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Results Of The Study Of Lupin Varieties In The Forest-Steppe Of The Central Black Earth Region.

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ABSTRACT

The article presents the results of comparative study of varieties and variety samples of blue and white lupine, conducted at various times in Belgorod State Agricultural University (BSAU) and Voronezh State Agricultural University (VSAU). In BSAU it was established that in the conditions of the forest-steppe of the Central Black Earth Region, the average yield of white lupine varieties (37.5 centner/ha) was significantly higher (by 13.2centner/ha) than blue lupine (24.3 centner/ha) for the period of four years. In addition, the average protein content of white lupine seeds (33.9%) was higher by 3.2 abs. %, than that of blue lupine. The variety of white lupine Desnyansky had the highest yield (43.2 centner/ha). It was followed by such varieties as Dega, Gamma (36.6 and 36.5 centner/ha) and Deter-1 (33.9 centner/ha). In VSAU, the variety Dega and variety samples of "All-Russian Scientific Research Institute of Lupine" Aif 5049, SN 990-09 and SN 816-09were the most high-yielding. Their protein content ranged from 30.8 to 32.5%. Together with traditional leguminous crops (peas, soybeans, chickpeas, etc.), it was proposed to cultivate a relatively new crop – fodder white lupine.

Keywords: blue lupine, white lupine, variety, variety sample, yield, protein content.

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INTRODUCTION

In the 1st century AD, Columella wrote in his works "On Agriculture": "I think that if the land owner does not have anything, then the lupine will always come to the rescue. If it is sown on bad soil, then is cut off with a plow or hoe in good time, andis ploughed under, then it will become the best fertilizer"[1].

After 19 centuries, Academician D.N. Pryanishnikov (1962, 1965), in his scientific works noted: "Lupine is undoubtedly marked out for a brilliant future ... It will replace the superphosphate plant and the plant of synthetic ammonia, and organic matter of the manure. All of this it will do due to solar energy, which it uses better than cereals, and even on the same field, which should be fertilized"[2, 3].

The statements of Academician A.A. Zhuchenko (1990, 1998) confirm the above opinions. To improve the biological intensification of plant breeding, "... such species and varieties are needed, which have not only high potential productivity and environmental sustainability, but also environmental and resource-restoring potential, including the ability to increase soil fertility, to use hard-to-reach nutrients, to improve the phytosanitary situation". And fodder lupine meets these requirements as a new innovative crop in modern biological farming and intensive forage production [4, 5, 6, 7].

Fodder sweet lupine –is a relatively young culture, created by crop breeders in the second half of the last century [8]. The first sweet forms, containing in the seeds and green mass only remains of alkaloids, were created by German researcher R. Sengbusch in 1928-1929. In the future, on their allelic basis, low-and non-alkaloid high-protein fodder varieties of various lupine species have been created (yellow, blue, white lupine) in many countries of the world (Sweden, Denmark, Poland, Italy, the USA, South Africa, Australia, as well as in Russia and Belarus).

All the varieties of cultivated lupine species contain from 32 to 43% of high-quality protein in seeds, so they are used as high-protein supplement in the rations of all types of livestock and poultry. The dry basis of lupine green mass contains 18% - 23% of protein. Lupine is used in the feeding of animals in green form, as well as for the preparation of high-protein coarse, juicy and concentrated fodders [9, 10].

At present, lupine is considered as a source of balanced, easily digestible and ecologically-clean protein, and as a factor of agriculture biologization, energy and resource saving. Cultivation of lupine contributes not only to the preservation of the soil natural fertility, but also to its extended reproduction. This crop can become an important link in the system of ecological farming [11, 12, 13].

The agrotechnological and ecological advantages of lupine cultivation are the following:

- it is a high-protein fodder crop. It excels peas, vetch, fodder beans at the amount of protein in the crop; and for the quality and digestibility of protein it is equal for soy;
- it is an excellent raw material for the production of comestible protein. Lupine protein isolates are used in bakery, macaroni, confectionery, sausage and meat-canning industries, in the production of dietary and curative-prophylactic products;
- the protein is of high quality and digestibility, due to the low content of trypsin inhibitors, and modern varieties of fodder lupine are low-alkaloid and can be used in feeds of all kinds of animals and birds, without preliminary heat treatment;
- it is undemanding to the conditions of growth, yields a good harvest, as on poor soils with low natural fertility, as on fertile chernozems;
- in symbiosis with nodule bacteria (Rizobium) it is able to fix up to 200 kg of nitrogen per hectare of planting. This provides with biological nitrogen the own need and, to a large extent (50%), the need of subsequent crops. It absorbs from the soil phosphorus and potassium, which are in the form, inaccessible for other plants;
- its powerful, well-developed taproot system is an effective "biological ripper", improves the structure and agrophysical properties of the soil, and thereby facilitates basic and presowing cultivation for subsequent crops [14, 15, 16, 17];

In Russia, lupine is widespread in the North-Western, Central and Volga-Vyatka regions of Nonblack Soil Zone, in the Central Black-Earth Region, in the Middle Volga Region, in the Urals and Sakhalin.

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In agricultural enterprises of the Russian Federation, the gross collection of fodder lupine seeds in 2014 on the area of 60,000 ha reached its maximum -90,000 tons, with an average yield of 1.50 tons/ha (Table 1).

Table 1: Cultivated areas, gross collections and yields of fodder lupine seeds in the Russian Federation

Years	Cultivated area, thousand ha	Gross collection, thousand tons	Yield, t/ha
2009	10,9	13,5	1,24
2010	20,0	19,8	0,99
2011	14,5	22,6	1,56
2012	23,3	34,5	1,48
2013	39,5	56,1	1,42
2014	60,0	90,0	1,50

The Central Black Earth Region of the Russian Federation is a large livestock producer. Therefore, lupine here can become a valuable fodder crop. So, in 2013, in OOO “Agrotekh-GarantPugachevsky”, located atAnninsky District of Voronezh Region, the yield of white lupine of variety Dega was 2.40 t/ha. In 2015, in ZAO “Bobravskoe” of Rakityansky District and in the peasant farm enterprise Bobylev V.G. of Ivnyansky District of Belgorod Region, the yield of white lupine Dega was 3.45 and 3.20 t/ha, respectively. It amounted to 1.60 t/ha in the peasant farm enterprise "May" of Lipetsk District inLipetsk Region. In 2016, in OOO "Agrofirma VTK" of Novousmansky District of Voronezh Region, the yield of grain harvest of white lupine Degawas 1.7 t/ha, and in the peasant farm enterprise“Ulyanich” of Usman District of Lipetsk Region, the yield of lupine of this variety was 2.15 t/ha. However, there are few such examples in the Central Black Earth Region. Lupine is still a new episodic culture, which, undoubtedly, is worthy of wider cultivation along with soy, chickpeas and peas. However, this is impeded by insufficient knowledge of varieties and agronomic technologies of lupine in conditions of the Central Black Earth Region. This was the reason for investigation of lupine.

CONDITIONS AND METHODS OF THE RESEARCH

Especially important is the selection of the most adaptive highly productive species and varieties of lupine for the conditions of the Central Black Earth Region.

The study of new varieties of blue and white lupine, applied to the soil-climatic conditions of the Central Black Earth Region has been started at Belgorod State Agricultural University since 2004, and at Voronezh State Agricultural University –since 2013.

In BSAU, lupine was sown in typical heavy loam chernozem with average level of fertility. The agrochemical characteristics of the soil are as follows: humus content in the plow layer is 4.5%, nitrogen content is 137.2 mg/kg, labile phosphorus - 138 mg/kg, exchangeable potassium - 126 mg/kg, pH of salt extract - 6.7.

Grain productivity of seven varieties of blue lupine (Lupinus angustifolius L.) and four varieties of white lupine (Lupinusalbus L.) of the fodder-grain direction of lupine selection of All-Russian Scientific Research Institute was determined. Seeds were sown with a manual drill to a depth of 3-4 cm with a seeding rate of 1.3 mln seeds per 1 ha.

During the years of field experiments (2004-2007), meteorological conditions were different, but on the whole, the moisture supply and temperature regime favorably affected on the formation of high yields of white and blue lupine seeds.

In VSAU, the research was carried out on the experimental fields in 2013-2016. Three varieties of white lupine, approved for the use in the Central Black Earth Region (Alyiparus, Dega, Desnyansky) and eight

variety samples of FSBSI "All-Russian Scientific Research Institute of Lupine" selection (Aif 5049, SN 816-09, SN 990-09, SN 67-08, SN 1014-09, SN 61-06 DT_1, SN 935-09, SN 1032-09 Alk.) were investigated.

Varieties and variety samples of lupine seeds were provided by the All-Russian Scientific Research Institute of Lupine (Bryansk).

The characteristics of soil at the experimental field: heavy loamy leached chernozem, humus content - 4.5-5.5%, pH of salt extract - 5.3-5.7, base saturation - 86-90%.

Winter wheat was the preceding crop. Lupine was sown with a row spacing of 15 cm with a selective seed drill (SR-8T). In 2013, the seeds were not treated with lupine rhizotorphin before the sowing; in 2014-2016 they were treated. The crops were weeded by hand. In 2016 the graminicide Fusilade Forte, EC (1.5 l/ha) in combination with micro-fertilizer Megamix-Profi were used. Lupine was reaped by plots, using selective harvester "Terrion Sampo" SR 2010.

The trial was one-factor, the replication was three-fold.

In May 2013 the weather were hot and dry. This caused prolonged uneven emergence of lupine seedlings that adversely affected its development and productivity. In 2014-2016 weather conditions were close to the long-time average annual norm.

RESEARCH RESULTS

On an average for four years, the most productive were the following varieties of blue lupine, in the experiments of Belgorod State Agrarian University: Kristall, Bryansky 45, Snezhet, Raduzhny and Belozerny 110, which provided rather high yields of grain - 2.53; 2.40; 2.28; 2.52 and 2.12 t/ha, respectively (Table 2). The yield of varieties Nadezhda and Yaroslavna was significantly lower in the same conditions – only 1.67 and 1.70 t/ha.

In general, the studied varieties of blue lupine were less productive (2.17 t/ha) than the varieties of white lupine (3.75 t/ha) by 72.8%.

Table 2: Yields of white and blue lupine in Belgorod State Agricultural University, t/ha

Variety	Years				Average for 4 years
	2004	2005	2006	2007	
Bluelupine					
Kristall	2,85	2,55	2,89	1,82	2,53
Bryansky45	2,89	2,43	2,57	1,72	2,40
Snezhet	2,45	2,28	2,35	2,03	2,28
Raduzhny	2,76	2,38	2,63	2,31	2,52
Belozerny110	2,35	1,87	2,25	2,01	2,12
Nadezhda	1,60	1,56	2,02	1,49	1,67
Yaroslavna	1,83	1,68	1,94	1,32	1,70
Average for all varieties	2,39	2,10	2,37	1,81	2,17
HCP_{05}	0,10	0,11	0,12	0,08	
White lupine					
Desnyansky	5,64	4,05	4,63	2,94	4,32
Gamma	4,29	3,64	4,05	2,61	3,65
Dega	3,83	3,67	4,12	3,02	3,66
Deter - 1	3,71	3,26	4,27	2,30	3,39
Averageforall varieties	4,36	3,66	4,27	2,72	3,75
HCP_{05}	0,10	0,17	0,11	0,07	

The yields of white lupine were widely different in terms of years and varieties. On the average for four years, they have changed from 3.39 to 4.32 t/ha. The maximum yield was provided by the variety Desnyansky - 4.32 t/ha.

The commercial quality of blue and white lupine seeds was quite high (Table 3). They contained protein 30.0-31.7% and 33.3-34.8%, fat - 3.7-4.4% and 8.9-10.4%, respectively.

The content of alkaloids in the seeds of blue and white lupine was low 0.033-0.057% and 0.053-0.073%, respectively.

Table 3: Biochemical evaluation of blue and white lupine seeds, Belgorod State Agricultural University, 2005-06

Variety	Contentin seeds,%			Carotene, mg/100 g
	proteins	fats	alkaloids	
Bluelupine				
Kristall	31,0	4,1	0,057	5,2
Bryansky 45	31,7	4,0	0,054	4,7
Snezhet	30,2	3,7	0,038	4,9
Raduzhny	30,0	4,1	0,044	5,0
Belozerny110	30,2	4,4	0,052	4,7
Nadezhda	30,4	4,1	0,033	5,2
Yaroslavna	30,1	4,0	0,049	3,9
Whitelupine				
Desnyansky	33,3	9,5	0,067	4,7
Gamma	34,8	9,6	0,053	4,4
Dega	33,4	10,4	0,062	4,5
Deter - 1	34,2	8,9	0,073	4,1

In similar experiments of Voronezh State Agricultural University for studying the varieties and variety samples of white lupine in 2013, the earliest ripening were Aif 5049, Dega, Desnyansky, SN 816-09, SN 990-09 and SN 67-08, which had a vegetation period of 80 days. The variety Alyiparusripened 6 days later; the varieties SN 1014-09, SN 61-06 DT_1 and SN 935-09 - ripened 16 days later; SN 1032-09 Alk. - 19 days later.

There was anomalously hot and dry weather (above 32°C) from 20 May till 6 June 2014. The plants of lupine were much suppressed. Some parts of plants of the variety Desnyansky and variety samples SN 1014-09, SN 61-06 DT_1, SN 935-09 and SN 1032-09 Alkdied. The growth of lupine plants normalized only on June 7, after the rains and decrease in heat. This weather anomaly had a strong negative impact on plants; their vegetation in 2014 was protracted. Thus, the studied varieties and variety samples of white lupine in 2013 vegetated 80-99 days, and in 2014 – 100-118 days. The variety Dega and variety samples SN 816-09, SN 990-09, SN 67-08 and Aif 5049 were the earliest ripening, as well as in 2013. The varieties Alyiparus, Desnyansky and variety samples SN 1014-09, SN 61-06 DT_1 and SN 935-09 ripened 9 days later, SN 1032-09 Alk. - 18 days later. In 2013, the varieties Desnyansky and Alyiparusripened 16 and 10 days earlier, than the variety samples SN 1014-09, SN 61-06 DT_1 and SN 935-09. In 2014, their ripening occurred simultaneously. The probable reason for the extension of vegetative period was the longer restoration of the varieties Desnyansky and Alyiparus after the abnormal weather conditions.

In May-July 2015, there were favorable weather conditions, cool and rainy. This has positive effect on the field germination, plant growth and productivity of lupine. Therefore vegetation of plants was longer than in 2013 and amounted to 88-107 days. However, in the early-ripening varieties and variety samples (Dega, SN 816-09, SN 990-09, Aif 5049), the period of flowering coincided with very hot dry weather and was very short. The variety Desnyansky and variety sample SN 87-08 blossomed a little later. During their flowering the temperature decreased, and the flowering phase were longer. Therefore, their vegetation was slightly prolonged and amounted to 96 days, that was 16 days longer than in 2013. Flowering and fruit formation of

later varieties and variety samples of white lupine (Alyiparus, SN 1014-09, SN 61- 06 DT_1, SN 935-09 and SN 1032-09 Alk.) occurred in better weather conditions. This positively affected their yield.

Weather conditions in 2016 allowed to obtain good lupine seedlings. April, May and June of 2016 were cool and rainy, that favorably influenced the growth and development of lupine. In the middle of July, there was hot dry weather. On July 14, all varieties and variety samples of white lupine dropped leaves, and their ripening began.

On the average for four years, the most high-yielding varieties were the following: Dega - 22.5 centner/ha, variety samples SN 990-09 and SN 816-09 – 22.1 and 22.0 centner/ha, Aif 5049 - 22.9 centner/ha (Table 4).

Table 4: Yields of varieties and variety samples of white lupine in Voronezh State Agricultural University, centner/ha

№	Variety, variety sample	2013	2014	2015	2016	Average
1	Desnyansky	17,0	10,0	13,2	26,2	16,6
2	SN 816-09	18,6	20,4	19,1	30,0	22,0
3	SN 990-09	18,3	22,3	19,1	28,6	22,1
4	Aif5049	18,2	17,3	24,2	31,9	22,9
5	Dega	17,7	23,2	19,2	30,0	22,5
6	SN 67-08	16,9	23,2	16,0	31,2	21,8
7	Alyiparus	15,0	16,0	18,4	31,4	20,2
8	SN 1014-09	9,7	10,0	21,0	32,4	18,3
9	SN 61-06 DT_1	9,5	13,6	16,4	30,0	17,4
10	SN 935-09	11,1	13,6	27,3	31,9	21,0
11	SN 1032-09 Alk.	11,3	10,0	27,3	34,3	20,7
	$НСР_{05}$	0,21	0,20	0,51	0,42	-

In 2013, both the yield and protein content of white lupine seeds were lower than in other years of experiments.

A low-yield variety sample SN 61-06 DT_1 had higher seed protein content in 2013 - 28.61% (Table 5). In 2014, the following variety samples had the highest protein content: SN 816-09 - 38.64%, SN 935-09 - 38.63% and SN 1014-09 - 38.24%. In 2015, such variety samples as: Aif 5049, SN 67-08, SN 1014-09 and SN 935-09had more protein in their seeds. On average for three years, the highest protein content in seeds was found in the variety samples SN 1014-09 - 33.76% and SN 935-09 - 33.72%.

Table 5: Protein content in seeds of white lupine varieties and variety samples in Voronezh State Agricultural University, %

№	Variety, variety sample	2013	2014	2015	Average
1	Desnyansky	26,69	36,40	31,40	31,50
2	SN 816-09	27,12	38,64	31,03	32,26
3	SN 990-09	27,13	34,21	31,15	30,83
4	Aif5049	25,37	36,44	35,79	32,53
5	Dega	27,13	34,63	30,71	30,82
6	SN 67-08	17,94	35,12	35,53	29,53
7	Alyiparus	23,19	36,00	33,78	31,00
8	SN 1014-09	27,50	38,24	35,53	33,76
9	SN 61-06 DT_1	28,61	35,12	32,90	32,21
10	SN 935-09	27,12	38,63	35,40	33,72

11	SN 1032-09 Alk.	23,19	36,41	33,78	31,13
HCP_{05}		0,57	0,29	0,35	-

On average for four years of research, the variety of white lupine Dega, and variety samples: Aif 5049, SN 990-09, SN 816-09, were the most high-yielding. Based on the results of four-year research, these varieties proved to be the most adapted to the conditions of the forest-steppe of Voronezh Region and produced stably high yields of seeds.

SUMMARY

So, lupine varieties, cultivated on typical chernozem, were studied in Belgorod State Agricultural University in 2004-2007, and lupine varieties, cultivated on leached chernozem were investigated in 2013-2016 in Voronezh State Agricultural University. Due to these researches, we can draw the following conclusions:

1. The conditions of the Central Black-Earth Regionforest-steppe better correspond to the biological requirements of white lupine, all varieties of which throughout all the years of the study produced higher yields of seeds, than blue lupine. For example, the averagefour-year yield of white lupine varieties (Desnyansky, Gamma, Dega and Deter-1) was 37.5 ccentner/ha, and the yield of the best varieties of blue lupine (Kristall, Bryansky 45, Snezhet and Raduzhny) was 3 centner/ha; that was 13.2 centner/ha less. In addition, the average protein content of white lupine seeds was 33.9%, and blue lupine - 30.7%, i.e. 3.2 % less.

2. In the experiments, carried out in Belgorod State Agricultural University in 2004-2007, the best yield had the variety of white lupine Desnyansky (43.2 centner/ha). It was followed by the varieties Dega and Gamma (36.6 and 36.5 centner/ha, respectively), and the variety Deuter-1 (33.9 centner/ha).

In Voronezh State Agricultural University (2013-2016), the variety Dega (22.5 centner/ha) and variety samples of “All-Russian Scientific Research Institute of Lupine” Aif 5049 (22.9 centner/ha), SN 990-09 and SN 816-09 (22.1 and 22.0 centner/ha) were the most high-yielding.

3. Seedsprotein content in all varieties of white lupine, as a rule, was more than 30%. Such varieties as Gamma (34.8%), Deter-1 (34.2%), and variety samples SN 1014-09 (33.76%), SN 935-09 (33.72%), Aif 5049 (32.53%), SN 816-09 (32.26%) and SN 61-06 DT_1 (32.21%) had higher protein content.

CONCLUSION

Thus, in the conditions of the forest-steppe of the Central Black-Earth Region, where agricultural enterprises traditionally cultivate peas, soybeans, chickpeas and other leguminous crops, it is quite possible and expedient to grow fodder lupine, especially white, which is a relatively new high-protein crop, capable of becoming a large reserve for increasing soil fertility, solving of protein problems in feed production, improving the quality and reducing the cost of livestock products. It is advisable to continue the study of fodder lupine, development and improvement of varietal agrotechnology, production testing and introduction of new adaptive high-yielding varieties, especially of white lupine, in the Central Black-Earth Region.

CONFLICT OF INTEREST: The authors confirm that the presented data don’t contain a conflict of interest.

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