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Effect of cultivar and environment on seed yield in alfalfa

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SUMMARY – The seed yield improvement is critical for the commercial development of alfalfa varieties. The seed yield of 12 varieties was analysed in 12 environments obtained through the combination of four locations and three years of harvest in a three-replicates design. At harvest, seed yield, above ground biomass, harvest index (calculated as the ratio between seed yield and the aerial biomass), seed weight per inflorescence and lodging susceptibility were measured. The main source of variation in seed yield among environments was the biomass. The genetic variance for seed yield was large and the cultivar   environment variance was small. Thus, its broad-sense heritability was high (0.55). The genetic correlation between seed yield and lodging was also high with the lodging-tolerant varieties showing a higher seed yield. Seed yield was genetically correlated with harvest index (r_g = 0.99). A higher harvest index was achieved through a genetic increase in seed weight per inflorescence (r_g = 0.91). There was no genetic correlation between seed yield and the vegetative biomass suggesting that breeding for a higher seed yield should not be deleterious to the vegetative growth and forage production potential. Seed weight per inflorescence could be a valuable selection criterion to be used under a spaced plant design.

Key words: *Medicago sativa*, genotype   environment interaction, heritability, biomass, inflorescence.

***RESUME –** "Effet de la variété et de l'environnement sur le rendement en graines de la luzerne". L'amélioration du rendement en graines est critique pour le développement commercial des variétés de luzerne. Le rendement en graines de 12 variétés a été analysé dans 12 milieux obtenus par la combinaison de quatre lieux et trois années de récolte, dans des dispositifs à trois répétitions. A la récolte, le rendement en graines, la biomasse aérienne, l'indice de récolte (calculé par le rapport entre le rendement en graines et la biomasse aérienne), le poids de graines par inflorescence et la sensibilité à la verse ont été mesurés. La source principale de variation pour le rendement en graines entre milieux a été la biomasse. La variance génétique pour le rendement grainier était importante et l'interaction variété   milieu était faible. Aussi, son héritabilité au sens large était importante (0,55). La corrélation génétique entre le rendement en graines et la verse était élevée, et les variétés résistantes à la verse avaient un plus fort rendement en graines. Le rendement en graines était corrélé, au niveau génétique, avec l'indice de récolte, lui-même corrélé génétiquement au poids de graines par inflorescence. Il n'y avait pas de corrélation génétique entre rendement en graines et biomasse végétative, suggérant que la sélection pour un plus fort rendement en graines ne serait pas négative sur la croissance végétative et le potentiel de rendement en fourrage. Le poids de graines par inflorescence pourrait être un bon critère de sélection, utilisable dans des dispositifs de plantes isolées.*

Mots-clés : Medicago sativa*, interaction génotype   milieu, héritabilité, biomasse, inflorescence.*

Introduction

Seed production is not part of the agronomic value of a forage crop. But, in alfalfa, as in all forage species, it is critical in the commercial development of a new variety (Falcinelli, 2000). Indeed, it determines its delivery to the farmers at a competitive price.

Major advances in seed production were achieved through optimisation of the agronomic practices, but little progress has been achieved in breeding over the last three decades. This is partly due to the lack of efficient selection criterion that could be easily used in routine in a breeding nursery. Genetic diversity for seed yield and seed yield components in alfalfa was described between and within-populations by Bolaños-Aguilar *et al.* (2000). Similarly, genetic variation was identified for pollen fertility (Viands *et al.*, 1988), ovule fertility (Rosellini *et al.*, 1998) and ease of tripping (Knapp and Teuber, 1994), traits that influence seed yield. These characters are not easy to measure on large numbers of plants and they are not the only limiting factors of seed yield in dense canopies. The present study was aimed to analyse the heritability of the seed yield and its components and to determine the genetic and environmental correlations among them. These will contribute to define the selection criteria.

Materials and methods

Twelve cultivars were chosen among the Flemish and Provence material currently grown in western Europe. They were drilled in four sites in France in spring 1997 in plots of 3 rows, 5 m long and 45 cm apart. The sowing density was 2.4 kg/ha. The four sites were located in the main areas for alfalfa seed production and run either by INRA or by FNAMS (Fédération Nationale des Agriculteurs Multiplicateurs de Semences).

The trials were studied in 1997 (Y0), 1998 (Y1) and 1999 (Y2). When needed, depending on the location, the crops were clipped in late April-early May. Pollination was ensured by native pollinators that were abundant in all trial sites and assumed not to be a limiting factor.

At harvest, a sample of 30 well-podded inflorescences was collected on each individual plot. A sub-sample of two pods per inflorescence was collected and threshed to estimate the number of seeds per pod and the mean seed weight. The seed weight per pod was measured. The total aerial biomass was measured by collecting all the material at the back of the combine harvester. The dry matter content was measured on a 500 g sample dried in an oven at 80ºC till weight stabilisation. The seeds were dried and cleaned to calculate the seed yield. The harvest index was calculated as the ratio between seed yield and total aerial biomass (seed + pod walls + vegetative parts).

The data were analysed by an analysis of variance. Because of the significant harvest year location interaction, each combination between year and location was considered an environmental condition. Genetic and environmental correlations were calculated from the MANOVA variance-covariance matrices.

Results and discussion

Effect of the cultivars and the environmental conditions

The trials were characterised by high seed yield, which averaged about 800 kg/ha. Seed yield among cultivars ranged from 421 to 1021 kg/ha. The highest seed yield was of the cultivar Radius bred in Poland (Table 1), the lowest were produced for two Y0 crops (257 and 366 kg/ha), whereas the highest seed yields, up to 1628 kg/ha, were achieved in Y1 and Y2 crops in Etoile (South-East of France).

Table 1. Seed yield (kg/ha) of 12 varieties in four locations in France over three years

Variety	Location											
	Marans			Etoile			Condom			Lusignan		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Variety												
Luzelle	632	540	390	569	881	1447	270	770	511	213	642	643
Sitel	707	950	518	543	1122	1770	388	1271	598	169	860	731
Diane	782	864	617	702	1335	1544	346	1222	675	336	847	871
Magali	443	536	357	534	1026	1495	284	962	414	287	714	513
Bella	693	800	597	765	1269	1812	441	1350	644	279	877	860
Radius	1004	1071	763	679	1583	1945	334	1545	686	212	998	1161
Medalfa	721	790	621	772	1225	1714	498	1295	600	364	794	816
Lp2507	927	1090	731	819	1425	1682	553	1528	762	325	909	991
Mercedes	673	635	491	664	1191	1733	322	14400	572	175	787	947
Coussouls	285	263	252	476	593	987	227	594	290 c	175	421	431
Europe	741	944	605	614	1462	1563	389	1227	507	320	900	864
Rival	647	592	446	780	1318	1848	338	1284	460	381	794	717
S.E.	93	76	90	85	100	191	73	171	95	41	96	84

The genetic variance for seed yield was large while the cultivar environmental condition variance was small. This led to high broad-sense heritability (h^2 = 0.55). Similarly, the broad-sense heritability was high for the harvest index (0.57) and the seed weight per inflorescence. On the opposite, it was low for the aerial biomass (0.16) and mean seed weight (0.14).

Correlations among traits

A high genetic correlation was detected between seed yield and harvest index (Table 2, Fig. 1) as well as between seed yield and seed weight per inflorescence (Fig. 2). A high harvest index was achieved through a high seed weight per inflorescence. This trait could be easily measured with small size samples, either in yield trials or in breeding nurseries in families or even in individual plants.

Throughout environmental conditions, seed yield was highly correlated with aerial biomass. Due to its high heritability and the large genetic correlations with seed yield, this trait could be a valuable selection criterion, easy to include in the breeding schemes to achieve genetic progresses in seed yield in alfalfa.

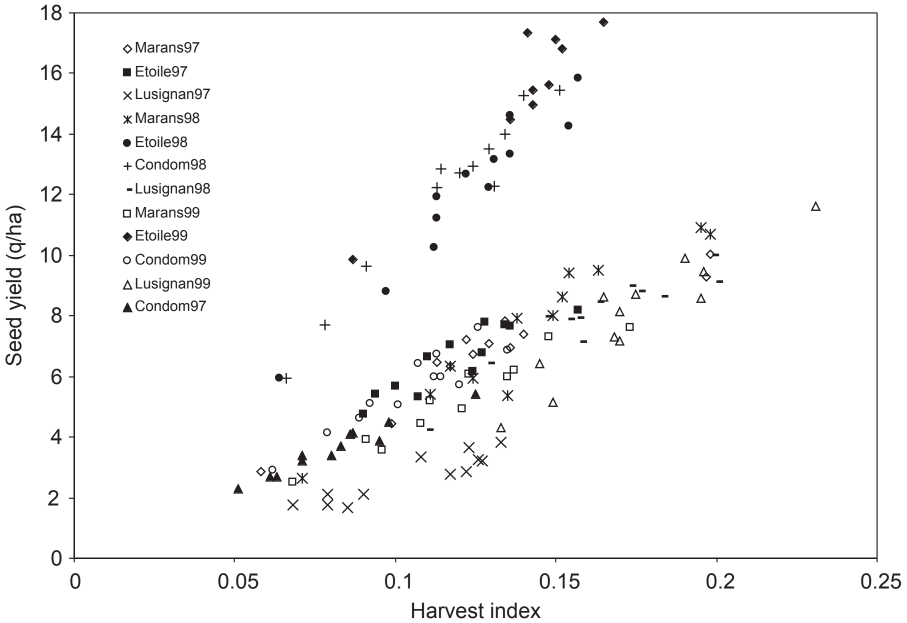

Fig. 1. Relationship between harvest index and seed yield among 12 cultivars in 12 environments.

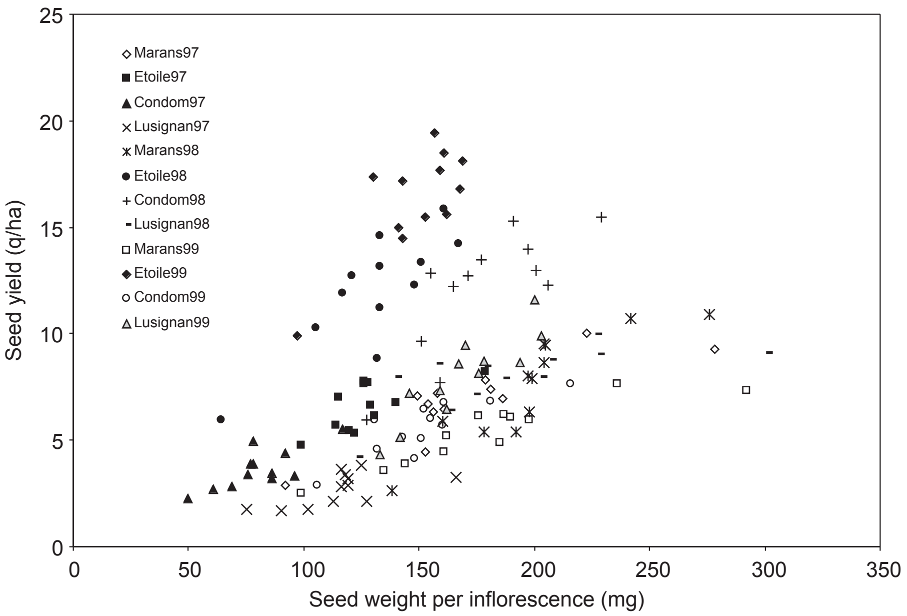

Fig. 2. Relationship between seed weight per inflorescence and seed yield among 12 cultivars in 12 environments.

Table 2. Genetic (above diagonal) and environmental (below diagonal) correlations between seed yield, biomass, harvest index and yield components

	Seed yield	Aerial biomass	Harvest index	Seed weight/ inflorescence	No. seeds/pod
Seed yield		0.79	0.99	0.91	0.81
Aerial biomass	0.94		0.69	0.58	0.35
Harvest index	0.40	0.07		0.96	0.80
Seed weight/ inflorescence	0.25	0.05	0.68		0.64
No. seeds/pod	0.35	0.13	0.75	0.83	

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References

Bolaños-Aguilar, E.D., Huyghe, C., Julier, B. and Ecalle, C. (2000). Genetic variation for seed yield and its components in alfalfa (*Medicago sativa* L.) populations. *Agronomie*, 20: 333-345.

Falcinelli, M. (2000). Temperate forage seed production: Conventional and potential breeding strategies. *Newsletter International Herbage Seed Production Research Group*, 31: 7-15.

Knapp, E.E. and Teuber, L.R. (1994). Selection progress for ease of floret tripping in alfalfa. *Crop Sci.*, 34: 323-326.

Rosellini, D., Lorenzetti, F. and Bingham, E.T. (1998). Quantitative ovule sterility in *Medicago sativa*. *Theor. Appl. Genet.*, 97: 1289-1295.

Viands, D.R., Sun, P. and Barnes, D.K. (1988). Pollination control: Mechanical and sterility. In: *Alfalfa and Alfalfa Improvement*, Hanson, A.A., Barnes, D.K. and Hill, R.R. Jr. (eds), *Agron. Monogr.* No. 29. ASA, CSSA, and SSSA, Madison, WI, p. 931-960.