R. R. Galeev et al /J. Pharm. Sci. & Res. Vol. 10(7), 2018, 1668-1671

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Yield Capacity and Grain Quality of Soybeans Depending on Agrotechnical Cultivation Methods

R. R. Galeev, S. K. Vyshegurov, I. S. Samarin, V. S. Demshina, M. A. Gumel

Novosibirsk State Agrarian University,
160, Dobroljubova St., 630039, Novosibirsk, Russian Federation

Abstract

The results of scientific research of growth and development, yield capacity and grain quality of soybean varieties of different maturity groups for 2014-2017 are presented. The efficiency of growing soybeans for grain in the conditions of the forest-steppe of Western Siberia is shown. Is it stated that while processing soybeans and during a growing season, growth regulators improve yield capacity of the studied crop by 24-39%. Growth regulators that are used, improve soybeans' quality. Among the studied varieties, Omskaya 4, Altom and SibNIISHoz-6 have been pointed out according to a set of economically valuable features.

Keywords: growth regulators, leaf area, photosynthetic potential, production quality, soybeans, variety, yield capacity.

INTRODUCTION

Soybeans are an important food crop. Deficiency of protein in the diet of Russians is more than 30%, which from the point of view of medicine is unfavorable for human health [1-6]. Expansion of acreage under leguminous crops is an important condition for solving the problem of vegetable protein. The low share of domestic soy production in Russia causes the need to import soybeans and processed soybean products for hundreds of millions of dollars annually [7-9].

Traditional feed crops (corn, oat, barley) and wheat, which are often used for fodder, are inferior significantly to peas and soybeans in protein content and are characterized by a deficiency of the essential amino acid lysine [10-12].

Among the cultivated leguminous and cereal crops, soybeans are inferior only to peanuts. The advantageous combination of nutrients makes it possible to cultivate soybeans widely for food, fodder and technical purposes [13-15].

Main soybeans' planting acreage is concentrated in the Far East (90%) [16]. Promotion to other regions of the Russian Federation, including Western Siberia, is difficult because of the absence of the varieties adapted to these regions and the insufficient knowledge of its agricultural technology. [17-20].

In recent years crop breeders of Siberia have created varieties of West-Siberian ecotype, that are characterized by high cold resistance. Therefore, appearance of new soybean varieties makes it possible to expand soybean planting acreage in Western Siberia.

Currently, available scientific developments on soybeans' cultivation for different regions may be partially applied to Western Siberia. However, the influence of individual technology elements (such as the use of growth regulators) on soybeans production requires further research and adjustments for new varieties and local conditions [21-23]. Also studies of economically valuable features of soybeans have not been conducted sufficiently.

The aim of the research is to improve the elements of cultivation technology with the introduction of optimal doses of growth regulators and methods of their application; and to identify yielding varieties of soybeans in the conditions of the forest-steppe of Western Siberia.

MATERIALS AND METHODS

In 2014-2017 for the research of soybean varieties a collection nursery was laid on the experimental field of the educational and production farm "Sad Muchurintsev" of the Federal State Budgetary Educational Institution of Higher Education "Novosibirsk State Agrarian University". The soil of the experimental area was grey forest heavy loam soil on noncalcareous clay loam. It was characterized by the average humus content of 4.5%, a slightly acidic reaction of the environment (pH 6.28), low availability of nitrate nitrogen (6-10 mg/kg), high availability of labile phosphorus (9.8-12.8 mg/100g) and medium availability of mobile potassium (6.2-6.4 mg/100g). The climate was sharply continental. Meteorological conditions in the years of the research were different both in temperature and in rain capacity. Higher average monthly temperature of 19.3°C was observed in 2016. Rain capacity during the growing season was higher in 2017 – 347 mm.

Varieties released in Western Siberia – SibNIIK-315 (selected by the Siberian Research Institute of Fodders of Russian Academy of Sciences), SibNIISHoz-6, Omskaya 4, Dina, Zolotistaya, Sibiryachka, Eldorado (Siberian Agricultural Research Institute), Altom (Altai Agricultural Research Institute), and varieties released in the Far East – Soer 4 and Sonata (Federal State Budgetary Educational Institution "Agricultural Research Institute of South-East" of Russian Academy of Sciences) – had been studied.

Among the studied varieties, only Zolotistaya was middle-early, the other varieties were early.

During the experiments with growth regulators, seeds were soaked for 120 minutes with Albit growth regulator – 2 mg/kg of seeds, 0.001% Argon, Novosil 0.12 ml/kg and Epin 0.2 ml/kg. During the growing season plants at a budding stage were sprayed with Albit - 100 ml/ha, Argon 0.001%, Novosil 150 ml/ha and Epin 0.001%. Hydraulic fluid consumption was 300 l/ha.

During the research phenological observations were conducted. Leaf area was defined with the distance method according to the method of N.P. Reshetsky. The height of the plants, the height of attachment of the lower beans, the number of branches of the first order, the number of seeds in the bean were studied according to the generally accepted measurement technique. The chemical composition of the soybean grain was determined by standard methods. Soybean sowing was carried out in the third decade of May with a seeding rate of 20 g of germinated seeds per 1 m^2, with the use of a wide-row method with a row spacing of 70 cm with the depth of seeding of 4-5 cm. The registration plot was 10 m^2, the replication was 4-fold with randomized placement of variants.

RESULTS

In 2014-2017 in the forest-steppe of Novosibirsk Ob River region released and promising varieties of soybeans for Western Siberia and the Far East were studied.

Is has been stated, that the earliest development of the sprouting and branching period was observed for the varieties SibNIISHoz-6 and Dina. Far Eastern varieties had a long-lasting period of this phase up to 16 days, while the standard for SibNIIK-315 was 9 days. The branching and budding phase was more rapid for SibNIIK-315 and SibNIISHoz-6.

Far Eastern varieties were characterized by slow rates of the branching and budding phase. The budding and blooming phase for SibNIIK-315 was detected within 5 days versus 12 days for Soer 4. The earlier rates of the blooming and ripening phase were noted for SibNIIK-315 standard and Omskaya 4; slow rates of this phase were observed for the majority of Far Eastern varieties.

According to the growing season, varieties of different ecogeographical origin differed significantly: Dina – 79-107 days, SibNIISHoz-6 – 85-95 days, Zolotistaya – 98-196 days, Sibiryachka – 97 days, Eldorado – 92-96 days, SibNIIK-315 – 90-98 days, Omskaya 4 – 90-105 days; varieties released in the Far East were characterized by a longer growing season, 100-126 days in average.

In the research of the growth regulators' efficiency, rapid ripening rates were by using Novosil for seeds' treatment, in combination with subsequent spraying with the same preparation as well as with Argon.

For the standard of SibNIIK-315 the maximum leaf area was 51.8 thousand m^2/ha, for SibNIISHoz-6 and Omskaya 4 it was 1.3 times higher (Table 1). Among Far Eastern varieties, Soer 4 had the largest leaf area. Omskaya 4 had the average leaf area – 60.3 thousand m^2/ha.

According to photosynthetic potential, Omskaya 4 was second to none, while Eldorado had the lowest rate. During the experiment with the use of growth regulators the maximum leaf area was noted (according to the research in 2014-2017) in the variants with the treatment of seeds with Novosil – 57.9 thousand m^2/ha. Control without seeds' treatment was significantly inferior to this variant. According to the average area in the variant with seeds' treatment, the largest rates were noted with Novosil.

By spraying soybean vegetative plants in the budding phase, the largest parameters of the maximum leaf area were with Novosil and Argon. Similar data were obtained for the average leaf area (Table 1). The photosynthetic potential of soybean sowing was 1.2 times higher for Omskaya 4 in comparison with SibNIIK-315 standard. Minimal rates of photosynthetic potential were observed for Eldorado. Soybeans treatment with growth regulators increased photosynthetic potential rates by 1.18 times. By spraying vegetative plants with the same preparations, photosynthetic potential increased in comparison with the seeds' treatment by 18-26%.

While measuring plants' height on July 15, the highest plants were among Zolotistaya and Eldorado (58.6 cm). Far Eastern varieties were much inferior in height to the Siberian varieties, and their height was 38 cm.

At the beginning of August, the greatest height was in the varieties SibNIISHoz-6, Zolotistaya, Sibiryachka, Eldorado; their rates were 68 cm in average. Far Eastern varieties lagged behind in height, their height varied from 35 to 46 cm.

The height of the attachment of the lower beans in the first decade of August was higher in Eldorado variety - 11.1 cm, which was 3 cm more than the standard (SibNIIK-315). The varieties of Far Eastern selection had lower attachment of lower beans.

While measuring on August 15 and 25, Eldorado demonstrated the greatest rates of the height of attachment of the lower beans – 13.2 cm on August 15 and 14.8 cm on August 25. The height of attachment of the lower beans for SibNIIK-315 standard was 10.0 cm in the middle of August and 12.1 cm on August 25. Far Eastern varieties demonstrated the height of attachment that was 1.5-1.8 times lower in comparison with Siberian varieties.

Table 1. Leaf area and photosynthetic potential of soybeans (average for 2014-2017).

Variant	Leaf area, thousand m^2/ha		Photosynthetic potential, thousand m^2 per day /ha
	maximum	average	
Variety testing			
SibNIIK-315 (St)	51.8	37.6	3,626
Altom	50.6	37.8	3,578
Zolotistaya	49.4	38.4	3,458
Omskaya 4	60.3	46.5	4,221
Sibiryachka	44.5	37.2	3,115
SibNIISHoz-6	54.5	38.3	3,818
Eldorado	34.6	34.6	2,422
Soer 4	47.3	41.2	3,311
Sonata	44.5	39.6	3,115
LSD_{05}	1.56	1.29	34.8
Growth regulators' application (SibNIIK-315)			
Seeds' treatment			
Water (control)	46.5	34.6	3,322
Albit	48.4	36.2	3,475
Argon	50.4	37.1	3,576
Novosil	51.9	37.6	3,625
Epin	48.3	36.4	3,508
Vegetative plants' spraying			
Water (control)	50.1	41.2	3,972
Albit	52.4	38.6	3,721
Argon	53.8	44.2	4,261
Novosil	54.2	45.7	4,405
Epin	49.3	44.4	4,280
LSD_{05}	1.24	1.38	41.2

Table 2. Yield capacity and quality of soybean grain (average for 2014-2017).

Variant	Yield capacity			Dry matter, %	Proteins, %	Fats, %	Carbohydrates, %	Vitamin C, %	Nitrates, mg/kg
	t/ha	Deviation from standard (control)							
		t/ha	%						
Variety testing									
SibNIIK-315 (St)	3.1	-	-	80.6	35.4	19.6	27.8	5.6	6.8
Altom	3.6	0.5	16	82.7	37.6	21.2	31.2	5.8	7.3
Zolotistaya	2.6	-0.5	-16	79.6	32.5	20.3	29.6	6.0	7.0
Omskaya 4	4.2	1.1	35	84.5	36.5	21.8	30.8	6.1	6.5
Sibiryachka	3.0	-0.1	-3	81.8	32.6	19.4	29.8	5.7	6.3
SibNIISHoz-6	3.4	0.3	10	82.6	37.5	20.1	25.8	5.8	5.7
Eldorado	2.8	-0.3	-10	76.2	36.2	17.8	26.3	5.4	6.7
Soer 4	1.2	-1.9	-61	68.1	21.4	14.3	28.6	6.1	10.6
Sonata	1.0	-2.1	-68	62.5	20.3	12.1	34.2	5.8	13.5
LSD_{05}	-	-	-	1.43	1.18	0.65	0.92	0.15	0.66
Yield capacity: LSD_{05}(special value) – 0,2; LSD_{05}(A) – 0,47; LSD_{05} (B and AB) – 0,39; index of determination: A (variety) – 29,6, B (year) – 24,5; AB – 19,7									
Growth regulators' application (SibNIIK-315)									
Seeds' treatment									
Water (control)	2.9	-	-	78.6	35.8	20.1	26.8	26.9	5.8
Albit	3.2	0.3	10	76.4	35.7	18.3	24.6	26.4	5.4
Argon	3.7	0.8	27	79.4	36.4	21.2	26.9	26.5	5.9
Novosil	3.9	1.0	34	82.5	36.3	20.8	28.3	31.2	6.0
Epin	3.5	0.6	19	81.2	36.0	19.6	27.4	27.4	5.2
Vegetative plants' spraying									
Water (control)	3.3	-	-	79.3	36.0	21.3	27.2	27.2	6.4
Albit	3.8	0.5	14	78.6	35.8	21.8	26.8	28.1	5.8
Argon	4.4	1.1	34	81.2	36.7	22.3	26.4	27.3	6.0
Novosil	4.6	1.3	39	82.3	37.8	203	28.3	28.6	6.2
Epin	4.2	0.9	26	80.6	38.1	21.6	27.0	26.5	5.9
LSD_{05}	-	-	-	1.23	1.48	0.75	0.29	0.48	0.49
Yield capacity: LSD_{05}(special value) – 0,15; LSD_{05}(A) – 0,34; LSD_{05} (B and AB) – 0,31; index of determination: A (method of treatment with growth regulators) – 36,8%, B (year) – 27,1; AB – 19,6%									

While counting the number of joints on August 5, plots with Zolotistaya and Eldorado varieties had the maximum number of joints (7 pcs); at that moment the standard had an average of 6 joints per plant. Far Eastern varieties had an average of 4 to 6 joints per plant.

While counting the number of joints on August 15, SibNIIK-315 (standard), SibNIISHoz-6 and Eldorado had the maximum number of joints – 8 pcs. All the other varieties had the rate of 5 to 7 pcs.

It has been stated, that in average for 2014-2017 in the experiments on variety testing, the yield capacity of SibNIIK-315 standard was significantly exceeded by Omskaya 4 – by 35%, Altom – by16%, and SibNIISHoz-6 – by 10% (early varieties). The middle-early variety of Zolotistaya was inferior to the standard in yield capacity by 16%. Far Eastern varieties of Soer 4 and Sonata in the conditions of the forest-steppe of Western Siberia formed a developed overground mass. However, yield capacity of these varieties was below the standard by 61-68%. According to the variance analysis of the two-factor complex, soybeans' yield capacity depended on the variety by 30%, on weather conditions – by 25%, on interaction of these factors – by 20%.

In the experiments on treatment the seeds with growth regulators, the increase with Albit was 10%, Argon – 27%, Novosil – 34%, and Epin – 19%. In the experiments on spraying soybean plants of SibNIIK-315 with growth regulators, the yield capacity increase to control (water) grew from 14% with Albit to 39% with Novosil.

The influence degree of the method of soybean seeds' treatment with growth regulators was 37%, year conditions – 27%, interaction of factors – 20% (Table 2).

While studying the chemical composition of soybean grain, it was found that the dry matter was higher in Omskaya 4, Altom and SibNIISHoz-6. Altom and SibNIISHoz-6 were second to none in protein content. Far Eastern varieties had lower rates of dry matter, protein and fats. The concentration of carbohydrates was higher in Far Eastern Sonata variety and Western Siberian Altom variety. The content of vitamin C was from 5.4 in Eldorado variety to 6.1 in Omskaya 4 and Soer 4. The content of nitrates in the experiment variants was lower than the maximum permissible concentration for soybean grain.

DISCUSSION

The problem of increasing soybeans' yield capacity is relevant. In the conditions of Western Siberia this problem is especially significant. With low rates of yield capacity in combination with unfavorable factors of external environment special attention should be paid to the selection of varieties and their adaptation to a specific area with the development of accelerated seed production on a virus-free basis. Yield capacity increase up to 35% was noted for Omskaya 4, Altom and SibNIIK-315. Far Eastern varieties had a powerful overground

mass and had no time to form sufficient yield capacity because of the lack of moisture and heat; seeds did not ripen in most experiments. Along with plasticity and stress-resistance, these Western Siberian soybean varieties had a set of economically valuable traits: high yield capacity, good seeds' quality, ecological suitability in the aspects of nitrate accumulation in products.

The use of growth regulators made it possible to increase yield capacity rates of SibNIIK-315 variety, released in the research area. Treatment of soybean seeds with growth regulators increased yield capacity by 27-34% in average, spraying the plants in the budding phase – by up to 39%.

CONCLUSIONS

On heavy loamy gray forest soils of the forest-steppe of Novosibirsk Ob region (Western Siberia), the efficiency of growing soybean varieties and methods of using growth regulators has been stated.

1. Earlier growth and development rates were revealed in soybean varieties of Western Siberian selection of SibNIIK-315 (standard), Omskaya 4, Altom, SibNIISHoz-6 and Sibiryachka. Early-ripening varieties of Far Eastern selection Soer 4 and Sonata in the conditions of the research area were characterized by a long growing season.
2. Maximum leaf area during the growing season was characteristic for Omskaya 4 (60.3 thousand m^2/ha) and SibNIISHoz-6 (54.5 thousand m^2/ha). The average leaf area was higher for Omskaya 4 (46.5 thousand m^2/ha). Parameters of photosynthetic potential varied from 2,422 thousand m^2 per day/ha for Eldorado variety to 4,221 thousand m^2 per day/ha for Omskaya 4. Growth regulators increased leaf area and photosynthetic potential by 24% in average, especially with spraying the plants during the growing season in the budding phase of soybeans.
3. Significant yield capacity increase to SibNIIK-315 standard (by 35%) was found for the Western Siberian variety of Omskaya 4, by 16% - for Altom, and by 10% - for SibNIISHoz-6. Far Eastern varieties had low rates: 3 times lower than the standard and 4 times lower than the rates of Omskaya 4.
4. The studied growth regulators provided yield capacity increase from 10 to 34% by treatment the soybean seeds for 120 minutes, especially with the use of Novosil (0.12 ml/kg of seeds) and 0.001% Argon. Spraying with growth regulators increased yield capacity up to 14-39%, especially with Novosil (150 ml/ha) with hydraulic fluid consumption of 300 l/ha by the yield capacity of the soybeans' variety of SibNIIK-315 4.6 t/ha.
5. It has been shown that Omskaya 4, Altom and SibNIISHoz-6 had better quality indicators. The content of nitrates in the studied early and middle-early Zolotistaya variety was significantly lower than the maximum permissible concentration level.
6. It has been statistically defined that soybeans' yield capacity depended on genotype by 30%, on growth regulators – by 37%, and on year conditions – by 27%.
7. The maximum number of beans per plant (24 pcs) and the mass of beans from one plant of 20.8 g, as well as the weight of 1,000 seeds of 189 g were characteristic for Omskaya 4, which was in average 1.3 times higher in comparison with the SibNIIK-315 standard. The use of growth regulators also increased the number of beans on the plant by 1.2 times, the weight of beans from one plant was increased by 1.15 times. The largest mass of 1,000 seeds was noted in the variant with spraying soybeans with Novosil - 174 g, which was 1.25 times higher than the control (water).

REFERENCES

1. Babich, N. N., Solution of the protein problem in the fields of the Tambov region, *Zernovye kul'tury* [Cereals] 1996, *4*, 12-14.
2. Baranov, V. F., Lukomets, V. M. (eds.), *Soja: biologiya i tehnologiya vozdelyvaniya [Soybeans: biology and technology of cultivation]*, All-Russian Research Institute of Oilseeds, Krasnodar 2005.
3. Caliskan, S., Ozkaya, I., Caliskan, M., Arslan, M., The effect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean – type soil, *Field Crops Res.* 2008, *108(2)*, 126-132.
4. Hungria, M., Franchini, J. C., Campo, R. J., Crispino, C. C., Moraes, J. Z., Sibaldelli, R. N. R., Mendes, I. C., Arihara, L., Nitrogen nutrition of soybean in Brazil: contributions of biological N2 fixation and N fertilizer to grain yield, *Can. J. Plant Sci.* 2006, *86(4)*, 927-939.
5. Krivosudska, E., Filova, A., Evaluation of selected soybean genotypes (Glycine max L.) by physiological responses during water deficit, *J. Cent. Eur. Agric.* 2013, *14(2)*, 691-706.
6. Ray, J. D., Fritschi, F. B., Heatherly, L. G., Large application of fertilizer N at planting affects seed protein and oil concentrations in the early soybean production system, *Field Crops Res.* 2006, *99(1)*, 67-74.
7. Galeev, R. R., Litvyanskiy, V. M,. *Intensivnye tehnologii vozdelyvaniya soi v Zapadnoj Sibiri [Intensive technologies of soybeans' cultivation in Western Siberia]*, Agro-Sibir' Publ., Novosibirsk 2002.
8. Oksinenko, I. A., *Vozdelyvanie soi s vysokoj jeffektivnost'ju. Prakticheskie rekomendacii [Soybeans' cultivation with high efficiency. Practical recommendations]*, Kursk 1997.
9. Kashevarov, N. I., Gorin, V. E., Lyakh, A. A. (eds.), *Vozdelyvanie soi v Zapadnoj Sibiri: rekomendacii [Soybeans' cultivation in Western Siberia: recommendations]*, Russian Academy of Agricultural Sciences, Siberian Scientific Research Institute of Forages, Novosibirsk 1999.
10. Galeev, R. R., *Perspektivy proizvodstva zernobobovyh kul'tur v Zapadnoj Sibiri [Perspectives of production of leguminous plants in Western Siberia]*, Agro-Sibir' Publ., Novosibirsk 2011.
11. Kashevarov, N. I., Solomenko, V. A., Vasyakin, N. I., Lyakh, A. A., *Soya v Zapadnoj Sibiri [Soybeans in Western Siberia]*, Russian Academy of Agricultural Sciences, Siberian Scientific Research Institute of Forages, Jupiter Publ., Novosibirsk 2004.
12. Mehmet, O., Nitrogen rate and plant population effects on yield and yield components in soybean, *Afr. J. Biotechnol.* 2008, *7(24)*, 4464-4470.
13. Penchukov, V. N., Medyannikov, N. V., Kappushev, A. U., *Kul'tura bol'shih vozmozhnostej [Culture of great opportunities]*, Stavropol' 1984.
14. Vashchenko, A. P., *Soya na Dal'nem Vostoke [Soybeans in the Far East]*, Dal'nauka Publ., Vladivostok 2010.
15. Rozhanskaya, O. A., *Soja i nut v Sibiri;kul'tura tkanej, samoklony, mutanty [Soy and chickpeas in Siberia; tissue culture, self-clones, mutants]*, Jupiter Publ., Novosibirsk 2005.
16. Shpaar, D., Postnikov, A., Taranukho, G., *Zernobobovye kul'tury [Leguminous crops]*, FUAinform Publ., 2000.
17. Popovic, V., Tatic, M., Sikora, V., Ikanovic, J., Drazic, G., Djukic, V., Mihailovic, B., Filipovic, V., Dozet, G., Jovanovic, L., Stevanovic, P., Variability of yield and chemical composition in soybean genotypes grown under different agroecological conditions of Serbia, *Rom. Agric. Res.* 2016, *33*, 29-39.
18. Ferreira, A. S., Balbinot Jr, A. A., Werner, F., Zucareli, C., Franchini, J. C., Debiasi, H., Plant density and mineral nitrogen fertilization influencing yield, yield components and concentration of oil and protein in soybean grains, *Bragantia* 2016, *75(3)*, 362-370.
19. Crozat, Y., Aveline, A., Coste, F., Gillet, J. P., Domenach, A. M., Yield performance and seed production pattern of field-grown pea and soybean in relation to N nutrition, *Eur. J. Agron.* 1994, *3(2)*, 135-144.
20. Valinejad, M., Vaseghi, S., Afzali, M., Starter nitrogen fertilizer impact on soybean yield and quality, *Int. J. Eng. Adv. Tech.* 2013, *3(1)*, 333-337.
21. Schmitt, M. A., Lamb, J. A., Randall, G. W., Orf, J. H., Rehm, G. W., In-season fertilizer nitrogen applications for soybean in Minnesota, *Agron. J.* 2001, *93(5)*, 983-988.
22. Chafi, A. A., Amiri, E., Nodehi, D. A., Effects of irrigation and nitrogen fertilizer on soybean (Glycine max) agronomic traits, *Int. J. Agric. Crop Sci.* 2012, *4(16)*, 1188-1192.
23. Kaschuk, G., Nogueira, M. A., De Luca, M. J., Hungria, M., Response of determinate and indeterminate soybean cultivars to basal and topdressing N fertilization compared to sole inoculation with Bradyrhizobium, *Field Crops Res.* 2016, *195*, 21-27.