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APPLICATION OF SODIUM SELENITE IN THE GROWING TECHNOLOGY OF WHITE LUPIN (*LUPINUS ALBUS* L.)

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Abstract: *Lupinus* is a very diverse genus with many species. The aim of this study was to determine the influence of different methods of application of sodium selenite on the nutritional value of white lupine variety Degas. The highest effect on the content of crude protein was obtained by spraying vegetating plants before the beginning of the flowering phase. In this variant, a class 1 grain was obtained while meeting other requirements of the feed lupin quality standard. This study reveals that the use of selenium contributed to increasing the collection of crude protein at the harvest of white lupin. It is assumed that selenium stimulated the processes of nitrogen entering plants and its redistribution from vegetative to generative organs, as well as activated the synthesis of proteins and their accumulation in the grain of white lupin. It was found that the content of alkaloids in the resulting crop of white lupin did not exceed acceptable levels, which allows it to be used for feed purposes and the preparation of various types of feed. The use of selenium contributed to the increase in the collection of crude protein content at the harvest of above-ground plant mass as it stimulates nitrogen processes in plants and its redistribution from vegetative organs to generative organs, as well as the synthesis of protein compounds in the lupin grain.

Key words: white lupin, sodium selenite, methods of application, spraying, crude protein content.

Introduction

Lupin species could be an actual sustainable alternative source of protein for animal feeding. However, only four of them – namely, *L. albus, L. angustifolius, L. luteus* and *L. mutabilis* – are cultivated. *Lupinus* is a very diverse, widespread genus of the *Fabaceae* family with numerous species. It is distributed in a wide range of climatic conditions, from subarctic regions to semi-deserts and subtropical

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climates, as well as from sea level to alpine ecosystems (Jezierny et al., 2010; Annicchiarico et al., 2014; Vishnyakova et al., 2021).

Recently, there has been a significant increase of interest in improving technologies for growing white lupin in the non-black soil zone, which makes it possible to increase its distribution area and solve the problem of obtaining high-protein feed for livestock. Lupin, being a high-protein field crop, is also characterized by the content of essential amino acids, which makes it possible to obtain feeds that are qualitatively better than those of other forage crops (Tsygutkin et al., 2011; Abraham et al., 2019).

Lupins are mostly used as fodder and food crops, and some species are also used ornamentally (Yaver and Bilgigli, 2021; Arnoldi et al., 2015; Fedulova et al., 2019).

The researchers address the main proteins of white lupin seed (*Lupinus albus*, L.) and report on the current state of knowledge of the structural and functional properties of these proteins with the aim of providing the first comprehensive, accurate and up-to-date survey on this topic. Of particular interest are the molecular and biological features of the four main protein families of lupin seed globulins, called α-, β-, γ-, and δ-conglutins. Their nutritional, technological, nutraceutical and allergenic potential is also important (Duranti et al., 2008; Shrestha et al., 2021).

At the same time, one of the disadvantages of lupin is the content of biologically active substances in the seeds and green mass – alkaloids, which negatively affect the living organism and reduce the nutritional quality of the product. Therefore, reducing the content of alkaloids in the grain and green mass of lupin improves the feed value of the resulting products (Vishnyakova et al., 2020).

This makes it possible to produce a full-fledged, environmentally safe vegetable feed protein, suitable for the preparation of concentrated and other types of feeds.

In addition, lupin has an agronomic importance (green manure), which allows increasing the stability of farming systems (Lucas et al., 2015).

The most productive of all lupin species is the white lupin (*Lupinus albus L.*) – grown in many countries and used for feed production and as a food crop. White lupin is characterized by the highest protein yield per unit area, surpassing other types of lupin (Lukashevich et al., 2018).

The aim of the research was to study various ways of applying sodium selenite to the feed value of the white Dega lupin crop.

Material and Methods

In order to examine the various ways of applying of sodium selenite, a field micro-experiment was conducted at the experimental site of the Department of Agronomic, Biological Chemistry and Radiology of the Russian State Agrarian

University – Timiryazev Moscow Agricultural Academy within three years. The subject of this study was a white lupin of the Degas variety. Lupin is a white variety of Degas, which is a variety of universal use, bred by the Lupin Research Institute and the Russian State Agrarian University – Timiryazev Moscow Agricultural Academy. In 2004, the variety was included in the state register of selection achievements (Gataulina et al., 2013). The experiment was carried out on urbanozem soil type with following agrochemical characteristics: exchange acidity close to neutral (pHkcl) – 6.0 (GOST 26483-85), hydrolytic acidity 0.9 (GOST 26212), the amount of absorbed bases (S) – 24.3 (GOST 27821-88). The humus content was 3.3% (GOST 26213-91). The presence of mobile forms of phosphorus – 125 mg/kg of soil (class IV), potassium – 120 mg/kg of soil (class IV) (according to Kirsanov) (GOST 26207-91).

The design of the experiment: as a one-factorial using the block system in four repetitions, vegetation plot shape – square, the total area of the plot was 1 m^2, the registered area of the plot was 0.64 m^2. All research results were statistically processed by using the one-way analysis of variance.

Mineral nutrients were prepared by manual addition ofammonium nitrate (NH_4NO_3), ammophos ($NH_4H_2PO_4$) and single-substituted potassium phosphate (KH_2PO_4) at a depth of 7–10 cm. In all variants, nitrogen, phosphorus and potassium were added at the rate of N20P115K145.

Selenium was applied in two ways: pre-seed treatment (PST) by soaking the seeds and spraying the vegetating plants (SVP) before the beginning of the flowering phase and after flowering with a 0.01% solution of sodium selenite salt (Na_2SeO_3). The control was a variant in which no sodium selenite was used.

After harvesting, the main white lupin quality indicators were determined using the SpectraStar 2500XL-R device. Sampling and preparation for analysis using the near-infrared spectroscopy method was performed in accordance with GOST 32040-2012. To determine the reliability of the obtained results, mathematical processing was employed using the multivariate method of variance analysis (Kobzarenko et al., 2015).

Results and Discussion

The main characteristic of the nutritional value of feed crops is the assessment of the impact of growing conditions on the content of crude protein in the grain and green mass and the collection of crude protein at harvest.

As obtained in field studies conducted with white lupin, the highest content of raw protein was obtained in the grain of the crop (Figure 1). It was found that the use of sodium selenite contributed to an increase in the crude protein content in the grain of white lupin. The highest amount of crude protein was obtained by spraying plants in the vegetative phase. This value increased to 39.6% compared to the

control variant (31.4%). It was found that, when using sodium selenite, the content of crude protein in the stems and pods decreased. It is assumed that the use of sodium selenite activated the processes of redistribution of assimilates from vegetative to generative organs and stimulated the synthesis of protein compounds in the grain, which led to an increase in the crude protein content in the grain of white lupin and an increase in its nutritional value.

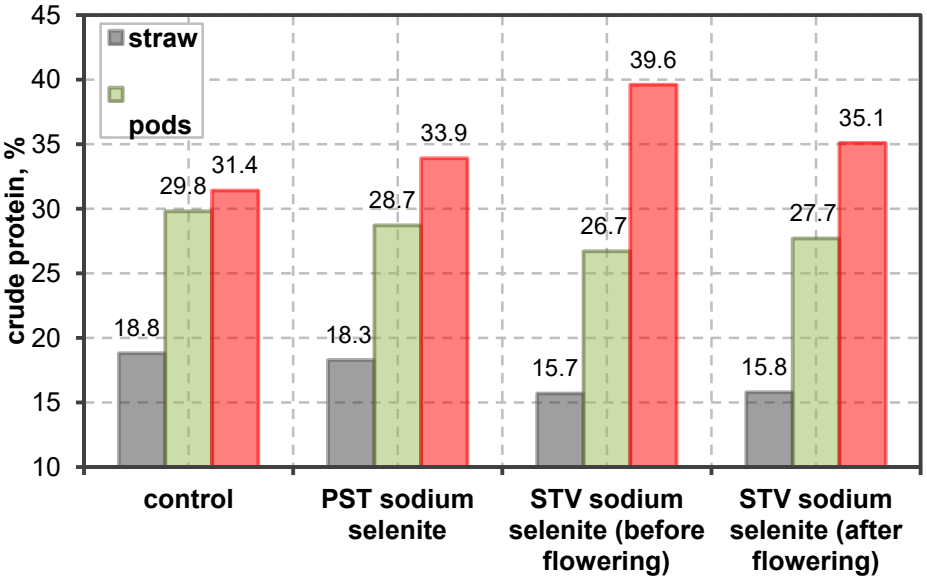

Figure 1. The crude protein content in white lupin plants when using sodium selenite.

In accordance with GOST R 54632-2011, the grain of white lupin is classified into classes 1, 2 and 3 in terms of crude protein content, subject to other requirements. The grain obtained in our study, when spraying the plants in the vegetative phase before the beginning of the flowering can be classified as class 1 in terms of crude protein content. In this variant, a grain with a crude protein content of 39.6% was obtained. When using sodium selenite by pre-sowing seed treatment and spraying the vegetating plants after the flowering phase, the grain can be classified as class 3. The crude protein content in these variants was 34.9% and 35.1%, respectively.

The results of research show that the use of sodium selenite contributed to an increase in the collection of crude protein compared to the control variant (Table 1). Most of the increase in crude protein collection was in the lupin stalks and pods. However, the contribution of each component to the total crude protein collection

by the above-ground mass of the plants differed, depending on the method of processing with sodium selenite. It was found that when using pre-sowing seed treatment, the total collection of crude protein by the above-ground mass of the white lupin crop was 403.2 g/m^2, which was 23% more than in the control variant.

At the same time, the collection of raw protein with a crop of stems has not changed, the collection of raw protein with a grain harvest has increased by 14%, the collection of raw protein with a crop of pods has more than twice.

Spraying plants with sodium selenite before the beginning of the flowering phase contributed to a significant increase in the crude protein collection in a grain and leaf harvest by more than twice.

At the same time, in this variant, the yield of crude protein in the crop of stems sharply decreased by 30%, which did not lead to a significant increase in the total yield of crude protein in the crop of aboveground mass of plants.

Spraying vegetating plants with sodium selenite after the flowering phase contributed to a 35% increase in the total collection of raw protein by the above-ground mass of plants. Also, the contribution of grain to the total collection of crude protein by above-ground plant mass increased by 1.9 times and the contribution of flaps increased by 1.6 times compared to the control variant. Thus, it can be concluded that the use of selenium contributed to an increase in the nutritional value of the resulting crop of white lupin by stimulating the nitrogen supply of plants and activating the synthesis of protein compounds.

Table 1. The collection of crude protein in a crop of Dega lupin using sodium selenite.

Variant	Method of processing	Crude protein, g/m^2			
		grain	pods	straw	mass of plants
control		42.3	49.2	237.0	328.5
sodium selenite	PST	48.3	116.1	238.8	403.2
sodium selenite	STV before flowering	95.1	80.1	165.0	34.2
sodium selenite	STV after flowering	78.9	149.7	203.4	432.0
SSD* $_{05}$		3.3	7.0	12.5	-

*the smallest significant difference.

One of the indicators for assessing the nutritional value of feed products, including white lupin, and suitability for feed production, is the content of alkaloids (Shakirov et al., 2016). In accordance with the existing classification of feed, the content of alkaloids in the products obtained from white lupin of all variants did not exceed the permissible amounts (Table 2). It is shown that the content of alkaloids in the grain of white lupin is 0.04–0.06%, in the pods – 0.03–0.04 %, whereas, it was not found in the stems.

Table 2. The alkaloid content in the above-ground mass of white lupin plants.

Variant	Method of processing	Alkaloid content, %		
		in the grain	in the pods	in the stems
control		0.06	0.04	-
sodium selenite	PST	0.06	0.03	-
sodium selenite	STV before flowering	0.04	0.04	-
sodium selenite	STV after flowering	0.05	0.03	-
SSD_{05}		0.01	0.01	-

Conclusion

The results of research have shown that the use of selenium contributes to an increase in the nutritional value of the crop of white lupin, as a result of increasing the content of crude protein in the grain and accumulation of crude protein at the harvest of above-ground plant mass. The highest crude protein content (39.6%) was obtained by spraying the plants with sodium selenite before the beginning of the flowering phase. If all the requirements of the quality standard for feed lupin are met, the grain obtained in this variant can be classified as class 1. This study reveals that the use of selenium contributed to increasing the collection of crude protein at the harvest of white lupin. It is assumed that selenium stimulated the processes of nitrogen entering plants and its redistribution from vegetative to generative organs, activated the synthesis of proteins and their accumulation in the grain of white lupin. It was determined that the content of alkaloids in the resulting crop of white lupin did not exceed acceptable levels, which allows it to be used for feed purposes and the preparation of various types of feed.

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PRIMENA NATRIJUM SELENITA U TEHNOLOGIJI GAJENJA BELE LUPINE (*LUPINUS ALBUS* L.)

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R e z i m e

Lupinus je veoma raznovrstan rod sa mnogo vrsta. Cilj ovog istraživanja bio je da se utvrdi uticaj različitih metoda primene natrijum selenita na nutritivnu vrednost bele lupine, sorte Degas. Najveći efekat na sadržaj sirovih proteina postignut je tretiranjem biljaka u vegetativnoj fazi pre početka faze cvetanja. Kod ove varijante, dobijeno je zrno klase 1 uz ispunjavanje ostalih zahteva standarda kvaliteta krmne lupine. Ova studija pokazuje da je upotreba selena doprinela povećanju nakupljanja sirovih proteina prilikom žetve bele lupine. Pretpostavlja se da je selen stimulisao procese ulaska azota u biljke i njegove preraspodele iz vegetativnih u generativne organe, kao i da je aktivirao sintezu proteina i njihovu akumulaciju u zrnu bele lupine. Utvrđeno je da sadržaj alkaloida u usevu bele lupine ne prelazi prihvatljive nivoe, što omogućava da se koristi za ishranu i pripremu raznih tipova hraniva. Upotreba selena doprinela je povećanju nakupljanja sirovih proteina prilikom žetve nadzemne mase biljaka zbog stimulisanja procesa azota u biljkama i njegove preraspodele iz vegetativnih organa u generativne organe, kao i sinteze proteinskih jedinjenja u zrnu lupine.

Ključne reči: bela lupina, natrijum selenit, načini primene, tretiranje, sadržaj sirovih proteina.

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