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Variation within improved cultivars and landraces of lucerne in Central Italy

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Summary

A variety must be distinguishable, uniform, stable and of sufficient productivity to be officially registered. In Italy landraces of lucerne are still widely used because they are characterized by a good persistence and productivity in their area of origin and adaptation.

The landrace from Casalina (20 km south of Perugia, Central Italy) has higher dry matter production than many other commercial cultivars. The objective of this paper was to measure the variation of the landrace Casalina and compare it with that of the commonest cultivars available on the market and with some lines selected from the landrace Casalina.

The experiment consisted of 11 entries: Casalina, two selections from Casalina (one for high seed yield and one for frequent cuttings), the registered landrace Italia Centrale and 7 registered cultivars. Each entry was represented by 80 genotypes transplanted in the field 60 × 40 cm apart in a randomized block design with 4 replications. In 1991 the following characters were recorded on a single plant basis: time of first flowering, height, number of shoots and dry matter yield at the first harvest, time of second flowering, leafiness, height, number of shoots and dry matter yield at the second harvest, height, number of shoots and dry matter yield at the third and fourth harvest. Height, number of shoots and dry matter yield at the first harvest, dry matter at the second and third harvest were recorded during the 1992 season.

Casalina was as variable as the other entries in 77% of the comparisons; it was more variable in 8% of the comparisons and less variable in 15% of the comparisons. In conclusion, the variation of landrace Casalina is equal to or less than that of registered varieties so that it could be directly registered at the National Registry of Varieties.

Introduction

Landraces are primitive cultivars and, according to the definition given by Harlan (1975), are balanced populations in equilibrium with the environment and pathogens; they are genetically dynamic with variations among sites and populations (heterogeneity in space) and within sites and populations (heterogeneity in time, i.e. variation between seasons and long term climatic, biological and socio-economic conditions).

A landrace is continuously subjected to selective pressures within its area of adaptation due to climatic, soil, biotic, and especially human factors. Cross-fertilized species grown in mountain areas or in areas characterized by natural obstacles have been subjected to restricted movement of their pollen with the consequence of a limited gene flow. The restriction of gene exchange, accompanied by even slightly different climatic, soil and biotic factors could have led, with time, to populations specifically adapted to their habitats and with well defined characteristics. The continuous selection by man, through the practice of sowing seed harvested from the best plants and with different crop management practices (soil cultivation, fertilization, time and methods of crop harvesting, etc.) could have further enhanced differences among landraces.

A wide range of environmental conditions are present in the Italian peninsula, which extends from 47° N to 37° N and is characterized by a continental climate in the north and a mediterranean climate in the south. In Central Italy the Appennine Mountains include several valleys (the Tiber Valley, the Nera Valley and others) and several plains at different altitudes. Many years ago differences for important agronomic characters were found in 4 landraces of maize (Bonciarelli, 1961) and in 5 landraces of lucerne (Lorenzetti et al., 1972) collected in these regions.

Although phenotypically similar, the individuals of a cross-fertilized landrace are highly heterozygous and genotypically different. Landraces are likely to be characterized by a much greater genetic variability than cultivars, whose fundamental requisites are uniformity, distincitiveness, and stability.

In 1992 there were 71 cultivars (35 from Italy, 10 from other parts of Europe, 21 from the USA and 5 from Australia) of lucerne (*Medicago sativa* 2n = 4 x = 32) registered in the Italian National Registry of Varieties, and 14 landraces. As a consequence of (i) their significant longer persistence, (ii) their good productivity, often higher than that of improved cultivars (P. Rotili, personal communication) and, (iii) the lower price of the seeds (50% less), landraces are used by farmers much more than varieties. In addition to the landraces registered *ex officio* by the Ministry of Agriculture in 1980, farmers also use on-farm seeds of landraces produced three or four years after establishment when the crop is no longer economically suitable for forage production (farmer-landraces). In Italy, recent estimates indicate that landraces represent over 80% of the lucerne seed market (Ligabue, 1993). However, registered cultivars are used more and more often by farmers because on-farm seed production is slowly being replaced by purchasing seed on the market.

European Community regulations aim to cancel landraces from the National Registry of cultivars and to abolish their marketing. In Italy landraces will be replaced by registered cultivars most probably by the year 2000. Without an effort to collect, evaluate and improve the existing landraces, precious and well adapted genetic materials will irreversibly be lost.

The objective of the present research was to evaluate the variation within the landrace Casalina, and compare it with that of two lines selected from Casalina, the registered landrace Italia Centrale and seven registered cultivars, including the National check, Equipe.

Materials and methods

The experiment was conducted at the experiment station of the Istituto di Miglioramento Genetico Vegetale, University of Perugia, located at San Martino in Campo, 10 km south of Perugia. The climate of Perugia is sub-mediterranean (Le Houerou, 1977), with a long term average annual precipitation of 796 mm. Lucerne start growing in February-March and continues throughout the summer till October. In November many plants start to become dormant due to the cold temperatures and there is no growth during winter.

Eleven entries of *M. sativa* were used in the experiment: Casalina (the local landrace), two lines selected from Casalina: one for high seed production (Casalina SY) and one for a frequent cutting regime (Casalina FC), the registered landrace Italia Centrale, and seven commercial cultivars (Boreal, Delta, Equipe, Estival, Miral, Robot and Tornese).

Seedlings were grown in jiffy-pots in the greenhouse during the winter, and in March 1991 80 random plants per entry were transplanted in the field at distances of 60 cm between rows and 40 cm within the row. Plants were arranged in a randomized complete block design with four replicates, each plot consisting of 2 rows of 10 plants each.

During the 1991 growing season the following observations were recorded on a single plant basis: time of first flowering, plant height, number of shoots and dry matter yield at the first harvest; time of second flowering, leafiness, number of shoots, plant height and dry matter yield at the second harvest; plant height, number of shoots and dry matter yield at the third and fourth harvest. During the 1992 season the observations were: plant height at the first harvest and dry matter yield at the first, second and third harvest.

Data were subjected to hierarchical analysis of variance and variation within entries was computed on residuals. F-tests were performed to compare variability of Casalina and of Italia Centrale with that of the other entries.

Results and discussion

Significant ($P < 0.05$) differences of the variability between Casalina and all other entries are reported in Table 1. In 147 out of 190 F-tests (77%), the variation of Casalina was the same as in the other entries (F-ratios not shown). It was significantly more variable in 14 cases (8%), and less variable in 29 cases (15%).

Table 1. Significant ($P < 0.05$) F-ratios between the variance of the lucerne landrace Casalina and that of each of the other lucerne entries for the agronomic characters evaluated. Numbers in bold means that the variance of Casalina was smaller than the variance of the entry used in the test, while numbers in italics means that the variance of Casalina was greater than the variance of the entry used in the test

Characters	Boreal	Cas.SY	Cas.FC	Delta	I.Centr	Equipe	Estival	Miral	Robot	Tornese
	Season 1991									
1st flowering	2.61	2.20	2.66	2.65	2.19	3.22	5.35	2.90	–	2.91
DMY 1st harvest	*1.52*	–	–	–	1.68	–	–	–	–	–
Plant height	–	–	–	–	1.87	–	1.92	–	–	–
No. of shoots	–	–	–	–	–	–	–	*1.47*	–	–
2nd flowering	–	1.74	–	–	–	–	–	–	–	–
DMY 2nd harvest	–	–	–	–	–	–	–	–	–	–
Leafiness	*1.47*	–	–	1.67	–	–	1.93	–	1.98	–
No. of shoots	–	–	1.61	–	–	–	–	–	–	–
Plant height	–	–	–	–	2.37	–	1.49	–	–	–
DMY 3rd harvest	*1.87*	–	–	–	–	–	–	–	*1.54*	–
Plant height	–	1.97	1.81	2.29	2.24	–	1.57	–	–	–
No. of shoots	–	–	1.64	–	–	–	–	–	–	1.52
DMY 4th harvest	–	–	–	–	–	–	–	1.50	–	–
Plant height	–	–	–	–	–	1.57	–	–	–	–
No. shoots	–	–	–	–	–	–	1.52	–	–	–
	Season 1992									
DMY 1st harvest	–	–	*1.47*	–	–	–	*1.68*	–	–	*2.01*
Plant height	–	–	–	–	–	*1.68*	–	*1.55*	–	*1.53*
DMY 2nd harvest	–	–	–	–	–	–	–	–	–	*1.72*
DMY 3rd harvest	–	–	–	–	–	–	–	–	*1.59*	*1.49*

Cultivars or populations of cross-pollinated species grown outside their area of adaptation are expected to show an explosion of variability mainly due to the interaction between the genotypes and the new environment (Mather, 1953). Several authors (Ludwig et al., 1953; Clausen & Hiesey, 1958; Cooper, 1959; Ceccarelli & Lorenzetti, 1977) have already reported this behaviour in a number of species; the entries of lucerne examined here showed the same behaviour. It is likely that some of the lucerne varieties tested in Perugia are characterized by a wide genetic base. For example, synthetics of lucerne released in the USA from both public and private companies are often developed by selecting parents from a large number of different sources, with the average number of parents being 92 (Short, 1986). If the varieties of lucerne were characterized by a narrow genetic base, then it is likely that they had been selected for an environment somewhat different from that of Perugia.

Casalina SY generally showed the same amount of variability as Casalina, but in 3 cases out of 19 (time of the first and second flowering and plant height at the third harvest of 1991) it was more variable. Casalina FC was less variable than Casalina in only one case (plant height at the first harvest of 1992), and it was more variable in 6 cases out of 19. This suggests that the selection conducted in Casalina for high seed yield and the adaptation to a more frequent cutting regime did not restrict the variation for important agronomic characters.

The landrace Italia Centrale, registered *ex officio* by the Ministry of Agriculture for Central Italy, was one of the most variable entries for dry matter yield per plant at the first and second harvest of 1991 and plant height in 1991 (Table 2). Italia Centrale was less variable in only 7% of the 190 comparisons with all other entries, but more variable in as many as 23% of them. This large variation could have been the consequence of a mechanical mixing of seeds produced by many farms licensed to multiply this landrace. A recent survey showed that Italia Centrale is multiplied by at least 53 farms scattered all over central Italy (F. Lorenzetti, personal communication), probably in areas with different environments.

Table 2. Significant ($P < 0.05$) F-ratios between the variance of the registered landrace of lucerne Italia Centrale and that of each of the other lucerne entries for the agronomic characters evaluated. Numbers in bold means that the variance of Casalina was smaller than the variance of the entry used in the test, while numbers in italics means that the variance of Casalina was greater than the variance of the entry used in the test

Characters	Boreal	Casalina	Cas.SY	Cas.FC	Delta	Equipe	Estival	Miral	Robot	Tornese
	Season 1991									
1st flowering	–	*2.19*	–	–	–	1.47	2.44	–	*1.58*	–
DMY 1st harvest	*2.55*	*1.68*	*1.91*	*1.63*	*1.79*	*2.09*	–	*1.55*	*1.68*	*2.10*
Plant height	*1.75*	*1.87*	–	–	–	*1.91*	–	–	*1.61*	*1.68*
No. of shoots	–	–	–	–	–	–	–	–	–	–
2nd flowering	–	–	2.10	–	–	–	–	–	1.73	–
DMY 2nd harvest	–	–	*1.67*	–	–	–	–	–	–	*1.74*
Leafiness	*1.67*	–	–	–	1.47	–	1.70	–	1.74	–
No. of shoots	–	–	*1.92*	–	–	*1.48*	–	–	–	–
Plant height	*2.24*	*2.37*	*1.78*	*2.41*	*1.64*	*2.68*	*1.59*	*3.06*	*1.87*	*1.75*
DMY 3rd harvest	*2.04*	–	–	–	–	–	–	–	*1.68*	–
Plant height	*1.72*	*2.24*	–	–	–	*1.92*	–	*1.60*	*1.59*	*1.80*
No. of shoots	–	–	–	1.66	–	–	–	–	–	1.53
DMY 4th harvest	–	–	*1.67*	–	–	–	–	–	–	–
Plant height	–	–	–	–	–	–	–	–	*1.51*	–
No. shoots	–	–	–	–	–	–	1.90	–	–	1.63
	Season 1992									
DMY 1st harvest	–	–	–	–	–	–	*1.57*	–	–	*1.89*
Plant height	–	–	1.51	–	–	–	–	–	–	–
DMY 2nd harvest	–	–	–	–	–	–	–	–	–	–
DMY 3rd harvest	–	–	–	–	–	–	1.70	–	–	–

Conclusions

The results indicate that Casalina is one of the most uniform of the entries tested in this trial. Its uniformity within its area of cultivation was somewhat expected while the large variation found in the cultivars recommended for Central Italy was totally unexpected. Their genetic base, although narrow compared with Casalina, was probably not narrow enough to restrict their phenotypic variation. This is a sufficient reason to state that Casalina is sufficiently uniform to be directly registered at the Italian National Registry of Varieties.

As Casalina is one of the less variable lucernes in the area of Perugia, other landraces of lucerne would probably show the same behaviour in their own area of adaptation. This has practical relevance both in breeding programmes and in seed legislation because in cross-pollinated species the uniformity and stability of landraces/varieties can be found only within their area of adaptation/selection. Therefore, public and private companies should be more careful in recommending improved varieties to farmers. In dense stand experiments conducted in our environment, Casalina has always shown a good yielding ability (Falcinelli et al., 1978) and was the best entry in another trial conducted for three years with the same materials included here (Russi et al., unpublished). Landraces are still so commonly used because it is difficult to outyield them in their environment. Farmers have always produced on-farm seeds only from the best fields of lucerne two to three years after establishment, thus conducting a sort of 'simple recurrent selection' where natural and human selection pressures have converged (Falcinelli et al., 1978).

One of the problems that farmers will be facing in the near future is that landraces will no longer be available on the market. It will be a disaster if good, adapted landraces (still common in Italy) are not collected soon and used in breeding programmes in order to develop varieties adapted to specific areas. A survey conducted in Central Italy by the Istituto di Miglioramento Genetico Vegetale indicated that some landraces, which were

available from farmers in 1990 were no longer available in 1993. Therefore, the need of collecting and storing them is urgent because of their great value as a source of adapted and productive germplasm.

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