SELECTION FOR SELF-FERTILITY AND SELF-FERTILITY IN ALFALFA AS A TOOL FOR BREEDING STRATEGY ASSESSMENT [1]

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ABSTRACT

Cultivar development in alfalfa relies on heterosis, that has been mainly exploited by intercrossing selected clones from diverse gemplasm sources; an alternative way was proposed, based on developing double cross cultivars obtained by crossing clones selected for self-sterility, propagated by somatic seed. A different breeding strategy was recently emphasized based on population improvement through inbreeding and recurrent selection; in this case, self-sterility would be selected against. If self-sterility is determined by genetic load, the second strategy should be preferred, and selecting for self-fertility may bring about positive correlated responses for forage yield. Divergent selection for self-fertility was applied in a central Italian alfalfa landrace to test this hypothesis. Ten self-fertile and ten self-sterile plants were selected and hand-crossed without emasculation in a n(n-1) diallel; seeds of reciprocal crosses were pooled, obtaining 45 full-sib families per fertility group. Ten plants per family were evaluated for self-fertility. Selection was effective for self-fertility (h^2_R=0.52), but not for self-sterility, a result expected if self-sterility is determined by genetic load. The forage yield of self-fertile progenies was 135% of the unselected control and 123% of the self-sterile progenies in a dense stand trial (first cut, seedling year), indicating that selection for self-fertility could be a tool for population improvement.

INTRODUCTION

Cultivar development in alfalfa is generally based on intercrossing clones from diverse germplasm sources, selected phenotypically or following progeny testing. While this method permits the exploitation of heterosys, it may cause problems when poorly adapted germplasm is introduced.

Another way that has been proposed for utilizing heterosys is developing double cross cultivars based on self-sterile clones propagated by somatic seed (Bauchan et al., 1991; McKearsie and Bowley, 1993). Substantial progress in the somatic seed technology must be attained before this approach can be practicable, and the genetic control of self-sterility has to be taken into account.

A different breeding strategy relies on population improvement through recurrent selection (Pfeiffer and Bingham, 1983; El Nahrawy and Bingham, 1989). In the light of the greater importance attributed to 'complementary gene interactions' with respect to allelic interaction in determining vigor (Bingham et al., 1994), inbreeding in the selection process could help reduce the genetic load and fix favorable linkage groups. Populations selected through inbreeding and recurrent selection should not demonstrate severe inbreeding depression, so performance of cultivars should not be affected by selfing.

Self-fertility in alfalfa is drastically reduced by inbreeding, usually more than forage yield (Wilsie, 1966; Busbice, 1968, 1970). It was attributed to 'relational incompatibility' (Fyfe, 1957), that can be related to genetic load (Busbice, 1968). If the genetic loads for fertility and for forage yield are at least partly coincident, selection for self-fertility may help reduce the genetic load and bring about positive correlated responses for forage yield. In this perspective, selecting self-sterile genotypes for developing hybrids would not be a valuable strategy. Divergent selection for self-fertility was applied in a central Italian alfalfa landrace to test the previous hypothesis.

MATERIALS AND METHODS

Five hundred plants of the central Italian landrace 'Casalina' were sown in pots under bee proof cages and evaluated for self-fertility (seeds produced per floret tripped, 30 to 40 florets per plant); 10 self-fertile (SF) and 10 self-sterile (SS) plants were selected on the basis of 3 evaluations of self-fertility made in different environmental conditions (Rosellini et al., 1994). The 10 plants of each group were hand crossed without emasculation in a n(n-1) diallel; equal amounts of seeds from reciprocal crosses were pooled, thus obtaining 45 full-sib families per group. Ten plants per family were grown in pots randomized within bee-proof cages and evaluated for self-fertility. In the spring 1996, 360 seeds from 30 random F_1 families per each fertility group (10 to 13 seeds per family) were bulked and sown in microplots 22.5 x 20 cm wide, in the field, with 4 replications (90 seeds per replication); unselected, open pollinated control seed was included. At 25% flowering, dry matter yield and percentage of plants alive per plot were evaluated.

RESULTS AND DISCUSSION

Selection was effective for self-fertility (h^2_R=0.52), but not for self-sterility (Table 1). These results are expected if self-sterility is determined by genetic load; a simple genetic model that explains the self-sterility of SS genotypes and the lack of response when selecting for self-sterility is presented in Figure 1. The SF plants, on the contrary, would have a low genetic load, i.e., a high frequency of dominant genes for fertility, and their progenies would show improved self-fertility.

The forage yield of SF progenies was significantly higher than that of the control (Table 1); their superiority to SS progenies was considerable (23%), though not significant. The percentage of plants alive was 67%, 89% and 88% for the control, SF and SS progenies, respectively. These results could be due to a higher percentage of S_1 in the open-pollinated control, with respect to SF and SS progenies obtained by hand-crossing. Carleton and Eslick (1967), Davis and Gartner (1966) and Gartner and Davis (1966) have indicated that the self-fertility level of the parents is not correlated with the percentage of S_1 plants in the progeny when manual crosses are made without emasculation. Unpublished data by the authors based on RAPD markers showed high average percentages of hybrid seed from hand-crossing between SF and between SS genotypes, irrespective of parental self-fertility.

If the dry matter yield of SF selected population should be demonstrated to be higher than that of SS population in the subsequent cuts, selection for self-fertility could be regarded as a tool for population improvement.

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Table 1
Results of divergent selection for self-fertility and effect on forage yield (dry matter, g per plot).
Means in a column followed by different letters are different at the 0.05 level according to the LSD test.

	Self-fertility (seeds per flower tripped**)**							**Dense stand trial**	
Population	x_S	N	S	x_1	N	R	h^2_R	Forage yield	%Plants alive
SF	2.61	10	1.80	1.76a	423	0.93	0.52	18a	89a
Control	0.81	453		0.83b	57			13b	67b
SS	0.01	10	-0.80	0.70b	383	-0.13	0.16	15ab	88a

Figure 1
Proposed mode of action of two fertility genes (1) segregating in the selfed and F_1 progenies of highly self-sterile alfalfa genotypes (2)