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Growth and Productivity of Maize Cultivated in No-Tillage in Succession of Different Cover Crops

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Abstract
The use of cover plants, especially leguminous, can improve the soil fertility by the nutrients cycling and N adds by symbiotic fixation. This work was carried out with the objective of evaluating, through the growth analysis, the effects of cover plants on the development of maize (*Zea mays*, L.) cultivar AG 1051, under no-tillage, in organic system of production. This study was conducted in Typic Dystrophic Red Latosol (Oxisol) at Experimental Station of Embrapa Rice and Beans, in Santo Antônio de Goiás, Goiás State, Brazil. The experiment was carried out in a complete randomized block design, using five treatments with four replications. The treatments were represented by cover crops: Cowpea (*Vigna sinensis*), Dwarf pigeon pea (*Cajanus cajan*), Sun hemp (*Crotalaria juncea*), Sorghum (*Sorghum technicum*), and fallow with spontaneous vegetation. Samples for evaluating leaf area and dry matter production were taken in ten replicates at seven days intervals. The growth analysis showed that for the variables leaf area and dry matter production was observed significant differences for the maize plants cultivated in succession to the leguminous in relation to those cultivated in succession to the spontaneous vegetation and sorghum. The average productivity of ears maize without husk was larger sun hemp-maize secession.
Key words: Nitrogen, leaf area index, leguminous, farming systems

1 Background and Objective of the Study

The use of cover crops, especially leguminous, can improve the soil fertility by the nutrients cycling and N adds (Perin et al., 2004). In the organic system of production is not allowed the use of fertilizer whit high solubility. Thus, the agricultural systems with leguminous species are an efficient strategy to accumulation of total N in the soil superficial layer, for the maize nutrition and growth (Oliveira et al., 2003).

The preference to the leguminous occurs, especially, because the soil nitrogen addition by symbiotic fixation by microorganisms, as the bacteria species of the *Rhizobium genus*. Throughout the years, the soil fertility is influenced by (the effect of) green manures, in function of the level increase of the level of organic substance, for the addition of phytomass, increase of the macro and micronutrients availability forms bythe plants; aid in the formation of acid organic basic to the process of and micronutrients mineral solubilizations; reduction in exchangeable aluminum levels; rise of soil pH and, consequently, reduction of the acidity, mainly for the action of the leguminous (Hunter et al., 1995; Oliveira, 1994; Osterroht, 2002;).

The maize cropping is practiced by all the class of producers, since small ones, which have small scale production, up to big producers which use of high technology. The maize, generally, is cultivated with intention to grains produce. Therefore, the production of fresh grain to consumption *in natura* comes as a viable alternative, mainly for small producers. Besides, beyond being harvested more early, making possible the farming systems, it presents, also, greater value of commercialization when compared with the maize use for grains (Wander et al., 2007).

The growth analysis is one way to verify the crops ecological adaptation to new environments, the competition between species, management crops effect and the identification of the productive capacity of different genotypes (Kvet, 1971). It allows evaluating the crops growth as a whole as well the contribution of different organs in the total growth. From the growth data the physiological activity, it is possible to evaluate, with sufficient precision, the causes of genetics growth variations between different plants or between plants growing in different environments (Benincasa, 1988).

This work was carried out with the objective of evaluating, through the growth analysis, the effects of cover plants on the development of maize (*Zea mays*, L.) cultivars AG 1051, under no-tillage, in organic system of production.

2 Methods

This study was conducted in Typic Dystrophic Red Latosol (Oxisol) with 473 g kg-1 of clay, 190 g kg^{-1} of silt and 366 g kg^{-1} of sand in the top 30 cm, located at Experimental Station of Embrapa Rice and Beans, in Santo Antônio de Goiás, Goiás State, Brazil. The 0-10 cm soil layer chemical characteristics at the beginning of the experiment were: P 7.6 mg dm^{-3}; K 98.0 mg dm^{-3}; Ca 25.2 $mmol_c$ dm^{-3}; Mg 4.6 $mmol_c$ and organic matter 2.0 dag dm^{-3}. According to classification of Köppen the research area is characterized by an Aw climate (tropical season savannah). The annual average of pluvial precipitation is 1,461.8 millimeters. The rainy season lasts from October to April and the dry season from May to September. The annual average air temperature is 22.6 °C. The monthly average temperature varies from 14.2 °C in June to 31.3 °C in September. The experiment was carried out in a complete randomized block design, using five treatments with four replications. The treatments were represented by cover crops: Cowpea (*Vigna sinensis*), Dwarf pigeon pea (*Cajanus cajan*), Sun hemp (*Crotalaria juncea*), Sorghum (*Sorghum bicolor*), and fallow with spontaneous vegetation. All the cover crops was sowing in early April with inoculated seeds, using a specific *Rhizobium* for each leguminous. Always, during the flowering, the cover crops were cutting and left the cultural remaining portions on the soil surface. In this occasion, the phytomass accumulation was determined according Speeding & Large (1957), and the total level of accumulated nitrogen according to Tedesco et al. (1985).

The sowing of the maize, cultivar AG 1051, was carried through with a density of 50,000 plants ha^{-1} after the management of the cover crops. The maize was sowing at the beginning of the rain season, subsequent to the management cover crops, whit 0.70 m between row and five seeds $meter^{-1}$. The control of the spontaneous weeds was carried through with manual weeding and to the control of Fall Armyworm (*Spodoptera frugiperda*) was used *Trichogramma* sp.

Maize plant samples for evaluating leaf area and dry matter production were taken in ten replicates at seven days intervals from 26° day after emergency. The leaf area (LA) was determined through an area measurer (Liquor, Incorporation Lincoln, NE, USA). The total dry matter (TDM) of maize and cover plants was considered all plant phytomass, except roots, after dries at 75 ºC. The leaf area index (LAI) was calculated considering: LAI = (LA (m^2)/area that the maize plant occupies in 1.0 m^2. Through the computational program data was adjusted to quadratic exponential equation (Portes & Castro Júnior, 1991). The yield and its components were evaluated to fresh and grain maize.

3 Results and Discussion

The sun hemp, followed of cowpea, presented higher production of dry matter in relation to the fallow, sorghum and the dwarf pigeon pea (Table 1). Although whit low production of dry mass, dwarf pigeon pea accumulated high nitrogen rate in its tissues. Cowpea was the species most efficient in relation to the nitrogen accumulation and sun hemp in dry mass accumulation. However, for all the cover crops, the dry mass production was inferior the 6.0 Mg ha^{-1} which, according to Darolt (1998), must be the minimum phytomass added in a crop rotation systems. The sun hemp and dwarf pigeon pea low phytomass productivity is related with sowing date (early April). According to Amabile et al. (2000), these species development is affected by the interaction photoperiod versus temperature, sowing date and latitude. Thus, the night along favours sun hemp and dwarf pigeon pea flowering induction and vegetative growth stage shortening.

Table 1. Dry matter and Nitrogen (N) of the aerial part of the cover crops.

Cover crops	Dry matter (kg ha^{-1})	N (%)
Cowpea	3,939	2.72
Dwarf pigeon pea	853	2.49
Sun hemp	4,256	2.13
Sorghum	3,101	1.32
Fallow	3,407	2.55

The maize in succession to the sun hemp, cowpea and dwarf pigeon pea, presented higher total dry matter accumulation during all cycle compared to the maize after sorghum and fallow (Figure 1). This behavior can be explained by the higher leaf area ratio (date not shown) of the maize plants cultivated in succession to sorghum and fallow. Maize plants after sorghum was lower efficient in producing leaf assimilates by unit of assimilation surface, compared to the maize plants cultivated after leguminous. The soil nitrogen increment added by the leguminous (Table 1) increase the maize plants surface assimilation. This resulted in higher yield in mass green grain production compared to maize cultivated after sorghum and fallow.

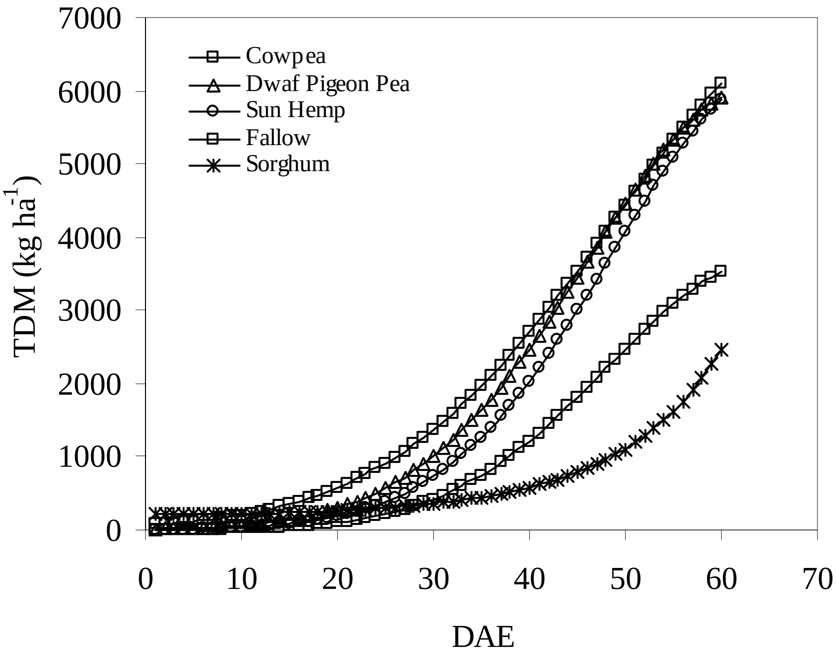

Figure 1. Total dry matter (TDM) after emergency (DAE) of maize plants cultivated in succession the different cover crops.

To LAI was observed higher values for maize plants cultivated in succession the leguminous compared to those cultivated after sorghum and fallow (Figure 2). The maximum values for the LAI in the leguminous-maize systems was: 2,41 m^2 m^{-2} to cowpea, 2,71 m^2 m^{-2} to dwarf pigeon pea and 2,62 m^2 m^{-2} to sun hemp, while for sorghum and fallow was respectively 1,86 m^2 m^{-2} and 2,19 m^2 m^{-2}. The equations adjusted for the leaf area index and total dry mass production are presented in Table 3.

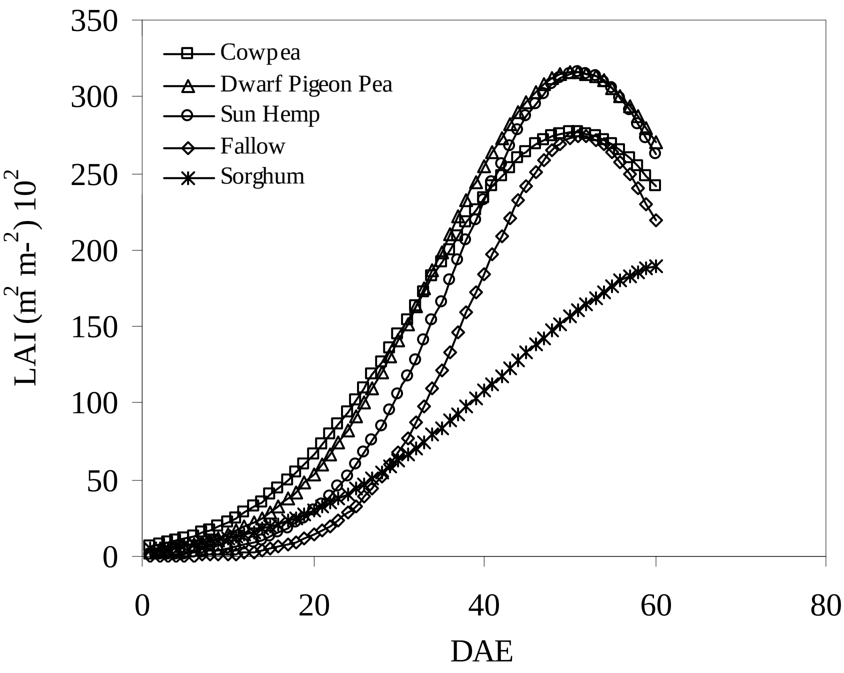

Figure 2. Leaf area index (LAI) after emergency (DAE) of maize plants cultivated in succession the different cover crops.

The spikes without husk, green and dry grain was higher for the treatment sun hemp, followed of the dwarf pigeon pea and cowpea (Table 2). Although sorghum has presented high phytomass production, probably it has had a less nutrient availability in the soil compared with the used leguminous species (Table 2). However, with inadequate nutrients levels the AG 1051 crop yield was compatible to observed yield in fresh maize exploration system that currently approximately the 10 ton ha^{-1} (Paiva Júnior, 2001). That confers to this cultivar high adaptability to the small producers in organic system of production.

Table 2. Production of spikes, mass of fresh grains, mass of dry grain and total dry matter of the maize cultivated in succession of the different cover crops[1].

Cover crops	Spikes without husk ($kg\ ha^{-1}$)	Mass of fresh grains ($kg\ ha^{-1}$)	Mass of dry grains ($kg\ ha^{-1}$)	Total dry matter ($kg\ ha^{-1}$)
Cowpea	9,348 ab	6,254 a	2,029 ab	3,481 a
Dwarf pigeon pea	10,318 a	6,952 a	2,293 a	3,332 a
Sun hemp	11,534 a	7,378 a	2,306 a	3,002 a
Sorghum	5,623 b	2,416 b	603 c	1,021 c
Fallow	8,104 ab	4,397ab	1,187 bc	1,812 b
CV (%)	20.75	26.70	29.99	35.60

[1]Values followed by the same letter are not significantly different at the 0.05 probability level.

Table 3. Quadratic exponential equations adjusted for the maize physiological index: Total Dry Mass (TDM) and Leaf Area Index (LAI).

Cover crops	Physiological Index			
	TDM		LAI	
	equation	r	equation	r
Cowpea	TDM= (60.15)exp((0.13)DAE+(-9.06E-04)DAE^2)	0.98	LAI = (0.0554) exp((0.15)DAE+(-1.53E-03)DAE^2)	0.90
Dwarf Pigeon Pea	TDM = (10.59) exp((0.198)DAE+(-1.54E-03)DAE^2)	0.98	LAI = (0.26) exp((0.189)DAE+(-1.86E-03)DAE^2)	0.85
Sun Hemp	TDM = (4.81)exp((0.22)DAE+(-1.63E-03)DAE^2)	0.99	LAI = (5.44E-03) exp((0.25)DAE+(-2.42E-03)DAE^2)	0.96
Sorghum	TDM = (216.91)exp((-7.17)DAE+(7.95E-04)DAE^2)	0.96	LAI = (4.08E-02)*exp((0.118)DAE+(-8.95E-04) DAE^2)	0.94
Fallow	TDM = (2.14) exp((0.229)DAE+(-1.75E-03)DAE^2)	0.98	LAI = (9.12E-04) exp((0.312)DAE+(-3.029E-03)DAE^2)	0.96

4 Conclusions

The leguminous cover crops significantly increase the maize growth, total dry mass production and yield, when compared with the sorghum and fallow

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