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Corn silage production in the northern oasis of Mendoza, Argentina

Producción de maíces sileros en el oasis norte de Mendoza, Argentina

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Abstract

Meat production in irrigated areas in Mendoza has increased over the last years. Corn silage emerges as an important forage alternative. This paper evaluates three corn hybrids for silage (ACA 417 RR2, ACA 485 MGRR2, ACA 498 MGRR2) cultivated in the northern oasis of Mendoza during the 2015-2016 and 2016-2017 crop cycles. The study was carried out at the agricultural experiment station of the Facultad de Ciencias Agrarias of Universidad Nacional de Cuyo in Luján de Cuyo, Mendoza (33°00'38" S y 68°52'28" W). No differences were detected in green matter (GM) or dry matter (DM) yields among the hybrids during the crop cycles. In the 2015-2016 crop cycle average dry matter yields and green matter yields were 73,760 kg ha^{-1} and 23,493 kg ha^{-1}, respectively, whereas during the 2016-2017 crop cycle green matter yields and dry matter yields were 58,390 kg ha^{-1} and 21,798 kg ha^{-1}, respectively. Genotypes were characterized according to plant height, number of ears of corn, and the ear dry weight/whole plant dry weight ratio. The quality of the three hybrids was also determined. Results obtained suggest that corn silage is a valid forage resource for intensive cattle farming in Mendoza.

Keywords
forage • corn silage • nutritional quality • *Zea mays*

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Resumen

La producción de carne bajo riego en Mendoza creció en los últimos años. El silaje de maíz aparece como una alternativa forrajera importante. En este trabajo se evaluaron tres híbridos de maíz (ACA 417 RR2, ACA 485 MGRR2, ACA 498 MGRR2) para silaje cultivados en el oasis norte de Mendoza, durante las campañas 2015-2016 y 2016-2017. El ensayo se realizó en el campo experimental de la Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Luján de Cuyo, Mendoza; 33°00'38" S y 68°52'28" O. No se obtuvieron diferencias de rendimiento de materia verde ni materia seca entre los híbridos en las campañas evaluadas. En la campaña 2015-2016 el rendimiento de materia verde promedio fue de 73.760 kg/ha y el de materia seca de 23.493 kg/ha; mientras que en la campaña 2016-2017 fueron de 58.390 kg/ha de materia verde y de 21.798 kg/ha de materia seca. Se caracterizaron los genotipos evaluados de acuerdo con: altura de plantas, número de mazorcas por planta, relación peso seco espiga/peso seco planta entera, y se determinó la calidad de los tres híbridos. Los resultados obtenidos confirman que el silaje de maíz es un recurso forrajero válido para intensificar la ganadería en la provincia.

Palabras clave

forraje • silaje de maíz • calidad nutricional • *Zea mays*

Introduction

One of the greatest problems cattle farms are confronted with is lack of feed at certain stages of the production cycle due to the seasonal nature of pasture. In order to ensure forage of high quality and yield to meet beef cattle requirements, preserved forages are used (2).

Corn silage is mainly used as the basic diet of feedlot dairy cattle and steers to supplement forage shortages in winter or the nutritional imbalances of pastures (1). The importance of corn silage as a forage resource lies in the possibility of providing a high quality, high-energy daily food ration year-round which is easy to produce and store, and is very well accepted by the animals (1).

One of the factors that affect corn silage production is the hybrid used. Each hybrid has a production potential that depends on the soil and climate where it is grown. Thus, it is highly useful to know the performance of corn hybrids under the environmental conditions in the region. Selection of the hybrid will depend on the production potential of the environment and on crop management (12).

The performance and nutritional quality of corn silage has been evaluated in different livestock farmin (3, 5, 13, 14, 15). Most of these evaluations were undertaken under rainfed conditions at INTA's experiment stations in the provinces of Buenos Aires, Santa Fe, Entre Ríos and Córdoba. However, there is record of irrigated corn in the province of Neuquén (4).

In Mendoza a few intensive livestock farming undertakings have adopted corn silage in their feeding plans (8, 17) but no experimental results have been published. In 2017 some 3,500 ha were planted with corn silage, representing a significant increase when compared to previous crop cycles (7).

Historically, livestock farming in Mendoza has focused on cattle breeding on natural pastures with an annual production of some 150,000 calves who, after weaning, are sent to provinces in the humid pampas for raising and fattening (10).

However, the province of Mendoza has a number of advantages for raising and fattening on irrigated pastures because its agro-climatic conditions are suitable for growing alfalfa, corn and other forages. Recent studies show that both raising and fattening in feedlots with corn silage as the basic forage would be feasible production alternatives from the technical and economic points of view (9, 10).

Objectives

The objective of this paper is to generate regional information on corn silage production under the farming conditions of Mendoza's northern oasis. Specific objectives are to:

• Compare the production of green matter (GM) and dry matter (DM) per hectare of three corn genotypes.

• Characterize the genotypes assessed according to plant height, number of ears of corn per plant, and the ear dry weight/ whole-plant dry weight (DW) ratio.

• Determine the quality of the three genotypes.

Materials and methods

The study was carried out at the agricultural experiment station of the Facultad de Ciencias Agrarias of Universidad Nacional de Cuyo in Luján de Cuyo, Mendoza (33°00'38" S y 68°52'28" W).

The alluvial soil has a clay-loam texture. Mean annual temperature is 15.7°C, while mean annual rainfall is 248.4 mm (Estación Meteorológica Chacras de Coria, 1959-2013).

During the 2015-2016 and 2016-2017 crop cycles three corn hybrids were grown: ACA 417 RR2, ACA 485 MGRR2, and ACA 498 MGRR2. Crop management is shown in the table 1.

Table 1. Cultural management of experimental corn plots, 2015-2016 and 2016-2017 crop cycles.

Tabla 1. Manejo cultural de las parcelas experimentales de maíces, campañas 2015-2016 y 2016-2017.

	2015-2016 crop cycle	**2016-2017 crop cycle**
Soil preparation Sowing date	Cross harrowing & furrowing 11/17/2015	Cross harrowing & furrowing 10/25/2016
Fertilization: diammonium phosphate (at sowing)	150 kg	150 kg
Weed control: glyphosate at 2 %	2 applications	1 application
Lepidoptera control: chlorpyrifos 0.6 l ha^{-1}	2 applications	Not needed
Water depth applied	Thirteen 30 mm irrigations: 390 mm Rainfall: 308 mm Total: 698 mm	Twelve 30 mm irrigations: 360 mm Rainfall: 226.6 mm Total: 586.6 mm
Harvest date	3/8/2016	3/7/2017

The experimental plots had four 10 m-long furrows 0.60 m apart; 5 seeds per linear meter were sown. The experimental design consisted of randomly selected plots with three replications. Plant stand was determined at harvest time, and the plants were harvested when the grain was at the milk-wax stage of ripeness. Only the two central rows in each plot were harvested; the green weight (GW) was determined; and 3 plants from each plot were taken to determine DW and yield components. Five plants per experimental plot were chopped up to obtain the sample on which forage quality was analyzed at the laboratory. Quality variables included crude protein (CP) and acid detergent fiber (ADF). The values obtained were used to calculate digestibility (Dig) with the following formula:

$$\% \ IVDDM = 88.9 - (\% \ ADF \ X \ 0.779)$$

Energy concentration (EC) of the chopped-up forage was calculated with the following formula:

$$ME = 3.61 \ x \ IVDDM$$

The results obtained from the variables were analyzed using the analysis of variance and the comparison of means (Tukey test).

Results and discussion

The GM and DM yields of the hybrids evaluated in both crop cycles are shown in tables 2 and 3 (page 373). No differences in yields among genotypes were detected in both crop cycles. In the 2015-2016 crop cycle average GM and DM yields were 73,760 kg ha^{-1} and 23,493 kg ha^{-1}, respectively, whereas during the 2016-2017 crop cycle average GM and DM yields were 58,390 kg ha^{-1} and 21,798 kg ha^{-1}, respectively.

Experiences in other parts of the country, though under rainfed conditions, show lower yields per hectare: 16,025 kg of DM on average for 18 corn hybrids tested at the AER INTA Totoras, province of Santa Fe (13); 15,753 kg per ha^{-1} on average in tests carried out on 13 corn hybrids in Río Cuarto, province of Córdoba (14); and 12,086 kg per ha^{-1} of DM in Chascomús, province of Buenos Aires (3). On the other hand, field studies in irrigated areas in the Precordillera (Andean foothills) of Neuquén had corn silage yields of about 12,400 kg ha^{-1} of MS (4).

As regards dry matter percentage at harvest, differences among hybrids were detected in the 2015-2016 crop cycle: the lower percentage was for ACA 417, the highest was for ACA 498 and ACA 485 was somewhere in the middle of the two. This difference could not be detected visually at harvest (grain 2/3 milk line). In the 2016-2017 crop cycle, no differences were found and the average DM percentage at harvest was 37.04%.

With respect to plant height, in the first crop cycle there were significant differences among hybrids, as shown in table 4 (page 373).

However, in the 2016-2017 crop cycle no differences in height were detected among hybrids (table 5, page 373). Plant height was significantly lower in the second crop cycle.

In the 2015-2016 crop cycle, hybrid ACA 498 had more ears of corn/plant than the rest (table 4, page 373), and in the 2016-2017 crop cycle there were no differences among hybrids: all genotypes bore only one ear of corn per plant.

In the first year the ratio of DW of ears of corn/DW of the whole plant showed no differences among hybrids, the average being 45.9%. In the second year ACA 485 showed a lower ratio while ACA 498 had the highest; the ratio for ACA 417 was somewhere in the middle of the two (table 5, page 373).

Table 2. Green matter (GM) yield, dry matter (DM) yield, and percentage of dry matter (DM) of corn hybrids included in the trial. 2015-2016 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 2. Producción de materia verde (GM) y materia seca (DM) y porcentaje de materia seca (DM) de los distintos híbridos de maíz incluidos en la prueba. Campaña 2015-2016, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Plants at harvest (nº)	GM yield (kg ha^{-1})	DM yield (kg ha^{-1})	DM (%)
ACA 417	68,824±1,380 **a**	77,534±6,183 **a**	23,594±2,329 **a**	30.43±1.8 **a**
ACA 485	64,823±8,686 **a**	69,680±3,338 **a**	21,927±625 **a**	31.49±0.68 **ab**
ACA 498	64,961±7,737 **a**	74,065±12,651 **a**	24,957±4,111 **a**	33.72±0.50 **b**

Table 3. Green matter (GM) yield, dry matter (DM) yield, and percentage of dry matter (DM) of corn hybrids included in the trial. 2016-2017 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 3. Producción de materia verde (GM) y materia seca (DM) y porcentaje de materia seca (DM) de los distintos híbridos de maíz incluidos en la prueba. Campaña 2016-2017, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Plants at harvest (N°)	GM yield (kg ha^{-1})	DM yield (kg ha^{-1})	DM (%)
ACA 417	68,669±5,620 a	57,393±5,972 a	20,560±1,947 a	35.90±2.23 a
ACA 485	66,843±767 a	51,575±11,595 a	18,883±4,745 a	36.48±0.90 a
ACA 498	71,712±2,837 a	66,201±15,354 a	25,950±7,761 a	38.75±3.14 a

Table 4. Plant height, number of ears of corn/plant, and DW ears of corn/DW whole plant ratio of the hybrids included in the trial. 2015-2016 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 4. Altura de planta, número de mazorcas/planta y relación DW mazorcas/D planta entera de los distintos híbridos de maíz incluidos en la prueba. Campaña 2015- 2016, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Plant height (m)	N° of ears of corn/ plant	DW ears of corn/DW whole plant (%)
ACA 417	2.83±0.05 b	1.22±0.19 a	46.80±4.97 a
ACA 485	2.64±0.06 a	1.22±0.19 a	44.79±1.28 a
ACA 498	2.73±0.08 ab	1.78±0.19 b	46.11±8.29 a

Table 5. Plant height, number of ears of corn/plant, and DW ears of corn/DW whole plant ratio of the hybrids included in the trial. 2016-2017 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 5. Altura de planta, número de mazorcas/planta y relación DW mazorcas/DW planta entera de los distintos híbridos de maíz participantes de la prueba. Campaña 2016-2017, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Plant height (m)	N° of ears of corn/ plant	DW ears of corn/ DW whole plant (%)
ACA 417	2.45±0.04 **a**	1.00±0.0 **a**	30.41±4.70 **ab**
ACA 485	2.31±0.14 **a**	1.00±0.0 **a**	27.83±5.60 **a**
ACA 498	2.37±0.18 **a**	1.00±0.0 **a**	39.65±1.32 **b**

Table 6. Hybrid quality: gross protein, acid detergent fiber, digestibility and energy concentration. 2015-2016 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 6. Calidad de los híbridos (proteína bruta, fibra detergente ácida, digestibilidad y concentración energética), campaña 2015-2016, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Gross protein (%)	Acid detergent fiber –ADF (%)	Digestibility (%)	Energy concentration EC (Mcal kg MS^{-1})
ACA 417	7.29±0.83 **a**	29.38±2.57 **a**	66.01±2 **a**	2.38±0.07 **a**
ACA 485	7.3±0.42 **a**	29.48±1.7 **a**	65.94±1.33 **a**	2.38±0.05 **a**
ACA 498	6.87±0.38 **a**	32±2.49 **a**	63.97±1.94 **a**	2.31±0.07 **a**

Table 7. Hybrid quality: gross protein, acid detergent fiber, digestibility and energy concentration. 2016-2017 crop cycle, Luján de Cuyo, Mendoza, Argentina.

Tabla 7. Calidad de los híbridos (proteína bruta, fibra detergente ácida, digestibilidad y concentración energética), campaña 2016-2017, Luján de Cuyo, Mendoza, Argentina.

Hybrid	Gross protein (%)	Acid detergent fiber – ADF (%)	Digestibility (%)	Energy concentration EC (Mcal kg MS^{-1})
ACA 417	7.09±0.33 a	28.44±2.55 a	66.74±1.99 a	2.41± 0.07 a
ACA 485	7.01±0.12 a	28.25±1.98 a	66.89±1.54 a	2.41±0.06 a
ACA 498	6.93±0.40 a	30.44±1.78 a	65.18±1.39 a	2.35±0.05 a

Differences in hybrid characteristics from one year to another may be due to changes in environmental conditions. The amount of water received in 2015-2016 was 111.4 mm larger than in 2016-2017. Besides, the latter cycle was noticeably warmer than the previous one. In December 2015 and January 2016 there were only two days when the maximum temperature was above 35°C whereas in December 2016 and January 2017 there were eleven days with temperatures above 35°C. Environmental conditions during the second crop cycle could be the reason for the lower plant height, for the smaller number of ears of corn per plant, and for the lower ratio of dry weight of ears of corn to whole-plant dry weight because temperatures above 35°C lead to heat stress in corn (11).

Tables 6 and 7 show the results corresponding to the quality of the hybrids evaluated during the 2015-2016 and 2016-2017 crop cycles. No differences were observed in the variables evaluated in both crop cycles. Protein values fall within the expected range (6.8±1.2 % CP) according to Santini, 2016. ADF values also fall within the expected range, and the digestibility calculated from these data is similar to that found by other researchers for other silage hybrids (6, 16). Energy concentration values are slightly lower than those reported by Montesano, 2013 (14).

Conclusions

It is feasible to achieve high yields from silage corn under irrigation in Mendoza's northern oasis. Similar behavior was observed in all the hybrids tested in both crop cycles. Results suggest that corn silage is an interesting forage resource for intensive cattle farming in the province of Mendoza.

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