Increasing Organic Production of Summer Squash by Modulating Plant Sex Ratio

A.A.A. Glala, E.E.H. Abd El-Samad and S.O. El-Abd
Horticultural Crops Technology Dept.
Vegetables Crop Research Dept.
National Research Centre
Dokki, Giza
Egypt

H.A. Obiadalla-Ali
Hort. Dept.
Fac. Agric.
Sohag University
Sohag
Egypt

Keywords: organic nitrogen, seed soaking, garlic extract, ethrel, earliness, fruit yield and quality

Abstract

Two year experiments were carried out in open field, to study the effect of complete replacement of mineral nitrogen fertilization by organic nitrogen source (chicken manure), combined with using garlic extract as seed soaking and/or spraying seedling by ethrel, on the vegetative growth parameters, earliness, sex ratio, number of fruit/plant, total production and fruit quality, of four squash cultivars: 'Eskandrany' and the hybrids 'Services plus', 'Rivera' and 'Mabroka'. The experiments occurred during summer growing seasons (June-August) in newly reclaimed sandy soil, aiming to overcome the negative impact of long day, high temperature and low availability of nitrogen in the soil and the productivity of the cultivars under the above environmental conditions, gathering with complete organic fertilization. Sixteen treatments resulted from the combination of seeds soaking in garlic extract and/or spraying seedling by ethrel and non treated (control), on the four squash cultivars. Results strongly showed that, complete replacement of mineral nitrogen fertilization by chicken manure combined with control treatment were associated with early flowering and lower fruit production. Whereas, soaking squash seeds in garlic extract and/or spraying squash seedling with ethrel, stimulate plant growth, increased female flowers ratio, fruit production and quality. In conclusion the best results were obtained when squash seeds were soaked in garlic extract before sowing and then the seedlings sprayed at 1-2 true leaves stage with ethrel.

INTRODUCTION

Squash (*Cucurbita pepo* L.) is one of the most popular vegetables grown in Egypt. The total production area amounted by 40000 ha in 2007, yielded about 699000 t, an average of 18.26 t/ha, according to the Ministry of Agriculture Statistics. Squash is a member of cucurbitaceous crops, which have a unique flowering habit among the vegetable crops. They bear two kinds of flowers, male and female, both on the same plant. In most monoecious cucurbit plants, although the femaleness ratio is subjected mainly to genetics, it may be greatly varied when the plants are grown under different environmental conditions, including high temperature, photoperiod, nutrient availability or application of exogenous plant hormones (Arora et al., 1985; Swiader et al., 1994; Atta-Aly, 1998). Kooistra (1967) demonstrated a clear effect of temperature and day length on cucurbits sex ratio, whereas long days and high night temperatures caused a shift towards more male flowers. Nitrogen level may modify the sex expression of many cucurbits, either very low or high nitrogen level in the soil increase the number of male flowers as reported by Kooistra (1967), Lau et al. (1995), Abd El-Fattah, Sorial (2000) and Santos et al. (2006). Exogenous application with ethylene-releasing compounds such as ethrel or ethephon, although not allowed in organic crop production, are among the growth regulators which could be used in conventional crops, to induce the femaleness in cucurbit crops, with a concentration ranged from 100 to 500 mg/L, as reported by Rudich et al. (1972), Arora et al. (1985), Atta-Aly (1992), El-Zawily and Moustafa (1997) and Mibus and Tatlioglu (2004). Many workers reported that the ratio of staminate to pistillate

flowers in cucurbit plants is a valuable and very important trait since total fruit yield depends upon this ratio (Atta-Aly, 1998; Abd El-Fattah and Sorial, 2000; Mibus and Tatlioglu, 2004; Santos et al., 2006).

The objective of this work was to evaluate the response of four squash cultivars to the use of garlic extract as seed soaking and/or spraying seedlings by ethrel and the use of organic nitrogen source instead of mineral source, on squash vegetative growth, fruit yield and quality.

MATERIALS AND METHODS

Two field experiments were performed at El-Nubaria Research and Production Station of National Research Centre, El-Behera Governorate, Egypt, during the summer of two consecutive growing seasons (2008 and 2009), to evaluate the response of four squash cultivars 'Eskandrany' and the hybrids 'Services plus', 'Rivera' and 'Mabroka' to the organic soil amendment with chicken manure as organic nitrogen source (75 m^3/ha) and the seed soaking in garlic extract and/or spraying seedlings with ethrel. The garlic extract was an aqueous solution prepared by homogenized 100 g of Baldi Egyptian garlic cloves in 1 L of distilled water in a blender, followed by filtration of the mixture through Whatman filter paper No. 1. Afterwards, quash seeds were soaked in aerated aqueous garlic extract solution overnight, at room temperature of 20±5°C. By the end of the seed soaking treatment, seeds were radicated with a radical length of 1-2 mm and then sown directly into the sandy soil. The spraying of the seedlings with freshly prepared solution of 250 ppm ethrel (2-chloroethanephosphonic acid), was carried out one time in the early morning, to run-off at 1-2 true leaves stage. Squash seeds were sown on ridges of 1 m width and 12 m length, on one side of ridge and 50 cm apart. Each experimental plot included 4 ridges with a net area of 48 m^2. All agricultural practices were carried out according to the recommendations of the Ministry of Agriculture, for summer squash production in Nubaria region. Sixteen treatments resulted from the combination of seeds soaking in aqueous solution of garlic extract and/or spraying seedling by ethrel and non treated (control), on four squash cultivars. Seeds of summer squash cultivars were sown on 26 May 2008 and 3 June 2009. Treatments were arranged in a split plot design with three replicates, where squash cultivars were randomly arranged within the main plot. The seed soaking, ethrel sprays, seed soaking plus ethrel sprays and control treatments were randomly distributed in the sub plots. After 45 days from sowing date, six plants were randomly chosen from each plot to measure plant length and the number of leaves/plant. A random sample of 4 plants from each treatment was labeled. Number of staminate (male) and pistillate (female) flowers per plant were counted all over the flowering and fruiting period and the sex ratio was recorded by dividing the average number of staminate by pistillate flowers. Squash fruits were harvest at 3 days intervals, upon reaching 12-15 cm length in both seasons. During the period of fruiting, the average fruit weight (early, med. and late season) and early yield was calculated, as a number of fruits/plant and weight of fruits (g/plant) of the early first four harvests. Fruit yield was calculated as number of fruits/plant and weight of fruits (g/plant) in mid and late season of production. The average total yield was recorded during the harvesting period as the total number of fruits/plant and the total weight of fruits (g/plant).

The obtained data were statistically analyzed and treatment means were compared by using Duncan's multiple range tests at 5% level of probability, according to Snedecor and Cochran (1980). The combined analysis of the data in both seasons was used, since the same trend of the result was obtained.

RESULTS AND DISCUSSION

Data presented in Table 1 show clearly that the squash cultivars growth measurements (plant length and number of leaves/plant) and the average fruit weight, in early, mid and late harvests, as well as the early yield expressed as the number and weight of fruits/plant, were significantly influenced by garlic extract seed soaking and ethrel application. Concerning the effect on the different squash cultivars, 'Eskandrany'

recorded the highest number of leaves/plant and average fruit weight in early harvest but the lowest values of average fruit weight in med and late harvests. 'Services plus' hybrid recorded the lowest plant length and average fruit weight in early and late harvests, but it recorded the highest values of early yield, when expressed as the number and weight of fruits/plant. 'Rivera' hybrid gave the highest average fruit weight in mid and late harvests, and the lowest early yield. 'Mabroka' hybrid recorded the highest plant length and the lowest number of leaves/plant. Combined data presented in Table 1 also indicate that soaking squash seeds in aqueous solution of garlic extract before sowing plus one seedling spray with 250 mg/100 kg ethrel at 1-2 true leaves stage, led to increased plant length, number of leaves/plant, average fruit weight in early, med. and late harvests (Fig. 1), as well as early yield, compared to the control treatment. The lowest values were obtained with control treatment, except for the average of fruit weight in mid and late harvests, where the lowest values were obtained with ethrel spraying treatment without soaking seeds in garlic extract. The interaction between squash cultivars and seed soaking and/or ethrel spraying was significant for all measured characters. Table 1 showed that squash plants of 'Services plus' grown from soaked seeds plus seedlings sprayed with 250 ppm ethrel, recorded the best value for early yield components (Fig. 2) while 'Mabroka' in the same treatment gave the best value for early yield, compared to the control treatment and to the other cultivars. Cultivar 'Mabroka' had the highest value of plant length when treated with seed soaking in garlic extract plus ethrel spraying and the lowest number of leaves/plant without these treatments. The lowest value of plant length was obtained from 'Eskandrany' in control treatment, while the highest value of number of leaves/plant was recorded with the same cultivar when treated with seed soaking in garlic extract plus ethrel spray. Concerning the interaction effect on average fruit weight, the highest values of average fruit weight in early harvest were recorded with 'Eskandrany' in the control treatment, followed by 'Rivera' in seed soaking treatment and 'Eskandrany' plants in seed soaking plus ethrel spray. Cultivar 'Services plus' in seed soaking plus ethrel spraying and 'Rivera' plants in control treatment had the highest average of fruit weight in med and late harvests, respectively (Fig. 1).

The obtained results are in good accordance with Rudich et al. (1969), Baha-Eldin et al. (1983), Verma et al. (1985), Atta-Aly (1992, 1998), Gad et al. (1993) and Mibus and Tatlioglu (2004). They stated that ethrel treatments applied at the 1-4 true leaf stage totally prevented the formation of male flowers, during the first 2-3 weeks of flowering and increased the number of pistillate flowers. This may be the reason for increasing the femaleness ratio and early yield. The significant increase in summer squash plant femaleness obtained by seed soaking plus ethrel spray, may be caused by increasing plant node number.

Table 2 shows the results for the mid and late harvests and the total yield for the 4 cultivars and it could be noticed that there were significant differences among studied cultivars. The highest values of mid and late harvests and the total yield were recorded by 'Rivera', whereas, 'Eskandrany' had the lowest values (Fig. 2).

The highest number and the heaviest weight of fruits in mid and late harvests and total yield (Table 1) were associated with soaked seeds and sprayed with ethrel treatments followed by seed soaking treatment, when compared to the control treatment. The interaction between different squash cultivars and seed soaking and/or ethrel spraying had significant differences concerning its effect on the number and weight of fruits in mid and late harvests and total yield. Squash plants of 'Rivera' grown from soaked seeds plus seedlings sprayed with ethrel gave the best values for both med harvest and total yield, whereas the lowest values were obtained with 'Eskandrany' in the control treatment (Fig. 2). The best value for the late harvest was obtained with 'Rivera' that received seed soaking treatment (6.44 fruit/plant and 514.44 g/plant) and the lowest were obtained with 'Eskandrany' treated with ethrel spray (1.22 fruit/plant) and with the same cultivar in the control treatment (40.0 g/plant).

Spraying squash plants by ethrel significantly improved both the number of fruit/plant and fruit weight as well as the total fruit yield. These findings were reported by

Matlob and Basher (1983), Atta-Aly (1992), Gad et al. (1993), Mancini and Calabrese (1999) and Mibus and Tatlioglu (2004). Many workers proposed that in cucurbit plants, there is a direct relationship between femaleness ratio and the total fruit yield (Atta-Aly, 1998; Abd El-Fattah and Sorial, 2000; Mibus and Tatlioglu, 2004; Santos et al., 2006).

The results of this work could be used for improving organic squash production for fresh consumption, especially in the summer season, if squash seeds were soaked in aqueous solution of garlic extract overnight before sowing and spraying squash seedlings with 1-2 true leaf once with ethrel 250 ppm for. These treatments give earlier yield and improve the total yield. In addition, such treatments could be recommended for F_1 hybrid squash seed production, since they promote sex ratio toward femaleness and delay the appearance of male flower for 2-3 weeks in maternal parents.

Literature Cited

Abd El-Fattah, M.A. and Sorial, M.E. 2000. Sex expression and productivity responses of summer squash to biofertilizer application under different nitrogen levels. Zagzig J. Agric. Res. 27:255-281.

Arora, S.K., Pandita, M.L., Parta, P.S. and Sidhu, A. 1985. Effect of ethephon, gibberllic acid and malice hydrazide on vegetative growth, flowering, and fruiting of cucurbitaceous crops. J. Amer. Soc. Hort. Sci. 110:442-445.

Atta-Aly, M.A. 1992. Chemical regulation of growth and sex expression in squash plants. Ann. Agric. Sci. Ain Shams Univ. 37:173-180.

Atta-Aly, M.A. 1998. Soaking summer squash seeds in low concentrations of cobalt solution before sowing increased plant growth, femaleness, and fruit yield via increasing plant ethylene level. J. Plant Growth Regul. 17:25-32.

Baha-Eldin, S.A., Helal, R.M., Awny, S.A. and Ragab, M.M. 1983. Studies on producing gynocious cucumber and squash strain by aid of ethrel foliar sprays. Ann. Agric. Sci. Ain Shams Univ., Cairo 28:917-933.

El-Zawily, A.I. and Moustafa, S.A. 1997. Effect of ethrel and plant population on monoecious cucumber *Cucumes sativus*. J. Agric. Res., Tanta Univ. 6:254-262.

Gad, A.A., Alsadon, A.A. and Wahdan, H.M. 1993. Sex expression and yield responses of summer squash to ethrel. Ann. Agric. Sci., Ain Shams Univ., Cairo 38:251-259.

Kooistra, E. 1967. Femaleness in breeding glasshouse cucumbers. Euphytica 6:1-17.

Lau, T.C., Lu, X., Koide, R.T. and Stephenson, A.G. 1995. Effects of soil fertility and mycorrhizal inflection on pollen production and pollen grain size of *Cucubita pepo*. Plant Cell and Enviro. 18:169-177.

Mancini, L. and Calabrese, N. 1999. Effect of growth regulators on flower differentiation and yield in zucchini (*Cucurbita pepo* L.) grown in protected cultivation. Acta Hort. 492:265-272.

Matlob, A.N. and Basher, E.A. 1983. The effect of growth regulators on sex expression and yield of summer squash (*cucurbita pepo* L.). Acta Hort. 137:361-366.

Mibus, H. and Tatlioglu, T. 2004. Molecular characterization and isolation of the *F/f* gene for femaleness in cucumber (*Cucumis sativus* L.). Theor. Appl. Genet. 109:1669-1676.

Rudich, J., Halevy, A.H. and Kader, N. 1969. Increase in femaleness of three cucurbits by treatment with ethrel, an ethylene releasing compound. Planta 86:69-76.

Rudich, J., Halevy, A.H. and Kader, N. 1972. Ethylene evolution from cucurbit plants as related to sex expression. Plant Physiol. 49:998-999.

Santos, B.M., Esmel, C.E. and Gilreath, J.P. 2006. Effects of nitrogen rates on summer squash. Proc. Fla. State Hort. Soc. 119:224-225.

Snedecor, G.W. and Cochran, W.G. 1980. Statistical methods (8th Ed.), Iowa Stat. Univ. press. USA.

Swiader, J.M., Sipp, S.K. and Brown, R.E. 1994. Pumpkin growth, flowering and fruiting response to nitrogen and potassium sprinkler fertigation in sandy soil. J. Amer. Soc. Hort. Sci. 119:414-419.

Verma, V.K., Singh, N. and Choudhury, B. 1985. Effect of growth retardants and ethephon on sex expression and growth in *Cucurbita moschata*. Indian J. Agr. Sci. 55(19):374-376.

Tables

Table 1. Effect of using chicken manure as source of nitrogen and soaking seed squash in garlic extract and/or seedlings spraying with ethrel at 1-2 true leaves stage, on plant growth and yield of four squash cultivars.

Cultivars (CV)	Treatment (T)	Plant length	Number of leaves	Average fruit weight (g)			Early yield	
				Early Season	Mid Season	Late Season	Number of fruits	Weight (g/plant)
Eskandrany	Control	28.00^{f}	22.00^{fg}	106.83^{a}	99.44^{d}	23.31^{h}	1.33^{h}	138.33^{j}
Services plus		28.33^{f}	22.00^{fg}	46.67^{g}	57.22^{g}	39.79^{fg}	1.50^{h}	69.44^{k}
Rivera		29.00^{ef}	21.00^{g}	53.89f^{g}	76.96^{ef}	107.39^{a}	1.72^{h}	91.11^{k}
Mabroka		34.00^{cd}	20.67^{g}	70.05^{e}	81.28^{e}	50.16^{def}	2.67^{g}	184.44^{i}
Control average		29.83^{c}	21.42^{c}	69.25^{c}	78.63^{c}	55.16^{c}	1.81^{d}	120.83^{d}
Eskandrany	Seed soaking (SS)	36.67^{c}	26.33^{abc}	97. 68^{ab}	82.68^{e}	52. 39de	3.67^{ef}	358.33^{de}
Services plus		33.00^{cde}	23.00^{defg}	63.99^{ef}	120.93^{b}	65. 81^{c}	6.67^{b}	422.22^{c}
Rivera		35.33^{cd}	24.67^{bcde}	103.93^{a}	111.53^{bc}	80.06^{b}	3.11^{fg}	323.33^{ef}
Mabroka		41.33^{ab}	22.33^{efg}	66.76^{ef}	96.35^{d}	48.40^{def}	4.50^{d}	300.00^{fg}
SS average		36.58^{b}	24.08^{b}	82.47^{b}	102.75^{b}	61.67^{b}	4.49^{b}	350.97^{b}
Eskandrany	Ethrel spraying (ES)	34.00^{cd}	27.00^{ab}	85.71^{bc}	68.12^{fg}	45.97^{ef}	3.00^{fg}	257.22^{gh}
Services plus		34.33^{cd}	23.00^{defg}	72.64^{de}	62.82^{g}	33. 74^{gh}	6.33^{b}	460.00^{c}
Rivera		32.00^{def}	25.00^{abcd}	83.94^{cd}	82.86^{e}	86. 35^{b}	3.00^{fg}	250.00^{h}
Mabroka		35.67^{cd}	20.67^{g}	71.67^{de}	81.73^{e}	48. 50^{def}	4.17^{de}	297.78^{fg}
ES average		34.00^{b}	23.92^{b}	78.49^{b}	73.89^{c}	53. 64^{c}	4.13^{c}	316.25^{c}
Eskandrany	SS+ES	37.33^{bc}	27.33^{a}	103.65^{a}	105.55^{cd}	65.22^{c}	5.56^{c}	574.44^{a}
Services plus		32.00^{def}	24.00^{cdef}	36.93^{ef}	131.83^{a}	43.40^{efg}	8.11^{a}	517.67^{b}
Rivera		41.00^{ab}	27.00^{ab}	95.47^{abc}	117.34^{b}	60.10^{cd}	3.89^{de}	371.11^{d}
Mabroka		43.00^{a}	26.00$^{ab\ c}$	97.36^{ab}	113.61^{bc}	103.67^{a}	6.00^{bc}	584.44^{a}
SS+ES average		38.33^{a}	26.08^{a}	95.15^{a}	117.08^{a}	68.10^{a}	5.89^{a}	511.92^{a}
Eskandrany		34.00^{b}	25.67^{a}	98.35^{a}	88.95^{b}	46.72^{c}	3.39^{c}	332.08^{b}
Services plus		31.92^{c}	23.00^{c}	61.68^{d}	93.20^{ab}	45.69^{c}	5.65^{a}	367.33^{a}
Rivera		34.33^{b}	24.42^{b}	84.31^{b}	97.05^{a}	83.48^{a}	2.93^{d}	258.89^{c}
Mabroka		38.50^{a}	22.42^{c}	76.96^{c}	93.24^{ab}	62.68^{b}	4.33^{b}	341.67^{b}
Significant level	CV	***	***	***	*	***	***	***
	T	***	***	***	***	***	***	***
	CV×T	*	*	***	***	***	***	***

Table 2. Effect of using chicken manure as source of nitrogen and soaking seed squash in garlic extract and/or seedlings spraying with ethrel at 1-2 true leaves stage, on average squash fruit weight in early, mid and late season of four squash cultivars.

Cultivars (CV)	Treatment (T)	Mid-season yield		Late-season yield		Total yield	
		Number of fruits	Weight (g/plant)	Number of fruits	Weight (g/plant)	Number of fruits	Weight (g/plant)
Eskandrany	Control	2.33^{i}	226.67^{i}	1.72^{hij}	40.00^{h}	5.39^{h}	405.00^{j}
Services plus		5.67^{g}	323.33^{h}	2.56^{efg}	100.56^{g}	9.72^{fg}	493.33^{j}
Rivera		15.00^{d}	769.44^{f}	3.67^{d}	391.11^{b}	15.39^{e}	1251.67^{f}
Mabroka		5.06^{gh}	410.00^{g}	2.44^{efg}	120.00^{ef}	10.17^{fg}	714.44^{hi}
Control average		5.76^{d}	432.26^{d}	2.60^{c}	162.92^{c}	10.17^{d}	716.11^{d}
Eskandrany	Seed Soaking (SS)	5.72^{g}	475.00^{g}	1.33^{ij}	67.22^{gh}	10.72^{f}	955.56^{g}
Services plus		9.00^{e}	1083.33^{e}	2.72^{ef}	177.78^{d}	18.39^{d}	1683.33^{d}
Rivera		13.56^{b}	1504.44^{b}	6.44^{a}	514.44^{a}	23.11^{b}	2342.22^{b}
Mabroka		8.00^{f}	765.67^{f}	2.17^{fgh}	102.22^{ef}	14.67^{e}	1167.89^{f}
SS average		9.07^{b}	957.11^{b}	3.17^{b}	215.42^{b}	16.72^{b}	1523.50^{b}
Eskandrany	Ethrel Spraying (ES)	4.33^{h}	296.67^{hi}	1.22^{j}	56.67^{h}	8.56^{g}	615.56^{i}
Services plus		11.44^{c}	718.89^{f}	3.00^{e}	101.67^{ef}	20.78^{c}	1280.56^{f}
Rivera		12.67^{b}	1050.00^{e}	4.67^{c}	402.22^{b}	20.33^{c}	1702.22^{d}
Mabroka		5.06^{gh}	411.67^{g}	1.89^{hij}	91.67^{fg}	11.11^{f}	851.11^{gh}
ES average		8.38^{c}	619.31^{c}	2.70^{c}	163.06^{c}	15.20^{c}	1598.61^{c}
Eskandrany	SS +ES	7.44^{f}	786.11^{f}	2.00^{ghi}	130.00^{e}	15.00^{e}	1490.56^{e}
Services plus		10.44^{c}	1374.44^{c}	4.67^{c}	202.22^{d}	23.22^{b}	2094.33^{c}
Rivera		16.50^{a}	1935.56^{a}	5.39^{b}	323.33^{c}	25.78^{a}	2630.00^{a}
Mabroka		10.61^{cd}	125.56^{d}	2.89^{e}	299.89^{c}	19.50^{cd}	2089.89^{c}
SS+ES average		11.25^{a}	1325.42^{a}	3.74^{a}	238.86^{a}	20.88^{a}	2076.20^{a}
Eskandrany		4.96^{d}	446.11^{d}	1.57^{d}	73.74^{c}	9.92^{d}	851.67^{d}
Services plus		9.14^{b}	875.00^{b}	3.24^{b}	145.65^{b}	18.03^{b}	1387.89^{b}
Rivera		13.18^{a}	1314.86^{a}	5.04^{a}	407.78^{a}	21.15^{a}	1981.53^{a}
Mabroka		7.18^{c}	698.22^{c}	2.35^{c}	153.45^{b}	13.86^{c}	1193.33^{c}
Significant level	CV	***	***	***	***	***	***
	T	***	***	***	***	***	***
	CV×T	***	***	***	***	***	***

Figures

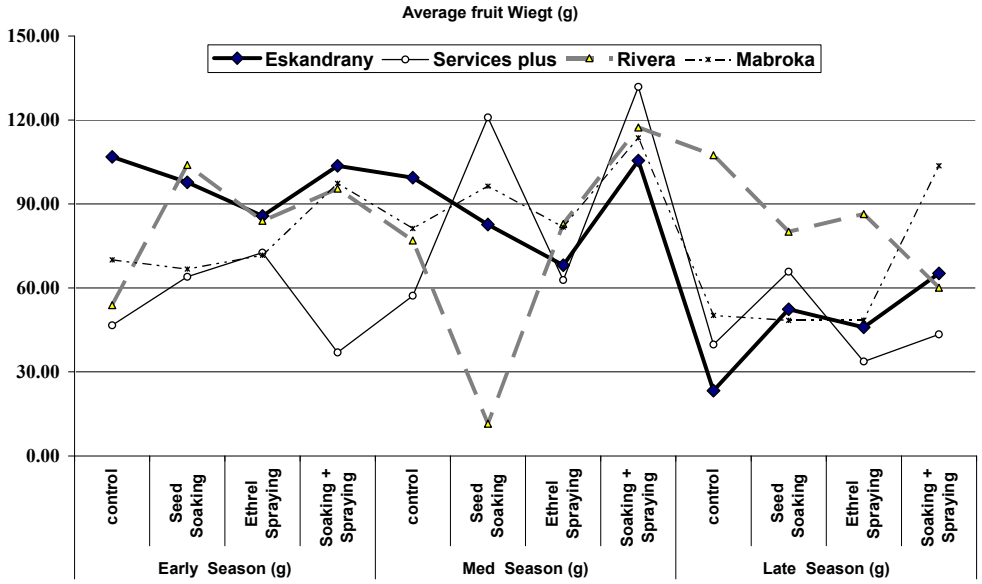

Fig. 1. Effect of seed soaking in garlic extract and/or seedlings spraying with ethrel at 1-2 true leaves stage, on squash average fruit weight (g), through early, mid and late season, under organic nitrogen fertilization.

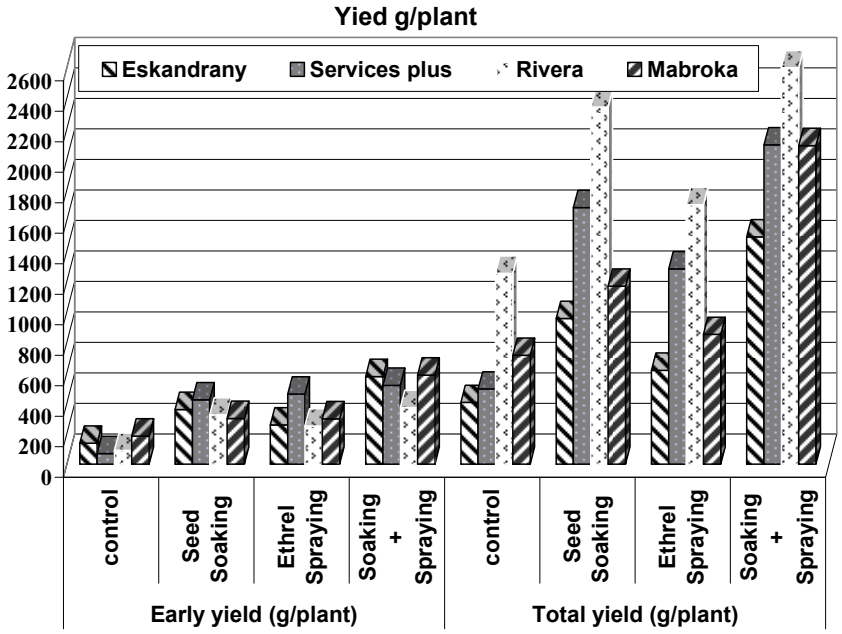

Fig. 2. Effect of seed soaking in garlic extract and/or seedlings spraying with ethrel at 1-2 true leaves stage, on squash early and total yield (g/plant) under organic nitrogen fertilization.