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PRODUCTIVITY OF WHITE LUPINE FROM LOW-ALKALOID VARIETIES (*LUPINUS ALBUS* L.) UNDER TRANSYLVANIA GROWING CONDITIONS

Criste Leontin Florin[*], Mierliţă Daniel[**]

[*]University of Agricultural Sciencies and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăştur, 400372, Cluj-Napoca, Romania;
[**]University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048, Oradea, Romania, e-mail: dadi.mierlita@yahoo.com

Abstract

The aim of the present study was to establish the pretability, productivity and economical efficiency of the white lupine with low alkaloids content culture in the specific agro-climatic conditions of the hilly area of Transylvania. The experimental studies were carried out during the April-August period of 2018 and consisted in setting up a white lupine culture of Amiga variety (variety improved in Poland, considered free of alkaloids and other anti-nutritional compounds), on an area of 0.87 hectares, in Sălaj county, Romania. By analyzing the obtained data it results that the white lupine Amiga variety behaves well in the pedoclimatic conditions of the hilly area of Transylvania, reaching out yields of 2942 kg grains / ha, even in the context of less favorable climatic conditions which labeled the year of 2018 (rainfall excess during the flowering and pod development stage). The production expenses related to one beans ton was 207.07 euro / ton of grains, being lower with ca. 91% compared to the price of acquiring one ton soybean meals (396,14 euro /ton – the market price of the September month of 2018). The production costs related 1 kg of crude protein were lower with 30.4% in lupine compared to soybean meals. Nevertheless, it must be stated the fact that the proteins of the white lupine beans are showing a lower biological value comparatively to those derived from soybean meals. The pretability to the natural conditions of the Transylvania area, the grains yield level, the production expenses relatively low warrant us to recommend the Amiga variety of the white lupine as a perspective variety with high yields, still requiring the assessment for a longer period, comparing to other white lupine varieties homologated in Europe.

Key words: Amiga cultivar, grains yield, agronomic caracteristics, economic efficiency.

INTRODUCTION

The white lupine varieties with low alkaloids content could play an important role in decreasing the deficit in fodders with high protein content and increasing the animal growing systems sustainability. Its contribution to a durable development of animal husbandry derives from dropping down the nitrogenous fertilizers consumption, rising up soil fertility and biodiversity (Annicchiarico et al., 2010).

The common agricultural policy of EU encourage the farmers to practice a durable culture rotation and promote, also, good, ecological agricultural practices, simultaneously with a substantial increment of the

vegetal protein yield (Borreani et al., 2007). The lupine use in animal feeding could rise up yield profitableness (McNaughton, 2011) and moreover, it improves soil fertility and increases the yield of further cultures in rotation (Gül et al., 2008).

However, the economical durability of this culture depends on its productivity. Unlike soy (*Glycine max* L.), white lupine (*Lupinus albus* L.) can be cultivated showing good bioproductivity results even in soils with lower fertility, in agro-climatic areas with lower temperatures and moreover no not require thermal conditioning, enabling it`s direct use in farms.

Lupine is not a traditional culture in Romania, as old varieties have a yield of grains potential relatively low (ca. 1.2 ton/ha), but then the use of beans in animal feeding is straitened due to its bitter taste assigned to the relatively high content in alkaloids (1.43%) (Yeheyis et al., 2012). The alkaloids have an anti-nutritional and toxic effect, showed especially in monogastrics, through hepatic affections, decrement of the performances and feed intake, undervaluing of the quantitative animal productions, which limited lupine beans use and cultivation.

The progress related lupine improvement, carried out through modern varieties considered free of alkaloids homologation (the beans contain below 0.02% alcaloids; some of the improved varieties in France even below 0.02% alcaloids) and with high productivity (especially the white lupin varieties, which can reach out over 4000 kg grains/ha - Annicchiarico et al., 2010), lead to the culture extending and to a growing demand for lupine beans on the market, as proteins and fat source for animal feeding, and even human, too. The white lupine culture extending for grains production in Europe (Poland, France, Germany, Italy, Holland, etc) was ensured on the one hand by the progress accomplished on the improvement of this species and the economical advantages, and on the other hand by the ecological factor that straiten the soy areas cultivated, undertaking other species with high protein content cultivation.

The pedoclimatic conditions of our country stand for gathering adequate quantitative and qualitative lupine grains yields (Mierliţă et al.; 2012, 2013a). The partial replacement of soybean meals with lupine beans in poultry feeding do not carry any risk related to poultry health and the quality of the yields aquired, since free alkaloids and anti-nutritional compounds varieties were used; these aspects are also proved by the results of the researches performed, reffered in scientific publications (Dora et al., 2002; Suchy et al., 2006; Strakova et al., 2006; Nalle et al., 2010; Mierliţă and Popovici, 2013b).

The input of lupine culture in Romania drives to the vegetal production diversification with a positiv impact related to the request:offer ratio on a market ruled up to now by cereals. Moreover, the lupine seeds do

not require thermal conditioning to spoil anti-nutritional compounds (ex. tripsininhibitors as in soy beans) and are not genetically modified, becoming an important protein source for ecological farms (Dora et al., 2002). These seeds of the legume family are not only a valuable protein source, but at the same time an energy one, due to the high fat content (8 - 11%; Petterson et al., 1997; Hickling 2003).

The aim of the present study was to establish the pretability, productivity and economical efficiency of the white lupine with low alkaloids content cultivation in the specific agro-climatic conditions of the hilly area of Transylvania.

MATERIAL AND METHOD

The study was carried out during the April-August period of 2018, under production conditions. The white lupine culture was attained on an area of 0.87 hectares, in Sălaj county, Gâlgău village ($47^0$17'03"N$23^0$40'34"E), on a brown podzolic soil, low up to moderate carbonatic, with a clay-loam texture, low alkaline reaction, medium content in humus, middling supplied in total nitrate, mobile phosphorus and potassium. Corn was the precursor plant. The field was fertilized with manure in the autumn of 2017, afterwards being ploughed, and in spring the seedbed was prepared for sowing.

Before sowing, a chemical fertilization was carried out, assuring 70 kg N + 25 kg P_2O_5 + 43 kg K_3O_2/ha. Amiga variety of the white lupine was used in the experiment, which belong to the low-alkaloids variety type. Seeds were imported from Holland, the Joordens Zaden B.V. company. Before sowing, the seeds were treated with an fungicide with a strong systemic action to ensure a high control of seed and soil born diseases, due to pathogen agents, especially those against anthracnose (*Colletroticum glocosporioides*), a very dangerous disease that threatens lupine culture. Germipro UFB was used, which contains carbendazim (177 g/l) and iprodione (350 g/l). Besides, 3-4 hours before sowing, seeds were inoculated with symbiotic bacteria (*Bradyrhizobium lupini*) by means of an aspersion pump, afterwards a nylon foil being laid over the seeds. This seeds inoculation is required and recommended for the first input of the lupine culture on the above field, to provide enough *Rhizobium* populations for ensuring effective nodulation, underlying suitable nitrogen fixing from atmosphere.

Sowing was performed on the 12th of April 2018, using the SU-29 sower, assuring a spacing of ca. 8-9 cm between the plants on row and 17cm between rows, insuring a sowing density of ca. 65 germinal grains/m^2. The depth of sowing was of 3-4 cm, using ca. 120 kg grains/ha.

Treplik PL herbicide (pendimetalin -125 g/l + linuron - 125 g/l), produced by the BASF Agro SAS trade was used right off the sowing, assuring 4 liters/ha for weed control. During the vegetation period, for weed control, on the 54th day from sowing Laureat herbicide (diflufenicanil - 25 g/l + chlortoluron - 400 g/l), produced by the Bayer CropScience trade was applied, ensuring 0,8 liters/ha. For disease and pest control, 22 days after the lupine culture spring a fungicide (tetrachloro-ftalonitril) joined with an insecticide (cypermethrin) were applied.

After harvesting beans humidity and yield (kg grains/ha) were ascertained. Before harvesting, the density of the erect and mature plants was established (number of plants/m^2) in four different parcels, by means of a consecrated technique (metric frame) and were randomized harvested 10 plants/parcel, which were used for the following assessments:

- ✓ plant weight,
- ✓ plant height,
- ✓ plant height up to the first pod developed,
- ✓ number of leaves on the main stem,
- ✓ number of pods per plant,
- ✓ number of grains completely developed in a pod,
- ✓ grains weight per plant, the mass of 1000 grains being calculated based on it,
- ✓ harvest index, calculated as the ratio between the grains weight in plant and the whole plant.

The number of pods per plant was calculated as the average of 40 plants harvested from four different parcels. The weight of 1000 grains was calculated by extrapolation based on the weight of the available grains (ca. 700 grains).

Data gathered in this study were compared to those achieved in other studies performed on the white lupine Amiga variety (Annicchiarico et al., 2010) or other strains or varieties with low alkaloids content (Pospisil A. si Pospisil M., 2015).

RESULTS AND DISCUSSION

Pretability of cultivating white lupine and its productivity

In Amiga variety white lupine culture, grains yield was influenced by the weather conditions (table 1). Although during the vegetation period of lupine (April-August 2018) temperature graphic was favorable for the vegetation stage, the total amounts of precipitation (394.3mm), but moreover the distribution of precipitations was total unfavorable (fig.1), Abundant precipitation during the floral initiation, flowering and pod

development stage (in May and especially in June) lead to flower loss (flower abortion) and pods loss, and therefore as consequence the decrement of grains yield (Atkins și Smith 2004). Indeed, the amounts of precipitation in July was integrated oneself with the multiannual values specific of the season (75.2), but then it was too late, since the flowering stage was ended and the pods were already developed.

Table 1

Average daily temperatures (^{0}C) and total precipitation (mm) registered in the vegetation period (data provided by the Weather Station Zalău)

	Vegetation period - 2018					Average or total (2018)	Average values: 2010-2017
	April	May	June	July	August		
Average temperature (^{o}C)	16.2	22.3	26.8	27.3	28.1	24.14	26.8
Total precipitation (mm)	56.8	72.3	125.2	75.2	64.8	394.3	273.1

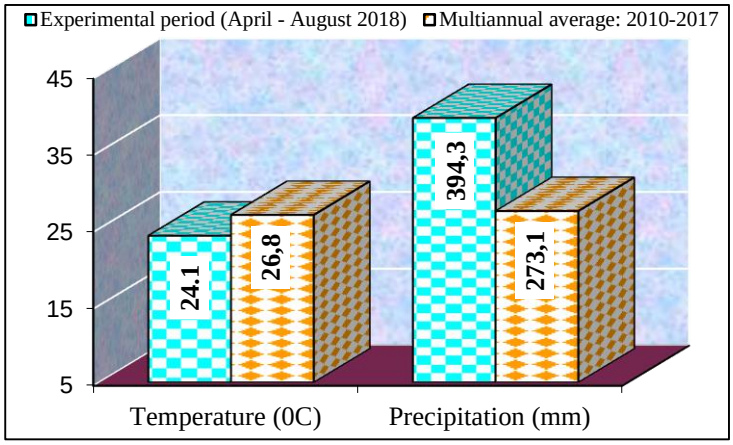

Fig. 1. Comparative data regarding the climatic parameters registered in the experimental period

The obtained data analysis indicate that the white lupine Amiga variety bear well the pedoclimatic conditions from the hilly area of Transylvania, reaching up yields of kg grains/ha. Natera et al. (1999) reported a grains yield of 2.8 t / ha throughout an adaptation and utilization of the white lupine study as an alternative protein source in Mexico and Heidel (2005) reported in Germany a grains yield of white lupine varieties free of alkaloids of 3.8 t / ha. However, the grains yield obtained in this study is higher related the one reported by Muyekho (1999), which registered an average grains yield of white lupine (Ultra variety – an alkaloid low content variety) of 2.5 t / ha, all of these after a vegetation period of three months. Nevertheless, the productivity achieved in this study

was lower related to the one reported by Mihailovic et al. (2008) (3.7 t / ha) of a white lupine culture in the specific pedoclimatic conditions of Serbia and by Fraser et al. (2005) (3.45 t / ha) of the white lupine culture in United Kingdom. Such differences could be attained throughout the pedoclimatic conditions and the agro-technique applied, but also the varieties used in the studies.

The lower grains yield achieved by us could be associated with the excess of precipitation during the whole vegetation season. Hill (2011) asserted that the white lupine is negatively affected by abundant precipitation in the vegetation season if the disposable humidity amount is greater that the soil moisture deficit. In this study, the average precipitation showed values of 394.3 mm in the vegetation period, being higher with ca. 44.4% compared to the average recorded in the April-August period from the last 7 years (fig. 1).

This excess of precipitation from the month of June induced a lower number of pods per plant 4.72), but also a lower number of grains per pod (3.74), compared to the data reported by Annicchiarico et al. (2010), of a white lupine Amiga variety (the same that we used) culture in the specific agro-climatic conditions from northern Italy (table 2). Thereby, the number of grains per plant (17.7) and the total grains yield (2942 kg grains/ha) recorded in our study, were lower compared to those reported by Annicchiarico et al. (2010), respectively 29.5 grains/plant and 4210 kg grains/ha (fig. 2). Opposite to these results, López-Bellido et al., (2000) point out that lupine is well adapted to various sowing densities, because the number of stems increases and a similar number of pods is produced regardless the sowing density or the extremely various climatic conditions. Though, the result achieved in this study related the white lupine productivity are comparable with those gathered by Pospisil A. si Pospisil M. (2015) of a white lupine Energy variety culture in Croatia and Faligowska et al. (2017) of a white lupine culture Butan variety in Poland.

The weight of 1000 grains of the white lupine Amiga variety was of 271 g, showing variations between 252 and 288 g. The values achieved are in agreement with those referred by Gdala et al. (1999); Mülayim et al. (2002), Erbaș et al. (2005) and Pospisil A. si Pospisil M., (2015) in various white lupine varieties.

Abundant precipitation during the vegetative development of lupine induced height plant growing, but also its weight, compared to the recorded data of Annicchiarico et al. (2010) related the same variety of white lupine (Amiga variety). A better of the plants from our study caused a significant decrement of the harvest index, which is calculated as the ratio between the grains quantity and the plant`s weight, from 0.517 referring to the study performed by Annicchiarico et al. (2010) up to 0.426 referred in our study,

value that is similar to the one obtained by Pospisil A. si Pospisil M., (2015) for the white lupine Energy variety (table 2). By comparing the data achieved in this study to those of Annicchiarico et al. (2010) on ascertain the remarks of Karadavut (2009), which proved a positive correlation between the number of pods per plant and the total yield grains/ha, but also a negative correlation between the weight of 1000 grains and plant`s height.

Table 2

Agronomic properties and productivity of the white lupine cultivated in the specific agro-climatic conditions of the hilly area of Transylvania

	Achieved values		Bibliographic references*	
	Average	(min. - max.)	1	2
Plant density (plants/m^2)	61,4	62,5 - 78,2	-	65,0
Plant height (cm)**	67,1	60,8 - 81,2	56,6	84,3
No. of leaves on the main stem **	16,1	10,3 - 19,7	14,9	-
Stem height up to the first pod **	48,5	41,8 - 53,6	44,6	51,9
No. of pods per plant**	4,74	4,18 - 5,71	7,2	3,9
No. of grains per pod **	3,74	3,14 - 4,30	4,10	4,13
No. of grains per plant **	17,7	14,3 - 28,6	29,5	16,1
Grains weight per plant (g)**	4,78	3,60 - 8,23	10,12	7,10
Weight of 1000 grains (g)	271	252 - 288	343	290,7
Grains yield (kg/ha)	**2942**	**-**	**4210**	**3033**
Harvest index**	0,426	0,395 - 0,648	0,517	0,420

* 1- Annicchiarico et al. (2010): white lupine Amiga variety, cultivated in northern Italy;
2 - Pospisil A. si Pospisil M., (2015): white lupine Energy variety, cultivated in Croatia.
** n = 40.

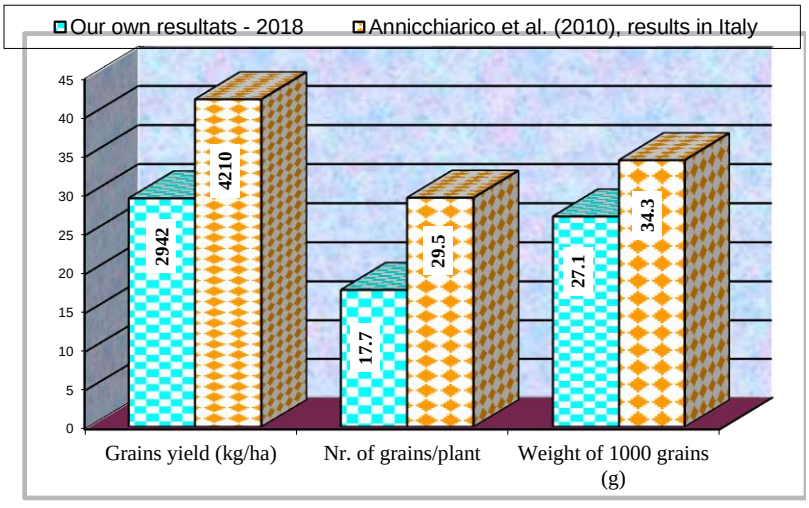

Fig. 2. Productivity and some agronomic properties of the white lupine culture in the hilly area of Transylvania, compared to the ones of the same variety (Amiga) cultivated in northern Italy

López-Bellido et al. (2000) point out that the weight of the grains per plant is the most important property related productivity, showing the higher direct and indirect impact on lupine yield of grains /ha. This remark was asserted also by the present study, where the weight of grains /plant was 2.1 lower compared to the one reported by Annicchiarico et al. (2010), which was showed also into a negative effect on the total yield of grains, that was lower with 30,1%.

Economic efficiency

The decision to cultivate the white lupine free of alkaloids for grains production in order to use it as protein source for animal feeding is argued by several factors, the profitability being the most important one (Czerwińska-Kayzer și Florek 2012).

The economic efficiency of cultivating the lupine in the agro-climatic conditions of Transylvania was assessed, based on the production costs and the market value of the lupine grains yield obtained, added up to the financial supports provided for this culture (table 3).

Table 3

The economic analysis of the white lupine free of alkaloids cultivation in the specific agro-climatic conditions of Transylvania

Total expenses (euro/ha): including:	**609,2**	**Total incomes** (euro/ha): including:	**1077,26**
- field preparation	102,8	- yield value	697,66
- fertilization	29,8	- EU financial support	379,6
- sowing	17,10		
- seed (120 kg)	129,0		
- chemical fertilizers (NKP)	205,6		
- culture maintenance (herbicides, fungicides, insecticides)	69,2		
- harvesting	55,7		
GROSS PROFIT (Incomes- expenses)	468,06 euro/ha		
Costs for 1 ton of white lupine grains	207,07 euro/tona		
Costs for 1 kg crude protein	0,613 euro/kg		

The production costs include: the costs related field preparation, seeds procurement, fertilizers (natural and chemical), chemical protection of lupine culture, harvesting and storage practices, labour, services, taxes and insurances. The market costs (TVA value included) of the first half of the year 2018, were considered for calculations. The costs for seeds, fertilizers and chemical protection of the culture (herbicides, fungicides, insecticides)

were estimated depending on the data provided by the agricultural inputs dealers at national level. The value of the lupine grains yield achieved was estimated based on the price referred by Faligowska et al. (2017), from the Poland market (237.14 euro/tone of grains). To establish the incomes achieved, the EU financial supports, in quantum of 379.60 euro/ha, including the direct area payment (107.59 euro), complementary area payments for legume seeds (241,.18 euro) and direct payments for certified seed (30.83 euro), were added to the value of the grains yield obtained. All the prices and costs were recalculated in euro according to the average monthly exchange rate published by BNR (The Romanian National Bank) in September 2018.

In the present study, the production costs per one hectare were estimated at 609.2 euro, based on the expenses registered for: field preparation, fertilization, seed, sowing, culture maintenance and grains harvesting (table 3). Considering the grains yield obtained of 2.942 tons/ha, the production costs per one ton of grains are of 207.07 euro, showing a lower value of ca. 91% related the ones of soybean meals (396.14 euro/ton - market price for the month of September 2018) (fig. 3).

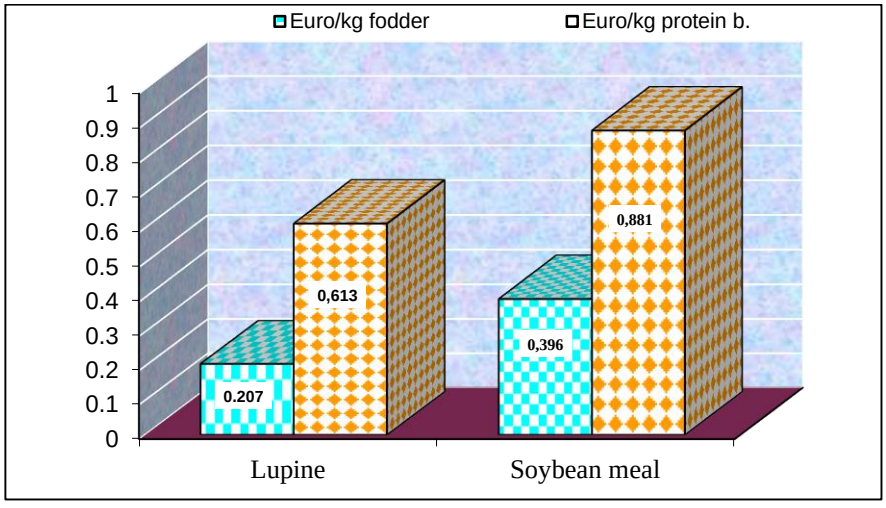

Fig. 3. Comparative analysis of lupine beans and soybean meals, related the costs per 1 kg fodder and respectively per 1 kg crude protein (the market price of the September month of 2018 was used for soybean meal; source: SC Ardealul SA).

The production costs of the lupine beans registered for 1 kg crude protein were of 0.613 euro/kg and of 0.881 euro/kg in the case of soybean meals (fig. 3). We can conclude that in the present study, the white lupine culture assured one kg of crude protein at a lower cost of 30,4%. than soybean meal. However, it must be noticed the fact that white lupin beans

are showing a lower biological value (modest content in methionine, lysine, threonine and tryptophan - Mierliţă et al., 2018) comparing to the ones derived from soybean meals.

The white lupine Amiga variety cultivation in the specific agro-climatic conditions of the hilly area of Transylvania ensured a gross profit (the profit tax value was not subtracted) of 468.06 euro/ha, where the EU financial support represented 81.1%. The financial support covered 62.3% of the total production costs of the white lupine culture.

CONCLUSIONS

Throughout the analysis of the obtained data conclude that the white lupine Amiga variety (considered being free of alkaloids and anti-nutritional compounds) bears well the pedoclimatic conditions of the hilly area of Transylvania, reaching out production values of 2942 kg grains/ha, respectively 994.5 kg crude protein/ha and 311.8 kg crude fat/ha, even in the context of the less favorable climatic conditions which characterized the year 2018 (precipitation excess in the flowering and pod development stage).

We consider that that the pretability, productivity and efficiency assesment whithin one year of the white lupin improved varieties cutivation in the agro-climatic conditions of the hilly area of Transylvania does not confer a certainty required to conclude appropriate remarks on this line.

The production costs per one ton of grains were of 207.07 euro/ton of grains, showing a lower value of ca. 91% related the price required for buying one soybean meals ton (396.14 euro/ton – the market price of the September month of 2018). The production costs registered per 1 kg crude protein were lower with 30.4% in lupine compared to soybean meals. However, it must be mentioned the fact that white lupine beans are showing a lower biological value (modest content in methionine, lysine, threonine and tryptophan - Mierliţă et al., 2018) comparing to the ones derived from soybean meals.

The white lupine Amiga variety cultivation in the specific agro-climatic conditions of the hilly area of Transylvania ensured a gross profit (the profit tax value was not subtracted) of 468.06 euro/ha, where the EU financial support represented 81.1%.

The pretability to the natural conditions of the Transylvania area, the grains yield level, the protein and fat content of the grains entitle us to recommend the Amiga variety of white lupine as lupine as a perspective variety with high yields, still requiring the assessment for a longer period, comparing to other white lupine varieties homologated in Europe.

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