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ECONOMIC JUSTIFICATION FOR THE USE OF BIOLOGICAL FUNGICIDES AND PLANT GROWTH STIMULANTS FOR GROWING SUNFLOWER

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ABSTRACT

The study presents economic substantiation of applying environmentally friendly plant growth stimulators in combination with biological fungicides in sunflower production under conditions of the South of Ukraine. The field research was conducted at Kherson State Agricultural University (Ukraine) in 2017 – 2019 under conditions of dark chestnut alkaline soils with the humus content of 2.5% in the plough layer. The results of the three-year field research prove that the net profit reached the absolute maximum in the variant of the hybrid LG 5580 under conditions of applying the bio-fungicide Fitotsyd-r with the stimulator Ahrostymulin at the stage of budding and amounted to $1081/ha. In this case the cost price was the least – $141.6/ha, and the profitability level was the highest – 196%.

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In the areas sown with the hybrid Tunca the variant with the combination of Fitotsyd-r and the growth stimulator Ahrostymulin also provided a positive result, but it yielded a little to the combination of the preparations Fitosporyn / Ahrostymulin: the net profit was $579.7/ha, the price cost made $203.4/ha and the profitability was 106 %.On the whole this analysis makes it possible to maintain that additional costs related to purchasing and applying fertlizers are totally compensated owing to the cost of an increase in the yield.

Keywords: Environmentally friendly fertilizers; Sunflower; Production costs; Product cost; Net profit; Profitability

1. INTRODUCTION

An important place in increasing yields and improving product quality belongs to the improvement of technologies for growing agricultural crops. Success in obtaining high stable yields in the face of rising energy prices can be achieved with the help of resource-saving technologies, which include a high level of agricultural technology, optimal fertilization rates and an integrated system for protecting plants from diseases, weeds and pests, and the introduction of new varieties and hybrids.

Modern conditions of agricultural production require measures to ensure the most realistic level of crop productivity, high quality grain and seeds, while reducing the cost of growing them. One of the most effective measures for solving these problems in the cultivation of agricultural crops is the use of biological growth-regulating preparations for inoculation of seeds and foliar feeding of plants.

Currently, the use of biological products is an integral aspect of modern crop production, they optimize plant nutrition, stimulate their development and increase productivity. In the context of climate change, taking into account modern scientific and practical approaches, taking into account the yield potential of modern varieties and hybrids, an important problem is the search for adaptive elements of their cultivation technologies, which provide an increase and stabilization of the productivity of agricultural crops by years of cultivation using modern multifunctional growth-regulating biological preparations, for which and research was directed.

2. LITERATURE REVIEW

The means of regulation of nutrient content in soils, nutrient intake by plants with different ratio is a system of nutrition regime. It has a radical impact on the level of supplying

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plants with mineral elements. But practice shows that mineral fertilizers do not solve all the problems related with the optimization of nutrition regime. During their growing season plants are under stress for quite a long time, their nutrition under such environmental conditions becomes less efficient (JASPERS; KANGASJÄRVI, 2010; CHIAPPERO, et al., 2019).

The task of a farmer is to provide suitable conditions for plants to overcome stress as fast as possible (RADY, 2012; HANSERUD et al., 2018).

There is a number of factors causing stress-reactions of plant organisms during the growing season. By the nature of impact they are divided into chemical (salts, gases, xenobiotics); biological (negative impact of pests, pathogenic agents, competition with other plants) and physical (excess or deficiency of moisture, temperature regime, light and radioactivity) (WHIPPS, 1997; GOSWAMI; DEKA, 2020).

Under these conditions it is necessary to apply complex multi-functional fertilizers, containing mixtures of organic, humic and fulvic acids, a number of micro-elements in a chelated form in their formulation causing their fungicide action and activating microorganisms. It ultimately leads to stimulation of growth processes and contributes to the overcoming stress phenomena of plant organisms (KUMAR et al., 2015; DOMARATSKIY, et al., 2018; DOMARATSKIY, et al. 2019).

Two trials were conducted on sunflower (Helianthus annuus L., 'Dwarf Sunsation') to compare the influence and interaction of arbuscular mycorrhizal fungi (AMF) inoculation with organic and conventional synthetic fertilisers on plant growth and development. Commercially produced AMF was applied as a spore application with liquid organic fertiliser (Quadshot®) applied at 0 and 20 L ha-1 in Trial 1; and 0, 20 L ha-1 and 40 L ha-1 in Trial 2, or liquid synthetic (inorganic) fertiliser (SF) applied at 0 or 100% concentration (Hoagland's solution regular strength with low P).

Results showed limited interaction between AMF and fertiliser type. Sunflower plants inoculated with AMF and synthetic fertiliser had greater plant height and stem diameter in Trial 1 and leaf chlorophyll content at various assessment times in both trials. The presence of mycorrhizal hyphae and arbuscules increased in sunflower plants grown with AMF inoculation and organic fertiliser. There was a strong treatment influence of AMF inoculation on plant height in Trial 2, and number of nodes, flower head diameter, AMF colonisation and AMF structures in both trials. In addition, SF increased the leaf chlorophyll content, number of nodes

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and flower head diameter in both trials, and flower number in Trial 2 (ABOBAKER, et al., 2018).

Plants are exposed to diverse abiotic stresses like drought, heat, salinity, and high-metal concentrations at different stages of their life cycle. As protection against stress, plants release signaling molecules that initiate a cascade of stress-adaptation responses leading either to programmed cell death or plant acclimation. application of exogenous NO alleviates the negative stress effects in plants and improves antioxidant activity in most plant species. In addition, S-nitrosylation and tyrosine nitration are two NO-mediated posttranslational modification. All these factors are important in protecting plants from diverse stresses and vary with the species (NABI, et al., 2019).

The scientific research conducted in North America establishes that plant growth regulators applied in low concentrations are able to affect the division and growth of cells, their structure and functioning (SMALL; DEGENHARDT, 2018). Direct application of such natural hormones and their synthetic analogs to plant stems, leaves and flowers increases their resistance to biotic and abiotic environmental factors, improves drought-resistance of crops and water-use efficiency (ROSTAMI; AZHDARPOOR, 2019). The studies show that such fertilizers are capable of increasing nitrogen use efficiency, contribute to an increase in root weight and also stimulate the growth and development of lateral roots, assist in enhancing photosynthesis. Organic biostimulants also prove to be helpful to affect plant physio-biochemistry and antioxidative defense system (REHMAN, et al. 2018; GUPTA, et al. 2019).

These substances are usually applied in agriculture, viticulture and horticulture to increase yields under conditions of low agricultural background, moisture deficit and other unfavorable environmental factors (SIDDIQI; HUSEN, 2017; ADNAN et al., 2019). Beyond the inhibitory action against the gibberellin biosynthesis, some plant growth retardants (PGRs) can play an important role in regulating plant responses to abiotic stress through the induction of different tolerance mechanisms (KARIMI, et al. 2019).

Brassinosteroids (BRs) are considered as the 6th group of plant growth regulators with significant growth promoting activity. BRs were initially extensively studied for their profound growth promoting physiological responses viz., growth, yield, seed germination, photosynthesis, senescence, photomorphogenesis, flowering etc.

BRs have been further explored for stress-protective properties in plants against a number of abiotic stresses like heat, chilling, freezing, drought, flooding, oxidative, salt,

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allelochemicals, radiation, light, wind, heavy metals stresses etc. It can be aptly stated that BRs induce plant tolerance to a wide spectrum of stresses. The ever-changing environmental conditions are causing serious damages to the plants as the present stressful environmental conditions are posing unrepairable morphological and anatomical changes wherein the growth and yield of plants is being greatly hampered (VARDHINI, 2017).

Ukraine is one of the leaders in the world export of the products of sunflower processing. The world market expects to receive 5.1 million tons of Ukrainian sunflower oil this season that is by 16% more than the rate of the previous year. An increase in sunflower concentration in the structure of sown areas to 35% will have a negative impact on productivity that will decrease in all biological and economic groups. The gross yield of grains will fall from 27.0 to 20.9 million tons, and there will be an increase in that of sunflower seeds – from 4.5 to 5.8 million tons. Under such conditions the total cost of gross production of grain and oil crops will fall by $0.25 billion (from $3.04 to $2.79 billion).

At first sight the scheme of maximum use of sunflower in crop rotation is not threatening, but this approach is certainly insecure in terms of increasing effect of droughts and spread of specific diseases and pests (MOKLYACHUK et al, 2019).

Crop yield stability in agricultural production aimed at meeting demands of a continuously increasing population of the planet is possible only under conditions of applying fertilizers containing basic nutrients for plants. However, the use of such chemical substances has a negative impact on the environment and human health. Therefore, application of micro-fertilizers of biological origin is considered to be the best substitute for chemical fertilizers as an environmentally friendly method of growing crops and increasing soil fertility.

These preparations intensify growth processes of plant organisms by means of different direct and indirect mechanisms of plant growth stimulation such as biological nitrogen fixation, production of various plant growth hormones, different hydrolytic ferments etc. Application of biological preparations increases the potential of vital nutrients supply in appropriate amounts to boost crop yields without damaging the environment (DIVJOT et al 2020).

The purpose of the study is to substantiate an economic component of using environmentally friendly preparations in technological schemes of sunflower production.

3. MATERIALS AND METHODS

The field research was conducted in the research field of Kherson State Agricultural University (GPS-coordinates: 46.699024, 32.451419) in 2017 – 2019. The soil on the research

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plots is dark chestnut alkaline. The humus content is 2.5% in the plough layer of the soil, the content of slightly hydrolyzed nitrogen is 35, the content of movable phosphorus – 32 and that of metabolic potassium – 430 mg/kg of the soil.The density of one-meter layer of the soil is 1.35, and its solid phases are 2.66 g/cm3, the general porosity – 49–50%. The reaction of the soil solution in the topsoil is close to neutral (pH 7.0). It is alkaline closer to the profile – (pH 7.4 – 7.9).

The hydrolytic acidity is 0.36–1.9 mg-eq per 100 g of the soil. The soil permeability for the first hour of absorption is 1.3-2.2 mm/min. Groundwater is deeper than 5 m and does not affect soil-formation processes. The climate is moderate and arid. Sowing of sunflower was carried out at the beginning of the optimal time in the last decade of April. The plants grew without irrigation.

The average annual air temperature is 10.30 C, and accumulation of active air temperatures starts in the 3rd decade of March and finishes in the 2nd decade of November.The experimental research was carried out by means of a tree-factor field experiment: Factor A – preparations: – control (clean water), Fitosporyn, Fitosporyn \ Hart Super, Fitosporyn / Ahrostymulin, FitoHelp, FitoHelp \ Hart Super, FitoHelp \ Ahrostymulin, Fitotsyd- r, Fitotsyd –r \ Hart Super, Fitotsyd-r \ Ahrostymulin; Factor B – sunflower hybrids of the company “Limagrein” (Tunca, LG 5580); Factor C – the period of applying preparations (seed treatment, the stage of budding).

The seeds were treated according to the research scheme – a day before seeding, the plant treatment – at the stage of budding (9–10 pairs of true leaves). Harvesting and accounting of the crop was carried out mechanically using a combine harvester with a device for mowing sunflower. The plots were placed by the block-splitting method. The exchange rate of the NBU was 1$ – 24.32 UAH.

4. RESULTS AND DISCUSSION

Application of bio-preparations is related to the necessity of increasing production costs anf. bio-fertilizers are substances with a low selling price. The calculation of the cost of fertilizers for treating sunflower seeds and plants is given in Table 1.

It is necessary to add the cost of the crop treatment to the obtained results. Spraying the crops with 200 l/ha of the treatment solution costs $11.5/ha. Therefore, the total costs of applying Fitosporyn will be $14.1/ha; Fito Help –$19.4/ha; Fitotsyd-R – $15.4/ha.

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Table 1: Calculation of the cost of fertilizers (prices on January, 1st 2019)

Fertilizers	Market price, US dollar/L	The dose of the fertilizer		The cost per 1 ha, US dollar	
		Per 1 t of seeds, l	Per 1ha of crops, l	Seed treatment	Plant treatment
Fitosporyn	6.6	0.15	0.4	0.1	2.6
Fito Help	15.8	0.8	0.5	1.2	7.9
Fitotsyd-R	13.2	0.15	0.3	0.2	3.9
Hart Super	33.7	0.02	0.8	0.1	26.9
Ahrostymulin	79	0.02	0.2	0.2	15.8

Source: Prepared by the authors (2019)

The stimulators were applied with bio-fungicides, therefore there were not additional costs.

The main aim of economic evaluation is to compare the product cost and production costs (Table 2).

Table 2: Sunflower product cost depending on bio-fertilizers (average for 2017–2019)

Fertilizers	The period of applying	Tunca			LG 5580		
		Productivity, t/ha	The cost of 1 t of seeds, US dollar	The product cost, US dollar/ha	Productivity, t/ha	The cost of 1 t of seeds, US dollar	The product cost, US dollar/ha
Control (clean water)		2.26	419.7	948.6	2.8	419.7	1179
Fitosporyn	seeds	2.4	419.7	1007	2.9	419.7	1200
	budding	2.5	419.7	1070	3.3	419.7	1406
Fito Help	seeds	2.4	419.7	1020	2.9	419.7	1196
	budding	2.5	419.7	1057	3.4	419.7	1423
Fitotsyd-R	seeds	2.3	419.7	982	2.9	419.7	1221
	budding	2.4	419.7	1003	3.4	419.7	1422
Fitosporyn / Ahrostymulin	seeds	2.5	419.7	1049	3.3	419.7	1376
	budding	3.0	419.7	1267	3.6	419.7	1532
Fitotsyd-R / Ahrostymulin	seeds	2.5	419.7	1049	3.4	419.7	1439
	budding	2.7	419.7	1125	4.0	419.7	1632

Source: Prepared by the authors

The calculation of the product cost with the determination of quality indexes was done for the sunflower with the fat content of 48%. This result was provided by the laboratory of the LLC “Nibulon”. If oil fat is lower by 1%, the price will be lower by 1/48*100 = 2.08%, and vice versa, the higher oil fat content is, the higher the price will be. But currently there is not such a system, therefore we used one price for all cases – $419.7.

An important element of economic analysis is the calculation of direct production costs. At first, according to the regulations, we calculated the total costs for growing, harvesting and transporting sunflower products and additional costs related to purchasing and applying

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fertilizers, and also, to harvesting and transporting additional products. The seed cost of the hybrids Tunca – $131.6 per the sowing unit and LG 5580 – $135.8 per the sowing unit are also referred to the difference in the costs.

The production costs of the variants in the experiment were equal to $508.9/ha. In our further calculations we added the cost of additional expenses, mentioned earlier, to this sum. Thus, the level of the costs for each variant of the experiment is the following (Table 3).

Table 3: Level of the direct production costs for sunflower depending on the hybrids and fertilizers (average for 2017–2019), US dollar/ha

Fertilizers	Periods of application	Tunca				LG 5580			
		Total costs	Purchasing and applying fertilizers	Additional harvesting	In total	Total costs	Purchasing and applying fertilizers	Additional harvesting	In total
Control (clean water)		508.9	-	-	508,9	510.6	-	-	510.6
Fitosporyn	1*	508.9	0.1	6.0	515,0	510.6	0.1	10	520.7
	2*	508.9	14.1	12.3	535,3	510.6	14.1	14.6	539.3
Fito Help	1	508.9	1.2	5.1	515,2	510.6	1.2	8.3	520.1
	2	508.9	19.4	13.0	541,3	510.6	19.4	16.5	546.5
Fititsyd-R	1	508.9	0.2	5.3	514,4	510.6	0.2	7.7	518.5
	2	508.9	15.4	13.9	538,2	510.6	15.4	17.3	543.3
Fitosporyn / Ahrostymulin	1	508.9	0.28	15.9	525,08	510,6	0.28	16.7	527.6
	2	508.9	29.9	18.1	556,9	510.6	29.9	21.1	561.6
Fititsyd-R / Ahrostymulin	1	508.9	0.37	15.1	524,37	510.6	0.37	19.7	530.7
	2	508.9	19.4	16.7	545	510.6	19.4	20.8	550.8

***:** *1* – seed treatment; 2* – plant treatment at the stage of budding*
Source: Prepared by the authors

The difference in the direct production costs between the control and the research variants reaches the maximum of $459.6 per hectare in the hybrid Tunca, and $5.1 per hectare in the hybrid LG 5580. It is worth noting that we calculated only direct production costs without considering the overheads: salaries for managers, tax payments, advertising, sales etc. (Table 4).

The investigation of the degree of impact of these factors on economic efficiency is a complicated but a very important stage in the development of every enterprise in particular and Ukraine AIC on the whole.

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Examining the experience of agricultural activity and the level of profitability of agricultural production we maintain that it is necessary to create a correlation and regression model of profitability of sunflower production with application of bio-preparations.

Table 4: The basic economic indicators of sunflower production with application of bio-preparations (the average for 2017-2019)

Fertilizers	Periods of aplyication	Tunca					LG 5580				
		Production costs, US dollar/ha	Product cost, US dollar/ha	Net profit, US dollar/ha	Product cost price, US dollar/ha	Relative level of profitability,%	Production costs, US dollar/ha	Product cost, US dollar/ha	Net profit, US dollar/ha	Product cost price, US dollar/ha	Relative level of profitability,%
Control (clean water)		508.9	948.6	438.4	225.2	86	510.6	1179	668	181.7	131
Fitosporyn	seeds	515.1	1007	492.3	214.6	96	520.7	1200	679.7	182.1	131
	budding	535.5	1070	534.8	210.1	100	539.4	1406	866.7	161.0	161
Fito Help	seeds	515.3	1020	504.6	212.1	98	520.1	1196	676.1	182.5	130
	budding	514.4	1057	516.3	214.8	95	546.5	1423	876.4	161.2	160
Fitotsyd-R	seeds	514.5	982.2	467.6	219.9	91	518.5	1221	702.9	178.1	136
	budding	538.4	1003	464.7	225.2	86	543.4	1422	879.5	158.9	162
Fitosporyn / Ahrostymulin	seeds	525.2	1049	524.1	210.0	100	527.6	1376	849	160.8	161
	budding	557.0	1267	710.5	184.4	127	561.5	1532	970.4	153.8	173
Fitotsyd-R / Ahrostymulin	seeds	524.5	1049	524.8	209.7	100	530.7	1439	908.9	154.7	171
	budding	545.1	1124	579.7	203.4	106	550.8	1633	1081	141.6	196

Source: Prepared by the authors (2019)

The data of the field research for 2017-2019 was used to conduct this research and create the model.

The developing multiple regression taking into consideration the profitability of sunflower production Dependent variable was used to determine the profitability of sunflower. This index was chosen because it reflects efficiency and appropriateness of agricultural activity. In order to create a multi-factor correlation and regression model we suggested using three independent variables: X1 – productivity, c/ha (an indirect index of soil fertility), X2 – production costs (US dollar per hectare), X3 – the price of the products sold (US dollar for 1 centre) (an indirect index of product quality).

The multiple regression was performed on the basis of the data of the field research conducted in the research field of Kherson State Agricultural University in 2017 – 2019.

The model of the multifactor linear regression was created by means of the statistical method for measuring correlations (correlation and regression analysis).

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To calculate the correlation coefficient, the following formula is used (by the example of calculating the correlation x2y):

$$r x_2 y = \frac{x_2 y - \bar{x}_2 \bar{y}}{\tilde{\sigma} x_2 * \tilde{\sigma} y} \qquad (1)$$

The calculations of the correlation coefficients (the matrix of the pair correlation) are given in Table 5. The proximity of the correlation coefficients to 1 between some factors indicates to a strong connection between them or its multiplicative character.

Table 5: Matrix of the pair correlation

Tunca	y	x_1	x_2	x_3
y	1	0.962	0.837	0.671
x_1	0.962	1	0.833	0.847
x_2	0.837	0.833	1	0.602
x_3	0.671	0.847	0.602	1
LG 5580	y	x_1	x_2	x_3
y	1	0.988	0.270	0.821
x_1	0.988	1	0.367	0.899
x_2	0.270	0.367	1	0.584
x_3	0.821	0.899	0.584	1

Source: Prepared by the authors (2019)

Considering the values of the matrix of the correlation coefficients can draw a conclusion that the most significant factors affecting profitability are the following: productivity, the price of the products sold and production costs.

The initial factors were the ones having the coefficient of the pair correlation within the range of 0.4 to 0.9. The profitability of sunflower was chosen as a dependent variable, productivity per hectare, production costs and the price for 1 t were chosen as independent variables. First of all, assumed that correlation of the dependent variable with other variables is linear, i.e.

$$У = a0 + a1x1 + a2x2 + a3x3 \qquad (2)$$

Unknown coefficients are determined by means of the method of least squares the essence of which is to minimize the sum of the squares of the deviations of the actual data from the theoretical data, obtained by the regression equation. The minimization criterion looks like this:

$$S = \sum (y - y_p)^2 \rightarrow \min . \qquad (3)$$

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Considering the function S as the function of the parameters a0, a1, a2 and making mathematical transformations (differentiations), we have a system of equations:

$$\frac{\partial S}{\partial a_i} = 0, \quad i = 0,1, \tag{4}$$

Transforming this system, we have obtained a system of normal equations for the stage of seeds. Solving it we find necessary coefficients. On this basis we have obtained the function for Tunca and LG 5580:

У = 48.507 +63.369x1 – 0.0041x2 – 0.005x3

У = 117.977 +77,83x1 – 0.017x2 +6.84x3

The most complicated step is interpreting the equation, i.e. translating it from the language of statistics into the language of economics. The regression coefficient – the parameter a0 is a reference point in the model on the diagram of the correlation field; the parameters a1-a3 show how the values of the dependent variable change on the average when the independent variable increases by the unit of its measurement.

The more the value of the regression coefficient is, the more considerable impact this factor has on the dependent variable. The sign before the regression coefficient indicating to the character of the impact on the dependent variable has special importance. The coefficient of x1 is equal to 77.83. It means that the dependent variable will increase by 77.83% when the productivity increases by 1%, the profitability will increase by 0.017% when the production costs per 1 t decrease by 1% and the profitability will increase by 6.84% when the selling price increases by 1 %.

Therefore, it is necessary to check the adequacy of this model. The following variants are possible:

- This model is adequate on the whole on the basis of checking it by the F-test of Fisher, and all the regression coefficients are significant. Such a model can be used for making decisions and creating forecasts;
- The model is adequate by the F-test of Fisher, but some regression coefficients are insignificant. In this case the model is suitable for making some decisions, but it is not good for creating forecasts;

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- The model is adequate by the F-test of Fisher, but all the regression coefficients are insignificant.

Therefore, the model is considered as totally inadequate. The coefficient of multiple correlation is 0.97, indicating that there is correlation of the dependent variable with the independent variables. But we cannot draw conclusions about the adequacy of the model on this basis.

The checking the adequacy of the model with testing the significance of each regression coefficient was done by means of Student's t-test:

$$t_p = \frac{|a_i|}{\sqrt{\sigma^2_{a_i}}}, \text{ де } \sigma^2_{a_i} = \frac{\sigma^2_y}{k} \quad (5)$$

The coefficient of the model will be considered as statistically significant if tp≥ tkp =0.619.

The calculated tpi are equal to 2.107; 35.589; -0.222; -0.601 respectively, i.e. only a1, a2 meet the requirements of significance.

By the F-test of Fisher we obtained F=45.12. Comparing it with the Table value of the Fisher-Snedecor distribution (F-distribution) F>F Table, where F Table=2.99 with the degree of probability of 95%. It proves that the model is adequate by the F-test of Fisher. The average approximation error ε =1.068%, though it should not exceed 12-15%.

The coefficient of multiple correlation is rather high, the model is adequate on the whole on the basis of checking it by the F-test of Fisher, and all the regression coefficients are significant. The average error does not exceed the established norm. Therefore, such a model can be used for making decisions and plans or creating forecasts.

5. CONCLUSIONS

The main indicator of economic suitability of this or that measure is a net profit. Neither cost price, nor profitability, but a net profit determines the real difference between the product cost and the level of production costs. For three years of the field research this indicator reached the absolute maximum in the hybrid LG 5580 when the bio-fungicide Fitotsyd-r and the stimulator Ahrostymulin were applied at the stage of budding, and it made $1081. In this case the cost price was the least – $141.6, and the level of profitability was the highest –196%.

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The variant with the combination of Fitotsyd-r / Ahrostymulin also provided a positive result in the hybrid Tunca, but it yielded a bit to the combination of the preparations Fitosporyn / Ahrostymulin, and the net profit was $579.7, the cost price – $203.4 and the profitability – 106 %.

On the whole this analysis makes it possible to receive evidence that additional costs, related to purchasing and applying fertilizers, are compensated by an increase in the yields.

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