Bulgarian Journal of Agricultural Science, 26 (No 4) 2020, 787–792

The influence of sowing time and micro-fertilizers on soybean productivity in the northern steppe of Ukraine

Tamara Shepilova, Mykola Mostipan, Dmytro Petrenko and Kateryna Vasylkovska*

Central Ukrainian National Technical University (CUNTU), Kropyvnytskyi 25006, Ukraine
**Corresponding author:* vasilkovskakv@ukr.net

Abstract

Shepilova, T., Mostipan, M., Petrenko, D. & Vasylkovska, K. (2020). The influence of sowing time and micro-fertilizers on soybean productivity in the northern Steppe of Ukraine. *Bulg. J. Agric. Sci., 26 (4)*, 787–792

Field studies conducted in 2016-2018 in the conditions of the northern Steppe of Ukraine with the mid-season soybean variety Romashka showed that the periods of sowing and application of micro-fertilizers have a significant impact on the growth and development of plants and their productivity. In particular, the efficiency of micro-fertilizer Quantum was higher than the early sowing at the soil temperature of 8–10°C (April 20) with the integrated application of seed treatment and crops, when a larger mass of plants was formed.The number of vacuoles and the number and weight of seeds of one plant increased. The shift of sowing to May 1, when the soil temperature was 10–12°C, resulted in a decrease in all indicators and a decrease in the efficiency of micro-fertilizers. The highest productivity was obtained at the sowing time on April 20 and the treatment of seeds and crops by micro-fertilizer, Quantum, was 2.22 tons per hectare, and the increase in crop productivity was significant and amounted to 0.28 t/ha (14.4%).

Keywords: soybean; microelements; sowing time; productivity; plant weight

Introduction

Soya is a widespread and profitable protein and oil crop that has a wide range of aplication for food, feed and technical purposes (Sichkar, 2016). There is a constant annual increase of the crop area in Ukrainewhich results in considerable gross collections, but the productivity remains low and unstable, mainly due to the non-observance of cultivation technology, in particular, varietal agricultural machinery. The increase in production volume should be reached due to the maximum realization of the genetic potential of new domestic soybean varieties (Petrychenko, 2011). Each variety needs optimal parameters of agrotechnical methods. According to some researchers (Shovkova, 2014), the optimal timing of sowing is the most controversial issue in the technology of soybean cultivation, which is especially important in climatic changes (Shevnikov, 2011; Tsekhmeistruk et al., 2016). According to Babych (2013), the time of sowing for soybeans is decisive, since it influences the moisture content, good sprouts, density of plants, the biometric indices, uniformity of ripening, the size and quality of the crop.

Soy is sensitive to a light day and this fact should be taken into account when selecting the optimal time of sowing. Babych et al. (2006) and others believe that for most soy varieties, the favourable duration of light day is 13-15 hours. It was established that due to late sowing, the period between sprouting and flowering of soybeans decreases, and as a result, this negatively affects both growth and productivity (Babych et al., 2013).

According to the recommendations of foreign scientists (Gibson, 2001) due to the danger of drought in July soybeans must be sown as soon as possible.

The main criterion for choosing the sowing time is the stable warming of the seed layer of the soil. The minimum temperature for soybeans is about + 8–10°C with the tendency of the soil temperature increase. The warming of the seed layer to + 12-14˚C provides friendly seed germination in the presence of moisture (Nizhegolenko et al., 2009; Shevnikov et al., 2013).The mid-season and late-season varieties should be sown until there are good conditions in order to ripen before first autumn frost (Artemenko, 2011; Silkova, 2014). It is known that the change of early sowing (soil temperature is 8-10˚C) for the late stage (soil temperature is 13-14˚C) causes a decrease in soybean productivity by 13.5% (Shepilova, 2009).

An important reserve for increasing soybean productivity is the use of micro-fertilizers. The effect of micronutrients on physiological and biochemical processes in plants is based on their inclusion in the so-called "accessor substances", that is, vitamins, hormones, enzymes and coenzymes that take part in the metabolism (Jarecki et al., 2016). They also enhance the process of photosynthesis and activate the work of many vitamins and enzymes involved in nitrogen and carbohydrate metabolism, oxidation-reducing processes (Shevnikov et al., 2015).

Nowadays, the micronutrients on the chelated basis have been widely spread.Their efficiency is 5–10 times higher than inorganic salts, due to their faster assimilation into biochemical processes of plants. In addition, chelating forms of micro-fertilizers are assimilated by almost 100%, and as a result the amount of their application decreases (Kushnir, 2014, Kulibaba, 2015).

Kirovohrad region (Ukraine) is the zone of insufficient moisture, where rainfall distribution is quite uneven in years and months, so it is important to know which agronomic techniques provide more rational use of the basic factors of plant life, and especially moisture.

Therefore, it is important to study of the effect of sowing time and micro-fertilizers on the productivity of the mid-season soya of Romashka variety in specific soil and climatic conditions.

Material and Methods

Field experiments were conducted during 2016-2018 in the experimental field of Central Ukrainian National Technical University (Kropyvnytskyi, Ukraine). The experimental field is located in the subzone of the northern Steppe of Ukraine. The climate is moderately continental with insufficient and unstable moisture. The soil of the experimental field is black medium-humus soil with deep heavy clay loam. The content of humus is 4.4%, the level of the main elements of feedingis average: nitrogen that is easily hydrolyzed – 10.9 mg/100 g of soil, labile phosphorus is 5.1 mg/100 g of soil, exchangeable potassium is 13.3 mg/100 g of soil. In spring, average reserves of productive moisture per meter of soil layer range from 121 to 160 mm.

The years of research were significantly different by their hydrothermal conditions. The amount of rainfall in the period of soybean vegetation in 2016 was 229 mm, in 2017 – 125 mm, in 2018 – 249 mm. Accordingly, the hydrothermal coefficients, calculated by H.T. Selyaninov's methodology, were 0.9, 0.5 and 1.1, which indicates dry conditions in 2017 and their negative impact on the productivity level.

The experiment was carried out by block method. Repeatability in the experiment is threefold. The area of the lots is 54 m². Field, laboratory and statistical methods were applied in the research. The experiment was carried out with a mid-season soybean of Romashka variety. The originator of the variety is the Institute of Steppe Agriculture of the National Academy of Agricultural Sciences. In the course of research we used agricultural techniques that are common for the growing zone. Soybeans were sown after spring barley.In autumn, after harvesting the predecessor, primary tillage was carried out at the depth of 6-8cm. Fertilizers were applied in the normal range – $N_{23}R_{60}K_{60}$ kg/ha of active fluid before ploughing to the depth of 22–25cm. In spring, the early spring harrowing was carried out. Tank mixtures of herbicides Harnes – 1.5 l/ha and Hezagard – 2 l/ha were applied, and pre-sowing cultivation was carried out. The sowing width between the rows was45 cm and the seeding rate was 600 thousand/ha. The depth of seeding was 5–6 cm. In the phase of 3 leaves, spraying of crops with the mixture of herbicides Basagran 2.5 l/ha and Fuzilad Forte 0.8 l/ha was applied.

Two sowing times were studied. The first time was with the soil temperature of 8–10°C (April, the 20th), the second time was with the soil temperature of 10–12°C (May, the 1st). The seeds and crops of the nil treatment were sprayed with water.

Micro-fertilizer Quantum was used for research purposes. It is a highly concentrated complex chelated fertilizer for endocrine fertilization of crops, as well as for seed treatment. It contains high content of copper, zinc and manganese. The manufacturer is research and production company "Kvadrat Ltd", Kharkiv, Ukraine.

Chemical composition and properties of micro-fertilizer are the following: N – 6% (57 g/l); P_2O_5 – 5% (52 g/l); K_2O – 8% (77 g/l); SO_3 – 3% (30 g/l); B – 0.6% (6 g/l); Zn – 1.2% (12 g/l); Cu – 1.1% (11 g/l); Mn – 1.1% (11.3 g/l); Mo – 0.03% (0.3 g/l); Ni – 0.01% (0.1 g/l); Co – 0.003% (0.03 g/l). The treatment of crops was carried out by the micro-fertilizer Quantum in the phase of soybean bud formation according to the experimental scheme. The flow rate was 250 l/ha withthe air temperature not exceeding 18°C.

Results and Discussion

The impact of agro-technical methods on the germination of seeds, the mass of plants and the number of vacuoles

Field germination of seeds is a rather variable feature which is characterized by a complex of soil-climatic and agro-technical factors. It is known that the treatment of seeds by micro-fertilizers contributes to increasing the germination of seeds and plant density, due to the activation of enzymes and enzyme systems responsible for the flow of exchange processes, photosynthesis, respiration, adaptation of plants to stressful conditions of cultivation.

It was established that field germination of seeds was within the range of 87.0–92.0% (Table 1). The application of micro-fertilizer Quantum increased the germination of seeds sown on April 20th by 3.8-4.2% (*the least significant difference* ($LSD_{0.05}$) by the factor B = 1.8%), and with the sowing time on May 1 – by 1.7–2.2%.

The shift of sowing time from the first period to the second period resulted in the increase in the germination of seeds by 2.8%. The highest indicator of 91.5-92.0% was at sowing time on May 1 and treatment of seeds by the micro-fertilizer.

The intensity of growth of the aboveground soy plants depends to a large extent on the sowing time, variety, soil and climatic conditions. It is known that the application of micro-fertilizers provides the formation of a larger mass of plants, the leaf area and the increase of individual productivity.

The mass of plants in the phase of seeds plumping was higher at the first stage of sowing with the average of 57.3 g, while at the second stage it decreased by 14.3 g ($LSD_{0.05}$ by the factor A = 1.3 g), which was 24.9%. The largest mass of plants was formed in the first sowing period with application of micro-fertilizer – 58.9–59.4 g.

The application of micro-fertilizer Quantum resulted in a significant increase in the mass of plants in relation to the control sample of both sowing times. Thus, at the first stage, it increased by 5.3–5.8 g, while at the second stage it increased by 2.3–3.0 g ($LSD_{0.05}$by the factor B = 1.6 g).

Immobilization of nitrogen by vacuole bacteria and its penetration into a plant most intensively occurs during the flowering period during the formation and growth of beans. Under normal conditions, an average of 21 to 80 vacuoles or more is formed per plant (Kulibaba, 2015).

Scientific research has shown that the application of micro-fertilizers has a positive effect on the symbiotic cell of soy, promotes the development of the root system, and stimulates the formation of vacuoles in the roots (Jarecki et al., 2016). Consequently, the number of vacuoles should increase.

High intensity of nitrogen immobilization is observed in the regions with a favourable water supply, and in the regions with insufficient moisture it happens only in the periods of sufficient rainfalls.

The calculationof the vacuoles on soybean roots in the phase of plumping showed that their number at the first stage of sowing was higher at the average of 46.5 pcs. The shift of sowing to the second stage resulted in a decrease in their number by 13.0 pcs. ($LSD_{0.05}$ by the factor A = 2.5 pcs.), or by 27.9%.

The maximum number of vacuoles (49.3 pcs.) was formed during sowing on April 20 and treatment of seeds and crops

Table 1. The impact of sowing time and Quantum micro-fertilizer on the germination of the seeds, mass of the plants and the number of vacuoles (2016–2018)

Sowing time (Factor A)	Micro-fertilizer (factor B)	Field germination, %	Plant mass, g	Number of vacuoles, pcs.
Soil temperature of 8–10°C (20.04)	Control sample (without treatment)	87.0	53.6	42.5
	Treatment of seeds with Quantum (3 l/t)	90.8	58.9	47.8
	Treatment of seeds and crops by Quantum (3 l/t + 3 l/ha)	91.2	59.4	49.3
Soil temperature of 10–12°C (1.05)	Control sample (without treatment)	89.8	41.2	31.2
	Treatment of seeds by Quantum (3 l/t)	92.0	43.5	33.5
	Treatment of seeds and crop by Quantum (3 l/t + 3 l/ha)	91.5	44.2	35.9
$LSD_{0.05}$ by factor A		1.4	1.3	2.5
$LSD_{0.05}$ by factor B		1.8	1.6	3.1
$LSD_{0.05}$ by factor AB		2.5	2.3	4.4

by micro-fertilizers. The application of micro-fertilizers increased the number of vacuoles in relation to the control sample of the first sowing date by 5.3–6.8 pcs.,while in the second stageby only 4.7 pcs.aftertreatment of seeds and crops by micro-fertilizer ($LSD_{0.05}$ by the factor B = 3.1 pcs.).

Elements of the yield structure depending on the sowing time and application of micro-fertilizers

Changing the elements of the soybean yield structure depends on many factors. In particular, the sowing time which determines the availability of plants with moisture during the vegetation period, is especially relevant for the dry conditions of the northern steppe of Ukraine. A significant influence on the elements of soybean productivity is the application of micro-fertilizers with their main purpose to improve plant growth processes, to intensify nitrogen-phosphorous fertilization, to increase crop productivity and to increase plant resistance to drought.

The selection of the optimal sowing time and application of micro-fertilizers improves the formation of optimal plant density, shows best indicators of individual productivity of plants, and first of all, increase of the mass of plants, the number of beans and seeds per plant, the height of affixture of beans of the lower layer.

Our studies have shown that the number of beans, depending on the agronomic techniques, was 16.3–24.7 pcs. (Table 2). A greater number of them was formed on the first sowing date – 20.8–24.7 pcs., while on the second sowing date their number was much fewer – 16.3–18.9 pcs. The application of Quantum micro-fertilizer significantly increased the number of beans in relation to the control sample of the first sowing time by 3.7–3.9 pcs., in the second time by 1.9–2.6 pcs. ($LSD_{0.05}$by the factor B = 0.9 pcs.).

The number of seeds sown on April 20 was higher and amounted to the average of 45.7 pcs., The shift of sowing to May 1 caused a significant decrease in their number by 11 pcs, which equaled to 24.1%. The application of micro-fertilizer at the first stage of sowing increased significantly the amount of seeds in relation to control – at 5.9–7.2 pcs. ($LSD_{0.05}$by the factor B 4.7 pcs.). At the second stage of sowing the amount of seeds increased insignificantly, by 3.2–3.7 pcs.

An important indicator that has an impact on the quality of harvesting is the height of affixture of the lower bean. The affixture height depends on the plant spacing in the area, plant height and the amount of light.

The micro-fertilizer Quantum did not have a significant effect on the height of affixture of the lower bean. This indicator depended on the sowing time. Thus, with the sowing date of April 20, the height to the lower bean was 16.4 cm on average, and with the sowing on May 1 it decreased to 14.3 cm, or 12.8%.

The individual productivity of plants in one way or another shows the effect of the investigated factors on the realization of the biological and genetic potential of the varieties and, to a certain extent, allows influencing the formation of grain productivity on time.

The mass of seed from one plant varied significantly depending on the sowing time. In the early sowing, it was larger in the range of 5.40–5.69, and when the sowing time was shifted on May 1, it significantly decreased to 4.71–4.98 g. When the seeds and the crop were treated with the micro-fertilizer Quantum during the first sowing time,the mass of the seed increased relative to the control seed by 0.29 g ($LSD_{0.05}$ by the factor B = 0.23 g) and during the second sowing time it increased by 0.26–0.27 g.

Soybean productivity depending on the sowing time and application of micro-fertilizers

Soybean productivity depends on many agro-technical methods of growing technology. However, the most contro-

Table 2. The influence of sowing time and application of Quantum micro-fertilizer on the elements of the yield structure (2016–2018)

Sowing time (factor A)	Micro-fertilizer (factor B)	Number of beans (pcs.)	Number of seeds (pcs.)	Seed mass (g/plant)
Soil temperature of 8–10°C (20.04)	Control sample (without treatment)	20.8	41.3	5.40
	Treatment of seeds with Quantum (3 l/t)	24.5	47.2	5.61
	Treatment of seeds and crops by Quantum (3 l/t + 3 l/ha)	24.7	48.5	5.69
Soil temperature of 10–12°C (1.05)	Control sample (without treatment)	16.3	32.4	4.71
	Treatment of seeds with Quantum (3 l/t)	18.2	35.6	4.98
	Treatment of seeds and crops by Quantum (3 l/t + 3 l/ha)	18,9	36.1	4.97
$LSD_{0.05}$by factor A		0.7	3.8	0.19
$LSD_{0.05}$by factor B		0.9	4.7	0.23
$LSD_{0.05}$by factor AB		1.2	6.6	0.33

versial, according to some researchers, is the optimal sowing time. Both early and late sowing times are harmful for soy. Early periods of sowing, especially in cooler springs, lead to thin planting, overgrowing with weeds, and low productivity. Delay with sowing leads to the fact that the seeds fall into the dried ground, the plants are rooted worse, and seeds do not ripen and have a high humidity level.

The results of the studies of many institutions have proven that micro-fertilizers contribute to a 15–45% increase in productivity. They improve growth processes in plants, improve the biochemical parameters of the quality of the products obtained, increase the fertilization of plants with macronutrients (nitrogen, phosphorus, potassium and sulfur) from fertilizers and from soil, enhance plant resistance to drought conditions and soil salinization (Babych et al., 2011; Venediktov, 2006).

Studies have shown that the productivity of soybean of Romashka variety sown on April 20 was higher and amounted to the average of 2.11 tons per hectare; the shift of sowing on May 1 caused a significant decrease of 0.26 tons per hectare, or 12.3% (Table 3).

The efficiency of Quantum micro-fertilizer increased during sowing on April 20. Thus, the increase in productivity in relation to control samples amounted to 0.23 t/ha (with the treatment of seeds) and 0.28 t/ha (with the treatment of seeds and crops). During sowing on May 1, only the complex application of micro-fertilizers for seeds and crop provided a significant increase in productivity up to 0.17 t/ha ($LSD_{0.05}$ by the factor B = 0.13 t/ha).

It should be noted that the additional spraying of crops by micro-fertilizer did not contribute to a significant increase in productivity compared to the treatment of seeds only, the productivity increase was 0.05–0.06 t/ha.

Thus, the early sowing time with the soil temperature of 8–10°C had a greater impact on micro-fertilizer efficiency witha substantial amount of moisture in soil, as opposed to a later sowing time with the temperature of 10–12°C. Early sowing is recommended for the varieties of the mid-season group in the northern Steppe of Ukraine (Pernak, 2004). This was confirmed by our research, when the shift of sowing time from April 20 to May 1 caused 12.3% decrease in average productivity.

In case of the application of Quantum micro-fertilizer there is an increase in the absorption of moisture and activation of enzymes in the treated seeds, which in turn increases its germination, and also contributes to the formation of more viable plants. In our studies, the seed germinationincreased by 3.8–4.2% in early sowing time compared to the control sample. This is confirmed by the fact that the efficiency of micro-fertilizer is higher when sufficient soil moisture is retained in the soil at earlier sowing time (Marushchak, 2005).

The studies show that Quantum macro-fertilizer stimulates the increase in the mass of plants and the number of vacuoles on one plant and the elements of the structure of the crop. But the greater effect can be observed in the process of treatment of seeds. Since this micro-fertilizer is recommended to be applied in the phases of branching, flowering, and the formation of beans (Serevetnyk, 2011), further studies are planned to identify the effectiveness of the application of several treatments of crops by micro-fertilizers.

Conclusion

Therefore, the research showed that the efficiency of Quantum micro-fertilizer was higherin the early sowing on April 20 with the complextreatment of seeds and crop. This resulted in a larger mass of plants (59.4 g), a higher number of vacuoles (49.3 pcs.), number of seeds (48.5 pcs.) and mass of seeds (5.69 g). The shift of sowing to May 1 led to a decrease of all indicators and the efficiency of micro-fertilizers.

Table 3. Soybean productivity depending on sowing time and application of micro-fertilizers, t/ha

Sowing time (factor A)	Micro-fertilizer (factor B)	Average for 2016–2018	± according to controlsample
Soil temperature of 8–10°C (20.04)	Control sample (without treatment)	1.94	–
	Treatment of seeds with Quantum (3 l/t)	2.17	+0.23
	Treatment of seeds and crops by Quantum (3 l/t + 3 l/ha)	2.22	+0.28
Soil temperature of 10–12°C (1.05)	Control sample (without treatment)	1.76	–
	Treatment of seeds with Quantum (3 l/t)	1.87	+0.11
	Treatment of seeds and crops by Quantum (3 l/t + 3 l/ha)	1.93	+0.17
$LSD_{0.05}$ by factor A		0.11	
$LSD_{0.05}$ by factor B		0.13	
$LSD_{0.05}$ by factor AB		0.19	

The highest productivity was obtained during sowing on April 20 and the treatment of seeds and crop by Quantum micro-fertilizer. The yield was 2.22 t/ha, the increase in crop productivity was significant and amounted to 0.28 tons/hectare (14.4%). The level of soybean productivity was higher during sowing on April 20, an average of 2.11 tons/hectare, and the shift of sowing to May 1 led to 12.3% decrease in productivity.

References

Artemenko, S. F. (2011). Effect of agro-technical measures and sowing time in different weather conditions on soybean productivity. *Bulletin of the Institute of Grain Farming, 40,* 40-45 (Ukr).

Babych, A. O. & Babych-Poberezhna, A. A. (2011). Selection, production, trade and use of soybeans in the world.Monograph, Kyiv, 548 (Ukr).

Babych, A. O., Bakhmat, M. I. & Bakhmat, O. M. (2013). Soya: agro-ecological basics of cultivation, processing and use. A Manual, Kamyanets-Podilskyi, 268 (Ukr).

Babych, A. O., Kolisnyk, S. I. & Venediktov, O. M. (2006). Stability of soybean agrophytocenosis. *Quarantine and Plant Protection, 6,* 11-14 (Ukr).

Babych, A. O., Kolisnyk, S. I. & Venediktov, O. M. (2001).Features of the formation of soybean productivity depending on sowing time and the system of crop protection from diseases in the conditions of the Central Forest-Steppe of Ukraine. *Forages and Fodder Production, 47,* 95-97 (Ukr).

Jarecki, W., Buczek, J. & Bobrecka-Jamro, D. (2016). Response of soybean (*Glycine max* (L.) Merr.) to bacterial soil inoculants and foliar fertilization. *Plant, Soil and Environment (PSE), 62,* 422-427.

Kulibaba, M. Yu. (2015). Growth and development of soy depending on the sowing time and microbial preparation. *Bulletin of Poltava State Agrarian Academy, 1-2,* 155-159 (Ukr).

Kushnir, M. V. (2014). Effect of pre-sowing treatment of seeds and extra-root crops on the productivity and quality of seeds of modern soybean varieties. *Selection and Seed Production, 106,* 134-140 (Ukr).

Marushchak, P. H. (2005). Improvement of the elements of technology of cultivation and fodder use of fast-growing soy varieties in the right-bank Forest-Steppe of Ukraine. The dissertation for the degree of candidate of agricultural sciences, Institute of Agriculture of the Ukrainian Academy of Sciences. Kyiv, 22 (Ukr).

Nyzheholenko, V. M., Protsenko, K. S., Polyakov, O. I. & Nikitenko, O. V. (2009). Influence of sowing time and seeding rates on soybean productivity in conditions of dry-farming and irrigation. *Scientific and Technical Bulletin of the Institute of Oil Seeds of UAAS, 14*, 196-206 (Ukr).

Paul Thomas Gibson (2001). Application of risotorphine as the main condition for increasing soybean productivity in Ukraine. *Storage and Processing of Grain, 10,* 28-30 (Ru).

Pernak, Yu. L. (2004). Influence of sowing time and depth of seeding on soybean productivity in the conditions of the Northern Steppe of Ukraine. *Forages and Fodder Production, 52,* 95-99 (Ukr).

Petrychenko, V. F. (2011). Scientific fundamentals of sustainable soy sowing in Ukraine. *Fodder and Fodder Production, 69,* 3-10 (Ukr).

Serevetnyk, O. V. (2011). Influence of the terms of foliar fertilization on the productivity of soybeans under the conditions of the right bank Forest-Steppe of Ukraine. *Forages and Fodder Production, 69,* 141-146 (Ukr).

Shepilova, T. P. (2009). Formation of high-yield soybeans under the influence of agro-technical techniques in Kirovohrad region, the dissertation abstract for the degree of candidate of agricultural sciences, Institute of Grain Farming of the National Academy of Sciences of Ukraine, Dnepr 19 (Ukr).

Shevnikov, M. Ya. (2011). Features of technology of soybean cultivation in the conditions of unstable moisture of the Forest-Steppe of Ukraine. *Forage and Fodder Production, 69,* 147-151 (Ukr).

Shevnikov, M. Ya. & Logvynenko, **O. M.** (2013). Influence of terms, methods of sowing, rates of seeding of various soybeans on their productivity. *Bulletin of Poltava State Agrarian Academy, 1,* 12-16 (Ukr).

Shevnikov, M. Ya., Lotysh, I. I. & Halych, **O. P.** (2015). Features of soya development depending on the sowing time in the conditions of the left-bank Forest-Steppe of Ukraine. *Bulletin of Poltava State Agrarian Academy, 4,* 14-17.

Shovkova, O. V. (2014). Photosynthetic productivity of soybean crops depending on the time of sowing and methods of application of micro-fertilizers. *Bulletin of Poltava State Agrarian Academy, 2 (73)*, 156-60 (Ukr).

Sichkar, V. (2016). Soybean potential: paper and real. *The Ukrainian Farmer, 11*, 34-36 (Ukr).

Tsekhmeistruk, M. G., Selyakin, V. O. & Glubokyi, **A. M.** (2016). Quality of seeds of soybean varieties depending on the sowing time in the eastern Forest-Steppe of Ukraine. *Forages and Fodder Production, 82,* 39-44 (Ukr).

Venediktov, O. M. (2006). Formation of yield and quality of soybean depending on technological methods of cultivation in the conditions of right-bank Forest-Steppe of Ukraine. The abstract of the dissertation of the candidate of agricultural sciences, Institute of fodders of the National Academy of Sciences of Ukraine,Vinnytsya, 20 (Ukr).

Received: December, 8, 2018; *Accepted:* August, 19, 2019; *Published:* August, 31, 2020