IZDEVNIECĪBA
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THEORETICAL AND PRACTICAL ASPECTS OF THE DEVELOPMENT OF MODERN SCIENTIFIC RESEARCH

Scientific monograph

Part 2

Riga, Latvia
2022

UDK 001(082)
Th310

Title: Theoretical and practical aspects of the development of modern scientific research

Subtitle: Scientific monograph

Scientific editor and project director: Anita Jankovska

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Publisher: Publishing House "Baltija Publishing", Riga, Latvia

Available from: http://www.baltijapublishing.lv/omp/index.php/bp/catalog/book/215

Year of issue: 2022

Theoretical and practical aspects of the development of modern scientific research: Scientific monograph. Part 2. Riga, Latvia: Baltija Publishing, 2022. 300 p.

ISBN: 978-9934-26-195-4

DOI: https://doi.org/10.30525/978-9934-26-195-4

The scientific monograph presents the theoretical and practical aspects of the development of modern scientific research. General questions of economics and enterprise management, regional economics, marketing, technical sciences, technology of food and light industry, and so on are considered. The publication is intended for scientists, educators, graduate and undergraduate students, as well as a general audience.

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RESEARCH OF EARLY RATING SOYBEAN VARIETIES ON TECHNOLOGY AND AGROECOLOGICAL RESISTANCE

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DOI: https://doi.org/10.30525/978-9934-26-195-4-18

Abstract. The monograph presents scientific and experimental research that reveals the theoretical and practical issues of production of soybean that can solve the problem of protein deficiency and replenish the world's food and feed resources. The research is based on the tasks of applied research on the topic: «Development of methods for improving the technology of growing legumes using biofertilizers, bacterial preparations, foliar fertilizers and physiologically active substances», state registration number 0120U102034. The authors' research is aimed at solving current problems of technological renewal and development of the agro-industrial complex of Ukraine. During the study it was found that the duration of the growing season precocious and ultra-early soybean varieties develop within 83-85 days. Thus, as of 2021, 17 precocious and ultra-precocious soybean varieties have been included in the State Register of Plant Varieties of Ukraine. Most of these varieties have a growing season of 85 days and only varieties of Dion – 83 days and Arnica – 84 days.

It is determined that the height of plants of early-maturing soybean varieties varies widely – 58-110 cm. It is proved that the height of attachment of lower beans in precocious soybean varieties is 10-16 cm from the soil surface. The lowest beans are the highest attached in the soybean varieties of OAC Brook – 16 cm, Rohiznyanka – 15 cm, Kobza and OAC Avatar – 14 cm each.

The highest resistance to lodging, which determines the completeness of mowing and selection of soybean stem mass, had plants varieties

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Aventurine, OAC Lakeview, Geba and Berkana – 9.0 points, OAC Avatar, Rogiznyanka, Golubka – 8.9 points.

All precocious varieties of soybeans are characterized by high resistance to seed shedding – 7.0-9.0 points. The most drought-resistant varieties are OAC Lakeview, Geba, Berkan – 9.0 points each. The most resistant to diseases are soybean varieties Aventurine, Kobza, Diona, Arrat, Rogiznyanka, Arnica – 9.0 points each.

The seed yield of precocious soybean varieties is 2.00-3.25 t/ha. The highest yields were Dion – 3.25 t/ha, Arrata – 3.0 t/ha. The least productive varieties are Rohiznyanka – 2.00 t/ha, OAC Brook – 2.03 t/ha, Kobza – 2.14 t/ha.

Soybean varieties had the highest protein content in seeds: Berkana – 43.4%, Rainbow – 42.3%, Dove and Melody – 42.1% each. The lowest protein content was in the varieties Arrata – 38.0%, Legend, Diona – 38.5%, Kobza – 39.1%.

The fat content in the seeds of Geba soybean varieties – 22.0%, OAC Lakeview – 21.7% and Golubka – 21.6% was the highest, and in the varieties Beauty – 19.3%, Arnica – 20.5% and Melody – 20.6% – the smallest.

1. Introduction

Legumes are valuable plants of agriculture in Ukraine in food, feed and agri-environmental aspects. However, due to a number of objective and subjective reasons, farmers grow these crops in very small areas. In Ukraine, legume crops are about 600.0 thousand hectares, which is only 2% of the structure of sown areas with the optimal rate – about 10%. This requires a significant expansion of the wedge of legumes in Ukraine. Today, the structure of legumes is dominated by peas and soybeans, which account for about 84%. However, in the context of climate change, the share of currently uncommon legumes should increase significantly: chickpeas, lentils, ranks, beans, beans, etc., which can fully realize their potential for productivity in specific soil and climatic conditions [1; 3–5].

The main cornerstone in the expansion of sown areas under legumes is the lack of awareness of modern varieties of these crops, their productivity, resistance to adverse weather conditions, pests and diseases. Often there is no comparative characteristic of all varieties included in the State Register of Plant Varieties of Ukraine, given in one scientific material, which can greatly simplify the choice of the optimal variety or culture for certain soil and climatic conditions.

When selecting varieties of legumes for certain soil and climatic conditions, it is necessary to take into account their yield potential, as well as indicators of cultivability. Determining parameters of the manufacturability of legume varieties are their resistance to lodging, shedding of beans, the suitability of plants for direct combining, the height of attachment of the lower bean, plant height and others.

In addition, it is necessary to take into account the maturity of the varieties, their reaction to weather and soil conditions. Drastic climate change in the direction of drought, rising temperatures, prolonged rainfall has led to the suppression of certain legumes or their varieties by drought, waterlogging, diseases, pests, weeds, and this has reduced their yields and deteriorating product quality.

Growing old «old» varieties, which once gave a high yield, in conditions of climate change and reducing their productivity leads to a refusal to grow one or another legume in general. This is also facilitated by the lack of sortosamini and varietal renewal of legumes. Therefore, the current direction of increasing the productivity of legumes is to take into account their varietal characteristics, taking into account specific soil and climatic conditions.

However, the realization of the varietal potential of legumes requires not only the correct selection of varieties, but also the appropriate technology of their cultivation, adapted to a particular variety.

Soybean is a profitable crop, so it occupies a significant share in the structure of sown areas of most agricultural enterprises in Ukraine. The reason for the increase in soybean acreage in Ukraine is the high export demand and high price on the world market due to the high demand of soybean importers in the world [1].

In 2016, Ukraine was a record holder in terms of growth in gross soybean harvest and the first in the world in terms of growth in soybean exports, ahead of global producers of this crop – the United States and Brazil. Based on this, in the near future Ukraine may export large amounts of soybeans abroad and thereby significantly increase the profitability of growing this crop [2].

Given the growth of soybean acreage in Ukraine in recent years and bringing its crops to 2 million hectares, there is a need to find promising varieties that would be characterized by higher productivity, resistance to drought, disease, pests, lodging, shedding of seeds with short growing season, high seed quality and high nitrogen-fixing ability [3]. It is the right choice of soybeans can provide a good profit.

2. Analysis of recent research and publications

Soybeans are heat- and moisture-loving crops. Therefore, in the absence of at least one of these factors, it is necessary to choose drought- or cold-resistant varieties of this crop. Also an important characteristic of the soybean variety is the period of its maturation [4].

When choosing a potential soybean variety, you should also pay attention to the protein content in the seeds, plant height and height of the lower beans, stem thickness, the nature of plant growth, the tendency to crack and shed seeds and others.

The protein content of soybean seeds will be an important indicator when exporting soybean seeds, in particular to the Asian market or during its processing. Soy is also used as an oil crop, so the fat content of its seeds also plays an important role. The content of protein or fat in soybean seeds can significantly affect its selling price [5].

Its productivity directly depends on the height of soybean plants. Also, tall soybean plants have a deep root system that is able to effectively use moisture from the lower layers of the soil, which is especially relevant in arid climates [6].

The height of the lower beans is directly related to the height of the plants and is important for quality harvesting. At low placement of beans from a soil surface their loss at combine harvesting is possible. Therefore, for combine harvesting of soybean varieties, the height of attachment of the lower beans should be at least 12 cm from the soil surface. Also helps to increase the height of the attachment of the lower beans by reducing the width of the rows when sowing soybeans [3].

The thickness of the stem of soybean plants is an important indicator that determines the resistance of the variety to lodging. Very dense sowing promotes soybean plants, as soybeans are light-loving crops, and in conditions of dense sowing they will experience a lack of light, which will reduce branching, but will increase plant height, thinning stems and lodging [7].

The tendency of soybean varieties to crack and shed seeds from beans can also lead to the loss of part of the crop. Therefore, this figure is also taken into account.

Parameters of soybean varieties such as plant height, lower bean attachment height, stem thickness, tendency to bean cracking and seed shedding are a group of technological indicators that affect the conditions of harvesting by combine harvester. Resistance of soybean varieties to drought, pests, diseases are agroecological characteristics that determine the stability of crop productivity under adverse environmental conditions [5].

In the early sowing of soybeans, it is desirable to choose varieties with pubescent leaves that are more resistant to lower temperatures. Different soybean varieties are characterized by different plant growth intensities in different periods during the growing season. Some varieties have very slow initial growth and are uncompetitive with weeds, while others have fast initial growth. There are varieties with a long flowering period, and others bloom only about one week, although the growing season is the same [2].

The weight of thousands of seeds depends entirely on the characteristics of the variety and directly affects the level of yield. With a larger mass of soybean seeds, it can be wrapped deeper, which will promote better germination in dry weather during sowing.

The timing of soybean ripening is important when using it as a precursor for winter wheat or for timely application of fertilizers and quality tillage for the next crop in crop rotation. Under such requirements it is necessary to choose precocious varieties [6]. According to the FAO International Classification, all soybean varieties are divided into 13 groups of ripeness, depending on the length of the growing season. In Ukraine, only the first five groups are suitable for cultivation: ultra-early varieties with a growing season of up to 85 days; early-ripening varieties – 86-105 days; medium-early varieties – 106-125 days; medium-ripe varieties – 126-135 days; medium-late varieties with a growing season of 136-145 days [8].

There is a recommended distribution of maturity groups of soybean varieties by geographical zoning of Ukraine. In particular, early-ripening varieties are recommended for the south of Ukraine, early-ripening and medium-ripening varieties are recommended for the central regions, and early-ripening, early-ripening and middle-early varieties are recommended for the north and west of Ukraine [7].

Also, when choosing soybean varieties, the following dependence is used: early-ripening varieties are used as precursors for winter wheat; medium-ripe – for soybean harvesting with optimal seed moisture without additional drying; late-ripening – if there are large areas under soybeans in the farms and it is impossible to collect it in a short time, which prevents the seeds from falling out when the plants overripe. Early-maturing soybean varieties reduce the risks due to unfavorable growing conditions, and varieties with a longer growing season are more productive [4].

The current yield potential of most soybean varieties included in the State Register of Plant Varieties of Ukraine is over 3.5 t/ha, but the actual yield on average in Ukraine is about 2 t/ha. Further increase in gross soybean harvest in Ukraine should be ensured by increasing its yield with rational use of varieties. The range of soybean varieties included in the State Register of Plant Varieties of Ukraine with their adaptation to different soil and climatic conditions can ensure that farmers receive not only high but also stable soybean yields [5].

At the same time, the large variety of soybean varieties in the State Register does not allow to choose the best option to ensure consistently high productivity, resistance to adverse environmental factors, because in some unfavorable years soybean varieties may mature, which increases their growing season, especially late sowing or for lowering the temperature during the growing season.

Since in the conditions of the Right-Bank Forest-Steppe of Ukraine the problem of lack of optimal precursors for winter wheat remains relevant, the cultivation of precocious soybean varieties can solve this problem. However, in the world soybean gene pool, including the State Register of Plant Varieties of Ukraine, the number of precocious varieties is the lowest, compared to varieties of other maturity groups. Also, most varieties of this maturity group have a common origin, so they have common shortcomings, including low productivity, susceptibility to cracking and others.

3. Literature review

Soy and soy products are the main source of food protein and an important factor in economic growth in many countries world. Stabilization of agriculture, elimination of protein deficiency, replenishment of fat resources, increase of productivity of other cultures as soy enriches the soil with nitrogen depend on its production. The constant demand for soy and soy products in both domestic and foreign markets of Ukraine has led to expanding the area under crops under this crop. Along with the increase in sown areas, the level of soybean yields remains low and unstable. Thus, research on ways to increase soybean yields through implementation is becoming increasingly important for Ukraine new high-yielding varieties and improving cultivation technology. The solution to this problem is possible due to the creation of high-yielding, drought-resistant soybean varieties of Ukrainian selection, which are not genetically modified, not inferior to foreign varieties in yield, and even better than them because they are adapted to our conditions [1].

For the successful realization of the biological potential of new soybean varieties it is necessary to have knowledge about the importance of the contribution of certain traits in the formation of the crop and its quality. After all, one's own knowledge of the variability of traits in combination with physiological aspects of their formation makes it possible to develop and implement agro-technical methods of influencing the plant [14; 22].

In view of this, one of the highest priority tasks today is the creation of adaptive systems with advanced self-tuning mechanisms that will ensure the stability of operation and stability of the final product in specific environmental conditions. Management of adaptive systems is qualitatively different – not through the regulation of the external environment, but through the impact on internal processes, ie management of biological processes of organic synthesis substances, its transformation into useful products of growth and development and phenotypic realization in general genetic information [33].

Soybean varieties of different maturity groups have not only biological differences in their own individual development, but also given the different length of the growing season are subject the impact of different weather conditions during their cultivation. Accordingly, in the process of building mathematical varieties, such varieties cannot be identified and perceived as a whole [17]. The critical period of soybeans is the formation of beans on plants. It is established that the air temperature negatively and moderately correlates with this feature. That is, with excessive rainfall during this period soybean plants produce less beans than under optimal growing conditions development. The number of seeds per plant was found to be negatively correlated with air temperature and тprecipitation (moderate bond), but humidity is positively correlated at low levels communication [18].

The formation of the mass of thousands of seeds is positively influenced by air temperature and quantity precipitation, but the closeness of the relationship at the level of weak correlation does not allow to consider these factors as determinants in the formation of the trait. It is determined that the main component of productivity of early soybean varieties – the mass of seeds from. Climatic factors such as air temperature and humidity have a significant effect on plants air and precipitation. As with the number of seeds per plant, these are weather factors are related by inverse force correlation and only humidity has a direct type of connection. So, excessive air temperatures and excessive rainfall contribute to much less plant productivity than under optimal weather conditions [12; 19; 40].

For each zone it is necessary to select varieties taking into account its ecological conditions. Even in regions where soybean breeding has been carried out for decades, there is a possibility of further growth of its yield potential [7; 15].

In general, all the quantitative characteristics of plants can be divided into five main groups: weight, fruit productivity, seed productivity, height and the number of nodes. Optimal the productivity of soybean plants can be formed due to the optimal ratio of all elements of productivity. After all, under the limit of conditions favorable for the development of one of the elements of the plant structure, the individual level of productivity can be compensated by the fuller development of other elements. A striking example here is the relationship between plant density and the number of branches or the formation of the number of knots and beans according to the optical parameters of crops, and so on. It is well known that some elements of productivity are formed at different stages of organogenesis of soybean plants, and therefore for their optimal development requires different, sometimes contrasting conditions. The factors that limited the formation of one trait serve as a kind of catalyst for another [1; 9; 10; 28].

4. Conditions, objective and methods of research

The purpose of the study was to analyze the State Register of Plant Varieties of Ukraine suitable for distribution in 2021, to investigate precocious varieties of soybean plants in terms of their cultivation, agri-environmental resistance to adverse growing conditions, yields and protein and fat content in seeds, which will recommend optimal precocious varieties of soybeans on a set of indicators.

Studies to assess the manufacturability, productivity, seed quality and agri-environmental sustainability of precocious soybean varieties were conducted by the State Register of Plant Varieties Suitable for Distribution in Ukraine in 2021 [9], Official Descriptions of Plant Varieties and Suitability Indicators presented in the «Bulletins plant varieties», placed in the Information and reference system «Variety» [10–13].

Soybean varieties according to the state qualification examination to determine indicators of suitability for distribution in Ukraine are assessed, among other things, by grain yield, resistance (tolerance) against disease, adverse weather conditions (drought) and other indicators, including resistance to lodging and seed shedding [14].

Agroecological resistance of soybean varieties was determined by the value of their drought resistance, as well as resistance to the most common diseases: downy mildew (*Peronospora manshurica Sydow*), ascochitosis (*Ascochytaso jaecola Abramov*), bacteriosis (*Pseudomonas Septoria, S. Pseudomonas and Glyconeopynais glyvanonois, Pseudomonas sepiaemortium*) fusarium wilt (*Fusarium Link.*).

The duration of the growing season of soybean varieties is set by reaching 2/3 of the beans on the plants, when the grains become firm, acquired the characteristic color and shape of the variety, shaking the lower part of the plants can be heard characteristic rustling of grains [14].

The relative resistance of soybean varieties to such adverse factors as disease resistance, drought resistance, resistance to lodging and seed shedding is set on a nine-point scale (1-9 points). According to the scale: 9 points is the highest stability, and 1 point – the lowest. The following gradation of resistance of soybean varieties by points is used: 9 points – excellent resistance; 7 points – stability of good; 5 points – stability is satisfactory; 3 points – poor stability; 1 point – stability is very poor [14].

These indicators of soybeans were established on the basis of the Methodology of examination of plant varieties of cereals, cereals and legumes for suitability for distribution in Ukraine. All experiments are conducted on plots of 10-25 m^2 with four repetitions [14].

The height of soybean plants is determined before harvesting in two non-adjacent repetitions with a measuring rail in 5 equidistant places of the site. Fallen plants are raised. The height of attachment of the lower beans in soybeans is determined by measuring the distance from the root collar to the place of attachment of the lower beans in 25 plants [14].

Determination of major soybean diseases was performed by the percentage of affected plants, according to the requirements of the method [14] and identified affected plants as follows: downy mildew – from the underside of soybean leaves a grayish-purple plaque, and from the top – light yellowish, later brown angular spots; leaf blade becomes wavy-convex; ascochytosis – brown vague spots are formed on the leaves and beans, ocher in the middle, sometimes concentric, on the spots – picnics, on the surface of the seeds – brown spots; bacteriosis – with small angular light brown spots on the leaves with an oily middle, which later turns black; septoria – small angular rusty, later black spots are formed on the leaves. The leaves turn yellow and fall off. On the spots – small black dots (pycnidia), sunk into the leaf tissue; Fusarium head blight – behind deep brown ulcers covered with bright pink pads on the cotyledons, which leads to plant rot [14].

Assessment of drought resistance of soybean varieties is carried out in accordance with the general guidelines with a visual assessment of plants during the growing season. The yield of soybean seeds is determined by harvesting them directly (14). The content of soy protein and fat in soybean seeds was determined by laboratory methods. We compared the studied parameters with the use of mathematical-statistical correlation-regression analysis.

5. Manufacturability of precocious soybean varieties

According to the length of the growing season, precocious and ultra-precocious soybean varieties develop during 83-85 days. As of 2021, 17 precocious and ultra-precocious soybean varieties have been included in the State Register of Plant Varieties of Ukraine. Most of these varieties have a growing season of 85 days and only varieties of Dion – 83 days and Arnica – 84 days.

Plant height is one of the determinants of soybean varieties. After all, taller varieties are better suited to mechanized harvesting with minimal losses. The height of plants of precocious varieties of soybeans varies widely – 58-110 cm. The highest plants are Arrata – 110 cm, Rogiznyanka and Christmas – 81 cm, OAC Avatar and Diona – 80 cm. The lowest identified varieties Aventurine – 58 cm, Kobza – 66 cm, OAC Lakeview and Geba – 68 cm, Rainbow and Beauty – 69 cm (Table 1).

Along with the height of plants, one of the important indicators of soybean varieties is the height of attachment of lower beans, because low attachment of beans from the soil surface may leave them on the unmown part of the stem, which significantly increases crop losses. The height of attachment of the lower beans in precocious soybean varieties is 10-16 cm from the soil surface. The lowest beans were placed in the Legend varieties – 10 cm, Aventurine, Arrata, Arnica and Golubka – 11 cm each.

Table 1

Manufacturability of precocious soybean varieties

Variety	Duration of the growing season, days	Height of plants, cm	Height attached lower bean, cm	Resistance to lodging, points	Resistance to falling, points
Lehenda	85	no data available	10	8,0	8,0
Aventurine	85	58	11	9,0	8,6
Kobza	85	66	14	8,7	8,8
OAC Avatar	85	80	14	8,9	8,9
Diona	83	80	13	8,0	8,0
Arrata	85	110	11	8,0	7,0
OAC Lakeview	85	68	no data available	9,0	9,0
OAC Bruk	85	77	16	8,5	8,9
Geba	85	68	13	9,0	9,0
Berkana	85	77	no data available	9,0	9,0
Rogiznyanka	85	81	15	8,9	8,8
Arnica	84	78	11	7,0	8,8
Golubka	85	72	11	8,9	8,9
Melodia	85	73	12	8,4	8,7
Raiduga	85	69	13	8,1	8,8
Krasyunya	85	69	13	8,8	8,8
Rizdvyana	85	81	13	8,7	9,0

The highest resistance to lodging, which determines the completeness of mowing and selection of soybean stem mass, had plants varieties Aventurine, OAC Lakeview, Geba and Berkana – 9.0 points, OAC Avatar, Rogiznyanka, Golubka – 8.9 points. Arnica soybean plants were the least resistant to lodging – 7.0 points, as well as Legend, Diona, Arrata – 8.0 points, although this is a fairly high rate of resistance.

All precocious varieties of soybeans are characterized by high resistance to seed shedding – 7.0-9.0 points. The most resistant to shedding, with a score of 9.0, were the OAC varieties Lakeview, Geba, Berkan and Christmas. OAC Avatar, OAC Brook and Golubka also had high resistance to shedding, with a score of 8.9. The least resistant to shedding are varieties Arrata – 7.0 points, Legend and Diona – 8.0 points.

6. Ecological stability, productivity and seed quality precocious soybean varieties

Ecological resistance of soybean varieties to adverse growing conditions is determined by their resistance to drought and disease. The most drought-resistant varieties are OAC Lakeview, Geba, Berkan – 9.0 points each, and the least drought-resistant: Legend – 6.0 points, Diona – 8.0 points, Rizdvyana, Kobza and OAC Avatar – 8.2 points each (Table 2).

he most resistant to diseases are soybean varieties Aventurine, Kobza, Diona, Arrat, Rogiznyanka, Arnica – 9.0 points each. The most vulnerable to diseases are varieties of soybeans Legenda – 8.0 points, Geba – 8.5 points.

The seed yield of precocious soybean varieties is 2.00-3.25 t/ha. The highest yields were Dion – 3.25 t/ha, Arrata – 3.0 t/ha. The least productive varieties are Rohiznyanka – 2.00 t/ha, OAC Brook – 2.03 t/ha, Kobza – 2.14 t/ha.

Soybean varieties had the highest protein content in seeds: Berkana – 43.4%, Rainbow – 42.3%, Dove and Melody – 42.1% each. The lowest protein content was in the varieties Arrata – 38.0%, Legend, Diona – 38.5%, Kobza – 39.1%.

The fat content in the seeds of Geba soybean varieties – 22.0%, OAC Lakeview – 21.7% and Golubka – 21.6% was the highest, and in the varieties Beauty – 19.3%, Arnica – 20.5% and Melodiya – 20.6% – the smallest.

Table 2

Ecological stability, productivity and seed quality precocious soybean varieties

Variety	Drought resistance, score	Resistance to diseases, score	Seed yield, t/ha	Protein content in seeds, %	Fat content in seeds, %
Lehenda	6,0	8,0	2,30	38,5	21,1
Aventurine	8,6	9,0	2,26	40,0	21,1
Kobza	8,2	9,0	2,14	39,1	20,7
OAC Avatar	8,2	8,9	2,18	40,4	21,2
Diona	8,0	9,0	3,25	38,5	21,0
Arrata	no data available	9,0	3,00	38,0	21,2
OAC Lakeview	9,0	8,8	2,56	41,7	21,7
OAC Bruk	8,5	8,8	2,03	41,7	21,3
Geba	9,0	8,5	2,25	40,2	22,0
Berkana	9,0	8,8	2,45	43,4	20,7
Rogiznyanka	8,6	9,0	2,00	41,3	21,2
Arnica	8,7	9,0	2,20	41,0	20,5
Golubka	8,5	8,8	2,33	42,1	21,6
Melodia	8,4	8,8	2,19	42,1	20,6
Raiduga	8,5	8,7	2,18	42,3	21,2
Krasyunya	8,3	8,8	2,18	41,3	19,3
Rizdvyana	8,2	8,8	2,23	40,4	21,3

7. Mathematical and statistical analysis of the study

Mathematical and statistical analysis revealed the average negative correlation between plant height of precocious soybean varieties and their resistance to lodging resistance (r = – 0.387), between the height of attachment of lower beans and the score of resistance of plants to lodging revealed a positive positive correlation (r = 0.385). A strong negative correlation was found between the height of soybean plants and their resistance to seed shedding (r = – 0.741). That is, the highest score of resistance to seed shedding have precocious varieties of soybeans with lower height.

The regression equation (y = – 0,0331x + 11,152) and the coefficient of determination (R2 = 0,549) of the dependence of the score of resistance of

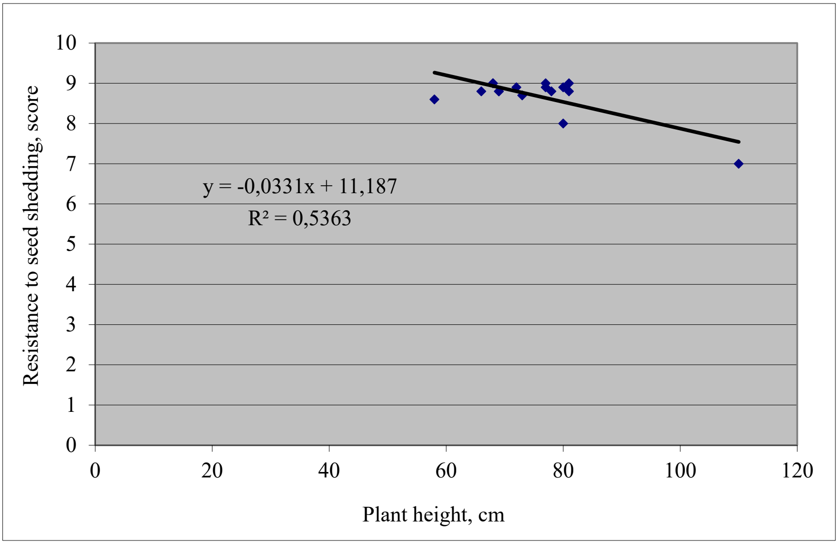

Figure 1. Correlation regression dependence, regression equation and coefficient of determination (R2) between plant height (x) and shear resistance score (y) of precocious soybean varieties

precocious soybean varieties to seed shedding (y) to the height of plants (x) indicates that when reducing the height of soybean varieties by 20 cm the score of their resistance to seed shedding increases by 0.55 (Figure 1).

An average positive correlation was found between the score of drought resistance and disease resistance of precocious soybean varieties (r = 0.656). The regression equation (y = 0.2364x + 6.8183) and the coefficient of determination (R2 = 0.4297) of the dependence of the score of resistance to diseases of precocious varieties of soybean (y) to the score of drought resistance (x) indicates that increasing the score of drought resistance by one resistance to disease increases by 0.43 (Figure 2).

An average positive correlation (r = 0.620) was established between the drought resistance score of precocious soybean varieties and their protein content. The regression equation (y = 1,2402x + 30,512) and the coefficient of determination (R2 = 0,3838) of the dependence of protein content in seeds of precocious soybean varieties (y) to the score of their drought

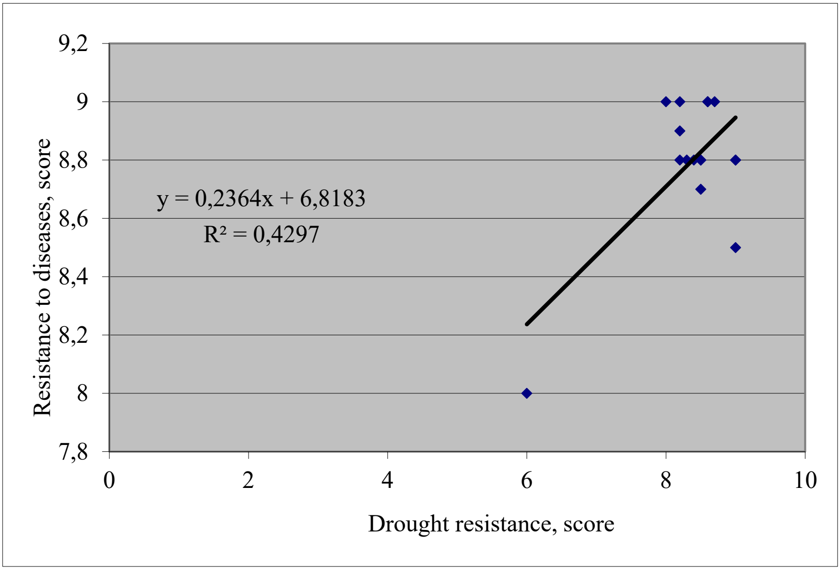

Figure 2. Correlation regression dependence, regression equation and coefficient of determination (R2) between the score of drought resistance (x) and the score of disease resistance (y) of precocious soybean varieties

resistance (x) indicates that when increasing the drought resistance score by one, the content protein in the seeds also increases by 1% (Figure 3).

A medium negative correlation was found between the yield of seeds of precocious soybean varieties and the protein content in it (r = –0.477). The regression equation (y = –2,2106x + 45,872) and the coefficient of determination (R2 = 0,2274) of the dependence of protein content in seeds of precocious soybean varieties (y) on seed yield (x) indicate that with increased yields by 1 t/ha the protein content in the seeds decreases by 1% (Figure 4).

The average positive correlation (r = 0.528) was found between plant height and seed yield of precocious soybean varieties. The regression equation (y = 0.0158x + 1.1529) and the coefficient of determination (R2 = 0.2781) dependence of the yield of precocious soybean varieties (y) to the height of plants (x) indicates that with increasing plant height by 10 cm seed yield increases at 0.27 t/ha (Figure 5).

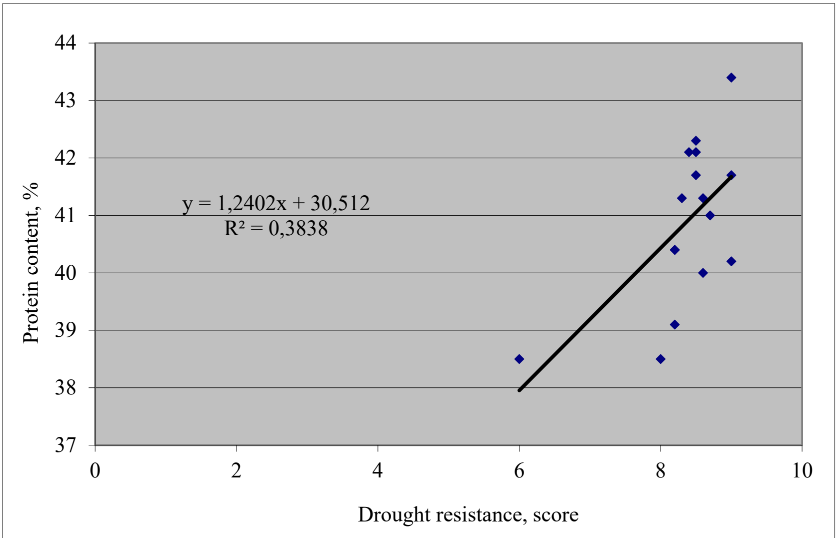

Figure 3. Correlation-regression dependence, regression equation and coefficient of determination (R2) between drought resistance score (x) and protein content in seeds (y) of precocious soybean varieties

Along with the revealed mathematical and statistical dependences, separate combinations of positive and negative factors of precocious soybean varieties have been established. In particular, the high seed productivity of Arrat and Diona is combined with the highest plant height of these varieties, the highest resistance to disease, but with the lowest protein content in their seeds and the lowest height of attachment of lower beans and the lowest resistance to seed shedding in Arrat. The highest height of Rogiznyanka plants is combined with the highest placement of lower beans on the stem. The greatest height of plants varieties OAC Avatar and Rogiznyanka combined with the highest resistance of these varieties to lodging, as well as the highest resistance to seed shed was marked OAC Avatar. Christmas varieties and AOC Avatar combined the highest plant height with the lowest drought resistance.

Soybean varieties with the lowest seed yield: Rohiznyanka and OAC Brook had the highest attachment of lower beans from the soil surface. The

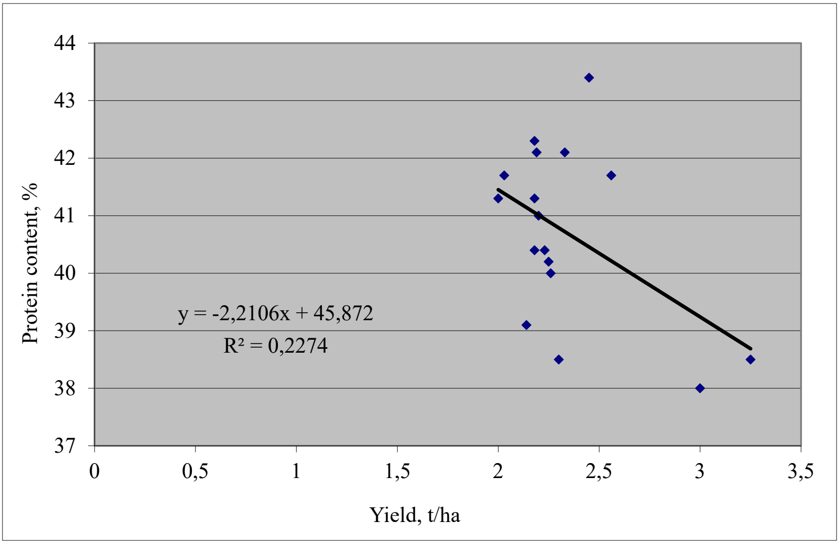

Figure 4. Correlation regression dependence, regression equation and coefficient of determination (R2) between yield (x) and protein content in seeds (y) of precocious soybean varieties

Aventurine variety combines low height with low placement of lower beans on the stem and high resistance to lodging.

8. Practical value and conclusions

Today, soybeans are a strategic crop for Ukraine, whose grain exports are more than 1 million tons per year. Unlike other market-oriented crops, soybeans help to improve soil fertility, increase crop yields within crop rotation. In addition, soybeans have universal use and play an important role in improving the economic efficiency of production.

For a long time, the zone of the right-bank Forest-Steppe of Ukraine, which includes the Vinnytsia region, was not part of the so-called "soy belt". But over the past 10 years, the area under this crop in the region has grown more than 10 times. Today, in terms of sown area, soybeans rank fourth in crop rotation after cereals, corn and sunflower. The emergence of new high-yielding soybean varieties has allowed not only to expand the

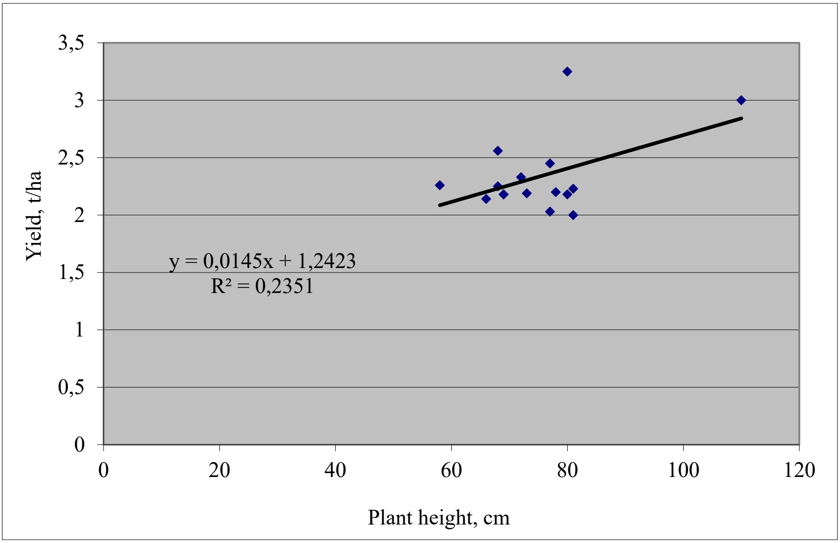

Figure 5. Correlation regression dependence, regression equation and coefficient of determination (R2) between yield (y) and plant height (y) of precocious soybean varieties

area of cultivation, but also to get a high yield. The State Register of Plant Varieties of Ukraine includes a large number of varieties of this culture of different maturity groups – from ultra-early to late-maturing. For the right-bank Forest-Steppe of Ukraine it is recommended to use varieties of early-ripening group. In addition, precocious soybean varieties are good precursors for winter cereals due to the accumulation in the available form of nitrogen in soil, contribute to the improvement of soil structure and early release of fields, which has a positive effect on soil preparation.

The introduction and distribution of varieties significantly depends on their biological characteristics and environmental conditions. Therefore, each variety must be grown in the region or zone where the highest realization of biological and genetic potential of productivity is manifested. Variety is one of the factors that significantly affects grain yield and quality.

Among the precocious and ultra-precocious soybean varieties included in the State Register of Plant Varieties of Ukraine for 2021, Dion and Arrat have the highest seed yields. The highest protein content in the seeds was found in the varieties Rainbow, Dove and Melody, fat – in the varieties Geba and Dove. The most drought-resistant varieties are OAC Lakeview, Geba, Berkana, the highest resistance to disease were varieties Aventurine, Kobza, Diona, Arrat, Rogiznyanka and Arnica. The most resistant to seed shedding were the varieties of OAC Lakeview, Geba, Berkan and Christmas. Resistance to lodging was highest in the varieties Aventurine, OAC Lakeview, Geba, Berkan. The highest height of attachment of the lower beans was in the varieties OAC Brook and Rogiznyanka. These varieties are characterized by higher productivity, rust quality, manufacturability during harvesting and agri-environmental stability during cultivation.

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