THE EFFECT OF ABIOTIC STRESS ON WHITE LUPIN (*Lupinus albus* L.) cv. "MIHAI" PLANTS IN DIFFERENT DENSITY CONDITIONS

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Abstract

Lupinus albus (white lupin) is a crop well adapted to marginal lands and has a large potential for enhanced bio economy use. In general, lupins have the ability to fix atmospheric nitrogen, mobilise soil phosphate and are suitable for low nutritional cultivation. Modern varieties should be selected for high yield of green silage or high yield of seeds which contain more than 20% oil, more than 40% protein and the remaining materials are carbohydrates, mainly oligosaccharides characterized as "prebiotics". In this experiment, three new white lupin sorts were tested in experimental fields. Breeding activities we compensated by optimized cultivation technology for these cultivars. One of the biggest problem in the white lupin cultivation this year was caused by the extreme draught and high temperatures registered during the vegetation period. Results present the observations obtained in 2022 season at the Ezăreni Farm. Comparison of the selected cultivars was performed using two different density condition. Results indicated that white lupins could be an interesting alternative for farmers and can contribute to new optimised crop rotation systems.

Key words: *Lupinus albus*, plants density, abiotic stress

Despite the fact that white lupine is a valuable leguminous species due to its high protein content, up to 44% (Lucas M.M. *et al*, 2015), that it enriches the soil with nitrogen and, last but not least, thanks to the simple cultivation technology, for farmers, it is still a little-known crop and used in farm farming.

According to the world statistical data on the culture of lupine in the last five years (2016-2020) recorded in the FAO databases (fao.org/faostat), the average annual area cultivated with lupine in the world was 965086 ha (*table 1*), the share of higher going to Australia (58.2%) and Europe (38.6%).

The world average production of lupine seeds, in the same interval (*table 2*), oscillated between 0.7 t/ha in Africa and 2.2 t/ha in Asia, the highest values being recorded by Australia and the Americas, in 2017.

The assortment of varieties of the *Lupinus albus* species is quite narrow, in the European Union being registered in the Common Catalog of Varieties 30 cultivars ((https://ec.europa.eu) and in Romania only three varieties are registered in the Official Catalog (https://istis.ro).

The production of the field depends, among other things, on ensuring an optimal thickness, in which there is no competition between the lupine plants or between them and weeds. Thus, the distance between the rows should be at least 25 cm (Römer P., 2007), to be possible to fight the weeds mechanically, without the lupine plants being injured. The results of research on the production of white lupine seeds in different culture systems (Faligowska A. *et al*, 2017) show that the highest income and the lowest cost per ton of seeds are obtained in the low-input system, without a treatment with only mechanical weed control, completed with chemical protection measures against weeds, under the conditions of sowing at a distance of 18 cm between rows and a thickness of about 70 plants/sqm.

Regarding the distance between the rows, the results from the specialized literature mention experiments with different sowing options, in narrow rows, of 18 cm, 20 or 25 cm, as well as in wider rows, at 45, 50, 60, 70 , 75 cm or even more (Smith L., 2005), without resulting in firm conclusions regarding the significant influence of sowing in narow or wider rows on seed production. The general conclusion of these researches leads to the idea that for an environment that was not limited by water, wider rows did not offer a production advantage (White P. *et al*, 2008, Pospišil A. *et al*, 2015).

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Table 1

Area harvested of lupins (thousands of ha)

Region / Year	2016	2017	2018	2019	2020	Average	Percentage
World	978.56	927.31	981.97	1049.09	888.51	965.09	100.00
Africa	94.36	94.89	94.81	94.65	94.79	94.70	9.81
Americas	28.09	33.73	40.32	36.82	27.73	33.34	3.45
Asia	0.05	0.05	0.04	0.05	0.05	0.05	0.005
Europe	321.98	284.04	234.78	256.43	281.70	275.78	28.58
Australia	534.08	514.60	612.01	661.14	484.24	561.22	58.15

Table 2

Seed yield of lupin (t/ha)

Region / Year	2016	2017	2018	2019	2020	Region average
World	1.31	1.74	1.21	1.26	1.18	1.3
Africa	0.70	0.70	0.70	0.70	0.70	0.7
Americas	1.53	1.80	1.58	1.73	1.71	1.7
Asia	2.17	2.23	2.25	2.23	2.16	2.2
Europe	1.63	1.61	1.45	1.53	1.63	1.6
Australia	1.22	2.00	1.17	1.21	0.98	1.3

MATERIAL AND METHOD

The biological material used was represented by the white lupine variety "Mihai", a variety created within the USAMV Iasi, approved at ISTIS in 2015 and patented in 2017. In order to evaluate the behavior of the plants and the potential of the variety, from the point of view of the activity for the production of seeds from higher biological categories, two variants of sowing plots were applied, of 35 cm, respectively 70 cm between rows, in six repetitions, the total area allocated to each plot variant being 2.5 ha. The average distance between the grains per row was 7 cm, thus resulting in average plots of 41 plants/sqm for V1 and 20.2 plants/sqm for V2.

The testing was carried out at the Ezareni farm within the Didactic Station of USV Iasi. The sowing was carried out mechanized, on April 7, 2022, on a chernozem type land, with an autumn wheat crop as the preceding plant. In the pre-emergence stage, the herbicide Challenge was applied, in a dose of 4 l/ha, and the maintenance of the culture during the vegetation period consisted of carrying out a mechanized weeding, to combat weeds.

The samples intended for biometric determinations consisted in the sampling of plants from two linear meters in a row, from each plot-repetition, at the maturity of the plants, in the second decade of September. In the laboratory, the plants were counted and biometric determinations were made on the following quantitative characters: plant height, insertion height of the first pods, height with pods, number of pods per plant, average length and width of pods, weight of pods, the number of seeds per plant and the weight of the seeds.

Evaluation of the phenotypic variability, the average values of the quantitative characters and the related coefficients of variability were calculated, and to highlight the differences between the two variants of the rows distances, the analysis of variance was used and the interpretation of the meanings of the differences compared to the control (variant V1) by the "limit differences" method (Saulescu N.A., Saulescu N.N., 1967).

RESULTS AND DISCUSSIONS

The climatic conditions of the Moldova area and of the crop year 2022 follow the general trend of global climate changes, with a direct effect on plant development and productivity. The average monthly temperatures of 2022 were higher than the multiannual values (*figure 1*), with the exception of March and September. The months of June, July and August are highlighted, unfortunately, by exceeding the multi-year averages by 1.7^0C (July) and 2.2^0C (June and August). Although the months preceding the sowing date (April 7) were deficient in terms of soil water reserves (*figure 2*), the precipitation recorded in April was double the volumetric volume compared to the multi-year average, a fact that created good conditions for the rapid and uniform germination of plants.

On the other hand, the months of June and July were extremely deficient in terms of the volume of precipitation, which totaled about 30% compared to the multi-year averages.

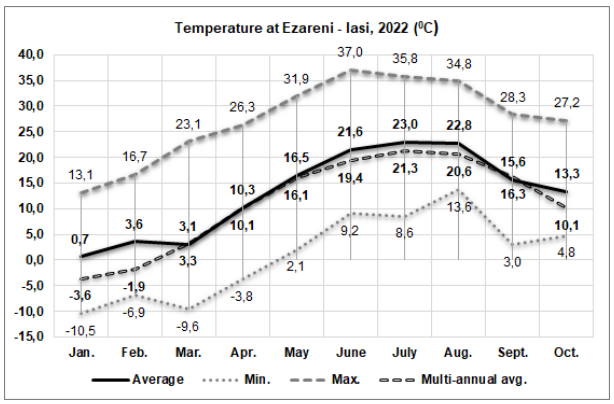

Figure 1 **Air temperature at Ezareni-Iasi, 2022**

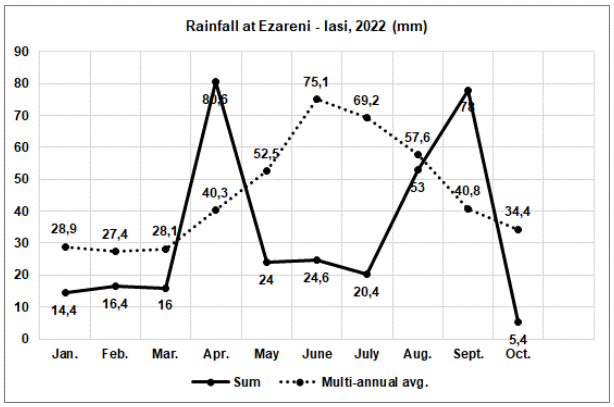

Figure 2 **Rainfall at Ezareni-Iasi, 2022**

The beginning of flowering, from the first decade of June (*figure 3*), the mass flowering of plants in the second decade of June (*figure 4*), as well as fruiting at the level of main inflorescences, from the third decade of June (*figure 5*), overlapped with intervals with major precipitation deficits, associated with very high temperatures, which affected the normal rate of growth and development of white lupine plants (*figure 6*).

The precipitation in August, in a volume similar to the multi-year monthly average and in association with the high temperatures, had the effect of stimulating the emergence and rapid development of weeds, which caused an additional stress on the lupine plants.

Figure 3 **The beginning of the flowering of the white lupine variety "Mihai" (01.06.2022)**

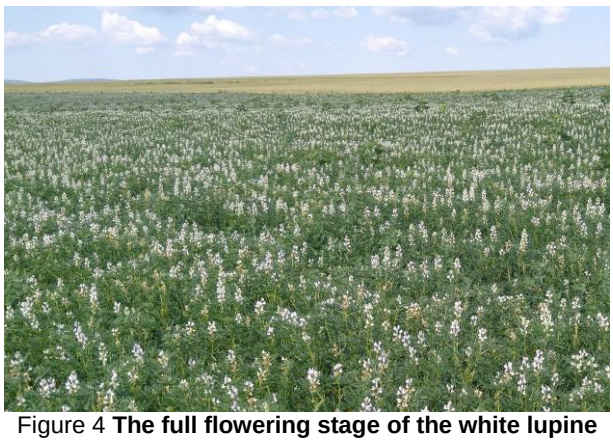

Figure 4 **The full flowering stage of the white lupine variety "Mihai" (16.06.2022)**

Figure 5 **The development of the main inflorescence in the white lupine variety "Mihai" (27.06.2022)**

Figure 6 **Sampling of plants from the "Mihai" white lupine variety at maturity (26.09.2022)**

Sowing at a wider rows of 0.70 m led to an increase in the average values for eight of the nine quantitative characters analyzed (*figure 7*). For half of these - the number of pods per plant, the weight of pods per plant, the number of seeds per plant and the weight of seeds per plant -, the resulting differences compared to the narrow rows of 0.35 m were very significant (*table 3*). Positive differences, statistically ensured, also resulted for the height with pods, the length of the pods and the height of the plants. Only the average width of the pods recorded a distinctly significant decrease in the variant in which it was sown at 0.7 m between rows. Since most of the characters with a direct impact in determining productivity registered significant increases following the doubling of the distance between the rows, it could be assumed that the average production per hectare should also increase in this variant.

In reality, the double number of plants per surface unit compensates for the lower values of the production capacity components so that in the version with a distance of 0.70 m between the rows, the seed production of 1.33 t/ha was significantly lower than of the production of the variant sown at 0.35 m between rows, of 1.68 t/ha.

The graphic representation of the size of the coefficients of variability (*figure 8*) highlights a high stability of the plant height, the insertion height of the first pods, the length and width of the pods.

At the opposite pole are the quantitative characters that are strongly influenced by environmental conditions - the height with pods, the number and weight of pods per plant, the number and weight of seeds per plant.

An interesting aspect is represented by the increase by about a third of the size of the coefficients of variability for the number and weight of pods per plant, respectively the number and weight of seeds per plant in the V2 variant (0.70 m between rows).

Table 3

The influence of the sowing density on the main yield component of white lupine „Mihai" cv.

Characters and units	Variant (distance between rows, m)	Average ± $s_{\bar{x}}$	Coefficient of variability (s%)	Difererences from standard variant	Meaning of the differences	LD 5%, 1%, 0,1%
Plants height (cm)	0.35	62.81 ± 1.06	9.05	4.64	*	4.31 6.76 11.51
	0.70	67.45 ± 1.38	10.89			
Insertion height of the first pods (cm)	0.35	41.21 ± 1.00	12.89	0.52		2.46 3.86 6.56
	0.70	41.73 ± 1.00	12.71			
Height with pods (cm)	0.35	16.48 ± 1.30	41.92	4.68	**	2.57 4.03 6.87
	0.70	21.16 ± 1.68	42.22			
Number of pods/plant (no.)	0.35	4.64 ± 0.34	39.78	2.44	***	0.70 1.10 1.88
	0.70	7.08 ± 0.78	57.79			
Pod length (cm)	0.35	7.73 ± 0.16	11.19	0.12	*	0.11 0.17 0.28
	0.70	7.85 ± 0.19	13.05			
Pod width (cm)	0.35	1.23 ± 0.02	9.72	-0.05	oo	0.02 0.04 0.06
	0.70	1.17 ± 0.02	7.40			
Pod weight/plant (g)	0.35	5.62 ± 0.46	43.99	3.30	***	0.42 0.65 1.11
	0.70	8.92 ± 0.97	57.62			
Number of seeds/plant (no.)	0.35	17.32 ± 1.34	41.69	10.07	***	1.29 2.02 3.44
	0.70	27.39 ± 2.97	57.07			
Seed weight/plant (g)	0.35	4.07 ± 0.34	44.64	2.48	***	0.30 0.47 0.79
	0.70	6.55 ± 0.72	57.75			
Seed production (t/ha)	0.35	1.68		-0.35	o	0.29 0.45 0.76
	0,70	1,33				

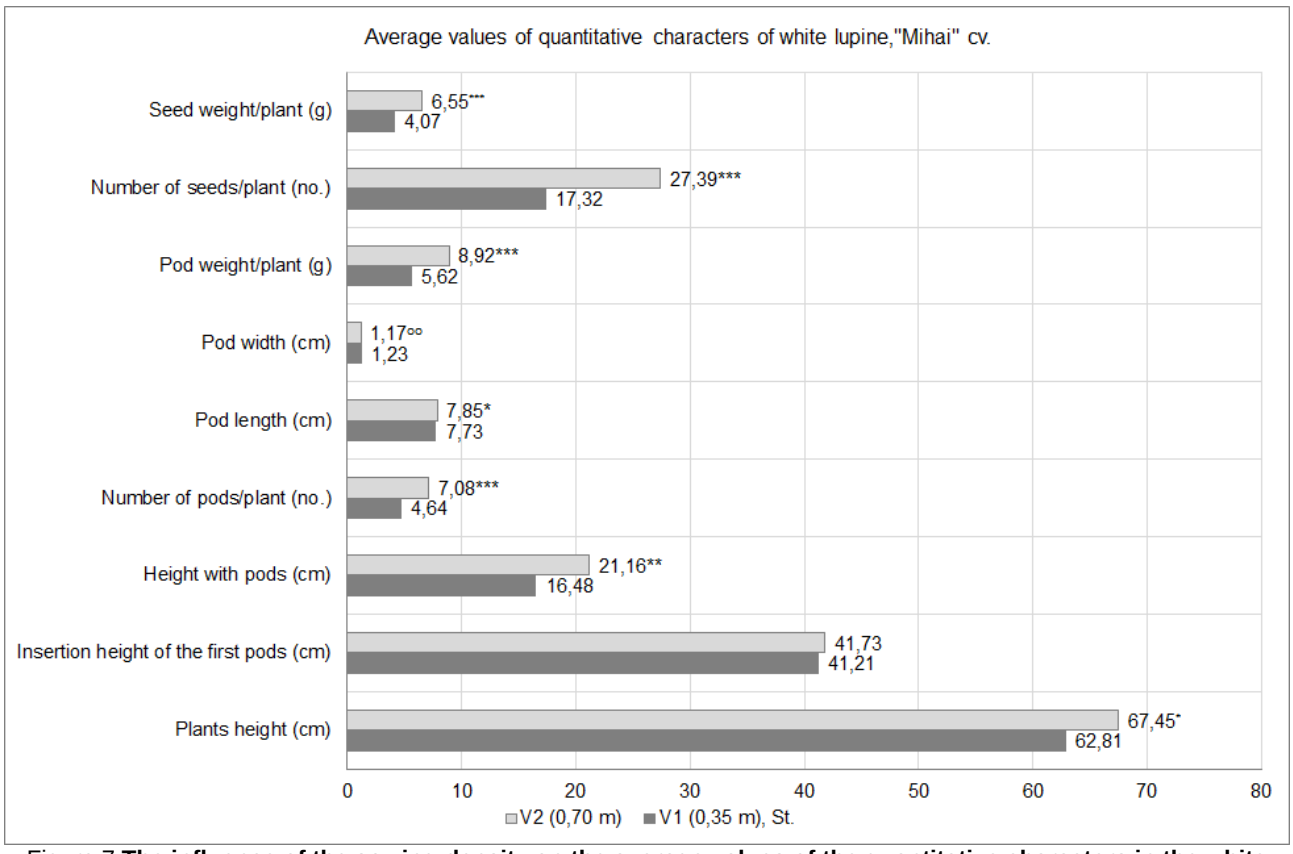

Figure 7 **The influence of the sowing density on the average values of the quantitative characters in the white lupine variety "Mihai"**

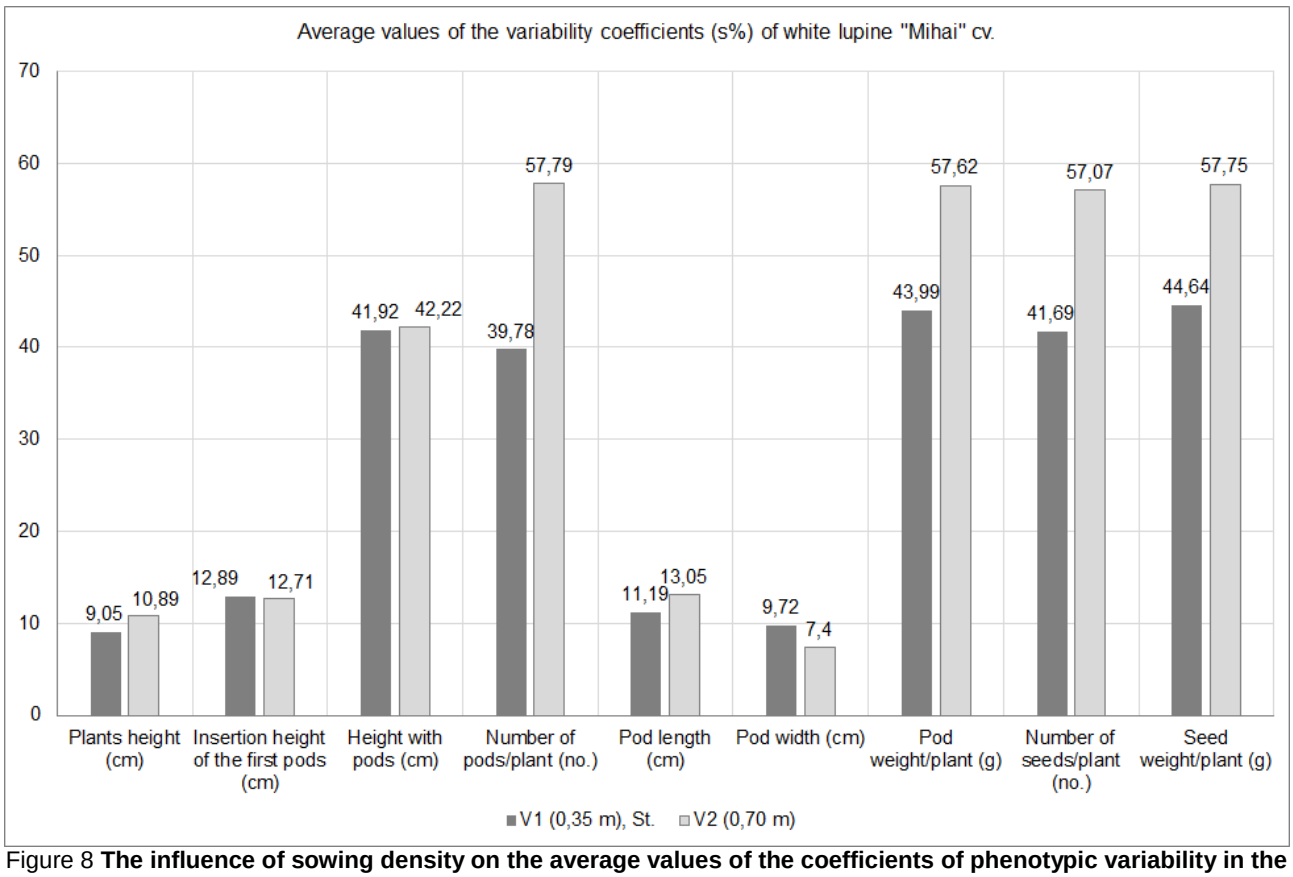

Figure 8 **The influence of sowing density on the average values of the coefficients of phenotypic variability in the white lupine variety "Mihai**

CONCLUSIONS

Although the distance of 70 cm between the rows determined, in general, the increase of the average values of the quantitative characters, the average production obtained was significantly lower than the one obtained at the distance between the rows of 35 cm.

One cause of this effect was the extremely unfavorable conditions for the crop in 2022, the long lack of precipitation causing poor competition of white lupine plants against weeds.

With the exception of the insertion height of the first pods and the width of the pods, for all the other quantitative characters analyzed, the increase in the distance between the rows was directly correlated with the increase in the values of the coefficients of phenotypic variability.

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