Relationships between dry matter yield, forage nutritive value, and some canopy parameters of alfalfa crop

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Introduction

Yield and quality of alfalfa forage are greatly influenced by the cultivar choice. Genotypic differences cause variation in the plant anatomy, morphology and chemical composition producing a large effect on alfalfa performances. Breeding programs improve quality by using nutritive values and morphological traits of alfalfa canopy, such as plant height, leaf dry weight, leaf area index (LAI), stem dry weight. In most cases, there is a negative correlation between yield and quality, and this is mainly due to the decrease of crude protein concentration with advancing maturity. The objective of this study was to investigate the relationships existing between yield and forage nutritive value and the main morphological traits of alfalfa plants subjected to an intensive harvest regime.

Material and Methods

The trial was conducted from March 2005 to November 2007 at the experimental farm of Padova University (NE Italy) on a silt loam soil, with pH 8.1. The climate in the area is considered sub-continental with an annual mean temperature of 12.3 C and average annual rainfall of 820 mm (Table 1). The experimental design was a split-plot with harvest regimes as the main plot. The plot size was 11.2 m^2 with the test area for yield of 6 m^2 (1.2 m x 5.0 m). Plots were seeded on April 29, 2005 with 16 cultivars: 'Barlydia', 'Centauro', 'Delta', 'Equipe', 'Garisenda', 'Gigante Romea', 'Hystory', 'La Torre', 'Linfa', 'Lodi', 'Palladiana', 'PR56S82', 'PR57N02', 'Riviera Vicentina', 'Robot', and 'Triade'. Before seeding the soil was fertilized with 65 kg ha^{-1} of P and 250 kg ha^{-1} of K. Then, plots were fertilized once a year in February with 65 kg ha^{-1} of P and 250 kg ha^{-1} of K. Plots were subjected to two harvest regimes based on phenological stage: early bud and early flower. In 2005 all plots received 4 cuts, in 2006 and 2007 plots harvested at bud stage received 7 cuts, while plots harvested at early flower received 6 cuts. At each cut a 0.5 kg herbage sample was collected from each plot to determine DM yield and forage nutrient components. Nutrient concentrations were determined using the near infrared reflectance (NIR) spectroscopy. The nutritive value (UFL = French milk forage units) was estimated and expressed as content per dry matter (DM) and per hectare. Plants in 30 cm of rows were collected at each harvest and leaves were separated from stems. Then LAI and stem area index (SAI) were measured using a rotary tape area meter. Finally, stems and leaves were dried at 65 C in forced air oven to determine leaf DM to stem DM ratio (LSR). Plant height was determined at each harvest by measuring the height of the canopy in four points randomly selected within each plot.

Photos 1 and 2: Alfalfa experimental plots after establishment; Comparison between two harvest regimes based on phenological stage (early bud and early flower).

Table 1: Monthly temperatures and precipitations from 2005 to 2007 at the experimental farm of Padova University, Legnaro, NE Italy.

	Avg. temperature (°C)			Total precipitation (mm)		
Month	**2005**	**2006**	**2007**	**2005**	**2006**	**2007**
January	2.5	2.3	5.8	4	31	17
February	3.2	4.7	7.2	2	33	60
March	8.1	7.8	10.5	5	44	79
April	12.1	13.1	16.0	79	42	2
May	18.0	17.1	19.2	117	92	147
June	21.9	21.4	21.3	38	15	61
July	23.7	24.9	23.4	100	48	31
August	21.3	20.1	22.1	241	122	48
September	20.0	20.6	17.6	72	178	105
October	14.2	16.3	13.7	181	16	36
November	8.3	9.2	7.9	143	29	23
December	3.4	6.3	4.0	49	49	32
Annual	13.0	13.6	14.0	1030	699	641

Results and Conclusions

Plant height in both 2006 and 2007 was negatively correlated with UFL in DM (Fig. 1), whereas it was positively correlated with DM yield (2006: $r^2 = 0.74$; $P < 0.001$; 2007: $r^2 = 0.79$; $P < 0.001$). These results are confirmed by other authors, who have reported plant height as an important yield component, and suggested that canopy height could be considered a valuable tool to make a rough estimation of dry matter yield. The plant height was also positively related to UFL ha^{-1}; however, the correlation was greater in 2007 ($r^2 = 0.79$; $P < 0.001$) than in 2006 ($r^2 = 0.63$; $P < 0.01$). A negative relationship was found between DM yield and UFL in 2006 ($r^2 = 0.54$; $P < 0.01$) and 2007 ($r^2 = 0.74$; $P < 0.001$). That correlation between yield and nutritive value has been broadly reported as a consequence of high yield productivity associated with high fibre and low protein content.

A strong positive correlation existed between LAI to SAI ratio and UFL (Fig. 2). LSR showed a similar correlation with forage nutritive value in 2006 ($r^2 = 0.77$; $P < 0.001$) and 2007 ($r^2 = 0.61$; $P < 0.01$), confirming the decrease in forage quality with reducing leaf contribution. From this study we have come to the conclusion that the major canopy parameters (plant height, LAI to SAI ratio, and LSR) can be recommended for alfalfa cultivar improvement for DM yield and forage quality under intensive harvest regimes.

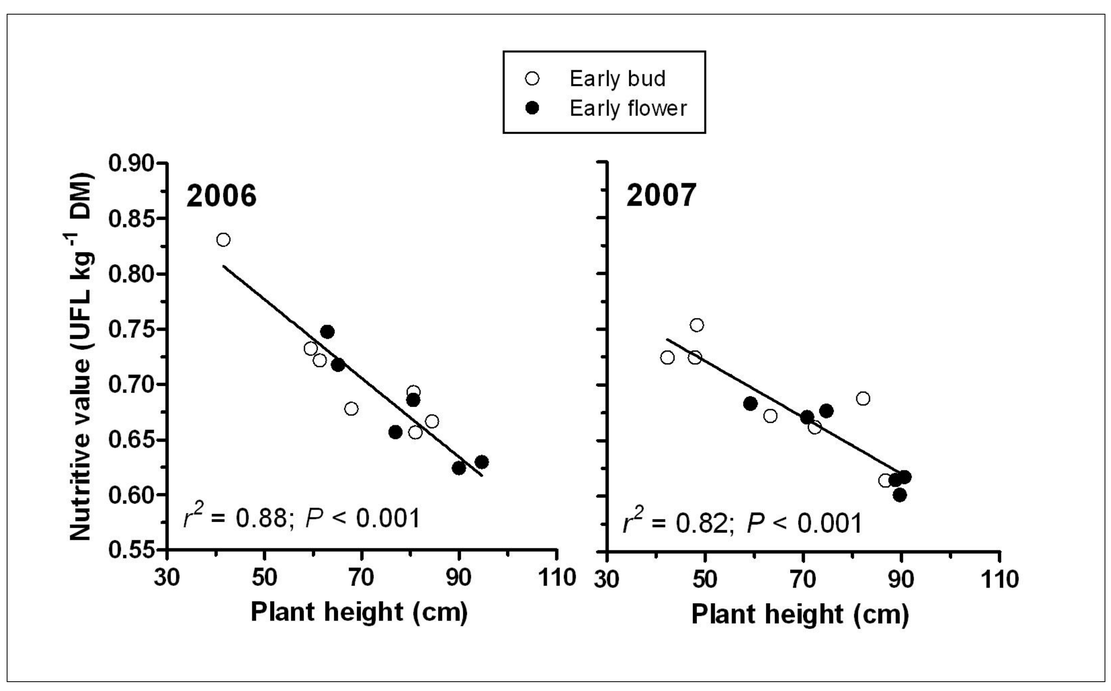

Figure 1: Relationship between alfalfa forage nutritive value and plant height at harvest in 2006 and 2007. Data points are the average of 16 cultivars harvested at early bud or early flower stage.

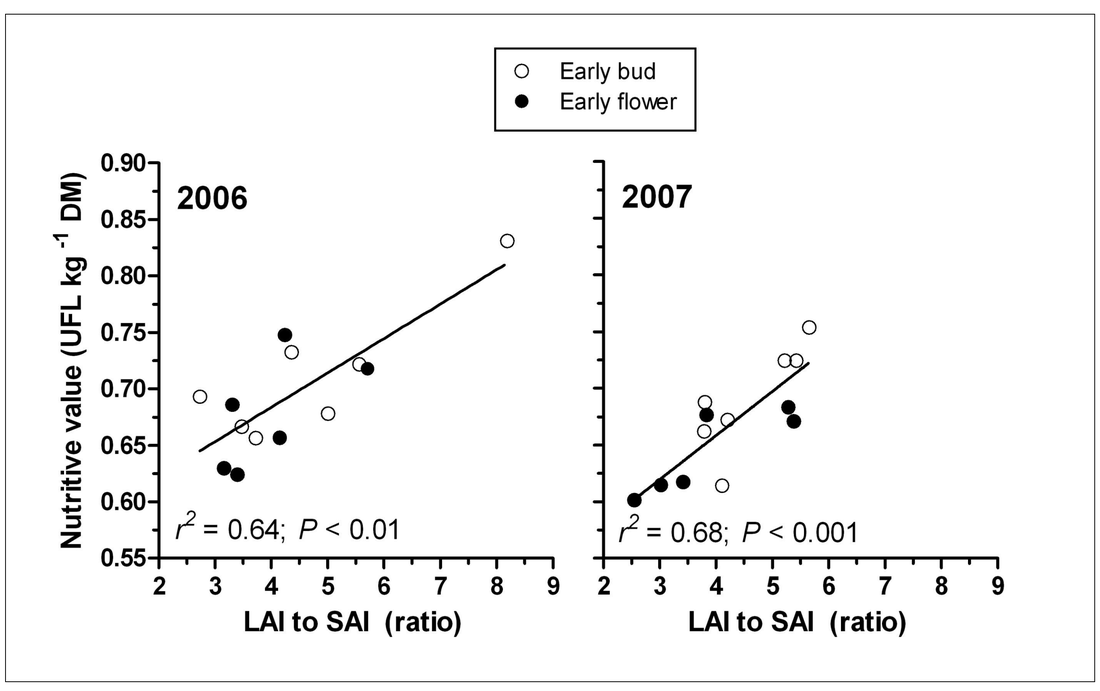

Figure 2: Relationship between alfalfa forage nutritive value and leaf area index (LAI) to stem area index (SAI) ratio in 2006 and 2007. Data points are the average of 16 cultivars harvested at early bud or early flower stage.