TECHNOLOGY OPTIMIZATION OF SOYBEAN GROWING FOR GRAIN IN THE WESTERN FOREST-STEPPE OF UKRAINE

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Species technology of soybeans growing in foliar fertilizers application has been studied. Fertilizers have positively influenced the growth and development of plants. Study of chelated fertilizers foliar application during the growing season are promising components of soybeans growing optimization technologies in modern plant selection.

Keywords: *soybean, variety, method of sowing, foliar application, chelated fertilizer*

On the of the 20th and 21st centuries eve the problem of protein is one of the most important challenges for humanity. According to international statistics the world deficit of food protein constitutes 23% [10]. An alternative solution of this problem became a soybean plant (Glycine hispida (l.)).

Amino acid composition of soy protein is the most balanced among all sources of plant protein and its structure is similar to the high-quality animal protein. In consequence, soya is a leader among annual legumes and oil-bearing crops [2].

The analysis of the Ukrainian and world scientific literature demonstrates the vast use of soybeans in such brunches as food and fodder production, medical, cosmetic and industrial. Daily use of soy seeds 210-250 g is able to satisfy the daily needs of the human protein and essential amino acids [3, 4, 11].

There are no secondary measures in the technology of soybeans growing. Any agrotechnical way is important and necessary. It’s impact on the end result – the yield – may experience to greater or lesser extent, depending on the growing conditions.

Optimization of species technologies, namely the study of the new varieties, their potential opportunities and also sowing method as well as making foliar

application on the background of basic fertilization are of great importance for modern plant selection.

As the influence of mineral fertilizers is well studied, but the implementation species capacity does not meet the maximum possible level, there is a need for a study of the soybean nutrition by micronutrients during the vegetation period. The basis for nutrition in the vegetation period is micronutrient fertilizers in chelated forms making it possible to totally assimilate them.

According to V.V. Marchenko and O. M. Tkachenko, 80% of the nutrients digested by soybeans in the period between beans tying and their physiological ripennes. In this period the plants need additional nutrients, so effective will be makeup with mineral fertilizers with the ratio of nitrogen, phosphorus and potassium respectively 10:1:3 [7].

Elements for puff application is 10 times more effective than making them in the soil, where they can bind to the unavailable compounds. Foliar fertilization with nitrogen is especially effective on healthy plants that are well stocked with other nutrients [6].

Purpose of the study is to research the soybean productivity depending on sowing type and foliar feeding in the South-West Forest-Steppe. Double spraying of yields will optimize the plants nutrition in critical for feeding plant phase of growth. Application of chelated fertilizers in the flowering and beans forming phases will allow to fully assimilate the fertilizing elements that will affect the processes of flowering and formation of beans.

Materials and research methods. Research of technology optimization of soybean growing for grain was carried out on experimental field Podilsky State Agrarian Technical University during 2009-2013. Such soybeans varieties as Podilska 1, Zolotysta, Elena, Omega vinnytska were used as a material for research. The seeding on the research areas was conducted in two ways – a common rowing with a width of 15 cm between rows and broad rowing with a row width of 45 cm. During flowering and beans formation such fertilizers as Oil Nutrìvant Plus, Reakom-R-soya and Basfolìar 6-12-6 were dressed. Field

experiments were established according to generally accepted methods [4] following the multiple scheme in four times repetition. The elementary plot sown area amounted to 65,4 m^2, the accounting area is 50,0 m^2. Mineral fertilizers in the norm of $N_{30}P_{60}K_{60}$ were used in fertilization practice. Selection and analysis of plants according to the elements of harvest structure were carried out by the State Species Testing and agricultural crops methods. Harvest records conducted by methods of continuous collection and weighting plants from each plot.

The research results. The need for plant nutrient elements of soy during the growing season is divided into three major periods: germination-budding – low level; bloom- beans forming– intense level and plumping of seeds-ripening - medium level. So taking into account of this process a foliar application is an additional source of obtaining the required elements.

Taking into account the photosynthesis process as a basis for the creation of biological substances such indicators as the formation of photosynthetic capacity and photosynthesis net productivity determination should be considered. Formation of photosynthetic capacity (PP) and determining the net productivity of photosynthesis (**NPP**) was determined by the formula: $\boldsymbol{Ф = Л_{ср} \times T_в}$ [1] $\boldsymbol{ЧПФ = \frac{M_2 - M_1}{0{,}5Д \times (П_{Л1} + П_{Л2})}}$ [8]. Accounting harvest was performed by continuous collection and weighing of each plot. Statistical analysis of the results was performed using the computer program Statistica-6.

Photosynthetic potential rate characterizes the potential capacities of soybean varieties photosynthetic leaf apparatus and is the sum of daily entire leaves planting area indicators for all the growing season or only for a part of it. In our research photosynthetic potential applying broad rowing method of sowing under control amounted for the Podilska 1 variety – 2,225 million m^2 of days/ha, Zolotysta – 2,175, Elena is 2,135, Omega vinnytska – 2,288 million m^2 of days /ha (table 1).

Positive dynamics of photosynthetic potential increase was observed between rows narrowing from 45 cm to 15 cm. On controlling, i.e. in areas without

foliar feeding, the photosynthetic potential was for Podilska 1 – 2,293 million m^2-nam/ha, Zolotysta – 2,220, Elena – 2,175, for Omega vinnitska – 2,327 million m^2 days/ha.

1. Formation of photosynthetic capacity and net photosynthetic productivity depending on the variety, method of sowing and foliar feeding (average for 2009 – 2013)

Variations of foliar feeding	Phase of beans formation							
	Podilska 1		Zolotysta		Elena		Omega vinnytska	
	PP*	NPP**	PP*	NPP**	PP*	NPP**	PP*	NPP**
String method of sowing (15 sm)								
Without feeding (control)	2,293	10,13	2,220	9,80	2,175	9,60	2,327	10,43
Nutrivan Plus Oil	2,318	10,23	2,233	9,86	2,178	9,62	2,336	10,57
Reacom-R-Soya	2,319	10,24	2,236	9,87	2,184	9,64	2,340	10,53
Baspholiar 6-12-6	2,336	10,31	2,241	9,89	2,190	9,66	2,345	10,61
Wide-row method of sowing (45 см)								
Without feeding (control)	2,225	9,82	2,175	9,60	2,135	9,42	2,288	10,10
Nutrivant Plus Oil	2,250	9,93	2,187	9,66	2,144	9,47	2,295	10,16
Reacom-R-Soya	2,253	9,94	2,191	9,67	2,152	9,50	2,300	10,13
Baspholiar 6-12-6	2,272	10,03	2,200	9,71	2,159	9,54	2,311	10,21

PP* - Photosynthetic productivity
NPP** - Net Productivity of Photosynthesis

With the introduction of Nutrìvant plus oil fertilizers the increased values photosynthetic capacity were observed and they were for a grade of Podilska 1 – 2,319, Zolotysta – 2,236, Elena – 2,184, Omega vinnytska – 2,340 million m^2 of days/ha. A similar trend photosynthetic potential growth was observed in areas with the use of fertilizers, Reacom-R-soya, the average of its value was based on the varieties of 2,318; 2,233; 2,178; 2,336 million m^2- days/ha.

With the introduction of foliar chelated fertilizers the growth of photosynthetic potential was marked. The increment, i.e. the value of the PP during

the wide row sowing with the introduction of Nutrìvant Plus Oil for the Podilska 1 species was 0,028 million m^2 of nam/ha, Zolotysta – 0,016, Elena – 0,017 and Omega vinnytska – 0,012 million m^2 of days/ha.

The photosynthetic capacity rate increased somewhat less in areas with the introduction of Reakom-R-soya and was averagely for species Podolska 1 – 0,025 million m^2 of nam/ha, Zolotysta – 0,012, Elena – 0,009, Omega vinnytska – 0,007 million m^2- days /ha to control. The highest rate of photosynthetic potential with wide row method of sowing was in the variant with the introduction of Baspholiar 6-12-6 chelated fertilizer to Podilska 1 species – 2,272 million m^2- days/ha, Zolotysta – 2,200, Elena is 2,159, and Omega vinnytska- 2,311 million m^2 – days/ha.

The study of soybeans crops photosynthetic potential revealed that the greatest figure was on the areas with Baspholìar 6-12-6 fertilizer dressing at the string sowing with a width of 15 cm between rows. This figure was for Podilska 1 – 2,336 million m^2- days/ha, Zolotysta is 2,241, Elena is 2,190, Omega vinnytska – 2,345 million m^2- days/ha.

In addition to the photosynthetic potential an important indicator of photosynthesis in crops is the pure productivity of photosynthesis. The net productivity of photosynthesis is the ratio of the plants dry matter mass increment for a specific period of time to the leaf surface unit. The average value of this indicator in our research depending on the experiment variants was between 9,42 g/m^2 per day to 10,35 g/m^2 per day.

So, during wide row sowing the verification version of this index was for Podilska 1 species – 9,82 g/m^2 per day, Zolotysta – 9,60, Elena – 9,42, Omega vinnytska – 10,10 g/m^2 per day. With the use of foliar feeding regardless of fertilizers the NPP photosynthetic productivity increased slightly. The variant with the introduction of Nutrivan plus oil the growth value against the control set at 0,12; 0,07; 0,08; 0,06 g/m^2 per day respectively for such species as Podilska 1 – Zolotysta – Elena – Omega vinnytska, in areas with the introduction of Reakom-R-soya increment to control was only 0,11; 0,06; 0,05; 0,03 g/m^2 per day

respectively. With the wide row sowing maximum average value of this indicator was with Basfolìar 6-12-6 fertilizer for such soybeans varieties as Podilska 1 – 10,03 g/m^2 per day, Zolotysta – 9,71, Elena – 9,54 and grade Omega vinnytska – 10,21 g/m^2 per day.

Interrow narrowing brought the positive dynamics of net photosynthetic capacity value growth . So, the verification version in this crop had the average of the increase of 0,31; 0,20; 0,18; 0,33 g/m^2 per day against the control variant of wide row sowing where this value was for species Podilska 1 - 10,13, Zolotysta – 9,80, Elena – 9,60, Omega vinnytska – 10,43 g/m^2 per day.

On the areas with fertilizers dressing the photosynthesis NET productivity rate increased to 0,02 g/m^2 per day in Elena species and variant with the introduction of Reakom-R-soya to 0,19 g/m2 per day in Omega vinnytska species and Baspholìar 6-12-6 dressing. So, the version with the use of Nutrìvant Plus Oil photosynthesis NET productivity indicator was to the Podilska 1 species – 10,24 g/m2 per day, Zolotysta is 9,87, Elena – 9,64, Omega vinnytska – 10,57 – g/m^2 per day. In the areas where Reakom-R-soya was used somewhat smaller increase was observed that was according to the sorts 10,23; 9,86; 9,62; 10,53 g/m^2 per day.

Analyzing the table 1data it should be noted that the maximum rate of net photosynthesis performance for grades was at version with fertilizer Basfolìar 6-12-6 dressing for the species Podilska 1 – 10,31 g/m^2 per day, Zolotysta – 9,89, Elena – 9,66 and Omega vinnytska – 10,21 g/m^2 per day.

Soybean, as an annual plant, depending on the species and type has a large variation in shape and height of stems, the number and shape of the leaf lamina, flowers, inflorescences, beans and seeds. According to Ukrainian scientists, soybean plant is characterized by straight stalk from 0.60 up to 1,5 m high, the number of nodes is from14-15, with up to 7 branches. Branching and the height of lower beans attachment is primarily dependent on the density of standing plants and varieties. In sowing of varieties adapted to intensive technology with optimum thickness of plants a bush is not formed but it is properly a plant almost without

branches. The number of leaves per plant ranges from 20 to 175 units with an average size of length of 6-18 cm and 3-11 cm width.

The inflorescence of a soybean, consisting of 2 - 5 florets, are located in the axils of the leaves. From flowers in inflorescences a fruit or bean is formed, characterized by the presence of one to four seeds. The complex of all elements, their survival in the ontogenesis process form soybeans yields.

The average rate of total number of beans and productive beans on the plant can be seen in table 2. So, their smallest number was in wide row sowing with the variant without fertilization and it was in Podilska 1 – 16,5 units, Zolotysta – 17,5, Elena – 18,4, and it was more in Omega vinnytska species – 20,9 pieces. According to this version, the number of productive bean was 15,4; 16,5; 17,5; 19,3 units./plant.

With the introduction of fertilizers during the bloom phase the average number of beans increased. So in areas with Nutrìvant Plus Oil dressing, total number of beans was in Podolska 1 – 16,7 PCs., Zolotysta – 17,8, Elena – 18,6 and Omega vinnytska – 21,1 PCs./plant. The number of productive beans in these variants was 15,6; 16,8; 17,7; 19,5.

A somewhat similar type of bean formation was observed with Reakom-R-soya fertilizer dressing, the total beans number increment up to control was in Podoilska – 0,3 PCs./plant, Zolotysta – 0,4, Elena – 0,3 and Omega vinnytska – 0,1 PCs./plant, and the number of productive beans amounted to respectively 0,3; 0,3; 0,3; 0,1 PCs./plant.

The largest total number of beans during wide row sowing was observed in areas with the introduction of Baspholìar 6-12-6 and amounted for Podilska 1 – 17,0 PCs./plant, Zolotysta – 17,9, Elena – 18,8 and grade Omega vinnytska – 21,1 PCs./plant, the number of productive beans was respectively 15,9; 16,9; 17,9; 19,5 PCs./plant.

2. Total number of beans and productive beans on one soy plant depending on the variety, method of sowing and foliar feeding (average for 2009 – 2013)

Foliar feeding variants	Species							
	Podilska 1		Zolotysta		Elena		Omega vinnytska	
	Total number of beans	Number of productive beans	Total number of beans	Number of productive beans	Total number of beans	Number of productive beans	Total number of beans	Number of productive beans
String method of sowing (15 cm)								
Without feeding (control)	16,6	15,5	18,6	17,5	19,0	18,1	21,6	20,0
Nutrivant Plus Oil	16,8	15,7	18,8	17,7	19,3	18,4	21,9	20,3
Reacom-R-Soya	16,8	15,7	18,7	17,6	19,2	18,3	21,8	20,2
Baspholiar 6-12-6	17,1	16,0	18,9	17,8	19,4	18,5	21,9	20,5
Wide-row method of sowing (45 cm)								
Without feeding (control)	16,5	15,4	17,5	16,5	18,4	17,5	20,9	19,3
Nutrivant Plus Oil	16,7	15,6	17,8	16,8	18,6	17,7	21,1	19,5
Reacom-R-Soya	16,7	15,6	17,8	16,8	18,6	17,7	21,0	19,4
Baspholiar 6-12-6	17,0	15,9	17,9	16,9	18,8	17,9	21,1	19,5

During the string method of sowing (15 cm) a slightly better formation of beans was observed and in areas without feeding the total number of beans of Podilska 1 – 16,6 PCs./plant, Zolotysta – 18,6, Elena – 19,0 and grade Omega vinnytska – 21,6 PCs./plant, the number of productive bean amounted respectively 15,5; 17,5; 18,1; 20,0 PCs./plant.

With the introduction of fertilizers with foliar feeding method beans formation happened to be more intensive. So, Nutrìvant plus oil fertilizer led the 0,2 PCs./plant increase of the total number of beans in Podilska 1, 0,2 – Zolotysta, 0,3 - Elena and 0,3 PCs./plant in Omega vinnitska. The increment in the number of productive beans amounted respectively to 0,2; 0,2; 0,3; 0,3 PCs./plant.

Reakom-R-soya provided an increment in the number of beans to 0,3 units/plant in Podilska 1, 0,1 – Zolotysta, 0,2 – Elena and 0,2 PCs./plant in Omega vinnitska.

The largest average number of beans in the research was with fertilizer Basphol̀ar 6-12-6. So, the total number of beans in Podilska 1 was – 17,1 PCs./plant, Zolotysta – 18,9, Elena – 19,4 and Omega vinnytska – 21,9 PCs./plant. The number of productive beans amounted respectively to 16,0; 17,8; 18,5; 20,5 PCs./plant.

Soybean ripeness lasts from seeds full pouring to complete maturity. This period ranges from 14 to 25 days, depending on the species ripeness group and weather conditions during cultivation. Full ripeness of soybeans comes when all the leaves are fallen and beans have acquired specific species coloring such as fulvous, brown or gray shades.

Soybeans yield capacities were determined by cultivation of research plots by selective combine Sampo – 500 at humidity rate of 14-16 %, cleaning from impurities and weighing separately from each plot. In future the mass of 1000 seeds was defined from given plants group.

Changes in yield capacities of soybeans researched varieties were influenced by meteorological conditions during the plants growing season, and primarily – temperature lowering at the initial stages of plants growth and development, as well as the reduction moisture in the soil, and in some years-high temperatures in the phases of beans formation, pouring and seeds ripening.

In 2009-2013 research the average soybean yield was different and it increased with the rows width lowering and application of different fertilizers to crops (table 3).

For example, on the control with the wide row method of sowing crop yield was in Podilska 1– 2,28 t/ha, Zolotysta – 2,35, Elena – 2,59, and Omega vinnytska – 2,71 t/ha with the corresponding weight of 1000 seeds: 185; 180; 161; 152 g.

Application of Nutrìvant Plus Oil fertilizers in phase of flowering and beans pouring increased the soybean yield and at this version it was in Podilska 1 –

2,46 t/ha, Zolotysta – 2,48, Elena is 2,81 and Omega vinnytska – 2,91 t/ha. The mass of 1000 seeds in these soybeans varieties was formed 185; 180; 161; 152 grams according to the studied varieties – Podilska 1 – Zolotysta – Elena – Omega vinnytska.

3. Yields Formation, t/ha and the mass, g of 1000 soybean seeds depending on variety, method of sowing and foliar feeding (average for 2009 – 2013)

Foliar feeding variants	Species							
	Podilska 1		Zolotysta		Elena		Omega vinnytska	
	Yield capacity t/he	Mass 1000	Yield capacity t/he	Mass 1000	Yield capacity t/he	Mass 1000	Yield capacity t/he	Mass 1000
String method of sowing (15 cm)								
Without feeding (control)	2,36	187	2,42	184	2,67	165	2,81	158
Nutrivant Plus Oil	2,54	188	2,56	186	2,90	167	2,99	160
Reacom-R-Soya	2,61	188	2,65	186	2,98	166	3,15	160
Baspholiar 6-12-6	2,69	189	2,70	187	3,06	168	3,18	161
Wide-row method of sowing (45см)								
Without feeding (control)	2,28	185	2,35	180	2,59	161	2,71	152
Nutrivant Plus Oil	2,46	187	2,48	182	2,81	164	2,91	155
Reacom-R-Soya	2,52	186	2,56	181	2,9	163	3,05	154
Baspholiar 6-12-6	2,59	187	2,62	182	2,98	165	3,09	156
$SSD_{0,5}^{*}$	**A**−0,09; **B**−0,06; **C**−0,09; **AB**−0,13; **AC**−0,18; **BC**−0,13; **ABC**−0,25.							

$SSD_{0,5}^{*}$ – smallest significant difference

Although the agrochemical analysis showed sufficient level of micro-and macroelements in soil, though the data analysis of soybean productivity showed that fertilization on leaf positively affected the plants ontogeny with increased

yields on variants. Reakom-R-soya fertilizer also showed positive dynamics in yields in average over years. So, the increase in soybean harvest to control was in the range of 0,21 t/ha in Zolotysta and 0,24 t/ha in Podolsk 1 to 0,31 t/ha in Elena and 0,34 t/ha in Omega vinnytska species.

The greatest plants yields during the wide row method of sowing (45 cm) was with the application of fertilizers Baspholìar 6-12-6 and it reached in Podolsk 1 – 2,59 t/ha, Zolotysta – 2,62, Elena – 2,98 and Omega vinnytska – 3,09 t/ha. The 1000 seeds mass at this variant was 187; 182; 165; 156 grams according to the species.

As we have already mentioned, with the row width narrowing to 15 cm, the number of seeds per area unit increased in our research, the yield data for species showed the same tendency. Yield increase in string method of seeding compared with wide row method totaled to 0,08; 0,07; 0,08; 0,10 t/ha of seeds in varieties of Podilska 1 – Zolotysta – Elena – Omega vinnitska. The 1000 seeds mass is not significantly different, and their mass difference ranged from 2 g to 6 g.

Foliar fertilizers application affected the plant ontogenesis and regardless the row width brought to greater accumulation of beans elements and greater yields. So, with the introduction of Nutrìvant Plus Oil with string sowing the crop yield was in Podolsk – 2,54 t/ha, Zolotysta – 2,56, Elena – 2,90 and Omega vinnytska – 2,99 t/ha of soybean. Slightly better impact on plants revealed Reakom-R-soya fertilizer and the highest yields both with the string sowing method and in general research the crop formed on the areas where fertilizer Basfolìar 6-12-6 was dressed. On the variant, with fertilizer application on rows width of 15 cm, soy varieties constituted such yields: Podolsk 1 – 2,69 t/ha, Zolotysta – 2,70, Elena – 3,06 and grade Omega vinnytska – 3,18 t/ha. The 1000 seeds mass in these areas was according to species to 189; 187; 168; 161 g.

Conclusions

1. Chelated fertilizers use in foliar cultivation revealed a positive influence on the formation of the soybeans productivity and yields.

2. Fertilizing with Nutrìvant Plus Oil, Reakom-R-soya and Baspholìar 6-12-6 reduced the inflorescences fall of plants and contributed to the formation of more productive beans on a soybean stalk.

3. Statistical analysis of the soybeans yields indicated the highest average yields in areas fertilized by Baspholìar 6-12-6 respectively at species: Podilska – 2,69 t/ha, Zolotysta – 2,70 t/ha, Elena – 3,06 t/ha, and Omega vinnytska – 3,18 t/ha using the string method of sowing. In areas with wide row way of sowing the crop yields were slightly lower.

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ОПТИМІЗАЦІЯ ТЕХНОЛОГІЇ ВИРОЩУВАННЯ СОЇ НА ЗЕРНО В УМОВАХ ЗАХІДНОГО ЛІСОСТЕПУ УКРАЇНИ

І. В. Трач

Вивчено сортову технологію вирощування сої за позакореневого підживлення. З’ясовано, що добрива позитивно впливають на ріст і розвиток рослин, а позакореневе внесення хелатних добрив впродовж вегетації є перспективним для оптимізації технології вирощування сої в сучасному рослинництві.

Ключові слова: *соя, сорт, спосіб сівби, позакореневе підживлення, хелатні добрива.*

ОПТИМИЗАЦИЯ ТЕХНОЛОГИИ ВЫРАЩИВАНИЯ СОИ НА ЗЕРНО В УСЛОВИЯХ ЗАПАДНОЙ ЛЕСОСТЕПИ УКРАИНЫ

И. В. Трач

Изучено сортовую технологию выращивания сои при внекорневой подкормке. Выяснено, что удобрения положительно влияют на рост и

развитие растений, а внекорневое внесения хелатных удобрений в течение вегетации являются перспективными составляющими оптимизации технологии выращивания сои в современном растениеводстве.

Ключевые слова: *соя, сорт, способ сева, внекорневая подкормка, хелатные удобрения.*