Maize silage production on high ridges in lowland soil

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Abstract

This study aimed to evaluate the silage maize production and quality under lowland soil in different soil tillage systems. During the 2002/03 and 2003/04 growing seasons, two experiments in a randomized blocks experimental design with four repetitions were conducted. Three preparations of soil were used: (i) soil tillage in high ridges without the use of irrigation (C-NI), (ii) soil preparing in high ridges and use of furrow irrigation (CI), (iii) conventional soil tillage (without high ridges) and without the use of irrigation (SI). It was observed that the use of high ridges, with or without irrigation, increases the leaf area index of maize plants. The content of raw fiber was 17.2, 19.11 and 17.89% for maize plants grown in CI, C-NI and SI, respectively.

Key words: furrow irrigation, dry substances, soil tillage.

Introduction

The state of Rio Grande do Sul, RS, BR, has registered an increase in regional inequalities, characterized by the increasing concentration of population and income in some regions, while in others it exacerbates the structural problems of the economy, generating losses of population, poverty and reduced quality of life. In this context, is adversely the south half, predominantly agricultural region, where the main economic activity is rice and beef cattle. This region has experienced over the past decades a profound process of loss of economic dynamism, facing difficulties that have slowed their economic and social development in comparison with the north half. The frequent rice crises put farmers in the region in difficult situation to make the agricultural production and generation of incomes for the region's economy. It's growing the increase in unemployment in the rural region and social pressure in cities with little infrastructure to generate new jobs. In this way, it is important the development of alternatives to maintain viable the agricultural activities, integrating the experience of farmers, the availability of machinery and property equipments, the maintenance of agricultural activity and reducing the risks of rural activity.

One of the characteristics of the lowland soils of Rio Grande do Sul south half is its use for agricultural activities during part of the year, because of the water table for long periods near the soil surface. This makes difficult the recommendations more that enable a more efficient occupation of agricultural land by farmers. Thus, it is necessary to test systems and methods that enable suitable earnings to high agricultural potential that this lands have.

The pursuit of sustainable agriculture involves, among other issues, the practice of crop rotation, often because the intensive use of modern inputs does not allow the farm to make it economically, socially and environmentally (MARCHEZAN, 1995). The use of alternative crops to rice in lowland areas provide a more intensive use of land, with the optimization of the labor use available, reducing the incidence of red rice in the area, the reduction of production costs, with increase productivity of rice, and diversification of income in the property (IRGA, 2001).

The cultivation of maize in non-drained lowlands greatly increases the risk of partial or total loss of productivity in years with excessive rainfall, especially if they occur in the first weeks after sowing. Taking into account this fact, the sowing of maize in high ridges is an interesting alternative for micro, small and medium producers. In this system, the high ridges are used as drains to remove the excessive water from the soil, and the furrows can lead the irrigation water to supply the needs of plants.

The drainage control interferes directly in productivity. In years with normal rainfall distribution during the summer, the yield potential of corn may be more than 6.000 kg ha^{-1}. However, when excess of rainfall occur in any period of plant development, productivity is severely reduced and in many cases to less than 180 kg ha^{-1}, preventing economically the culture (PIRES, 2005). Using the cultivation of maize in high ridges, the productivity observed in several regions of Rio Grande do Sul, in years with El Niño, was over 4.800 kg ha^{-1}. These results enable the cultivation of maize in the lowland soils.

Corn silage can be an alternative to intensified activity of beef cattle in the region, supplying the food shortages during the winter in Rio Grande do Sul and contributing to the reduction in age at slaughter, increasing the reproductive rates of cattle herds of the State (RESTLE et al., 2000). The use of corn in feed for cattle, due to the quality of silage, adds value to the product and increases the profitability of agricultural activities.

This study aimed to evaluate the production and quality of silage maize plants grown in lowland soil in two soil tillage systems (with and without high ridges) and irrigated by furrows.

Material and methods

The work was conducted in Santa Maria, Central Depression of Rio Grande do Sul in the agricultural years of 2001/02 and 2002/03. The experimental area is located at 29 ° 50'57 " Latitude S, 53 º 36'21, 2" Longitude W and average altitude of 61 meters. The climate is classified as subtropical humid, class "Cfa", according to the classification of Köppen (MORENO, 1961). The average annual rainfall in the region varies from 1322 to 1.796mm. The soil of the site is classified as Planossolo Háplico distrófico arênico (EMBRAPA, 1999).

In the years of 2002/03 and 2003/04 two experiments in randomized blocks with four replications experimental design were conducted. Each experiment consisted of three treatments: (i) soil tillage in high ridges without the use of irrigation (C-NI), (ii) in high ridges soil tillage and use of furrow irrigation (CI), and (iii) conventional soil tillage (no high ridges) and without the use of irrigation (SI). Two rows of maize were grown on high ridges, spaced at 40cm, with the distance of 185cm between the furrows of the irrigation. The experimental plots were consisted of eight lines of maize cultivation with dimensions of 7.4 x 14m (103.6 m^2). In 2002/03, the high ridges were constructed on December 28th 2002, and in 2003/04 were reconstructed on October 20th 2003. In 2002/03 the corn was sown on January 09th 2003 and in 2003/04 on January 21st 2004. The plant population was approximately 60,000 plants ha^{-1}. Irrigation was performed by furrows and consisted of applying a layer of irrigation, which, by opening up the channel led to water supply by gravity from the reservoir to the furrows.

The irrigation management was performed through the estimation of reference evapotranspiration (ETo), as determined by the method of Penman-Monteith. The values of temperature, relative humidity, wind speed and solar radiation to calculate the ETo were obtained from a compact weather station, installed near the place of conduction of the experiment. The maximum evapotranspiration of the crop was determined by use of culture factors, according to Doorenbos and Kassan (1979). The date of corn emergence was considered when 50% of seedlings had emerged. After emergence, three plants per plot (similar in height and number of leaves) for non-destructive determination of leaf area were selected and identified, twice a week. Leaf area was determined individually for each leaf, since the emergence of leaves on the cartridge until the appearance of the sheath. Leaf area of plants was determined by the product of the length and width of each leaf of the plant multiplied by 0.75 (STICKLER et al., 1961). The leaf area index was calculated by the relationship between photosynthetically active leaf area of plant and soil surface occupied by this plant. The ground surface occupied by the plant was calculated by the ratio between the area and population of plants contained in that area.

The sample for quality and quantity analysis of silage 'of corn plants was made in the center of each plot in an area of 0.925 x 4.00 m (3.7 m^2). The corn plants samples for chemical analysis were dried in a forced draft oven at 60 ºC until constant weight, for determination of dry matter (DM). Subsequently they were ground in *Wiley* type mill, sieved (mesh of 2mm in diameter) and kept in closed plastic pots at a temperature of 5 °C. The samples were ground and sieved (mesh of 1mm diameter) one more time in order to carry out the chemical analysis. The chemical analyses of corn plants for silage were performed at the Laboratory of Animal Nutrition, Department of Zootecnia of UFSM (LANA). DM, CP (crude protein), EE (ether extract), CF (crude fiber) and NFE (non nitrogen extractives - for calculation) were analyzed, according to AOAC (1990). It was determined the TDN (total digestible nutrients), by calculation, using the procedures described by McDowell et al. (1974). The statistical analysis was performed by the Statistical Analysis System (SAS). Analysis of variance and Tukey test were determined at 5% level of error probability.

Results and discussion

The figure 1 is presenting the leaf area index (LAI) over the course development of corn plants. In 2002/03, C-NI showed higher LAI throughout the development course (Figure 1a). In 2002/03 the corn grown in CI and SI had lower values of LAI, when compared to 2003/04. The lower values of LAI observed in SI, in 2002/03, are associated with the large amount of rainfall occurred during the crop cycle, which caused water excess in the root zone of plants grown without high ridge, reducing the oxygenation of soil layer committing the development of corn plants. The negative effect of water excess on the root system of maize was not observed in treatments that used high ridges, because in these crops the channels formed by high ridges use favored the draining of rainfall water excess.

It can be observed that the maximum LAI occurred at tasseling in both crop years, regardless of the cultivation system used. The LAI of corn plants in 2002/03 was increased until the tasseling, when the maximum of 3.68, 4.01 and 3.04 for plants grown in CI, NI and SI, respectively (Figure 1a) were observed. Throughout the development cycle of corn plants the values of LAI for plants grown in high ridges were higher than plants grown without high ridge. Almeida (1999) observed LAI of 4.65 and 3.09 in 1996/97 and 1997/98, respectively, working in soil and similar conditions.

In table 1 the results of the medium square analysis of variance for fresh and dry mass of accumulated silage of corn plants are presented. It can be observed that only the dry mass of stem and leaf showed differences between soil tillage during 2002/03. The coefficients of variation (CV) were higher in 2003/04 with an average of 26.4%; when compared to 2002/03 with an average value of 18.0%.

The table 2 presents the results of the variance analysis for CP, EE, CF, NFE and TDN of corn

Figure 1. Leaf area index of maize plants grown in lowland soil in 2002/03 (a) and 2003/04 (b). The vertical lines represent the standard deviation. Santa Maria, RS, 2007.

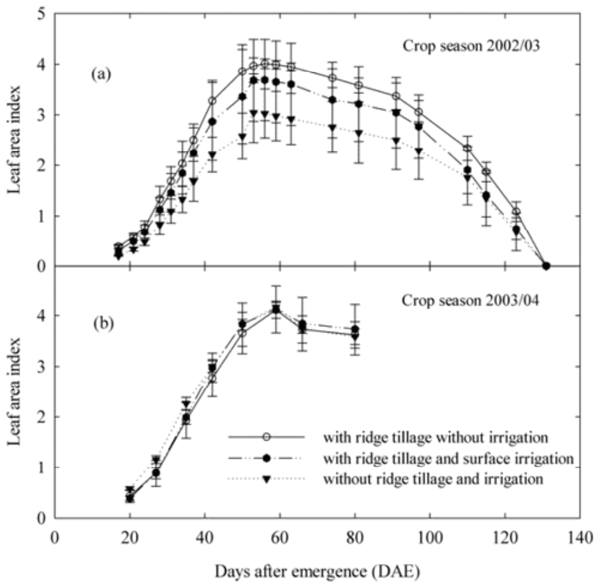


Table 1. Variance analysis for fresh and dry mass of accumulated silage of corn plants grown in lowland soil, with soil preparing in high ridges without the use of irrigation; with soil preparing and use of high ridges in irrigation furrows; and with conventional soil tillage (no high ridges) and without the use of irrigation. Santa Maria, RS, 2007.

Variables	Block	Soil Preparing	Residue	CV (%)
	GL = 3	GL = 2	GL = 6	
		Agricultural year of 2002/03		
Dry mass of spike	9,79^{ns}	9,23^{ns}	2,49	10,45
Dry mass of leaf	1,85^{ns}	2,33^{ns}	1,01	15,08
Dry mass of stem	2,49^{ns}	7,41*	1,29	16,89
Total dry mass	32,80^{ns}	52,95^{ns}	12,29	12,29
Dry mass of spike	4,62^{ns}	4,59^{ns}	5,53	33,90
Dry mass of leaf	0,18^{ns}	0,74*	0,10	14,82
Dry mass of stem	0,19^{ns}	0,27^{ns}	0,08	16,68
Total dry mass	3,46^{ns}	11,52^{ns}	6,55	23,64
		Agricultural year of 2003/04		
Dry mass of spike	0,93^{ns}	44,88^{ns}	10,10	25,62
Dry mass of leaf	2,03^{ns}	0,97^{ns}	2,26	21,59
Dry mass of stem	0,03^{ns}	3,60^{ns}	4,70	39,90
Total dry mass	4,84^{ns}	59,35^{ns}	37,37	24,11
Dry mass of spike	0,09^{ns}	9,46^{ns}	1,95	23,99
Dry mass of leaf	0,23^{ns}	0,04^{ns}	0,37	24,38
Dry mass of stem	0,02^{ns}	0,09^{ns}	0,16	29,28
Total dry mass	0,24^{ns}	11,12^{ns}	4,58	22,07

** = Significant at 5% level of probability of error, ns = not significant; CV = coefficient of variation; GL = degrees of freedom.*

plants grown in lowland soil. In 2002/03 the results of CF showed differences between the soil tillage. In 2003/04 there was no difference between treatments for any of the bromatological components evaluated in corn silage. The CVs were higher in 2003/04, with an average of 9.3%; when compared to 2002/03, with an average value of 7.7%.

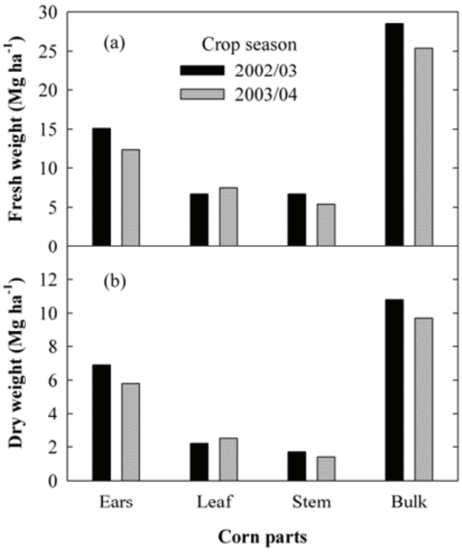
The dry mass of stem and leaves of maize (Table 3), observed in 2002/03, when El Niño occurred, were higher for plants grown in CI, not differing from plants grown in C -NI. The fact that the high ridges work as drains, on days of high amount of rain, possibly increased the oxygenation of the plants roots. According to Matzenauer et al. (2002), the amount of accumulated precipitation for the period of January to June in the region of Santa Maria, is 863mm. However, in the same period in 2003, the amount of rain accumulated was 1.370mm, an increase of 59% from the average normal. This increase in rainfall was caused by the occurrence of El Niño. The percentage of CF, in 2002/03, was higher for maize plants grown in C-NI (Table 3).

Table 2. Variance analysis for the production of silage from whole maize plants grown in lowland soil with a soil preparing in high ridges and without the use of irrigation; with soil preparing in high ridges and use of irrigation furrows; and with soil conventional preparing (without high ridges) and without the use of irrigation. Santa Maria, RS, 2007.

Variable	Block	Soil Preparing	Residue	CV (%)
	GL = 3	GL = 2	GL = 6	
		Agricultural year of 2002/03		
Crude protein (CP)	0,32^{ns}	0,13^{ns}	0,11	6,10
Ether extract (EE)	1,73^{ns}	0,13^{ns}	0,32	21,56
Crude fiber (CF)	5,99*	3,49*	0,39	3,49
Non-nitrogenous extractives (NFE)	12,21*	4,88^{ns}	1,21	1,57
Total digestible nutrients (TDN)	71,30*	3,48^{ns}	12,82	6,00
		Agricultural year of 2003/04		
Crude protein	0,16^{ns}	0,08^{ns}	0,20	6,04
Ether extract	0,31^{ns}	0,04^{ns}	0,13	10,66
Crude fiber	1,24^{ns}	12,12^{ns}	4,29	10,72
Non-nitrogenous extractives	20,85^{ns}	13,65^{ns}	10,46	5,34
Total digestible nutrients	48,87^{ns}	71,36^{ns}	62,16	13,95

** = Significant at 5% level of probability of error, ns = not significant; CV = coefficient of variation; GL = degrees of freedom.*

Figure 2. Medium values for fresh mass (a) and dry mass (b) of spike, leaf, stem and total plant grown in lowland soil in 2002/03 and 2003/04. Santa Maria, RS, 2007.



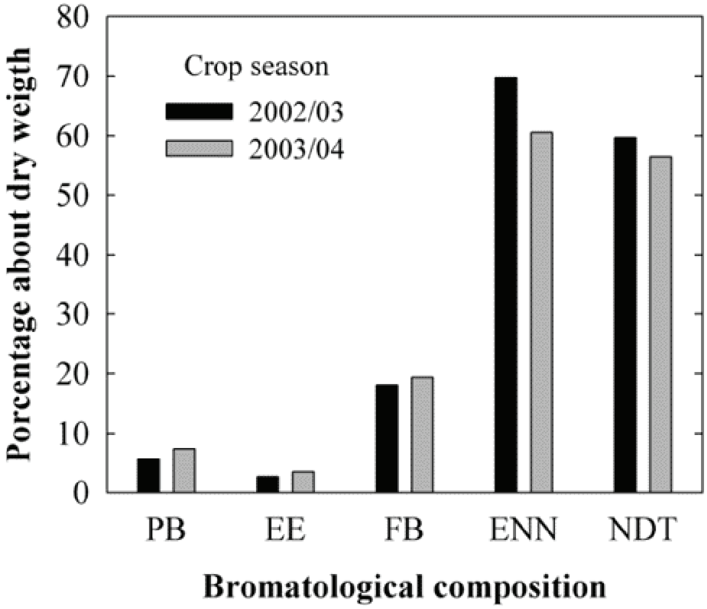
In the figure 2 are presented the medium values for weight (Figure 2a) and dry (Figure 2b) of silage crops accumulated in lowland soil. It is observed that the production of fresh and dry mass was greater in 2002/03, except for dry mass and fresh leaves. The results of the percentage in spike of total dry mass of maize were 64 and 60% for cultures performed in 2002/03 and 2003/04, respectively. These values are higher than observed by Monteiro et al. (2000) (48%) for the same hybrid grown in different locations in Minas Gerais. For green mass, the percentage of spikes was 53 and 49% for cultures performed in 2002/03 and 2003/04, respectively. Melo et al. (1999), using the same hybrid in Lavras, Minas Gerais, obtained percentage of spike in green mass lower (40%) to the results observed in two years of cultivation. Within two years, the average agricultural production of total fresh and dry mass was 27.0 and 10.3 Mg ha^{-1} respectively. Almeida Filho et al. (1999), evaluating the agronomic characteristics of cultivars of maize, obtained similar yields of dry mass, with values ranging from 12.7 to 10.4 Mg ha^{-1}. LAMB (1991), working with irrigated corn, also obtained similar amounts of dry matter, ranging from 10.9 to 15.6 Mg ha^{-1}. Mittelmann et al. (2005), using the same hybrid maize in the 2001/02, obtained production of 10.0 and 12.0 Mg ha^{-1} dry mass in cultures performed in Ijuí, and Teutonia, respectively. Maggi (2003), using the same hybrid in Santa Maria, (RS) in 2001/02, obtained a production of 34.1 Mg ha^{-1} fresh and dry mass of 13.2 Mg ha^{-1}. From these comparisons it can be said that the production of silage maize in the lowland soil was not affected by water excess, as presented productivity of mass (fresh and dry) of similar cultures conducted in the area of uplands.

Table 3. Fresh mass of stem, leaf and dry mass of crude fiber for corn grown in lowland soil in 2002/03. Santa Maria, RS, 2007.

Variable	Soil Prepairing		
	C-NI	CI	SI
Fresh mass of stem (Mg ha-1)	6,6 ab	8,2 a	5,5 b
Dry mass of leaves (Mg ha-1)	2,2 ab	2,6 a	1,8 b
Crude fiber (%)	19,1 a	17,3 b	17,9 ab

C-NI = soil tillage on high ridges and without the use of irrigation; CI = soil tillage in high ridges and use of irrigation furrows, SI = conventional soil tillage (without high ridges) and without the use of irrigation. Lines followed by same letter do not differ significantly by Tukey test (P <0.05).

Figure 3. Average crude protein (CP), ether extract (EE), crude fiber (CF), non-nitrogen extractives (NFE) and total digestible nutrients (TDN) on the dry mass of corn plants grown in lowland soil in 2002/03 and 2003/04. Santa Maria, RS, 2007.



In figure 3 are presented the average values of bromatological components from the dry mass of corn plants. The results of CP, EE and CF of corn plants were low in the first year of cultivation (2002/03) and had a slight increase in the second year (2003/04). The high volume of rainfall and the delay in planting in 2002/03 may explain these lower values. Although low, the values are still close to the extreme values determined by Fancelli and Neto (2000): PB 6.2 to 7.3%; CF 15.3 to 21%, EE 2.2 to 3,6% and above 60% for total digestible nutrients (TDN). MAGGI (2003) and Mittelmann et al. (2005) obtained similar values of CP, 7.5 and 6.3% respectively.

Conclusions

The leaf area index of maize plants increases with the use of high ridges in lowland soils, regardless of the irrigation use. The production of maize silage grown on high ridges in a lowland soil, is affected by excessive rains. In excessive rainfall years the cultivation of maize in lowland soil on high ridges provides an increase in crude fiber content of silage, compared to growth without high ridge.

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