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THE STUDY OF TARTARIC ACID BASED NEW COMPLEX PREPARATION OF PLANT GROWTH ACTIVATION

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Abstract

The effect of 2 preparations of plant growth stimulator (phytostimulators) «Complex» and «Complex Plus» which were elaborated in National Polytechnic University of Armenia (NPUA) based on natural tartaric acid which is purified from the cream of tartar on a number of higher flowering plants of various taxonomic groups is considered in current research.

The laboratory and field experiments were carried out on important agricultural crops, decorative and medicinal plants: cactus *(Stapelia grandiflora Masson)*, medicinal aloe *(Aloe vera)*, decorative *(Kalanchoe blossfeldiana*, *Kalanchoe daigremontiana)*, blue agave *(Agava tequilana)*, American agave *(Agava americana L. trifasciata)*, potatoes *(Solanum tuberosum)*, garlic *(Allium sativum)*, beans *(Phaseolus vulgaris)*, strawberries *(Fragaria×ananassa)*, cucumbers *(Cucumis sativus)* and lentils *(Lens culinaris)*.

The maximal effect was obtained for succulent plants.

According to primary ecologically-toxicological study, the preparations are medium toxic and low allergenic mixture of ecologically safe substances produced by green chemistry technologies. At

present two preparations of «Complex» and «Complex Plus» are being considered for state registration and patenting in RA.

Key words: tartaric acid, micronutrient fertilizer, agricultural plants, plant growth stimulator (phytostimulator), chelating complex.

Introduction

One of the urgent problems of modern agriculture is increasing the productivity of cultivated plants. Optimization of cultivation conditions is very important, especially in the aspect of providing the necessary level of synthesis of phytohormones and growth factors (auxins, gibberellins, etc.) by the target plant. Since plants are not always able to provide themselves with sufficient levels of these compounds, growth stimulators are being often used.

The use of phytostimulators is very important, despite the fact that synthetic activators of tissue proliferation and organ differentiation are not always safe due to their carcinogenicity in industrial use [1-3].

The beneficial effect of natural organic and in particular dicarboxylic and tricarboxylic and aldaric acids which are simultaneously antimicrobial agents on the parameters of plant growth activity is a well-known fact. The ability of compounds of this class to prevent the development of phytopathogenic fungi, as well as toxigenicity of fungi and other phytopathogenic microorganisms [4-6] is widely known. This is largely due to their ability to form complexes with cations of the most important micro- and submicroelements, which involves organic carboxylic acids in the regulation process in the water-salt metabolism of plants [7, 8].

Conflict setting and set of methodology

Recently the properties described above have been studied for tartaric, lactic, citric and oxalic acids. These substances are now successfully used in world practice in the production of environmentally friendly agrochemicals. Tartaric acid is especially widely used, being the most widespread organic acid in the plant world. Tartaric acid, as well as its salts of alkali and alkaline earth metals, are considered safe food additives (E334 - E337, E354), having widespread use in the world production of chelated fertilizers. Also, tartaric acid is used both in free form and in amide forms [9-11].

The development of new safe phytostimulators is extremely important. That is why the effect of a plant growth stimulator which was elaborated in Basic Research Laboratory of «Agrarian Pesticides Creation & The Quality Control» at National Polytechnic University of Armenia (NPUA) on the basis of natural tartaric acid obtained by purifying it from tartar on the growth of a number of higher flowering plants of various taxonomic groups is studied in current paper.

According to the technology proposed in our laboratory, technically pure tartaric acid was obtained from natural cream of tartar (cheap row material, which is the waste product of winery), and then, by the enrichment of several microelements 2 preparations «Complex» and «Complex Plus» were elaborated with an addition of Imidaclopride insecticide.

The experiments were carried out with the support of the specialists of the Scientific Center of Agrobiotechnology SNCO, the National Agrarian University of Armenia and the SPC «Armbiotechnology» NAS RA (Fig. 1) [12].

The following succulent xerophytic indoor decorative plants were chosen as the object for laboratory and field tests of the stimulant effect: cactus Stapelia grandiflora Masson, medicinal aloe

Aloe vera, decorative Kalanchoe blossfeldiana, Kalanchoe daigremontiana, blue agave Agava tequilana and American agave Agava americana L. trifasciata.

Field trials were carried out on the following crops: Solanum tuberosum potatoes, Allium sativum garlic, Phaseolus vulgaris beans, Fragaria×ananassa strawberries, Cucumis sativus cucumbers and Lens culinaris lentils [13,14].

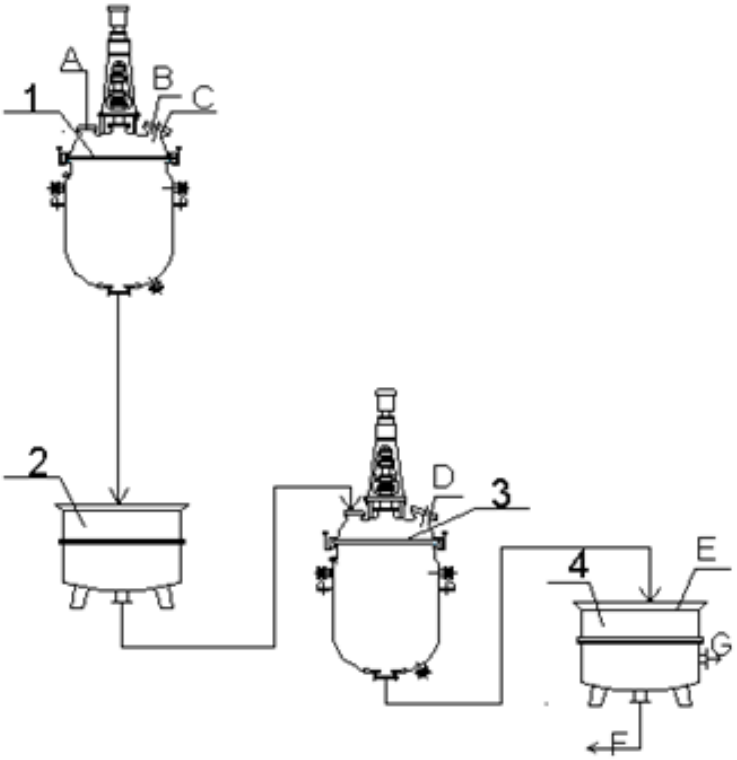

Fig. 1 Tartaric Acid purification technology form the cream of tartar

A - natural cream of tartar; B - 10% - hydrochloric acid; C - heating (60-65°C); D - hot filtration; cooling (10-15°C) with regulation of acidity; E - 70% technically purified tartaric acid (92%) in the form of sediment; F - stock solution for plant growth stimulant enriched with microelements; G - vacuum; 1 - and 3 - mixers, 2 - hot filter, 3 - suction filter.

The tests were carried out in June 2019 during 2 periods of spraying in the territory of the experimental fields with an area of 50m^2 of Hovtamej district of Armavir region, RA. «Complex» and «Complex Plus» preparations were tested at concentrations of 100g/10L and 150g/10Lon crops of various important agricultural plants in 06.06.2019 and 21.06.2019. In field experiments the following crops were used: cucumber (variety «Alliance»), potatoes (variety «Impalla»), beans (at the stage of green pods, variety «Fidai» beans and red beans of local variety «Red Armenian»), strawberries (varieties «Victoria»), garlic (local variety «Armenian»). A territory of the same area was used as a control sample with the cultivation of the indicated plants using generally accepted standard methods. After 15 days, comparative measurements were carried out: the amount of biomass and the intensity of its accumulation, the morphological parameters of the aboveground part of the plant, the indicators of flowering, fruiting, the rate of fruit ripening as well as the yield of the tested crops in experimental and control samples.

Research Results

According to the obtained data, the studied drug has physicochemical properties. It is a dark green-brown solution (with colloidal parts), d^4_{20} - 1.150-1.154, soluble in water, pH of an aqueous solution (1%, 20^{o}C) - 3.0-3.5. In the course of the research, the effects of both preparations were analyzed. «Complex Plus» preparation includes the following components: active ingredients: natural

tartaric acid (CAS («Chemical Abstracts Service» - internationally registered number which is a unique identifier of a particular chemical substance) # 147-71-7) - 20-25g/L, K (in the form of chloride) - 45g/L, Ca (in chloride-chelated form) -23g/L, Cu (chelated) - 2.5-3g/L, Fe (chelated) - 10-10.5g/L, Zinc (chelated) - 5.5-6g/L, imidacloprid (CAS # 138261-41-3 technical) 20g/L. Surfactants (surfactants) / co-solvents / additives - ionic (sodium salt of lauryl trisulfoether, CAS # 68585-34-2, 70% -) - 10g/L, non-ionic: mixture (octylphenylether polyethilenglycol, CAS # 9002-93-1g/L, technical cocamide, CAS # 68603-42-9,) - 20g/L, glycerin (CAS # 56-81-5) - 10g/L, Polyethylene glycol) 300 (CAS # 25322- 68 -3) - 10g/L. The formula of chelating complex of tartaric acid with Cu and alkali metals is presented in Fig. 2.

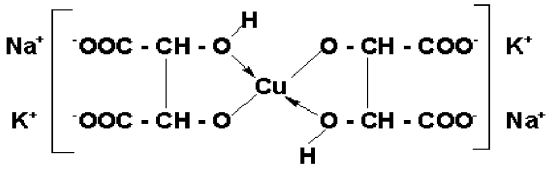

Fig. 2 Tartaric acid complex with Cu and alkali metals

In addition to these components, the stimulant also contains certain amounts of amino acids, vitamins and other important nutritious organic compounds due to the acid hydrolysis of yeast residues in the composition of tartar during the purification of tartaric acid using hydrochloric acid. Protein determination was carried out by the Lowry method and showed an average of about 55mg/g [15].

Table 1

Study of changes in the morphological and phonological parameters of agricultural plants under the action of drugs to stimulate growth: S - sample, C - control, A - cucumber, B - beans, C - bean pods, D - strawberries, E - potatoes, F - garlic.

S	Number of vegetative organs			Number of generative organs			Number of flowers in inflorescences		
	«Complex-100»	«Complex-150»	C	«Complex-100»	«Complex-150»	C	«Complex-100»	«Complex-150»	C
A	5	6	4	18	19	16	-	-	-
B	8	8	6	16	18	12	-	-	-
C	12	15	11	21	24	19	-	-	-
C	-	-	-	22	24	21	12	14	11
D	6	7	5	-	-	-	-	-	-
E	1	1	1	1	1	1	-	-	-

The stimulant also contains vitamins, pectin and other wall components, alkaloids, products of partial proteolysis, carbohydrates, oils, pigments. A laboratory study of the effect of 1% and 2% stimulant solutions on the growth of *Stapelia grandiflora Masson* cultivated in pots with soil, 100-120g in volume, showed a positive effect in increasing the biomass of the underground and above-ground parts of the plant intensifying the green color and accelerating the growth rate in comparison with control samples. Similar results were obtained also when applying the stimulant to other representatives of the experimental succulents under conditions of standard watering. *Kalanchoe blossfeldiana* also showed an intensification of the formation of generative buds and a 15% lengthening of the flowering period and in the case of *Aloe vera*, significant leaf hypertrophy was observed.

The data of the primary toxicological analysis are as follows: the average lethal dose (per os)` DL_{50} = 805 mg/kg, skin irritative toxicity DL_{50} > 1000 mg/kg, toxicity and skin-irritating effect on intact skin is absent, slightly irritating effect on the mucous membrane of the eye presents, and as a result it's being considered as the substance of IV class of allergenicity (weak allergen) and II class of hazard. Thus, it might be considered as a drug of medium toxicity [16].

Table 2

Research of parameters of productivity of the most important agricultural plants after exposure to growth preparations. N - and studied samples (A - cucumber, B - red beans, C - green beans, D - garlic, E - potatoes, F – strawberries)

N	Productivity on 50м^2 (кг)			Productivity per 1ha (t.)		
	«Complex-100»	«Complex-150»	Control	«Complex-100»	«Complex-150»	Control
A	150	156	148	320	3200	29,6
B	16,2	17	16	3,21	36	3,2
C	20	21	19,8	4	4,2	3,96
D	38	39	37	7,6	7,8	7,4
E	167,7	180	160	32	36	31,9
F	30	32	29	6	6,4	5,8

Table 3

Effect of the stimulant on the growth of Stapelia grandiflora Masson. «+» - sample after injection into 120 g of soil, 5 ml of 2% stimulant solution; «-» - control sample, * - formation of a vegetative bud (0.5 cm), # - the formation of a vegetative bud (1.5 cm)

Sample of plants		0 moment		30 days		60 days	
		shoot length (cm)	root length (cm)	shoot length (cm)	root length (cm)	shoot length (cm)	root length (cm)
1	-	9,3	3,5	11,5	3,9	15,5	4,5
2	+	8,8	4,2	13,7	4,8	17,5	5,2
3	_	8,2	2,2	12,5	4,2	14	4,3
4	+	7,5	2,5	14,5	3,1	16,5	3,5
5	-	4,3	1,7	6,1	2,1	7,2	3,2
6	+	3,7	1,8	6,5*	4	6,5#	4,5
7	-	2,7	0,3	3,5	1,8	4,3	2,3
8	+	2,5	0,3	4,8	1,5	5,7	2,4
9	-	4	1,4	5,9	2,2	7	2,7
10	+	4,6	1,3	7,2	4,3	8,5	5,5

According to the presented tables 1-2, the growth of the generative and vegetative parts of plants as well as the yield indicators are noticeably higher than the values of similar parameters of the control samples. The data of the primary toxicological analysis are as follows: average lethal dose (the main quantitative characteristics of toxicity) (per os)` DL_{50} = 805 mg/kg, skin irritative toxicity DL_{50} cut > 1000 mg/kg, toxicity and skin-irritating effect on intact skin is absent, slightly irritating effect on the mucous membrane of the eye, IV class of allergen properties (weak allergen), II class of hazard - a drug of medium toxicity.

A laboratory study of the effect of 1% and 2% solutions of a stimulant on the growth of *Stapelia grandiflora Masson*, cultivated in pots with soil and a volume of 100-120 g showed a positive effect in increasing the biomass of both the underground and aboveground parts of the plant, intensifying the green color and accelerating the growth rate compared with control samples under standard watering conditions (Tab. 3).

Similar results were obtained also when applying the stimulant to other representatives of the experimental succulents (Fig. 3). Kalanchoe blossfeldiana also showed an intensification of the formation of generative buds and a 15% lengthening of the flowering period was observed with significant leaf hypertrophy in case of Aloe vera.

Fig. 3 Effect of a stimulant on the growth of *Stapelia grandiflora Masson*
A - prototype, B - control sample

Tab. 4 shows the results of the effect of the stimulant on the germination and growth of seedlings of lentil Lens culinaris under laboratory conditions. During the research, the stimulating effect of the drug was revealed leading to an increase in green biomass, the number of roots both lateral and adventitious.

Earlier germination of seeds and emergence of seedlings were also noted in comparison with the control samples (Fig. 4).

Results of field tests of the «Complex Plus» preparation based on the insecticide imidacloprid and a growth stimulator based on tartaric acid and chelated micro- and submicroelements, on callus and seed crops of Solanum tuberosum potatoes (1% solution (100L/ 10L of water) - for leaf food, 2% solution (200/10L of water) - for root nutrition - 4-6 according to the calculation of one water path) are shown in Fig. 4 and Tables 1-4.

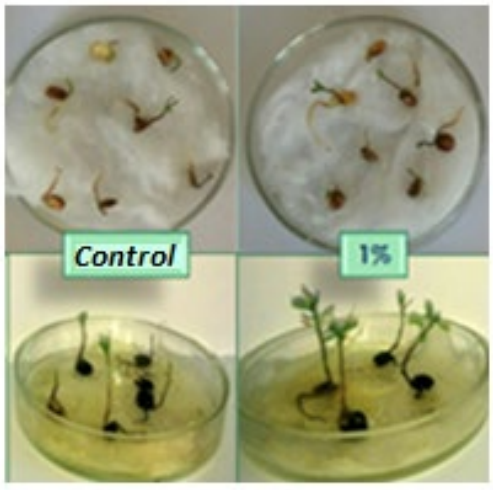

Fig. 4 Laboratory tests of the stimulant effect on the growth of lentil seedlings Lens culinaris

Table 4

Analysis of the effect of the stimulant on the growth of lentil seedlings Lens culinaris. S - experimental sample, C - control sample.

Sample	0 moment		4 days		7 days	
	shoot length (cm)	main root length (cm)	shoot length (cm)	main root length (cm)	shoot length (cm)	main root length (cm)
1%	0	0	1,4	0,31	2	0,7
2%	0	0	1,6	0,5	3,2	1,3
C	0	0	1,25	0,25	1,8	0,5

According to the collected data (Fig. 4-5), the level of green biomass growth is significantly different in the experimental and control samples. And it's notable in both laboratory tests and field trials.

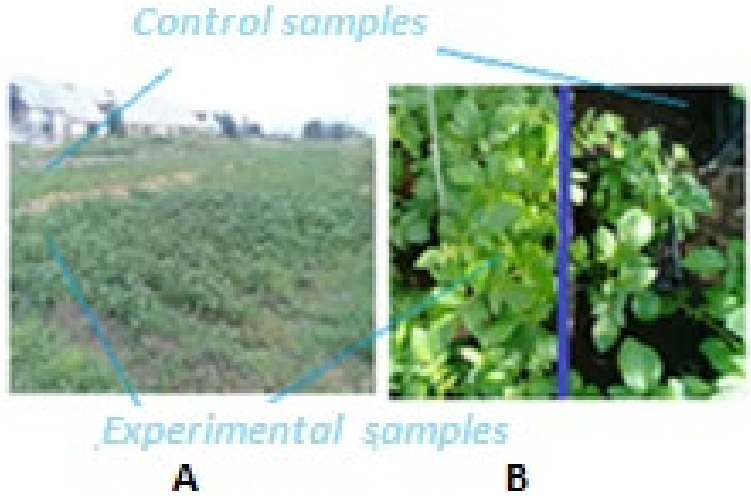

Fig. 5 Greenhouse and field experiments of the phytostimulator on 2 varieties of sowing (A) and callus (B) crops of Solanum tuberosum potatoes

Cream of Tartar is the waste of the wine industry which xxxxxxxmakes it an affordable and inexpensive raw material for obtaining targeted agricultural products. According to literature data. Tartar contains various organic compounds, including amino acids, vitamins and other processed products of yeast and grapes [17].

Based on the literature data, the agricultural preparations based on tartar are successfully used, as, for example, the preparation «Lalvigne Aroma» which is used to improve the aromatic properties of grapes in the process of phenolic ripening [18].

Plant growth regulators are also known such as oxalic, succinic, indoleacetic and others based on various organic acids [19]. Tartaric acid is one of the most important compounds in plant metabolism [20]. Therefore, the intensification of growth is associated with the intensification of metabolism under the influence of tartaric acid.

Conclusions

According to the initial toxicological assessment, these substances are of moderate toxicity and low allergenicity. The stimulating effect of the «Complex» and «Complex Plus» preparation on decorative succulent and the most important agricultural crops was investigated and proved which manifests itself in the intensification of growth processes, an increase in chlorophyll content in green

parts of plants, a shortening of the period between flowering and fruiting, an increase in the biomass growth of both underground and ground parts of the plants. During the usage of complex preparation of foliar feeding which is acting as a microfertilizer, the absence of pests in the test samples was noted which is defined by the effect of the insecticidal component of the preparation. Currently the presented drug is being prepared for state registration and patenting.

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ԲՈՒՅՍԻ ԱՃՆ ԱԿՏԻՎԱՑՆՈՂ ԳԻՆԵԹԹՎԻ ՀԻՄԱՆ ՎՐԱ ՆՈՐ ԿՈՄՊԼԵՔՍԱՅԻՆ ՊԱՏՐԱՍՏՈՒԿԻ ՈՒՍՈՒՄՆԱՍԻՐՈՒԹՅՈՒՆ

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[2]ՀՀ ԳԱԱ «Հայբիոտեխնոլոգիա» ԳԱԿ, «Էկոլոգիական անվտանգություն» լաբորատորիա

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Ուսումնասիրվել է Հայաստանի ազգային պոլիտեխնիկական համալսարանում (ՀԱՊՀ) մշակված, գինեքարից անջատված բնական գինեթթվի վրա հիմնված, «Կոմպլեքս» և «Կոմպլեքս Պլյուս» 2 նոր կոմպլեքսային բույսերի աճի խթանիչ (ֆիտոստիմուլյատոր) պրեպարտները:

Ֆիտոստիմուլյատորի ազդեցությունը՝ տարբեր տաքսոնոմիական խմբերի մի շարք բարձրակարգ ծաղկավոր բույսերի վրա: Կատարվել են մի շարք լաբորատոր և դաշտային փորձարկումներ գյուղատնտեսական մշակաբույսերի, դեկորատիվ բույսերի և դեղաբույսերի վրա՝ կակտուս (*Stapelia grandiflora Masson)*, բուժիչ ալոե (*Aloe vera)*, դեկորատիվ կալանխոե (*Kalanchoe blossfeldiana*, *Kalanchoe daigremontiana)*, կապույտ ագավա (*Agava tequilana)*, ամերիկյան ագավա (*Agava americana L. Trifasciata),* կարտոֆիլ *(Solanum tuberosum)*, սխտոր (Allium sativum), լոբի *(Phaseolus vulgaris)*, ելակ *(Fragaria × ananassa)*, վարունգ *(Cucumis sativus)* և ոսպ *(Lens culinaris)*: Առավելագույն էֆֆեկտը դիտվում է սուկկուլենտ բույսերի համար:

Ըստ նախնական էկոտոքսիկոլոգիական բնութագրից՝ տվյալ միջոցն իրենից ներկայացնում է էկոլոգիապես մաքուր նյութերի խառնուրդ, որն արտադրվել է «կանաչ քիմիայի» մեթոդներով. այն միջին թունավոր և թույլ ալլերգեն է:

Բանալի բառեր. գինեթթու, միկրոպարարտանյութ, գյուղատնտեսական բույսեր, բույսերի աճի խթանիչ (ֆիտոստիմուլյատոր), խելացնող կոմպլեքսներ:

ИССЛЕДОВАНИЕ НОВОГО КОМПЛЕКСНОГО ПРЕПАРАТА НА ОСНОВЕ ВИННОЙ КИСЛОТЫ ДЛЯ АКТИВАЦИИ РОСТА РАСТЕНИЙ

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В статье рассмотрено влияние двух комплексных стимуляторов роста растений (фитостимуляторов) «Комплекс» и «Комплекс Плюс», полученных на основе природной винной кислоты, выделенной из винного камня, согласно методике, разработанной в Национальном политехническом университете Армении (НПУА), на рост ряда высших цветковых растений.

Был проведен ряд лабораторно-полевых испытаний сельскохозяйственных культур, декоративных и лекарственных растений: кактуса (*Stapelia grandiflora Masson)*, лекарственного алоэ (*Aloe vera)*, декоративного каланхоэ (*Kalanchoe Blossfeldiana)*, каланхоэ (*Kalanchoe daigremontiana)*, голубой агавы (*Agava tequilana)*, американской агавы (*Agava americana L. trifasciata*), картофеля (*Solanum tuberosum)*, чеснока (*Allium sativum)*, фасоли (*Phaseolus vulgaris)*, клубники (*Fragaria × ananassa)*, огурцов (*Cucumis sativus)* и чечевицы (*Lens culinaris)*. Максимальный эффект наблюдался у суккулентов.

Согласно данным предварительной экотоксикологической характеристики, данное средство представляет собой смесь экологически чистых веществ, произведенных по технологиям «зеленой химии», обладает умеренной токсичностью и слабой аллергенностью. В настоящее время препараты «Комплекс» и «Комплекс Плюс» готовятся к государственной регистрации и патентованию в РА.

Ключевые слова: винная кислота, микроудобрения, сельскохозяйственные растения, стимулятор роста растений (фитостимулятор), хелатные комплексы.

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