factors on sex determination of flowers of watermelon, short day (8 h) and a day temperature of 27 ^{o}C increased the tendency towards female flowers and day length of 16 h and a day temperature of 32 ^{o}C inhibited the development of female flowers.

Growing degree days are determined by calculating the daily average of the maximum and minimum air temperature and subtracting a base temperature, usually the minimum germination temperature for the crop **(Katharine and Wehner, 1996)**.
Phenological development of the crop is based on daily heat unit accumulation (**Arnold *et al.*, 1995).**

Wehner and Guner (2004) in their study on cucumber mentioned that, Heat units were more stable over planting dates than days after planting.

The growth parameters of bottle gourd i.e., vine length, the number of primary branches and the number of days to first harvest were affected by different sowing dates as well as the fruits characteristics i.e., the length of fruit, the diameter of fruit and weight of fruit **(Kumar *et al.*, 2015).**

Thus keeping in view the above aspects, the aim of this study is to find out the best planting date for bottle gourd plant which gives the suitable growing conditions to get good growth and yield depending on calculating of growing degree days (GDD) under the agro-climatic condition of Al-Behaira governorate in Northern Egypt.

2. MATERIAL AND METHODS

The field experiment was carried out at Al-Bousaily farm which belongs to the Central Laboratory for Agricultural Climate (CLAC), located at AL-Behaira governorate- Egypt, during the growing summer seasons of 2012 and 2013. Al-Bousaily coordinate is 30˚ 35′ N latitude, 30˚36′ E longitude. The aim of the experiment was investigate the effect of different planting dates on growth and yield of bottle gourd plant, cv. Pusa Summer Prolific Long, as well as the effect of accumulated heat units, which calculated as growing degree days (GDDs) on the plant development from one stage to another, under agro-climatic conditions of AL-Behaira governorate.

Physical and chemical properties of the experiment soil were analyzed two weeks before cultivation (the first of March) in 2012 studied season; the results are tabulated in Table (1). The physical analysis was determined by the dry sieving method according to **Jackson (1958)**. The chemical analysis was carried out for the soil paste samples according to **Richards (1954)**. The permanent wilting point (PWP) and field capacity (FC) of the trial soil were determined according to **Israelson and Hansen (1962)**. The EC of the irrigation water ranged from 0.7 to 0.9 dS / m.

Table 1. Physical and chemical properties of the experimental soil.

Physical properties		Chemical properties	
Sand (%)	95.31	EC (dS / m)	3.00
Clay (%)	4.30	PH	7.89
Silt (%)	0.36	Ca^{++} (meq / l)	30.00
Texture	Sandy	Mg^{++} (meq / l)	10.00
FC (%)	16.77	Na^{+} (meq / l)	14.26
PWP (%)	5.65	K^{+} (meq / l)	1.66
Bulk density (g / cm^{3})	1.44	$HCO3^{-}$ (meq / l)	2.50
		Cl^{-} (meq / l)	12.60

The climatic data such as minimum and maximum air temperatures and relative humidity of Al-Bousaily site, AL-Behaira governorate, Egypt were recorded during the both growing seasons by the meteorological station of CLAC, and the data are presented in Table (2).

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Table 2. Maximum and minimum air temperature and the relative humidity of experimental site during 2012 and 2013 growing seasons.

Month	2012			2013		
	T max. (°C)	T min. (°C)	RH (%)	T max. (°C)	T min. (°C)	RH (%)
Mar.	24.4	10.0	80.4	21.9	8.7	76.6
Apr.	27.1	12.1	75.0	26.0	11.7	74.4
May	30.7	17.0	76.4	30.4	15.6	73.8
Jun.	31.9	19.2	80.2	30.9	19.6	77.0
Jul.	33.8	21.5	80.1	30.4	22.1	79.2
Aug.	34.1	22.7	79.6	33.2	21.3	78.5
Sep.	31.5	19.3	80.2	30.2	18.5	79.4

Experimental layout

Transplants of bottle gourd were produced in the nursery, the nursery tray media was a mixture of peat moss and vermiculite (1:1) (v/v) (the recommended transplant production media for protected cultivation).

The seeds of bottle gourd were sown in the nursery on the February 15, March 15 and April 15 for both growing seasons. The transplants were set up in the open field on March 15, April 15 and May 15, respectively. The experiment was conducted in a complete randomized plots design with three replicates. The experiment included 9 experimental plots (3 replicates x 3 planting dates). The area of the experimental plot was 30 m^2. Each plot consisted of three rows; each row was 30 m length 1 m width. The plant distance was 1 m apart. Drip irrigation system was used to irrigated and fertilized plants.

Growth and Planting dates relationships

The relationship between vegetative growth parameters and the days after planting in different planting dates was calculated by using regression formula Y = a + bX, where Y is independent variable (vegetative growth parameters), X is dependent variable (days after planting), a is constant and b is regression coefficient. The correlation (R^2) was also calculated according to **Joreskog and Sorbom (1996)**

Growing Degree days (GDDs) calculation

Daily maximum and minimum air temperatures were obtained from the metrological station during both growing seasons. Heat unit or (GDD) summations above the base temperature of bottle gourd plant were calculated for each sowing date based upon the following formulae according to **(Arnold *et al.*, 1995).**

$H_{ui} = [(T_{mx} + T_{mm}) / 2] – T_b$ Where:

H_{ui} = growing degree day (GDDs)

T_{mx} = maximum air temperature

T_{mm} = minimum air temperature

T_b = base temperature, Where the lower base temperature of bottle gourd is 10°C.

Recorded Data

Maximum and minimum air temperatures were recorded daily during both growing seasons of 2012 and 2013. The recorded data used in the calculation of daily growing degree days of bottle gourd plants in each growth stage of the plant.

Vegetative growth parameters i.e., vine length, no. of leaves, no. of branches, vine diameter, leaf area, no. of male and female flowers were recorded weekly during both growing seasons.

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The leaf area of the fourth leaf from apical growing tip of bottle gourd plant was estimated by using this equation y = -58.66 + (19.77 * L) where y is the leaf area cm^2 and L is the leaf length **(Shaik and Murthy, 2001),** sex ratio estimated by dividing total number of male flowers on total number of female flowers.

Flowering and earliness parameters such as number of days from transplanting to male flower formation, number of days from transplanting to female flower formation and number of days from transplanting to edible fruit harvesting were recorded in both growing seasons.

Yield and its components i.e., average fruits number, average fruit weight (g / plant), average fruit yield (g / plant) and average fruit yield (ton / feddan) were recorded in both growing seasons.

Statistical Analysis

All data were subjected to statistical analysis according to the procedures ANOVA reported by **Snedecor and Cochran (1980)**. Treatments means were compared by the Least Significant Difference test (L.S.D) at 5% level of probability in two seasons of experimentation.

3. RESULTS AND DISCUSSION

Growth and Planting dates relationships

The relations between days after cultivation in different planting dates and vegetative growth parameters such as vine length (cm), number of leaves, vine diameter (mm), number of branches and leaf area (cm^2) in both growing seasons were presented in Figures 1, 2, 3, 4 and 5, respectively.

Data in Figure 1, obviously cleared that there was a strong relationship between days after cultivation in different planting dates and the growth rate of vine length the equation of this relation was y = 63.186x - 107.66, the correlation value (R^2) reached to 0.95.

Concerning the relationship between days after cultivation in different planting dates and number of leaves per plant, Figure 2 illustrated that the number of leaves per plant also affected by different planting date as well as vine length. The equation was y = 23.5x - 32.77 and R^2 was 0.98. In addition, Figure 3 revealed that the relationship between days after cultivation in different planting dates and vine diameter was less strong than of these of vine length and number of leaves. The equation of this relationship is y = 2.48x + 8.40 and R^2 was 0.85.

Although, there was no significant difference in number of branches among different planting dates but there was a strong relationship between days after cultivation in different planting dates and number of branches per plant.

According to data in Figure 4, R^2 was 0.98 so; it was very strong relationship comparing by vine length and vine diameter. On the other hand, the relationship between leaf area and days after planting in different planting dates showed in Figure 5, the correlation value was 0.7. It means that the relationship between leaf area and days after planting in different dates of planting is not very strong.

That may be due to the growth of leaf length was stopped after about 60 to 70 days from planting and the leaf area depends on leaf length in their estimation. Previous results cleared that there were positive and strong relationship between number of days from planting and all growth parameters that may be due to the strong relation between climatic conditions especially, air temperature and plant growth parameters **(Shaik and Murthy, 2001).**

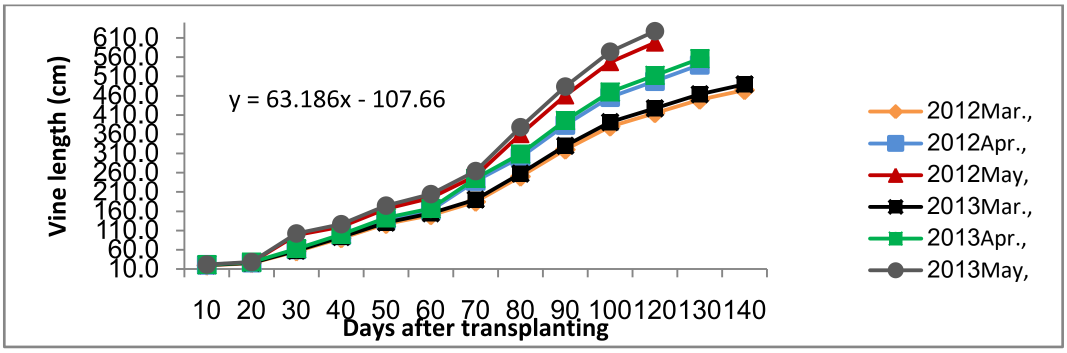

Fig 1. The effect of different planting dates on vine length of bottle gourd plant during 2012 and 2013 growing season.

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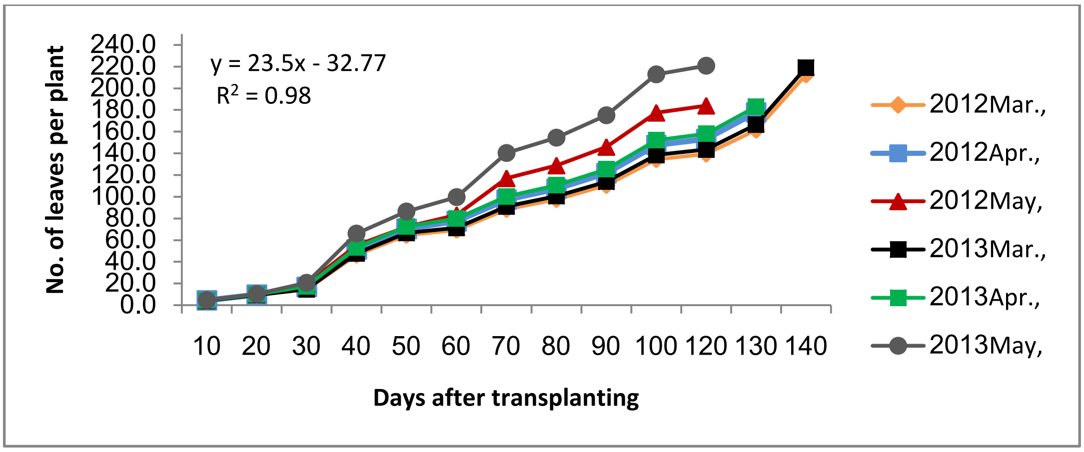

Fig 2. The effect of different planting dates on no. of leaves of bottle gourd plant during 2012 and 2013 growing seasons

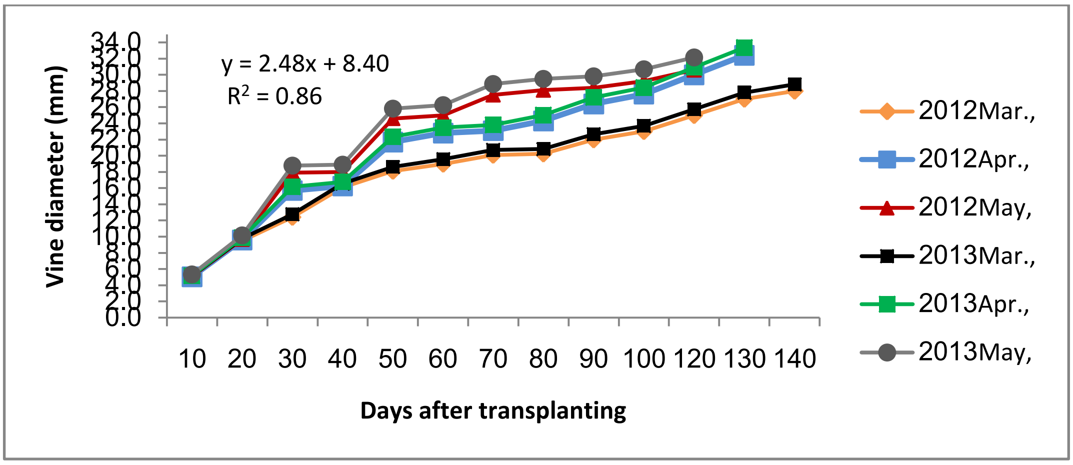

Fig 3. The effect of different planting dates on vine diameter of bottle gourd plant during 2012 and 2013 growing seasons

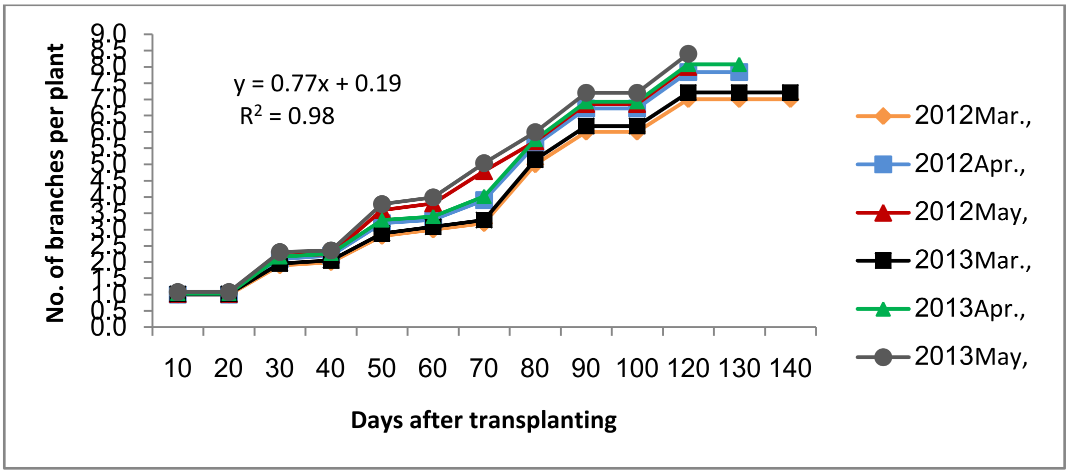

Fig 4. The effect of different planting dates on no. of branches of bottle gourd plant during 2012 and 2013 growing seasons

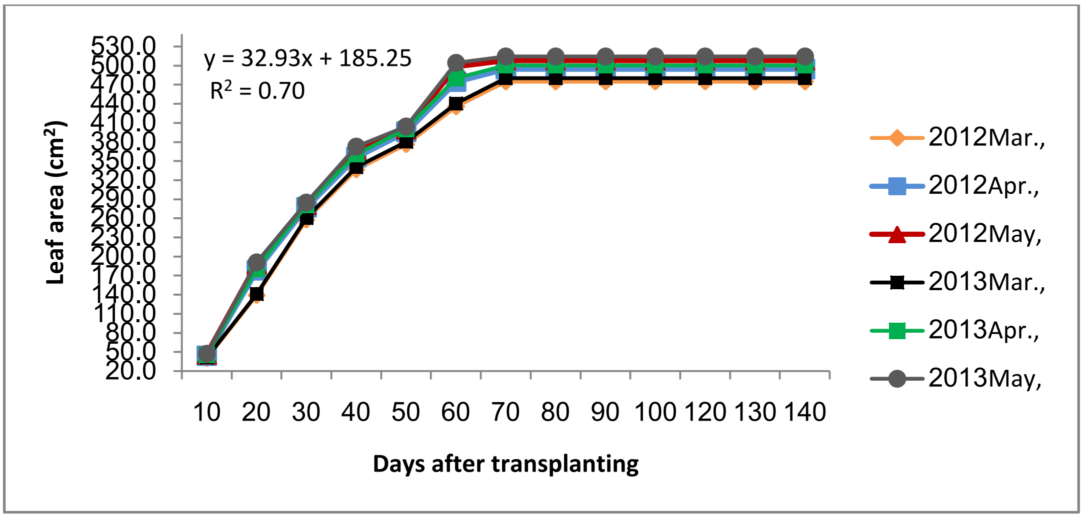

Fig 5. The effect of different planting dates on leaf area of bottle gourd plant during 2012 and 2013 growing seasons.

Vegetative growth

Data in Table (3 & 4) show the effect of different planting dates on growth parameters of bottle gourd plant i.e., vine length, no. of leaves per plant, vine diameter, no. of branches per plant and leaf area after 30, 50 and 70 days from cultivation in both growing seasons.

There was a significant effect of different planting dates on all growth parameters except no. of branches per plant. The highest values were obtained in May, 15 planting date and the lowest values resulted from planting on March, 15 in both growing seasons.

These results may be due to suitable climatic conditions, air temperature and relative humidity for plant growth in the duration between May to the end of growing season. These results are in agreement with those of **Kumar *et al.*, (2015).**

Table 3. The effect of planting dates on vine length (cm), no. of leaves and vine diameter (mm) of bottle gourd plants during 2012 and 2013 growing seasons.

	Vine length (cm)					
Season	**2012**			**2013**		
	Days after planting			**Days after planting**		
Planting Dates	**30**	**50**	**70**	**30**	**50**	**70**
March, 15	56.3	126.8	184.9	89.9	152.7	201.0
April, 15	60.9	138.7	238.3	108.1	163.3	237.2
May, 15	97.7	166.0	252.1	121.2	179.3	256.1
L.S.D. at 5%	4.1	7.6	12.3	6.5	8.1	11.2
	No. of leaves per plant					
March, 15	14.3	30.8	46.2	20.0	32.8	39.5
April, 15	16.7	34.2	51.6	22.4	33.2	48.0
May, 15	19.5	36.7	55.3	28.0	37.1	51.4
L.S.D. at 5%	1.8	1.5	2.2	1.1	2.3	4.3
	Vine diameter (mm)					
March, 15	12.4	18.1	20.1	13.4	18.7	19.4
April, 15	15.7	21.7	23.1	18.1	24.4	26.3
May, 15	17.9	24.6	27.5	20.1	27.4	29.7
L.S.D. at 5%	0.9	0.7	0.6	0.5	1.2	2.1

Table 4. The effect of planting dates on no. of branches, leaf area (cm^2) and sex ratio of bottle gourd plants during 2012 and 2013 growing seasons.

	No. of branches per plant					
Season	**2012**			**2013**		
	Days after planting			**Days after planting**		
Planting Dates	**30**	**50**	**70**	**30**	**50**	**70**
March, 15	1.9	2.8	3.2	2.1	3.0	3.3
April, 15	2.1	3.2	3.9	2.9	4.1	4.4
May, 15	2.2	3.6	4.8	4.0	4.3	4.7
L.S.D. at 5%	NS	NS	NS	NS	NS	NS
	Leaf area (cm^2)					
March, 15	196.0	290.9	323.8	212.1	319.4	355.8
April, 15	218.1	366.6	505.1	228.8	399.6	534.7
May, 15	233.5	453.3	589.1	254.3	460.3	626.1
L.S.D. at 5%	1.4	4.5	3.1	1.5	5.2	2.7
	Sex ratio (Male flo./ female flo.)					
March, 15		1.6			3.6	
April, 15		3.7			4.6	
May, 15		4.7			5.7	
L.S.D. at 5%		0.6			0.9	

Regarding the sex ratio of bottle gourd plant, data in Table (3) also show that the effect of different planting dates on the sex ratio in both growing seasons.

Data stated that the sex ratio was affected by different dates of cultivation. It was high on May, 15 and April, 15 planting dates and low in March, 15 planting dates.

That means the no. of male flowers in May, 15 planting date was higher than no. of male flowers in March, 15 planting date. These results may be due to the increasing of air temperatures in this period of May than those of March as presented in Table (2).

The high temperatures encourage male flowers formation and the low temperatures encourage female flowers formation. These results are agreed with those of **Rudich and Peles (1976)**.

Flowering and earliness

The effect of different planting dates on number of days and growing degree days (GDDs) from planting to male flower formation, female flower formation and first edible fruit harvesting were shown in Table (5).

The maximum days the plant has taken to the first male flower formation were 33 and 32 days from cultivation on March, 15 for 2012 and 2013 growing seasons, respectively. But the minimum days the plant has taken were 27 and 25 days when plants cultivated on May, 15 in both seasons, respectively.

The maximum days from cultivation to female flower formation as well as edible fruit harvesting obtained by cultivation on March, 15 in both growing seasons and the minimum no. of days were obtained by cultivation on May, 15.

On the contrary, the maximum growing degree days (GDDs) values to male, female and edible fruit formation resulted from cultivation on May, 15 in both growing seasons.

But the minimum values of growing degree days (GDDs) were obtained from cultivation on March, 15 in both experimental seasons. These results may be due to the low values of air temperature during March delay the flowering initiation due to the low accumulation of growing degree days (GDDs).

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But the high values of air temperature during May encourage flowering, especially male flowers and gave the earliest harvesting date of edible fruit. These results are in agreement with those of **Nasrabadi and Nemati (2015)**.

Table 5. The effect of planting dates on no. of days and GDDs from transplanting to male flower formation, female flower formation and edible fruit harvesting of bottle gourd plants during 2012 and 2013 growing seasons.

	Male flower initiation			
Season	**2012**		**2013**	
Planting Dates	DAT	GDDs	DAT	GDDs
March, 15	33	258	32	259
April, 15	30	325	28	332
May, 15	27	396	25	399
	Female flower initiation			
March, 15	52	439	50	452
April, 15	49	607	48	599
May, 15	45	683	44	691
	Edible fruit harvesting			
March, 15	72	713	71	716
April, 15	68	869	66	893
May, 15	66	1047	65	1068

DAT= days after transplanting, GDDs = growing degree days

Growing degree days (GDDs)

Growing degree days (GDDs) or accumulated heat unit (AHU) for bottle gourd plant was estimated in different planting dates during both growing seasons and data showed in Fig. 6.

The maximum increments of GDDs were obtained by cultivation on May, 15 in both growing seasons which were 1798 and 1836, respectively.

On the other hand, the minimum amount of GDDs resulted from cultivation on March, 15 in both experimental seasons which were 1653 and 1656, respectively.

Obviously, results cleared that the amount of AHU or GDDs depends on the average air temperatures which dominate in the agro-climatic region and we can control it by cultivation in different planting dates. Also, Heat units were more stable over planting dates than days after planting. These results are matched with those of **Parthasarathi *et al.*, (2013); Wehner and Guner (2004) & Baker and Reddy (2001)**.

Yield and its components

Data in Table (6) showed that the different planting dates significantly affected on yield and its components i.e., ave. fruits no. per plant, ave. fruit weight, ave. fruit yield per plant and total yield per feddan of bottle gourd plant.

The maximum no. of fruits, ave. fruit weight, ave. fruit yield per plant as well as, the total yield of fruit was obtained by cultivation on March, 15 in both growing seasons. On the contrary, the lowest values of previous aspects were obtained by cultivation on May, 15 in both experimental seasons.

These results cleared that GDDs is not the only factor affecting on plant growth and production of bottle gourd. The another important factor in this regards is the distribution of GDDs during growing season of plant and the direct effect of air temperature on plant physiology and metabolism.

Despite, May, 15 planting date was the highest value of GDDs and March, 15 was the lowest value but the total yield of edible fruits resulted from cultivation on March, 15 in both growing seasons.

These results confirmed that the climatic conditions on March, 15 planting date was more suitable than the other planting dates for bottle gourd plant. These results are in agreement with those of **Kumar *et al.*, (2015).**

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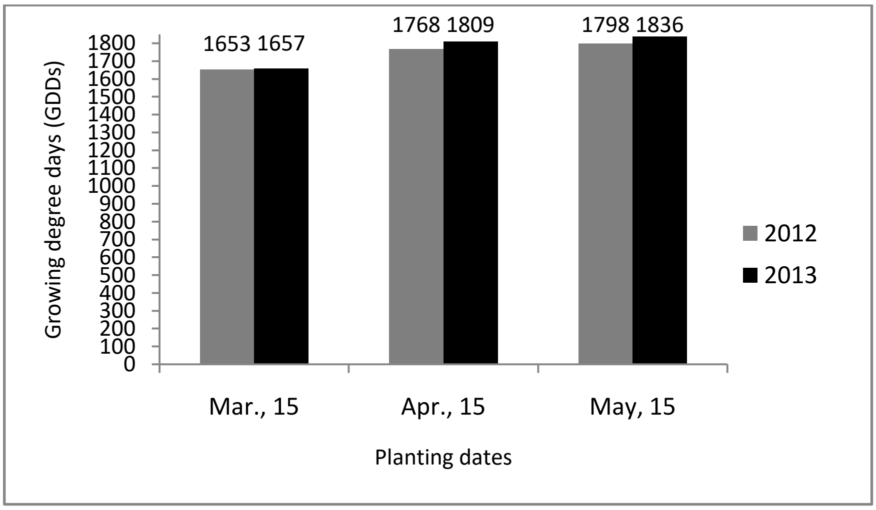

Fig 6. The effect of different planting dates on Growing Degree Days (GDDs) of bottle gourd plant during 2012 and 2013 growing seasons.

Table 6. The effect of planting dates on ave. fruits no., ave. fruit weight (g), ave. fruit yield (g / plant) and ave. fruit yield (ton / feddan) of bottle gourd plants during 2012 and 2013 growing seasons.

Planting Dates	Ave. fruits no. / plant		Ave. fruit weight (g)		Ave. fruit yield (g / plant)		Total yield (ton / feddan)	
	2012	2013	2012	2013	2012	2013	2012	2013
March, 15	11	12	430	445	2100	2200	8.8	9.2
April, 15	9	9	350	360	1800	1850	7.6	7.8
May, 15	8	7	280	295	1750	1760	7.3	7.4
L.S.D. at 5%	0.33	0.24	5.3	9.4	51.3	48.8	0.21	0.16

4. CONCLUSION

Bottle gourd is not main vegetable crop in Egypt so; farmers are not concerning with its cultivation. Bottle gourd has valuable edible fruits for human beings. There are not enough knowledge about cultivation and suitable climatic conditions for bottle gourd in Egypt. Growing degree days (GDDs) for bottle gourd plant were estimated during the growing season. The different planting dates gave different values of GDDs ranged from 1653 to 1836. So, bottle gourd plant can grow in the large range of air temperatures during summer season under northern Egypt climatic conditions. The best yield of bottle gourd edible fruits resulted from cultivation on March, 15 planting date, about 9 ton per feddan comparing with Apr., 15 and May, 15 planting dates, 7.5 and 7 ton per feddan, respectively.

5. REFERENCES

[1] Arnold, J. G., M. A. Weltz, E. E. Alberts and D. C. Flanagan. 1995. Simulating Crop Phenological Responses to Water Deficits, Plant Growth Component. P 8.1 – 8.41

[2] Baker, J. T. and V. R. Reddy. 2001. Temperature Effects on Phenological Development and Yield of Muskmelon. Annals of Botany 87: 605-613.

[3] Israelsen, O.W. and V.E. Hansen. 1962. Irrigation principles and practices. third edition, John Wiley and Sons, Inc New York, London.

GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

[4] Jackson, M.L. 1958. Soil chemical analysis prentice. Hall. Inc., Englewood Cliffs, N.J., U.S.A.

[5] Joreskog, K. G., and Sorbom, D. (1996) LISREL8: Structural equation modeling with the simpls command language. Chicago. Scientific Software Internatinal.

[6] Katharine, B. P. and T. C. Wehner. 1996. A heat unit accumulation method for predicting cucumber harvest date. Hort. Technology 6 (1): 27-30.

[7] Kumar, S., V. K. Batra, P. S. Partap and N. Kumar. 2015. Early season cultivation of bottle gourd: Effect of dates of sowing and growing conditions on different growth parameters. International Journal of Tropical Agriculture 33 (2): 1139-1143.

[8] Nasrabadi, H. N. and H. Nemati. 2015. Temperature affects vigor and pollen viability of melon. Agricultural and Biological Sci. Jour. 1 (5): 183-185.

[9] Parle, M. and K. Satbir. 2011. Is Bottle gourd a natural guard?. IRJP 2(6): 13-17

[10] Parthasarathi, T., G. Velu and P. Jeyakumar. 2013. Impact of Crop Heat Units on Growth and Developmental Physiology of Future Crop Production: A Review. Journal of Crop Science and Technology 2 (1): 2319–3395.

[11] Richard, L.F. 1954. Diagnosis and improvement of saline and alkaline soils. Agric. Hand Book, U.S.A. (60).

[12] Rudich, J. and A. Peles. 1976. Sex Expression in Watermelon as Affected by Photoperiod and Temperature. Scientia Horticulturae 5:339-344

[13] Shaik, M. and V. R. K. Murthy. 2001. Rapid, simple indirect method of leaf area estimation in bottle gourd (Cucurbitaceae sp.). Crop Research (Hisar). 21(2): 178-180.

[14] Wehner, T. C. and N. Guner. 2004. Growth stage, flowering pattern, yield, and harvest date prediction of four types of Cucumber tested at 10 planting dates. Acta Hort. (637): 223-229.

[15] Snedecor, G. M. and W. G. Cochran. 1980. Statistical methods, Sixth Edition, Lowa State Univ. Press, Amer. Lowa, USA.