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Seed weight effect on germination properties and seedling growth of some cultivars of lupine

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Abstract. A laboratory experiment was carried out and repeated at field of College of Agricultural Engineering Sciences, University of Baghdad in 2017. First factor was three cultivars of lupine 'Giza-1', 'Giza-2' and 'Hamburg'. Second factor was three seed weights (lower weight, medium weight and higher weight) which was following the cultivars factor. Nested design was used. Results showed supremacy of 'Giza-1' cultivar significantly and gave higher germination ratio, radical length, seedling dry weight, seedling vigour index, field emergence ratio, plant height and number of leaves per plant. The treatment ('Giza-1'×higher seed weight) was supremacy significantly and gave higher germination ratio, radical length, plumule length, and seedling vigour index, while the treatment ('Giza-1'×lower seed weight) was supremacy significantly and gave higher seedling dry weight, field emergence ratio and number of leaves per plant. It can be concluded that the studied cultivars have potential energy related to the nature of their genotype, which makes them different in their behavior under laboratory and field conditions. The interaction between cultivar and seed weight has a role at the variance of this behavior under a wide range of environmental conditions. Therefore, it can be recommended to cultivate seeds with a lower weight of Giza-1.

Keywords: *Lupinus albus*, white lupine, seedling vigour, seed vitality, seed size, field emergence, leaves number

1. Introduction

Lupine seeds developed from many genotypes that have been studied and improved within various breeding programs since the beginning of the last century. Lupine seeds weights were varying among the varieties and also within the same species (Aniszewski et al., 2001). Lupine seeds are characterized by quadruple and compressed, and pod fruits contain 3-6 seeds (Erbas et al., 2005). Lupin are a source of protein in food and feed around different regions of the world, as well as plant adaptability to a wide range of environmental conditions (Faluyi et al., 2000 and Kohajdova et al., 2011). It is an economic crop of agricultural and industrial values (Sujak et al., 2006, Gulewicz et al., 2008, Zielinska et al., 2008 and Martinez-Villaluenga et al., 2009). According to FAO statistics in 2018, this crop has not been planted in Iraq for production since 1961, The total word production of this crop is 1,610,969 tons from total harvested area 930,717 hectares (FAO, 2018). The difference in



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the chemical content of the seeds between the different species is due to the difference in the weight of the seeds, crop, the environmental conditions, and the soil and crop maintenance. The weight of seeds is an important biological factor affecting on germination percent, germination rate and the growth of seedling even in the same variety. The difference in the seedling growth may be continue until maturity stage or this difference become insignificant over time due to the relative growth rate between seedlings of different seeds weights (Zhang and Maun, 1990). The proportion of germination between small and large seeds varies according to the varieties. In many cases, the germination rate and seedling of large seeds is higher than that of small seeds. On the other hand, small seeds germinate more rapidly than large seeds and thus have a competitive advantage (Hamza, 2006). Elshookie (1991) reported that the size of the seed in each cultivar had an effect on germination and emergence values. Generally small and medium seeds gave better germination rate due to mechanical damage during harvesting and cracking in the field. Large seeds, which make it easy to attacked by pathogens and easy damage which lead to loss or damage their nutritional content, stop embryo growth. Jaddoa et al. (2008) found that the size of the seed has a significant effect on the percentage of field emergence, but it is not sufficient unless the size of seeds is studied with soil temperature and its relation to the mechanical resistance of the seed during its emergence, as well as the enzymatic stress and soil moisture and the seeds treatment with chemicals and other treatments. Hamza et al. (2010) found that there is a significant relationship between seed vigour and genetic makeup. This was reflected in the length of the root and the plumule and the seedling dry weight in the standard germination test. with good relationship between seed vigour and its size, so the seeds size 0.4 mm showed the better vigour than smaller seeds. Al-Fahad and Al-Ubaidi (2017) advise to make a seed scaling and choose larger ones for sowing in the field or to improve seed germination of low-yielding varieties. In a comparative study of these three types of white Lupin, Hasan, et al. (2018) found that the interaction between cultivar and seed weight was significant, and the cultivars had a significant effect on stem anatomical traits. 'Hamburg' cultivar recorded the highest stem diameter, cortex thickness and xylem vascular diameter, while cultivar 'Giza-1' recorded the lowest values for the same traits as well as the highest collenchyma layer thickness, vascular bundle thickness, and xylem thickness. Cultivar 'Giza-2' recorded the lowest vascular bundle thickness and xylem thickness, so 'Hamburg' cultivar with lower seed weight was found best for field sowing to get higher yield with lower seed cost. Therefore, the process of sorting seeds and planting the homogeneous seeds may reduce the differences between the plants resulting from any weight of the seeds. This may be one of the factors that effect on increasing the productivity of the crop because the homogenization of seeds germination and seedling growth. Due to the economic importance of lupine crop as a high content of carbohydrates and protein up to 35% each, and its nutritional and medicinal values, in addition to the lack of research related to the weight of seeds and its relationship with cultivated varieties of this crop, it has applied this study to figure out the effect of seed weight (size) on germination characteristics and seedling growth of several varieties of white lupine.

2. Materials and methods

A laboratory experiment was carried out and repeated at field at laboratories and fields of College of Agricultural Engineering Sciences, University of Baghdad in 2017. First factor was three cultivars of lupine 'Giza-1', 'Giza-2' and 'Hamburg'. Second factor was three seed weights (lower weight, medium weight and higher weight) which was following the cultivars factor. Seed weight was calculated after manually sorted into three sizes (50 seed per size) (Table 1). Three cultivars of white lupine (*Lupinus albus* L.) were obtained from the Agricultural Research Center in Egypt. 'Hamburg' is an Australian sweet taste variety characterized by small vegetative growth and small seed size. 'Giza-1' is Egyptian cultivar having bitter taste, strong growth and large seed size. 'Giza-2' is another Egyptian cultivar having bitter taste, strong growth and early blooming as compare to 'Giza-1'. Seed dormancy was broken by germinator at 5°C for 7 days (ISTA, 2013) before sowing. Seed were sow in germinator according to the recommendation of International Seed Testing Association (ISTA, 2013).

Also, the seed were planted in the field in 1st of Nov.2017 at the terraces of 75 cm width, 40 cm between the plant and another. Soil and crop management were done as required until the completion of the required readings, which lasted only one month of cultivation. Studied traits were germination ratio (%), radical length (cm), plumule length (cm), seedling dry weight (mg) and seedling vigour index at the laboratory experiment according to the recommendation of International Seed Testing Association (ISTA, 2013) and Abdul-Baki and Anderson (1973), and field emergence ratio (%), plant height (cm), number of leaves per plant and leaf content of chlorophyll (SPAD) at the field experiment. Statistical analysis of data was done according to the nested design, because of seed weight factor was following the cultivars factor. Layouts of complete randomized design at the laboratory experiment and randomize complete block design at the field experiment were used with four replications. The means of treatments were compared with a test of least significant difference (LSD) at 5% probability (Steel and Torrie, 1981).

Table 1. Mean weight of 50 seed (g) of white lupine cultivars

Cultivars	Seed symbol	Weight of 50 seed (g)				Mean weight of 50 seed (g)	Standard Deviation
		Sample1	Sample 2	Sample 3	Sample 4		
Giza-1	Lower weight	11.12	11.25	11.20	10.90	11.12	±0.15
	Medium weight	14.95	14.33	14.73	14.46	14.62	±0.28
	Higher weight	22.76	22.25	22.24	22.63	22.47	±0.27
Giza-2	Lower weight	9.76	9.82	9.14	9.30	9.51	±0.34
	Medium weight	15.23	15.34	15.42	15.68	15.42	±0.19
	Higher weight	20.25	20.02	19.85	19.98	20.03	±0.17
Hamburg	Lower weight	9.70	10.08	9.36	9.98	9.78	±0.32
	Medium weight	13.60	13.21	13.70	13.09	13.40	±0.30
	Higher weight	15.57	15.40	15.55	15.32	15.46	±0.12

3. Results and discussion

The results of the analysis of variance showed a significant effect of the cultivar, as well as a significant effect of the interaction between the cultivar and the seed weight with all studied traits under laboratory or field conditions, except for the effect of the cultivar with the plumule length (Tables 2 and 3). The interaction effect between the cultivar and the seed weight was higher than the effect of cultivar with the studied traits under laboratory conditions (Table 2), while the result was adverse with the studied traits under field conditions (Table 3). This may mean that homogenous laboratory conditions have greatly reduced the intrinsic differences in performance between species. These differences have subsequently emerged clearly under field conditions, when there are different environmental stresses, which were not present under laboratory conditions. This enhances the role of genotype and seed weight in improving germination characteristics and seedling growth with side preponderance to the genotype, seed weight and seed vigour, which gives a clear indication of its germination ratio and vitality to reach a true estimate of high quality seeds under normal stress conditions in the field.

Table 2. Mean of squares (MS) according to analysis of variance (Nested design) for effect of cultivar and seed weight on traits studied in lupine under laboratory conditions.

Source of Variance	df	Germination ratio	Radicle length	Plumule length	Seedling dry weight	Seedling vigour index
Cultivars	2	116.408*	5.737*	0.1331	0.0163928*	236642*
Cultivars × Seed weight	6	249.918*	5.708*	2.7587*	0.0177746*	573444*
Error	27	2.912	1.57	0.6841	0.0003071	20982
SE		1.7	1.25	0.83	0.0175	144.85
CV		1.9	8.5	4.7	8.5	4.9

* Significant at P 0.05

Table 3. Mean of squares (MS) according to analysis of variance (Nested design) for effect of cultivar and seed weight on traits studied in lupine under field conditions.

Source of Variance	df	Field Emergence	Plant height	Leaves number per plant	Chlorophyll leaf content
Replications	3	5.232	1.8557	0.3819	0.233
Cultivars	2	515.253*	62.5301*	7.6687*	314.803*
Cultivars × Seed weight	6	619.777*	3.7979*	4.2874*	32.358*
Error	24	9.539	0.5602	0.3147	1.29
SE		3.09	0.75	0.56	1.14
CV	4	4	6.5	6.4	3.2

* Significant at P 0.05

3.1. Germination ratio (%)

The results in table 4 showed that there are significant differences between each cultivar. Giza-1 was superior and gave the highest average of germination ratio (94.5%). The treatment (Giza-1 × higher seed weight) was superior significantly compared to the other treatments and gave the highest average (97%), although it did not differ significantly with the treatments (Giza-2 × medium seed weight) and (Giza-2 × higher seed weight) (Table 4). The variance between species in germination may be due to self or natural genetics differences between the genotypes. These differences may reach a certain amount of seed for the same genotype. This is evidenced by the difference in the ratio of germination between the cultivars when evaluated according to the weight of the seed of the cultivar or between the cultivars, which gave dissimilar results, also may indicate the role of food storage and the proportions of its components available in the seed to provide the growth of the radicle and plumule with growth requirements before begin the seedling to relay on itself through photosynthesis.

Table 4. Effect of cultivar and seed weight on germination and its characteristics in lupine

Cultivars	Seed weight	Germination ratio	Radicle Length	Plumule length	Seedling dry weight	Seedling vigour index
Giza-1	Lower weight	94.7 ^b	14.7 ^{bc}	17.7 ^b	331 ^a	3063 ^b
	Medium weight	94.5 ^a	15.2 ^a	17.6 ^a	241 ^a	2861 ^b
	Higher weight	97 ^a	16.8 ^a	18.1 ^{ab}	172 ^d	3380 ^a
Giza-2	Lower weight	88.5 ^c	14.9 ^{ab}	17.7 ^a	270 ^b	2326 ^c
	Medium weight	96.3 ^a	16.4 ^{ab}	19.1 ^a	222 ^c	3413 ^a
	Higher weight	95.1 ^a	14.5 ^c	16.5 ^c	129 ^e	2956 ^b
Hamburg	Lower weight	90 ^b	14.1 ^c	17.4 ^{bc}	203 ^c	2856 ^b
	Medium weight	94.7 ^b	13.9 ^b	17.5 ^a	176 ^d	2832 ^b
	Higher weight	84.7 ^d	13 ^c	17.4 ^{bc}	123 ^e	2569 ^c

Means followed by the same letters didn't differ significantly at P 0.05

3.2. Radicle length (cm)

The results in table 4 showed that Giza-1 was superior to the other two cultivars and gave the highest average of radicle length (15.2 cm) with significant difference with Hamburg cultivar only, as it did not differ significantly with Giza-2. The treatment (Giza-1 × higher seed weight) was superior significantly on other treatment (Giza-2 × medium seed weight) (Table 4). This may be due to the different genotypes among them, as well as the difference in the ratio and content of seed components among them depending on their weight. This difference was reflected on the seed performance and the metabolism process inside it, which began with imbibition and ended up forming a normal seedling that has the ability to provide the growth requirements from the surrounding environment. Higher or medium seed weight was better than the lower seed weight because they contained higher amounts of food, chemical and etc. than lower seed weight (Table 4).

3.3. Plumule length (cm)

The results in table 4 showed no significant differences between the cultivars. The treatment (Giza-2 × medium seed weight) was significantly superior on other treatments and gave the highest average (19.1 cm), but did not differ significantly with the treatment (Giza-1 × higher seed weight) (Table 4). This may be due to the fact that higher or medium seed weight grow to superior normal seedling with performance due to the available of high food storage in the seed and its direct relationship to the speed and amount of metabolic processes that occur in the seed during the germination stage compared to lower seed weight, and that was supported by the results of germination ratio and radicle length (Table 4).

3.4. Seedling dry weight (mg)

The results in table 4 showed significant differences between each cultivar. Giza-1 was superior and gave the highest average of seedling dry weight (241 mg). The treatment (Giza-1 × lower seed weight) was significantly superior on other treatments and gave the highest average (331 mg) (Table 4). The superiority of Giza-1 at the seedling dry weight is due to its pre-superiority at the lengths of radicle and plumule on the other two cultivars (Table 4). The superiority of lower seed weight of Giza-1 at this trait in contrast to the results in table 2 of the radicle and plumule lengths of the same treatment, may be due to that the length of radicle or plumule or both may not reflect decisively the seedling dry weight, may be to associate this trait too with the thickness and number of radicle branches, which may increase the seedling dry weight regardless of radicle length.

3.5. Seedling vigour index

The results in table 4 showed that Giza-1 was superior to the other two cultivars and gave the highest average of seedling vigour index (3101). The treatment (Giza-2 × medium seed weight) significantly exceeded the rest of the treatments and gave the highest average (3413), note that it did not differ significantly with the treatment (Giza-1 × higher seed weight) (Table 4). This is due to the pre-superiority of the Giza-1 or the treatment of the interaction between it and seed weight at the traits of germination ratio and lengths of radicle and plumule (Table 4).

3.6. Field emergence ratio (%)

The results in table 5 showed significant differences between each cultivar. Giza-1 was superior to the other two cultivars and gave the highest average of field emergence ratio (84.4%). The treatment (Giza-1 × lower seed weight) was significantly superior on other treatments and gave the highest average (91.5%) and did not differ significantly with the treatment (Giza-1 × medium seed weight) (Table 5). The results of field emergence confirm the laboratory results of the superiority of Giza-1 on the other two cultivars (Tables 4 and 5). The performance of this cultivar differed when its superiority was associated with lower seed weight under field conditions, as opposed to its associated with the higher seed weight under laboratory conditions. This may be due to the fact that the large size of the seed caused by the weight increase is a physical obstacle to cracking the seed coat and the emergence of the radical and the plumule, or may be the lower seed weight characterized with seed vigour and embryo vitality and high tolerance to field stress, or perhaps increasing the seed surface area of higher seed weight compared to lower seed weight makes them more susceptible to bacterial attacks and microorganisms and other adverse conditions, which reduces their ability to emerge compared to the lower seed weight.

Table 5. Effect of cultivar and seed weight on field emergence and some growth traits in lupine

Cultivars	Seed weight	Field emergence	Plant height	Leaves number per plant	Chlorophyll leaf content
Giza-1	Lower weight	91.5 ^a	13.6 ^{ab}	10.4 ^a	39.2 ^b
	Medium weight	84.4 ^a	13.4 ^a	9.6 ^a	38 ^b
	Higher weight	70.7 ^d	12.8 ^{bc}	8.5 ^{bc}	34.5 ^d
Giza-2	Lower weight	70.4 ^d	13 ^{ab}	9.8 ^a	41.3 ^a
	Medium weight	76.1 ^b	12 ^b	8.4 ^b	39 ^a
	Higher weight	88.9 ^a	11.8 ^{cd}	7.1 ^d	37 ^c
Hamburg	Lower weight	83 ^b	7.5 ^f	7.8 ^{cd}	30.1 ^e
	Medium weight	71.5 ^c	9 ^c	8.1 ^b	30.1 ^c
	Higher weight	55.7 ^e	9.8 ^e	7.8 ^{cd}	33.1 ^d

Means followed by the same letters didn't differ significantly at P 0.05

3.7. Plant height (cm)

The results in table 5 showed that there are significant differences between each cultivar. Giza-1 was superior to the other two cultivars and gave the highest average of plant height (13.4 cm). The treatment (Giza-1 × medium seed weight) significantly exceeded the rest of the treatments and did not differ significantly with the treatments (Giza-1 × lower seed weight) and (Giza-2 × lower seed weight) (Table 5). This may be due to the pre-superiority of this treatment at the field emergence ratio (Table 5), which reflects the seed vigour and good performance of the seedling resulting from the weight of the lower seed of Giza-1 under field conditions.

3.8. Leaves number per plant

The results in table 5 showed that Giza-1 was superior to the other two cultivars and gave the highest average number of leaves per plant (9.6). The treatment (Giza-1 × lower seed weight) significantly exceeded the rest of the treatments and gave the highest average of leaves number per plant (10.4), and did not differ significantly with the treatments (Giza-1 × medium seed weight) and (Giza-2 × lower seed weight) (Table 5). This may be due to the pre-superiority of this treatment at the field emergence ratio and plant height (Table 5), which later led to the formation more leaves number compared to the rest of the other treatments under field conditions.

3.9. Chlorophyll leaf content (SPAD)

The results in table 1 showed that there are significant differences between each cultivar. Giza-2 was superior to the other two cultivars and gave the highest average of chlorophyll leaf content (39 SPAD). The treatment (Giza-2 × medium seed weight) was significantly higher than the rest of the treatments. The highest average of chlorophyll leaf content was 41.3 SPAD, and did not differ significantly with the two treatments (Giza-2 × lower seed weight) and (Giza-1 × medium seed weight) (Table 5). Although reading the chlorophyll leaf content reflects the health and nutritional status of the plant, but the high value of this reading does not mean that lower reading to a certain extent does not represent the ideal state of the chlorophyll leaf content to supply the other parts of the plant with products of photosynthesis process, and the evidence of that is the superiority of the treatment of (Giza-1 × lower seed weight) at the previous traits compared to the superiority of treatment (Giza-2 × medium seed weight) at the chlorophyll leaf content.

4. Conclusion

It can be concluded that the studied cultivars have potential energy related to the nature of their genotype and their seed vigour, which makes them different in their behavior under laboratory

and field stress conditions. The interaction between cultivar and seed weight has a role at the variance of this behavior under a wide range of environmental conditions. Therefore, it can be recommended to cultivate seeds with a lower weight of Giza-1, which lead to reduce seed amount that should use per cultivated area, which already lead to reduce economical cost to crop planting,

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