Scientific Papers. Series B, Horticulture. Vol. LIX, 2015
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

RESPONSE OF SEXUAL EXPRESSION OF ZUCCHINI SQUASH TO SOME FOLIAR FERTILIZERS TREATMENS

Dimka HAYTOVA, Nikolina SCHOPOVA

Agricultural University, 12 Mendeleev str., 4000 Plovdiv, Bulgaria
E-mail: haitova@abv.bg

Corresponding author email: haitova@abv.bg

Abstract

The application of foliar sprays is an important crop management strategy, which may help maximizing crop yield and quality. The influence of different agricultural practices, such as foliar application on generative expressions of zucchinis is slightly studied. The objective of our research was to assess the influence of some foliar fertilizers treatments on sexual expression of zucchini squash. The experiments were carried out during the period 2007-2009, on Experimental field of Department of Horticulture at the Agricultural University of Plovdiv, Bulgaria. Variety 'Izobilna F1' was used as an object of the experiments. The field experiments were done by randomized block design with four replications. Complex foliar fertilizers Fitona 3, Hortigrow and Humustimin in three concentrations, separately and in background on soil fertilization $N_{16}P_{16}K_{16}$ were used. The number of male and female flowers per plant, proportion male:female flowers, number of fruits per plant and percentage of fructification were determinate. The results of this experiment indicate that optimal mineral nutrition and providing additional nutrients through foliar application during the period of intensive growth and fruiting influenced positively on the number of fruit formation and increase the percentage of fruit development. The highest number of fruits and the highest percentage of fruit formation is outstanding the variant $N_{16}P_{16}K_{16}$+0.3% Humustim, followed by $N_{16}P_{16}K_{16}$ + 0.2% Hortigrow and by $N_{16}P_{16}K_{16}$ + 0.3% Hortigrow.

Key words*: fertilization, foliar application, fruits formation, Cucurbita pepo L.*

INTRODUCTION

In monoecious plants, such as cucurbits, the ratio between males and females flowers varies considerably depending on various environmental conditions. The formation and differentiation, as well as their ratio also depend of nutrient regime, on the activity of endogenous phytohormones and by treatment with growth regulators (Lau and Stephenson, 1993; Swiader et al, 1994). Change from vegetative growth to generative stages is a complex process regulated by many factors (Sure et al. 2013).

Studies on specificities of flowering under zucchinis are conducted by many scientists (Nitsch et al, 1952; Yakovlev, 1987; Loy, 2004; Grumet, 2011). One of the main conclusions of the authors is that the formation of female flowers and sufficient male flowers are the limiting factor in production.

The application of foliar sprays is an important crop management strategy, which may help maximizing crop yield and quality (Panayotov, 2004; Panayotov, 2005; Fernandez and Eichert, 2009). The influence of different agricultural practices, such as foliar application on generative expressions of zucchinis is slightly studied.

In this study we aimed to trace the formation of male and female flowers, the ratio between them, and the percentage of initiated fruit set to female flowers in separately foliar application and combining it with soil fertilization.

MATERIALS AND METHODS

The investigations were conducted in the period 2007–2009 under open field conditions with zucchini (*Cucurbita pepo* L. var. *giromontia*), cultivar Izobilna F1 on the experimental field of the Agricultural University of Plovdiv, Bulgaria. The soil of the field is classified as Molic Fluvisols (Popova and Sevov, 2010). The depth of the humus horizon is 28–30 cm. The soil is loamy (clay content from 30% to 41%).

Chemically, the soil is characterized by a low content in organic matter (1.46 %), pH neutral to slightly alkaline (7.17–7.37) and by the

presence of large amounts of $CaCO_3$, which gives more favorable physicalchemical water and soil properties, despite the heavy physical composition. Nitrogen content was low (32–46 $mg.kg^{-1}$), while there was a good stock of soluble phosphorus (P_2O_5 - 16.7-18 $mg.kg^{-1}$) and potassium (K_2O – 67 - 96 $mg.kg^{-1}$).

For the purpose of the experiment three different complete foliar fertilizers were used: Fitona (7.20% N, 5.20% K_2O, 1.5% Ca, 0.9% Mg, 0.1% Fe, 0.1% B, Cu, Zn, Mn, Mo. Fitotech Ltd., Bulgaria), Hortigrow® (20% N, 20%, P_2O_5, 20% K2O, 0.06% Fe, 0.02% Zn, 0.01% Mn, 0.01% Cu, 0.02% B, 0.001% Mo and 1% amino acids, Hortiland Ltd,. The Netherlands), Humustim® (on base of potassium humates-3% N, 1.14% P_2O_5, 7.83% K_2O, 3.92% Ca, 1.1% Mg, Cu, Zn, Mo, Mn Co, B, S. Agrospeis Ltd., Bulgaria).

Soil fertilization was carried out with NPK using a ratio $N_{160}P_{160}K_{160}$. Phosphorus [Ca $(H_2PO_4)_2$ – 46% P_2O_5]; and potassium (K_2SO_4 – 50% K_2O) fertilizers were applied with last tillage of soil before planting. Nitrogen fertilizer, introduced as NH_4NO_3 (34% N), was applied twice during the growing season.

First application was after formation of new leaves of plants after planting, and the second – 20 days after the first. Water solution of foliar fertilizers was prepared. Foliar fertilizers were applied in the given concentrations three times in the following phases: beginning of flowering, beginning of fruit production and beginning of mass fruit production. Solution with the needed concentration was prepared for the different treatments. Control plants were treated with pure water. The consumption of working solution in the first spraying was 600 $l.ha^{-1}$, and in the second and third 800 $l.ha^{-1}$. Plants were cultivated according to the conventional technology for early field production of marrows, using previously produced seedlings (Cholakov, 2009).

The seedlings were planted after thirty days of cultivation in non-heated polythene tunnel. Plants were planted on bed-furrow surface, according to scheme 100+60/50 cm and density of plantation 25000 $plants.ha^{-1}$ in beginning of May.

Growth period was 45 days after planting.

Treatments of the experiment:

1. Control - non fertilized;
2. Foliar fertilization with 0.2% Fitona;
3. Foliar fertilization with 0.3% Fitona;
4. Foliar fertilization with 0.4% Fitona;
5. Foliar fertilization with 0.1% Hortigrow;
6. Foliar fertilization with 0.2% Hortigrow;
7. Foliar fertilization with 0.3% Hortigrow;
8. Foliar fertilization with 0.2% Humustim;
9. Foliar fertilization with 0.3% Humustim;
10. Foliar fertilization with 0.4% Humustim;
11. Soil fertilization with $N_{160}P_{160}K_{160}$;
12. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.2% Fitona;
13. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.3% Fitona;
14. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.4% Fitona;
15. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.1% Hortigrow;
16. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.2% Hortigrow;
17. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.3% Hortigrow;
18. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.2% Humustim;
19. Soil fertilization with $N_{160}P_{160}K_{160}$+ 0.3% Humustim;
20. Soil fertilization with $N_{160}P_{160}K_{160}$ + 0.4% Humustim.

The number of fruits per plant, number of male and female flowers per plant, in tree phases - beginning of fruitfulness, mass fruitfulness and end of fruitfulness were determined. Proportion ♂:♀ was determinate and percentage of fructification.

Statistical analysis: the results were elaborated using the dispersion analysis method for one factor field trial and regression analysis (Dimova and Marinkov, 1999), using the program BIOSTAT (ANOVA).

RESULTS AND DISCUSSIONS

The results of field experiments show that zucchini are consistent in their flowering, despite the known differences in climatic conditions from year to year (Table 1). However, the factors do not change with variations outside the biological requirements of the species, in any of the experimental years. Growing zucchini without soil fertilization and foliar application (control) leads to a lowering of the number of male and female flowers,

compared to the other variants of the experiment. At the same time, plants form a smaller number of fruits (Table 1.) and the lowest rate of fructification (Table 2).

Table 1. Number of fruits per plant, number of male and female flowers per plant, and proportion ♂: ♀, per year and average for 2007-2009

Variants			number of fruits			♂	♀	♂:♀
			2007	2008	2009			
1.	Control		3.50	3.50	3.25	29.75	24.25	1.23
2.	Fitona	0.2%	3.50	4.25	3.75	19.42	16.08	1.21
3.		0.3%	3.50	4.00	3.50	20.17	16.92	1.19
4.		0.4%	3.75	4.00	3.50	22.25	19.08	1.17
5.	Hortigrow	0.1%	3.50	4.25	3.50	22.25	19.00	1.17
6.		0.2%	4.00	4.50	3.75	18.17	16.00	1.14
7.		0.3%	3.25	3.75	3.25	17.08	14.83	1.15
8.	Humustim	0.2%	4.00	4.50	4.25	20.08	18.00	1.12
9.		0.3%	3.75	4.25	3.75	19.25	16.33	1.17
10.		0.4%	3.75	4.00	3.75	15.92	13.67	1.16
11.	$N_{160}P_{160}K_{160}$		4.00	4.50	4.00	14.83	13.00	1.14
12.	$N_{160}P_{160}K_{160}$ Fitona	0.2%	4.00	4.75	4.25	11.75	12.25	0.96
13.		0.3%	4.00	4.50	4.00	12.75	11.58	1.10
14.		0.4%	4.50	5.25	4.50	12.67	11.58	1.09
15.	$N_{160}P_{160}K_{160}$ Hortigrow	0.1%	4.50	5.00	4.75	11.33	11.08	1.02
16.		0.2%	4.50	5.00	4.50	11.00	10.33	1.06
17.		0.3%	5.00	5.50	5.00	10.83	10.92	0.99
18.	$N_{160}P_{160}K_{160}$ Humustim	0.2%	4.75	5.50	4.75	11.75	11.67	1.01
19.		0.3%	5.50	5.75	5.25	10.83	10.67	1.01
20.		0.4%	5.25	5.75	5.00	13.75	12.58	1.09

This specificity is most likely due to the fact that the plants are placed in conditions of lack of nutrients to ensure that the vegetative growth, normal course of flowering and fruit set of formed. Additionally, the reason can be found in the large number of aborted flowers, which is most likely due to the poor quality of pollen fertility declining ability under the influence of foliar fertilization applied alone or with soil fertilization there are changes in the number of flowers of each gender, by year and average for the period.

The number of male flowers on average for the period decreased by 29.75 units for the control to 10.83 units for $N_{160}P_{160}K_{160}$ + 0.3% Humustim and $N_{160}P_{160}K_{160}$ + 0.3%Hortigrow.

The number of female flowers remains relatively constant at all tested variants both in years and average for the period. In variants of separately foliar application this number is slightly higher than those in which plants are grown $N_{160}P_{160}K_{160}$ background. On the other hand, in these variants are formed by a smaller number of fruits (Table 1.) and fructification rate is lower (Table 2).

Table 2. Percentage of fructification in different variants of fertilization

Variants			Average for year		
			2007	2008	2009
1.	Control		15.24	14.05	13.21
2.	Fitona	0.2%	23.41	25.66	22.35
3.		0.3%	21.93	22.55	20.17
4.		0.4%	21.42	20.13	17.78
5.	Hortigrow	0.1%	19.49	21.66	17.78
6.		0.2%	26.88	27.78	23.27
7.		0.3%	21.94	24.22	21.75
8.	Humustim	0.2%	23.26	23.85	21.61
9.		0.3%	23.33	25.50	22.12
10.		0.4%	30.28	28.37	29.12
11.	$N_{160}P_{160}K_{160}$		32.32	33.67	30.44
12.	$N_{160}P_{160}K_{160}$ Fitona	0.2%	36.91	35.89	35.04
13.		0.3%	36.91	36.99	37.11
14.		0.4%	40.65	43.85	38.33
15.	$N_{160}P_{160}K_{16}$ Hortigrow	0.1%	42.59	47.06	41.61
16.		0.2%	45.09	48.61	44.00
17.		0.3%	50.30	50.13	42.61
18.	$N_{160}P_{160}K_{160}$ Humustim	0.2%	44.04	45.79	40.09
19.		0.3%	53.81	50.73	47.81
20.		0.4%	45.45	45.05	40.01

Zucchinis as annual crops for their short growing season are unable to keep plenty of underlying flowers, as well as regulating and preserving formed fruits. The number of male flowers is reducing. The ratio ♂: ♀ is changing, respectively of 1.22 for the control, to 1.00 for variants which utilize Humustim at concentrations 0.2% and 0.3% and fertilization with $N_{16}P_{16}K_{16}$. In 2008 and 2009 the ratio ♂: ♀ is slightly lower than 1.00 only for $N_{16}P_{16}K_{16}$ + 0.2% Fitona, respectively 0.98 and 0.96. The result is probably an anomaly caused by the fluctuation in the number of male flowers.

Used for the experiment cv. Izobilna F1 is characterized by continuous flowering in terms of early field production. Differences between variants are insignificant. Not observed deviations from normal course of flowering, which are caused as a result of the use of fertilizers. Foliar fertilizers applied separately or soil fertilization background with $N_{160}P_{160}K_{160}$ affects the number of initiated fruits (Table 1). The amendments between variants are small, but with a greater number of shaped fruit per plant are distinguished those with mixed fertilization (soil and foliar). Fertilization $N_{16}P_{16}K_{16}$ + 0.3%Humustim causes the formation of the largest number of

fruits per plant in comparison with the control. The same trends were observed in the percentage of fructification (Table 2). The highest percentage of fructification has plants fertilized with $N_{160}P_{160}K_{160}$ + 0.3%Humustim in the three years of experiments, respectively, 53.81%, 50.73% and 47.81%. Immediately after them of rank are $N_{160}P_{160}K_{160}$ + 0.3% Hortigrow, $N_{160}P_{160}K_{160}$ + 0.2% Hortigrow and $N_{160}P_{160}K_{160}$ + 0.4% Humustim. Adequate mineral nutrition and additional nutrients in an easily absorbable form in periods of rapid growth and fructification have a positive impact on the number of fruits and increase the percentage of fructification. The reason for such a reaction of zucchinis, Stephenson et al. (1988) found in “dominance of the first fruits", which temporarily inhibit flowering during the growth of fruits.

CONCLUSIONS

The results of the assays on the influence of foliar fertilization on the biological behaviours of zucchini indicated that the use of foliar fertilizers during the growing season have a positive influence on the growth and development of plants.

Optimal mineral nutrition and providing additional nutrients through foliar application during the period of intensive growth and fruiting influenced positively on the number of fruit formation and increase the percentage of fruit development.

The highest number of fruits and the highest percentage of fruit formation is outstanding the variant $N_{160}P_{160}K_{160}$+0.3% Humustim, followed by $N_{16}P_{16}K_{16}$ + 0.2% Hortigrow and by $N_{160}P_{160}K_{160}$ + 0.3% Hortigrow.

ACKNOWLEDGEMENTS

The authors would like to thank the Research Fund of the Agricultural University of Plovdiv, Bulgaria for financial support.

REFERENCES

Cholakov D. 2009: Technology for cultivation of marrows in vegetable-growing, Academic publishers of Agricultural University -Plovdiv, pp. 150-158 (in Bulgarian).

Dimova D., Marinkov E. 1999. Experimental work and biometry, Academic publishers of Agricultural University, Plovdiv (in Bulgarian)

Fernández V, Eichert T .2009. Uptake of hydrophilic solutes through plant leaves: current state of knowledge and perspectives of foliar fertilization. Crit Rev Plant Sci 28:36–68

Grumet R., Taft J. 2011. Sex expression in cucurbits, Genetics, Genomics and Breeding of Cucurbits, p. 353-375

Lau, T. C.; Stephenson, A. G., 1993. Effects of soil nitrogen on pollen production, pollen grain size, and pollen performance in Cucurbita pepo (Cucurbitaceae)., American Journal of Botany 80 (7) : 763-768

Loy J.B. 2004. Morpho-Physiological aspects of productivity and quality in squash and pumpkins (Cucurbita spp.), Critical Reviews in Plant Sciences, 23(4):337-363

Nitsch J.P., Kurtz E.B., Liverman-Jr J.L., Went F.W. 1952. The development of sex expression in cucurbit flowers, American Journal of botany, vol. 39, №1, p.32

Panayotov, N. 2005 Morphological behaviours and productivity of pepper plants under influence of foliar fertilizer Kristalon. Analele Universitii “Valahia” Targoviste. Facilia VI “Tehnologia produselor alimentare, pescuit si acvacultura”. The annals of “Valahia” University of Targoviste, Fascicle VI “Food technology, aquaculture and fishing”, pp, 24-30.

Panayotov, N., 2004. Morphological development and productivity of pepper plants after application of foliar fertilizer Hortigow. Scientific researches on the Union of Scientists in Bulgaria-Plovdiv, Series B "Technique and Technology," Scientific session "Technology, Agricultural Sciences and Technology" –vol.III, pp 97-104 (in Bulgarian).

Popova.R, Sevov A., 2010. Soil characteristic of experimental field of crop production department as result of cultivation of grain. technical and forage crops. Agricultural University of Plovdiv, Scientific works, vol.LV, book1, pp. 151-156 (in Bulgarian).

Stephenson, A.G., Devlin, B., Horton, J.B. 1998. The effect of seed number and prior fruit dominance on the pattern of fruit production in Cucurbia pepo(zucchini squash). Annals of Botany 62:653-661.

Sure S., Arooie H, Azizi M. 2013. Effect of GA3 and Ehtephon on sex expression and oil yield in medicinal pumpkin *(Cucurbita peop* var. styriaca*)*. IJFAS Journal-2013-2-9/196-201.

Swiader J.M., Sipp S.K., Brown R.E. 1994. Pumpkin growth, flowering and fruiting response to nitrogen and potassium sprinkler fertigation in sandy soil, J. Amer. Soc. Hort. Sci. 199(3):414-419

Yakovlev, MS 1987. Embryology of cereals, legumes, vegetables cultivated plants. Kishinew, "Shtiintsa. Russian.