BREEDING FOR IMPROVED FORAGE QUALITY IN ALFALFA

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Abstract: Currently there is much interest in breeding for improved forage quality in alfalfa. Several winterhardy alfalfa varieties with higher forage quality have been released, however these varieties are generally unadapted in California. In several studies, small but consistent differences in forage quality have been detected among current nondormant and semidormant varieties. We have successfully generated many experimental multifoliolate cultivars that have superior forage quality and yield. These new experimentals are being widely tested to insure that multiple pest resistance, persistence, and performance are competitive across a wide range of conditions.

Keywords: Alfalfa forage quality, multifoliolate leaves, acid detergent fiber, neutral detergent fiber, protein concentration, total digestible nutrients.

INTRODUCTION

Although alfalfa is the premier forage crop, significant losses in forage quality occur under normal management and harvest conditions. Our objective is to improve the genetic potential for forage quality of the standing alfalfa crop, while continuing to improve forage yield, multiple pest resistance, and persistence. It is intended that new varieties bred for improved forage quality will maintain their quality advantage through maturity, and perhaps be more tolerant of field losses even under suboptimal harvest conditions.

Two general strategies to improve forage quality are: 1) to modify the plant architecture to improve leafiness, and 2) to alter chemical composition of the the crop. In winter dormant alfalfa, resistance to numerous foliar diseases has led to improved leaf retention and forage quality. Several researchers have exploited the multifoliolate (ML) trait in alfalfa to increase leafiness. Most alfalfa germplasms have a small percentage of ML plants, and breeders have selectively bred for a high degree of ML expression.

The advent of near infrared reflectance spectroscopy (NIRS) has greatly enhanced alfalfa breeders' ability to screen large numbers of entries for several parameters of forage quality. Presently there are nine winter dormant varieties from five alfalfa breeding firms which were bred for improved forage quality. Eight ML cultivars are being marketed, and one company released a variety bred for increased forage quality *per se*. Unfortunately, these winter dormant cultivars are not widely adapted in California. This report summarizes our breeding program to increase forage quality in semidormant and nondormant alfalfa.

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MATERIALS AND METHODS

In 1987, many strain crosses were made between elite VISTA nondormant breeding lines and ML plants from three donor sources: a 1979 germplasm release from the University of Arizona, AZMFA-1 (3), VISTA winter dormant lines, and random ML "sports". The resulting progenies were screened for ML expression alone, or ML plus pest resistance and crossed to initiate a second cycle of selection. Many lines with limited numbers or similar pedigrees were bulked, and all lines were then entered into our mainstream breeding program for multiple pest resistance and agronomic performance.

Since 1988, breeder seed has been produced on many ML populations, and these are routinely evaluated for forage yield, pest resistance and forage quality. Prior to each harvest, plant samples are obtained to evaluate ML expression and for NIRS analyses. The forage quality parameters estimated from NIRS are: protein concentration, acid detergent fiber (ADF), and neutral detergent fiber (NDF) (1). From these data, we also estimate total digestible nutrients (TDN), relative feed value (RFV), and pounds of crude protein per acre (CP/A).

Space-planted breeding nurseries are established each year to select for elite agronomic performance and forage quality on an individual plant basis. In 1990 and 1991, breeder seed was produced on several ML populations which had been further selected by NIRS. These experimentals are now being tested.

RESULTS AND DISCUSSION

The ML trait was easily tansmitted into many nondormant and semidormant backgrounds. Seedling ML expression ranged from 0 to 39% ML plants in progenies from crosses between trifoliolate and ML parents, and 0 to 12% from intercrosses among ML sports. Field ML expression has been evaluated at every harvest over a three-year period in early VISTA experimentals. The percentage of ML plants in 23 experimental varieties ranged from 12 to 94%, and is stable over cuttings and years.

Small but significant differences in forage quality were demonstrated at every sampling date. Because of the wide range in maturity differences (fall dormancy classes 6 to 9), caution must be used in interpretation of forage quality data. However within groups of nondormant, intermediate, and semidormant entries, there were consistent differences in forage quality. The performance data are presented in chronological order: 1988 experimentals tested in 1989 - 1991, 1989 experimentals tested in 1990 - 1991, and 1990 experimentals tested in 1991.

Over three years in a 1988 yield trial at Woodland, three ML experimentals had average protein concentration, TDN, and RFV significantly higher than six standard trifoliolate entries, (Table 1). However forage yield and CP/A of these ML entries were 90% and 96%, respectively, of the trifoliolate varieties.

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In a replicated clonal nursery established at Woodland in 1990, significant differences were detected for all traits evaluated. Although the plants were purposely selected for similar maturity there was a high degree of genetic variability (Table 2). Of 190 plants, the highest yielding plant yielded 374% more dry matter than the poorest plant, but also had the lowest protein concentration. The best plant for protein concentration also had the highest RFV. Several experimental varieties were derived from plants with good forage yield and quality, and these are now being tested.

We believe that by exploiting both the ML trait and NIRS technology we can successfully release new cultivars bred for improved forage quality for California. It appears that we have slightly improved forage quality in a standing crop of alfalfa, and we will likely continue to make progress. Future on-farm trials are planned to determine if a quality advantage is actually obtained across a range of normal hay and haylage operations. Although the potential genetic gains are small, high quality varieties combined with proper crop management and handling techniques will benefit both the cash hay farmer and the on-site feeder.

CONCLUSIONS

From these studies, we have concluded that the ML trait can be successfully incorporated into nondormant and semidormant backgrounds. The ML expression of numerous VISTA experimental varieties is stable across cuttings and years. Several experimentals selected only for ML expression have superior forage quality and yield when compared to conventional trifoliolate varieties. Significant and consistent genetic variability for forage quality exists both within and among alfalfa populations, and progress through conventional plant breeding should be effective.

REFERENCES

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Table 1. Forage quality summary of VISTA multifoliolate (ML) experimental varieties and trifoliolate (tri) check varieties in forage yield trials at Woodland, CA.

	Yield	----------Mean Across Cuts--------						CP/A
	t DM/A	%ML	%Prot	ADF	NDF	RFV	TDN	lbs
	(1988 Trial, seeded 10/88, harvested 1989 - 1991							
3 ML lines	31.06	70	21.5	32.0	44.8	133.6	58.3	13356
6 tri	34.40	0	20.3	33.0	44.9	131.0	57.6	13966
MAX **Yield**	**39.05**	0	18.9	33.9	45.6	127.7	56.9	14761
MIN **Yield**	**29.22**	89	22.4	31.2	43.9	137.0	59.0	13091
MAX **%Prot**	29.22	89	**22.4**	31.2	43.9	137.0	59.0	13091
MAX **%Prot**	39.05	0	**18.9**	33.9	45.6	127.7	56.9	14761
	(1989 Trial, seeded 10/89, harvested 1990 - 1991)							
14 ML lines	24.71	59	21.3	32.1	44.9	132.7	58.3	10526
22 tri	25.76	0	20.6	32.5	44.7	132.5	57.9	10613
MAX **Yield**	**28.32**	0	20.3	32.6	44.6	132.6	57.9	11498
MIN **Yield**	**23.05**	90	23.0	30.0	43.4	140.5	59.8	10603
MAX **%Prot**	23.05	90	**23.0**	30.0	43.4	140.5	59.8	10603
MIN **%Prot**	26.39	0	**18.9**	34.1	45.1	128.7	56.8	9975
	(1990 Trial, seeded 10/90, harvested 1991)							
20 ML lines	14.89	65	20.8	32.0	44.5	133.9	58.3	6194
16 tri	14.69	0	19.8	33.1	45.5	129.2	57.5	5817
MAX **Yield**	**16.12**	50	20.3	33.1	45.3	129.6	57.5	6545
MIN **Yield**	**13.24**	0	19.8	33.3	45.8	128.2	57.4	5243
MAX **%Prot**	13.56	83	**22.8**	30.1	43.5	140.1	59.7	6184
MIN **%Prot**	15.12	0	**19.0**	33.8	46.0	126.9	57.0	5745

Table 2. Variability in forage quality among 190 replicated nondormant ML clones harvested four cuttings in 1990 and 1991 at Woodland.

		Yield	----Mean Across Cuts---				CP
		g/plant	%Prot	ADF	NDF	RFV	g/plant
MAX **Yield**	C-503	**384.2**	15.7	35.5	41.5	139.7	60.5
MIN **Yield**	C-508	**81.0**	20.4	29.3	34.5	178.2	16.5
MAX **%Prot**	C-197	129.9	**21.5**	27.7	23.9	190.4	28.0
MIN **%Prot**	C-503	384.2	**15.7**	35.5	41.5	139.7	60.5
MAX **RFV**	C-197	129.9	21.5	27.7	23.9	**190.4**	28.0
MIN **RFV**	C-602	108.0	16.7	35.5	41.6	**137.2**	18.1