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# SCREENING OF WHITE LUPIN ACCESSIONS FOR MORPHOLOGICAL AND YIELD TRAITS

S. RAZA and B. JØRNSGÅRD
The Royal Veterinary and Agricultural University, Department of Agricultural Sciences, Hoejbakkegaard Alle 5, DK-2630 Taastrup, Denmark

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## ABSTRACT

Evaluation studies for landraces of white lupin (*Lupinus albus),* collected in Egypt, were carried out in field experiments during 1998/99 at Ismailia and 1997/98 and 1998/99 at New Valley along with locally developed cultivars Giza 1 and Giza 2, and exotic germplasm for seed yield and major morphological characteristics. These two locations represent different soil types and climatic conditions in Egypt. The cultivars showed low differences of growth and development, and also a variation in days to maturity, plant height and number of branches per plant. There were significant differences between cultivars in yield components in both locations. The results further suggest that the local landrace germplasm may be an important source of alleles for shortening the vegetative period, reducing plant height, as well as for improving some yield components. These germplasm lines will be useful as genetic stocks for exploitation in a breeding programme.

*Key Words*: Egypt, *Lupinus albus*

## RÉSUMÉ

Les études d'évaluation des races de terre du lupin blanc *(Lupinus albus)*, collecté en Egypte, étaient menées dans des champs expérimentaux durant 1998/99 à Ismailia et 1998/99 le long de New Valley avec des variétés localement développées Giza 1 et Giza 2, et de germplasme exotique pour le rendement de graine et des caractéristiques morphologiques majeures. Ces deux locations représentent différents types de sols et conditions climatiques en Egypte. Les variétés ont montré des faibles différences de croissance et de développement, et une variation en jours de maturité, hauteur de plante et nombre des branches par plante. Il y avait des différences significatives entre les variétés en composantes du rendement dans les deux locations. Les résultats en plus suggèrent que le germplasme de la race locale peut être une importante source des allèles pour écourter la période végétative, réduire la hauteur de plante, ainsi que améliorer certaines composantes de rendement. Ces lignes de germplasme seraient utiles comme réserves génétiques pour l'exploitation dans un programme de reproduction.

*Mots Clés*: Egypte, *Lupinus albus*

## INTRODUCTION

Lupin (*Lupinus albus*) is cultivated in a wide range of environments across Egypt. It is suitable for both rich clay soil as well as the newly reclaimed lands. These soils are characterised by high calcium and high salt levels (El-Attar *et al.*, 1987; Anonymous, 1993). Its seeds have a nutritional quality similar to soybean seed and superior to other legume seed (Robert, 1999), and could be an important source of protein and oil. In fact, lupin seeds have been used for human consumption and as a medicinal plant in Egypt (Kattab, 1986; ARC, 1994) and other countries for thousands of years.

In order to rescue lupin genetic resources, collection of landraces was carried out in Egypt (Raza *et al.*, 1999). Their utilisation and exploitation as a grain crop have been constrained by several factors, including low yield, late maturity and susceptibility to fusarium wilt which cause heavy losses in seed yield (Osman *et al.*,1986; Fahim *et al.*,1986).

The importance of collection and evaluation of wild and landraces of lupin was recognised by early breeders in Germany, Poland and Holland. Identification of phenotypes that are adapted to local climatic conditions and soil types may provide large improvements in grain yield (Raza *et al.*, 1997).

Presently, Egyptian lupin cultivation is characterized by old landraces, relatively low yielding, with medium to high alkaloid content (Hamman *et al.*, 1987). Introduction of modern varieties has not been attempted, but, if done it should be accompanied by the simultaneous conservation of existing genetic variability. The crop is gradually out competed by improved cereal cultivars and other more developed crops. Nonetheless, white lupin landraces are grown all over the country in relatively small plots with total area of approximately 3,500 ha with an average of yield 1.5 t $ha^{-1}$ (Anonymous, 1993).

The objectives of this study were to (i) evaluate the collected white lupin landraces for yield potential and morphological characteristics, (ii) identify high yielding white lupin cultivars for specific locations (iii) identify promising germplasm for development of new cultivars for the reclaimed areas.

## MATERIAL AND METHODS

The present study was conducted at the Ismailia and New Valley Research Stations during the seasons of 1997/98 and 1998/99. The latitude and longitude at the study sites were (30.37.16 N & 32.15.58 E) and (24.27.28 N & 31.46.50 E) respectively. The main climatic and soil characteristics of the experimental sites are given in Table 1.

Twenty one landraces (including 8 common landraces in both locations) and 1 modern variety (Dijon-2) from France were evaluated and compared with two check cultivars, Giza 1 and Giza 2 (improved cultivars by the Agricultural Research Center of Egypt about 30 years ago (ARC 1994).

The experiments were sown on 6 November 1998 at Ismailia, 2 November 1997 and 4 November 1998 at New Valley. At Ismailia each experimental plot consisted of 4 rows of 3 m with a row spacing of 0.6 m; and at New Valley the plot consisted of 3 rows of 3 m with a row spacing of 0.6 m. Seeds were sown in hills 15 cm apart with 2 seeds per hill.

The experiments were planted in a randomised complete block design with three replicates. Fertilisers were added to all experimental plots at the rate of 30 kg of N (as urea 46%N), 60 kg of P and 40 kg of K $ha^{-1}$. The experiments were irrigated seven times (at 20-22 days interval).

Days to flowering were recorded when 50% of the plants were blooming. The plots were harvested at full maturity of pots on 10 May at Ismailia 1998, and on 28 April 1988 and 22 April 1999 at New Valley. At harvest, five random plants in a plot were used for recording days to maturity

TABLE 1. Climatic and soil characteristics at the study sites in Egypt

| Location | Climatic characteristics | | | Soil characteristics | | | | |
|---|---|---|---|---|---|---|---|---|
| | Rainfall (mm) | Temperature (C°) | Sunshine (%) | Clay (%) | pH | CaCO3 (%) | O.M (%) | E.C. |
| Ismailia | 38 | 20.7 | 77 | 7.8 | 7.8 | 7.2 | 0.02 | 1.4 |
| New Valley | 2 | 25.3 | 87 | 7.2 | 7.9 | 6.5 | 0.20 | 3.95 |

Rainfall (average yearly precipitation). Temp. (daily mean temperature C°). Sunshine (hours in pct. of potential); O.M. (organic matter); PH (1:2.5, soil: water); E.C. (electric conductivity); CaCO3 (calcium content) (date of sowing until maturity of pods), plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, seed yield per plant, seed yield weight per plot and seed index (weight of 100 seeds (s.w)), were determined. The data were analysed for each location and combined over locations with the PROC GLM procedure (SAS Institute, 1997).

## RESULTS

At the Ismailia location, the means for number of days to maturity, plant height, number of branches, pods per plant, seeds per plant and seed yield per plot revealed significant ($P<0.05$) differences between the cultivars (Table 2). There were significant ($P<0.05$) differences in seed yield per plot between the cultivars, for example accession 79 and 53 produced more yield compared with Giza 1 and Giza 2. The average yield in this location for these accessions were 1305 and 1245 g plot$^{-1}$, respectively, compared to Giza 1 and Giza 2 which yielded 1057 and 1018 g plot$^{-1}$, also accession 53 matured by 9 and 8 days earlier, respectively, than both Giza 1 and Giza 2 (Table 2). The yield components except seed index (weight of 100 seeds g$^{-1}$), showed significant differences between cultivars . The differences were in seeds per pod, seed yield per plant as well as seed yield per plot. Accession 79 produced significantly ($P<0.05$) more pods, seed yield per plant and seed yield per plot compared to Giza 1, which produced 21 pods and 26 g seed/plant while accession 53 followed the same tendency except seeds per pod. However, only a few landraces outyielded the local checks at Ismailia, a traditional location for lupin cultivation.

At New Valley, a new location for lupin cultivation in Egypt, the calculated means for

TABLE 2. Mean values for agronomic characteristics of the 24 selected white lupin cultivars at Ismailia (1999) (Average of random sample of 5 plants/plot)

| Cultivars | DF | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|---|
| Acc.5* | 79 | 161 | 98 | 4.1 | 26 | 3.7 | 24 | 747 | 26.6 |
| Acc.8* | 80 | 166 | 97 | 4.0 | 25 | 3.5 | 22 | 693 | 26.6 |
| Acc.18* | 77 | 172 | 97 | 3.9 | 31 | 3.7 | 27 | 862 | 24.6 |
| Acc.19* | 77 | 175 | 94 | 3.7 | 28 | 3.4 | 22 | 652 | 26.6 |
| Acc.20* | 77 | 167 | 97 | 3.8 | 21 | 3.2 | 22 | 742 | 30.0 |
| Acc.25* | 80 | 161 | 99 | 3.9 | 33 | 3.7 | 30 | 733 | 26.0 |
| Acc.26* | 78 | 162 | 98 | 4 | 25 | 3.5 | 25 | 785 | 26.6 |
| Acc.28* | 81 | 176 | 103 | 4.6 | 29 | 3.1 | 26 | 977 | 29.6 |
| Acc.33* | 80 | 171 | 98 | 4.6 | 30 | 3.1 | 26 | 827 | 26.0 |
| Acc.35* | 81 | 160 | 92 | 3.9 | 29 | 3 | 23 | 731 | 26.6 |
| Acc.79* | 75 | 171 | 115 | 4.6 | 34 | 3.7 | 35 | 1305 | 27.7 |
| Acc.41* | 75 | 151 | 83 | 3.7 | 28 | 3.3 | 22 | 595 | 29.3 |
| Acc.43* | 77 | 150 | 77 | 3.3 | 20 | 2.9 | 15 | 476 | 31.3 |
| Acc.53* | 77 | 162 | 111 | 3.9 | 32 | 3.5 | 37 | 1245 | 30.3 |
| Acc.54* | 75 | 163 | 98 | 3.8 | 30 | 3.1 | 27 | 965 | 30.6 |
| Acc.57* | 80 | 165 | 84 | 3.6 | 20 | 3.7 | 24 | 930 | 31.0 |
| Acc.60* | 75 | 167 | 99 | 4.2 | 34 | 3.4 | 28 | 927 | 24.0 |
| Acc.72* | 75 | 170 | 93 | 3.5 | 22 | 3.8 | 28 | 1040 | 31.0 |
| Acc.89* | 78 | 171 | 90 | 3.5 | 30 | 3.4 | 28 | 933 | 27.3 |
| Acc.94* | 78 | 170 | 88 | 3.9 | 27 | 3.4 | 29 | 1023 | 30.3 |
| Acc.98* | 81 | 170 | 92 | 4.2 | 32 | 3.1 | 24 | 794 | 25.6 |
| Dijon-2 | 75 | 172 | 105 | 4.4 | 32 | 3.7 | 37 | 1209 | 31.0 |
| Giza 1 | 75 | 171 | 94 | 4.1 | 21 | 3.8 | 26 | 1057 | 29.7 |
| Giza 2 | 76 | 170 | 99 | 3.7 | 22 | 3.6 | 26 | 1018 | 30.3 |
| LSD(0.05) | 5.1 | 3.9 | 15.7 | 0.7 | 11.6 | 0.5 | 9.2 | 359 | 4.5 |

* Collection number in the Egyptian gene bank

DF = days to flowering, DM = days to maturity, PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = 100 seed weight (g)

*Thick solid is for the promising accession compare to Giza 1 and Giza 2* agronomic characteristic for two seasons are presented in Table 3. The cultivars differed significantly (P<0.05) in days to maturity, plant height, number of branches. The promising accessions, 64, 87, 51 and 53, yielded > 1800 g plant$^{-1}$ compared to about 1400 g plant$^{-1}$ in Giza 1 and Giza 2. More landraces outyielded the local checks at New Valley than at Ismaaila. The effect of cultivar was significant (P<0.05) for yield component. The effect of year was not significant (P>0.05) for days to maturity, plant height, number of branches, pods per plant, seeds per plant, as well as seed yield per plot (Table 4).

The modern variety (Dijon-2) was well adapted to both of the two locations, as shown by their higher yields, than the local checks (Tables 2 and 3). The genotype-by-location interaction was also significant for some characteristics, indicating that some genotypes were better fit to a specific location than others. Differences in crop development and yield level in the two sites could be related to different soils, (Table 5). It was easy to identify better landraces compared to the locai check for earliness, short plant height and stem length, as well as for yield components, such as number of pods and seeds per plant.

## DISCUSSION

From the results, it is clear that the local landrace may be an important source of alleles for shortening the vegetative period in local cultivars, for reducing plant height and stem length, and for improving some yield components, such as number of pods and seeds per plant. It also has a potential for enhancing crop production in new locations of lupin cultivation such as New Valley. The outstanding performance of the local checks, Giza 1 and Gaza 2, supports the utilisation of local germplasm for further betterment of locally

TABLE 3. Mean values for agronomic characteristics of the 24 selected white lupin cultivars at New Valley (1998 and 1999). (Average of random sample of 5 plants/plot)

| Cultivars | DF | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|---|
| Acc.22* | 76.1 | 156.3 | 97.5 | 7.7 | 22.4 | 4.05 | 32.8 | 1700 | 35.7 |
| Acc.32* | 74.1 | 159.3 | 100.0 | 10.4 | 25.3 | 3.66 | 36.6 | 1350 | 39.0 |
| Acc.52* | 72.6 | 158.6 | 106.6 | 7.3 | 20.4 | 3.85 | 28.2 | 1001 | 35.3 |
| Acc.53* | 75.5 | 156.3 | 100.8 | 10.7 | 27.8 | 3.65 | 42.0 | 1816 | 45.0 |
| Acc.77* | 70.5 | 156.1 | 101.6 | 7.2 | 21.3 | 4.13 | 36.8 | 1633 | 41.3 |
| Acc.54* | 71.5 | 157.0 | 107.5 | 8.5 | 23.1 | 3.58 | 34.6 | 1608 | 41.7 |
| Acc.33* | 77.6 | 159.0 | 103.3 | 8.5 | 25.8 | 3.86 | 33.5 | 1658 | 34.0 |
| Acc.98* | 76.6 | 155.5 | 100.8 | 5.8 | 17.5 | 3.83 | 25.6 | 1458 | 37.7 |
| Acc.62* | 63.6 | 154.0 | 95.8 | 7.0 | 22.1 | 4.15 | 26.8 | 1300 | 33.7 |
| Acc.60* | 73.1 | 157.6 | 85.0 | 5.6 | 18.2 | 3.51 | 24.3 | 1508 | 39.7 |
| Acc.87* | 69.0 | 155.3 | 110.0 | 8.6 | 25.9 | 3.75 | 39.0 | 2066 | 37.3 |
| Acc.82* | 72.1 | 153.8 | 89.1 | 6.5 | 16.0 | 3.71 | 18.6 | 1316 | 30.7 |
| Acc.72* | 67.8 | 152.6 | 84.1 | 6.4 | 17.6 | 3.63 | 26.4 | 1183 | 38.7 |
| Acc.94* | 71.6 | 153.1 | 90.8 | 6.5 | 17.6 | 3.63 | 26.0 | 1641 | 40.3 |
| Acc.93* | 78.5 | 153.6 | 80.8 | 7.6 | 19.3 | 3.06 | 19.8 | 1141 | 33.0 |
| Acc.78* | 66.1 | 154.3 | 98.3 | 9.2 | 29.0 | 3.33 | 32.4 | 1700 | 32.3 |
| Acc.57* | 76.6 | 155.1 | 80.8 | 8.0 | 23.7 | 3.78 | 32.0 | 1416 | 36.0 |
| Acc.74* | 72.6 | 155.5 | 86.6 | 9.1 | 24.7 | 3.86 | 32.5 | 1316 | 31.7 |
| Acc.64* | 69.0 | 155.6 | 104.1 | 7.3 | 21.8 | 3.96 | 33.2 | 2375 | 38.7 |
| Acc.51* | 73.0 | 157.6 | 93.3 | 7.8 | 24.3 | 3.85 | 31.6 | 1925 | 33.0 |
| Acc.79* | 77.1 | 157.5 | 93.3 | 8.4 | 26.7 | 4.08 | 40.4 | 1466 | 38.7 |
| Dijon-2 | 78.0 | 157.3 | 92.5 | 6.6 | 14.5 | 3.63 | 26.8 | 1116 | 44.7 |
| Giza 1 | 75.3 | 156.3 | 95.8 | 8.0 | 21.6 | 3.50 | 27.9 | 1425 | 36.3 |
| Giza 2 | 74.3 | 154.6 | 98.3 | 8.0 | 18.4 | 4.38 | 34.1 | 1425 | 43.3 |
| LSD(0.05) | 1.3 | 3.1 | 17.0 | 2.1 | 6.5 | 0.42 | 9.5 | 459 | 6.43 |

* Collection number in the Egyptian gene bank

DF = days to flowering, DM = days to maturity PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = 100 seed weight (g)

*Thick solid is for the promising accession compare to Giza 1 and Giza 2*

TABLE 4. Mean squares of the analysis of variance across two locations for agronomic characteristics of the 24 selected white lupin cultivars at Ismailia and New Valley. (A total of 21 landraces (including 8 common landraces in both locations) and 1 modern variety (Dijon-2) with two check cultivars, Giza 1 and Giza 2)

| Source | d.f. | DF | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|---|---|
| Rep. | 2 | 3.8 n.s | 21.87 n.s | 2740*** | 17.45* | 58.68 n.s | 0.18* | 186.82* | 197704*** | 4.048n.s |
| Loc. | 1 | 969*** | 5187.5*** | 2.22 n.s | 717*** | 1531*** | 5.88*** | 1033.2*** | 1949220*** | 2979.3*** |
| Year. | 1 | 19.5* | 0.006 n.s | 14.06 n.s | 1.06n.s | 1.01 n.s | 0.006 n.s | 54.45** | 85556* | |
| Acc. | 36 | 62*** | 91.2*** | 348.4** | 5.31** | 73.84** | 0.366*** | 165.2*** | 421201*** | 36.56*** |
| Loc.*Acc. | 10 | 19.9*** | 27.65*** | 178.9 n.s | 4.6 n.s | 89.13* | 0.27** | 67.75** | 145711** | 18.30n.s |
| Acc.*Year | 23 | 0.62 n.s | 5.006 n.s | 17.68 n.s | 0.44 n.s | 6.94 n.s | 0.009 n.s | 25.11 n.s | 18722 n.s | |
| Mean | | 74.54 | 159.4 | 95.8 | 6.53 | 23.8 | 3.654 | 29.41 | 1310.5 | 32.85 |
| C.V. % | | 2.76 | 1.67 | 15.2 | 24.3 | 26.4 | 9.62 | 25.93 | 27.82 | 10.27 |
| Error | 142 | 4.2 | 7.16 | 213.7 | 2.52 | 39.50 | 0.12 | 58.19 | 133019 | 11.39 |

DF = days to flowering, DM = days to maturity, PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = 100 seed weight (g); n.s. **, and *** indicate non-significant, and significant at 1% or 0.1%, respectively

adapted lupin in Egypt. Both cultivars were bred based on the basis of mass selection within landrace germplasm. Correlations between yield components, such as pod number, seeds per pod and seed size are important to stabilise the yield in lupin. Pod and seed losses affecting seed yield may be overcome by increased seed size in this crop (Herbert and Hill, 1978; Christiansen *et al.*, 1997).

A positive and highly significant correlation (P<0.001) between the characters studied was found at Ismailia and New Valley (Tables 6 and 7). There was also a positive and highly significant correlation between seed yield and number of pods per plant for all the cultivars. But it is known that the number of pots per plant is affected by environmental factors. However, the final seed yield correlated with low $R^2$ values to plant characteristics. The wide variation in yield components of germplasm collection may allow the development of superior genotypes. Perhaps, early flowering, short, branched plant, with several pods bearing many heavy seeds may be considered for ideotype breeding in Egypt. However, further phenotypic and genetic correlations among morphological characteristics, yield components and yield should determine whether such a plant might be developed in this germplasm for lupin improvement in Egypt. Further breeding of lupin in Egypt should focus on its adaptation to stressful environments and low input cultivation as those observed in reclaimed dessert areas. Cascarilla (1997) found that genetic gain for yield under low input cultivation was possible working with adapted barley landraces.

Selection of genotypes under low input cultivation could be important to achieve success in breeding programmes dealing with strong genotype-by-environment interactions (Cascarilla, 1996; Christiansen *et al.*, 2000). The relatively high yield of landraces and the significant genotype-by-location interaction observed in our experiments suggest that a similar strategy could be used to develop lupin germplasm adapted to low input growing environments in Egypt. Yield gains in some crops have been achieved through manipulation of the harvest index (Wallace *et al.*, 1993). We did not calculate this index because no total biomass weight was recorded in our experiment. This characteristic should be assessed

TABLE 5. Mean values for agronomic characteristics over locations of the selected white lupin cultivars

| Location | DF | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|---|
| Ismailia | 77.54 | 166.34 | 95.94 | 7.82 | 27.56 | 3.77 | 30.95 | 885 | 28.30 |
| New Valley | 73.04 | 155.95 | 95.72 | 3.95 | 21.92 | 3.42 | 26.31 | 1522 | 37.40 |
| LSD (0.05) | 0.589 | 0.763 | 4.171 | 0.45 | 1.79 | 0.10 | 2.17 | 104 | 1.11 |

DF = days to flowering, DM = days to maturity, PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = 100 seed weight (g)

TABLE 6. Correlation coefficients between the characters studied of the cultivars at Ismailia

| Characters | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|
| DF | 0.06888 | -0.05924 | 0.11503 | 0.04474 | -0.07222 | -0.05565 | -0.28624*** | -0.20230 |
| DM | | 0.32383** | 0.37653*** | 0.18389 | 0.26855* | 0.36677*** | 0.38284** | -0.07579 |
| PH | | | 0.57716*** | 0.61214*** | 0.15838 | 0.66414*** | 0.52793*** | -0.21307 |
| NB | | | | 0.59657*** | 0.01902 | 0.47370*** | 0.29303** | -0.27841** |
| PP | | | | | -0.13387 | 0.65200*** | 0.24251* | -0.51237*** |
| SP | | | | | | 0.39224*** | 0.37681*** | -0.01174 |
| YP | | | | | | | 0.59718*** | -0.06862 |
| Y/P | | | | | | | | 0.06968 |

DF = days to flowering, DM = days to maturity, PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = Seed Weight
Coefficient values marked with *, **, *** are significant at 0.05, 0.01 and 0.001 probability

TABLE 7. Correlation coefficients between the characters studied of the cultivars at New Valley

| Characters | DM | PH | NB | PP | SP | YP | Y/P | SW |
|---|---|---|---|---|---|---|---|---|
| DF | 0.22346** | -0.08902 | 0.00099 | -0.14987 | -0.10749 | -0.10918 | -0.15098 | 0.11470 |
| DM | | 0.37021*** | 0.41024*** | 0.26524* | 0.05826 | 0.30926** | 0.17140 | 0.18283 |
| PH | | | 0.44807*** | 0.53392*** | 0.12461 | 0.51781*** | 0.77423*** | 0.09648 |
| NB | | | | 0.82022*** | 0.13077 | 0.80556*** | 0.32307** | 0.14341 |
| PP | | | | | 0.12999 | 0.88200*** | 0.47978*** | -0.06686 |
| SP | | | | | | 0.40339** | -0.01973 | 0.13004 |
| YP | | | | | | | 0.45290*** | 0.27323* |
| Y/P | | | | | | | | 0.06149 |

DF = days to flowering, DM = days to maturity, PH = plant height (cm), NB = number of branches, PP = pods per plant, SP = seeds per pod, YP = yield (g) per plant, Y/P = yield (g) per plot, SW = Seed Weight
Coefficient values marked with *, **, *** are significant at 0.05, 0.01 and 0.001 probability

in new experiments to determine the harvest index and the potential for yield improvement of white lupin in Egypt. Furthermore, correlations between seed yield, total biomass and earliness should be considered when developing new cultivars (Wallace *et al.*, 1993).

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## REFERENCES

Anonymous, 1993. Statistical pocket book of Egypt. Cairo.

ARC, 1994. Agricultural Research Centre, Min. Agriculture of Egypt. *Bulletin* 226:1-8.

Cascarilla, S. 1996. Positive interpretation of genotype by environment interactions in relation to sustainability and biodiversity. In: *Plant Adaptation and Crop Improvement.* Cooper, M. and Hammer, G.L. (Eds.), pp. 467-486. Oxon, UK: CAB International.

Cascarilla, S. 1997. Adaptation to low/high input cultivation. In: *Adaptation in plant breeding.* Tigerstedt, P.M.A. (Ed.), pp. 225-236. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Christiansen, J. L., Jørnsgård, B., Buskov, S. and Olsen, C. E. 1997. Effect of drought stress on content and composition of seed alkaloids in narrow-leafed lupin, *Lupinus angustifolius* L. *European Journal of Agronomy* 7:307-314.

Christiansen, J.L., Raza, S. and Ortiz, R. 2000. Potential of landrace germplasm for genetic enhancement of white lupin in Egypt. *Genetic Resources and Crop Evolution* 47:425-430.

Hamman, A.M., Hammadi, K.A., El-Hashimy, F. S.A. and El-Mohandes, A.A. 1987. Biochemical studies on Egyptian lupin seeds "*Lupinus termis* L." Chemical analysis and elimination of bitter taste. *Acta Agronomica Hungarica.* pp. 337-344.

El-Attar, H., Abd El-Rahman, S., Kasem, Y. and Morgan, F. 1987. The spotted crop pattern of soil Al-Nahda project. *Egyptian Journal of Soil Science* 27:397-408.

Fahim, M. M., Sahab, A. F., Osman, A. R. and El-Kader, M. M. A. 1986. Agricultural practices and fungicide treatments for control of fusarium wilt of lupin. *Egyptian Journal of Phytopathology* 15:1-2, 35-46.

Herbert, S.J. and Hill, G.D. 1978. Plant density and irrigation studies on lupin. 1. Growth analysis of *Lupinus angustifolius* cv. "WAU11B". *New Zealand Journal of Agricultural Research* 21:467-474.

Kattab, H. A. 1986. Plant wealth in ancient Egypt. Min. Agriculture of Egypt. (In Arabic).

Osman, A., Fahim, M.R., Sahab, A.M. and El-Kader, M. A. 1986. Losses due to wilt of lupin. *Egyptian Journal of Phytopathology* 15:1-2, 27-34.

Raza, S., El-Gamil, K., Ali, K., Christiansen, J. L. and Jørnsgård, B. 1999. Collection of landraces of *Lupinus albus* in Egypt. In: *Proceedings of the 8th International Lupin Conference.* California, USA.

Raza, S., El-Hamid, M.W., Kaoud, E.E., Christiansen, J.L. and Jørnsgård, B. 1997. Growth of Polish, French and local lupin species under different conditions of Egyptian soils and P-fertilization. Mansoura University. *Journal of Agricultural Science* 22:4697-4704.

Robert, J. van Barneveld. 1999. Understanding the nutritional chemistry of lupin (*Lupinus* spp.) seed to improve livestock production efficiency.. *Nutrition Research Reviews* 12:203-230.

SAS Institute, 1997. SAS/STAT Software: Changes and Enhancements through Release 6.12. edition. Cary, NC, USA.

Wallace, D.H., Baudoin, J. P., Beaver, J., Coyne, D. P., Halseth, D.E., Masaya, P. N., Munger, H.M., Meyers, J.R., Silbernagel, M., Yourstone, K.S. and Zobel, R.W. 1993. Improving efficiency of breeding for higher crop yield. *Theoretical and Applied Genetics* 86:27-40.