Indian Journal of Ecology (2020) 47(3): 624-629

Manuscript Number: 3055
NAAS Rating: 4.96

Economic Efficiency of Applying Environmentally Friendly Fertilizers in Production Technologies in the South of Ukraine

Ye. Domaratskiy, O. Kozlova and A. Kaplina

Kherson State Agrarian and Economic University, Ukraine, 73006, Kherson, Stritens'ka str. 23
E-mail: jdomar1981@gmail.com

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 2016-2018 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%.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

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 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 and Kangasjärvi 2010). 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 and 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). 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 and 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 and 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. 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 and Husen 2017, Adnan et al 2019).

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 (Kour 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

MATERIAL AND METHODS

The field research was conducted in the research field of Kherson State Agricultural University in 2016-2018. The soil on the research 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 cm^{-3}, 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. The average annual air temperature is 10.3^0 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). The plots were placed by the block-splitting method. The exchange rate of the NBU was 1$ – 24.32 UAH.

RESULTS AND DISCUSSION

Application of bio-preparations is related to the necessity of increasing production costs. 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. 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).

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

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

growing, harvesting and transporting sunflower products and additional costs related to purchasing and applying 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^{-1}. 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). 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 (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. Examining the experience of agricultural activity and the level of profitability of agricultural

Table 2. Sunflower product cost depending on bio-fertilizers (average for 2016-2018)

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

Table 3. Level of the direct production costs for sunflower depending on the hybrids and fertilizers (average for 2016-2018), US dollar ha^{-1}

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 production we maintain that it is necessary to create a correlation and regression model of profitability of sunflower production with application of bio-preparations. The data of the field research for 2016-2018 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: X_1 – productivity, c/ha (an indirect index of soil fertility), X_2– production costs (US dollar per hectare), X_3 – the price of the products sold (US dollar for 1 centner))(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 2016-2018. The model of the multifactor linear regression was created by means of the statistical method for measuring correlations (correlation and regression analysis).

To calculate the correlation coefficient the following formula is used (by the example of calculating the correlation x_2y):

$$rx_2y = \frac{x2y - \overline{x}_2\overline{y}}{\widetilde{O}x_2 * \widetilde{O}y}$$

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. 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.

$У = a_0 + a_1x_1 + a_2x_2 + a_3x_3$

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:

$$S = \Sigma(y - y_p)^2 \rightarrow \min .$$

Considering the function S as the function of the parameters a_0, a_1, a_2 and making mathematical transformations (differentiations), we have a system of equations:

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

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

Table 4. The basic economic indicators of sunflower production with application of bio-preparations (the average for 2016-2018)

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

function for Tunca and LG 5580 :

$У = 48.507 + 63.369x_1 – 0.0041x_2 – 0.005x_3$

$У = 117.977 + 77,83x_1 – 0.017x_2 + 6.84x_3$

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 a_0 is a reference point in the model on the diagram of the correlation field; the parameters a_1-a_3 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 x_1 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.
- 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:

$$t_p = \frac{|a_i|}{\sqrt{\sigma_{ai}^2}}, \pi e \sigma_{ai}^2 = \frac{\sigma_y^2}{k}$$

The coefficient of the model will be considered as statistically significant if $t_p \geq t_{kp}$ =0.619.The calculated t_{pi} are equal to 2.107; 35.589; -0.222; -0.601 respectively, i.e. only a_1, a_2 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.

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

CONCLUSION

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%. 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.

REFERENCES

Adnan M, Islam W, Shabbir A, Khan KA, Ghramh HA, Huang Z, Chen H and Lu G 2019. Plant defense against fungal pathogens by antagonistic fungi with *Trichoderma* in focus. *Microbial Pathogenesis* **129**: 7-18.

Kour D, Rana KL, Yadav AN, Yadav N, Manish Kumar, Vinod Kumar, Vyas P, Dhaliwal HS and Saxena AK 2020. Microbial biofertilizers: Bioresources and eco-friendly technologies for agricultural and environmental sustainability. *Biocatalysis and*

Agricultural Biotechnology **23**: 1-11.

Domaratskiy EO, Bazaliy VV, Domaratskiy OO, Dobrovol'skiy AV, Kyrychenko NV and Kozlova OP 2018. Influence of mineral nutrition and combined growth regulating chemical on nutrient status of sunflower. *Indian Journal of Ecology* **45**(1): 126-129.

Domaratskiy Ye, Berdnikova O, Bazaliy V, Shcherbakov V, Gamayunova V, Larchenko O, Domaratskiy A and Boychuk I 2019. Dependence of winter wheat yielding capacity on mineral nutrition in irrigation conditions of southern Steppe of Ukraine. *Indian Journal of Ecology* **46**(3): 594-598.

Goswami M and Deka S 2020. Plant growth-promoting rhizobacteria-alleviators of abiotic stresses in soil: A review. *Pedosphere* **30**(1): 40-61.

Hanserud OS, Cherubini F, Ogaard AF, Müller DB and Brattebo H 2018. Choice of mineral fertilizer substitution principle strongly influences LCA environmental benefits of nutrient cycling in the agri-food system. *Science of The Total Environment* **615**: 219-227.

Jaspers P and Kangasjärvi J 2010. Reactive oxygen species in abiotic stress signaling. *Physiology Plant* **138**: 405-413.

Kumar A, Pathak AK and Guria Ch 2015. NPK-10:26:26 complex fertilizer assisted optimal cultivation of Dunaliella tertiolecta using response surface methodology and genetic algorithm. *Bioresource Technology* **194:** 117-129.

Moklyachuk L, Furdychko O, Pinchuk V, Mokliachuk O and Drag M 2019. Nitrogen balance of crop production in Ukraine. *Journal of Environmental Management* **246:** 860-867.

Rady MM 2012. A novel organo-mineral fertilizer can mitigate salinity stress effects for tomato production on reclaimed saline soil. *South African Journal of Botany* **81:** 8-14.

Rostami S and Azhdarpoor A 2019. The application of plant growth regulators to improve phytoremediation of contaminated soils: A review. *Chemosphere* **220**: 818-827

Siddiqi KS and Husen A 2017. Plant response to strigolactones: Current developments and emerging trends. *Applied Soil Ecology* **120**: 247-253

Small C and Degenhardt D 2018. Plant growth regulators for enhancing revegetation success in reclamation: A review. *Ecological Engineering* **118**: 43-51.

Whipps JM 1997. Developments in the biological control of soil-borne plant pathogens. *Advances in Botanical Research* **26**(C): 1-134.

Received 29 May, 2020; Accepted 26 August, 2020