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Cientific Paper

Potential of corn silage production in different sowing times in the Paraná Midwest region

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Abstract

The aim of this study was to evaluate the effects provided in the corn fields of early cycle sown in late times in the Parana Midwest region on production and plant components for the silage production. The experimental design was a randomized block consisting of four treatments, with each treatment corresponded to a different sowing time (T_1: First week of November, T_2: Second week of November; T_3: Third week of November; T_4: Fourth week of November) and three replications, where each repetition consisted of a parcel with an area of 16 m^2. Corn plants were harvested in the hard dough stage where it was determined plant height, ear height, green biomass production, dry matter production and grain yield, in addition to the percentage physical composition of the anatomical structures of the plant (stem, leaves, bracts, cob and grain). In general context, crops sown in the first and second week of November showed superior results compared crops sown in the third and fourth week of the month concerning because resulted in increased production of dry biomass (28.321; 26.179; 20.291 and 18.758 kg ha^{-1} respectively), and higher grain yield (6.699; 7.147; 5.722 and 5.271 kg ha^{-1} respectively). Generally, the sowing of corn for silage from the third week of November to Guarapuava-PR region reduced the production of biomass per unit area.

Key words: Plant composition, sowing periods, dry biomass production

Potencial produtivo do milho para silagem em diferentes em épocas de semeadura na região Centro Oeste do Paraná

Resumo

O objetivo deste trabalho foi avaliar os efeitos proporcionados nas lavouras de milho de ciclo precoce semeadas em épocas tardias na região Centro-Sul do Paraná sobre a produção e os componentes da planta destinadas a produção de silagem. O delineamento experimental foi o de blocos casualizados, composto por quatro tratamentos, onde cada tratamento correspondeu a uma época diferente de semeadura (T_1: Primeira semana de Novembro; T_2: Segunda semana de Novembro; T_3: Terceira semana de Novembro; T_4: Quarta semana de Novembro), e três repetições, onde cada repetição foi composta por uma parcela com área útil de 16 m^2. As plantas de milho foram colhidas no estádio de grão farináceo onde determinaram-se altura de planta, altura de espiga, produção de biomassa verde, produção de biomassa seca e produção de grãos, além da composição física percentual das estruturas anatômicas da planta (colmo, folhas, brácteas, sabugo e grãos). Em âmbito geral, as lavouras semeadas na primeira e segunda semana de novembro apresentaram resultados superiores em relação as lavouras semeadas na terceira e quarta semana do concernente mês, pois acarretaram em maior produção de biomassa seca (28.321; 26.179; 20.291 e 18.758 kg ha^{-1} respectivamente), e

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maior produção de grãos (6.699; 7.147; 5.722 e 5.271 kg ha^{-1} respectivamente). De forma geral, a semeadura do milho para silagem a partir da terceira semana de novembro para região de Guarapuava-PR reduziu a produção de biomassa por unidade de área.

Palavras chave: composição da planta, épocas de semeadura, produção de biomassa seca.

Potencial productivo de maíz para ensilaje, en diferentes épocas de siembra en la región del Centro Oeste de Paraná

Resumen

El objetivo de este estudio fue evaluar los efectos causados en los cultivos de maíz del ciclo temprano sembrados en épocas tardías en la región centro-sur del Estado de Paraná en la producción y los componentes de la planta destinada para la producción de ensilaje. El diseño experimental fue de bloques al azar, compuesto de cuatro tratamientos, en donde cada tratamiento correspondió a una diferente época de la siembra (T_1: Primera semana de noviembre, T_2: Segunda semana de noviembre; T_3: Tercera semana de noviembre; T_4: Cuarta semana de noviembre) y tres repeticiones, donde cada repetición consistió en una parcela con superficie de 16 m^2. Las plantas de maíz fueron cosechadas en estado de grano farináceo donde se determinó la altura de planta, la altura de la espiga, la producción de la biomasa verde, la producción de biomasa seca y la producción de granos, además de la composición física porcentual de las estructuras anatómicas de la planta (tallo, hojas, brácteas, mazorcas y granos). En general, los cultivos sembrados en la primera y segunda semana de noviembre mostraron mejores resultados que los cultivos sembrados en la tercera y cuarta semana del referido mes, pues presentaron una mayor producción de biomasa seca (28.321; 26.179; 20.291 y 18.758 kg ha^{-1}, respectivamente), y mayor rendimiento de grano (6.699; 7.147; 5.722 y 5.271 kg ha^{-1}, respectivamente). En general, la siembra de maíz para ensilaje a partir de la tercera semana de noviembre en la región de Guarapuava-PR reduce la producción de biomasa por unidad de superficie.

Palabras clave: composición vegetal, fechas de siembra, producción de biomasa seca.

Introduction

The silage is an excellent way to assist in the maintenance and expansion of production of ruminant animals, especially in periods of low forage production. Corn silage, specifically, among the materials for the production of silage, is considered the main for its nutritional importance and the fermentation profile. This importance comes from the corn has very obvious characteristics with a view to its high energy content, low fiber, high dry matter production per area, in addition to a good fermentation standard and well as the absence of compulsory use of additives (PEREIRA et al., 2004).

However, these characteristics only, do not guarantee a good silage. Regarding the planning of the crop, it is important to know the planting season analyzing the entire crop cycle, trying to predict the environmental conditions in all its phenological stages, for soil and climatic differences of each region much affect decision-making planting season the corn crop. According to the agro-meteorological Monitoring System (2014), the best time for sowing corn in the Parana Midwest region is between mid-September and October.

Meanwhile, in this same region, there is a great demand of winter cereals production, mainly wheat and barley. Such cultures have the end of its cycle in the period from October to November, which sometimes ends up delaying the time considered ideal for sowing of corn crops.

Also, many times it is necessary to delay sowing due to avoid the weather problems that can directly influence the production, especially if they occur in the critical phase, ranging from entry into the reproductive phase and the beginning of grain filling (BERGAMASCHI et al., 2004). The temperature and humidity, water availability and the incidence of light, are factors directly related to the development and plant productivity (NASCIMENTO et al., 2011).

With all these regional peculiarities as productive obstacles, breeders have developed hybrids more efficient at absorbing water, light, temperature and nutrient absorption (BORGHI et al., 2012). This suggests a diverse response in different sowing time.

In this context, the objective of this study was to evaluate the effects provided in the early maturing corn crop sown in late times in the Paraná Midwest region on production and plant components for the production of silage.

Material and Methods

The experiment was conducted in areas with good features of fitness and use for growing corn in Animal Production Center (NUPRAN) of the Center for Agricultural and Environmental Sciences at the Universidade Estadual do Centro Oeste (UNICENTRO).

The average values of temperature and rainfall, expected and closed in corn cultivation period are shown in Figure 1, while the average values of relative humidity and insolation are shown in Figure 2.

The soil of the area is classified as Oxisol Typical. The experimental area had been utilized in recent years, with pastures annual cycle in the winter season, and corn crops and soybeans in the summer season, getting every growing season, phosphorus and potassium fertilization, as the Fertilization and Liming recommendations to the states of Rio Grande do Sul and Santa Catarina (1995).

The climate of Guarapuava-PR region is Cfb (wet mesothermal Subtropical), with no dry season, cool summers and mild winter, according to the Köppen classification, in altitude of about 1100 m, average annual rainfall of 1944 mm, average temperature annual minimum of 12.7°C, maximum annual average temperature of 23.5°C and relative humidity of 77.9%.

The soil of the field in October, prior to planting time, had the following chemical characteristics (profile 0-20 cm): 0.01M $CaCl_2$; pH: 4.7; Q: 1.1 mg dm^3; K+: 0.2 cmolc dm^{3-}; Mo: 2.62% dag kg^{-1}; Al^{3+}: 0.0 cmolc dm^{3-}; $H^+ + Al^{3+}$: 5.2 cmolc dm^{3-}; Ca^{2+}: 5.0 cmolc dm^{3-}; Mg 2^+: 5.0 cmolc dm^{3-} and base saturation: 67.3%.

Quantitative agronomic characteristics of corn plant under the influence of different sowing dates were evaluated: T_1: First week of November, T_2: Second week of November; T_3: Third week of November; T_4: Fourth week of November.

The corn crop (*Zea mays* L.) were implanted in no-till system, in succession to forage mixture black oat (*Avena strigosa)* and ryegrass (*Lolium multiflorum)*, which was dried out with herbicide Glyfosate base.

The sowing of hybrid DOW 766, early cycle, we used spacing of 80 cm, sowing depth of 4 cm and five plants per meter density, as recommended by the improvement company. The corn planting was carried out in plots with total area of 28.8 m^2 (4.8 mx 6.0 m) and is used to evaluate the floor area of 16 m^2 (3.2 mx 5.0 m). The basic fertilization consisted of 350 kg ha^{-1} formulation 08-30-20 (N-P_2O_5-K_2O) as the fertilization and liming recommendations for the

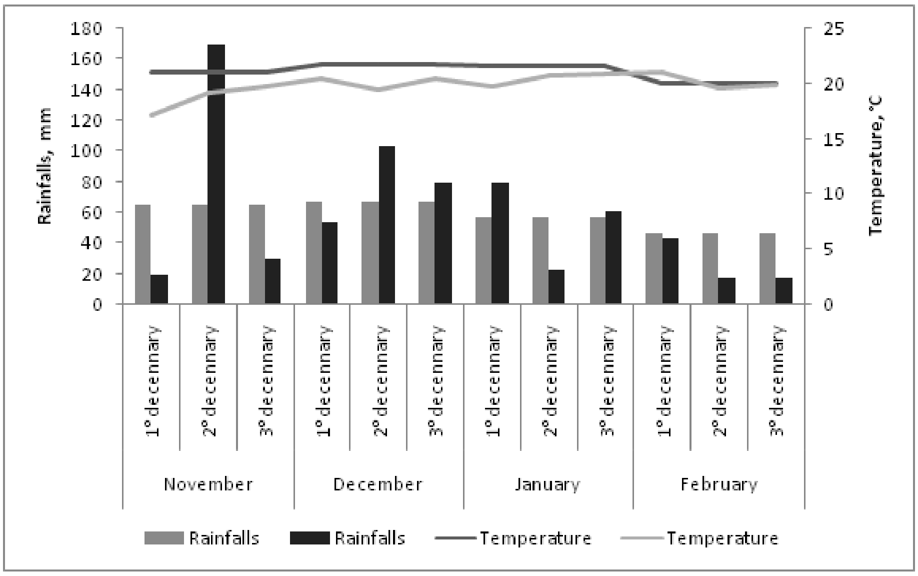

Figure 1. Mean in ten days for rainfall and expected normal temperature and occurred in the corn growing season, Guarapuava-PR.

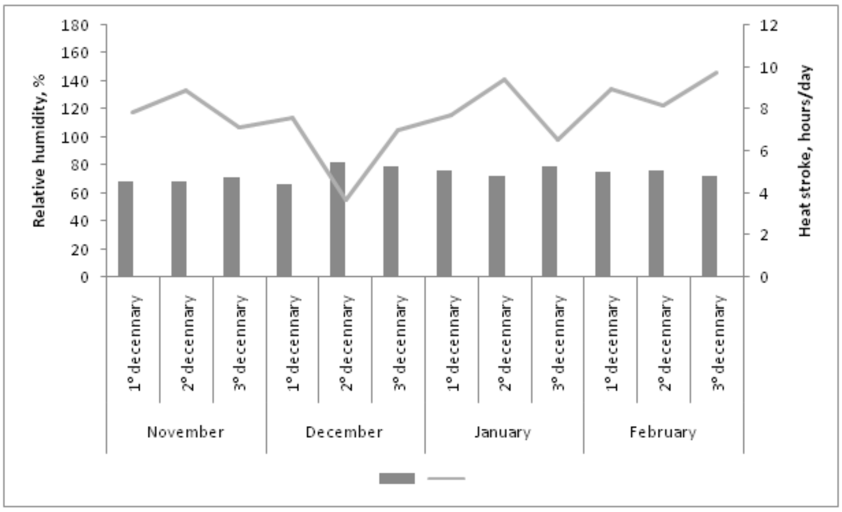

Figure 2. Means for ten days in relative humidity and level of heat stroke occurred in the corn growing season, Guarapuava-PR.

states of Rio Grande do Sul and Santa Catarina (1995), and in coverage, 35 days after planting, were applied 135 kg ha^{-1} N as urea (45-00-00). Except for N sowing, all N was to source urea.

The management of the corn crop, within 30 days after plant emergence, involved control practices of weeds by chemical method. It was used the herbicide Atrazine base (commercial product Atrasina: 4 L ha^{-1}) + oil (product commercial Assist: 1.0 L ha^{-1}), and *Spodoptera cartridge* control (*Spodoptera frugiperda*), with the insecticide to base Lambdacyhalothrin (commercial product Karate: 150 ml ha^{-1}) by a technical report of crops. The thinning of plants was carried out 15 days after sowing, adjusting the final population to 65.000 plants ha^{-1}.

Corn plants were harvested at the reproductive stage R4 - grain dough, for silage production of the whole plant, as phenological scale RITCHIE et al. (1993). At harvest, we proceeded to agronomic evaluation, measuring the height of plant and first spike insertion, as well as whole plants of floor area up collected from each plot manually cut to 20 cm of soil, weighing, to estimate the productive potential of green biomass, drought and crop grains. Subsequently, a homogeneous sample of whole plants was collected and manually segmented. It was evaluated physical components: stem, leaves, bracts and grains to determine the structural physical composition of the plant, and the amounts are fixed as a percentage of dry matter.

Samples of whole plant physical and structural components were pre-weighed and dried in a forced air oven at 55 °C. After 72 hours of drying, they were weighed again to determine the dry matter content, according to AOAC (1995).

The experimental design was a randomized block consisting of four treatments and three replications. The data collected for each parameter were subjected to analysis of variance and mean comparison analysis by 5% Tukey test, using the SAS program (1993).

The statistical model used was as follows:Yijk= μ + Si + Bj+ Bj(S)i+ Eijk; where: Yijk= dependent variable;μ = average of observations; Si = effect of sowing date of order "i"; Bj = effect of the order block "j"; BJ (S) i = effect based on the random block inside the treatment (the error); i = 1 ... 4 (index of processing); j = 1 ... 3 (repetition rate); and Eij = residual random error, assuming average normal distribution of zero and variance μ 2 (b error).

Results and Discussion

Table 1 shows the dry matter of the structural components stem, leaves, bracts, cob and grains, and whole plant at the time of harvest corn crop in different sowing dates.

Sowing times did not cause significant changes in dry matter of the stem component, with a mean value of 28.3%, showing that a stable component and little influenced by the conditions of different sowing times. The component leaves

Table 1. Levels of dry matter of the structural components stem, leaves, bracts, cob and grain and whole plant at the time of harvest corn crop in different sowing dates.

Sowing	Drymatter, %					
time	Stem	Leaves	Bracts	Cob	Grains	Wholeplant
T1	30.2 a	34.4 ab	46.4 ab	41.8 c	51.7 b	41.1 a
T2	26.6 a	34.7 ab	41.4 b	46.2 b	54.8 a	40.5 a
T3	26.7 a	31.3 b	33.5 c	41.1 c	56.3 a	33.2 c
T4	29.5 a	37.3 a	50.5 a	52.3 a	57.1 a	37.7 b
Average	28.3	34.4	42.9	45.3	55.0	38.1
C.V., %	13.58	3.79	7.43	7.95	4.30	2.20
P > F	0.5803	0.0079	0.0014	0.0294	0.0054	0.0001

[a, b, c] *Means in the column followed by different lower case letters differ by 5% Tukey*

showed lower (P <0.05) dry matter content, when the corn was sown in the third week of November compared to the fourth week (31.3% versus 37.3%), but did not differ (P> 0.05) of values found in the first and second week sowing.

The DM content of the bracts and cobs differ (P <0.05) between sowing times, being more concentrated in the fourth week of sowing (50.5% of bracts and 52.3% cob) and lower in the third (33.5% bracts and 41.1% cob). The grains had lower (P <0.05) percentage of DM in the first week of sowing compared to other seasons. This aspect, important when you want to produce silage of high quality, since the component grains, according NUSSIO (1992) is the main responsible for the final quality of the silage.

The whole plant DM was not statistically different (P> 0.05) between the first and second week of sowing (41.1% versus 40.5%), however, differed significantly (P <0.05) in third and fourth (33.2% and 37.7% respectively). This could be justified by the rainfall and sunshine granted to crops the first two weeks after sowing (Figure 1 and 2). On average DM content of the whole plant was in 38.1%, similar to that found by NEUMANN et al. (2009) which was 38.2%.

Indeed, the nutritional value of the silage is correlated with the agronomic performance of the plant, including the physical composition and the dry matter (MELLO, 2004), which in turn are closely related to the time of sowing material. Thus, cultivating and sowing time are variables it may consider of high quality silage production.

Based on the overall average of the data, the dry matter of the grain component (55.0%), regardless of the evaluated sowing time was higher than the stems (28.3%), leaves (34.4%), bracts (42.9%) and cob (45.3%), showing that the dry matter content of the grains associated with percentage share of this component in the plant structure becomes the principal in determining the dry content of the resulting silage.

Table 2 shows the physical composition of the corn plant, early cycle, seeded four different late seasons. Note that there was no statistical difference (P> 0.05) for upper stem, lower leaves and cobs, with mean values of 4.3%, 12.8% and 14.5%, respectively.

between the first and fourth week of sowing (15.3% and 15.2% respectively), but showed differences (P <0.05) with the second and third week (12% both).

The percentage of upper leaves were higher (P <0.05) in the first and second week sowing (13.2% and 12.2% respectively) compared with the third and fourth weeks (10.6% and 10.2% respectively). In the harvest moment, some of the lower leaves are already in senescence (stay green), and the upper having a higher concentration of soluble carbohydrates in relation to them.

According to FAIREY and DAYNARD (1978), another important fact is that the three upper leaves are responsible for transport of nutrients to grains (main source of soluble sugars of the plant), while the photosynthesis by the three products leaves located below the main ear would be responsible to supply the root system (not an integral portion of the silage). The higher the concentration of soluble sugars implies in a better silo fermentation, resulting lowering of pH, and finally, the material storage (ROOKE and HATFIELD, 2003).

The data presented in Table 2 shows the direct impact that climate variations in different seasons impose on the plants, and consequently the quality of the resulting silage.

NEUMANN et al. (2000) evaluated the physical composition of corn plants of early cycle sown in two different times (end of September to mid-December), revealed significant differences (p<0.05) on the components participation. Leaves, bracts, cob and grain mainly in plant structure at harvest for silage, which had average values based on dry matter of 22%, 37%, 16%, 14% and 09% for the crop sown in early, and 19%, 22%, 12%, 11% and 36% for the time of late, respectively.

Note that the sowing in the first week of November differ (P <0.05) from the other times for grain production. This grain yield observed for the later sowing dates have great influence at the beginning of the summer solstice. This period is comprised of longer days with higher light intensity, which is one of impacting factors on grain yield.

According BASI et al. (2011), good silage corn hybrids should contain more than 40% of grains in its dry basis nutrients available so that there is a good fermentation in the silo and thus maintaining the nutritional quality of the silage closest to the time of harvest. In contrast, the larger the proportion of stem, bracts and cobs from the plant, there is a tendency to increase the fiber fraction and thereby reduce the final digestibility of silage.

NEUMANN (2011) infers that the corn plant for silage must have values below 20% of stem and 25% more cob bracts, but more than 15% leaves and 35% of grain in the physical composition of the plant at the time of ensiling , like to obtain values less than 50% neutral detergent fiber and 32% acid detergent fiber, these components that have high correlation with the daily intake capacity of dry matter and energy density of the resulting silage, respectively (VAN SOEST et al., 1991).

According to data presented in Table 3, it is observed that in general average, sowing hybrids in the first and second week of November stood out (P <0.05) the sown later in the production of dry biomass and grain yield compared to the third and fourth week of November.

However, the time of sowing the first week of November was statistically (P <0.05) lower than the other in relation to plant height, showing that plant size can no longer be used as a single parameter for choosing a good hybrid for silage or relate it directly to the production of dry biomass and grain yield.

To reinforce this hypothesis, OLIVEIRA et al. (2013) evaluated the production of green biomass and dry biomass of an implanted corn crop at the beginning of October, in the same soil conditions and harvested grain maturity stage similar to the present study, reached values of 50565 and 12944 kg ha^{-1}, respectively. These data, lower than those obtained in this study, although numerically the same authors reported average plant height higher than the average obtained in this study (2.19 m from 2.6 m).

MARCONDES et al. (2012) emphasize that corn hybrids tend to lower height ratio greater leaf and stem, which would lead to higher levels of digestible nutrients final silage because the sheets having higher concentrations of total digestible nutrients compared to the stem component.

LUPATINI et al. (2004) emphasize that the greater the contribution of the stem plant structure, something present in hybrids of greater heights, the lower the quality of the resulting silage by high fiber and neutral detergent restricted digestibility of this structural component in relation to the sheets.

Importantly, the corn crop is very demanding in water, especially during flowering and grain formation (SILVA et al., 2014). From this it is clear how the production of green biomass, dry biomass and grain decreases with the advance of planting over the period considered less rainfall for the growing region.

Table 2. Plant height, height of ear, production of green biomass, dry biomass and grain yield at harvest of corn grown in different sowing dates.

Sowing time	Height, m		Biomassproduction, kg ha^{-1}		
	Plant	Ear	Green	Dry	Grains
T1	1.90 b	1.06 a	68879 a	28321 a	6699 a
T2	2.16 a	1.28 a	64681 a	26179 a	7147 a
T3	2.11 a	1.20 a	61140 a	20291 b	5722 b
T4	2.06 ab	1.19 a	49737 b	18758 b	5271 b
Avarage	2.06	1.18	61109	23387	6210
C.V., %	3.11	9.34	5.43	5.76	7.55
P > F	0.0073	0.2555	0.0053	0.0009	0.0052

[a, b, c] *Means in the column followed by different lower case letters differ by 5% Tukey*

Conclusion

The present data show that the sowing of corn silage from the third week of November to Guarapuava-PR region reduces the production of biomass per unit area.

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