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Evaluation of the Allelopathic Effects of Sorghum Crop Residues on Initial Maize Development

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Abstract

The grains are one of the main segments of the agricultural sector, not only national but also worldwide. Among the main produced, sorghum and maize are highlighted. The management techniques adopted for production are often not the most satisfactory, mainly referring to the planting of maize in succession to sorghum planting. We can highlight problems related to productivity, since it is known that sorghum has proven allelopathy, producing a complex of lipid and protein substances called generically sorgoleone, which acts in inhibiting the growth of other nearby organisms. Therefore, this study aimed to evaluate the allelopathic effects of sorghum crop residues on the initial development of maize. The experiment was carried out in pots at Faculdade Católica do Tocantins, during the year 2017. The experimental design was completely randomized (DIC), with four treatments: (1) control, without effect of sorghum (SFS), (2) planting direct (PD) on straw of sorghum, (3) incorporation of sorghum straw into soil (PI) and (4) minimal cultivation with straw removal (CMRP). The variables evaluated were plant height, stem diameter, length of the last leaf, root length, dry mass of the aerial part and dry mass of the root. The evaluated data were subjected to analysis of variance and the averages compared by the Tukey test at 5% significance. The incorporation of sorghum straw showed to be more harmful to the subsequent crop of maize, resulting in lower developmental indices vegetative.

Keywords: *Zea mays; Sorghum bicolor; Palhada; Sorgoleone*

Introduction

Among the sectors that comprise the national economy, agriculture has a fundamental importance, its beginning of sugarcane production, which has evolved to large monocultures such as maize and sorghum, and at the same time large diversifications of production with family farming. Among all this production, the grains were widely used in the composition of animal feed, as well as in human food.

The specific sorghum showed significant expansion in the last agricultural years. From the agronomic point of view, this growth is mainly explained by the potential of the crop in question as high grain and dry matter production, the ability to withstand environmental stresses. Thus, sorghum has been an excellent option for grain and forage production in all situations where the *deficit* and low soil fertility conditions offer greater risks to other crops, notably maize [1].

With the expansion and technification in the production chain of these grains occurring over the years with the technological advancement by the agricultural sector, studies are developed, such as soil tillage management for planting in succession to a culture with potential allelopathic, as well as the case of sorghum, thus generating better production results.

Allelopathy comes to be any beneficial or harmful effect, direct or indirect, caused by a plant or microorganism in another, by releasing organic substance into the environment. Allelopathic substances are usually classified as secondary compounds of plants, most of which originate from amino acids from the biochemical pathway [2].

Most of these allelopathic substances originated from the secondary metabolism of plants have the function of protecting it and/or defending it. This is because during the evolution of the plants, these compounds showed some efficiency against the action of different microorganisms, insects and viruses, stimulating the development and growth of the plant or inhibiting the action of these pathogens and predators [3].

According to Guenzi and McCalla (1966) and Trezzi [4] decomposition sorghum residues release expressive amounts of the ferulic, vanillic and siringic acids. According to Netzley and Butler (1986) and Trezzi [4] isolated from roots of Sorghum granífero contains to group of benzoquinone Called sorgoleone, what can be extracted with mixtures of dichloromethane and small amounts of acetic acid.

Sorgoleone is a strong inhibitor of the respiration of the photosystem II, acting in the same site of action of the herbicides Atrazine and Diuro and also a strong inhibitor of mitochondrial respiration [5].

In summary, the present work aims to evaluate the possible negative effects of allelopathic substances originating from the cultural rest of sorghum plants, on plant development and production of maize plants based on techniques of common management, such as minimal cultivation with straw removal, no-tillage and incorporation of the remains cultures.

Objectives of the Study

General Objective

Evaluate the allelopathic effects of graniferous sorghum on the initial development of maize crop.

Specific Objective

- To Evaluate the methods of management: No-tillage, minimal cultivation with straw removal and incorporation of crop residues, which provide greater effect in relation to the possible allelopathic effects of the graniferous sorghum *Sorghum bicolor* (L.) Moench.
- Evaluate the allelopathic effect of sorghum on the dry biomass of maize, plant height, stem diameter, root length and the last fully developed leaf, and green tint of the plant (SPAD Index).

Referential Theoretical

Culture of the corn

Maize (*Zea mays L.)* is a species belonging to the Poaceae family of the genus Gramineae, for more than 8000 years and it is cultivated in many parts of the World (United States of America, People's Republic of China, India, Brazil, France, Indonesia, South Africa, etc.). Its great adaptability is represented by various genotypes, allows its cultivation from Ecuador to the limit of temperate lands and from sea level to altitudes higher than 3600 meters, finding, like this in climates tropical subtropical seasoned. This plant is intended to use human and animal food, due to its high nutritional qualities, containing almost all known amino acids, except for lysine and tryptophan [6].

Its economic importance and characterized by the various forms of its use. The use of maize in grain with animal feed represents about 70% of the consumption of this cereal in the world. The different grades of technology donation make it a segmentation between producers with high productivity and others with low yields [7].

The third most cultivated crop in the world, in Brazil, is harvested on average 12 million hectares of maize each harvest, which places the country as the third in the world ranking of harvested area. In addition to its economic importance as the main component in the feeding of poultry, pigs and cattle, maize plays an important technical role for the viability of other crops, such as soybean and cotton, through crop rotation, minimizing possible problems such as Galha nematodes, cyst nematode and diseases such as white mold and others [8].

Maize can be industrialized through the processes of wet and dry grinding, according to Garcia., *et al.* [5], of this process result by-products such as corn flour, cornmeal, chirera, Farelos, oil and ungreasy whole flour, involving scales smaller production and lower industrial investment. The industrial processing of maize yields, on average, 5% of its weight in the form of oil. Through the wet grinding process, the main byproduct obtained is starch, whose product name was practically replaced by the commercial designation of Maizena.

In its cultivation one must pay attention to several factors that may end up limiting its production, among them the interspecific competition and its possible allelopathic effects. According to Karam and Betterance [9], several invasive plants have allelopathic capacity that affect the development of maize, such as rice grass (*Echinochloa crusgalli*), and the grass-tail-of-Fox (*Setaria faberil*). The degree of weed interference may vary according to climatic conditions and production systems. However, average reductions motivated by the interference resulting from the coexistence of maize with infestations have been described as the order of 13.1%. So that, in cases apart from control methods, this reduction can reach approximately 85% when these plants are not handled properly.

Allelopathy

According to Rice (1984) and Veronka., *et al.* [10], the term allelopathy, created by Molish in 1937, refers to any direct or indirect effect, beneficial or harmful, of a plant or of microorganisms on another plant, by the production of chemical compounds (allelochemicals) originating from secondary plant metabolism, which are released into the environment. According to Mano (2006), the release of these compounds in an agrosystem can occur by volatilization in the aerial part, leaching in the aerial or subterranean part, decomposition of plant tissues, or even by exsudation of the root system. Recent research has suggested the exploration of allelopathy as an alternative in plant management infectants.

Researches have been conducted prospecting genes and plants that favor this natural inhibition, consisting in the production of allelopathic substances that Act inhibiting the growth and development of other organisms. Such organisms already identified in nature have bacteria, liquens, fungi and plants. The latter may use allelochemicals in their plant-plant, insect-plant and even plant-herbivorous relationships [11]. Due to its recognized allelopathy, sorghum produces soluble and hydrophobic chemical substances, which are responsible for the allelopathic effects.

Among the vegetables of economic interest over the years, it has been proven that plants produce chemical substances with properties that affect beneficial or poorly, some plant species. This phenomenon was given the name of allelopathy and the substances responsible for these properties, of allelochemicals. These compounds are found distributed in varying concentrations in different parts of the plant, and during their life cycle. Allelochemicals when released in sufficient quantities cause allelopathic effects that can be observed in the germination, growth and/or development of already established plants, and also in the development of microorganisms (Carvalho, 1993 and Mano 2006).

As stated by Putman (1985) and Rodrigues [12], allelopathic substances are compounds that can be produced in any part of the plant, such as leaves, flowers, fruits, buds, aerial stems, rhizomes, roots and seeds, but the compounds concentrate mainly on leaves, followed by stems, flowers and roots, however, their concentration is altered from species to species and in the same species, depending on the stage of plant development and also of the organ producing the substance.

Among the vegetables the sorghum fits due to its allelopathic potential caused by sorgoleone, according to Dayan (2006) and Santos., *et al.* [11], the term sorgoleone is most often used to describe the predominant component of the exudate of sorghum roots called 2-hydroxy-5-methoxy-3-[(Z, Z)-8 ´, 11 ´,14 ´-pentadecatriene]-P-benzoquinone. They comprise about 90% of the oily secretion of sorghum roots, the remaining 10% of the composition of sorghum exudate are of minor substances, although similar to sorgoleone.

The release of allelochemicals from plants to the environment can occur from different means, such as by leaching through tissues, by volatilization, by decomposition of plant residue or even by root exudation [12].

Figure 1: *Allelochemical release Pathways. Source: Sánchez [13].*

Gatti (2004) and Oliveira., *et al.* [14] states that allelopathic substances exert a defensive function and are involved in the processes of inhibition and modification of growth patterns and plant development. Most of the time the allelochemicals are selective in their actions and also the plants present selectivity in their responses, which makes it difficult to clarify the mode of action of these compounds.

To identify such effects, an adaptation of Koch's postulated was proposed by Fuerst and Putnam (1983) and Trezzi [4] to prove a hypothesis of allelopathy, this adaptation is based on the following steps: (a) identification and quantification of symptoms; (b) Isolation, identification and synthesis of substances and characterization of their biological activity; (c) Obtaining similar symptoms with the simulation; (d) Quantification of the release of the substance and its absorption by the plant. To describe the chemical nature of the allelopathic substances according to their chemical similarity Rice (1984) and Trezzi [4] established 14 categories of allelopathic compounds, they are: hydrolysable tannins, galic acids, amino acids and polypeptides, alkaloids and cyanohydrins, purines and nucleotides, simple phenols, benzoic acid, coumarins, flavonoids, condensed tannins, water-soluble organic acids, long-chain fatty acids, terpenoids and phenolic acids.

According to Barros [6], the sorghum vegetation cover provides a significant reduction in corn dry mass production as a subsequent crop, or less accumulation of phytomass.

Researches have been conducted prospecting genes and plants that favor this natural inhibition, consisting in the production of allelopathic substances that act inhibiting the growth and development of other organisms. Such organisms already identified in nature have bacteria, liquens, fungi and plants. The latter may use allelochemicals in their plant-plant, insect-plant and even plant-herbivorous relationships [11]. Due to its recognized allelopathy, sorghum produces soluble and hydrophobic chemical substances, which are responsible for the allelopathic effects.

Planting direct

No-tillage was a revolutionary technique in modern agriculture, such technique emerged in trials in England and the United States in the 1950 decade, meeting in Brazil fertile soils to test all its potentialities, and definitely changed the scenery of World agriculture. At the beginning of 1970 years, erosion devastated the most fertile lands in the state, threatening to compromise the chain of agricultural activity in Paraná. Already baptized in Brazil as SPD (no-tillage system) the technique adopts the cultivation without soil revolving, but with crop rotation and permanent vegetation cover in the soil, contrary to common sense that used to burn the straw of winter crops and remove the soil for cultivation again [15].

According to EMBRAPA [1] and Vilas Boas and Garcia [16] the SPD is a conservationist cultivation technique, whose objective is to keep the soil always covered by plants in development and by plant residues, this cover has for purpose to protect the soil from the impact of raindrops, surface runoff and water and wind erosions. This planting system is considered as a minimum cultivation, since soil tillage is limited to the seeding of the sowing, proceeding both to sowing in unrevolving soil, as to fertilization and herbicide application in a single operation.

With a low initial growth, in terms of area, it was from the decade of 1990 that there was a great expansion of the area under SPD, both in the southern region and in the Cerrado region, where the SPD began only to be used in the 1980 years, are currently cultivated in Brazil about 20 million hectares under no-tillage. Globally, the area under SPD is 64 million hectares and Brazil occupies the second largest area, the United States being the country that presents the largest area under this system [17].

To Mazuchowski and Derpsch (1984) and Júnior., *et al.* [18] the no-tillage system prepares a maximum of 30% of the soil surface and consists of a sequence of three operations: harvesting and spreading the cultural remains, eliminating weed plants via herbicide application and using specific equipment. The limitations of this system reside in the inadequate management of herbicides, in addition to the high requirement of specialized technical assistance. According to Tormena., *et al.* (1998) and Júnior., *et al.* [18] soil and water losses are efficiently controlled by the no-tillage system, but the misuse of the system as excessive traffic of machinery and implements, coupled with the non-revolting of the soil, can cause compaction. It can also be cited as a negative point of no-tillage the excessive use of herbicides, which may, if poorly managed, favor the emergence of weed plants resistant.

Culture of the Sorghum

Sorghum culture *(Sorghum bicolor L.)* same botanical family of maize, is among the five most important in the world, being surpassed only by the crops of wheat, maize, rice and barley. Its greatest use is in animal feed, in the formulation of rations or as fodder and industrial. Its use in human food is possible, but, for cultural reasons, it is restricted to some regions of Africa and Asia. Nutritional mind, sorghum presents 95% of the biological value of maize. Sorghum can substitute 100% of maize in diets for ruminants and 40 to 60% in monogastric diets [19].

According to Diniz [20] and EMBRAPA [1], agronomically, the sorghums are classified into four groups: graniferous; Forage for silage and/or Sacarino; Forage for grazing/cutting; Green/Fenation/dead cover and broom. The First group includes low-sized types that are adapted to mechanical harvesting. The second group includes high-sized types suitable for silage and/or production of sugar and alcohol. The third group includes sorghums used for grazing, green cutting, fenation and mulching. The fourth group includes types whose panicles are made of brooms. The sorghum plant adapts to a range of environments, mainly under conditions of water deficiency, unfavorable to most other cereals. This feature allows the culture to be suitable for development and expansion in crop regions with irregular rainfall distribution and in succession to summer crops.

From the market point of view, sorghum cultivation in succession to summer crops has contributed to the sustainable supply of good quality products and low cost for animal feed, both for livestock farmers and for the agro-industry of rations. Currently, in sorghum grain producing regions of Central Brazil, the product has liquidity for the farmer and comparative advantage for the industry, which increasingly seeks alternatives to compose their rations with quality and lower cost [21].

According to data from Conab (National Supply Company), with the dissemination of the "10th Survey 2015/16", in July/16, there is a strong decrease in the area at the national territory level as well as a reduction in production due to the much more conjuncture favorable to maize, which is a product that best leverages the devalued currency due to the large external demand. Culture is increasingly being used for sites close to cattle production centers and/or feed production, while other sites are preferred by corn production [22].

Materials and Methods

Location experimental

The experiment was carried out in the Catholic greenhouse of Tocantins, Campus of Agrarian and Environmental Sciences in Palmas-TO, located in the geographic coordinates 48º 16' 34"W and 10º 32' 45"S at an altitude of 230m.

According to the International Classification of Köppen, the climate of the region is of type C2wA ' a ' - humid subhumid climate with small water deficiency, in winter, evapotranspiration potential annual average of 1,500 mm, distributing in the summer around 420 mm over the three consecutive months with higher temperature, with average annual temperature and precipitation of 27.5ºC and 1,600 mm, respectively [23].

Outline experimental

The experimental design adopted for this evaluation was completely randomized (DIC) with four treatments, which are, (minimum cultivation with straw removal), (no-tillage), (incorporation of the crop residues) and a following witness (area without Sorghum cultivation), so that the cultivation of maize is subsequently cultivated in such areas.

Soil preparation and planting

For the development of the work, it was made use of 28 vessels with measures equivalent to 23 cm of mouth diameter, 18 cm height and 19 cm in the bottom diameter, totaling a volume of 0.006 m^3 for planting of grain sorghum plants and subsequently the planting of maize, One plant per pot, 7 replicates were made per treatment totaling 3 treatments adopting different management techniques and one control. The vessels were positioned within the greenhouse in an equidistant way to facilitate displacement, data collection and plant development as shown in figure 2.

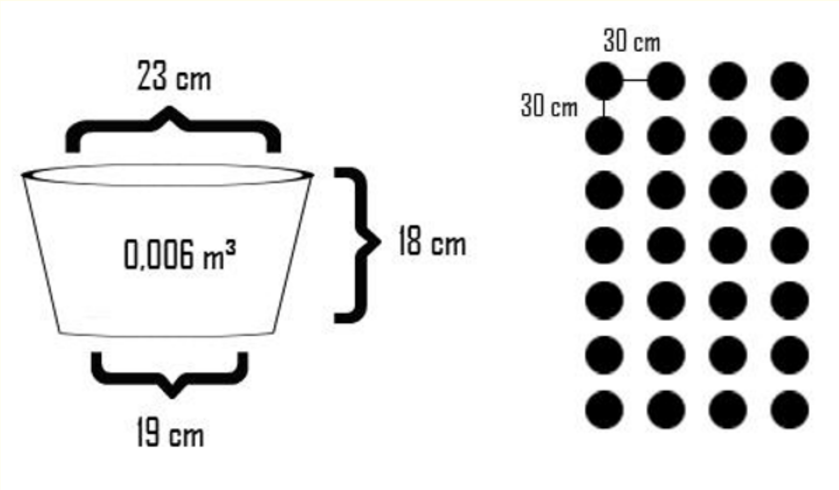

Figure 2: *Representation of vessel measurements and positioning. Source: Own Author, 2017.*

Characteristics of the only

Before planting was done a soil preparation in terms of chemical fertilization according to soil analysis. The results of the soil analysis are expressed in: pH (H_2The - 4,93; P (Meh) - 0,91 $mg.dm^{-3}$; K ($cmolc.dm^{-3}$) - 0,08; As ($cmolc.dm^{-3}$) - 0,26; Mg ($cmolc.dm^{-3}$) - 0,11; B ($mg.dm^{-3}$) - 0,07; With ($mg.dm^{-3}$) - 0,14; Fe ($mg.dm^{-3}$) - 74,44; Mn ($mg.dm^{-3}$) - 1,78; Zn ($mg.dm^{-3}$) - 0,60; To ($cmolc.dm^{-3}$) - 0,37; H + To ($cmolc.dm^{-3}$) - 5,50; M.O. ($g.dm^{-3}$) - 10,49; SB ($cmolc.dm^{-3}$) - 0,45; CTC ($cmolc.dm^{-3}$) - 5,95; V - 7,56%; m - 45,12%; Ca/CTC - 4,37%; Mg/CTC - 1,85%; K/CTC - 1,34%; Ca/Mg - 2,36; Areia ($g.Kg^{-1}$) - 470; Clay ($g.Kg^{-1}$) 0.295; Tags ($g.Kg^{-1}$) - 235.

Correction of base saturation (60%) with dolomitic limestone by calculation of base saturation: Need for Limestone = (V2 - V1) * T * F/100 totaling a need for limestone of 3.39 T. Ha^{-1}. The phosphate fertilization (Super Simple) based on the manual of the fifth approximation of the soils of the cerrado for soils with low clay content (21 to 40%) Totaling 80 kg. ha^{-1} of P_2O_5.

Planting of Sorghum

The seeds of sorghum granifero cultivar BRS 373, planted on April 29, 2017, were subjected to a seed viability test as follows, out of a laboratory germination test to evaluate the germination viability of the seeds which was composed of the following steps, out distributed the quantity of 300 grain sorghum seed in 3 gerbox boxes, totaling 100 seeds per each box distributed in equidistant form over 2 layers of filter paper and subsequently moistened with water with the aid of a dropwise and placed in ambient temperature condition. After 7 days, the count of germinated seeds was done totaling a 92% germination medium. Similar test was also done with corn seeds on a smaller scale containing 50 seeds per box totaling 150 seeds and 3 boxes, after 7 days out counted totaling a 96% average of germination.

The sorghum was planted in the pots using 3 seeds of the same distributed in an equidistant way in the intuit of minimizing the failures of germination by pot, after 10 days of seedling emergence was made the thinning of the other less vigorous, totaling only 1 sorghum plant per pot, passed around 110 days until sorghum enters physiological maturation, thus initiating the harvest of the panicle simulating as occurs in the commercial plantations among others.

After harvesting the sorghum panicles, the division of the treatments was initiated according to the different management techniques commonly adopted and subsequently to corn planting. For the no-tillage (PD) the sorghum plant was corded in smaller pieces with the aid of a machete and deposited on the surface of the vessel simulating the surface straw of the crop, and subsequently made the planting of maize, for the minimum cultivation with straw removal (CMRP) the whole aerial part was removed leaving the root system, and subsequently made the planting of corn, to incorporate the straw (PI) with the aid of a machete the whole plant was cut into smaller pieces then incorporated into the entire profile of the vessels and subsequently made the planting of maize, finally the witness which was not subjected to sorghum planting, only was done the planting of corn.

Planting of Corn

For maize planting was used seeds of the hybrid 30F35, planted on August 23, 2017, immediately after the harvest of sorghum and preparation of the treatments, with 4 seeds per pot distributed in an equidistant way to minimize the failures of planting and subsequently made the thinning of the other plants less vigorous, totaling only 1 plant of corn per pot. A common nitrogen fertilization Was made after 25 days of emergence, that is, in the same proportion for all treatments based on the manual of the fifth approximation of the cerrado soils for soils with low organic matter content (1.4%) totaling 150 kg/No of N, taking into account the measures of the vessel of 0.006 m^3 and the percentage of N contained in ammonium sulfate (about 20% of N) totaled 2,25g of ammonium sulfate per glass.

Finally, after the initial period was spent totaling 65 days after planting, which the plants uniformly were already in the vegetative stage V7 entering V8, the initial collection of vegetative development data was initiated, such as, height of plant (cm), stem diameter (mm), length of the last fully developed leaf of the plant (cm), root length (cm), evaluation of the dry matter of the aerial part (g) and root system (g) and chlorophyll (0.00 to 99.99 the a dimensional unit).

Description of the variables analyzed

Data collection was performed on October 27, 2017, when maize was in the V6-V7 stage, 65 days after germination. For the respective assessments, data collected from all repetitions except the repetitions 2 and 3 of all treatments, fact due to plant deaths caused by factors such as irregular irrigation. The evaluations were divided into two phases, first the field with the morphological measurements and subsequently in the laboratory after drying for the evaluation of the dry matter, to evaluate the results obtained due to the possible allelopathic effect by maize planted in succession to sorghum, a measuring tape graduated in (mm, CM and M) was used to make the measurements of: plant height (cm), stem diameter (mm), length of the last fully developed leaf of the plant (cm), root length (cm).

Height of plant

To measure the height of the plant was used a graduated tape (tape measure) The beginning of the measuring tape was positioned at the soil level of the vessel, measuring up to the curvature of the last fully developed leaf of the plant in question.

Diameter of high

To measure the diameter of the stalk was also used a tape graduated in millimeters (tape measure) stipulating the measurement of the 2° intern hatred visible between the 5° and the 6° visible node to make the respective measurement.

Length of last sheet fully developed

The length of the last fully developed leaf the measurements were based on the leaf collar to the tip at the end of the central rib with the aid of a measuring tape for data collection.

Length radicular

And for the root length the plants were removed from their respective vessels and with the aid of a watering water, debiting and unwinding with caution the roots, then measured with the beginning of the measuring tape at the last knot where the roots begin until the End of the last root, i.e. longest radicular wire.

Chlorophyll

And finally, the evaluation of chlorophyll with the aid of a chlorophyll meter. The readings performed with chlorophyll meter were made in points in the adaxial (upper) part situated at half the total length of the last fully developed leaf. The meter used was the Chlorofilog, model CFL1030 of Falker®.

According to the Company Falker® [24] Chlorofilog uses 3 light frequency bands, allowing for detailed analysis and obtaining quick and accurate measurements. These measurements can be viewed instantaneously or stored for analysis on the computer. The optical measurement analyzes the absorption of light by the leaf, indicating the presence of chlorophyll generating arbitrary value between 0.00 and 99.99, Unit, the higher the value, the greater the amount of Chlorophyll.

Air dry mass and radicular

The second stage began with the division of Materials, aerial part (stalk and leaves) and underground part (roots) in paper bags (2 bags for each plant), that is, a bag with the leaves and stem of a single plant and another bag with the root of it properly identifies The cut for division of the aerial and subterranean part was done at the last in the rooted plant (4th knot), subsequently the bagged materials were taken to greenhouse at 65°C for a period of 72 hours (3 dais) with the objective of evaluating the dry mass of both Parts.

Analyze statistics

The data obtained were submitted to analysis of variance from the software Sisvar 5.6, 2016 [25], Beta and the averages compared by the Tukey test at 5% probability level.

Results and Discussions

In the analysis of variance it can be observed that there were significant differences for the types of management in relation to the use of sorghum straw at the level of 1% of significance in the variables plant height, stem diameter, length of the last leaf, length Dry mass of the aerial part and root dry mass (Table 1).

					QM			
FV	**GL**	**ALT**	**DIAM**	**CMFOLHA**	**CMRAIZ**	**CLR**	**MSFC**	**MSR**
Manejo	3	54,52**	8,96**	6,05**	15,88**	2,54ns	67,85**	64,16**
Erro	16	77,01	3,8	177,08	195,62	31,26	8,5	2,02
Total	19							
Media Geral		70,23	12,55	61,31	50,89	23,31	18,14	8,4
CV (%)		12,3	15,53	21,7	27,48	23,98	16,13	16,94

Table 1: *Summary of the analysis of variance of maize performance (Zea mays L.) in succession to sorghum planting (Sorghum bicolor L.) under different management techniques.*

*** Significant at the 1% probability level (p <. 01) * Significant at the 5% probability level (. 01 = < P <. 05) NS not significant (p > =. 05). ALT: Plant Height; DIAM: Stem Diameter; CMFOLHA: Length of the last fully developed sheet; CMRAIZ: Length of the root; CLR: Chlorophyll; MSFC: Dry Mass of leaves and stalk; MSR: Dry Mass of Root.*

It can be observed (Table 2) that all variables referring to the embedded planting (IP) except the CLR were statistically lower in relation to the others and in no-tillage (PD) there is lower production in relation to MSFC and MSR.

Adopted Management	ALT	DIAM	CMFOLHA	CMRAIZ	CLR	MSFC	MSR
SFS	81,16a	13,00a	68,60a	58,84a	27,04a	27,78a	13,81a
PD	78,60a	13,60a	64,80a	58,42a	23,70a	16,19b	5,33b
IP	27,84b	8,80b	36,56b	14,66b	17,70a	3,75c	2,95b
CMRP	93,32a	14,80a	63,04a	71,66a	24,82a	24,84a	11,50a

Table 2: *Averages of the variables evaluated in the initial development of maize (Zea mays L.) in succession to sorghum planting (Sorghum bicolor L.) on different management techniques: control, Without Effect Of Sorghum (SFS), Planting Direct (PD) Na Straw Of Sorghum Incorporation of sorghum straw in soil (PI) and minimal cultivation with straw removal (CMRP).*

The averages followed by the same letter do not differ statistically. The Tukey test Was applied at a 5% probability level. ALT: Plant Height; DIAM: Stem Diameter; CMFOLHA: Length of the last fully developed sheet; CMRAIZ: Length of the root; CLR: Chlorophyll; MSFC: Dry Mass of leaves and stalk; MSR: Dry Mass of Root.

According to the results expressed in table 2, the management techniques adopted influence the initial development of maize, a lower development rate of maize is perceived in practically all the variables studied when the whole dry matter of sorghum (stalk, leaves and roots) after harvest, highlighting the production of phyto-mass in relation to leaves and stalk, perceives a lower proportion regarding the values of MSFC and MSR in the management IP behavior similar according to Yang., *et al.* (2004), Garcia and Sutier [26] who observed the dry matter production of the lower aerial part of soybean cultivated in succession to two sorghum cultivars and one of the mechanisms of sorgoleone induction is the inhibition of photosynthesis by interactions with components of photosystem II.

A negative aspect referring to the use of sorghum cover was also found by Alves (2002) and Faria [27] when using sorghum as a proportional vegetal cover a linear reduction in maize MSPA due to the increase in the coverage concentrations because of the action of allelochemical inhibitors that mainly act in the division and elongation of cell phone.

With a specific plant height ratio, Garcia and Sutier [26] observed that the residual effects of sorghum in the soil negatively affect the soybean plant height from the initial phases to the pre-harvest phase, such sorghum residues incorporated causes a low condition vegetative of cereals planted an area that weed biomass was lower where sorghum had previously been planted.

The results of the present study are similar in part to the results found by Forney and Foy (1985) and Trezzi [4] that found the toxic action of the hydrophobic fractions of sorghum plants roots on the development of ryegrass and alfalfa. Also, hydrophilic extracts from the roots of sorghum plants inhibited the development of the root and aerial part of *Amaranthus sp* [28-30].

Conclusion

In short, the sorghum planted with removal of the straw afterwards the harvest does not cause any harmful effect to maize in succession, however, with the use of no-tillage there was a decrease of the root and aerial dry mass and, this effect becomes more evident with the Incorporation of sorghum to soil, decreasing all variables, except the chlorophyll index.

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