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Biennial results for evaluation of Squash (*Cucurbita pepo*) seed and fruit influenced by planting patterns and exogenous ethylene application

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ABSTRACT

Squash is important horticultural crops worldwide, but there has been relatively little research to systematically describe yield components and improve productivity in this plant. This research outlines some of the basic growth-analysis techniques for describing different aspects of productivity and attempts to summarize investigations on physiological and morphological aspects of productivity. In order to evaluate the distance cultivation effects and ethylene spray on fruit and seed production in squash, field experiments were conduct in spring and summer, 2007 and 2008. The factors were three dose of ethylene (0, 50 and 100 ppm of 2-Chloro-ethylphosphonic acid) and three density of planting (100*50 Cm, 150*50 Cm and 200*50 Cm). Evaluated characters in this research were Number Fruit per Area (NFA), Fresh Seed Yield (FSY), Dry Seed Yield (DSY), Number of Seed per Fruit (NSF), 100-Seed Weight (100SW) and Weight of Fruit (WF). Although the combinations of 100ppm ethylene*100*50cm made the most number of fruit in area but the most of the weight of fruit, weight of fresh seed made by 100ppm ethylene and 200*50cm density. Results in two years showed that 100 ppm of ethylene and 200*50Cm density was the best combination. Correlations between weight of fruit and weight of seed and number seed per fruit were positive and between fruits weight and fruits number was negative.

Key words: Squash (*Cucurbita pepo*), planting density, Ethylene (2-Chloro-ethylphosphonic acid).

INTRODUCTION

The use of traditional medicine and medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has been widely observed. Furthermore an increasing reliance on the use of medicinal plants in the industrialized societies has been traced to the extraction and development of several drugs and chemotherapeutics from these plants as well as from traditionally used rural herbal remedies. Cucurbits belong to the family *Cucurbitaceae* and consist of about 118 genera and 825 species (Jeffrey, D.1990). Although cultivated cucurbits are very similar in above ground development and root habit, they are extremely diverse for fruit characteristics. Cucurbits are among the largest and the most diverse plant families, have a large range of fruit characteristics, and are cultivated worldwide in a variety of environmental conditions. Length of period of sowing to harvesting for this plant is 4.5 month therefore is summer crop (UNESCO, 1998, 1996). Mean of yield is 600-1500 kg/ha. Now in Iran farmers planting by rows that distance between rows are 1-2 meter but not appear that what linkage of number fruit and seed yield, is few fruit with more weight or farther fruit with few weights has more yields? Density of planting by effect of competition between plants is effective in fruit production and seed yield and therefore could show to farmers the

best density in this plant. In the other hand, Ethylene is one of the hormones that increase the female flowers and then increase yield. In this research evaluate the effect of different densities and various concentrations of ethylene. Squash seed yield and quality can be improved by proper population plant spacing and the ethylene sprayer. The main objective of the present study was to determine the effects of, and the interactions between, spray of ethylene and plant density on DSY, yield components and correlation between various characters.

MATERIAL AND METHODS

Ethylene concentrations and densities

Three concentrations of ethylene (0, 50 and 100 ppm) and three densities of plantings (50*100 Cm, 0*150 Cm and 50*200 Cm) were used. Squash seedlings used throughout this work. 24 hours before planting, seeds were soaked and infected by Carboxin Tiram (100-150 g per 100 Kg seed). Spray of ethylene was conducted in V_2 stage and weeding and thinning 20 days after the plants had four true leaves.

Experimental conditions

Field experiment was conducted at Shahrekord (latitude 50 ^{0} 51 / N, 32^0 17/ E), located at about 500 Km of capital town of Iran on spring and summer 2007, 2008. The medial annual rainfall is about 337.2-mm per year. Average annual temperature is 11.2 ^{0}C. Soil texture was Loam. C, N, P and K content, EC, pH and percentage of sand, silt and clay were determined (Table 1). The experiment was arranged in a randomized complete block design with a split plot layout and three replications. Concentrations of ethylene were main plots and three density of planting as the sub plots. Each block consisted of three main plots. The main plots had three subplots that consisted of four rows spaced 150 cm apart and 8m length. Sowing was achieved in 22May in each year.

Topsoil of the experimental plot area was kept moist throughout the growing season when necessary. The characteristics under investigation were Number Fruit per Area (NFA), Fresh Seed Yield (FSY), Dry Seed Yield (DSY), Number of Fruit per Plant (NFP), Number of Seed per Fruit (NSF), 100-Seed Weight (100SW) and Weight of Fruit per Area (WFA). Plants after deletion of 50cm of head and endrows were sampled on full maturity and with several machines, properties were calculated. All data were subjected to ANOVA using the statistical computer package SAS_9 and treatment means separated using Duncan's multiple range test at P ≤0.05 level.

RESULTS

The effects of ethylene on DSY and yield component are given in Table 2 and Table 3. We found significant different effects induced by ethylene on growth parameters of squash. Plant cultivars also showed different responses due to spray with ethylene concentrations. Ethylene treatments in 100ppm increased significantly NFA, FSY, DSY and NSF in both years. Treatment by ethylene promoted fruit production over control treatment, where the highest values for yield were observed by combination of 100ppm and density of 50*200Cm. Similar result was obtained for NFA, FSY, DSY and NSF. We observed that the more Ethylene spray produced the more NFA, FSY, DSY and NSF. Plants inoculated with ethylene had greater DSY than non-inoculated control. The most promising effect for DSY production was obtained from 100ppm and density of 50*200Cm. Spray of 100 ppm ethylene resulted in a significant (P ≤0.01)

Table 1: Some physical and chemical properties of soil for field experiment (0-30 cm)

Year	Texture	pH	EC (dS m^{-1})	O.C	N_{total} (%)	P (mg kg^{-1})	K	Zn	Fe	Mn	Cu
1	Loam	8.3	0.47	0.79	0.07	8.1	245	1.1	3.4	3.8	1.1
2	Loam	7.8	0.44	0.70	0.06	7.8	235	1.1	3.1	3.5	1.0

Table 2: Weight of Fruit (WF), Number Fruit per Area (NFA), Fresh Seed Yield (FSY), Weight of Dry Seed Yield (DSY), Weight of 100 Seed (100SW) and Number Seed per Fruit (NSF) produced by squash plants that infected by various concentrations of ethylene in the first year

Ethylene	Density	WF (kg/ha)	NFA	FSY (kg/ha)	DSY (kg/ha)	100SW (g)	NSF
0 ppm	50*100 Cm	13838.33 ± 2935.28	21000 ± 4358.89	919.46 56.09	437.85 ± 26.7	23.66 ± 0.11	89.85 ± 13.07
	50*150 Cm	21063 ± 4685.81	22666.66 ± 2886.75	1293.08 ± 118.6	587.76 ± 53.91	23.01 ± 0.07	112.98 ± 3.76
	50*200 Cm	27010 ± 6070.85	14666.66 ± 2081.66	1853.23 ± 149.93	699.33 ± 56.58	23.15 ± 0.35	207.29 ± 16.13
50 ppm	50*100 Cm	24016.66 ± 1701.77	16333.33 ± 3214.55	1374.99 ± 89.03	654.73 ± 42.4	23.23 ± 0.32	177.36 ± 38.59
	50*150 Cm	27443.33 ± 2501.92	13000 ± 1000	1617.96 ± 183.15	735.43 ± 83.24	23.53 ± 0.05	242.74 ± 45.96
	50*200 Cm	32764.66 ± 3279.35	12666.66 ± 2081.66	2380.46 ± 411.4	898.26 ± 55.23	23.23 ± 0.28	307.78 ± 54.41
100 ppm	50*100 Cm	25832 ± 1041.47	20666.66 ± 3055.05	2847.49 ± 1153.67	1355.93 ± 49.3	23.36 ± 0.32	274.03 ± 66.81
	50*150 Cm	30000 ± 1000	14666.66 ± 2081.66	3138.18 ± 1181.85	1426.43 ± 37.21	23.2 ± 0.17	434.86 ± 13.89
	50*200 Cm	33333.33 ± 1527.52	10333.33 ± 2516.61	4135.02 ± 1274.01	1560.36 ± 80.79	25.66 ± 3.66	600.88 ± 51.92

Table 3: Weight of Fruit (WF), Number Fruit per Area (NFA), Fresh Seed Yield (FSY), Weight of Dry Seed Yield (DSY), Weight of 100 Seed (100SW) and Number Seed per Fruit (NSF) produced by squash plants that infected by various concentrations of ethylene in the second year

Ethylene	Density	WF (kg/ha)	NFA	FSY (kg/ha)	DSY (kg/ha)	100SW (g)	NSF
0 ppm	50*100 Cm	16003.97 ± 3997	23871.67 ± 4855	1032.82 77	489.3 ± 27	26.25 ± 0.06	79.6 ± 11
	50*150 Cm	24457.68 ± 6958	25767 ± 3151	1453.41 ± 161	656.85 ± 58	25.53 ± 0.1	100.11 ± 3.9
	50*200 Cm	31259.96 ± 8129	16666.33 ± 2227	2082.55 ± 206	781.5 ± 60	25.68 ± 0.52	183.52 ± 11
50 ppm	50*100 Cm	27578.63 ± 914	18557 ± 3514	1543.04 ± 87	731.72 ± 45	25.77 ± 0.49	156.95 ± 32.5
	50*150 Cm	31503.46 ± 1839	14775.67 ± 968	1814.17 ± 176	821.99 ± 92	25.99 ± 0.16	215.81 ± 39.1
	50*200 Cm	37571.87 ± 1780	14430.33 ± 2611	2667.17 ± 419	1004.38 ± 176	25.66 ± 0.13	274.52 ± 54
100 ppm	50*100 Cm	29729.72 ± 1936	23538.67 ± 3852	3187.29 ± 255	1514.7 ± 310	25.81 ± 0.17	243.21 ± 55
	50*150 Cm	34577.78 ± 3178	16659.33 ± 2139	3513.39 ± 282	1593.52 ± 96	25.62 ± 0.18	384.89 ± 82
	50*200 Cm	38441.34 ± 4075	11754.67 ± 2856	4633.73 ± 380	1743.13 ± 32	28.34 ± 0.75	534.81 ± 35

Table 4: Complex Analysis of variance of Weight of Fruit (WF), Number Fruit per Area (NFA), Fresh Seed Yield (FSY), Weight of Dry Seed Yield (DSY), Weight of 100 Seed (100SW) and Number Seed per Fruit (NSF) produced by squash plants that infected by various concentrations of ethylene

Source of Variation	Degree of freedom	WF (kg/ha) Mean of square	NFA (ha) Mean of square	FSY (kg/ha) Mean of square	DSY (kg/ha) Mean of square	100SW (g) Mean of square	NSF mean of square
Year(Y)	1	213882702*	66806740.2*	934348.32^{ns}	160395.02^{ns}	85.26**	12545.16^{ns}
R/Y	4	38094958.25^{ns}	15919494.825^{ns}	1757091.34^{ns}	348451.19^{ns}	2.43^{ns}	21397.028^{ns}
Ethylene(A)	2	479220233**	167339872.7**	22762572.5**	4252902.353**	3.6^{ns}	371203.38**
Y*A	2	1869076^{ns}	666317.2^{ns}	70307.17^{ns}	12931.113^{ns}	0.005^{ns}	1293.03^{ns}
Ea	8	25337394.875	9561074.45	1556263.66	295153.35	1.32	11877.01
Density(B)	2	502178368**	240649879.1**	62345513.33**	284424.224**	3.16^{ns}	148809.42**
Y*B	2	2579424^{ns}	982212.4^{ns}	20596.93^{ns}	885.153^{ns}	0.007^{ns}	475.53^{ns}
A*B	4	17340389^{ns}	47254977.3**	98522.44**	3795.02^{ns}	5.18*	19161.91**
Y*A*B	4	104261^{ns}	214088.4^{ns}	355.38^{ns}	12.13^{ns}	0.014^{ns}	65.24^{ns}
Eb	24	6878577	6950777	23190.46	3735.4	1.65	4223.5
C.V		9.32	15.2	6.6	6.21	5.19	25

ns,* and ** : Non significant, significant at the 5% and 1% levels of probability, respectively

increase by over 100% than control treatment. Similar pattern was also demonstrated for density of planting that density of 50*200Cm produced more 100% DSY than density of 50*100Cm. although we didn't see any significant differences between treatments in 100seed weight but the highest 100SW achieved by density of 50*200Cm and 100ppm. The amount of FNA was affected by ethylene spray in various densities in this study (Table 4). Because Squash plants are indeterminate flowering that in less density produced the major fruit and less void seed.

DISCUSSION

This work has shown the effects of ethylene spray on the yield components of squash in three densities. However, detect of the best dose of ethylene for increased production under diverse climates, improved compatibility and competitiveness and higher DSY have been shown that can improve rate of planting (Nerson, 2004). Recent studies showed that relatively high plant densities were required to obtain the highest DSY and quality in watermelon (Edelstein and Nerson, 2002) and muskmelon (Nerson, 2002). These results are in line with several vegetable crops like onion (Kanwar et al., 2000) and cabbage (Singh et al., 2000) in which high seed yields were achieved at high plant densities. The effects of ethylene concentrations on plant growth and yield components were given in Tables 3-4. We found significant different effects induced by ethylene on growth parameters of squash. Plant densities also showed different responses due to various ethylene concentrations.

Ethylene concentration significantly ($P \leq 0.01$) increased WFA, NFA, FSY, DSY, 100SW and NSF in both years. Ethylene spray promoted plant growth and development over planting without ethylene, where the highest values for DSY and yield components were observed by combination of more ethylene and less density. Increasing plant spacing resulted in higher NSF, independent of pollen amount. It was a reflex of both the increased number of fruits per plant and the tendency to obtain more NSF when increasing plant spacing. Plant spacing did not influence the NSF produced per hectare, showing that an increasing NSF in a higher plant

spacing compensated lower population. The results pointed the plant spacing of 200 * 50 Cm as the most adequate. Since fewer plants would be necessary to obtain the desired yield in a certain area, crop management would be easier and some plant diseases would not be favoured. Increasing plant spacing resulted in higher DSY (Table 2 & 3). Loy (1990, 1988) mentioned that a low DSY is due to small weight or quantity of fruits in high density planting. High plant population causes competition for place, light and nutrients resulting in a lower DSY, and small fruits with lower weight. Ho (1992) mentioned that the production of growing substances in the presence of seeds stimulates the fruit growth, confirming the idea that higher seed amount per fruit results in bigger fruits. The higher the plant space, the higher the seed production. The most DSY obtained in 50 * 200 Cm plant spacing was 1560-1740 Kg/ha. Results showed that an increase of DSY is possible without increasing WF, as long as the pollen amount is increased or, probably, the insect pollination amount, since an artificial pollination was as efficient as natural pollination. A high 100SW was reached with a low population density (50 x 200Cm). Nakagawa (1986) mentioned that increasing plant population reduces the NFA and NSF, as well as increasing the size. In this experiment, the difference between the employments of more density, increase 100SW significantly. Seeds would be formed first (in number) and after that the filling process would be initiated (weight) interferes both in seed size and in yield per area. We could emphasize that 100SW can be considered a parameter both for yield and quality analysis. First because it enables the determination of 100SW, showing its size and second because the seed size may influence vigour and germination tests due to greater energy storage (Vieira & Carvalho, 1994). There was a general tendency of decrease in NSF and in the mean 100SW when decreasing plant density (table 2-3). DSY increased with increasing WF in the 100 ppm ethylene concentration.

DSY in squash can increase by concentrations of ethylene but correlation between this increase and more density, is negative. In this research in more characters by increase of density in 50*100Cm to 50*200Cm, NSF, DSY and FSY increased and NFA decreased. Squash is one of the indeterminate plants and in these plants if don't heading result that at the end of growth season, produced vegetative and reproductive organs and competition between these organs were appeared. This competition was ingenerated for water and mineral materials. In some investigations period of irrigation of squash was reported every 5day (Ertek, A et al., 2003). In this research for investigation the results for farmers and not input the other factor in the research, heading not conducted and permit the plants to maximum growth and development. Because by augment of density, interact specific competition was increase and therefore competition between plants was increase. Ethylene was used but for competition in dense of plants, yield is decreased. Nerson (2005) in research that conducted on plant density and affects it on squash seed yield reported that by increase of NFA, 100SW was decreased. There was near relationship between NFA and DSY in another research that prepared by Sant parkash (1995) in India, there was significant differences between interaction factors as the best density and date of planting were 90*60Cm and 10march respectively. Reiners and Riggs (1999) to evaluate the effect of different density in squash in two places for determine the value of purchase, revealed that increase of plant number in 2990 to 8960 per hectare made the further NFA and DSY in places and varieties and DSY was increased of 49ton/ha to 61.4 ton/ha. Increase rows distances of 1.8 to 3.6 meter made the significant effect of decrease of NFA but no effect of DSY. The relationship between fruit shape and DSY was positive (data no published). Plant density had a significant effect on DSY. The highest DSY was obtained at 4plants/m^2 (Nerson, 2004). The NFA is probably the main factor that dictates the DSY limit. The seed yield index, which expresses the DSY, was a reliable parameter to identify seed production efficiency in muskmelons (Nerson, 2002a). This work has shown the effects of ethylene spry on the squash production in various densities.

CONCLUSION

This study showed that plant growth and DSY potential increased by ethylene spry varies with various densities. Spry the squash with ethylene resulted in higher NSF, 100SW, FSY, and Weight of Fruit (WF) and weight of seed per plant (data no

published) and thereby produced greater DSY. The results indicate that in spite of the fact that spry of ethylene can increase the proportion of seed per fruit and productivity in plants, application of increasing plant spacing for planting is needed.

REFERENCES

1. Edelstein, M., Nerson, H., Genotype and plant density affect watermelon grown for seed consumption. *HortScience.* **37**: 981-983 (2002).
2. Ertek, A., Suat, Sensoy, Cenk Küçükyumuk, Ibrahim Gedik., Irrigation frequency and amount affect yield components of summer squash (*Cucurbita pepo* L.). *Agricultural Water Management* **67:** 63–76.DOI: 10.1016/ j. agwat.2003.12.004 2004.
3. Ho, L.C., Fruit growth and sink strength. In: Marshall, C., Grace, J. *Fruit and seed production:* aspects of development, environmental physiology and ecology. Cambridge: University Press. 101-124 (1992).
4. Jeffrey, D., Appendix: An outline classification of the *Cucurbitaceae*. In: Bates, D.M., Robinson, R.W., Jeffrey, C. Biology and utilization of the *Cucurbitaceae*. Ithaca and London : Cornell University, 1990. 449-463. 485 (1990).
5. Loy, J.B., C.E Broderick., Growth, assimilate partitioning, and productivity of bush and vine *Cucurbita maxima*. In: Bates, D.M., Robinson, R.W., Jefferey, C. Biology and utilization of the *Cucurbitaceae*. Ithaca and London : Cornell University, 436-447. 485 (1990).
6. Loy, J. B., Improving seed yield in hull-less seeded strains of *Cucurbita pepo*. *Cucurbit Genetics Cooperative*, **11**: 72-73 (1988).
7. Kanwar, J.S., Gill, B.S., Bal, S.S., Response of planting time and density to onion seed yield and quality. *Seed Res.,* **28**: 212-214 (2000).
8. Nerson.H., Effects of fruit shape and plant density on seed yield and quality of squash. *Scientia Horticulturae.* **105:**293–304.DOI: 101016/ *J. Scienta.* 2004.11.008 (2004).
9. Nerson, H., Relationship between plant density and fruit and seed production in muskmelon. *J. Am. Soc.Hort. Sci.* **127**: 855-859 (2002a).
10. Nerson, H., Effects of seed maturity, extraction practices and storage duration on germinability in watermelon. *Sci. Hort.* **93**: 245-256 (2002b).
11. Reiners-S; Riggs-DIM., Plant population affects yield and fruit size of pumpkin. *Hort. Science*. **34:** 6, 1076-1078; 13ref (1999).
12. Sant. Parkash, Jamwal.RS, Thakur-DR, Parkash-S., Response of field pumpkin (Cucurbita pepo) to sowing date and plant spacing. *Ndian-Journal-of-Agronomy.* **39**: 3, 488 (1994).
13. Singh, R.C., Biswas, V.R., Arya, M.C., Mehta, J.S., Narenda, K., Kumar, N., Effect of plant population and dates of transplanting on seed yield of cabbage (*Brassica oleracea*). *Ind. J. Agric. Sci.* **70**: 405-406 (2000).
14. UNESCO, Culture and health, Orientation texts-world for cultural development 1998-1997, Document CLT/DEC/PRO-1996, Paris, France, 129 (1996).
15. UNESCO, FIT/504-RAF-48 terminal report: promotion of Ethnobotany and the sustainable use of plant resources in Africa, 60, Paris (1998).