CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF

PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.1304351

Available online at: http://www.iajps.com *Research Article*

A COMPARATIVE EVALUATION OF MACRO- AND MICROELEMENT COMPOSITION OF PLANTS OF WHITE LUPINE AND SOYBEAN

Sergey V. Lukin*, Svetlana V. Selyukova, Ekaterina A. Prazina, Natalia S. Chetverikova

FGBU "Center for Agrochemical Service, Belgorod State University, 308015, Belgorod, Pobeda Street, 85, Russia

Abstract:

The studies were conducted in the forest-steppe zone of Belgorod region. The soil cover was represented by typical chernozems and leached chernozems. The objective of the research was to analyze and assess the accumulation of major macro- and microelements in the plants of white lupine and soybean. It was found that the content of macroelements: nitrogen, phosphorus, potassium, sulfur in white lupine beans is lower than in soy. The trace elements in white lupine beans are arranged in descending order: Zn>Mo>Cu>Ni>Co>Cr, and in soy beans - Zn>Cu>Ni>Mo>Cr>Co. White lupine beans, as compared to soybean beans, contain 6.3 times more cobalt, 9.8 times more molybdenum, 1.3 times more zinc, while copper content is 2 times less, and nickel - 2.2 times less. The content of zinc, copper, nickel, molybdenum, cobalt in lupine beans was higher, and chromium is lower than in straw. In soy beans, the content of all trace elements was higher than in straw, with the exception of cobalt, which showed inverse trend.

Keywords: *nitrogen, potassium, phosphorus, sulfur, zinc, copper, cobalt, molybdenum, chromium, nickel, white lupine, soybean.*

Corresponding author:

Sergey V. Lukin,

Doctor of Agricultural Sciences,

Principal FGBU "Center for Agrochemical Service,

Belgorod State University, 308015, Belgorod, Pobeda Street,

85, Russia

E-mail: serg.lukin2010@yandex.ru

QR code

Please cite this article in press Sergey V. Lukin et al., ***A Comparative Evaluation Of Macro- And Microelement Composition Of Plants Of White Lupine And Soybean,*** *Indo Am. J. P. Sci, 2018; 05(06).*

INTRODUCTION:

An important task of modern Russian agriculture is to eliminate the deficit of vegetable protein. This problem is especially acute in Belgorod region, which is the largest meat producer in Russia. In 2016, 806.8 thousand tons (13.1% of the Russian Federation) of poultry and 787.4 thousand tons (18.1%) of pigs were slaughtered in the region.

To meet the needs of animal husbandry in the vegetable protein in the area, soybean areas (Glycine max), which is one of the most widespread and popular crops in the world, are significantly increased. Soybean is a crop of temperate climatic zone and comes from the mountainous areas of central and western China [1, 2].

In recent years, white lupine (Lupinus albus) has become more and more interesting, which modern varieties are not inferior to soybeans in terms of protein content and its quality, but exceed it in yields. This crop has long been cultivated in the Mediterranean countries (Greece, Western Turkey, Sicily, etc.). For the conditions of the Central Chernozem Region, early ripening varieties of determinant type with limited branching have been created. The period of their growing season is 100-140 days, the yield of seeds is 3-4 tons/ha, the protein content in seeds is 35-40% [3, 4]. If in 2012 this crop was cultivated on an area of 0.2 thousand hectares, then in 2016 - on an area of 5.7 thousand hectares. For comparison: in 2016 the soybean area was 210.4 thousand hectares.

The chemical composition of soybean and white lupine plants varies greatly, depending on the soil-climatic conditions, the characteristics of the variety and agricultural technology. In many respects, the individuality of the chemical composition of each plant species is related to the features of the chemical composition of the medium where this species was formed [5]. The effectiveness of agricultural technology also depends on the duration and intensity of farming [6] and monitoring of soil fertility, which shows significant progress achieved in the Belgorod region in recent years [7, 8].

Objective of the study is to analyze and assess the accumulation of the main macro- and microelements in plants of white lupine and soybean.

MATERIALS AND METHODS:

In our studies we used the materials of local agroecological monitoring of white lupine and soybean crops in the forest-steppe zone of the Belgorod region conducted in 2015-2017. The soil cover of the surveyed areas was represented by the predominant soils in the region: typical chernozem and leached chernozem. The weighted average content of organic matter in the soil according to Tyurin was 5.6%, hydrolytic acidity - 3.57 cmol/kg, pH_{KCl} - 5.5.

The content of mobile forms of phosphorus and potassium was determined by Chirikov method. The extractant was 0.5M acetic acid solution (GOST 26204-91). To extract the mobile forms of sulfur from the soil, a 1M solution of potassium chloride was used (GOST 26490-85). The determination of phosphorus and sulfur was carried out by photometrical method, and potassium - by flame-photometrical method. The method of determining alkaline hydrolyzable nitrogen by Kornfield is based on the hydrolysis of nitrogen-containing organic compounds with a solution of 1M NaOH.

The total content of microelements (5M HNO_3 extractant) and the concentration of their mobile forms in the soil extracted by the acetate-ammonium buffer solution with pH 4.8 (with the exception of Mo) were determined by atomic emission spectrometry in accordance with M-MVI-80-2008. The content of mobile forms of molybdenum in the soil was determined photometrically by Grigg method; an oxalate-buffer solution with pH 3.3 was used for extraction.

The content of nitrogen in crop production was determined in accordance with GOST 13496.4-93, phosphorus -
GOST 26657-97, potassium - GOST 30504-97. Determination of the content of zinc and copper was carried out in accordance with GOST 30692-2000, cobalt - according to OST 10.155-88. The content of nickel, chromium, molybdenum and sulfur was determined on the basis of the methodological guidelines [9-11].

During the statistical processing of the results of laboratory analysis, the confidence interval was calculated for the mean value ($\bar{x} \pm t_{05} s_{\bar{x}}$) and the coefficient of variation (V, %) using Microsoft Excel 2007.

RESULTS AND DISCUSSION:

The average content of mobile forms of phosphorus, potassium and sulfur in the plow layer of the investigated soils was 99, 137 and 2.4 mg/kg, respectively. Alkaline hydrolyzable forms of nitrogen according to Kornfield - 180 mg/kg. According to Russian standards, the level of soil supply with mobile forms of phosphorus is estimated as average, potassium - as high, sulfur - as low, alkaline hydrolyzable forms of nitrogen - as average.

The content of basic nutrients in white lupine beans averaged: nitrogen - 5.3, phosphorus (in terms of P_2O_5) - 1.02, potassium (K_2O) - 1.61, sulfur (S) - 0.22%. For comparison: the average content of these elements in soybeans was higher: 6.26, 1.88, 2.52, 0.30%, respectively. The straw of white lupine contained significantly less nitrogen, sulfur and especially phosphorus than in beans, and more potassium. In the soybean straw, the content of all macronutrients was lower than in beans (Table 1). For comparison: the experiments conducted in Nizhny Novgorod region showed that the content of white lupine nitrogen in beans was in the range of 4.53-5.64, P_2O_5 - 1.35-1.63, K_2O - 1.69-1.93% [12].

Table 1.**Variable-statistical indicators of the content of macroelements in white lupine and soybean plants, % of absolutely dry matter**

Element	Type of product	White lupine			Soybean		
		$\bar{x} \pm t_{05}s_{\bar{x}}$	lim	V, %	$\bar{x} \pm t_{05}s_{\bar{x}}$	lim	V, %
N	beans	5.30±0.20	4.38-5.95	8.1	6.26±0.13	4.79-7.28	11.1
	straw	0.41±0.02	0.37-0.51	10.8	1.02±0.02	0.84-1.26	11.8
P_2O_5	beans	1.02±0.09	0.73-1.47	19.4	1.88±0.05	1.58-2.29	13.0
	straw	0.07±0.01	0.05-0.09	19.7	0.43±0.01	0.23-0.64	12.0
K_2O	beans	1.61±0.07	1.43-1.94	9.5	2.52±0.05	2.12-2.94	10.5
	straw	2.23±0.30	1.18-3.54	28.7	2.07±0.04	0.71-2.31	10.4
S	beans	0.22±0.02	0.17-0.28	14.9	0.30±0.01	0.22-0.35	9.0
	straw	0.07±0.01	0.05-0.11	31.8	0.19±0.004	0.10-0.22	10.3

The percentage abundance of the gross content of chromium, zinc, nickel, copper, cobalt, molybdenum in soils, according to A.P. Vinogradov (1957) is, respectively, 200, 50, 29, 20, 8, 2.6 mg/kg [13]. According to modern estimates, the percentage abundance of the following elements in the world soils is: zinc - 70, chromium - 59.5, copper - 38.9, nickel - 29, cobalt - 11.3, molybdenum - 1.1 mg/kg [14]. The gross content of these elements in the investigated soils was lower than their percentage abundance (Table 2).

Table 2. **Variable-statistical indicators of the content of trace elements in the arable layer (0-20 cm) of leached chernozem,** mg/kg

Element	Gross content			Content of mobile forms		
	$\bar{x} \pm t_{05}s_{\bar{x}}$	lim	V, %	$\bar{x} \pm t_{05}s_{\bar{x}}$	lim	V, %
Zn	37.1±2.44	26.7-51.2	14.1	0.74±0.06	0.52-0.93	17.2
Ni	24.9±0.79	22.5-28.4	6.8	0.63±0.07	0.50-1.05	22.2
Cr	21.0±0.86	17.3-25.1	8.7	0.44±0.02	0.37-0.50	7.9
Cu	13.8±0.34	12.7-14.8	5.3	0.110±0.004	0.10-0.12	7.1
Co	7.74±0.22	6.81-8.63	6.2	0.085±0.003	0.07-0.10	7.6
Mo	1.57±0.11	1.23-2.01	15.2	0.200±0.015	0.13-0.24	15.6

The gross content of trace elements in the arable soils hardly allows determining their availability to plants. To assess the supply of crops with microelements in the soil, the concentration of their mobile forms is determined. Background content of mobile forms of zinc, copper, cobalt were 0.74, 0.11, 0.07 mg/kg, respectively, which corresponds to a low level according to the Russian scale for arable soils. The content of mobile forms of molybdenum (0.2 mg/kg) corresponds to the average level of supply. The average content of mobile forms of nickel is 0.63, chromium - 0.44 mg/kg. To maintain these elements, the supply scale has not been developed. For agroecological normalization of the content of mobile forms of nickel and chromium in soils, the level of maximum permissible concentration (MPC) is equal to 4 and 6 mg/kg. Arable soils exceeding these MPCs have never been identified in the territory of the region.

According to their content in white lupine beans, trace elements are arranged in descending order: Zn>Mo>Cu>Ni>Co>Cr. The straw has a quite different regularity: Zn>Cu>Mo>Co>Cr>Ni. In soybeans, the elements form a descending series by their concentration: Zn>Cu>Ni>Mo>Cr>Co, and in straw - Zn>Cu>Ni>Cr Mo>Co (Table 3).

Table 3. **Variable-statistical indicators of the content of microelements in white lupine and soybean plants,** mg/kg of absolutely dry matter.

Element	Type of product	White lupine			Soybean		
		$\bar{x} \pm t_{05} s_{\bar{x}}$	Lim	V, %	$\bar{x} \pm t_{05} s_{\bar{x}}$	lim	V, %
Zn	beans	43.2±2.02	36.5-53.1	10.0	34.4±0.5	31.9-37.0	3.5
	straw	9.07±1.43	5.37-16.25	32.6	6.12±0.34	5.39-9.10	12.8
Cu	beans	5.93±0.65	3.03-8.18	23.4	11.70±0.04	8.30-12.9	7.7
	straw	1.94±0.13	1.39-2.58	14.6	3.58±0.10	3.00-4.12	6.7
Mo	beans	6.73±0.87	3.89-11.33	27.7	0.69±0.04	0.63-0.85	12.6
	straw	0.58±0.05	0.36-0.77	18.1	0.21±0.04	0.08-0.34	41.0
Co	beans	0.88±0.14	0.51-1.41	31.8	0.14±0.01	0.10-0.19	17.2
	straw	0.54±0.08	0.33-0.89	28.3	0.19±0.03	0.08-0.25	30.5
Ni	beans	2.34±0.22	1.42-3.04	19.8	5.15±0.34	4.53-7.22	15.2
	straw	0.39±0.06	0.23-0.74	29.0	0.70±0.11	0.34-1.45	37.8
Cr	beans	0.34±0.03	0.23-0.45	20.1	0.42±0.01	0.37-0.45	5.6
	straw	0.41±0.04	0.29-0.64	21.9	0.38±0.03	0.31-0.43	14.9

Zinc is an integral part of various enzymes, therefore it performs important and diverse functions in the physiological processes occurring in plants. The background content of the element in plants is usually in the range of 20-60, and the concentration at which the yield decreases is about 300-500 mg/kg of dry matter [15]. In lupine beans, the average zinc content was 43.2 mg/kg, which is 4.8 times higher than in straw. In soybeans, the average content of this element was slightly lower and was 34.4, in straw - 6.12 mg/kg.

Copper is a part of oxidative enzymes. It is partially concentrated in chloroplasts and influences the processes of photosynthesis [16]. The average content of the element in white lupine beans was 5.93, and in straw - 1.94 mg/kg. For comparison: in soybeans, the average copper content was almost twice as high as 11.70 mg/kg.

Nickel performs a variety of physiological functions: promotes the movement of nitrogen and germination of seeds; restores plants to growth; affects the activity of the enzyme urease, which catalyzes the hydrolysis of urea, regulates the formation of histones; takes part in the transamination process. However, a completely biochemical role of nickel has not yet been studied [17]. Among crops, soy ranks first for the accumulation of this metal [18]. In the beans of this culture, the nickel content was 5.15, in the straw - 0.70 mg/kg. In white lupine beans, the average nickel content was 2.34, and in straw - 0.39 mg/kg.

Molybdenum is an integral part of some enzymes that perform the binding of atmospheric nitrogen in the process of biological fixation. Therefore, the element is very important for the growth and development of legumes. In terms of its practical value, molybdenum takes a leading place among other microelements, as it is a significant factor in solving two pressing problems of modern agriculture: providing plants with nitrogen, and farm animals with protein [16]. In plants, molybdenum is distributed unevenly: its main quantity is concentrated in grain or beans rich in proteinaceous substances, and in leaves and stems its concentration is much lower. In white lupine beans, the average metal content was 6.73 mg/kg, and in straw - only 0.58 mg/kg. For comparison: the content of this element in soybean beans averages 0.69, in straw - 0.21 mg/kg.

Cobalt intensifies the respiration rate of plants, participates in the process of photosynthesis, activates protein metabolism enzymes and redox enzymes [16]. The element is necessary for legumes, since it plays an important role in the process of fixing molecular nitrogen. The average content of this metal in white lupine is relatively high and is 0.88 in beans and 0.54 mg/kg in straw. For comparison: soybeans contain 0.14, and straw - 0.19 mg/kg.

Chromium in plants participates in the synthesis of protein, affects the increase in chlorophyll content in leaves and the productivity of photosynthesis. However, an excessive concentration of the element may cause decrease in growth, oppression, and high concentrations may lead even to plant death [19]. The average chromium content was 0.34 in beans and 0.41 mg/kg in white lupine straw. According to the content of this element, white lupine differs little from soybean, where the average content in beans is 0.42, and in straw - 0.38 mg/kg.

In accordance with the technical regulations of the Customs Union "On the Safety of Grain" for food purposes, the maximum content of trace elements studied in lupine and soybean beans is not standardized.

CONCLUSION:

Thus, the content of macroelements: nitrogen, phosphorus, potassium, sulfur in white lupine beans is lower than in soy. The trace elements in white lupine beans are arranged in descending order: Zn>Mo>Cu>Ni>Co>Cr, and in soy beans - Zn>Cu>Ni>Mo>Cr>Co. White lupine beans, as compared to soybean beans, contain 6.3 times more cobalt, 9.8 times more molybdenum, 1.3 times more zinc, while copper content is 2 times less, and nickel - 2.2 times less. The content of zinc, copper, nickel, molybdenum, cobalt in lupine beans was higher, and chromium is lower than in straw. In soy beans, the content of all trace elements was higher than in straw, with the exception of cobalt, which showed inverse trend.

REFERENCES:

[1] Singkh, G., 2014. Soybean: biology, production, use. Kyiv, Ukraine, p. 656.

[2] Lukin, S.V., Seliukova, S.V., 2017. Agro-environmental assessment of the microelement composition of soybean plants.Achievements of science and technology of agroindustrial complex, 6: 34-36.

[3] Gataulina, G.G., Belyshkina, M.E., Medvedeva, N.V., 2016. Yields of seeds and productivity elements in different varieties of white lupine in different years according to meteorological conditions. News of the TAA, 6: 32-42.

[4] Gataulina, G.G., Medvedeva, N.V., 2008. White lupine as a promising forage crop. Achievements of science and technology of the agroindustrial complex, 10: 49-51.

[5] Vinogradov, A.P., 1952. Basic regularities in the distribution of microelements between plants and the environment. Microelements in the life of plants and animals. Moscow, Russia: 7-20.

[6] Lisetskii, F., Stolba, V.F., Marinina, O., 2015. Indicators of agricultural soil genesis under varying conditions of land use. Steppe Crimea. Geoderma, 239–240: 304–316.

[7] Lukin, S.V., 2017. Dynamics of the agrochemical fertility parameters of arable soils in the south-western region of central chernozemic zone of Russia. Eurasian Soil Science, 50(11): 1323–1331.

[8] Chetverikova, N.S., Lukin, S.V., Martsinevskaya, L.V., 2011. Monitoring of the Fertility of Chernozems in Forest–Seppe Zone. Belgorod State University Scientific Bulletin: Natural sciences, 15(9): 184–190.

[9] 2004. Methodological guidelines for the identification of sulfur in plants and plant forage. Moscow, Russia, p. 8.

[10] 1992. Methodological guidelines: Atomic absorption methods for the identification of toxic elements in food products and food raw materials. Moscow, Russia, p. 61.

[11] Samokhvalov, S.G. et al. 1977. Methodological guidelines for the colorimetric determination of trace elements in feed and plants. Moscow, Russia, p. 40.

[12] Titova, V.I., Dabakhova, E.V., Titova, E.O., 2015. Influence of microfertilizers on yield and quality of grain of white lupine of Degas variety. Bulletin of Ulyanovsk State Agricultural Academy, 3(31): 42-47.

[13] Vinogradov, A.P., 1957. Geochemistry of rare and dispersed chemical elements in soils. Moscow, Russia, p. 238.

[14] Kabata–Pendias, A., 2011. Trace Elements in Soils and Plants: 41.

[15] Chernykh N.A., Sidorenko S.N., 2003. Environmental monitoring of toxicants in the biosphere. Moscow, Russia, p. 430.

[16] Fateev, A.I., Zakharova, M.A., 2005. Fundamentals of the application of microfertilizers. Kharkiv, Ukraine, p. 134.

[17] Kovalskii, V.V., Raetskaia, Iu.I., Gracheva, T.I., 1971. Microelements in plants and forages. Moscow, Russia, p. 235.

[18] Khizhniak, R.M., 2016. Environmental assessment of the content of microelements (Zn, Cu, Co, Mo, Cr, Ni) in agroecosystems of the forest-steppe zone in the southwestern part of the Central Black Earth region: author's abstract PhD Biology. Moscow, Russia, p. 24.

[19] Alekseev, Iu.V., 1987. Heavy metals in soils and plants. Leningrad, Russia, p. 142.