BREEDING NEW WHITE LUPIN FOR EGYPT

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ABSTRACT

Modern high yielding varieties has not been developed in Egypt and high yielding varieties from Europe can not be grown successfully due to environmental differences. Egyptian farmers have been growing landraces of white lupins since the pharaoh's era. Due to farmed saved seeds large diversity and local adaptation has been developed during thousands of years, however, the landraces are generally characterised by being vegetative tall low yielding plants with bitter seeds. High yielding genotypes from Europe have been crossed to Egyptian landraces to create high yielding varieties with local adaptation in Egypt. Crossing high yielding, *Fusarium* resistant and sweet lines from Europe with elite lines from Egyptian landraces selected for yield, *Fusarium* resistance and calcium tolerance provides large phenotypic variation. Elite plants have been selected in F3 to F5 generation on reclaimed calcareous desert land and in old fertile clay Nile land in Upper Egypt. The outcome of the best crosses are high yielding early elite lines with a crop height of 70 to 130 cm, with good soil and climatic adaptation on both fertile and reclaimed land and yields ranging from 4 to 6 ton ha^{-1} for the best lines on fertile land.

KEYWORDS

Lupinus albus, repatriation in Egypt, plant structure, fusarium resistance breeding

INTRODUCTION

Most of the consumed lupins in Egypt are imported. The area of lupin cultivation in Egypt has decreased and is approximately 4000 ha. Lupin cultivation in Egypt is characterised by small plots of old low yielding landraces. Due to climatic and soil conditions in Egypt foreign high yielding varieties can not been grown successfully (Christiansen *et al.* 2000), and high yielding modern varieties of lupin has not been developed for Egypt. Consequently farmers prefer higher yielding improved crops of other species. The Egyptian landraces have excessive vegetative growth and are often near 2 m tall, however, they have been grown since ancient time and provide important genetic diversity for traits as adaptation to alkaline and calcareous soils, non shattering pods, *Fusarium* resistance, seed size and plant structure (Christiansen *et al.* 2000; Raza *et al.* 2000; El-Sayed *et al.* 2007). *Fusarium* root rot and wilt are major diseases in Egypt and causes significant yield losses (El-Sayad and Ebtehag, 2002). Sources for *Fusarium* resistance have been reported in Egyptian landraces (El-Sayad and Ebtehag, 2002; Raza *et al.* 2000) and from European germplasm (Kuptsov *et al.* 2002).

The ideo-type searched for under Egyptian conditions has good growth and high yield under Egyptian soil and climatic conditions, high disease resistance particular to *Fusarium*, resistance to viruses and lodging, and shattering, tolerance to high planting densities, and a height of 80 to 120 cm and medium to big seed size. High protein and low alkaloid content are important but of second priority.

This paper reports on evaluation of existing material, and progress in breeding improved varieties for Egyptian conditions by combining selected Egyptian landraces possessing calcium tolerance, *Fusarium* resistance and high yield traits with European material possessing determinate plant structure, low alkaloid content and *Fusarium* resistance.

MATERIALS AND METHODS

In 2003 a germplasm collection of *albus* from Europe and Egypt were screened in a dirty plot with high disease pressure of soil borne diseases. This field is a sandy loam located 40 km south of Copenhagen in Egoeje village. Disease pressure of soilborne diseases has been built up by growing *Fusarium* susceptible lupins nine successive times. Disease pressure in this field is high and susceptible genotypes wilt completely before flowering and the disease symptoms appears homogen over the experimental area. To identify the prevalent lupin pathogens, fungi was isolated from diseased plants. Symptomatic plants were selected for isolation of root pathogens. The top of the stem was removed and the remaining root system was washed by gently rubbing with ordinary hand soap and subsequent washing under running tap water. The roots and epicotyls were surface disinfected in 70% ethanol. Sections from the interface between healthy and diseased tissue were incubated on PDA and SNA media amended with 25 ppm tetracycline and 50 ppm chloramphenicol.

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In 2004 crosses were made between genotypes from Europe selected for branching structure and yield potential, earliness, disease resistance and alkaloid level and landraces from Egypt selected for calcium tolerance, *Fusarium* resistance, earliness and yield and their progenies advanced. In 2005 F_2 derived F_3 families and a large collection of Egyptian landraces and hybrids between these, and a collection from Europe were planted in reclaimed desert land in El-Gabal 60 km from Luxor in upper Egypt (Tables 1, 2 and 3). A large part of the material was lost probably due to high calcium content, infertile soil and problems with the drop irrigation system. Surviving elite plant and bulk seeds were harvested in April 2006 and advanced in Denmark in 2006. In November 2006 selected F_4 and F_5 elite plants and bulk populations were sown again in El-Gabal and in a neighbouring fertile clay soil in Dandare, where plants are grown on ridges with flooding irrigation. In April 2007 harvested elite plants from both locations were planted in Denmark for evaluation and multiplication. In November 2007 best elite plant and F5 derived F6 and F7 populations were planted at El-Gabel and Dandara and selected elite lines were also planted at Ismailia and in Sinai at Ras Sudr (Tables 1, 2 and 3). At the Ras Sudr location all lupin died before two month due to salinity in soil and irrigation water and near 20% $CaCO_3$ in the soil.

The thirty best and most homogenous lines were multiplied in 40 m^2 plots and yield measured in 4 m^2 of the central part of the multiplication plot at the Dandara location. In may 2008 360 elite lines from Dandara and El-Gabal were planted in the *Fusarium* field at Egoeje.

The best Egyptian landraces from the Egyptian genebank and a set of 13 elite landraces, mutant lines, Giza1 and Giza1, and a reselection of Kief mutant have also been tested in Dandara and El-Gabal in 2007 and 2008.

Plant structure is described by measuring the height to the top of main stem pods, height to top of first order branch pods, height to the top of pods of second order branch and so forth. A typical Egyptian landrace have a structure 90, 150, 190 cm, and a European modern line a structure of 50, 70, 100, 110 cm.

RESULTS AND DISCUSSION

Lupins have a very vigorous and homogenous growth at the Dandara location on the old fertile clayish Nile bands. However, at the other locations on reclaimed land growth is restricted by salinity and high $CaCO_3$ content. At the Ras Sudr location all lupin died before two month due to salinity in soil and irrigation water and near 20% $CaCO_3$ in the soil. At Ismailia salinity was also high in irrigation water, however, some lines survived and tolerant lupin lines have been identified (Tables 1, 2).

None of the *albus* germplasm comprising the Egyptian landrace collection and a number of accessions from Europe and South America and the test lines from the Giza Research institute, provide directly or after reselection significant progress as new improved varieties in Egypt. European material had generally poor growth and Egyptian material were very vegetative and low yielding. For this material we have recorded yields up to 2.5 ton per ha which is in agreement with results obtained by El-Sayad *et al.* (2007), and Christiansen *et al.* (2000). The Egyptian landraces and mutant lines were 1.5 to 2 m tall on the clay soil in Dandara and responded to increased plant density by reduced pod set and increased lodging.

Large diversity is observed in cross populations between elite lines of Egyptian landraces and modern high yielding genotypes from Europe; in plant structure, earliness, lodging, pod attraction, yield potential, and alkaloid and protein level and these populations are very promising for the development of improved high yielding new varieties for Egypt. In the segregating population very different plant structures were observed. At flowering tall plants of more than 140 cm were removed in all hybrid populations and the plant stand were reduced in the neighbouring areas around the smallest plant. The elite plants selected at harvest were in general not the highest yielding and tallest plants, but shorter plants with a good branching structure, which despite hard competition from taller neighbouring plants produced many pods on the main stem but also on branches. The highest yielding lines originate from crosses between Fus1-008, a Belarusian *Fusarium* resistant line with high yield potential determinate growth and strong branches, and Giza1, a 30 year old variety released by the Giza Research Institute, based on a reselection of Egyptian landraces. The best lines from these crosses are early flowering and maturing; they yield near 6 t/ha and have short strong branches and a plant height of 80-130 cm on fertile clay soil (Fig. 1).

Fig. 1. Breeding material: on the left is a typical Egyptian landrace, followed from left to right by the new and gradually more determinant higher yielding varieties originating from crosses with Fus1-008.

Other promising lines are obtained from crosses between Fus1-008 and Acc4 a *Fusarium* and calcium tolerant Egyptian landrace. The low alkaloid line Marianna from Europe is also an excellent crossing partner with Egyptian material. However, branches in these progenies have a tendency to break on lines with a high number of pods.

Crossing the French winter types Luxe and CH1811 to Egyptian Acc4 resulted in extremely diversity in plant development, ranging from early flowering lines, over lines which stayed in rosette and did not enter the flowering stage under the southern Egyptian conditions, to lines with excessive vegetative growth of up to 2 m height. The long rosette stage (high vernalisation requirement) is a recessive character in these crosses. Most lines obtained from the crosses with Luxe and CH1811 were prone to viruses, however, 2 lines were resistant to viruses and one of them had very high pod attraction (high number of pods per plant).

Table 1. Soil characteristics of testing sites.

Location	Soil	pH	EC*	Anions (meq./L)			Cation (meq./L)				$CaCO_3$ %	O.M. %
				HCO_3	CL	SO_4	Ca	Mg	Na	K		
El-Gabal	r.s.	7.8	13.0	7.1	55	106	59	20	75	14.1	6.5	0.16
Dandara	clay	7.6	2.7	7.1	4.6	16	12	10	5	1.2	1.7	1.71
Ismalia	r.s	8.2	19.1	3.1	141	122	55	27	180	5.0	1.2	0.06
Ras Suder	r.s.	7.6	52.1	10.2	503	227	110	115	510	6.0	19.2	0.10

(Reclaimed desert sand r.s.; *EC is measured in mmhos/cm.)

Table 2. Irrigation water characteristic of testing sites.

Location	pH	EC*	Ppm	Anions (meq./L)			Cation (meq./L)				SAR %
				HCO_3	CL	SO_4	Ca	Mg	Na	K	
El-Gabal	7.4	0.73	467	0.06	6.0	1.8	2.1	1.5	4,2	0.09	3.2
Dandara	7.5	0.30	192	0.06	2.3	2.0	2.1	0.6	1.6	0.15	1.4
Ismalia	7.3	5.20	3354	0.50	22	35.1	6.8	2.7	47.5	0.15	21.9
Ras Suder	7.1	4.70	3027	0.06	23	31.4	14.8	10.1	30.0	0.25	8.5

(*EC is measured in mmhos/cm; Sodium Adsorption Ratio (SAR).)

Table 3. Climatic characteristic of testing sites. T_{max} and T_{min} are monthly average of daily maximum and minimum temperatures. The data from Luxor are representative for El-Gabal and Dandara locations and Ismalia for Ras Suder.

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ismalia T_{max} (ºC)	19.2	20.9	23.3	28.6	31.8	34.8	35.7	35.3	33.1	30.0	25.4	20.9
Ismalia T_{min} (ºC)	7.6	8.3	10.3	14.1	16.4	19.5	21.3	21.5	19.7	16.6	12.7	8.9
Ism. rainfall (mm)	7.0	6.0	7.0	2.0	2.0	0.0	0.0	0.0	0.0	2.0	6.0	5.0
Luxor T_{max} (ºC)	23.0	25.4	27.4	35.0	39.2	41.4	41.1	40.4	38.8	35.3	28.9	24.4
Luxor T_{min} (ºC)	5.4	7.1	10.4	16.0	20.2	22.6	23.6	23.2	21.3	17.3	11.6	7.1
Luxor rainfall (mm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0

The dominating pathogens isolated from diseased lupins with root rot and wilt symptoms in the *Fusarium* field are in descending order *F. oxisporum, F. solani, F. culmorum,* and *F. avenaceum*. From 366 breeding lines from Egypt tested in the *Fusarium* field in Denmark 2008, only 10 lines have normal growth until after flowering, 90% of the lines wilted completely before they reached a height of 20 cm. The most resistant lines originate from progenies where Fus1-008, Nelly, or BestFusResEgypt2003 are one of the crossing partners.

We breed for earliness in Egypt to reduce the length of the growing cycle, improve water use efficiency, and to clear the land for following summer crop. Lupin establishment and growth before flowering in November in Egypt are under high temperature short day regimes (Table 3). Selected early material under these conditions has proven to be very early flowering under Danish spring growing conditions, characterised by relatively low temperatures and long days. These lines being early under both high and low temperatures and long and short days, we consider having a high level of thermo- and day length neutrality, which is an important trait for the stability of European spring sown crops.

It appears that lines with very restricted branching and/or height less than 90 cm yield less than taller lines in Egypt. The reason for this could be a sub-optimal plant density in the breeding and yield plots (near 12 plants m^{-2}) for these determined lines. Future breeding progress will be search for in the direction, early, determined *Fusarium* resistant lines with a broad soil adaptation, high pod attraction, grown under significant higher plant densities of 20 to 30 plants m^{-2}.

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