WEIGHT AND VOLUME GAIN BY HYDRATED GRAINS OF BITTER ALBUS LUPINS GROWN IN CHILE

J. Lobos[2], H. Miranda[2] and M. Mera[1,2]

[1]Instituto de Investigaciones Agropecuarias, Casilla 58-D, Temuco, Chile
[2]Universidad de La Frontera, Casilla 54-D, Temuco, Chile

Corresponding author's email: mmera@inia.cl

ABSTRACT

Bitter lupins (*Lupinus albus* L.) produced in Araucania, southern Chile are exported to European and Arab countries and consumed as a salty snack, after a process of soaking and boiling that removes bitterness. Commercialisation of the product, generally known as 'lupini beans', is typically by volume, occasionally by weight, therefore weight and volume gain by hydrated seeds may affect profitability. Nine lupin lines (3 Local, 3 Italian, and 3 Moroccan) were grown in three environments. Forty plants per entry per location were randomly chosen. Twenty random single plants were threshed mechanically and 20 by hand. Five replicates used for analysis consisted each of 100 seeds obtained by sampling five random seeds per plant. Soaking time was 16 h in distilled water. Weight and volume gain means were 130% and 45%, respectively. Local and Moroccan lines gained 3% more weight than Italian lines. However, Italian lines gained 14% more volume than Moroccans and 24% more than Locals. Mechanical threshing increased weight gain by 2.8% but had no significant effect on volume gain, compared with hand-threshing. No association was found between weight and volume gain. Interestingly, volume gain was strongly linked (r = 0.86) with dry seed weight whereas weight gain was inversely correlated (r = - 0.42**) with dry seed weight. Thus, larger seeds increased their size proportionately more than smaller seeds, even when they did not absorb more water. Small though significant differences were found among lines, even within a type. Variance component analysis (REML) estimated a significant genotypic effect, with heritabilities of 0.21 and 0.74 for weight and volume gain, respectively.**

KEY WORDS

lupini beans, *Lupinus albus*, white lupin, seed imbibition

INTRODUCTION

Bitter lupin (Lupinus *albus* L.) is an attractive export crop for small farmers of Araucania, southern Chile. These lupins are commercialised as 'lupini beans' in several countries. They are considered the national snack of Italy and are also popular in Portugal, Spain, Greece, Turkey, Lebanon, Morocco, and Egypt, among other countries. Prices paid by importers from Mediterranean countries are extremely variable but always larger grains are better valued than smaller ones. High-quality grains are sold to consumers by volume, typically in glass jars, less often in cans, whereas lower-quality ones are sold usually by volume but occasionally by weight, in plastic bags. Since weight and volume gain by hydrated seeds may affect profitability, we planned preliminary experiments to determine the presence of genetic variation for these traits.

MATERIALS AND METHODS

Nine lupin lines, belonging to cultivated types Local (3), Italian (3), and Moroccan (3), were grown in three environments. Forty plants per line were randomly chosen at each environment. Twenty random single plants were threshed with a plot thresher with overshot spiked tooth cylinder/concave, and 20 by hand. Five replicates were used for analysis, each consisting of 100 seeds obtained by sampling five random seeds per plant. Soaking time was 16 h in distilled water. Weight gain was calculated by subtracting dry seed weight to imbibed weight and dividing by dry seed weight. This ratio was multiplied by 100 to express it as a percentage. Draining time of imbibed seeds was constant. In order to determine volume gain, the dry seeds (100) were placed in a graduated cylinder with 150 mL distilled water and water displacement was measured.

The process was repeated with the seeds imbibed for 16 h, after draining excess water with a colander. Volume gain was calculated by subtracting dry-seed water displacement to imbibed-seed water displacement and dividing by dry-seed water displacement. This ratio was multiplied by 100 to express it as a percentage. Each replicate was processed in one daily session to avoid variations in temperature, as water temperature is known to affect seed water uptake.

Analyses of variance and Tukey multiple range tests were performed with JMP v5 (SAS, Institute, Cary, NC). Variance components were estimated with the restricted maximum likelihood (REML) iterative method of SAS (SAS, Institute, Cary, NC). Broad sense

IN J.A. Palta and J.B. Berger (eds). 2008. 'Lupins for Health and Wealth' Proceedings of the 12th International Lupin Conference, 14-18 Sept. 2008, Fremantle, Western Australia. International Lupin Association, Canterbury, New Zealand. ISBN 0-86476-153-8.

Table 1. Mean seed weight, mean weight gain of hydrated grains, mean volume gain of hydrated grains for nine lines of bitter white lupin from three different origins.

Line	Mean seed weight (mg)	Tukey 0.05P	Mean weight gain (%)	Tukey 0.05P	Mean volume gain (%)	Tukey 0.05P
Italian 925	874.9	a	126.8	e	50.8	a
Italian 1158	854.0	b	125.3	f	49.1	bc
Italian 912	836.5	c	128.6	d	50.1	ab
Moroccan 1229	765.5	d	132.5	b	48.1	c
Moroccan 1230	732.8	e	128.9	d	44.9	d
Moroccan 1213	710.6	f	131.7	bc	44.8	d
Local 822	632.8	g	130.5	c	41.2	e
Local 752	623.7	g	128.2	d	40.0	f
Local 658	575.4	h	135.3	a	39.6	f
Coefficient of variation (%)	1.8		1.3		3.1	

heritability was calculated as the ratio of lines variance to the sum of the following inversely correlated (r = □0.42**) with dry seed variances: lines, lines × environment interaction, lines × threshing interaction, lines × environment × threshing interaction, and error (Fehr, 1987).

RESULTS AND DISCUSSION

The overall means for weight and volume gain were 130% and 45%, respectively. Compared to hand-threshing, mechanical threshing increased weight gain by 2.8%, due to the presence of micro fractures in the seed coat that became evident during imbibition, but had no significant effect on volume gain. Local and Moroccan lines gained 3% more weight than Italian lines. However, Italian lines gained 14% more volume than Moroccans and 24% more than Locals. Small though significant differences were found among lines, even within a type (Table 1). Means for seed weight, weight gain and volume gain are presented in Table 1. It was also found that temperature strongly enhances seed water uptake (data not shown), corroborating previous reports (Booth and Bai, 1999).

Volume gain was strongly linked (r = 0.86**) with dry seed weight. However, weight gain was inversely correlated (r = 0.42**) with dry seed weight. Thus, larger seeds increased their size proportionately more than smaller seeds (Fig. 1), even when larger seeds absorbed equal or even less amount of water than smaller seeds.

The lack of association between weight and volume gain is enigmatic. We presume that a soaking time of 16 h was insufficient for large seeds to reach their full water uptake potential, while it was for small seeds. Nevertheless, water uptake may have been enough for large seeds to modify the structure of the cotyledonary tissues, adopting new dimensions which resulted in an increased seed size. The examination of cotyledonary cells of two contrasting lines showed that the large-seeded line had cells larger than the small-seeded line (Fig. 2).

Variance component analysis (REML) pointed out significant genotypic effects, particularly for volume gain: Broad sense heritabilities were 0.36 and 0.80 for weight and volume gain, respectively (Table 2). The value for seed weight was 0.85, confirming that it is a highly heritable trait in white lupins, since a value of 0.83 was estimated in a previous work (Mera *et al*. 2006). Therefore, the results presented here indicate that volume gain by processed bitter lupins is a character which can be improved by breeding. Due to the strong link between volume gain and seed weight, selection for seed weight would indirectly increase volume gain capacity. Successful pure line selection for seed weight has already been practised within highly heterogeneous materials of bitter *L. albus* grown in Chile, accomplishing a 36% seed weight improvement in a few years (Mera and Miranda, 2004).

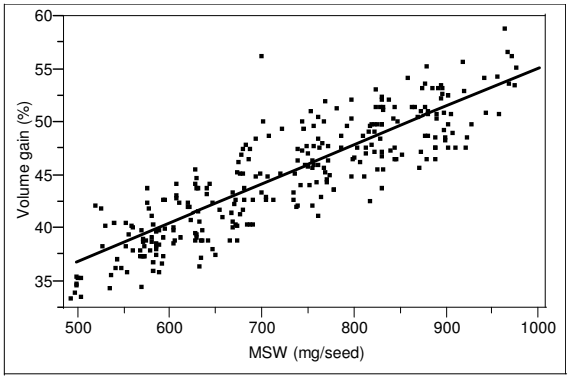

Fig. 1. Relationship between volume gain by hydrated seeds and mean dry seed weight of bitter white lupins (msw, mg/seed). Coefficient of determination, r^2 = 0.73**; n = 270.

ACKNOWLEDGEMENTS

Partial funding from INDAP and CONICYT Chile through FONDECYT Project 1070232.

LITERATURE CITED

Booth, D.T. and Y. Bai. 1999. Imbibition temperature affects on seedling vigour: In crops and shrubs. Journal of Range Management 52: 534-538.

Fehr, W. R. 1987. Principles of Cultivar Development, Vol. 1. Theory and Technique. Macmillan, New York.

Mera, M., L. Beltran, H. Miranda, and J.L. Rouanet. 2006. Strong heritability across years and sites for pod wall proportion and specific weight in *Lupinus albus* and genotypic correlation with other pod and seed attributes. Plant Breeding 125: 161-166.

Mera, M. and H. Miranda. 2004. Selection for seed weight within bitter landraces of *Lupinus albus*. 5th European Conference on Grain Legumes and 2nd International Conference on Legumes Genemics and Genetics. Dijon, France, 7-11 June 2004.

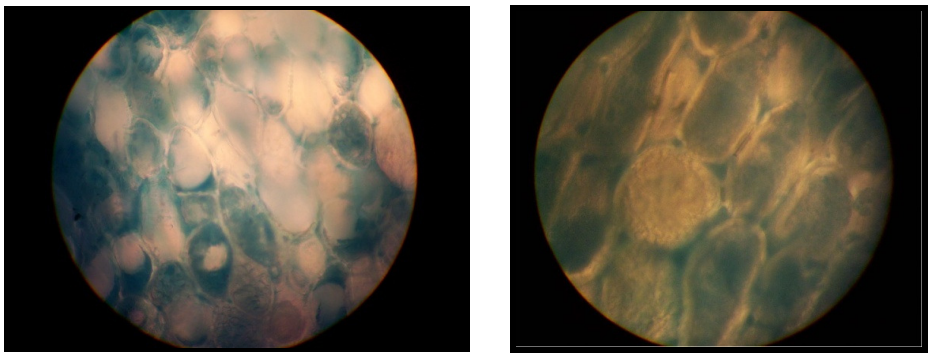

Figure 2. Difference in size of parenchymatous cotyledon cells of two lines of bitter white lupin with contrasting mean seed weight (MSW); 40x magnification. Left: Local 658, MSW = 575 mg; right: Italian 1158, MSW = 854 mg.

Table 2. Mean squares, variance components and broad sense heritability for dry seed weight, and weight and volume gain by hydrated seeds, obtained with nine bitter lupin lines evaluated at three environments, with two threshing methods.

Source	d.f.	Mean squares			Variance	REML estimates		
		Seed weight	Weight gain	Volume gain		Seed weight	Weight gain	Volume gain
Environment (E)	2	248939.2	1285.27	230.74				
Rep [E]	12	614.0	598.31	67.12				
Threshing (T)	1	56564.7	834.4	7.54				
T x E	2	32726.7	105.56	47.95				
T x Rep [E]	12	908.7	20.61	7.16				
Line (L)	8	352158.2	280.36	573.17	σ^2_L	11325.5	6.87	18.58
L x E	16	12392.3	60.88	15.66	σ^2_{LE}	627.1	3.04	0.22
L x T	8	5074.9	42.73	12.69	σ^2_{LT}	0.0	0.88	0.00
L x T x E	16	6644.4	30.69	13.84	σ^2_{LTE}	1188.5	5.54	2.29
Error	192	178.7	2.74	2.02	σ^2_e	178.7	2.74	2.03
H_{BS}						0.85	0.36	0.80