

Evaluation of Seed Retention in Improved Populations of Cocksfoot (*Dactylis glomerata* L.)

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ABSTRACT

Two experimental populations derived from the U.S. cocksfoot cv. Hallmark, and improved under spaced plant conditions for seed retention using backcross and phenotypic recurrent selection respectively, were grown in rows for seed production, and in a dense stand for forage production. In the seed production trial the improved populations did not differ for seed yield, but yielded significantly higher than the original cv. Hallmark. The results showed that the selection response was clearly present under the agronomic conditions typical for seed production, and that the two breeding methods were equally efficient for transferring seed retention. Forage yield in dense stand conditions did not differ significantly among cv. Hallmark and the two improved populations.

Additional index words: *Dactylis glomerata*, seed shattering, backcross, phenotypic recurrent selection.

INTRODUCTION

Cocksfoot or orchardgrass (*Dactylis glomerata* L.) is a perennial grass native to western and central Europe now spread throughout the temperate zones of the world. In this species, as in many other forage grasses, the seeds do not mature and ripen uniformly because of staggered flowering (McWilliam 1980; Young, 1991). Consequently, early maturing seeds frequently shatter before late developing ones mature (Bean, 1965; Griffiths, Lewis and Bean, 1980; Wilkins, 1991). Normally, maximum yields of viable seed of commercial cultivars of cocksfoot are obtained at the cream cheese stage (Pegler, 1976), which corresponds to about 40% moisture content (Klein and Harmond, 1971). Early harvesting to avoid seed shattering can result in a large quantity of unripened seeds that must then be removed during cleaning, whereas if harvesting is delayed, seed loss through shattering becomes predominant. Losses of more than 20% have been reported (Nellist and Rees, 1963; Andersen and Andersen, 1980) due to delayed harvesting.

Several agronomic strategies can be used by seed producers to minimise seed losses (Loch and Harvey, 1983), but the additional costs involved have limited their use. Therefore, as in several other forage grasses, selection for seed retention in this species is strongly recommended (Elgersma, Leeuwangh and Wilms 1988; Hides and Desroches, 1989; Hampton, 1991; Lorenzetti, 1993). Previous papers (Falcinelli, Veronesi and Lorenzetti, 1983; Falcinelli, Veronesi and Negri, 1984) reported that cocksfoot populations from southern and central Italy did not shatter seed even at the full maturity stage. Seed shattering is delayed until late autumn and seed retention is under genetic control with a high degree of heritability (Falcinelli, Negri and Veronesi, 1989).

The objectives of the present study were to:

- (a) – evaluate whether the U.S. cv. Hallmark, improved for seed retention with different breeding strategies under spaced plant conditions, maintained adequate seed retention when grown in rows for seed production;
- (b) – evaluate whether the forage production of cv. Hallmark was affected by the introduction of seed retention;

- (c) – compare the backcross and the phenotypic recurrent selection methods for possible differences which could have arisen in cv. Hallmark as a result of the improvement for seed retention (Piccirilli and Falcinelli, 1989).

MATERIALS AND METHODS

The study was carried out using the following populations:

- (1) The U.S. cv. Hallmark, improved by two cycles of backcrossing to the Italian cv. Marta (donor of seed retention) (Falcinelli, 1991), hereafter called HSB (Hallmark Selected Backcross).
- (2) The cv. Hallmark improved by phenotypic recurrent selection in the following way: the same F₁ plants selected for backcrossing to cv. Hallmark were cloned and allowed to intercross instead of backcrossing to cv. Hallmark. The intercrossing was performed in pollen-proof cabins built by Clear Span Ltd. Greenfield near Oldham. UK. The complex of pollen-proof cabins is made up of 48 separate cabins each 200 cm in height with a floor of 144 x 144 cm. Each cabin is provided with fresh, filtered air to keep the inside temperature low and to improve pollination. Water is supplemented by capillarity through a sand layer to avoid opening of the doors. A complete set of clones from each of the 20 selected plants was placed in each cabin. An equal amount of seed harvested from each of the 20 plants was mixed and used to grow 1,200 F₂ plants among which 20, showing the characteristics of cv. Hallmark, but with the seed retention of cv. Marta, were selected. The 20 plants were cloned and intercrossed. This phenotypic recurrent selection was repeated twice, giving rise to Hallmark improved by polycrossing selected progenies, hereafter called HSP (Hallmark Selected by Polycrossing).
- (3) The cv. Marta characterised by high seed retention, hereafter called M.

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(4) The cv. Hallmark, hereafter called H.

Two trials were carried out by sowing the four types of seed in spaced rows for seed production and in a dense stand for forage production. In the trial for seed production, each plot consisted of four rows 2 m long, spaced 50 cm apart. The sowing rate was 5 kg ha⁻¹. In the trial for forage production, each plot was 1 m long and 1.5 m wide. The amount of viable seed sown was 40 kg ha⁻¹.

Both trials were arranged according to a randomised complete block design with four replications. The trials were sown in the experimental field of the Plant Breeding Institute of the University of Perugia (43°05' N) in October 1991. Seed production and other characters were determined in 1992 and 1993. Seed yield was measured at two separate harvest dates in each year by harvesting 50 cm of the two central rows of each plot. The first harvest (I) was made when more than 50% of the last internodes of H and M were yellow. The second harvest (II) was made 15 days after the first harvest. Seed weight (mg/1000 seeds) was determined for both harvests.

In 1992 main panicles were randomly chosen at heading time from each plot and labelled. On these panicles several characters were determined: (1) heading date (days from 1 April), (2) flowering date (days from 1 April), (3) plant height (cm) at flowering (inflorescence included), (4) length (cm) and width (mm) of the flag leaf and (5) seed shattering. Seed shattering was determined when the last internode of each labelled panicle had turned from green to yellow by harvesting the inflorescences, striking each panicle on a piece of white cardboard and scoring using a scale of 1 = less than five seeds shattered to 9 = all seeds shattered. This work was done by the same person who tapped the panicle on a piece of cardboard only once. Arcsin transformation was used on the percentages

of seed losses estimated by the following formula:

Data are reported in actual units.

$$\text{Seed loss (\%)} = \frac{\text{yield I harvest} - \text{yield II harvest}}{\text{yield I harvest}} \times 100$$

In the forage production trial one cut was performed during the month of May in both years. The harvest was made by hand when about 50% of the panicles of the plots were heading. The green forage was dried at 110°C for 48 hours and the dry matter yield (g m⁻²), hereafter called DMY, was determined.

RESULTS AND DISCUSSION

The two improved populations (HSB and HSP) did not differ from the original H population for heading time, flowering time, plant height and flag leaf length and width (Table 1), whereas population M differed significantly from the other populations for all these characters except flag leaf width (Table 1). Seed shattering was similar in the two improved populations (3.9 and 4.2 for HSB and HSP respectively), but intermediate between the two cultivars (Table 1).

Seed yield of the two improved populations was significantly greater than that of the original H population at both harvests in 1992 (Table 2). Yield for all three populations was lower (by 20.4, 23.4 and 23.3 g m⁻² for HSB, HSP and H respectively) at the second harvest because of shattering losses which ranged from 44.4 to 68.9% (Table 2). Population M had

Table 1. Characteristics of two populations of cocksfoot improved for seed retention, and two control populations.

	Heading time (days)	Flowering time (days)	Plant height (cm)	Length of flag leaf (cm)	Width of flag leaf (mm)	Seed shattering (1=min-9=max)
HSB	30.1 A	42.9 B	119.8 B	22.9 A	10.9 A	3.9 B
HSP	29.1 B	42.5 B	120.4 A	25.5 A	12.3 A	4.2 B
M	38.6 A	54.4 A	99.9 B	15.4 B	8.1 B	1.8 C
H	28.9 B	42.6 B	115.6 A	24.5 A	10.5 AB	8.6 A

Within columns, means followed by the same letter are not significantly different at $P < 0.05$.

only 8% seed losses (Table 2) confirming the resistance of this cultivar to shattering. The low seed yield (27.8 and 25.5 g m⁻² (Table 2) is a characteristic of many Italian cocksfoot cultivars (Falcinelli and Veronesi, 1990).

The seed loss data do not account for losses that occurred before the first harvest, and consequently for populations characterised by early seed shattering (e.g H), the loss is underestimated. The data do confirm however that both breeding

methods were equally effective in improving the seed retention of H.

In 1992 M had a thousand seed weight (TSW) significantly lower than H, and both improved populations had intermediate values between M and H, but always significantly higher than M (Table 2). A comparison between the values of the two harvest times shows that the losses caused by shattering did not modify the TSW.

Table 2. Seed characters of four populations of cocksfoot in 1992 and in 1993

Seed yield (g m ⁻²)	Harvest			
	I ¹		II ²	
	1992	1993	1992	1993
HSB	45.9 A	90.1 A	25.5 A	43.5 A
HSP	47.1 A	85.6 A	23.7 A	37.3 A
M	27.8 C	48.9 C	25.5 A	45.3 A
H	33.8 B	70.0 B	10.5 B	18.3 B

Seed losses (%)	1992		1993	
	HSB	44.4 B	51.7 B	
HSP	49.7 B	56.4 B		
M	8.0 C	7.4 C		
H	68.9 A	73.9 A		

1,000 Seed weight (mg)	Harvest			
	I ¹		II ²	
	1992	1993	1992	1993
HSB	1110 B	1040 A	1139 B	1119 A
HSP	1122 B	990 A	1101 B	1001 A
M	865 C	820 B	848 C	848 B
H	1211 A	1110 A	1228 A	1118 A

Within columns, means followed by the same letter are not significantly different at $P < 0.05$.

¹ harvested when more than 50% of the internodes of H and M were yellow.

² harvested 15 days after I.

Results obtained in 1993 were substantially the same as in 1992 (Table 2). Overall seed yields were higher in 1993 probably due to better development of the plants. H had a significantly higher TSW in 1992, but in 1993 the differences between H and the two selected progenies were not significant.

In 1992 there were no significant differences among populations for DMV (mean = 364 g m⁻²) but in 1993 M had a significantly higher yield (737 g m⁻²) than the other entries (573 g m⁻²). This was due to a loss of plants in all the plots containing H, HSP and HSB. The poor adaptation of foreign *D. glomerata* cultivars to the central Italian climate has been previously reported (Falcinelli and Ceccarelli, 1977).

In summary, two cocksfoot populations exhibiting good seed retention as spaced plants maintained this characteristic when grown in rows for seed production. Forage production was not significantly affected by selection for seed retention. Backcrossing appears to be equally efficient for the improvement of seed retention in orchardgrass.

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