UDC 635.655: 631.527: 631.5: 581.16 DOI: 10.30835/2413-7510.2022.271751

EFFICIENCY OF MODERN SOYBEAN VARIETIES IN TERMS OF YIELD AND SEED QUALITY

Riabukha[1] S.S., Chernyshenko[1] P.V., Bezuhla[1] O.M., Holokhorynska[2] M.H.
[1]Plant Production Institute named after V.Ya.Yuriev of NAAS, Ukraine
[2]Bukovyna State Agricultural Experimental Station of the Institute of Agriculture of the Carpathian Region of NAAS, Ukraine

For seed yield, the best conditions for soybeans were in the Forest-Steppe (2.37 t/ha) and Woodlands (2.20 t/ha). In the Forest-Steppe, the protein (0.957 t/ha), oil (0.489 t/ha) and protein + oil (1.447 t/ha) yields were significantly higher than those in the Steppe (0.747 t/ha, 0.396 t/ha and 1.143 kg ha, respectively). The Forest-Steppe was the most favorable region for growing varieties Rizdviana, Sloboda and Fortetsia; the Woodlands and Forest-Steppe – for the varieties Raiduha and Fantaziia. Variety Pysanka turned out to be the most adapted in terms of yield and seed quality to all the test zones.

Keywords: *soybean, variety trial, seed yield, protein, oil, content in seeds, protein yield, oil yield, test zone*.

Introduction. The domestic soybean (*Glycine max* (L.) Merr.) is one of the world's leading agricultural crops, a source of high-quality protein and oil. In Ukraine, an industrial soybean complex is developing; it has great prospects and consequences for the economy of agriculture and the state as a whole [1]. In the global ranking of soybean producers, Ukraine ranks first in Europe and eighth-tenth in the world, and is a major exporter of soybeans on the world market. The main countries importing soybeans from Ukraine are Turkey, Iran, Egypt, and China [2]. In the medium-term perspective (until 2030), it is predicted that the production of soybean seeds will increase to 7,500,000–8,000,000 tons, which will also provide more than 450,000–600,000 tons of biological nitrogen [3].

Literature Review and Problem Articulation. Breeding plays a leading role in increasing seed yield and improving product quality; therefore, the variety is a necessary and indispensable link in the complex of measures aimed at boosting the production of high-quality products. The optimal performance of a variety is within 60–70% of its potential yield, and 30–40% is a sufficient reserve for increasing its performance under optimal conditions. Modern varieties and hybrids should maximally meet novel cultivation technologies and be competitive. In agricultural crop seed yield, 20–60% is allocated to the role of a variety, depending on effects of environmental conditions and crop cultivation technologies [4–12].

Stabilization of plant production, along with the rational placement of crops and action of other factors, is largely determined by enhancing requirements for selection of varieties that are maximally adapted for growing in different soil and climatic zones and characterized by high environmental plasticity. It is known that the variety is the biological basis of soybean cultivation technologies [13]. The growing importance of this technological element is attributed, first of all, to the ability of varieties, as active biological factors, to effectively counteract adverse effects of other factors in the process of self-regulation of ecological systems [14]. The high genetic potential of soybean performance is evidenced by seed yields of over 10.0 t/ha [15]. Modern varietal policy involves the cultivation of a wide assortment of varieties, which differ by a set of characteristics, ensuring the reliability and stability of production [16]. The basis of the soybean belt is varietal zoning in accordance with the bioclimatic resources of a region, which largely depends on the biology of a variety and environmental conditions determining the varietal policy

ISSN 1026-9959. Селекція і насінництво. 2022. Випуск 122.

of its cultivation [17]. The soybean performance can be increased by 30–45% due to variety replacement and renewal as well as due to implementation of adaptive varietal cultivation technologies [18]. Expanding the norms of reaction of varieties to environmental conditions is the main objective of breeding, especially for regions with weather stressors [19]. Modern domestic soybean varieties potentially yield 4.0–4.5 t/ha and even more, but this potential can only be fulfilled if the biological requirements of the crop for major biotic and abiotic factors are met [20]. Despite successes in the development of the country's soybean complex, with a soybean seed yield in Ukraine of 1.2–1.6 t/ha, in the countries - leading soybean producers (USA, Argentina, Brazil), the seed yield was 2.1–2.9 t/ha, which was 2-fold in relation to the Ukrainian achievements. The genetic potential of soybean varieties for seed yield in Ukraine is fulfilled by 38–56%, while in Canada and the USA – by 70–73% [21].

Seed yield is the most important comprehensive indicator of the economic value of a crop; it combines the performance of an individual plant, biocenotic factor, and environmental conditions [22]. However, for the vast majority of crops, seed yield is an indirect indicator of their economic productivity, since processing and extraction of major products are also expected. For example, the productivity of sugar beet is determined by sugar yield per unit area; in sunflower and rapeseed, it depends on oil yield [23]. In soybeans, such indicators are the protein and oil yields per unit area.

Purpose and Objectives. To determine the efficiency of growing soybean varieties in terms of seed, protein and oil yields in different soil and climatic zones of Ukraine.

Materials and Methods. Six early-ripening soybean varieties grown for grain, bred at the Plant Production Institute (PPI) of NAAS and listed in the State Register of Plant Varieties Suitable for Dissemination in Ukraine were investigated: Pysanka, Raiduha, Rizdviana, Sloboda, Fortetsia, and Fantaziia. The seed yields of the soybean varieties were measured in the competitive variety trial (CVT) of the Laboratory of Grain Legume Breeding (Elitne village, Kharkivskui District, Kharkivska Oblast). Experiments were carried out in four replications, with a plot area of 25 m^2 in accordance with the methodology of the state variety trials [24, 25]. For comparison, we used data on the seed yields and quality of these varieties obtained during the qualification examination for suitability for dissemination conducted by the Ukrainian Institute of Plant Variety Examination (UIPVE) [26]. Data were processed in STATISTICA 10 and Excel, as B.O. Dospekhov described [27].

Results and Discussion. Pysanka, which was submitted for qualification examination in 2012, yielded 1.26 t/ha in the CVT, exceeding the check variety, Yuh 30, by 0.23 t/ha. With the protein content in seeds of 38.3% and the oil content of 21.5%, this variety produced 0.754 t/ha of protein and oil, exceeding the check variety by 0.168 t/ha (Table 1).

Table 1

Economic and biological parameters of soybean variety Pysanka (CVT, average for 2010–2012)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Pysanka	95	1.26	+0.23	38.3	21.5	0.754	+0.168
Yuh 30 (check variety)	98	1.03	–	36.9	20.0	0.586	–
$LSD_{0.05}$	–	0.16	–	–	–	–	–

During the qualification examination, the average yield of Pysanka was 2.20 t/ha, which was 0.94 t/ha higher than that in the CVT. With the average protein content in seeds of 41.3% and the average oil content of 20.0%, this variety produced 0.909 t/ha of protein, 0.440 t/ha of oil, or 1.349 t/ha of protein and oil totally. The variety showed no significant difference in its yield across the test zones. In the Forest-Steppe, it yielded 2.26 t/ha of seeds, providing 0.949 t/ha of protein, 0.468 t/ha of oil, or 1.417 t/ha of protein and oil totally. In the Woodlands, the performance values were as follows: seed yield – 2.14 t/ha, protein yield – 0.869 t/ha, oil yield – 0.417 t/ha, and the total yield of protein and oil – 1.286 t/ha. In the Steppe, the variety gave 2.20 t/ha of seeds; 0.909 t/ha of protein, 0.436 t/ha of oil and 1.344 t/ha of protein + oil (Fig. 1).

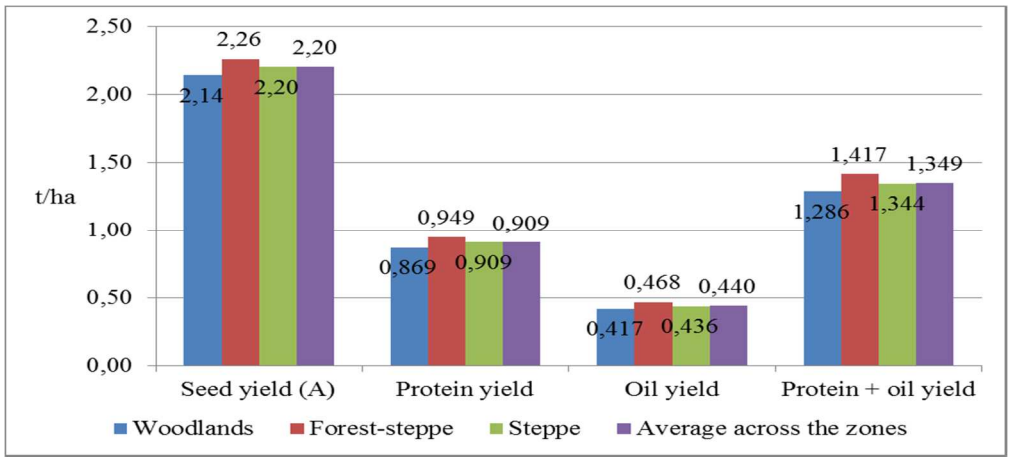

Figure 1. Economic parameters of soybean variety Pysanka (average for 2013–2015). LSD $(A)_{0.05}$=0.14

Pysanka gave a high maximum yield: in the Woodlands – 2.46 t/ha (Volyn Regional State Center for Plant Variety Examination (RSCPVE) and Horodenka Experimental Breeding Station (EBS) in the Ivano-Frankivska Oblast, 2014); in the Forest-Steppe – 3.47 t/ha (Sumy RSCPVE, 2014); in the Steppe – 2.48 t/ha (Kiliia EBS in the Odeska Oblast, 2014). Pysanka has been allowed to be distributed in the Woodlands and Forest-Steppe since 2017 [26].

Raiduha, which was submitted for qualification examination in 2013, yielded 1.46 t/ha of seeds in the CVT, exceeding the check variety by 0.23 t/ha. The protein content in its seeds of 38.2% and the oil content of 21.0% provided the protein + oil yield of 0.864 t/ha, which was 0.164 t/ha higher than that from the check variety (Table 2).

Table 2

Economic and biological parameters of soybean variety Raiduha, (CVT, average for 2011–2013)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Raiduha	97	1.46	+0.23	38.2	21.0	0.864	+0.164
Annushka(check variety)	92	1.23	–	36.9	20.0	0.700	–
$LSD_{0.05}$	–	0.16	–	–	–	–	–

According to the UIPVE's data, Raiduha on average yielded 1.96 t/ha of seeds, which was 0.50 t/ha higher compared to the yield in the CVT. With the average protein content in seeds of

42.5% and the oil content of 21.7%, the variety on average yielded 0.833 t/ha of protein, 0.425 t/ha of oil, and 1.258 t/ha of both ingredients (Fig. 2).

Optimum conditions for this variety were in the Woodlands and Forest-steppe, where almost the same yield of seeds was harvested: 2.19 t/ha and 2.18 t/ha, respectively. In the Woodlands, the variety yielded 0.926 t/ha of protein, 0.464 t/ha of oil, and 1.391 t/ha of protein + oil. In the Forest-steppe, the variety produced 0.935 t/ha of protein, 0.491 t/ha of oil, and 1.426 t/ha of protein + oil. The yield of seeds was significantly lower in the Steppe (1.51 t/ha), where the variety yielded 0.639 t/ha of protein, 0.325 t/ha of oil, and 0.963 t/ha of protein + oil.

The highest yield of this variety was recorded as follows: in the Woodlands – 3.00 t/ha (Andrushivka EBS in the Zhytomyrska Oblast, 2016); in the Forest-Steppe – 3.07 t/ha (Vinnytsia RSCPVE, 2016); in the Steppe – 2.03 t/ha (Dnipro RSCPVE, 2016). Since 2017, Raiduha has been recommended for distribution in the Forest-Steppe and Steppe [26].

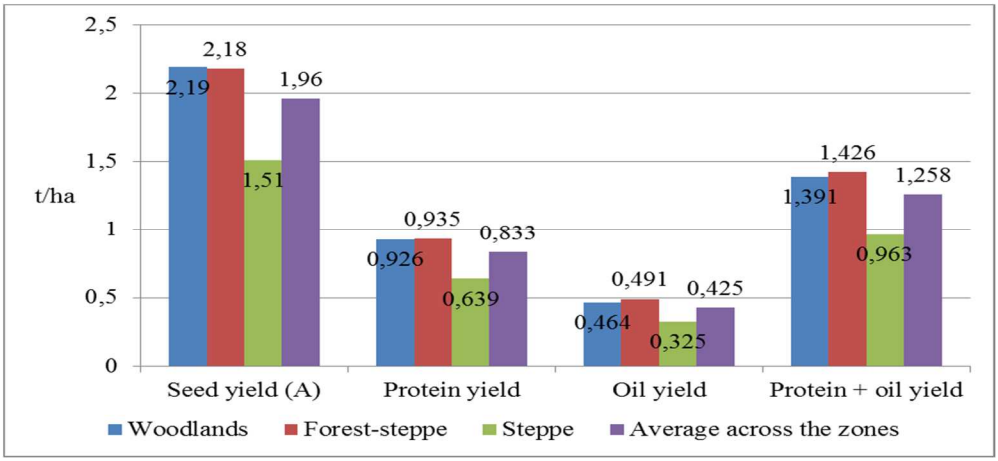

Figure 2. Economic parameters of soybean variety Raiduha (average for 2014–2016). LSD $(A)_{0.05}$=0.14

Rizdviana submitted for qualification examination in 2014 yielded 1.91 t/ha of seeds in the CVT, exceeding the check variety, Annushka, by 0.30 t/ha. With the protein content in seeds of 37.9% and the oil content of 21.5%, the variety produced 1.135 t/ha of protein + oil, or by 0.217 kg/ha more than in the check variety (Table 3).

Table 3

Economic and biological parameters of soybean variety Rizdviana, (CVT, average for 2012–2014)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Rizdviana	99	1.91	+0.30	37.9	21.5	1.135	+0.217
Annushka(check variety)	94	1.61	–	37.0	20.0	0.918	–
$LSD_{0.05}$	–	0.16	–	–	–	–	–

During the qualification examination, Rizdviana on average across the zones yielded 2.05 t/ha of seeds, which was by 0.14 t/ha more than in the CVT (Fig. 3).

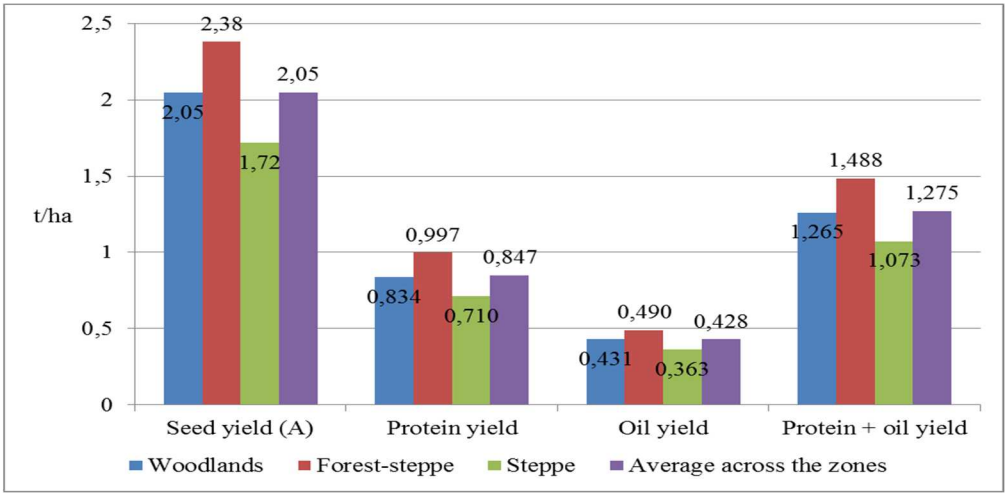

Figure 3. Economic parameters of soybean variety Rizdviana (average for 2015–2016). LSD $(A)_{0.05}$=0.17

With the average protein content in seeds of 41.3% and the oil content of 20.9%, the variety yielded 0.847 t/ha of protein, 0.428 t/ha of oil, and 1.275 t/ha of protein + oil. The seed yield of the variety was significantly higher than the average in the Forest-steppe (2.38 t/ha), where it produced 0.997 t/ha of protein, 0.490 t/ha of oil, and 1.488 t/ha of protein + oil. In the Steppe, the seed yield was significantly lower (1.72 t/ha), the protein yield was 0.710 t/ha, the oil yield was 0.363 t/ha, and the protein and oil yield was 1.073 t/ha. In the Woodlands, the yield was equal to the average across the test zones (3.05 t/ha), which provided 0.834 t/ha of protein, 0.431 t/ha of oil and 1.265 t/ha of protein + oil. The maximum yield of the variety by zone was recorded as follows: in the Woodlands – 2.72 t/ha (Andrushivka EBS in the Zhytomyrska Oblast, 2016), in Forest-Steppe – 3.12 t/ha (Vinnytsia RSCPVE, 2016), in the Steppe – 2.13 t/ha (Dnipro RSCPVE, 2016). Since 2017, Rizdviana has been recognized as suitable for distribution in the Woodlands and Steppe [26].

Sloboda submitted to determine the suitability for dissemination in 2016, yielded of 2.56 t/ha of seeds in the CVT, which was 0.26 t/ha more than in the check variety. The protein content in seeds was 38.7% and the oil content was 20.8%, providing the total yield of protein and oil of 1.523 t/ha, which was 0.207 kg/ha more than that of the check variety (Table 4).

Table 4

Economic and biological parameters of soybean variety Sloboda, (CVT, average for 2014–2016)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Sloboda	99	2.56	+0.26	38.7	20.8	1.523	+0.207
Diona (check variety)	95	2.30	–	36.7	20.5	1.316	–
$LSD_{0.05}$	–	0.22	–	–	–	–	–

During the qualification examination, Sloboda had the average yield of seeds across the zones of 2.06 t/ha, or by 0.50 t/ha lower than in the CVT (Fig. 4).

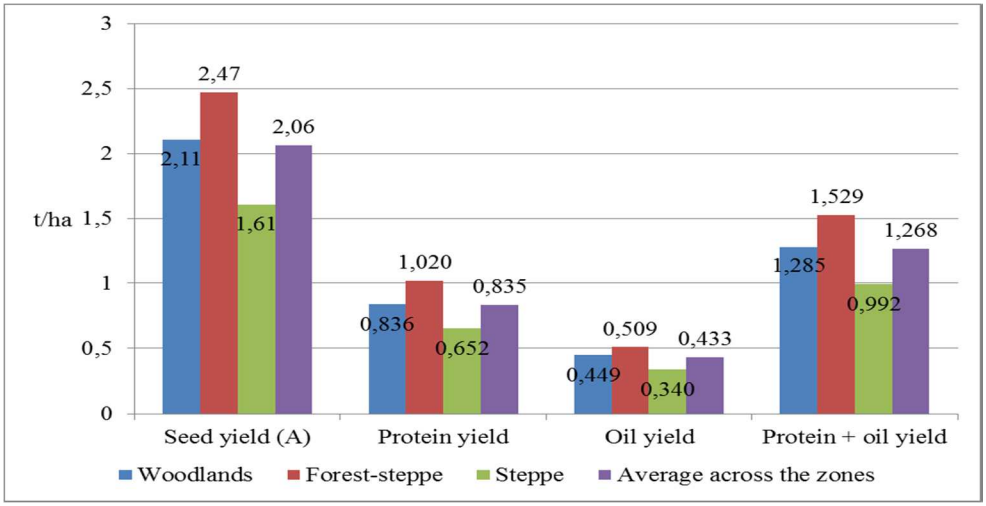

Figure 4. Economic parameters of soybean variety Sloboda (average for 2017–2018). LSD $(A)_{0.05}$=0.14

Seeds of the variety contained 40.5% of protein and 21.0% of oil. This provided the average yield of protein of 0.835 t/ha, oil yield of 0.433 t/ha, and their total yield of 1.268 t/ha. A significantly higher seed yield of the variety was recorded in the Forest-Steppe (2.47 t/ha). There, the variety produced 1.020 t/ha of protein, 0.509 t/ha of oil and 1.529 t/ha of protein + oil. In the Steppe, the average yield of seeds was significantly lower (1.61 t/ha). The protein yield was 0.652 t/ha, the oil yield was 0.340 t/ha, and the protein + oil yield was 0.992 t/ha. The seed yield of the variety in the Woodlands (2.11 t/ha) did not differ significantly from the average across the test zones. There, the protein yield amounted to 0.836 t/ha, the oil yield – to 0.449 t/ha, and the protein + oil yield – to 1.285 t/ha. The maximum yield of the variety by zone was as follows: in the Woodlands – 2.96 t/ha (Volyn RSCPVE, 2018), in the Forest-Steppe – 3.03 t/ha (Chernivtsi RSCPVE, 2018), in the Steppe – 2.19 t/ha (Krynychky Sector of the Dnipro RSCPVE, 2017). Since 2019, Sloboda has been recognized as suitable for distribution in Ukraine in the Woodlands and Steppe [26].

Fortetsia was submitted for qualification examination in 2017. The CVT yield of seeds from the variety was 1.90 t/ha, which was higher than that from the check variety, Diona, by 0.28 t/ha (Table 5).

Table 5

Economic and biological parameters of soybean variety Fortetsia, (CVT, average for 2016–2018)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Fortetsia	95–98	1.90	+0.28	39.0	21.0	1.140	+0.210
Diona (check variety)	92	1.62	–	37.4	20.0	0.930	–
$LSD_{0.05}$	–	0.20	–	–	–	–	–

With the protein content in seeds of 39.0% and the oil content of 21.0%, the variety produced 1.140 t/ha of protein + oil, or by 0.210 kg/ha more than the check variety. The qualification examination of Fortetsia showed that its average yield by zone was 2.20 t/ha, or by 0.30 t/ha higher compared to that in the CVT (Fig. 5).

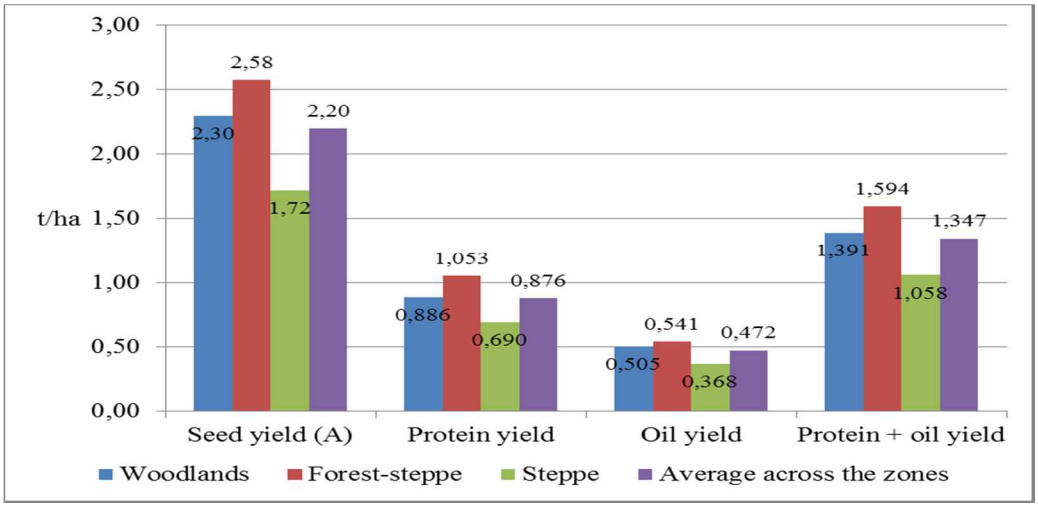

Figure 5. Economic parameters of soybean variety Fortetsia (average for 2018–2019). LSD $(A)_{0.05}$=0.15

Seeds of the variety contained on average 39.9% of protein and 21.5% of oil. This meant 0.876 t/ha for the average yield of protein, 0.472 t/ha for the oil yield, and 1.347 t/ha for their total yield. The seed yield was significantly higher in the Forest-Steppe (2.58 t/ha). There, the variety produced 1.053 t/ha of protein, 0.541 t/ha of oil and 1.594 t/ha of protein + oil. A significantly lower yield of seeds than the average across the zones was recorded in the Steppe (1.72 t/ha). There, the protein yield was 0.690 t/ha, the oil yield was 0.368 t/ha, and the protein + oil yield was 1.058 t/ha. The seed yield in the Woodlands (2.30 t/ha) did not differ significantly from the average, ensuring the protein yield of 0.886 t/ha, the oil yield of 0.505 t/ha and the protein + oil yield of 1.391 t/ha. The variety had the maximum yield of seeds as follows: in the Woodlands – 3.10 t/ha (Volyn RSCPVE, 2018), in the Forest-Steppe – 3.59 t/ha (Kharkiv RSCPVE, 2018), in the Steppe – 2.30 t/ha (Kirovohrad RSCPVE, 2018). Since 2020, Fortetsia has been recognized as suitable for distribution in all natural and climatic zones.

Fantaziia was submitted for determination of suitability for distribution in 2018. In the CVT, Fantaziia yielded 1.65 t/ha of seeds, exceeding the check variety, Diona, by 0.23 t/ha. With the protein content in seeds of 38.0% and the oil content of 20.6%, the variety provided the protein + oil yield of 0.967 t/ha, or by 0.152 kg/ha more than the check variety (Table 6).

Table 6

Economic and biological parameters of soybean variety Fantaziia, (CVT, average for 2016–2018)

Variety	Growing period, days	Seed yield		Content in seeds, %		Protein + oil yield	
		t/ha	+/- to/from the check variety	Protein	Oil	t/ha	+/- to/from the check variety
Fantaziia	94–96	1.65	+0.23	38.0	20.6	0.967	+0.152
Diona (check variety)	92	1.42	–	37.4	20.0	0.815	–
$LSD_{0.05}$	–	0.20	–	–	–	–	–

During the qualification examination, Fantaziia had the average yield of seeds across the zones of 2.22 t/ha, which was 0.57 t/ha higher than that in the CVT. Fantaziia seeds contained on

average 38.8% of protein and 20.8% of oil, so the variety yielded 0.862 t/ha of protein, 0.462 t/ha of oil, and 1.324 t/ha of protein + oil.

The yields in the Woodlands (2.41 t/ha) and Forest-Steppe (2.38 t/ha) did not significantly differ from the average across the zones. In the Woodlands, the variety produced 0.921 t/ha of protein, 0.500 t/ha of oil, and 1.421 t/ha of protein + oil. In the Forest-steppe, the protein amount was 0.975 t/ha, the oil amount – 472 t/ha, and the protein + oil amount – 1.447 t/ha. In the Steppe, the seed yield (1.88 t/ha) was significantly lower than the average, the protein yield was 0.697 t/ha, the oil yield – 0.409 t/ha, and the protein + oil yield – 1.106 t/ha (Fig. 6).

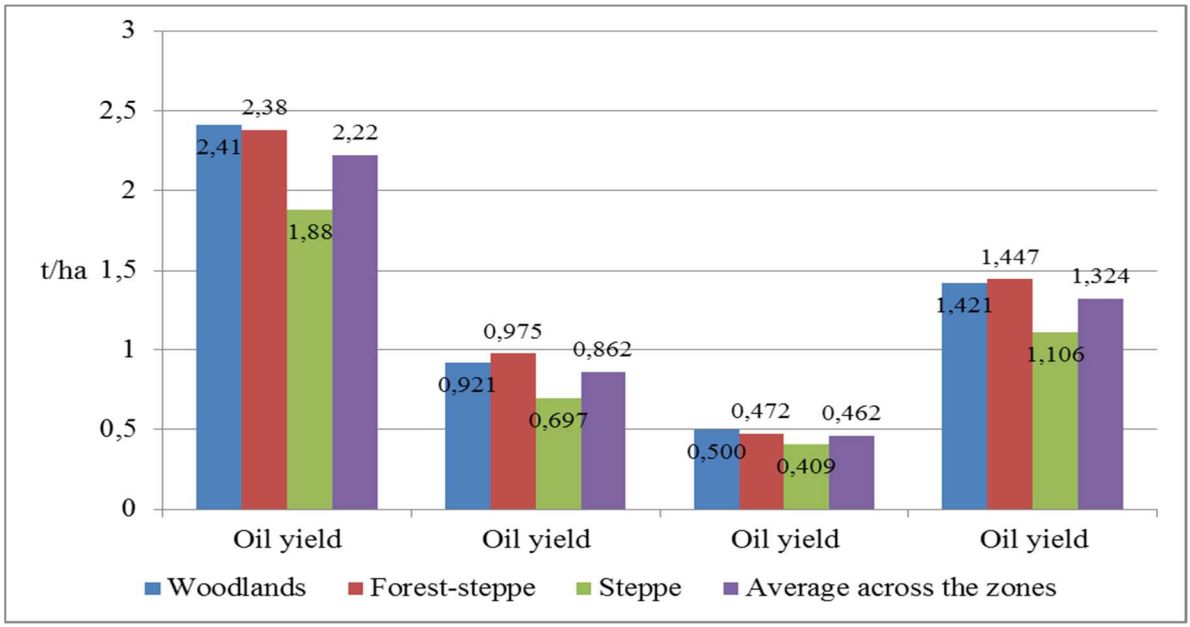

Figure 6. Economic parameters of soybean variety Fantaziia (average for 2019–2020). LSD $(A)_{0.05}$=0.14

The maximum yield of seeds from this variety by zone was as follows: in the Woodlands – 3.35 t/ha of seeds (Rivno branch of the UIPVE, 2020), in the Forest-Steppe – 3.22 t/ha (UIPVE branch, Sumy RSCPVE, 2019), in the Steppe – 3.32 t/ha (UIPVE branch, Dnipro RSCPVE, 2019). Since 2021, Fantaziia has been recognized as suitable for distribution in the Steppe.

Analysis of the average values of seed yield and economic parameters of the varieties studied in different soil and climatic zones of Ukraine showed that the most favorable conditions for their cultivation were in the Forest-steppe (Fig. 7).

The soybean seed yield in the Forest-steppe amounted to 2.37 t/ha, which was significantly higher than that in the Woodlands (2.20 t/ha), or in the Steppe (1.77 t/ha) or than the average yield of seeds across the test zones (2.12 t/ha). The lowest yield of seeds was observed in the Steppe (1.77 t/ha). The seed yield in the Woodlands (2.20 t/ha) did not differ significantly from the average yield across the zones.

The protein yield in the Forest-Steppe (0.957 t/ha) significantly exceeded the corresponding value in the Steppe (0.747 t/ha), but did not differ significantly from the Woodland value (0.879 t/ha) or from the average across the test zones (0.860 t/ha).

The same trend was observed for the total yield of protein and oil. The protein + oil yield in the Forest-Steppe (1.447 t/ha) significantly exceeded the corresponding value in the Steppe (1.143 kg/ha), but did not differ significantly from the average in the Woodlands (1.340 kg/ha) or from the average across the test zones (1.309 kg/ha).

The oil yield in the Forest-Steppe (0.489 t/ha) was significantly higher compared to that in the Steppe (0.396 t/ha), but did not differ significantly from the Woodland value (0.461 t/ha) or from the average across the test zones (0.449 t/ha).

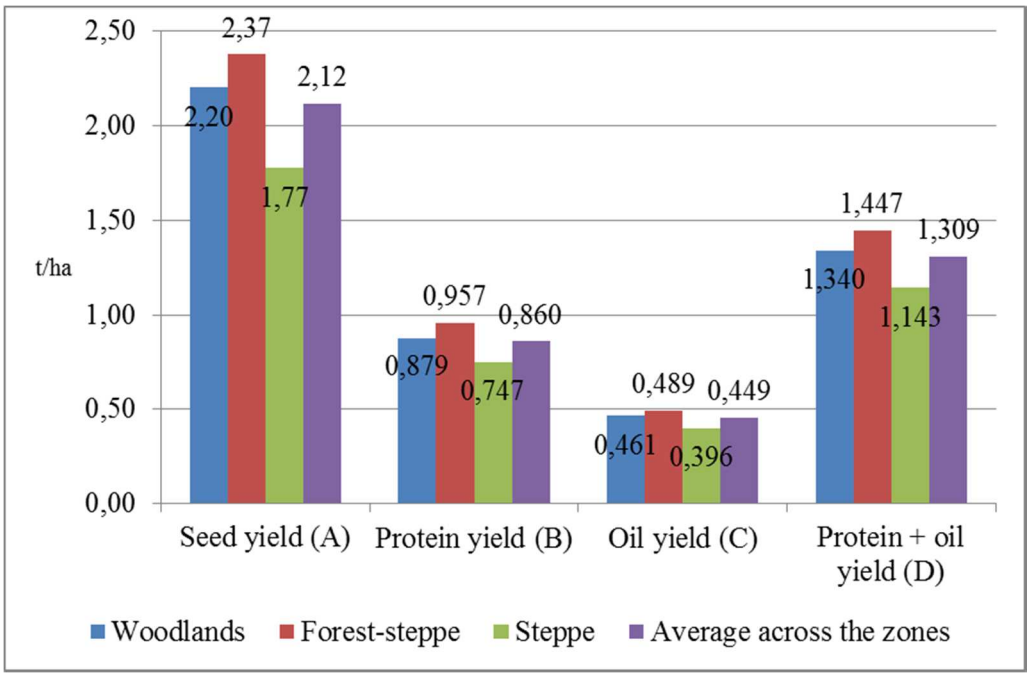

Figure 7 Economic parameters of the soybean varieties listed in the State Register ($LSD_{0.05}$(A) = 0.16; $LSD_{0.05}$(B) = 0.116; $LSD_{0.05}$(C) = 0.055; $LSD_{0.05}$(D) = 0.145).

Comparison of the varieties' yields studied in different soil and climatic zones of Ukraine showed that for the Forest-Steppe was the most favorable region for growing Rizdviana, Sloboda and Fortetsia; this means that these varieties belong to the Forest-Steppe ecotype. Pysanka, Raiduha and Fantaziia yielded similarly in the Woodlands and Forest-Steppe. In the aridest region, Steppe, all varieties under investigation, except for Pysanka, gave significantly lower yields. The same trend was found for the protein and oil yields. Thus, Pysanka turned out to be the most stable variety in terms of seed yield and quality.

Conclusions. The seed yield and economic parameters (protein yield, oil yield and their total amount per hectare) of the new soybean varieties meet the high requirements of current agricultural production and processing industry and are on a par with the best domestic and foreign breeding achievements. The most favorable conditions for growing soybeans were in the Forest-Steppe (the average yield of seeds was 2.37 t/ha) and Woodlands (the average yield of seeds was 2.20 t/ha). The protein yield in the Forest-Steppe (0.957 t/ha) significantly exceeded that in the Steppe (0.747 t/ha), but did not differ significantly from the value in the Woodlands (0.879 t/ha) or from the average across the test zones (0.860 t/ha). The oil yield in the Forest-Steppe (0.489 t/ha) was significantly higher compared to that in the Steppe zone (0.396 t/ha), but did not differ significantly from the Woodland value (0.461 t/ha) or from the average across the zones (0.449 t/ha). A similar trend was found for the total yield of protein and oil, which in the Forest-steppe (1.447 t/ha) significantly exceeded the corresponding value in the Steppe (1.143 kg/ha), but did not differ significantly from the average in the Woodlands (1.340 kg/ha) or from the average across the test zones (1.309 kg/ha). We demonstrated that it was possible to differentiate the varieties according to their adaptability to different natural and climatic zones. The Forest-Steppe was the most favorable region for growing Rizdviana, Sloboda and Fortetsia, while Raiduha and Fantaziia yielded similarly in the Woodlands and Forest-Steppe. Pysanka turned out to be the most stable variety in terms of seed yield and quality in all the natural and climatic test zones, i.e. the most adapted to contrasting environmental conditions.

Список використаних джерел.

1. Сніговий С.В. Еколого-економічні передумови збільшення виробництва сої в Україні. *Корми і кормовиробництво.* 2004. Вип. 53. С. 179–185.
2. Украинский рынок сои – на пути к новым вершинам. http://shareuapotential.com/ru/BE/Ukrainian_soya_2016.html. дата звернення 20.04.2017 р.
3. Петриченко В.Ф. Виробництво зернобобових культур і сої в Україні: сучасні виклики та перспективи. 2016: зернобобові культури та соя для сталого розвитку аграрного виробництва України: матер. міжнар. конф., 11–12 серпня 2016 р. Вінниця, 2016. С. 10–11.
4. Бабич А.О., Бабич-Побережна А.А. Селекція, виробництво, торгівля і використання сої у світі. Київ: Аграрна наука, 2011. 548 с.
5. Дробітько А.В. Вибір сортотипів і агротехнічних прийомів вирощування сої в південно-західному Степу. *Збірник наукових праць Інституту землеробства УААН.* 2000. Вип. 1. С. 73–79.
6. Нетіс В.І. Формування елементів продуктивності сої за різних заходів вирощування. *Таврійський науковий вісник.* 2018. № 99. С. 100–107.
7. Середа Л.М. Вплив агротехнічних заходів на урожайність і якість насіння сої в умовах Лісостепу України. Виробництво, переробка і використання сої на кормові та харчові цілі: матер. третьої Всеукр. конф. Вінниця, 2000. С. 47–48.
8. Черенков А.В., Артеменко С.Ф., Ільєнко О.В. Сортова реакція сої різних груп стиглості на способи сівби і норми висіву при різних погодних умовах. *Корми і кормовиробництво.* 2003. Вип. 51. С. 114–116.
9. Balatti P.A., Piepkke S.G. Cultivars specific interaction of soybean with *Rhizobium fredii* are regulated by genotype of the root. *Plant Physiology.* 1990–94. No 4. P. 1907–1909.
10. Mackay I.J., Horwell A., Garner J. et al. Reanalysis of the historical series of UK variety trials to quantify the contributions of genetic and environmental factors to trends and variability in yield over time. *Theor. Appl. Genet.* 2011. V. 122. Issue 1. P. 225–238.
1. DOI: 10.1007/s00122-010-1438-y.
11. Peltonen-Sainio P., Jauhiainen L., Laurila J.P. Cereal yield trends in Northem European conditions: changes in yield potential and its realization. *Field. Crops Res.* 2009. Vol. 110. Issue 1. P. 85–90. DOI: 10.1016/j.fcr.2008.07.007.
12. Rijk B., van Ittersum M., Withagen I. Genetic progress in Dutch crop yield. *Field Crops Res.* 2013. V. 149. P. 262–268. DOI:10.1016/j.fcr.2013.05.008.
13. Камінський В.Ф. Значення сорту в сучасних технологіях вирощування зернобобових культур. *Корми і кормовиробництво.* 2006. Вип. 57. С. 84–94.
14. Зубов А.Е. Селекция гороха на увеличение пригодности к механизированной уборке (технологичность). *Селекция и семеноводство*. 1997. № 2. С. 14–18.
15. Камінський В.Ф. Основні завдання і результативність селекційної роботи із зернобобовими культурами в ННЦ "Інститут землеробства НААН". 2016. Зернобобові культури та соя для сталого розвитку аграрного виробництва України: матер. міжнар. конф., 11–12 серпня 2016 р. Вінниця, 2016. С. 12–14.
16. Паламарчук В.Д., Климчук О.В., Поліщук І.С., Колісник О.М., Борівський А.Ф. Еколого-біологічні та технологічні принципи вирощування польових культур. Вінниця, 2010. 36 с.
17. Родин Е.А. Влияние крупности семян на урожай гороха. *Селекция и семеноводство.* 1971. № 5. С. 41–42.
18. Циганська О.В. Вплив фону мінерального живлення та способів обробки мікродобривом на формування плодоелементів сортів сої в умовах Лісостепу правобережного. *Корми і кормовиробництво.* 2015. Вип. 81. С. 82–87.
19. Бабич А.О., Іванюк С.В., Коханюк Н.В. Ідентифікація рослин за вегетативними ознаками в селекції сої. *Корми і кормовиробництво.* 2013. Вип. 76. С. 3–7.

20. Бабич А.О., Іванюк С.В., Бабій С.І. Прояв трансгресії за основними кількісними ознаками продуктивності бобів кормових в F_2. *Корми і кормовиробництво.* 2010. Вип. 66. С. 20–24.
21. Вожегова Р.А. Селекційно-технологічні аспекти вирощування сої в умовах зрошення півдня України. 2016. Зернобобові культури та соя для сталого розвитку аграрного виробництва України: матер. міжнар. конф., 11–12 серпня 2016 р. Вінниця, 2016. С. 16–17.
22. Евдокимова Т.Г., Баранова Т.А., Фадеева А.Н. Результаты селекции гороха по комплексным селекционным программам. В кн.: Селекция и семеноводство зернобобовых культур. Орел, 1987. С. 36–38.
23. Кушнір М.В. Вплив передпосівної обробки насіння та позакореневих підживлень на урожайність та якість насіння сучасних сортів сої. *Селекція і насінництво.* 2014. Вип. 106. С. 134–140. DOI: https://doi.org/10.30835/2413-7510.2014.42142.
24. Методика державного сортовипробування сільськогосподарських культур. К., 2000. Вип. 1. 100 с.
25. Методика державного сортовипробування сільськогосподарських культур. К., 2001. Вип. 2. 68 с.
26. Жаркова О. Сортовий арсенал сої на 2017 рік. *Пропозиція.* 2017. (260) 4/17. С. 66–68.
27. Доспехов Б.А. Методика полевого опыта. М: Колос, 1985. 423 с.

References

1. Snihovyi SV. Environmental and economic prerequisites for increasing soybean production in Ukraine. Kormy i Kormovyrobnytstvo. 2004; 53: 179–185.
2. The Ukrainian soybean market is on the way to new heights. Available from: http://shareuapotential.com/ru/BE/Ukrainian_soya_2016.html. date of application 04/20/2017
3. Petrychenko VF. Production of grain legumes and soybeans in Ukraine: current challenges and prospects. 2016: Grain Legumes and Soybeans for the Sustainable Development of the Agrarian Production in Ukraine: Abstracts of the International Conference, August 11–12, 2016. Vinnytsia, 2016. P. 10–11.
4. Babych AO., Babych-Poberezhna AA. Breeding, production, trade and use of soybeans in the world. Kyiv: Ahrarna Nauka, 2011. 548 p.
5. Drobitko AV. Selection of cultivars and agrotechnical methods for soybean cultivation in the south-western steppe. Zbirnyk Naukovykh Prats Instytutu Zemlerobstva UAAN. 2000; 1: 73–79.
6. Netis VI. Formation of soybean performance elements upon different farming techniques. Tavriiskyi Naukovyi Visnyk. 2018; 99: 100–107.
7. Sereda LM. Effect of farming techniques on the soybean seed yield and quality in the Forest-Steppe of Ukraine. Production, Processing and Use of Soybeans for Fodder and Food Purposes: Abstracts of the 3rd All-Ukrainian Conference. Vinnytsia, 2000. P. 47–48.
8. Cherenkov AV, Artemenko SF, Ilienko OV. Varietal response of soybeans of different ripeness groups to sowing methods and seeding rates under different weather conditions. Kormy i Kormovyrobnytstvo. 2003; 51: 114–116.
9. Balatti PA, Piepkke SG. Cultivars specific interaction of soybean with *Rhizobium fredii* are regulated by genotype of the root. Plant Physiology. 1990–94; 4: 1907–1909.
10. Mackay IJ, Horwell A, Garner J et al. Reanalysis of the historical series of UK variety trials to quantify the contributions of genetic and environmental factors to trends and variability in yield over time. Theor. Appl. Genet. 2011; 122(1): 225–238. DOI: https://doi.org/10.1007/s00122-010-1438-y.
11. Peltonen-Sainio P, Jauhiainen L, Laurila JP. Cereal yield trends in Northem European conditions: changes in yield potential and its realization. Field. Crops Res. 2009; 110(1): 85–90. DOI: 10.1016/j.fcr.2008.07.007.

12. Rijk B, van Ittersum M, Withagen I. Genetic progress in Dutch crop yield. Field Crops Res. 2013; 149: 262–268. DOI: https://doi.org/10.1016/j.fcr.2013.05.008.
13. Kaminskyi VF. The value of a variety in modern technologies of growing grain legumes. Kormy i Kormovyrobnytstvo. 2006; 57: 84–94.
14. Zubov AE. Pea breeding for increased suitability for mechanized harvesting (producibility). Selektsiya i Semenovodstvo. 1997; 2: 14–18.
15. Kaminskyi VF. The main tasks and effectiveness of the grain legume breeding at the NSC "Institute of Agriculture of NAAS". 2016. Grain Legumes and Soybeans for the Sustainable Development of the Agrarian Production in Ukraine: Abstracts of the International Conference, August 11–12, 2016. Vinnytsia, 2016, P. 12–14.
16. Palamarchuk VD, Klymchuk OV, Polishchuk IS, Kolisnyk OM, Borivskyi AF. Ecological, biological and technological principles of field crop growing. Vinnytsia, 2010. 36 p. 17. Rodin YeA. The effect of seed size on pea yield. Selektsiya i Semenovodstvo. 1971; 5: 41–42.
17. Rodin Ye.A. The effect of seed size on pea yield. Selektsiya i Semenovodstvo. 1971. No. 5. P. 41–42.
18. Tsyhanska OV. The influence of basic mineral nutrition and microfertilization methods on the formation of fruiting elements in soybean varieties in the Right-Bank Forest-Steppe. Kormy i Kormovyrobnytstvo. 2015; 81: 82–87.
19. Babych AO, Ivaniuk SV, Kohaniuk NV. Identification of plants by vegetative traits in soybean breeding. Kormy i Kormovyrobnytstvo. 2013; 76: 3–7.
20. Babych AO, Ivaniuk SV, Babii SI. Manifestation of transgression for major quantitative traits of the fodder bean performance in F_2. Kormy i Kormovyrobnytstvo. 2010; 66: 20–24.
21. Vozhehova RA. Breeding and technological aspects of soybean growing on irrigation in the south of Ukraine. 2016. Grain Legumes and Soybeans for the Sustainable Development of Agrarian Production in Ukraine: Abstracts of the International Conference, August 11–12, 2016. Vinnytsia, 2016. P. 16–17.
22. Yevdokimova TG, Baranova TA, Fadeyeva AN. Results of pea breeding within complex breeding programs. In: Grain Legume Breeding and Seed Production. Oryol, 1987. P. 36–38.
23. Kushnir MV. The effect of pre-sowing seed treatment and foliar fertilization on the seed yield and quality of modern soybean varieties. Selektsiia i Nasinnytstvo. 2014; 106: 134–140. DOI: https://doi.org/10.30835/2413-7510.2014.42142.
24. Methodology of the state variety trials of agricultural crops. K., 2000. Issue 1. 100 p.
25. Methodology of the state variety trials of agricultural crops. K., 2001. Issue 2. 68 p.
26. Zharkova O. Varietal arsenal of soybeans for 2017. Propozytsiia. 2017; (260) 4/17: 66–68.
27. Dospekhov BA. Methods of field experimentation. M: Kolos, 1985. 423 p.

ЕФЕКТИВНІСТЬ СУЧАСНИХ СОРТІВ СОЇ ЗА ПОКАЗНИКАМИ ВРОЖАЙНОСТІ ТА ЯКОСТІ НАСІННЯ

Рябуха С.С.[1], Чернишенко П.В.[1], Безугла О.М.[1], Голохоринська М.Г.[2]
[1]Інститут рослинництва ім. В.Я. Юр'єва НААН, Україна
[2]Буковинська державна сільськогосподарська дослідна станція Інституту сільського господарства Карпатського регіону НААН, Україна

Мета і задачі дослідження. Визначити ефективність вирощування сортів сої за показниками врожайності та збору білка і олії у різних ґрунтово-кліматичних зонах України.

Матеріали і методи дослідження. Матеріалом для досліджень були шість ранньостиглих сортів сої зернового напряму використання селекції ІР НААН, внесених в Державний реєстру сортів рослин, придатних для поширення в Україні: Писанка, Райдуга, Різдвяна, лобода, Фортеця і Фантазія. Вивчення врожайності сортів сої проводили у конкурсному сортовипробуванні (КСВ) лабораторії селекції зернобобових культур (с. Елітне,

Харківський район, Харківська обл.) у чотириразовому повторенні з обліковою площею ділянки 25 м^2. Для порівняння використовували дані по врожайності та якості насіння цих самих сортів, отримані у мережі проведення кваліфікаційної експертизи на придатність до поширення Українського інституту експертизи сортів рослин (УІЕСР). Обробку результатів досліджень проводили за Б.О. Доспеховим із використанням програм STATISTICA 10 та Excel.

Обговорення результатів. Урожайність сортів сої у поєднанні із показниками якості насіння визначає збір основного товарного продукту (білок та олія) з одиниці площі. У конкурсному сортовипробуванні ІР НААН усі досліджувані сорти показали істотне перевищення над сортами-стандартами, як за врожайністю, так і за збором білка і олії. Сорти виявили специфічну реакцію на ґрунтово-кліматичні умови різних зон випробування. Зафіксовано максимальні рівні врожайності сортів по зонах випробування. Для сорту Писанка: у Поліссі – 2,46 т/га, у Лісостепу – 3,47 т/га, у Степу – 2,48 т/га. Для сорту Райдуга досягнута врожайність становила: у Поліссі – 3,00 т/га, у Лісостепу – 3,07 т/га, у Степу – 2,03 т/га. Сорт Різдвяна забезпечив рівень урожайності: у Поліссі – 2,72 т/га, у Лісостепу – 3,12 т/га, у Степу – 2,13 т/га. Максимальна врожайність сорту Слобода становила: у Поліссі 2,96 т/га, у Лісостепу – 3,03 т/га, у Степу – 2,19 т/га. Максимальна врожайність сорту Фортеця становила: у – Поліссі 3,10 т/га, у Лісостепу – 3,59 т/га, у Степу – 2,30 т/га. Найвищі рівні врожайності сорту Фантазія: у Поліссі – 3,35 т/га, у Лісостепу – 3,22 т/га, у Степу – 3,32 т/га.Аналіз середньої урожайності та середніх значень господарських показників досліджуваних сортів у різних ґрунтово-кліматичних зонах України показав, що найбільш сприятливі умови для їх вирощування склалися у Лісостепу, де врожайність сягала 2,37 т/га, що істотно вище ніж у Поліссі (2,20 т/га), у Степу (1,77 т/га) та у середньому по зонах випробування (2,12 т/га). Найменша врожайність спостерігалась у Степу – 1,77 т/га. Урожайність у Поліській зоні (2,20 т/га) істотно не відрізнялась від середньої врожайності по зонах. Збір білка у Лісостепу (0,957 т/га) суттєво перевищував даний показник у Степу (0,747 т/га) і не мав істотних відмінностей із його значеннями у Поліссі (0,879 т/га) та у середньому по зонах випробування (0,860 т/га). Таку ж тенденція спостерігали і за сумарним збором білка і олії: збір у Лісостепу (1,447 т/га) істотно перевищував даний показник у Степу (1,143 кг/га) і не мав істотної різниці із середнім значенням по Поліссю (1,340 кг/га) та по зонах випробування (1,309 кг/га). Збір олії у Лісостепу (0,489 т/га) був суттєво вищим порівняно із зоною Степу (0,396 т/га), проте не мав істотних відмінностей від даного показника у Поліссі (0,461 т/га) та від середнього по зонах (0,449 т/га).Порівняльний аналіз урожайних даних досліджуваних сортів у різних ґрунтово-кліматичних зонах України показав, що для сортів Різдвяна, Слобода та Фортеця найбільш сприятливим регіоном вирощування виявився Лісостеп, що дозволяє віднести ці сорти до лісостепового екотипу. Сорти Писанка, Райдуга та Фантазія мали однакові рівні врожайності у Поліссі та Лісостепу. У більш посушливому регіоні Степу усі досліджувані сорти за винятком сорту Писанка формували істотно нижчій рівень урожайності. Така ж тенденція виявлена за зборами білка і олії. Отже, сорт Писанка виявився найбільш стабільним за показниками врожайності та якості насіння.

Висновки. Рівні врожайності та господарських показників (збору білка, олії та їх сукупної кількості з 1 га) у сортів сої відповідають високим вимогам сучасного аграрного виробництва та переробної промисловості і знаходяться на рівні кращих вітчизняних та світових селекційних досягнень. Найбільш сприятливі умови вирощування сої склалися у Лісостепу (середня врожайність – 2,37 т/га) та Поліссі (середня врожайність – 2,20 т/га). Збір білка у Лісостепу (0,957 т/га) істотно перевищував даний показник у Степу (0,747 т/га) і не мав істотних відмінностей із його значеннями у Поліссі (0,879 т/га) та у середньому по зонах випробування (0,860 т/га). Збір олії у Лісостепу (0,489 т/га) був суттєво вищим порівняно із зоною Степу (0,396 т/га), проте не мав істотних відмінностей від даного

показника у Поліссі (0,461 т/га) та від середнього по зонах (0,449 т/га). Аналогічну тенденцію виявлено і за сумарним збором білка і олії, який у Лісостепу (1,447 т/га) істотно перевищував даний показник у Степу (1,143 кг/га) і не мав істотної різниці із середнім значенням по Поліссю (1,340 кг/га) та по зонах випробування (1,309 кг/га). Виявлено диференціацію сортів за пристосованістю до умов різних природно-кліматичних зон. Для сортів Різдвяна, Слобода та Фортеця найбільш сприятливим регіоном вирощування є Лісостеп, а сорти Райдуга та Фантазія мали однакові рівні врожайності у Поліссі та Лісостепу. Сорт Писанка виявився найбільш стабільним за показниками врожайності та якості насіння в усіх природно-кліматичних зонах випробовування, тобто найбільш адаптованим до контрастних умов довкілля.

Ключові слова: *соя, сортовипробування, врожайність, білок, олія, вміст у насінні, збір білка, збір олії, зона випробування.*

EFFICIENCY OF MODERN SOYBEAN VARIETIES IN TERMS OF YIELD AND SEED QUALITY

Riabukha[1] S.S., Chernyshenko[1] P.V., Bezuhla[1] O.M., Holokhorynska[2] M.H.
[1]Plant Production Institute named after V.Ya.Yuriev of NAAS, Ukraine
[2]BukovynaState Agricultural Experimental Station of the Institute of Agriculture of the Carpathian Region of NAAS, Ukraine

The purpose and objectives of the study. To determine the efficiency of growing soybean varieties according to the indicators of yield and protein and oil collection in different soil and climatic zones of Ukraine.

Research materials and methods. The material for the research was six early-ripening soybean varieties of the grain direction using the IR NAAS selection entered in the State Register of plant varieties suitable for distribution in Ukraine: Pysanka, Raiduha, Rizdviana, Sloboda, Fortetsia and Fantaziia. The study of the yield of soybean varieties was carried out in the competitive variety test (CSV) of the laboratory of the selection of grain and leguminous crops (Elitne village, Kharkiv district, Kharkiv region) in four repetitions with a plot area of 25 m^2. For comparison, we used data on the yield and quality of the seeds of these same varieties, obtained in the network of qualification examination for suitability for distribution of the Ukrainian Institute for Plant Variety Examination (UIPVE). Processing of research results was carried out according to B.O. Dospehov using STATISTICA 10 and Excel programs.

Discussion of results. The productivity of soybean varieties in combination with seed quality indicators determines the collection of the main commercial product (protein and oil) from a unit of area. In the competitive variety test of the IR of the National Academy of Sciences of the Russian Academy of Sciences, all studied varieties showed a significant excess over the standard varieties, both in yield and in terms of protein and oil collection. Varieties showed a specific reaction to the soil and climatic conditions of different test zones. The maximum yield levels of the varieties in the test zones were recorded. For the Pysanka variety: in Woodlands – 2.46 t/ha, in Forest-steppe – 3.47 t/ha, in Steppe – 2.48 t/ha. For the Raiduha variety, the yield achieved was: in Woodlands – 3.00 t/ha, in Forest-steppe – 3.07 t/ha, in Steppe – 2.03 t/ha. The Rizdviana variety ensured the yield level: in Woodlands – 2.72 t/ha, in Forest-steppe – 3.12 t/ha, in Steppe – 2.13 t/ha. The maximum yield of the Sloboda variety was: 2.96 t/ha in Woodlands, 3.03 t/ha in the Forest Steppe, and 2.19 t/ha in the Steppe. The maximum yield of the Fortetsia variety was: 3.10 t/ha in Woodlands, 3.59 t/ha in the Forest-steppe, and 2.30 t/ha in the Steppe. The highest yield levels of the Fantasia variety: in Woodlands – 3.35 t/ha, ha in the Forest-steppe – 3.22 t/ha in the Steppe – 3.32 t/ha. The analysis of the average yield and average values of the economic traits of

the investigated varieties in different soil and climatic zones of Ukraine showed that the most favorable conditions for their cultivation were in the Forest-steppe, where the yield reached 2.37 t/ha, which is significantly higher than in Woodlands (2.20 t/ha), in the Steppe (1.77 t/ha) and on average in the test zones (2.12 t/ha). The lowest yield was observed in the Steppe – 1.77 t/ha. The yield in the Woodlands zone (2.20 t/ha) did not significantly differ from the average yield in the zones. The collection of protein in the Forest-steppe (0.957 t/ha) significantly exceeded this indicator in the Steppe (0.747 t/ha) and had no significant differences with its values in the Woodlands (0.879 t/ha) and the average of the test zones (0.860 t/ha). The same trend was observed for the total collection of protein and oil: the collection in the Forest-steppe (1.447 t/ha) significantly exceeded this indicator in the Steppe (1.143 kg/ha) and did not have a significant difference with the average value for Woodlands (1.340 kg/ha) and by test zones (1.309 kg/ha). The collection of oil in the Forest-steppe (0.489 t/ha) was significantly higher compared to the Steppe zone (0.396 t/ha), but did not differ significantly from this trait in Woodlands (0.461 t/ha) and from the zone average (0.449 t/ha). A comparative analysis of the yield data of the researched varieties in different soil and climatic zones of Ukraine showed that for the Rizdviana, Sloboda and Fortetsia varieties, the most favorable growing region was the Forest-steppe, which makes it possible to attribute these varieties to the Forest-steppe ecotype. Pysanka, Raiduha and Fantasia varieties had the same yield levels in Woodlands and Forest-steppe. In the more arid region of the Steppe, all investigated cultivars, with the exception of the Pysanka cultivar, formed a significantly lower yield level. The same trend was found for protein and oil collections. So, the Pysanka variety turned out to be the most stable in terms of yield and seed quality.

Conclusions. The levels of productivity and economic traits (collection of protein, oil and their total amount per 1 ha) of soybean varieties meet the high requirements of modern agricultural production and processing industry and are at the level of the best domestic and world breeding achievements. The most favorable conditions for growing soybeans were in the Forest-steppe (average yield – 2.37 t/ha) and Woodlands (average yield – 2.20 t/ha). The collection of protein in the Forest-steppe (0.957 t/ha) significantly exceeded this trait in the Steppe (0.747 t/ha) and had no significant differences with its values in Woodlands (0.879 t/ha) and the average for the test zones (0.860 t/ha). The collection of oil in the Forest-steppe (0.489 t/ha) was significantly higher compared to the Steppe zone (0.396 t/ha), but did not differ significantly from this indicator in Woodlands (0.461 t/ha) and from the zone average (0.449 t/ha). A similar trend was found in the total collection of protein and oil, which in the Forest-steppe (1.447 t/ha) significantly exceeded this indicator in the Steppe (1.143 kg/ha) and had no significant difference with the average value in Woodlands (1.340 kg/ha) and in test zones (1.309 kg/ha). The differentiation of varieties according to their adaptability to the conditions of different natural and climatic zones was revealed. For the Rizdviana, Sloboda and Fortetsia varieties, the most favorable growing region is the Forest-steppe, while the Raiduha and Fantaziia varieties had the same yield levels in the Woodlands and the Forest-steppe. The Pysanka variety turned out to be the most stable in terms of yield and seed quality in all natural and climatic test zones, i.e. the most adapted to contrasting environmental conditions.

Key words: *soybean, variety trial, seed yield, protein, oil, content in seeds, protein yield, oil yield, test zone*.