Effect of plant density on yield and forage quality of corn for silage

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Keywords: Dry matter yield, forage quality, plant composition, light interception.

Introduction

There is evidence that plant density of maize crops for silage affects herbage yield and quality (Cusicanqui and Lauer 1999). However, most of experimental information comes from trials with a range of plant densities between 20,000 and 140,000 plants per hectare (Pl/ha). This range would be insufficient to establish functional relationships between yield, forage quality, light interception and plant composition (Bertoia 1994). In addition, it is known that dry matter partitioning between plant components varies according to the environmental conditions of a given year (Andrade *et al*. 1991).

The objective of this study was to determine the relationship between the light interception, yield, plant composition and herbage quality of corn for silage across a wide range of plant densities.

Methods

Two experiments were carried out at Pergamino Experimental Station of INTA (33º52´S; 60º33´W) in 2010 (Year 1) and 2011 (Year 2). The experiments were sowing on September 20th and 21st respectively on a typical Argiudol soil. There were 6 plant density treatments: 28,000, 64,000, 100,000, 136,000, 172,000 and 210,000 Pl/ha, arranged in a randomized block design (n = 4). Each plot had 4 rows of 0.7 m apart and 4.0 m long. The experiments were fertilized and weeds were prevented according to standard procedures. All treatments were harvested at the maturity stage of 1/3 of kernel milk line. Measurements included interception of photosynthetically active radiation (IPAR), dry matter yield, morphological plant composition (grain, cob, stem and leaf plus sheath), neutral detergent fiber percentage in plant and stem (NDFp, NDFs, respectively), NDF digestibility in stem (NDFDs) and plant degradability (PDeg). Quality analyses were performing using a Daisy II incubator (Ankom Technology Corporation, Fairport, NY). Data were analyzed by a combined analysis of variance using the Anova Procedure of SAS (2003). Also, linear and quadratic regressions were performed with the Reg procedure of SAS. During the growing period, rainfall was 598 and 364 mm in 2010 and 2011, respectively. In the last year supplementary irrigation was necessary. Even so, yields of high density treatments were lower than in the first year.

Results and Discussion

Except NDFDs, for the remainder of the variables a year by

Table 1. Light interception, yield, plant composition and quality in corn crops for silage with different plant densities over two years.

Year	Treatment Pl/ha	IPAR (%)	Yield (t/ha)	Grain (%)	Leaf (%)	Stem (%)	NDFp (%)	NDFs (%)	PDeg (%)	DNDFs (%)
1	28	48.0	14.2	49.1	22.7	20.2	34.8	47.0	62.5	32.1
	64	60.2	20.6	51.5	21.3	17.5	37.6	48.9	64.1	32.6
	100	80.6	22.9	54.3	21.5	15.0	39.9	55.7	59.1	24.5
	136	78.8	21.9	50.0	24.4	17.8	37.1	62.5	61.5	27.0
	172	78.4	23.5	53.1	23.4	14.1	39.5	63.4	58.9	29.4
	210	81.0	24.1	52.5	23.8	13.8	42.6	61.0	64.0	36.7
2	28	59.1	14.4	52.6	20.6	18.1	40.8	54.6	69.5	37.6
	64	70.6	17.9	51.7	22.8	17.8	46.5	60.4	63.9	35.9
	100	80.8	19.8	50.7	24.8	16.5	45.6	65.6	66.5	36.2
	136	91.2	18.9	43.3	29.4	20.6	48.8	64.5	64.1	35.0
	172	94.9	20.2	49.3	22.5	20.0	43.8	63.4	65.5	34.5
	210	94.3	19.4	38.7	31.9	23.1	45.6	55.6	68.3	39.6
Year	*P* value	***	***	***	***	***	***	***	***	***
	l.s.d.	---	---	---	---	---	---	---	---	3.10
Treatment	*P* value	***	***	***	***	***	***	***	***	*
	l.s.d.	---	---	---	---	---	---	---	---	5.37
Year x treatment	*P* value	*	*	***	***	***	*	***	***	NS
	l.s.d.	6.40	2.47	4.47	2.93	3.27	3.49	5.84	2.14	---

* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$, NS = not significant, l.s.d. Fisher $P < 0.05$

Table 2. Regressions among yield, IPAR and quality variables in corn crops for silage with different plant densities, over two years (n= 6).

Year	Variable X	Variable Y	Model significance	R^2adj.	Equation
1	IPAR	Yield	P<0.01	0.92	$Y = -41.1 + 1.68 x - 0.01 x^2$
2	IPAR	Yield	P<0.01	0.90	$Y = -30.1 + 1.14 x - 0.01 x^2$
1	Yield	NDFp	P = 0.03	0.67	$Y = 25.2 + 0.63 x$
2	Yield	NDFp	NS		
1	Yield	NDFs	P = 0.06	0.54	$Y = 23.6 + 1.55 x$
2	Yield	NDFs	P<0.01	0.87	$Y = 28.8 + 1.81 x$
1	DNDFs	PDeg	P<0.01	0.90	$Y = 46.55 + 0.52 x$
2	DNDFs	PDeg	P = 0.08	0.47	$Y = 32.98 + 0.91 x$
1	NDFs	DNDFs	NS		
2	NDFs	DNDFs	P = 0.06	0.55	$Y = 55.9 – 0.32 x$

treatment interaction was detected (Table 1). So, treatments means are shown separately for each year. Total DM yield and grain content increased to 100,000 Pl/ha. The highest yields, in both years, were achieved when IPAR at flowering was greater than 80%. Quadratic functions were fitted in both years (P<0.01, r^2= 0.92 and r^2=0.92 in 2010 and 2011, respectively, Table 2). The minimum plant density for such IPAR percentage was 100,000 Pl/ha.

NDFs was linearly associated with DM Yield (P<0.06, r^2= 0.54 and P<0.01, r^2= 0.87 in 2010 and 2011, respectively) and PDeg was positively related to NDFDs (P<0.01, r^2= 0.90 and P<0.08, r^2= 0.47 in 2010 and 2011, respectively). In both experiments, higher NDFDs values tended to be recorded with either lowest or highest plant densities (P<0.06). The differences among treatments in the structure of the plant (*e.g.* smaller and thinner plants with high plant densities vs. taller and thicker plants with low plant densities), the ratio cortex/marrow of the stalk and the intrinsic quality of these tissues might be involved in such results (Pinheiro 1984; Di Marco 2003).

Conclusion

Plant population density is a key determinant of dry matter yield and quality of corn for silage. The light interception during flowering is a good estimator of dry matter yield and the degradability of DM was highly related to the digestibility of stem NDF. Although digestibility of stem NDF is rather low, it could contribute to the plant quality, even with high percentage of grain in the plant

Acknowledgments

The authors thank Dr. Oscar Di Marco for assistance in the development of this study.

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