Breeding a pasture and feed legume adapted to subacid Italian Mediterranean areas: the blue lupin

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Summary - *Lupinus angustifolius* L. (blue lupin) is a Mediterranean wild species growing profusely in subacid, sandy or vulcanic soils, particularly of Tyrrhenian Italy. These wild types are well adapted to poor, marginal soils, mainly used for cereals and for pastures for ruminants. A breeding programme has been developed to select domesticated lines mainly by tranferring domestication characters present in cvs bred in Australia and Poland into 3 Italian wild selections, highly adapted to Central and South Italy and highly productive. Several crosses were made and selection performed for desired genetic traits. Results of the research and main characteristics of the new selections for high biomass and seed production are reported.

Kew-words: *Lupinus angustifolius,* breeding, selections

Résumé - *Le lupin bleu est sauvage dans le bassin de la Méditerranée. Varietés et lignes domestiques obtenues en Australie et Pologne ont été croisées aveclignes sauvages selectionnées en Italie, pour obtenir lignes domestiques adaptées aux conditions agronomiques italiennes. Les premières donnés obtenues dans ce programme sont presentés dans la contribution.*

Mots-clés: Lupinus angustifolius, *breeding, selections*

Introduction

The four presently cultivated lupins of the old world (*Lupinus albus, L. luteus, L. angustifolius* and *L. cosentini*) all originated in the Mediterranean basin (Gladstones,1970). However, domesticated lines belonging to those species, showing high biomass production, earliness, non shattering pods and permeable, large, white, sweet seeds, are now mostly cultivated in unfertile, subacid, often sandy, soils located in North-Eastern Europe, Australia, South Africa and USA .The highly efficient symbiosis with the specific N-fixing bacteria are, in fact, providing strong advantage to lupins in those conditions.

Wild *L. angustifolius* L. has a very wide adaptation in the Mediterranean Region (see Fig. 1) and in all Tyrrhenian coastal areas, including the large Islands. These wild types are particularly adapted to poor, marginal and often non cultivated soils in sandy and/or organic areas or in detrital slopes formed by schists, slate, intrusive or extrusive vulcanic rocks.

Mainly neutral or subacid in reaction, these soils form a medium into which the lupin seeds, after shattering, can roll and become easily covered, and where the lupin's deep and rapidly penetrating root system is extremely advantageous (Gladstones, 1974; 1977).

Strangely enough, the blue lupin has been highly neglected by Italian plant breeders as a possible feed and forage legume,particularly in coastal Tyrrhenian provinces, where subacid and vulcanic soils cover some hundred thousand hectares. Improved domesticated lines, introduced from Australia or Eastern Europe, have produced seed yields exceeding 3 tons ha^{-1} in these coastal areas (Postiglione, 1982; Postiglione *et al.* 1994; Bozzini *et al.* 1997).

However, these lines, bred in other agroecological conditions, are certainly not ideal in Italy.

The Authors conducted for several years a careful analysis of many wild blue lupin populations located in Roma and Viterbo provinces, identifying three lines, characterized by high adaptation, leading to high biomass and high seed production (Bozzini, unpublished).

Two parallel breeding programmes have been then developed: 1) by crossing Australian with Polish material, to exploit the variability present in domesticated lines selected in quite different environments and 2) by crossing mainly Australian lines with the three Italian wild selections, to transfer the domestication genes into a genetic background better adapted to agro-ecological conditions of Central Italy, in both cases with the aim to obtain lines characterized by high biomass (for grazing) and/or high seed (for feed) production (Bozzini, 1997; Bozzini and Chiaretti, 1998).

Fig 1 Distribution of wild *Lupinus angustifolius* (after Gladstones, 1974).

Materials, Methods and Results

Four Australian indeterminate cultivars (Yandee; Illyarrie; Unicrop and Danja); four Polish lines -all early and with determinate habit-(ROD 506/89; ROD 511/89;ROD 526/89 and PRM 585/89) and three Italian blue lupin wild selections (IT 1-Viterbo; IT 2-Maccarese and IT 3-Casaccia) were utilized as parents in crosses, as reported in Table 1.

Crosses involving wild lines were performed using the domesticated lines as mother plants, also in order to verify, in the F_1, if the cross was successfull; then all the F_2 seeds were scarified. The first generation was grown in glasshouse, in winter, to avoid outcrossing.

The following F_2 and F_3 generations were grown in the field. In F_2 and F_3 generations, plants with white or pink flowers were preferentially selected: white or pink flower colour, being recessive, provides a good marker to identify possible outcrosses with wild material, during the new varieties seed production. Pods from F_2 plants were collected before ripening, to avoid shattering. F_3 plants, instead, were left well over complete ripeness, to select for

non-shattering individuals. Also selection for soft seeds was automatically performed in F_2 and F_3 progenies, since hard seeds did not, or only partially, germinate.

Then ten or twenty seeds coming from F_3 plants with white (or pink) flowers, non shattering pods and soft seed testa were analyzed for presence of different degree of bitterness. Some 1650 seeds, belonging to 138 F_3 progenies were individually tested (Table 1) and classified for the presence of bitter compounds. After the analysis, 105 F_4 individual plants, selected for seed sweetness, were grown in the glasshouse. During the F_4 generation, further selection was applied, mainly for agronomic parameters (plant development and biomass production, earliness, determinate or indeterminate habit, plant fertility, number of seeds per pod, seed size etc.).

The following F_5 generation, consisting of 41 progenies, was grown in 1999, in the field, for seed multiplication and analysis in normal growing conditions (Table 1).

All of them were white flowered, with indehiscent pods, sweet, soft and white seeds; variability within and among progenies was found in many other characters: plant size and habit (determinate or indeterminate), earliness, no. of pods per plant, pod and seed size and colour etc. In all the materials were present many different and interesting types.

However, the variability found in crosses between the wild and domesticated lines was - as expected- much larger than in the crosses between Australian and Polish domesticated lines, with particular reference to plant and leaf size, plant development and health, stem branching, earliness, mean number of flowers and of pods per plant, seed shape and size etc.

We are confident that, in two more generations, final selections could be made to release some new, fully domesticated varieties, more productive for seeds and biomass than those previously available, because more adapted to the Italian agro-ecological conditions.

Table 1 - Crosses performed and number of F_3 and F_5 selected progenies

Crosses	No. of F_3 progenies	No. of F_5 progenies
ROD 506/89 x Jandee	17	8
ROD 511/89 x Jandee	6	1
PRM 585/89 x Illiarrie	6	3
PRM 585/89 x Unicrop	5	4
Jandee x IT 1 Viterbo	3	1
Illiarrie x IT 1 Viterbo	13	4
Danja x IT 1 Viterbo	3	2
Unicrop x IT 1 Viterbo	1	0
Jandee x IT 2 Maccarese	18	3
Illiarrie x IT 3 Casaccia	8	1
Danja x IT 3 Casaccia	9	2
Unicrop x IT 3 Casaccia	32	7
ROD 526/89 x IT 3 Casaccia	16	5
Total	138	41

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