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STRAW PRODUCTION IN DIFFERENT INTEGRATED CROP LIVESTOCK SYSTEMS UNDER NO-TILLAGE SOIL MANAGEMENT

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ABSTRACT

An important annual crops management system for carbon sequestration from the atmosphere is the crop livestock integrated system managed under no-tillage system. In the Brazilian state of Mato Grosso, the problems pointed out in the integrated NT system are lack of crop options for rotation and insufficient soil cover. The research activities of the present study were and extension activity as demonstrative unit of crop options of combinations of plant species producing high amount of vegetable dry matter. In which were focused on the contribution of varied amounts of dry mass and straw production and surface accumulation to the soil from production models consisting of annual cultures, successions, rotations and/or crop consortiums. The results confirm crop sequence soybean and cotton, provide low dry mass production. The crop sequences and second crop season that contain high-biomass sorghum and the maize consortium with palisade grass are the ones that provide higher dry matter production in the form of straw, being often above that minimum values in the tropical humid conditions, to keep the soil organic matter content stable. The sequence of crop that includes hybrid biomass sorghum was the one that showed higher mass production and has the potential for recovery of soil cover for those soils.

Key words: crop-livestock integrated systems; no-till systems; crop biomass production

INTRODUCTION

One of the most important annual crops conservative management system for carbon sequestration from the atmosphere is the crop livestock integrated system managed under no-tillage system. The no-tillage system (NT) has three basic assumptions: no soil revolving, crop rotation and permanent and adequate soil cover with straw. The lack of soil cover or inadequate cover, for a prolonged period, has been a problem pointed to the adequate soil management of crops conducted with NT system in the tropical region of Brazil. One of the factors that contribute to the effective success of the no-tillage system is based on crop rotations that provide high addition of different types of crop residues to the soil (FIDELIS et al., 2003). In the state of Mato Grosso, the problems pointed out in the integrated NT system are lack of crop options for rotation and insufficient soil cover. This may compromise the quality of crops managed with integrated NT system, mischaracterizing them as Low Carbon Agriculture (DERPSCH et al., 2010).

The annual crops of Mato Grosso state are usually managed without soil tillage, but not always in accordance with the precepts of NT systems. One of the factors that contribute to the effective success of the no-tillage system is based on crop rotations that provide high addition of different types of crop residues to the soil. In conservationist managements, under tropical and subtropical climate, it is recommended the addition of high amounts of cultural residues, offsetting the rapid decomposition, in order to keep the soil surface protected for as long as possible and to increase soil organic matter (BOER et al., 2008; DERPSCH et al., 2010). Bayer et al. (2000) and Petter et al. (2017) suggest that it is necessary to produce by the crop sequences about 12 to 16 Mg ha^{-1} of straw to maintain stable or increase the organic matter levels of tropical soils under cultivation.

MATERIAL AND METHODS

The field research activities, developed between 2013 and 2016, was a research and extension activity in the form of demonstrative unit of crop options of combinations of plant species producing high amount of vegetable dry matter. In which were focused on the contribution of varied amounts of dry mass and straw production and surface accumulation to the soil from production models consisting of annual monocultures, successions, rotations and/or crop consortiums. The systems studied for straw production, reflecting different intensities of plant dry mass production were soybean/biomass sorghum, soybean/maize + palisade grass 1 (recommended sowing density), soybean/maize, soybean/millet, soybean/maize + palisade grass 2 (twice the recommended sowing density), which constituted the treatments. An experiment was used in the experimental area of Embrapa Agrossilvipastoril, in the municipality of Sinop, Mato Grosso state, on crop rotation managed with NT system. The soil class of plots area are a Typic Clayey Dystric Haplustox. The experiment included the study of crop rotations in the mitigation of soil compaction and began in 2013.

The plots, with 30 m^2, with five replicates, were sown with soybean (cultivar BR 8665 RR) in the first harvest, rotated with five crop sequences: cotton, only in the 2nd season 2013/2014 (cultivar BR 365 RRF), millet (cultivar AMN 17), palisade grass *(Brachiaria brizantha* cv. Marandu) and maize (hybrid DKB 390 PRO) associated with palisade grass sown in the second crop, except for the soybean/maize + palisade grass 2 treatment, which from the second year replaced second crop season cotton due to difficulties to manage cotton crop. The cover and accumulation of straw in the systems were evaluated. The accumulation of straw from the plants of the production systems was determined by collecting straw samples in the treatments. The straw samples, five replicates, positioned close to the soil, were collected at intervals ranging from 30 to 45 days (Oliveira and Borszowskei, 2012). Six samples were collected in the first and second harvests, totaling twelve evaluations per crop. In the present work, only the results of the end evaluations of each crop are presented. The means of the straw sum of 1st and 2nd crop seasons were compared with Dunnett test ($\alpha = 0.05$), and the treatment soybean/maize was the control.

RESULTS AND DISCUSSIONS

In this paper are presented results obtained in the 2013/2014, 2014/2015 and 2015/2016 harvest obtained in a four-year experiment conducted at Embrapa Agrossilvipastoril, in Sinop-MT, in clayey tropical soil.

The treatment soybean/high-biomass sorghum (hybrid BRS 716) was added in the crop season 2014/2015. Were obtained in each plot, the values of grain yield and dry matter of the straw added to the soil at the time of harvest, from six samples of 1 m^2. The results of dry mass production for the three crop seasons were showed in Table 1. In the three crops seasons, 2013/2014, 2014/2015 and 2015/2016, the soybean and maize plots were obtained grain yields around the regional average respectively of 3,200 and 6,300 kg ha^{-1} (data not shown). The results presented in Table 1 show the need to maintain crop rotations in NT systems, mainly with crops or crop consortia that generate high amounts of straw in the post-harvest (CECCON et al., 2011; SEREIA et al., 2012). In the 2013/2014 harvest, the average dry mass after cotton crop harvest had the lowest value among all evaluated during the three years of the experiment. This common crop sequence in the state of Mato Grosso has resulted in low production of residual straw for soil cover, often with values far below those considered by Bayer et al. (2000) and Petter et al. (2017) as minimum for the maintenance of a soil cover with adequate straw and for stabilization or increase of the organic matter content of soils of the humid tropic region.

Table1. Dry mass production means and season accumulations, in kg by hectare, of soybean, cotton (crop season 2013/2014 only), maize, millet, sorghum, and palisade grass.

After harvest Crop Dry Mass, kg ha^{-1}							
Crop season 2013/14							
	Soybean	Maize	Cotton	Millet	Palisade grass	Total 1st season	Total 1st + 2nd season
Soybean* /cotton	3,725	-	2,146	-	-	3,725	5,871 B
Soybean* /maize	3,774	5,988	-	-	-	5,988	9,762 A
Soybean* /millet	3,811	-	-	6,152	-	6,152	9,963 A
Soybean /maize + pal. grass 1	3,622	6,336	-	-	4,991	11,327	14,949 C
Crop season 2014/2015							
	Soybean	Maize	High-biomass Sorghum	Millet	Palisade grass	Total 1st season	Total 1st + 2nd season
Soybean* /sorghum**	3,715	-	14,666	-	-	14,666	18,381 B
Soybean* /maize + pal. grass 2	3,564	7,558	-	-	4,261	11,819	15,383 B
Soybean* /maize	3,536	6,413	-	-	-	6,413	9,949 A
Soybean* /millet	4,789	-	-	5,714	-	5,714	9,250 A
Soybean* /maize + pal. grass 1	3,535	6,786	-	-	5,157	11,943	15,479 B
Crop season 2015/2016							
	Soybean	Maize	High-biomass Sorghum	Millet	Palisade grass	Total 1st season	Total 1st + 2nd season
Soybean* /sorghum**	4,329	-	17,575	-	-	17,575	21,904 C
Soybean* /maize + pal. grass 2	3,969	12,201	-	-	3,125	15,327	19,296 C
Soybean* /maize	4,057	7,869	-	-	-	7,869	11,926 A
Soybean* /millet	3,612	-	-	6,700		6,700	10,312 A
Soybean* /maize + pal. grass 1	4,109	10,034	-	-	2,325	12,359	16,468 B

*Soybean grown in the 1st crop. Intercropping soybean/maize + palisade grass 1, sown at the recommended sowing density, i.e., 5 kg ha^{-1} of viable seeds; soybean/maize + palisade grass 2, sown with twice the recommended sowing density. Means compared by Dunnett test ($\alpha = 0.05$) with control treatment soybean/maize. ** High-biomass sorghum BRS 716.

In the 2014/2015 and 2015/2016 crop season, it was observed that the sequences of soybean/high-biomass sorghum and soybean/maize + palisade grass 2 crops were the treatments that resulted in higher dry straw mass production, especially the first sequence. It can be affirmed that treatments involving maize or millet in the second crop season, despite providing high dry mass production, do not always reach those values considered adequate for the study region. Guimarães Jr. et al., 2010; Ceccon et al. (2011); Sereia et al. (2012) and Cavalli et al. (2018) observed that for maize grown in the second harvest to reach high values of grain yields and dry mass, it is necessary that the crop has adequate rainfall supply and that the rainy season also extends until the end of April or beginning of May. This also allows the maize + palisade grass intercropping, with forage sown in higher density, to produce a high amount of biomass, without reducing maize grain production (GUIMARÃES JR. et al. 2010; COLETTI JR. et al., 2015). It is important to highlight that higher dry mass yields will have as favorable results to the NT system, greater soil cover with straw, greater persistence of this cover until the beginning of the subsequent harvest and greater contribution of organic matter, and, consequently, greater addition of organic carbon in the soil, increases in organic matter and greater amount of nutrients being cycled for subsequent harvests (DERPSCH et al., 2010; OLIVEIRA & BORSZOWSKEI, 2012; PETTER et al., 2017).

CONCLUSIONS

In the crop season 2013/2014, the sequence of soybean followed by cotton, provided low dry mass and a not suitable soil cover.

The results obtained show the need to maintain crop rotations in no till systems and crop livestock integrated systems, and mainly with crops that generate high amounts of straw in the post-harvest.

The crop sequences (soybean only) and second crop season that contain high-biomass sorghum and the maize consortium with palisade grass are the ones that provide higher dry matter production in the form of straw, being often above the value of 15 Mg ha^{-1}, above that minimum values in the tropical humid conditions, to keep the soil organic matter content stable.

The sequence of crops in harvest and second crop season that includes hybrid biomass sorghum was the one that showed higher mass production and has the potential for recovery of soil cover for those soils that have reduced soil cover due to management problems or with low in the ability of agricultural use.

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