Theor Appl Genet (1985) 71:238–241

Prospects for interspecific hybridization of *Lupinus atlanticus* Gladst. with *L. cosentinii* Guss.

N. N. Roy and J. S. Gladstones

Department of Agriculture, South Perth, Western Australia 6151, Australia

Received April 22, 1985; Accepted July 25, 1985
Communicated by J. Mac Key

Summary. Successful crossing is reported between *L. atlanticus* Gladst. (2n=38) and *L. cosentinii* Guss. (2n=32), using lines of both species selected for crossability followed by selection of relatively fertile progenies. In one cross, 82E75, from a single F_2 segregating plant, 22 F_3 seeds were obtained. Some other less crossable combinations were completely sterile in the F_1 or F_2. Backcrossing to both parent species was successful, but some crosses gave relatively more seed by using F_2 plants for backcrossing rather than F_1's. It is concluded that potential exists for introgression of useful genes in both directions.

Key words: Interspecific cross – Wild lupins – *L. atlanticus* Gladst. – *L. cosentinii* Guss. – Crossability

Introduction

The rough-seeded Mediterranean-African wild lupins offer interesting prospects for future domestication (Gladstones 1984). Though fertile hybrids are reported to be common in crosses among wild species of the New World, almost complete genetic isolation exists among the Mediterranean and African species (Gladstones 1974, 1984; Williams 1984). *L. atlanticus* is, however, a newly described species, collected from the High Atlas foothills and Anti Atlas region of Southern Morocco (Gladstones 1974). Its chromosome number 2n=38 (Pazy, cited by Plitmann et al. 1980) is intermediate between *L. pilosus* (2n=42) and *L. cosentinii* (2n=32). It is also morphologically intermediate in many respects. Gladstones (1984) found *L. atlanticus* to cross quite readily with both *L. pilosus* and *L. cosentinii*, but the F_1 plants produced only aborted seeds. The present investigation was carried out in an attempt to overcome hybrid sterility in such crosses by using selected lines of *L. atlanticus* and *L. cosentinii*, with the hope that some might prove more cross compatible.

Materials and methods

A set of the selected lines of *L. atlanticus* were crossed with Erregulla-s, a soft-seeded selection from *L. cosentinii* cv 'Erregulla' (Anon 1977), in the greenhouse during the 1982 winter. The *L. atlanticus* lines were direct introductions from different parts of the species' natural range in southern Morocco, together with low-alkaloid and other artificially-induced mutants derived from them. The 'Erregulla' selection, as well as being soft seeded, carried other domestication genes artificially induced (viz., low alkaloid, white flower/seed, early flowering) or naturally occurring (viz., reduced pod-shattering). The crosses were more successful when *L. atlanticus* was used as the seed parent. In general, 8–10 buds of appropriate stage were used in making a cross.

F_1 seed set was variable; 5 to 55 seeds per cross were obtained depending on the *atlanticus* lines used and the number of crosses made. In all, 14 *L. atlanticus* lines in crosses with Erregulla-s gave enough F_1 seed to carry out this study. From each cross 5–6 seeds (F_1) were sown in rows at South Perth during the 1983 winter along with *atlanticus* and *cosentinii* parents and other selections.

In the 1984 winter, one or two F_2 seeds from the four successful interspecific crosses (82E13, 82E30, 82E73 and 82E75) as well as BC_1F_1 seeds from the two back crosses (83E2 and 83E4) were sown in the greenhouse. From one cross only, 82E75, three extra F_2 seeds were available which were planted in the field at South Perth. At flowering all these plants were manually self-pollinated and also backcrossed with pollen from both *atlanticus* (wild/mutant) and *cosentinii* (Erregulla-s).

Results

F_1 plants

The F_1 plants when grown in the field in 1983 and 1984 showed good hybrid vigour, with profuse branching

Fig. 1. Plant growth and vigour. F_1 vs. F_2 and parent (*L. atlanticus*). *Front row:* Left *atlanticus*-wild; *Centre* 82E75 (F_2)-2 plants only; *Right* 82E30 (F_1)

and rapid growth compared with *atlanticus* (Fig. 1). They were intermediate in leaf and stem colour and in days to flowering.

The F_1 plants produced prolific, near-normally developed pods, but at maturity these were found to contain only aborted seeds. Out of 14 crosses of *L. atlanticus* × *L. cosentinii* (Erregulla-s), only four produced a few (up to four) F_2 seeds during the 1983 and 1984 seasons. Two crosses, 82E75 and 82E30, produced four F_2 seeds. In spite of a large number of attempted backcrosses using pollen from *atlanticus* and *cosentinii* parents and selections, only one seed was obtained from each of two backcrosses, namely 83E2 (with *atlanticus* pollen) and 83E4 (with 'Erregulla' as seed parent).

F_2/BC_1(F_1) plants

In 1984 five single F_2 plants involving the four straight inter-species crosses were raised separately in the greenhouse, along with the two BC_1F_1 plants. Apart from one backcross, 83E4, all the plants were of more or less intermediate plant type but showed evidence of segregation in flowering dates and plant height.

Variability was again evident in seed set among the F_2/BC_1 plants, both in the greenhouse and in the field (Tables 1 and 2). The maximum F_3 seed obtained was again from individual plants of the same two crosses, namely 82E30-1 (greenhouse) and 82E75-2 (field); the latter gave 22 F_3 seeds, the maximum so far recorded. Two other F_2 plants from the same cross, 82E75-1 (greenhouse) and 82E75-3 (field) were completely sterile, indicating segregation for seed fertility in this cross. There was relatively more success at the F_2 plant level than in the F_1 in seed set through backcrosses (except in 82E75). 82E13-1 and 82E30-2 backcrossed to *cosentinii* (Erregulla-s) gave 6 and 3 seeds, respectively. Both these plants gave 2–3 seeds when backcrossed to the other parent, *atlanticus* (mutant or wild).

All these F_2 plants, except 82E73-1, were bitter. 82E73-1 was sweet but failed to give any F_3 or backcrossed seed, and was lost (Table 1).

Table 1. Seed set in 7 F_2 plants of four interspecific crosses (*atlanticus* × *cosentinii*) through self-pollination and backcrosses

Cross/backcross	Location	Seed	
		Generation	No.
82E13-1 (F_2)	GH	F_3	NIL
82E13-1 × ATL (M)	GH	BC_1 (F_1)	2
82E13-1 × COS (ERGS)	GH	BC_1 (F_1)	6
82E30-1 (F_2)	GH	F_3	3
82E30-1 × ATL (W)	GH	BC_1 (F_1)	1
82E30-1 × ATL (M)	GH	BC_1 (F_1)	2
82E30-1 × COS (ERGS)	GH	BC_1 (F_1)	NIL
82E30-2 (F_2)	GH	F_3	1
82E30-2 × ATL (W/M)	GH	BC_1 (F_1)	NIL
82E30-2 × COS (ERGS)	GH	BC_1 (F_1)	3
82E73-1 (F_2)	GH	F_3	NIL
82E73-1 × ATL (W/M)	GH	BC_1 (F_1)	NIL
82E73-1 × COS (ERGS)	GH	BC_1 (F_1)	NIL
82E75-1 (F_2)	GH	F_3	NIL
82E75-1 × ATL (W/M)	GH	BC_1 (F_1)	NIL
82E75-1 × COS (ERGS)	GH	BC_1 (F_1)	NIL
82E75-2 (F_2)	FLD	F_3	22
82E75-3 (F_2)	FLD	F_3	NIL

M = Mutant, W = Wild, ERGS = Erregulla Selection, GH = Greenhouse, FLD = Field, ATL = *atlanticus*, COS = *cosentinii*

Table 2. Seed set in two BC_1F_1 plants of 83E2 and 83E4 through self-pollination or second backcrosses

Backcrosses	Seed	
	Generation	No.
83E4 (BC_1F_1)	BC_1 (F_2)	12
83E4 (BC_1F_1) × COS (ERGS)	BC_2 (F_1)	1
83E4 (BC_1F_1) × ATL (M/W)	BC_2 (F_1)	NIL
83E2 (BC_1F_1)	BC_1 (F_2)	1
83E2 (BC_1F_1) × COS (ERGS)	BC_2 (F_1)	NIL
83E2 (BC_1F_1) × ATL (M/W)	BC_2 (F_1)	NIL

COS = *cosentinii*, ERGS = Erregulla Selection, ATL = *atlanticus*, M = Mutant, W = Wild

Among the two backcrosses, 83E2 gave only 1 F_2 seed (Table 2). 83E4, which was Erregulla-s × (*atlanticus* × Erregulla-s), looked essentially like Erregulla-s in plant type (green stem and leaf), flower colour (white, small) and seed character (sweet, white, small). It was, however, largely infertile due apparently to poor pollen, and produced only 12 BC_1F_2 seeds. When backcrossed a second time with profuse, fertile pollen from 'Erregulla', 83E4 did not set good seed, indicating possible differences at the chromosomal level.

Discussion

As a previously undescribed species, little is known about the agronomic possibilities of *L. atlanticus.* Limited trials and nursery row observations (Roy and Gladstones 1983; Gladstones 1984) indicate that it could be a species of considerable potential for arid and other problem environments of Australia and perhaps elsewhere. Further work on the improvement or domestication of this species therefore appears to be justified.

Mutation has played an important role in the domestication of several lupin species. Similar improvement through mutation should be possible in *L. atlanticus.* Already some chemically-induced mutants selected by Gladstones (unpublished) are available, including lines with white flowers and seeds and freedom from alkaloids. Recently, a soft-seed type has also been isolated (Roy, unpublished). These mutant lines as well as the wild *atlanticus* selections are rather slow growing and late in maturity under Western Australian conditions and need further improvement. A possible approach is the introgression of useful genes through interspecific crosses, particularly involving *L. cosentinii* which is easily crossable.

The present work has shown that despite the difference in chromosome number, there are grounds for thinking that the genetic gap between *L. cosentinii* and *L. atlanticus* may not be so wide as to preclude the introgression of useful genes from one species to the other. Each has useful genes to contribute, i.e. the 'domestication' genes (already enumerated) in *L. cosentinii* and possibly genes for greater cold resistance, adaptation to heavy soils and more determinate growth habit from *L. atlanticus.*

The use of colchicine to overcome the sterility barrier by doubling F_1 chromosomes appears to hold little promise, because of lupins' already high chromosome number. Many attempts to obtain tetraploids in Mediterranean Lupins using colchicine have failed (Kazimierski and Kazimierska 1981). In the present study the use of colchicine was not therefore considered for improvement of F_1/F_2 seed set.

The alternative approach used has been to identify genotypes in the involved species which, when hybridised, are more likely to set seed than usual. This method has been used with some success in *Hordeum*/*Secale* crosses (Fedak 1977), in interspecific crosses of *Phaseolus* species (Mok et al. 1978), and in *Brassica* species (Roy 1977, 1980). In the present study there were definite signs of such differences, together with some recovery of fertility with selection in the progeny of one cross. One F_2 plant, 82E75-2, alone gave 22 F_3 seeds, the highest recorded in any true interspecific cross among Mediterranean lupins.

As in interspecies crosses of *Brassicas* (Roy 1980) there was more success using F_2 plants for backcrossing than with F_1's (Tables 1 and 2).

References

Anon (1977) *Lupinus cosentinii* Guss. (sandplain lupin) cv. 'Erregulla'. J Aust Inst Agric Sci 43:87–89

Fedak G (1977) Haploids from barley × rye crosses. Can J Genet Cytol 19:15–19

Gladstones JS (1974) Lupins of the Mediterranean region and Africa. Dept Agric W Aust, Tech Bull 26

Gladstones JS (1984) Present situation and potential of Mediterranean/African lupins for crop production. In: Proc 3rd Int Lupin Conf, La Rochelle (in press)

Kazimierski T, Kazimierska EM (1981) Polyploids of *Lupinus* Rothmaleri Klink. Genet Pol 22:433–436

Mok DWS, Mok MC, Rabokoarihanta A (1978) Interspecific hybridisation of *Phaseolus vulgaris* with *Phaseolus lunatus* and *Phaseolus acutifolius.* Theor Appl Genet 52:209–215

Plitmann U, Heyn CC, Pazy B (1980) Biological flora of Israel. 7. *Lupinus palaestinus* Boiss and *L. pilosus* Murr. Isr J Bot 28:108–130

Roy NN (1977) Interspecific cross-compatibility and F_1 sterility in oilseed Brassicas. In: Proc 3rd Int SABRAO Congr, vol 2 (a), pp 31–33

Roy NN (1980) Species crossability and early generation plant fertility in interspecific crosses of *Brassica.* SABRAO J 12:43–54

Roy NN, Gladstones JS (1983) Species variability of yield-component in lupins under stress condition. Aust Plant Br Genet Newslett 33:48–51

Williams W (1984) Lupins in crop production. Outlook on Agriculture 13:69–76