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ORIGINAL ARTICLES

Plant spacing with seed chilling or plant girdling affect of Pumpkin (C. moschata) growth and yield components

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ABSTRACT

Production of pumpkin cv "Kafr Saad" (*C. moschata*), Damietta landrace, was assessed for plants rose from chilled seeds and girdled plants comparing with untreated ones when grown 50, 75 and 100 cm apart. Sowing was done on May of summer 2010 and 2011. The greatest number of leaves per plant and the highest leaf total sugar content (35 and 40 d after planting) was detected when growing at 75 cm within-row space. Growing plants 75 cm apart gave the highest fruit yield. Fruit yield of plants from chilled seeds substantially surpassed the yield of girdled plants and untreated. The increase in the yield from plants rose from chilled seeds averaged 36.00 – 40.44% over that of the untreated plants. Girdling either did not change the fruit yield or slightly reduced it as compared to control treatment. Fruit harvested from plants grown 75 cm apart was larger in weight than those produced from plants grown 50 cm apart but smaller than others grown at 100 cm. However, growing at 75 in-row space produced fruits containing elevated carotene, TSS and dry matter comparing with the other spaces. These internal fruit traits were the highest in girdling followed by seed chilling treatments. This study recommends growing pumpkin 75 cm apart employing seed chilling as a simple treatment that adding no production costs while can significantly enhance fruit yield and quality.

Key words: carotene, crop production, fruit yield, landraces, TSS.

Introduction

Plant spacing is crucial for production of pumpkins and both inter- and intra-row spaces have received renewed interest of researchers (Damarany and Farag, 1994; Cortes and Hernandez, 1996; Reiners and Riggs, 1997; Dufault, 1998; Dufault and Korkmaz, 1998; Lu Ping *et al*., 1999; Reiners and Riggs, 1999a; Reiners and Riggs, 1999b; Maynard,2000; Adirai *et al*., 2002 and Fanadzo *et al*., 2010). Growth vigor of pumpkin plants are cultivar- and -environmental condition-dependant (Mohamed *et al*., 2010 and Abdel-Rahman, 2011) and this necessitates proper certain spaces for a given cultivar under the condition where it is grown. Proper growing space allows opportunity to obtain large plants with balanced root and shoots growth such that to get sufficient nutrients and water and to synthesize photosynthetic assimilate allowing the production of full sized mature fruits with upgraded quality. In general, closer in-row spaces elevate fruit yield through increasing number of fruits but weight per fruit decreases (Damarany and Farag, 1994; Reiners and Riggs, 1997; Reiners and Riggs, 1999b; Maynard,2000; Fanadzo *et al*., 2010 and Abdel-Rahman, 2011).

The cv. "Kafr Saad" (*C. moschata*), Damietta landrace, is recommended for production under Upper Egypt conditions. Dates for growing this cultivar landrace have been identified (Mohamed *et al*., 2010 and Abdel-Rahman, 2011). Delaying cultivation from March to April in summer season reduced fruit yield by 10 to 17%. Further yield depression has even been shown when planted during May. On the other hand, pre-sowing seed treatments have been shown to improve fruit yield and quality in late plantings under Assiut conditions (Hussein *et al*., 2010 and Abdel-Rahman, 2011). Girdling enhanced fruit quality but did not affect yield. While both pre-sowing seed chilling and plant girdling affected plant growth, reduced growth was observed, specially, as result of girdling. It is here presumed that adjusting plant to closer spacing within-row may overcome yield depression in late planting during summer season. Therefore, the objective of the current study was to evaluate combination of in-row spacing and seed chilling or plant girdling for cv "Kafr Saad" when grown late in summer season.

Materials and Methods

This study was carried out at the Experimental Farm of Faculty of Agriculture, Assiut University, Assiut, Egypt, during May of summer 2010 and 2011. Pumpkin cultivar "Kafr Saad" (*C. moschata*) Damietta landrace] was used. Seeds of this local pumpkin landrace were obtained from farmers in Damietta province. Seeds used in

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the whole course of this study were from the same seed lots. Two to three seeds were planted per hill on May, 23 in 2010 and 2011. Sowing was done on the southern side of the ridge (3 m apart and 5 m long "each plot occupying 15 m^2 area" at 100, 75 or 50 cm spacings). Land preparation and all cultural practice were done as recommended for production of pumpkins (Hassan, 2004). The experiment was laid out as arrangement as split plot in randomized complete-blocks with four replicates. The tested flowering induction was in main plot while treatments of spacings were randomly distributed in the sub-plots. Treatments were: (pre-sowing seed chilling) seeds of the pumpkin landrace were imbibed in tap water for 36 h and chilling (4-5 ^{o}C) for 12 d. Time of cold treatment were scheduled so as to have cold treated seeds for 12 days periods simultaneously ready at the time of sowing (May, 23 in 2010 and 2011). Girdling, thirty-d-old pumpkin plants were girdled by a single knife cut. Girdling was made through the bark of the main stem of plant at about 5 cm above the soil surface, taking care to avoid injuring the xylem or removing bark. The control plants were untreated.

Recorded data and statistical analysis:

Data were recorded for average content of total sugar (mg/100g fresh leaf tissue, 30, 35 and 40 days after planting) (Dobois, *et al.,* 1956), number of opened female flowers per plant, average femininity tendency [(female/male and female flowers) X100], main vine length (cm), number of leaves, fruit yield (kg/m^2), average fruit weight (kg), fruit dry matter, carotene content and total soluble solids (TSS) of fruit flesh juice (measured using Carl Zeiss hand refractometer, A.O.A.C.,1985).

Data of this study was subjected to analysis of variance according to Gomez and Gomez (1984). Means were compared using the Least Significant Difference Test (LSD) at 0.05 level of probability.

Results and Discussion

Apparently, 'Kafr Saad' (*C. moschata*) pumpkin plants raised from chilled seeds produced significantly higher yield whether grown at 100 or 75 or 50 cm apart (Table 1, A). When grown at 100 cm in-row spaces, the harvested fruit yield from these plants recorded 36.00 % (2010) and 40.44 % (2011) increase over the yield of plants raised from untreated seeds. At 75 cm within-row spaces, the increase was 66.9% and 66.4% (2010 and 2011, respectively). Plants of chilled seeds grown 50 apart showed 56.2% and 58.5% increased fruit yield in 2010 and 2011, respectively. The highest fruit yield was harvested from the plants raised from pre-sowing chilled seeds planted 75 apart in both years of the study. Such fruits were sized, on average, 5 kg (Table 1, B). The fruit flesh tissues had higher TSS (Table 1, C), dry matter (Table 1, D) and carotene content (Table 2, A) as compared with controls untreated ones. This result clearly indicates that chilling pre-sowing seed is a potential treatment to substantially enhance pumpkin fruit yield per cultivated unit area. Chilling influentially affecting growth and development of pumpkins has been noticed by Mostafa (2006). The author showed that 10 d seed vernalization at 4-5 OC before sowing of recalcitrant to flower pumpkin cultivars sown on mid-April under conditions of neighboring province (Sohag) in Upper Egypt induced male and female flower anthesis. On the other hand, pre-sowing seed and girdlind treatments have been shown to improve pumpkin fruit yield and quality in late plantings under Assiut conditions (Hussein *et al*., 2010 and Abdel-Rahman, 2011), Seed chilling of some broad bean (*Vicia faba* L.) lines (Metwally, 2003) enhanced progress toward flowering and elevated seed yield. In consistence with findings by Mohamed *et al*., (2010) and Abdel-Rahman, (2011), the superior fruit yield had substantially higher total reduced sugar content in the leaves (Table 2, B, C and D). It is suggested that exposure of seeds to low temperature may induce antioxidants generating resistance to unfavorable stress conditions. Antioxidants lead to greater efficiency in chloroplasts to manufacture photosynthetic assimilates (Devlin and Witham 1983).

As much as 77.60% and 91.04% increase in leaf total sugar content was detected in 35-day-old plants raised from chilled seeds in 2010 and 2011, respectively, over the control (untreated). Leaf total sugar content increase was accounted for 63.6% and 76.0% in the leaves 40 d after planting. This indicates an enhanced physiological status of the chilled seed-derived plants. As carbohydrate availability enhanced, the chilled seeds in the present study resulted in plants showing greater number of opened female flowers per plant (Table 3, A), femininity tendency (Table 3, B) and smaller number of days to open the first female flower (data not shown) than the untreated plants. Subjection to low temperature induces gibberellins (GAs) biosynthesis (Dennis *et al*., 1996) and GAs stimulate cell mitotic division (Devlin and Witham 1983). The data here (Table 3, C) show a greater numbers of leaves formed on plants derived from chilled seeds than the untreated. Thus these plants developed larger photosynthetic active surface. Fruit yield from 'Kafr Saad' plants received girdling either was not significantly affect (100 or 75 cm apart in 2010) or otherwise slightly but significantly lessened as compared to control plants (untreated) (Table 1, A). Girdling reduces assimilate flow from shoots to root through phloem (Davie *et al*., 1995). Thus carbohydrates (soluble sugar and starch) are accumulated above the girdle. In the current study, girdling resulted in elevated leaf reduced sugar content 5d after girdling (Table 2, C) that became obviously the highest among all other treatments 10d after girdling. However, the result of fruit yield suggests

that root growth is important in determining pumpkin productivity as providing nutrient elements and water. Probably fruit yield enhancement would be obtained if girding is delayed beyond the 30 d. Similar to plants from seed chilling, the highest fruit yield from girdled plants was obtained from planting at 75 cm apart. Fruits were on average 3 to 4 kg in weight (Table 1, B). Among other treatments flesh tissues of fruits from plant girdling had the highest TSS, dry matter and carotene content (Tables 1, C and D and 2, A) due to the high level of carbohydrate availability in plant shoot.

Carbohydrate availability in plant shoot reflected also in greater femininity tendency, fewer days to female flower anthesis while forming larger number of leaves per plant than the untreated plants. However, plants derived from chilled seeds remained superior to girdled plants in this regard in addition to fruit yield. The aforementioned depict clearly indicates that production of cv 'Kafr Saad' was most fitted at 75 cm within-row spaces. Closer in-row spaces (50 cm) may have limited area for root growth and space for shoot growth and, therefore, produced plants with longer vine (Table 3, D) having greatly reduced number of leaves (Table 3, C). Although this narrow in-row space seemed to exert enforcement conditions leading to slight early female flower anthesis and increased femininity, it is clearly unprofitable with regard to the produced inferior fruit quality (TSS, dry matter and carotene contents) and reduced or inappreciable yield increase. The current study concurs with others (Damarany and Farag, 1994; Reiners and Riggs, 1997; Reiners and Riggs, 1999b; Maynard,2000; Fanadzo *et al*., 2010 and Abdel-Rahman, 2011) on the notion of the prominent role of plant spacing for production of pumpkins. However, direct comparison may not be precise due to differential cultivars, cultivation conditions and in-row spaces used.

Conclusion:

This study introduce seed chilling as simple profitable treatment to produce enhanced pumpkin fruit yield and quality at no additional production costs. The seeds is imbibed for 36 h and chilled at 4 - 5° C for 12 d before planting on May. Growing cv 'Kafr Saad' within row spacing of 75 cm apart on ridges 3 m wide could be recommended under Assiut province conditions or quite similar environmental regions.

Table 1: Fruit yield (kg/m2), average fruit weight (kg), percentage of total soluble solids (TSS%) and fruit dry matter (DM%) for 'Kafr Saad' landrace germplasm grown on May during summer seasons of 2010 and 2011 as affected by girdling (at 30 days after planting) or Chilling (4-5˚C for 12 days after soaking in water for 36 h)[1].

Spacings / Treatments	100 cm	75 cm	50 cm	Mean	100 cm	75 cm	50 cm	Mean
	A- Fruit yield (kg/m^2)							
	2010				2011			
Untreated	7.924c[2]	13.534b	14.080a	11.846	8.569c	14.271a	13.339b	12.060
Chilling (36 h /12 d)	11.385c	19.170a	17.775b	16.110	11.756c	20.172a	18.884b	16.937
Girdling (30 days)	8.168c	13.154a	11.073a	10.798	7.141c	11.270a	11.314a	9.908
Mean	9.159	15.286	14.309	12.918	9.155	15.238	14.512	12.968
$LSD_{0.05}$[3]	0.513				0.994			
	B- Average fruit weight (kg)							
	2010				2011			
Untreated	6.686 a	5.914 b	4.263 c	5.621	6.816 a	6.216 b	4.159 c	5.730
Chilling (36 h /12 d)	5.354 a	5.019 b	3.203 c	4.525	5.610 a	5.692 b	3.501 c	4.934
Girdling (30 days)	4.703 a	4.486 b	2.708 c	3.966	4.319 a	3.918 b	2.742 c	3.660
Mean	5.581	5.140	3.391	4.704	5.582	5.275	3.467	4.775
$LSD_{0.05}$	0.153				0.183			
	C- TSS %							
	2010				2011			
Untreated	8.2 b	8.6 a	8.3 b	8.3	7.9 c	8.5 a	8.2 b	8.2
Chilling (36 h /12 d)	9.4 c	9.9 a	9.6 b	9.6	8.7 b	9.7 a	8.8 b	9.1
Girdling (30 days)	9.5 c	10.9 a	9.7 b	10.0	9.3 c	10.9 a	9.8 b	10.0
Mean	9.0	9.8	9.2	9.3	8.6	9.7	8.9	9.1
$LSD_{0.05}$	0.3				0.4			
	D- DM %							
	2010				2011			
Untreated	8.7 b	9.2 a	8.8 b	8.9	8.4 b	9.0 a	8.8 a	8.7
Chilling (36 h /12 d)	9.0 c	9.5 a	9.2 b	9.2	8.3 b	9.3 a	8.4 b	8.7
Girdling (30 days)	10.1 c	11.7 a	10.4 b	10.7	9.9 c	11.6 a	10.4 b	10.7
Mean	9.3	10.1	9.5	9.6	8.9	10.0	9.2	9.4
$LSD_{0.05}$	0.3				0.4			

[1] variance of treatments x spacing treatments x year interaction was significant.

[2] means within row followed by same letter(s) are not significantly different at 0.05 level of probability by using the Least Significant Difference (LSD) Test.

[3] to compare treatment received same spacing treatment.

Table 2: Content of carotene (mg/100g) of fresh fruit flesh and content of total sugar (mg/100g) in fresh leaves 30, 35 and 40 days after planting for 'Kafr Saad' landrace germplasm grown on May during summer seasons of 2010 and 2011 as affected by girdling (at 30 days after planting) or Chilling (4-5°C for 12 days after soaking in water for 36 h)[1].

Spacings / Treatments	100 cm	75 cm	50 cm	Mean	100 cm	75 cm	50 cm	Mean
	A- Content of carotene (mg/100g) of fresh fruit flesh							
	2010				2011			
Untreated	17.756c[2]	18.545a	17.853b	18.051	15.232c	17.687a	16.855b	16.591
Chilling (36 h /12 d)	19.859c	22.034a	21.186b	21.026	20.419c	22.976a	20.952b	21.449
Girdling (30 days)	20.561c	23.368a	21.234b	21.721	19.846c	23.163a	22.230b	21.746
Mean	19.392	21.316	20.091	20.266	18.499	21.275	20.012	19.929
$LSD_{0.05}$[3]	0.286				0.571			
	B- Content of total sugar (mg/100g fresh leaves 30 days after planting)							
	2010				2011			
Untreated	30.066a	30.923a	30.051a	30.346	28.938a	29.750a	27.888b	28.859
Chilling (36 h /12 d)	53.184b	56.704a	53.884b	54.591	56.025b	59.263a	55.305c	56.864
Girdling (30 days)	30.019a	30.889a	30.020a	30.309	28.895a	29.719a	28.852c	29.155
Mean	37.756	39.506	37.985	38.416	37.953	39.577	37.348	38.293
$LSD_{0.05}$	1.362				2.667			
	C- Content of total sugar (mg/100g fresh leaves 35 days from planting)							
	2010				2011			
Untreated	34.332c	36.177a	34.835b	35.115	33.304c	35.094a	33.793b	34.064
Chilling (36 h /12 d)	60.747c	64.766a	61.587b	62.367	63.384c	67.580a	64.261b	65.075
Girdling (30 days)	36.496c	39.103a	37.031b	37.543	34.448c	36.907a	34.953b	35.436
Mean	43.858	46.682	44.484	45.008	43.712	46.527	44.336	44.858
$LSD_{0.05}$	3.295				3.681			
	D- Content of total sugar (mg/100g fresh leaves 40 days from planting)							
	2010				2011			
Untreated	37.407b	40.814a	37.284b	38.502	36.296b	39.601a	36.177b	37.358
Chilling (36 h /12 d)	60.941c	66.847a	61.189b	62.992	63.592c	69.757a	63.852b	65.734
Girdling (30 days)	61.596b	72.786a	61.071c	65.151	58.145b	68.702a	57.649c	61.499
Mean	53.315	60.149	53.182	55.548	52.678	59.353	52.559	54.863
$LSD_{0.05}$	3.415				3.851			

[1] variance of treatments x spacing treatments x year interaction was significant. [2] means within row followed by same letter(s) are not significantly different at 0.05 level of probability by using the Least Significant Difference (LSD) Test. [3] to compare treatment received same spacing treatment.

Table 3: Number of female flowers/plant, femininity tendency, number of leaves per plant and average vine length (cm) for 'Kafr Saad' landrace germplasm on May grown during summer seasons of 2010 and 2011 as affected by girdling (at 30 days after planting) or Chilling (4-5°C for 12 days after soaking in water for 36 h)[1].

Spacings / Treatments	100 cm	75 cm	50 cm	Mean	100 cm	75 cm	50 cm	Mean
	A- Number of female flowers/plant							
	2010				2011			
Untreated	8.3 b[2]	9.1 a	8.8 a	8.7	8.8 ab	9.1 a	8.6 b	8.8
Chilling (36 h /12 d)	14.8 b	15.2 a	14.8 b	15.0	14.6 a	14.1 b	14.4 ab	14.4
Girdling (30 days)	12.1 a	11.7 b	10.9 c	11.6	11.5 a	11.4 ab	11.1 b	11.3
Mean	11.7	12.0	11.5	11.8	11.6	11.6	11.4	11.5
$LSD_{0.05}$[3]	0.6				0.7			
	B- Femininity tendency [(female/male and female flowers) X100]							
	2010				2011			
Untreated	6.6 c	7.4 b	8.2 a	7.4	7.1 c	7.8 b	8.7 a	7.9
Chilling (36 h /12 d)	8.3 c	9.2 b	10.3 a	9.2	8.9 c	9.7 b	10.7 a	9.8
Girdling (30 days)	8.1 c	8.8 b	9.9 a	8.9	8.2 c	8.9 b	10.2 a	9.1
Mean	7.7	8.4	9.4	8.5	8.1	8.8	9.9	8.9
$LSD_{0.05}$[3]	0.3				0.2			
	C- Number of leaves per plant (after 90 days from sowing)							
	2010				2011			
Untreated	157.5 a	108.6 b	85.6 c	117.2	160.0 a	109.2 b	86.7 c	118.6
Chilling (36 h /12 d)	176.9 a	121.9 b	96.2 c	131.6	180.9 a	123.4 b	98.0 c	134.1
Girdling (30 days)	168.7 a	116.3 b	91.7 c	125.6	171.7 a	117.2 b	93.1 c	127.3
Mean	167.7	115.6	91.2	124.8	170.9	116.6	92.6	126.7
$LSD_{0.05}$	0.5				3.9			
	D- Average vine length (cm)							
	2010				2011			
Untreated	373.7 c	394.8 b	415.0 a	394.5	385.5 c	407.1 b	427.6 a	406.7
Chilling (36 h /12 d)	321.8 c	344.1 b	366.4 a	344.1	330.7 c	353.2 b	375.8 a	353.2
Girdling (30 days)	361.3 c	386.3 b	409.0 a	385.5	359.0 c	383.9 b	406.5 a	383.1
Mean	352.3	375.1	396.8	374.7	358.4	381.4	403.3	381.0
$LSD_{0.05}$	17.3				8.9			

[1] variance of treatments x spacing treatments x year interaction was significant.
[2] means within row followed by same letter(s) are not significantly different at 0.05 level of probability by using the Least Significant Difference (LSD) Test. [3] to compare treatment received same spacing treatment.

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