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The Effect Of Foliage Density and Amount of Irrigation Water Supply Per Plant On Leaf Area, Staminate& Pistillate Flowers Production, Sex Expression, And Total Yield Of Summer Squash *(Cucurbita pepo* L. cv. Nour hybrid).

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Abstract

Two field experiments were conducted during the years of 2005 and 2006 growing seasons at Azzafarania Agri.Exp. Sta., in Baghdad, Iraq. Treatments were consisted from plants grown with 2, 4, 6, 8, 10, 12, leaves per plant; each treatment consisted of four sub treatments represented by quantities of irrigation water; 1/2 L, 1 L, 1 1/2 L, and 2 L a day given to plants of each treatment.Results of 2005 growing season indicated that plants with 4, 6,10, 12 leaves per a plant produced significantly higher no. of staminate flowers in comparison with plants with 8 leaves and plants of the control (no leaves thinning). Plants with 12 leaves produced a significant increase in pistillate flowers whose ovaries developed to a marketable fruits (4 cm. in diameter); however, plants with 12 leaves produced significantly a higher yield followed by plants with 6 and 10 leaves, with significant differences in between. As leaf area considered, there were significant differences did occur among the various treatments of both growing seasons.Staminate flowers production did not response significantly to amounts of water added to each plant during first growing season, but they did so in the second. Plants received 1/2 l of water produced a significant increase in staminate flowers while addition of 2 l resulted in a significant decreased. Variations between time periods of the second growing season indicated that plants produced significantly higher staminate and pistillate flowers in comparison with first growing period.

الخلاصة

أجريت تجربتين حقليتين خلال موسمي ألنمو لعامي 2005 و 2006 في محطة ألزعفرانية للبستنه– ألتابعة للشركة ألعامة للبستنه والغابات في بغداد. معاملات ألدراسة تضمنت ألكثافة ألورقية حيث نمت ألنباتات ألمزروعة بعدد محدد من ألأوراق طيلة موسم ألنمو: نباتات بورقتين، أربعة، ستة، ثمانية، عشرة، أثنى عشر، إضافة إلى نباتات ألمقارنة التي لم تخف أوراقها. تضمنت ألمعاملة ألواحدة أربعة مستويات من كمية ماء ألري، حيث تضمنت 1/2، 1، 11/2، و 2 لتر للنبات ألواحد في أليوم طيلة موسم ألنمو. نتائج ألدراسة لموسم ألنمو 2005 بينت أن ألنباتات ذات 4، 6، 10، 12 ورقة.

تفوقت بزيادة معنوية بعدد ألأزهار ألمذكرة مقارنة بالنباتات ذات ألثمانية أوراق ونباتات ألمقارنة.كما تبين أن معاملة ألنباتات ذات أثنى عشرة ورقة أنتجت وبزيادة معنوية أزهارا مؤنثة بمبايض نمت إلى ثمارا تسويقية(ذات قطر 4سم) مقارنة بالمعاملات ألأخرى ، كما أنها أنتجت حاصلا من ألثمار يزيد بفارق معنوي مقارنة بالمعاملات ألأخرى، تلتها نباتات ألمعاملات ذات 6 و 8 أوراق مع وجود اختلافات معنوية بينهما. ألأزهار ألمذكرة لم تتأثر معنويا بكميات ماء ألري ألمضافة خلال موسم ألنمو ألأول لكنها استجابت لذلك في موسم ألنمو ألثاني ، حيث أنتجت ألنباتات ألتي سقيت بنصف لتر من ألماء أزهارا مذكرة بتفوق معنوي بينما ألنباتات ألتي سقيت بلترين يوميا أنتجت ألعدد ألأقل معنويا. موسم ألنمو ألثاني عند اعتباره كفترتي نمو، ظهر أن ألفترة ألثانية تفوقت وبزيادة معنوية بعدد ألأزهار ألمذكرة والأزهار ألمؤنثة مقارنة بفترة ألنمو ألأولى .

Introduction

Summer squash crop *Cucurbita pepo* L. is monoecious and native to tropical America (De Menezes *et al.*, 2005; and Splittstoesser, 1990). It is cultivated in all major temperate and subtropical regions of the world, (De Menezes *et al.*, 2005; Paris,1996; and FAO,1994). It is generally characterized by an optimal soil germinating-temperature range 21-35°C; and growing temperature range 18-24°c (Molinar, *et al.*, 2006; and Kemble, *et al.*, 2005).

The majority of its hybrid cultivars tend to produce female flowers first then followed by the appearance of male flowers (Minges, *et al.*, 1977) and the plants tend to increase in

feminity gradient as the growing season proceed (Wien,1999).It was indicated that there was a self- compatibility between flower sexes of summer squash plants as the male and female flowers opened, and pollen grain viability and stigma receptivity occur within a short period of time(Merric, 1999; and Nepi and Pacini, 1993), Meanwhile, pollen grains characterized by their resistance to dehydration and relatively of a longer time of viability (Robinson, 1999; NeSmith, *et al.*, 1994; and Gay and Dummas, 1987). Pollination within both flowers sexes of such plants would not be an obstacle as long as honey bees were available(Barth, 1991). Flowering, Sex expression, and the fruit yield were strongly effected by several environmental factors such as light, photoperiod and temperature variation (Lin, *et al.*, 2007; Wien, 2006; Stapleton, *et al.*,2000; Kuhlemeier, *et al.*, 1987; Cantliffe,1981; and Berry and Bjorkman, 1980).Meantime, in spite of normal vine growth. Fruitlessness appeared to be associated with periods of high temperature (Wien, et. al.,2004). However, Climatic conditions appeared to be secondary to physiological factors in effecting flowering and fruit set (Stapleton, *et al.*, 2000; and Berry and Bjorkman, 1980). Cultural practices such as plant spacing, fertilizers, soil moisture, irrigation intervals are significant factors in effecting fruit size, fruit shape, and crop yield. (Ertec, *et al.*,2004; and Ells, *et al.*, 1994). It was well established that temperatures of 32/27°C (day/night) inhibit female flowers but allow males to develop(Carle and Loy, 1996; and Molinar, *et al.*, 2006). While Berry and Bjorkman 1980 reported that temperatures influenced the rate of photosynthesis even for a single leaf, and this kind of effect was dependent on other environmental factors such as leaf age, light, water, and nutrients availability. Another report mentioned that, during vegetative growth, stem extension rate and the development of leaf area was linearly dependent on the mean air temperatures within the range of 19- 26°C. (Krug and Liebig, 1980). It was found that leaf area limitation can be considered a first line defense against drought, stem growth also affected by the same forces that limit leaf growth during stress(Taiz and Zeiger 1991). However, Hafidh , 2001 reported that foliage densities is an critical factor affecting flowers sex and flowers production as well.

Materials and methods

Two field studies were conducted during 2005 and 2006 growing seasons at Azaafarania Agric. Experiment station in Baghdad, Iraq; to investigate the effect of foliage density and water level supply on flowers production, sex expression, and total yield of summer squash crop, *Cucurbita pepo* L. cv. Nour hybrid.

In both growing seasons, mineral fertilizer N- P_2O_5- K_2O at a rate of 100 kg/hectare of each was broadcasted before soil preparation. As the soil well prepared, it was divided to four replications. The main treatments include no. of leaves per plant; 2,4,6,8,10,12, and with no thinning treatment as the control , while the sub treatments consisted from four levels of water : ½ L , 1 L , 1½ L , and 2 L per a plant a day. All treatments and sub treatments were randomized within each replication in a complete block design,(Gomez and Gomez 1976).

Squash seeds were planted on March 12, 2005 and 2006 respectively directly in 1m width rows at 0.40 cm spacing in between in the row for all treatments.\

In 2006 growing season, the plants were killed a month after seedling emergence due to sever viral infection associated with wide spread of aphids and white fly in the field station as well as in the surrounding farms regardless of pesticide sprays. So, the seed replanted on 7/6 with no promising results and for the third try with all precaution were taken, seeds were replanted again on 29/6.

As the plants grown up, and first leaves reached their full expansions, leaves thinning as well as water level supply started for all treatments. As the sign of

senescence appeared on those leaves left on plants of each specific treatment, there were replaced by new expanded ones.

Daily data were taken considering the onset of flowering, flowers sex , fruits set, development of pistillate flowers ovaries to marketable size fruit as well as those failed to develop, and fruits weight were obtained during the growing season as well. But during 2006 growing season; and due to late planting date, foliage densities were not considered because the plants were remain stunted probably because the hot dry weather of summer time where temperature exceeds 50°C., but two periods intervals were regarded; the first one started from Aug.22 until Sept.14 while the second one from Sept.19 until Oct.15, when this study was determinates. Leaf areas were recorded in both growing seasons while number of leaves just for the second season.

Sex ratios as well as total staminate and total pistillate flowers were included within tables (1 and 2) to give a comprehensive idea for the effectiveness of the factors considered in this study.

Results and Discussion

Results of this study indicated that plants with 4, 6, 10, leaves produced significantly higher number of staminate flowers in comparison with plants having 8 leaves and the control plants, while no significant differences were found between plants with 2 leaves and plants of other treatments (Table 1). It was observed that the onset of staminate flowers on plants with 2, 4 leaves and plants of the control appeared first while staminate and pistillate flowers appeared together at the same time on plants with 6, 8, 10, and 12 leaves. However, no significant differences were found in production of staminate flowers produced by plants with 12, 10, 6, 4, 2 leave in comparison with those produced by plants with no leaves thinning. These results supported by earlier results reported by (Hafidh, 2001). However, it is interesting to find out that staminate flowers produced on plants with 2 and 4 leaves were relatively in higher numbers as early as the onset of flowering then started to be decreased gradually as the growing season proceeds towards its end, while pistillate flowers production were relatively slow and there were increased gradually towards the middle period of the growing season, then decreased as the plants aged. This is almost occurred in an opposite pattern to staminate flowers production. (Wien, 1999; Splittstoesser, 1990; and Minges, *et al.*, 1977). Developed pistillate flowers ovary to a local marketable fruits (4 cm. in diameter) obtained were significantly higher with plants having 12 leaves as compared with plants of other treatments; and a significant decreased was obtained as number of leaves per plant decreased from 12 downwards to 4, followed by plants where no leaves thinning taken place (plants of the control), while plants with 2 leaves produced the lowest (Hafidh, 2001; Robinson, 1999; and NeSmith, *et al.*,1994). Regarding total fruits yield, the results obtained indicated that plants with 12 leaves produced significantly the highest yield followed by plants with 10 leaves and 8 leaves respectively. Foliage densities also affected the number of undeveloped pistilate ovaries (those which failed to reach to a marketable size fruits). Plants with 2 leaves produced significantly higher number of undeveloped ovaries followed by plants with 4 leaves in comparison with those obtained from plants of other treatments, but still significant differences did occur within plants of other treatments due to foliage densities variation (Hafidh, 2001; Taiz and Zeiger 1991; Kuhlemeier, *et al.;* 1987; and Merric, 1999).This means that no. of leaves per plant is not just critical factor for staminate flowers production but also for pistillate flowers as well. They seems of a great effect on the success of ovaries to continue their development to mature fruits, (Lin, *et al.*, 2007; Stapleton *et al.*, 2000).

Table(1).The effect of foliage density on leaf area, flowers production,sex expression, and total yield per plant of summer squash crop.

No. of Leaves	Number of flowers Staminate	Pistilate dev.ovar.	Pistilate undev.ovar.	Total Pist. flowers	Stam.to Pist. ratio	Leaf Area (cm²) first reading	Leaf Area (cm²) sec.read.	Total Fruits Weight (gms)
First Growing Season (2005)								
2	12.781² ab	1.917 g	5.429 a	7.346 b	1.739	217.833 ab	171.000 b	198.333 e
4	13.906 a	3.333 e	5.067 b	8.400 a	1.655	214.750 ab	249.083 a	228.308 e
6	13.141 a	3.600 d	4.643 c	8.243 a	1.594	202.583 b	222.667 ab	467.750 b
8	11.844 b	3.769 c	3.000 e	6.769 b	1.749	265.167 a	217.917 ab	361.615 c
10	13.266 a	3.867 b	4.643 c	8.510 a	1.559	193.667 b	218.917 ab	492.500 b
12	13.719 a	4.857 a	4.000 d	8.857 a	1.548	185.333 b	263.500 a	615.000 a
Control	11.625 b	3.000 f	3.250 d	6.550 c	1.774	191.000 b	204.917 ab	304.091 d

1. Average per plant of each treatment for four replications.
2. Means within columns of the same growing season having different letters are significantly different at P=0.05 according to Duncan's multiple range test.

As leaves area considered, significant differences were obtained among plants with various numbers of leaves, but this could be attributed to other factors rather than the factors under this investigation (Wien, *et al.*, 2004; Ells, *et al.*, 1994; Berry and Bjorkman, 1980; and Gay and Dummas, 1987) also those variations might be related to seeds vigor, plants location within the field, wind direction; uniformity of soil depth as well as soil texture. Mean time, no significant variation were found between leaf number per plant for all the treatments. However, at normal vegetative growth conditions, squash plants usually produce an average of 19-25 leaf per plant, while at the second growing season, several factors effected such normal growth such as, late planting date; the insufficient quantities of irrigation water for such bush type plants grown under those condition; an abnormal increase in average temperature at the peck of vegetative growth period as well as fruiting period. Water level supply did show significant effects on flowers production, flowers sex, and other characteristics in both growing seasons of the years 2005 and 2006. (Table 2).

Plants received the various levels of water a day did not show any significant differences between staminate flowers produced during 2005 growing season ,while plants grown in the second growing season of the year 2006 and received 0.5 L ,1 L , and 1.5 L produced significantly higher staminate flowers as compared with those received 2 L of water a day.

Water level supply had a significant effect on developed and undeveloped ovaries of pistilate flowers, regardless of their numbers on plants of each treatment. (Ertec, *et al.*, 2004; Ells, *et al.*, 1994; Gay and Dummas, 1987; and Berry and Bjorkman, 1980).

Table (2). The effect of water level supply per plant on leaf area, flowers production, sex expression, and total yield of summer squash[1].

Water Level Supply (L)	Number of Flowers: Staminate	Number of Flowers: Pistillate Dev. Ovaries	Number of Flowers: Pistillate Undev.	Total Pist. Flowers	Stam.to Pist. ratio	Leaf Area (cm²): first reading	Leaf Area (cm²): sec.read.	Total Fruits Weight (gm)
First Growing Season (2005)								
0.5	13.393[2]	3.416 b	3.308 d	6.724 c	1.991	238.190 a	250.667 ab	51.286 b
1	11.447	3.235 b	4.154 b	7.389 a	1.549	175.667 b	210.524 bc	113.750 ab
1.5	12.973	3.208 b	4.080 c	7.288 b	1.780	199.857 ab	169.714 c	87.568 ab
2	13.919	4.654 a	5.440 a	10.094 a	1.378	226.476 ab	301.286 a	134.583 a
Second Growing Season (2006)								
						Leaf area(cm²)		*no.of leaves*
0.5	22.500[3] a	0.735 b	8.955 a	9.690	2.321	178.429 b		11.430
1	18.750 b	1.188 b	7.642 b	8.830	2.123	167.096 b		12.200
1.5	21.167 b	2.784 a	4.633 c	7.417	2.853	184.386 ab		17.330
2	4.900 c	0.115 b	0.552 d	0.667	7.346	220.881 a		14.170

1. Average per plant of each treatment for four replications.
2. Means within columns of the same growing season having different letters are significantly different at P=0.05 according to Duncan s multiple range test.
3. Average per plant of each treatment for three replications.

The highest water level supply per a plant 2 L, 1.5 L, and 1 L consequently produced fruits significantly higher than those obtained from plants received 0.5 L water during first growing season. It is obvious when water availability is relatively low to be absorbed and to substitute instead of the water lost by high rate of transpiration, so, the leaves dramatically pull the waters from the developing fruits resulting in failure of the ovaries to be developed. While in the second growing season, ovaries of pistilate flowers failed to develop to their marketable size .This failure could be attributed to late planting date due to the death of plants in earlier dates as there were severely attacked by white flies and high population of aphids. Meantime, such failure could be also attributed to high evapotranspiration rate due to the hot, dry weather in the region (Kemble, *et al.,* 2005; Ertec, *et al.,* 2004; and Stapleton, *et al.,* 2000), especially at the summer month of August when the temperature exceeded 50°c at midday's and quantities of water given to the plants might be lost soon after(Lin, *et al.,* 2007; Wien, 2006 ; Molinar, *et al.,* 2006; Kemble, *et al.,* 2005; Carle and Loy, 1996 ; and Cantliffe, 1981); in addition to that, this failure could be also related to receptivity failure of stigma (Stapleton, *et al.,* 2000; Merric, 1999; Paris, 1996; and Nepi and Pacini, 1993); no pollination taken place within both flower sexes especially where no honey bees available within the region (Barth, 1991; Gay and Dummas, 1987; and Cantlife,1981).

As foliage densities and water level supply interactions considered, results showed that a significant differences were existed within foliage densities and water quantities of the various treatments and sub treatments as well (Table 3).

Results of both growing periods of the second growing season showed that a significant differences were obtained between staminate flowers production in both growing periods, meantime there was a significant increase was found in developed ovaries and undeveloped ones of pistilate flowers produced in the second period in

comparison with those obtained during the first period.(Table 4).It is necessary to be mentioned that even though, the ovaries developed but they did not reach their marketable size, there were turned to yellowish in color, shriveled, wilted, while they were still unpicked from their plants, this could be as a result of high days temperature caused a high transpiration rate which exceeded the capability of the amount of water to be absorbed by plants roots. However, DeMenezes, *et al.*, 2005; Paris, 1996; FAO, 1994; NeSmith, *et al.*, 1994; Nepi and Pacini, 1993; Berry and Bjorkman, 1980; and Krug and Liebig, 1980, reported that temperature and water were an effective factors in plants survival.

Table (3). The effect of foliage densities and water supply interactions on the average of staminate flowers production per plant of (2005) growing season.

No. of Leaves	Water Level (L)	Aver. of staminate flowers
	0.5	11.813 abc
	1	12.063 abc
2	1.5	13.563 ab
	2	14.688 a
	0.5	14.188 a
4	1	12.375 abc
	1.5	12.625 abc
	2	13.438 ab
	0.5	14.375 a
6	1	11.375 bc
	1.5	11.125 bc
	2	12.688 abc
	0.5	11.813 ab
8	1	12.125 ab
	1.5	11.625 ab
	2	9.813 cb
	0.5	12.375 ab
	1	10.688 bc
10	1.5	12.438 abc
	2	12.563 abc
	0.5	12.813 abc
	1	11.938 bc
12	1.5	13.813 ab
	2	12.313 abc
	0.5	13.125 ab
	1	13.313 ab
control	1.5	14.625 ab
	2	12.438 abc

1. Average per plant of each treatment for four replications.
2. Means within the column having different letter (s) are significantly Different at p= 0.05 according to Duncan s multiple range test.

Table (4).The effect of time periods on flowers sex characteristics , ovaries development per plant of summer squash grown during the growing season of the year, 2006.

Period	Flowers			Total Pist. flowers	Stam. to Pist. ratio	Undev. to Dev. ovary ratio
	Staminate	Pitilate Flowers				
		developed ovary	undev.ovary			
First	30.410[1] a	1.682 b	6.652 b	8.334 b	3.648	3.954
Second	36.900 b	3.140 a	15.130 a	18.270 a	2.019	4.818

1. Means within columns having different letters are significantly different at p=0.05 according to Duncan's multiple range test.
2.No fruits were obtained during both growing periods.

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