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RESEARCH ARTICLE

The effect of fertilizer system on soybean productivity in the conditions of right bank forest-steppe

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The influence of mineral fertilizer rates and various methods of treatment with a complex of Microfol Combi microelements on the formation of yield of soybean grain of cultivars of different maturity groups has been investigated. The authors have made the energy analysis and determined that the most effective is the model of technology of cultivating soybean of both Horlytzia and Vinnychanka cultivars, which involves the application of mineral fertilizers at the rate of N30P60K60, presowing seed treatment with a complex of Microfol Combi microelements (150 g/ton), along with top dressing with the same preparation at the rate of 0.5 kg/ha at the budding stage that provides for the highest indicator of the energy sowing coefficient amounting to 2.53 for the cultivar of Horlytzia and 2.75 for the cultivar of Vinnychanka, that is, respectively, 0.89 and 0.99 more than check.
Keywords: Soybean; yield; energy efficiency; fertilizer rates; complex of microelements

Introduction

Yield is the result of complex interaction of plants in accordance with their genetic potential and a set of environmental factors. The effect of a complex of growth and development conditions on plants is manifested in changing the parameters of their productivity elements. It is the relationship between the main groups of factors that determines soybean yield capacity. However, the current requirements for environmental safety of products, adapted to European standards, take priority over the development of new technologies for growing this crop since the emergence of new soybean cultivars and new types of fertilizers, requires a number of studies on their use. Therefore, there is a need to develop a technology for growing soybeans, which would provide high yields with the maximum possible environmentally friendly systems of its fertilization (Babych et al., 2000).The level of productivity of agricultural products is one of the main indicators, by which the expediency of application of one or another agricultural activity is revealed (Kalenska et al., 2011). Along with this, numerous studies of scientists have established the influence of weather conditions and a number of elements of crop production technology on their productivity (Starchenkov, 1996; Shannon et al., 1992).

The main indicator showing the energy efficiency of crop cultivation is the energy technology coefficient, which shows the ratio of the energy obtained from the harvest to the amount of total energy that has been spent on the cultivation of this crop. This indicator provides a broader picture of energy adjustments in agricultural production (Smakhlii et al., 2004). Cultivation technology is considered to be energy efficient, if this coefficient is greater than 1 (Tarariko et al., 2006). The rational use of energy resources is one of the most important prerequisites for the growth of agricultural production. In this regard, it is expedient to analyze the energy costs for the cultivation of modem cultivars including soybean cultivars, with the use of already known and new elements of cultivation technology (Shyshkyn, 2003).

Methods available for treatments of waste water

The field studies on the influence of mineral fertilizers and methods of treatment with a complex of Microfol Combi microelements on the productivity of soybean cultivars of different maturity groups were conducted in the experimental field of Vinnytsia National Agrarian University located in the central part of Vinnytsia Region. The territory of the experimental field has a smooth relief. The soil cover of the experimental plot is represented by grey forest clay-loam. In view of this, the weather conditions of the growing season in the years of research were quite contrasting, with the deviation of average daily temperature and precipitation from the average long-term indicators, but these conditions were quite favorable for the productivity of the soybean cultivars under study.

According to the agrochemical survey, the tilth top soil has the following physical and chemical indicators: the content of humus (by Tiurin) is 22.02-2.15%, alkaline hydrolyzed nitrogen (by Cornfield) is equal to 60-67 mg/kg, mobile phosphorus and exchangeable potassium (by Chyrykov) are 149-155 and 80-90 mg per 1 kg of soil, respectively, and the pH of salt extraction is 5-6.0. Hydrolytic acidity is equal to 1.10-1.21 mg-eq per 100 g of soil. The weather conditions of the growing season in the years of research were quite contrasting, with the deviation of the average daily temperature and precipitation from the average long-term indicators, but these conditions were quite favorable for the growth, development and formation of productivity of the soybean cultivars under study. The field studies were conducted during 2012-2014 in the experimental field of Vinnytsia National Agrarian University. The action and interaction of the three factors: A-cultivars; B-mineral fertilizer rates; C-methods of treatment with a complex of microelements, were studied during the research. The pre-sowing treatment of seeds and foliar fertilizing were carried out according to the field trial design (Table 1).

Table 1. Field trial design.

Factor A-	**Factor B-mineral fertilizer**	**Factor C-methods of treatment with a complex of microelements**
1. Horlytzia	1. without fertilizers (check)	1. without treatment (control)
2.Vinnychanka	2. $P_{60}K_{60}$	2. pre-sowing seed treatment+foliar fertilizing with Microfol Combi (150 g/t)
	3. $N_{30}P_{60}K_{60}$	3. foliar fertilizing with Microfol Combi (0.5 kg/ha)
		4. pre-sowing seed treatment+foliar fertilizing with Microfol Combi

The gradation of factors is 2 × 3 × 4. The number of experience replications is four. The placement of variants is systematic in three tiers. The accounting area is 25 m^2, total area amounts to 40 m^2. The soil preparation and tilling for soybeans are generally accepted for the Forest-Steppe Zone of Ukraine and aimed at maximum weed killing, soil surface smoothing and water conserving that in turn have created the favorable conditions for plant growth and development.
The conventional methods, namely the method of field experience of (Dospekhov, 1985), were applied during the research, and the energy assessment of soybean cultivation was made according to the methods of O. K. Medvedovskyi and P. I. Ivanenko (1988).

Result and discussion

Our studies conducted in the conditions of Right Bank Forest-Steppe on grey forest soils suggest that the magnitude of yield of soybean cultivars of different maturity groups largely depends on the hydrothermal conditions of the years of research and factors studied, namely, fertilizer rates and different ways of treatment with a complex of Microfol Combi microelements.
Thus, on average during 2012-2014, the grain yield capacity ranged from 1.64 to 3.01 t/ha for the cultivar of Horlytzia and from 1.73 to 3.22 for the cultivar of Vinnychanka (Table 2).

Table 2. Soybean grain yield depending on fertilizer application and treatment with a complex of microelements, t/ha.

Level of fertilizing (Factor B)	**Treatment with a complex of microelements (Factor C)**	**Years**			**Average**	**± to control**
		2012	**2013**	**2014**		
Horlytzia (Factor A)						
Without fertilizers	1	1.49	1.74	1.69	1.64	-
	2	1.55	1.81	1.75	1.7	0.06
	3	1.61	1.87	1.8	1.76	0.12
	4	1.64	1.92	1.86	1.81	0.17
$P_{60}K_{60}$	1	2.12	2.45	2.39	2.32	0.68
	2	2.26	2.64	2.56	2.49	0.85
	3	2.34	2.7	2.62	2.55	0.91
	4	2.45	2.83	2.79	2.69	1.05
$N_{30}P_{60}K_{60}$	1	2.29	2.68	2.59	2.52	0.88
	2	2.5	2.91	2.82	2.74	1.1
	3	2.61	3.02	2.95	2.86	1.22
	4	2.72	3.2	3.11	3.01	1.37
Vinnychanka (Factor A)						
Without fertilizers	1	1.59	1.83	1.77	1.73	-
	2	1.63	1.9	1.81	1.78	0.05
	3	1.7	1.99	1.92	1.87	0.14
	4	1.74	2.04	1.98	1.92	0.19
$P_{60}K_{60}$	1	2.33	2.63	2.56	2.51	0.78

	2	2.5	2.84	2.74	2.69	0.96
	3	2.61	2.93	2.85	2.8	1.07
	4	2.65	3.05	2.97	2.89	1.16
$N_{30}P_{60}K_{60}$	1	2.53	2.85	2.77	2.72	0.97
	2	2.74	3.09	3.02	2.95	1.22
	3	2.83	3.25	3.12	3.07	1.34
	4	2.96	3.41	3.29	3.22	1.49
HIP0.5 t/ha	2012	A=0,052, B=0,064, C=0,074, AB=0,0,90, AC=0,104, BC=0,128, ABC=0,180.				
	2013	A=0,040, B=0,050, C=0,057, AB=0,0,70, AC=0,081, BC=0,099, ABC=0,140.				
	2014	A=0,047, B=0,057, C=0,066, AB=0,0,81, AC=0,094, BC=0,115, ABC=0,162.				

Note: 1. Without treatment; 2. Seed treatment with Microfol Combi; 3. Foliar fertilizing with Microfol Combi; 4. Seed treatment+foliar fertilizing with Microfol Combi.

The use of both mineral fertilizers and a complex of microelements significantly increased the level of grain productivity of soybean cultivars. Thus, the application of phosphate-potassium fertilizers at the rate of P60K60 ensured an increase in the soybean yield, on average, by 0.68-0.78 t/ha, while the use of additional starter of nitrogen N30 contributed to an increase in yield, respectively, by 0.19-0.20 t/ha compared to options where only phosphorus-potassium fertilizers were used, and by 0.88-0.97 t/ha compared to the check (HIP0.5 0.057-0.074 t/ha).

Along with a significant increase in grain productivity, depending on the rates of mineral fertilizers, the pre-sowing seed treatment (150 g/t) and foliar fertilizing (0.5 kg/ha) with Microfol Combi had a positive effect on the formation of this indicator. Thus, seed treatment with Microfol Combi prior to sowing ensured the increased soybean grain yield by 0.05-0.23 t/ha, or by 2.8-8.4% in comparison with the check, depending on cultivars and the level of mineral nutrition. Along with this, foliar fertilizing at the budding stage provided an increase in the level of grain yield depending on cultivars and mineral fertilizer rates, respectively, by 0.12-0.35 t/ha, or by 7.3-12.8%.

The most effective technological method turned out to be the combination of pre-sowing seed treatment along with foliar fertilizing, since under these conditions there was the greatest increase in grain yield, respectively, by 0.17-0.50 t/ha, or 10.3-18.3%. It should be noted that the optimization of nutrition of soybean cultivar plants on the basis of the application of pre-sowing seed treatment and foliar fertilizing with Microfol Combi was the most effective against the complete mineral fertilizing of N30P60K60.

In view of this, on the basis of the research results the highest yields of soybean seeds of both Horlytzia cultivar amounting to 3.01 t/ha, and Vinnychanka cultivar equal to 3.22 t/ha were obtained on the field experiment plots, where the nitrogen and phosphorus-potassium fertilizers at the rate of N30P60K60 were applied, as well as seed treatment and foliar fertilizing with a complex of Microfol Combi microelements, which were, respectively, by 1.37 and 1.49 t/ha more compared to the check (HIP0.5 0.140-0.180 t/ha), were conducted.

The modeling of one or another technology of agricultural crop cultivation should be energetically and economically advantageous.

The energy analysis enables to accurately determine and give an objective assessment of the efficiency of crop cultivation, to conduct a comparative assessment of the proposed elements of cultivation technology and to reveal the causes of inefficient agricultural production, to perfectly organize and use energy resources, to program energy-intensive techniques and technologies for growing crops including soybeans (Technique of bioenergetic evaluation of technologies of agricultural crop production, 1971, Kulyk et al., 1997).

Based on the detailed analysis of the indicators of energy efficiency of cultivation of soybean cultivars for grain it was determined that on average during the years of research the lowest costs of aggregate energy were in the check variants of the experiment and amounted to 23.08 GJ/ha for the cultivar of Horlytzia, and 22.90 GJ/ha for the cultivar of Vinnychanka, the gross energy yield was respectively 37.86 and 40.32 GJ/ha, and the energy ratio was 1.64 and 1.76.

On the experience variations, where the phosphorus-potash mineral fertilizers at the rate of $N_{30}P_{60}K_{60}$, were applied along with the increased yield of soybean cultivar seeds, the energy output per unit area was increased as well. Thus, on these variations the crops of soybean cultivars accumulated, respectively, 54.48 and 59.44 GJ/ha, the total energy costs of cultivation were equal to 25.52 and 25.34 GJ/ha, the net energy revenue amounted to 28.97 and 34.10 GJ/ha, and the energy planting coefficient was 2.14 and 2.35.

The most effective was the application of a complete mineral fertilizer at the rate of $N_{30}P_{60}K_{60}$, and despite the rising total cost of energy up to 26.60 GJ/ha for the cultivar of Horlytzia and 26.42 GJ/ha for the cultivar of Vinnychanka, the gross energy output from the harvest significantly increased and were, respectively, 59.45 and 64.67 GJ/ha. In this case, the net energy revenues were, respectively, 32.85 and 38.25 GJ/ha, and the energy ratio was equal to 2.23 and 2.45.

The use of a complex of Microfol Combi microelements, along with mineral fertilizers, had a certain influence on the variability of the energy efficiency indicators.

In general, the pre-sowing seed treatment with Microfol Combi (150 g/t) ensured an increase in the gross energy output from the harvest by 3.1-9.4 % depending on cultivars and mineral nutrition. The application of Microfol Combi to foliar fertilizing (0.5 kg/ha) contributed to the increase in the gross energy output, respectively, by 7.6-14.3% compared with the variations without fertilizers (Table 3).

Among the variations without mineral fertilizers and against the application of $N_{30}P_{60}K_{60}$, the experiment variations, where the pre-sowing seed treatment was combined with foliar fertilizing with Microfol Combi, were the most effective that provided an increase in the gross energy output by 10.9-20.5%.

Table 3. Energy efficiency of soybean cultivar cultivation depending on the fertilizing level and methods of treatment with a complex of microelements, on average for 2012 – 2014.

Level of fertilizing	**Treatment**	**Costs of**	**Gross energy output,**	**Net**	**Energ**	**Energy efficiency**
Horlytzia (Factor A)						
Without fertilizers	1	23.08	37.86	14.78	1.64	1.06
	2	23.11	39.43	16.33	1.71	1.1
	3	24.8	40.77	15.97	1.64	1.06
	4	24.83	42.01	17.18	1.69	1.09
$P_{60}K_{60}$	1	25.52	54.48	28.97	2.14	1.38
	2	25.54	58.68	33.14	2.3	1.48
	3	27.23	60.39	33.15	2.22	1.43
	4	27.26	63.72	36.46	2.34	1.5
$N_{30}P_{60}K_{60}$	1	26.6	59.45	32.85	2.23	1.43
	2	26.62	65.06	38.44	2.44	1.56
	3	28.32	68	39.69	2.4	1.53
	4	28.34	71.66	43.32	2.53	1.6
Vinnychanka (Factor A)						
Without fertilizers	1	22.9	40.32	17.41	1.76	1.14
	2	22.93	41.59	18.66	1.81	1.17
	3	24.62	43.74	19.11	1.78	1.14
	4	24.65	45.01	20.36	1.83	1.17
$P_{60}K_{60}$	1	25.34	59.44	34.1	2.35	1.51
	2	25.36	64.13	38.77	2.53	1.63
	3	27.06	66.81	39.75	2.47	1.59
	4	27.08	69.07	41.99	2.55	1.63
$N_{30}P_{60}K_{60}$	1	26.42	64.67	38.25	2.45	1.57
	2	26.45	70.54	44.09	2.67	1.7
	3	28.14	73.64	45.5	2.62	1.67
	4	28.17	77.36	49.2	2.75	1.74

Note: 1. Without treatment; 2. Seed treatment with Microfol Combi; 3. Foliar fertilizing with Microfol Combi; 4. Seed treatment+foliar fertilizing with Microfol Combi

Thus, according to the results of the conducted energy analysis, we have found that the most effective is the model of technology of cultivating soybean of both Horlytzia and Vinnychanka soybean cultivars, which involves the application of mineral fertilizers at the rate of $N_{30}P_{60}K_{60}$, pre-sowing seed treatment with a complex of Microfol Combi microelements (150 g/ton), along with top dressing with the same preparation at the rate of 0.5 kg/ha at the budding stage that provides for the highest indicator of the energy sowing coefficient amounting to 2.53 for the cultivar of Horlytzia and 2.75 for the cultivar of Vinnychanka, that is, respectively, 0.89 and 0.99 more than check.

Conclusions

The best conditions for ensuring the yield capacity of soybean seeds of both Horlytzia cultivar in the amount of 3.01 t/ha and Vinnychanka cultivar-3.22 t/ha and obtaining the highest indicator of the energy sowing coefficient amounting to 2.53 for the cultivar of Horlytzia and 2.75 for the cultivar of Vinnytschanka, are created in Right Bank Forest-Steppe on grey forest soils subject to the application of mineral fertilizers at the rate of $N_{30}P_{60}K_{60}$, presowing seed treatment with a complex of Microfol Combi microelements (150 g/ton), along with top dressing with the same preparation at the rate of 0.5 kg/ha at the budding stage that provides for the highest indicator of the energy sowing coefficient amounting to 2.53 for the cultivar of Horlytzia and 2.75 for the cultivar of Vinnychanka.

References

Babych, A. O., Drobytko, A. V., & Drobytko, O. M. (2000). Formation of soybean yield depending on the selection of cultivars and

technological practices in terms of the South-Western Steppe of Ukraine. Materials of the Third All-Ukrainian Conference "Production, processing and use of soybean for feed and food purposes". Vinnytsa, pp. 9-10.
Dospekhov, B. A. (1985). The methodology of field experiment (with the basics of statistical processing of research results). 5th revised and enlarged edition. M.: Agropromizdat, p. 351.
Smakhlii, O. F., Malynovskyi, A. S., & Kardashov, A. T. (2004). Energetic assessment of agro-ecosystems. Zhytomyr: Publishing house "Volyn", p. 132.
Kalenska, S. M., Novytska, N. V., & Andriets, D. V. (2011). Photosynthetic activity of soybean crops on typical black soils. Scientific Bulletin of the National University of Bioresources and Nature Resource Management of Ukraine, 162(1), 82-89.
Medvedovskyi, O. K., & Ivanenko, P. I. (1988). Energy analysis of intensive technologies in agricultural production. K.: Urozhai, p. 205.
Technique of bioenergetic evaluation of technologies of agricultural crop production (1971). M.: Kolos, 2, 239.
Kulyk, M. F., Babych, A. O., & Semenchuk, V. M. (1997). Methodology of bioenergetic evaluation of livestock product and feed manufacture technologies. Vinnytsa, p. 54.
Starchenkov, E. P. (1996). Problem of symbiotic nitrogen fixation: national economic significance, achievements and prospects of research. Physiology and Biochemistry of Cultivated Plants, 28(1), 36-52.
Tarariko, Yu. O, Horodnii, M. M., & Serdiuk, A. G. (2006). Bioenergetic evaluation of the systems of fertilizers and agricultural technologies; educational edition guidelines. Publishing unit of UVK NAU, p. 34.
Shyshkyn, R. V. (2003). Saving of energy costs in soybean cultivation. Agrarian science, 12, 14-15.
Shannon, D. A., Kueneman, E. A., Wright, M. J., & Wood, C. W. (1992). Fertilization effect of soy bean grown and yield in the southern Guinea savanna of Nigerian Journal of Plant Nutrition, 15(5), 639-658.

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