ATLANTIS PRESS

Advances in Engineering Research, volume 151

International Conference on Smart Solutions for Agriculture (Agro-SMART 2018)

Accumulation of Mineral Nutrients in Leaves of Momordica Charantia L. And Trichosanthes Cucumerina L. Grown Using Grafting

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***Abstract*— The article examines accumulation of macro- and microelements in the leaves of *Momordica charantia* L. and *Trichosanthes cucumerina* L. grown using a grafting method. It contains data on the content of key mineral nutrients in the leaves of examined crops. It marks high calcium content in the leaves, reaching 6.51-10.73%, which is peculiar to the plants of *Cucurbitacee* L. family. It has been determined that grafting of *Momordica charantia* L. and *Trichosanthes cucumerina* L. results in changes in accumulation of mineral nutrients in plant leaves, the nature and the trend of which depended on the type of the stock.**

Keywords— Momordica charantia L., Trichosanthes cucumerina L., Cucurbit species, scion, stock, graft compatibility, mineral nutrition, survival ability

I. INTRODUCTION

The main source of bioactive substances and antioxidants for a human body is plant food. Analysis of Russian Statistics Committee data demonstrates that consumption of vegetables in the Russian Federation is 3 to 4 times below normal.

Traditional cultivated crops are not able to meet bioactive substances and antioxidants requirements in full. Various under-studied species, including vegetables are of peculiar interest. Among such non-traditional and under-studied crops, *Momordica charantia* L. and *Trichosanthes cucumerina* L., *Momordica charantia* L. and *Trichosanthes cucumerina* L. attract attention due to diverse biochemical and mineral composition of all the parts of the plants.

Fruits of *Momordica charantia* L and *Trichosanthes cucumerina* L. contain ascorbic acid, licopin, catechins, alcaloids, phenolic compounds, organic acids and a substantial number of microelements [3, 10]. Leaf extract has an antibacterial and immune-stimulating effect. Fruits, leaves, flowers and roots are used in folk medicine and cookery [4].

In the last decade, these crops have become widespread in Russia as crops of amateur vegetable gardening, but they are certainly of interest for farms as well as for extending a range of vegetable crops in greenhouse farming.

The line of research aimed at introduction of rare and new crops, according to a number of researchers [5], should be one of priorities in development of national economy, as the introduction allows better development of plant recourses.

A substantial problem in introduction of thermophytes in the temperate region is their low fitness for local soil and environmental conditions.

One of highly effective and environmentally friendly methods to improve plants resistance to adverse growing conditions is their grafting to resistant stocks.

Grafting is one of the most ancient methods of propagation and improving resistance of grafted plants in olericulture, pomiculture and landscape gardening.

Application of this technique to herbatious crops, mainly to vegetable ones, started only in the beginning of the XX century. It was determined that a more aggressive root system of some species used as grafting stock, resistant to environmental variations, assured high and sustainable yield of a number of vegetable plants (cucumber, water-melon, melon, tomato, eggplant) both on the field and under cover [2].

A stock gives the plants higher sustainability and allows adjusting growth and development rate, and the scion retains all valuable and economically practical properties [9].

Usage of grafting method improves resistance to adverse conditions as well as yield rate and quality of seed grains of the plants. There is no available data on grafting of *Momordica charantia* L. and *Trichosanthes cucumerina* L. to stocks. To improve adaptive capabilities of tropical species in the eastern part of the nonchernozem belt, grafting can be used to sustainable stocks that is best for local growing conditions. Earlier research determined that the most suitable kind of grafting in this area for cucurbit plants is approach grafting.

The role of mineral nutrition in growth and development of plants is well known. Absorption and accumulation of mineral nutrients by plants have specific and cultivar-specific peculiarities, depend on their content and availability in root habitable zone and growing technology.

Chemical analysis of the plants serves to determine the total amount of nutrient substances consumed by vegetable crops [6; 11]. The content of key mineral nutrients in the leaves of traditional cucurbits grown on their own roots is sufficiently well studied. According to N. Gluntsov [6], an optimal content of nitrogen in the leaves of *Cucumis sativus* L. during fruiting season amounts to 2-2.8% of dry matter, phosphorus – 0.5%, potassium 1.0-1.4%. The optimal content of nitrogen, phosphorous and potassium in the lamina in the end of fruiting amounts to 3.5-4.7%; 0.9-1.1 % and 2.5-3.3 % of dry matter, respectively. In contrast, there are virtually no available data on accumulation of mineral nutrients by *Momordica charantia* L. and *Trichosanthes cucumerina* L., including those grown with grafting to stocks.

Analyses of the leaves of *Cucumis sativus* L. made in the end of crop rotation showed [12] that the leaves of plants grafted to *Cucurbita ficifolia* Bouche, *C. pero* L. and *C. maxima* Duch. contained significantly more nitrogen by 35.5%, 24.8% and 9.8%, respectively, as compared to own-rooted plants.

Nitrogen content in the leaves of grafted plants was at the level of own-rooted ones. Phosphorus content in the stems of grafted plants was increasing by 10.3-23.9 % as compared to own-rooted plants.

Grafting to *Lagenaria siceraria* (Molina) Standl. promoted significant reduction of potassium content in the leaves and stems of the plants by 21.6% and 20.6%, respectively, as compared to own-rooted plants. Reduction of potassium was noted in the stems of plants grafted to *C. ficifolia* – by 17.6% compared to own-rooted ones.

Thus, earlier researches proved [12] that under the influence of grafting, significant changes occur in accumulation of mineral nutrients by the plants of *Cucumis sativus*. That is why it was essential to determine characteristics of mineral nutrients accumulation in the leaves of *Momordica charantia* L. and *Trichosanthes cucumerina* L. grafted to various stocks as well.

II. MATERIALS AND METHODS

The researches were made in Udmurt Federal Research Center of the Ural branch of the Russian Academy of Sciences, in Izhevsk, in the central agrocli-matic area of the Udmurt Republic. Momordica charantia L. and Trichosanthes cucumerina L. (scions) were grafted to five types of stocks: Cucurbita ficifolia Bouche, Lagenaria siceraria (Molina) Standl., Cucurbita moschata Duch., Cu-curbita pero L., Cucurbita maxima Duch. Own-rooted samples of scions served as reference. Seeds preliminary disinfected with 1% potassium permanganate solution, after beginning of germination were sowed to cassettes with com-partments of 25cm3, filled with peat and soil. Grafting was done at the stage of complete opening of cotyledons of the seedlings. In 14 days after grafting and adaptation to external conditions, own-rooted and grafted plants were planted to pots of 0.3l .

In the course of experiments, there were performed phonological obser-vations, yield and survival rate recording, testing of leaves and fruits of grafted and own-rooted plants in main development stages for dry matter – GOST 290-31, for reducing sugars – using the Bertrand method, for ascorbic acid – using Muri method; content of micro- and macro-elements was determined by atomic absorption spectrometry, statistical processing of the obtained data was made using computer programs.

III. RESULTS AND DISCUSSION

Survival rate recording showed that the best performance was obtained when grafted to Cucurbita maxima (Table 1). It should be noted that there were attempts of grafting to Benincasa hispida (Thunb.) Cogn., yet considerable dif-ferences were observed in seedling growth and development rate showing themselves in significant development retardation of stock compared to the scion which precluded from carrying out a valid grafting. Afterwards, the variant of grafting to Benincasa hispida was excluded from the experiments.

During the first period of observation, a seeding period, own-rooted plants were developing better than grafted ones, which is caused by grafting wound stress. Grafted plants required time to grow to stock, which is why retardation occurred in growth and development rate as compared to own-rooted plants. After concretion with a stock, grafted plants of

Momordica charantia L. and Trichosanthes cucumerina L. started to develop more intensively than own-rooted plants which showed itself in earlier transition to blooming stage – 35-37 days, and fruiting stage – 56-58 days as compared to own-rooted plants (reference) – 40-42 days and 60-62 days, respectively.

TABLE I. PLANTS SURVIVAL RATE DEPENDING ON TYPE OF STOCK, %

Variant	Momordica charantia	Trichosanthes cucumerina
Cucúrbita pépo	46.7	73.3
Cucúrbita maxima	100	70.0
Cucúrbita moschata	86.7	60.0
Cucúrbita ficifolia	86.7	80.0
Benincasa hispida	6.7	46.7
Lagenaria siceraria	66.7	88.9

Analyses of macro- and microelements content in the leaves of examined species (Table 2) showed that leaves of plants of the examined species have high content of calcium compared to potassium, which amounted to 6.51% to 10.73%, which is peculiar to the plants of Cucurbitaceae family [8]. It is noted that high calcium accumulation may be connected with a fact that metal cations can penetrate the leaves through stomata or cuticle and then be transported to roots, shoots and other plant organs [1]. At the same time, higher accumulation of calcium in plant leaves may occur under influence of high temperature and be a reaction to stress [12].

TABLE II. PLANTS SURVIVAL RATE DEPENDING ON TYPE OF STOCK, %

Variant, stock	Zn, %	Cu, %	Mn, %	Fe, %	P2O5, %	K2O, %	Ca, %	Mg, %
M. charantia (K)	0.005	0.0003	0.008	0.02	0.42	3.38	7.74	1.66
C. ficifolia	0.003	0.0002	0.026	0.01	0.42	4.38	10.73	0.23
C. maxima	0.005	0.0002	0.011	0.02	0.39	4.00	7.66	0.69
C. moschata	0.003	0.0003	0.008	0.02	0.37	4.00	7.66	1.06
L. siceraria	0.004	0.0003	0.008	0.02	0.42	3.89	6.51	0.78
T. cucumerina (K)	0.003	0.0002	0.032	0.02	0.53	2.75	7.28	1.29
L. siceraria	0.006	0.0001	0.009	0.02	0.77	3.19	7.43	0.41
C. ficifolia	0.002	0.0002	0.029	0.02	0.45	2.63	8.97	0.69
C. pépo	0.002	0.0003	0.033	0.02	0.81	3.00	8.05	0.97

Atmospheric metals get into the plant leaves having floccose or rough surface more intensively [7]. Morphological features and characteristics of biochemical composition of cuticle and epidermis are predominantly the explanation of existing specific differences between the plants in accumulation of metals by the plants [1].

IV. CONCLUSION

Grafting of Momordica charantia and Trichosanthes cucumerina to cucurbit species during introduction in limited heat conditions allows improving plants growth and development depending on stock as compared to own-rooted plants. The nature of accumulation of macro- and microelements and their ratio in leaves of Momordica charantia L. and Trichosanthes cucumerina L. is similar to Cucumis sativus L. Grafting of Momordica charantia L. and Trichosanthes cucumerina L. was resulting in changes in accumulation of mineral nutrients in plant leaves, nature and trend of which depended on the type of stock.

References

[1] I. Cakmak., R.M. Welch., J. Harh., W.A. Norvell., L. Ozturk., L.V. Kochian, "Uptake and retranslocation of leaf-applied cadmium (109 Cd) in diploid, tetraploid and hexaploid wheats", J. Exp. Bot, 2000, Vol. 51, No.343, pp. 221-226.

[2] A. Fedorov, T. Tutova, A. Paponov, Primeneniye privivki i fiziologicheski aktivnykh veshchestv pri vyrashchivanii ogurtsa [Application of grafting and physiologically active substances when growing cucumbers], Izhevsk, 2006, p. 114

[3] U. Foteev, T. Sookushkina, G. Kudriavtseva, V. Belousova, "Biohimicheskiy sostav i pishchevyye dostoinstva novykh dlya Sibiri ovoshchnykh kultur" [Biochemical composition and nutrition values of vegetable crops new for Siberia], August 4-6, 2008. All-Russian Scientific Research Institute for Vegetable Crops Se-lection and Seed Breeding, Moscow, 2008, Vol. 2, pp. 373-375.[Traditions and Modern trends in vegetable crops selection and seed breeding, perspectives: materials of the 1st international research and practice conference, 2008]

[4] U. Foteev, G. Kudriavtseva, V. Belousova, "Introduktsiya ekzoticheskikh teplolubivykh ovoshchnykh rasteniy v Sibiri", Olericulture of Siberia: collection of studies, Novosibirsk, 2009, pp. 176-188.

[5] M. Gins, A. Kvochkin, V. Meshkov, "Introduktsiya netraditcionnykh i redkikh rasteniy" [Introduction of non-traditional and rare plants], Herald of the Russian Academy of Agricul-tural Sciences, 2008, No.5, p. 15.

[6] N. Gluntcov, Agrohimicheskaya laboratoriya ovoshchevoda [Agrochemical laboratory of a vege-table grower], Moscow, Rosagropromizdat, 1989, p.192.

[7] B. Godzic, "Heavy metals content in plants from zinc dumps and reference areas", Polish. Bot. Stud., 1993, Vol. 5., pp. 113-130.

[8] E. Grigoray, G. Tabalenkova, I. Dalke, T. Golovko, "Urozhay i nakoplenie mineralnykh elementov teplichnoy kulturoy ogurtca v zavisimosti ot osveshchennosti" [Yield and mineral elements accumulation by greenhouse cucumber crop depending on light intensity], Agrochemistry, 2015, No.4, pp. 74-79.

[9] R. Kudriavets, S. Shliapnikov, "Privivka plodovykh i dekorativnykh derevyev i kustarnikov" [Grafting fruit and or-namental trees and shrubs], Moscow, MSP Publishing House, 2007, 128 p.

[10] T. Orlovskaya, "Vezhkh-analiz plodov momordiki" [HPLC-analysis of momordica fruits], Farmatsiya, 2010, No.1, pp. 8-11.6.

[11] Scaife A. A pump/leak/buffer model for plant nitrate uptake / A. Scaife // Plant Soil, 1989, Vol. 14. No.1., pp. 139-141.

[12] Sundyreva M. Vliyanie gidrotermicheskikh usloviy vegetatcii na izmenenie fiziologicheskogo sos-toyaniya sorto-podvoinykh kombinatciy vinograda v svyazi s ustoichivostyu k abioticheskim stress-oram [Effect of hydrothermal conditions of vegetation on change of physiological state of culti-var stock combinations of grape in connection with resistance to abiotic stressors] / M. Sun-dyreva, N. Nenko, U. Yakuba, Y. Ushakova // Herald of Agroindustrial Sector of Stavropol Re-gion, 2016, No.1(21), pp. 187-193.