

Forage production of nine alfalfa cultivars in the semiarid region of Puerto Rico¹

Luis E. Tergas, Jaime Vélez-Santiago and Doralisa Vera de Saldaña²

ABSTRACT

Dry forage production of alfalfa (*Medicago sativa*) cultivars with overhead irrigation was determined by cutting every 30 to 35 days for 3 years (1983-85) at the Fortuna Agricultural Research and Development Center. Florida 66 and 77, and a mixture of these two cultivars, produced highest yields with mean annual dry forage (DF) of 25.38, 28.86 and 26.96 ton/ha, respectively. Raidor and ARC were the least productive cultivars, with means of 15.40 and 16.27 ton DF/ha, respectively. Forage production per cutting was inversely related to rainfall, highest yields were obtained with irrigation during the dry season. Mean crude protein, phosphorus, potassium, calcium and magnesium contents for all cuttings were 20.2, 0.40, 4.54, 1.39 and 0.38%, respectively. Results confirm that it is feasible to grow alfalfa for hay on well drained Cumulic Haplustolls in the southern coast with well adapted cultivars and proper agronomic practices.

INTRODUCTION

The dairy industry in Puerto Rico depends on concentrate feeds because the forage quality of tropical grasses and legumes is not sufficient to meet the nutritional requirements of specialized dairy cattle during most of the lactation period (10). Alfalfa (*Medicago sativa*) is the highest quality forage used in intensive dairy production systems in the United States (11). It is fairly well adapted to the cool climate at high altitudes in the tropics of South America (4) and grows well on fertile soils in semiarid environments in the subtropics (9). However, it is very susceptible to foliar diseases in wet environments (3) and it does not tolerate acid soils high in soluble Al and Mn (7).

In Puerto Rico, previous research has indicated that with supplemental irrigation, alfalfa can be grown for hay in the semiarid southern region (5). Crop persistence has been affected by a fungus disease caused by *Phytophthora megasperma* under poorly drained conditions in the Lajas Valley (12). However, several cultivars were highly productive and persisted for 2 years in the semiarid climate and in the well drained soils of the southern coastal areas at Fortuna, Puerto Rico, with proper crop management (13)

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²Associate Professor, Agronomy and Soils Department; Associate Agronomist, (ret.), Corozal Substation; and Research Assistant, Corozal Substation, respectively, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P. R.

The objective of the present research was to continue studies on forage production and persistence with clipping at regular intervals of adapted alfalfa cultivars grown in a promising semiarid environment.

MATERIALS AND METHODS

The experiment was conducted at the Fortuna Agricultural Research and Development Center, lat. 18° 2' N and long. 66° 31' W, in the semiarid region of Puerto Rico. Mean annual rainfall is 877 mm distributed mainly from May through November, and mean daily air temperature is 26 C°. The soil is a San Antón clay (Cumulic Haplustolls), average pH is 7.5 with 48 p/m available P (Bray I) and 796 p/m exchangeable K in the top 20 cm. A randomized complete block design with four replications was used. The treatments were nine alfalfa (*Medicago sativa*) cultivars and a 1:1 mixture of two of the latter (both from Florida), planted January 1983. The alfalfa cultivars are identified in table 1. The plots were 6.1 x 1.8 m including 10 rows of plants with 25.5 cm between rows.

The seeds were inoculated with proper *Rhizobia* immediately before planting (2) and handseeded at a rate of 13.4 kg/ha. The herbicide Trifluralin was used as a preemergent at a rate of 1.4 kg a.i./ha and incorporated into the soil 24 h prior to planting (1). The experiment was topdressed annually with 224 kg/ha of P, 672 kg/ha of K and 6 kg/ha of borax. Aerial irrigations were applied daily after planting, and thereafter 3 to 5 times per month throughout the experimental period, except during the rainy months of September, October and November.

The plants were cut at a height of 5 cm in nearly full-bloom stage every 30 to 35 days. The green forage was weighed in the field and subsamples were dried at 60° C in a forced-air oven for 48 h for dry matter determination. Subsamples were composited by replication in each harvest interval and analyzed for N, P, K, Ca and Mg. Crude protein (CP) content was computed as N x 6.25.

TABLE 1.—*Identification and origin of alfalfa cultivars*

Cultivar	Origin
1. Valador	Northrup King & Co., Minneapolis, Minnesota
2. Maxidor	Northrup King & Co., Minneapolis, Minnesota
3. Raidor	Northrup King & Co., Minneapolis, Minnesota
4. Brand 819	Northrup King & Co., Minneapolis, Minnesota
5. ARC	USDA-Agricultural Research Service, Beltsville, Maryland
6. Moapa	FAO-United Nations Development Program, Santo Domingo, Dominican Republic
7. Maracay	Dept. Agronomy, Venezuela Central Univ., Maracay, Venezuela
8. Florida 66	Agronomy Dept., Univ. of Florida, Gainesville
9. Florida 77	Agronomy Dept., Univ. of Florida, Gainesville

TABLE 2.—Mean dry forage yields of alfalfa cultivars at Fortuna during 1983

Cultivar	Number and date of cutting										Mean
	1 Mar 29	2 May 2	3 May 31	4 Jun 30	5 Aug 10	6 Aug 30	7 Sept 29	8 Oct 31	9 Dec 5	10 Jan 8	
	<i>t/ha</i>										
Florida 77	3.14 ¹	3.33 a	2.92 a	3.63 a	2.36 a	2.05 abc	3.14 a	3.09 a	2.49 a	2.91 a	2.90 ab
Raidor	3.04 a	3.21 a	2.42 a	2.78 a	1.78 a	1.63 bc	1.98 c	1.89 c	1.76 c	2.29 ab	2.28 abc
Brand	2.79 a	2.81 a	2.83 a	3.41 a	2.51 a	2.38 abc	3.23 a	3.18 a	2.15 abc	2.64 ab	2.84 abc
Valador	2.77 a	3.18 a	3.03 a	3.36 a	2.79 a	2.05 abc	3.24 a	3.03 a	2.32 abc	2.60 ab	2.91 a
Maracay	2.68 a	3.37 a	3.12 a	3.52 a	2.70 a	2.50 a	3.24 a	3.03 a	2.32 abc	2.60 ab	2.91 a
Florida 66	2.57 a	2.76 a	2.59 a	3.56 a	2.88 a	2.16 abc	2.83 ab	2.95 a	2.34 ab	2.46 ab	2.72 abc
Florida 66 & 77	2.53 a	3.12 a	2.74 a	3.29 a	2.62 a	2.41 ab	3.16 a	2.97 a	2.31 abc	2.84 ab	2.80 abc
ARC	2.48 a	3.40 a	2.28 a	2.57 a	1.72 a	1.44 c	2.10 bc	2.07 c	1.83 bc	2.02 b	2.20 c
Maxidor	2.46 a	3.10 a	2.57 a	3.18 a	1.83 a	1.86 abc	2.47 abc	2.31 bc	1.79 bc	1.79 bc	2.38 abc
Moapa	2.28 a	2.98 a	2.97 a	3.09 a	2.51 a	1.94 abc	2.84 ab	2.64 ab	1.93 bc	2.46 ab	2.56 abc
Mean	2.70	3.13	2.75	3.24	2.37	2.04	2.79	2.70	2.11	2.49	2.63

¹Means in columns followed by the same letter do not differ significantly at the 5% probability level, Duncan's Multiple Range Test.

Duncan's Multiple Range Test was used to compare treatments with regard to dry forage (DF) yield for each harvest, for each year and over the full 3-year experiment.

RESULTS AND DISCUSSION

All cultivars were highly productive in 1983, the first year of the experiment, with mean annual yields of over 2.2 t DF/ha per cutting (table 2). The most productive cultivar, Maracay, was not significantly different from the others ($P=0.05$) among cultivars for the first five cuttings; thus all were fairly well adapted to environmental conditions at Fortuna. Yields of cultivars ARC and Raidor began to decline in the rainy season, August through November, but they recovered after the December cutting.

During the second year of the experiment, most of the cultivars, other than ARC and Raidor, were highly productive with mean annual yields over 2.5 t DF/ha per cutting (table 3). Florida 77 produced the highest mean yield, but it was significantly higher than ARC and Raidor only. All cultivars produced high yields of DF in most of the cuttings. DF yields in 1984 were greater than in 1983, except during the rainy season, October through December.

The mean annual yields of the Florida cultivars were over 2.0 t DF/ha per cutting during the third year of the experiment (table 4). Florida 77 was the most productive cultivar, although it was not significantly different ($P=0.05$) from Florida 66 and the mixture of these two. Maracay, Valador, Brand 819, Maxidor and Moapa were intermediate; ARC and Raidor produced the lowest yields and were invaded by weeds toward the end of the experiment.

Florida 77 was the most productive cultivar during the three years of the experiment with a mean total yield of 28.87 t DF/ha/year, although this advantage was not significant ($P=0.05$), except when compared with Raidor and ARC, which produced the lowest yields (table 5). The mean total DF production for all cultivars in 1983 and 1984, 26.31 and 27.16 t DF/ha/year, respectively, were not significantly different ($P=0.05$). Thereafter, 1985 yields declined significantly ($P=0.05$) to 15.77 t DF/ha/year (table 5).

Forage productivity was related to rainfall distribution for most of the duration of the experiment. Highest yields were usually obtained with irrigation in the drier months of the year, whereas heavy rainfall during April and May, and September, October and November resulted in lower yields per cutting (fig. 1). Apparently, alfalfa cultivars were tolerant to a root rot caused by *Phytophthora megasperma*, but were still susceptible to temporary waterlogged conditions right after intensive rainfall in the rainy season.

TABLE 3.—Mean dry forage yields of alfalfa cultivars at Fortuna during 1984

Cultivar	Number and date of cutting										Mean
	11 Feb 16	12 Mar 21	13 Apr 23	14 May 21	15 Jun 25	16 Aug 2	17 Sept 4	18 Oct 5	19 Nov 9	20 Dec 13	
	<i>t/ha</i>										
Florida 77	3.13 a ¹	4.29 a	4.13 a	3.40 a	3.84 ab	3.55 a	3.56 ab	2.78 a	1.51 ab	1.90 ab	3.22 a
Maracay	3.11 a	3.76 ab	3.93 a	3.30 a	4.01 a	3.43 ab	3.77 a	2.22 bc	1.42 ab	1.88 ab	3.08 a
Valador	2.96 a	3.96 a	4.10 a	3.27 a	4.08 a	2.95 abc	3.44 abc	2.14 bcd	1.49 ab	1.77 ab	3.02 a
Florida 66 & 77	2.94 a	3.41 ab	3.51 a	3.13 ab	3.68 ab	3.11 abc	3.30 abc	2.44 ab	1.70 a	1.94 ab	2.91 a
Florida 66	2.85 a	3.55 ab	3.59 a	3.03 abc	3.19 ab	3.15 abc	3.02 abc	2.51 ab	1.50 ab	2.03 a	2.84 ab
Moapa	2.54 a	3.27 ab	3.69 a	2.81 abc	2.92 b	2.81 abc	2.89 abc	1.82 d	1.11 ab	1.40 b	2.53 abc
Brand 819	2.54 a	3.66 ab	3.75 a	3.07 abc	3.47 ab	3.00 abc	3.21 abc	1.88 cd	1.24 ab	1.59 ab	2.74 ab
Maxidor	2.51 a	3.28 ab	3.48 a	2.53 bc	3.53 ab	2.85 abc	3.44 abc	1.91 bcd	1.00 b	1.55 ab	2.61 abc
Raidor	2.46 a	2.82 b	3.11 a	2.42 c	3.18 ab	2.38 abc	2.34 c	0.95 w	0.34 c	0.39 c	2.04 c
ARC	2.35 a	2.87 b	3.34 a	2.49 bc	3.04 ab	2.62 bc	2.51 bc	1.22 e	0.90 b	0.48 c	2.18 bc
Mean	2.74	3.49	3.66	2.94	3.49	2.98	3.15	1.99	1.22	1.50	2.72

¹Means in columns followed by the same letter do not differ significantly at the 5% probability level, Duncan's Multiple Range Test.

TABLE 4.—Mean dry forage yields of alfalfa cultivars at Fortuna during 1985

Cultivar	Number and date of cutting										Mean
	21 Jan 18	22 Feb 25	23 Mar 27	24 Apr 29	25 May 30	26 Jun 28	27 Aug 2	28 Sept 4	29 Oct 10	30 Nov 20	
	<i>t/ha</i>										
Florida 77	2.69 a ¹	2.83 a	3.07 a	3.92 a	3.26 a	3.36 a	2.75 a	1.66 a	0.87 a	0.96	2.54 a
Florida 66 & 77	2.32 ab	2.75 a	2.90 ab	3.15 ab	3.07 ab	2.88 ab	2.89 a	1.68 a	0.98 a	1.08 a	2.37 ab
Maracay	2.25 abc	2.62 ab	2.82 ab	3.04 ab	2.50 abc	2.25 bc	1.63 bc	0.55 bcd	0.38 bc	0.22 b	1.83 bc
Valador	2.24 abc	2.44 ab	2.78 ab	2.98 ab	2.40 bc	2.44 ab	1.54 bc	0.73 bc	0.32 bcd	0.25 b	1.81 bc
Florida 66	2.20 abc	2.33 abc	2.80 ab	3.05 ab	2.64 abc	2.68 ab	2.20 abc	1.13 ab	0.72 a	0.77 a	2.05 abc
Brand 819	1.78 bc	2.11 bc	2.34 bc	2.87 b	2.47 abc	2.32 b	1.50 bcc	0.80 bc	0.40 b	0.31 b	1.69 cd
Moapa	1.68 bc	1.80 c	1.90 c	2.25 b	1.86 c	1.38 c	0.66 cd	0.19 cd	0.08 bcd	0.01 b	1.18 d
Maxidor	1.53 c	2.16 bc	2.51 ab	2.47 b	2.10 c	2.20 bc	1.16 bc	0.39 cd	0.17 bcd	0.18 b	1.49 cd
ARC	0.69 d	0.94 d	0.99 d	1.15 c	0.76 d	0.44 d	0.10 d	0.03 d	0.05 ed	0.00 c	0.51 e
Raidor	0.53 d	0.46 d	0.61 d	0.69 c	0.39 d	0.27 d	0.08 d	0.02 d	0.00 e	0.00 c	0.30 e
Mean	1.79	2.04	2.27	2.56	2.15	2.02	1.45	0.72	0.40	0.38	1.58

¹Means in columns followed by the same letter do not differ significantly at the 5% probability level, Duncan's Multiple Range Test.

TABLE 5.—Mean total dry forage yields of alfalfa cultivars at Fortuna from 1983 to 1985

Cultivar	Year			Mean
	1983	1984	1985	
	<i>t/ha</i>			
Maracay	29.09 a ¹	30.81 a	18.26 bc	26.05 ab
Florida 77	29.05 a	32.19 a	25.36 a	28.86 a
Valador	28.38 abc	30.16 a	18.11 bc	25.55 abc
Florida 66 & 77	28.04 abc	29.14 a	23.70 ab	26.96 ab
Florida 66	27.21 abc	28.42 ab	20.52 abc	25.38 abc
Brand 819	27.18 abc	27.41 ab	16.91 cd	23.83 bc
Moapa	25.63 abc	25.28 abc	11.81 d	20.90 bed
Maxidor	23.79 abc	26.06 abc	14.89 cd	21.58 bc
Raidor	22.77 abc	20.40 c	3.04 e	15.40 d
ARC	21.96 c	21.81 bc	5.15 e	16.27 d
Mean	26.31	27.17	15.77	23.08

¹Means in columns followed by the same letter do not differ significantly at the 5% probability level, Duncan's Multiple Range Test.

Yields of DF of the well-adapted alfalfa cultivars Florida 66 and 77, and the mixture of these two cultivars, were higher in the present investigation than those reported in Florida (8) and the Dominican Republic (6), but similar results were obtained in a previous experiment conducted in the same region of Puerto Rico in the first year of evaluation (13). However, crop persistence in this experiment was better; acceptable yields were still produced after 27 cuttings (table 4).

Crude protein, P, K, Ca and Mg content, means for all cuttings, were 20.2, 0.40, 4.54, 1.39, and 0.38%, respectively (table 6). These values are similar to those reported before in a similar experiment in the same location (13), except for K, which was about 1% higher in the present trial.

These results confirm that it is feasible to grow alfalfa for hay with adapted cultivars on the well drained Cumulic Haplustolls soils in the semiarid region of Puerto Rico. Proper agronomic practices, including inoculation with effective *Rhizobia*, fertilization with P and K, weed and insect control when required, and supplemental irrigation during the dry season assure good yields and crop persistence.

RESUMEN

Producción de forraje de nueve cultivares de alfalfa en la región semiárida de Puerto Rico

Se realizó un experimento por tres años para determinar la producción de forraje seco (DF) en el Centro de Investigación y Desarrollo de Fortuna en la costa sur de Puerto Rico de 1983 a 1985. Las cultivares más productivas al cabo de los tres años fueron Florida 66 y 77 y una mezcla de ambas, con una producción media anual de 25.38, 28.86 y 26.96 tons. de DF/ha.,

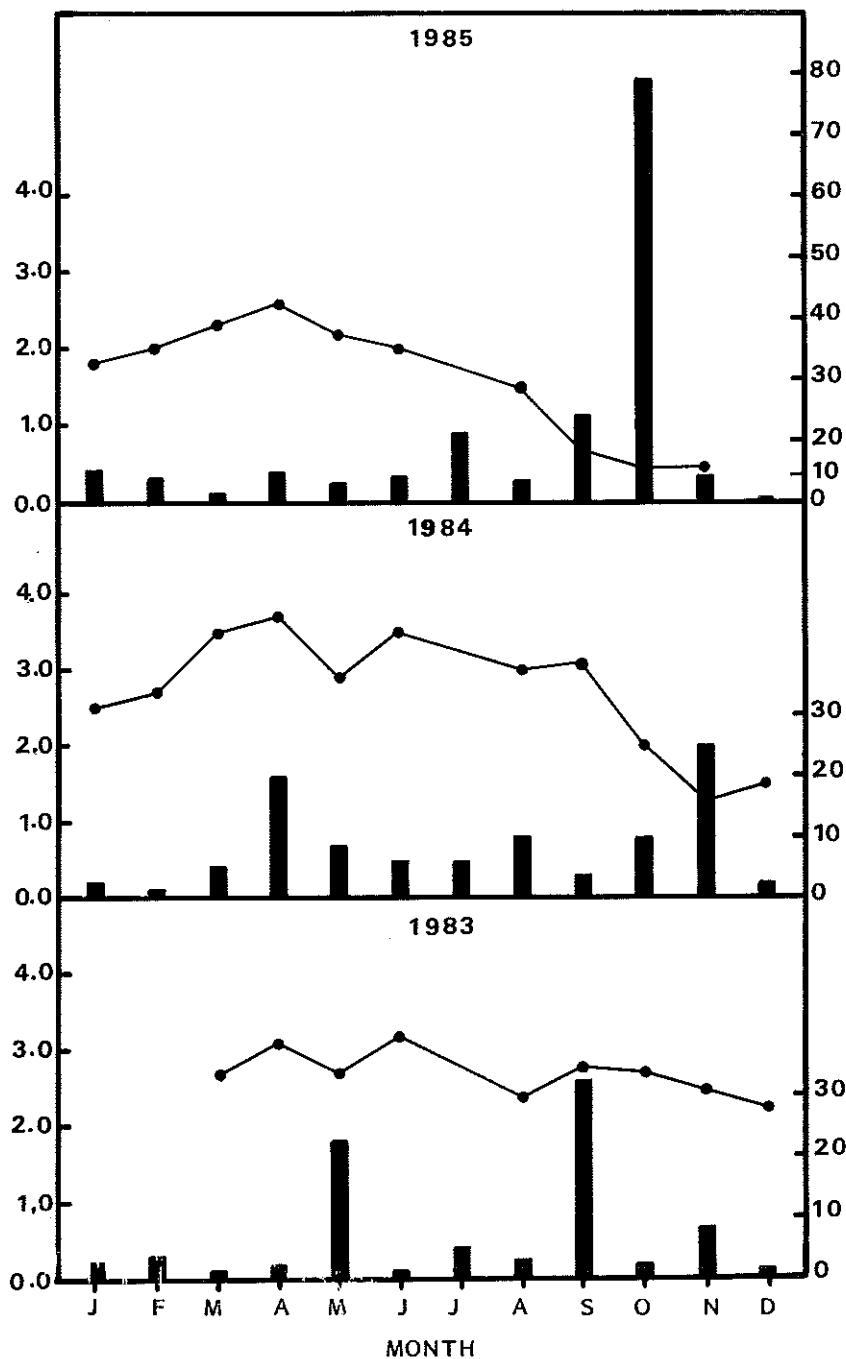


FIG. 1.—Seasonal dry mean forage yields for all alfalfa cultivars cut every 28 to 38 days.

TABLE 6.—Crude protein and mineral contents¹ of alfalfa cultivars at Fortuna from 1983 to 1985

Cultivar	Crude protein	P	K	Ca	Mg
		%			
Florida 77	20.9	0.42	4.51	1.45	0.39
Florida 66 & 77	21.3	0.42	4.60	1.41	0.39
Maracay	17.9	0.37	4.21	1.40	0.35
Valador	20.3	0.40	4.67	1.43	0.38
Florida 66	18.7	0.39	4.33	1.42	0.37
Brand 81\$9	19.9	0.39	4.52	1.41	0.37
Moapa	19.8	0.40	4.62	1.40	0.36
Maxidor	19.6	0.39	4.56	1.43	0.38
ARC	21.1	0.40	4.60	1.28	0.40
Raidor	22.9	0.43	4.75	1.29	0.38
Mean	20.2	0.40	4.54	1.39	0.38

¹Mean for all cuttings.

respectivamente. La producción por corte estuvo relacionada con la distribución de las lluvias, siendo menor durante los meses más lluviosos, debido posiblemente a las condiciones ocasionales de encharcamiento a pesar de que el suelo tiene características de buen drenaje. El contenido medio en todos los cortes en proteína bruta, fósforo, potasio, calcio y magnesio de las 9 cultivares fue 20.2, 0.40, 4.54, 1.39 y 0.38, respectivamente, el cual fue similar a otros resultados obtenidos en un experimento anterior en la misma región. Los resultados confirman que es posible sembrar alfalfa para heno en suelos Cumulic Haplustolls bien desaguados en la región semiárida, contando con cultivares adaptadas e irrigación, y realizando prácticas agronómicas adecuadas.

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