Research Article

Cameroon Journal of Biological and Biochemical Sciences **2020, Vol 28, Serie 2, 1-13**
ISSN 1011-6451/*CJBBS*.2020. Published Online (January 2020) (www.camjournal-s.com)

Intercropping *Zea mays* with *Stylosanthes guianensis* better improves sustainable agropastoral productions in Sub-Saharan Africa

TCHUENTEU TATCHUM Lucien*, AYAGNIGNI Emilienne, MEGUENI Clautilde
Department of Biological Sciences, Faculty of Science, University of Ngaoundere-Cameroon
* : Corresponding author ; Email : tatchumlucien@yahoo.fr; Phone : 00 237 699145141

Abstract

Several constraints hinder livestock development in Adamawa Cameroon, particularly the scarcity of pastures in dry season which causes transhumance practice that is source of agropastoral conflicts. In this respect, the effects of intercropping maize-forage plants on plants productivity were conducted. Randomized complete block design with 05 treatments (03 monocrops: maize; *Stylosanthes guianensis* and *Brachiaria ruziziensis*; 02 intercropping: maize-*S. guianensis* and maize–*B. ruziziensis*) and 03 replications were used. Development, growth and production parameters are studied. Results show that intercropping *Z. mays*-*B. ruziziensis* delays flowering and fruiting of maize plants. Maize seeds yield from monocrop and from intercropping with *S. guianensis* are respectively 1.5 fold and 1.44 fold higher than that from maize–*B. ruziziensis* intercropping. Overall, there is no significant effect between *B. ruziziensis* monocrop and maize–*B. ruziziensis* intercropping on *B. ruziziensis* growth. *S. guianensis* biomass from monocrop is 1.75 fold higher than that from intercropping with maize. Land Equivalent Ratio (LER) of maize-*S. guianensis* intercropping (1.51) is greater than that of maize–*B. ruziziensis* intercropping (1.30). The both studied intercropping systems are advantageous, but maize-*S. guianensis* intercropping system is the most benefic. By practicing maize-*S. guianensis* and maize–*B. ruziziensis* intercropping systems in Sub-Saharan Africa, we contribute not only to ensure food security, but also the rational management of cultivable land, the availability of forage and reduction of agropastoral conflicts while ensuring sustainable agriculture.

Key words: Forage plants, *Zea mays*, intercropping, productivity, Sub-Saharan Africa.

INTRODUCTION

The world in general and Africa in particular, is facing population increasing. This demographic increase is putting considerable pressure on natural resources (Bellefontaine *et al*., 2001, ICRAF, 2003). Today, nearly 800 million people are chronically hungry (FAO, 2015). This growth has led to an increase in food demand that can only be satisfied by intensification of agropastoral activity (Kasongo, 2008). However, this intensification has led to several negative effects on the environment and natural resources (Balde, 2011).

In Central Africa, Cameroon is one of the major livestock-producing countries because of level of its livestock and potentialities that are still unexploited in this subsector (MINEPIA, 2011). Adamawa region is Cameroon's largest cattle ranch

(Harchies *et al*., 2007). However, several constraints hinder the development of livestock in this region, notably the lack of forage production policy (Pamo, 1989; MINCOOP, 1993), the fragility of forage crops due to land insecurity and the scarcity of pastures during dry season; with consequence the use of transhumance which is sometimes a source of agropastoral conflicts (Liba'a *et al*., 2011).

Traditionally, herds' feeding is based essentially on the exploitation of natural pastures (Martin, 2002). During the dry season, these courses are found in straw state and become rare and less nutritious (Coulibaly, 2016). To this climatic constraint, is added the bad use of the lands of course due to some parameters such as the presence of different ethnicities and breeders with their way of land exploitation (Yonkeu, 1993). To these difficulties, farmers should adopt the intensive cultivation of forage plants for dietary needs of their livestock (MINEPIA, 2016). Forage resources in Adamawa Cameroon are dominated by grasses. *Brachiaria* and *Stylosanthes* genus are fodder highly appreciated by livestock in this region (Pamo *et al*., 1997).

In addition, the increase of human pressure on agricultural areas, the absence of land ownership outside the original region, and the precarious stability of rangelands, does not encourage the creation of fodder plots (Cesar *et al*., 2004). In several regions of the world, the integration of plants crop and livestock allows for more diversification of income sources and less risk of production losses. Thus, the practice of intercropping food crops with forage crops would increase land use by increasing biomass production per unit area while maintaining soil fertility (Pinchinat et al., 1976) and limiting agropastoral conflicts that often cause deaths in Adamawa Cameroon region.

Several studies revealed that intercropping systems are advantageous when plants are associated with Legume (Ghanbari *et al*., 2010; Nchoutnji *et al*., 2010). In addition, our recent studies (Tchuenteu *et al*., 2013; Derogoh *et al*., 2018) on intercropping systems in Cameroon reavealed that intercropping of castor bean with various Legumes are benefits for Cameroonians peasants. However, no studies have been conducted on intercropping between *Zea mays* and fodder plants in Adamawa Cameroon region. Thus, *Z. mays* intercropped with *B. ruziziensis* and *S. guianensis* would contribute to improving plants productivity, to rationally manage of cultivable land, to limit agropastoral conflicts in this region while ensuring sustainable agriculture. *B. ruziziensis* and *S. guianensis* are both fodder plants popularized by Agricultural Research Institute for Development of AdamawaCameroon region and maize is the most consumed cereal in this region. This study aims to intensify forage crops in Adamawa Cameroon region while preserving food security. Specifically, it consists (1) to evaluate the effects of intercropping *Z. mays*-*S. guianensis* and *Z. mays*-*B. ruziziensis* on plants growth; (2) to determine the impact of intercropping *Z. mays*-forage crops on seeds maize yield. The importance of this study is based on the fact that the intercropping system (maize-forage plant) that will be more beneficial will be popularized.

I. Materials and methods

I.1. Study Site

Study was conducted within campus of the University of Ngaoundere Cameroon in the season cropping year 2018. Ngaoundere Cameroon belongs to agro-ecological zone II known as sudano-guinean savannahs with six months dry season (November to March) and six months raining season (April to October. Mean annual temperature and total annual precipitation is respectively 25.75 °C and 1898.6 mm (Derogoh *et al*., 2018). Study site was located at latitude 03°38'805'', at longitude 08°20'806'' and at 1106 m elevation. The vegetation of study area is a herbaceous savanna dominated by *Imperata cylindrica*, *Pennisetum purpureum*, *Annona senegalensis* and *Piliostigma thonningii*.

I.2. Materials

The seeds of *Zea mays* (CMS 8704 variety), *Brachiaria ruziziensis* and *Stylosanthes guianensis* are used (figure 1). Maize seeds are from Agricultural Research Institute for Development of Adamaoua-Cameroon. Benedict or CMS 8704 variety of maize are yellow in color. It is an improved variety, much appreciated as fresh corn and having a short life cycle (03 months). *B. ruziziensis* and *S. guianensis* are fodder plants with small seeds about 2 to 2.5 mm and 1.5 to 2 mm length respectively. These both fodders are highly appreciated by cattle. There are used for their nutritional quality (rich in protein), their high biomass and their resistance to various environments (Pamo *et al*., 1997; Husson *et al*., 2008).

A : CMS 8704 variety seeds of *Zea mays* **B** : Seeds of *Brachiaria ruziziensis* **C :** Seeds of *Stylosanthes guianensis*

Figure 1 : Seeds of *Zea mays, Brachiaria ruziziensis* and *Stylosanthes guianensis*

I.3. Methods

I.3.1. Land preparation and experimental design

The experimental site was plowed at 30 cm deep and a fence was set up. After cleaning the field, fifteen (15) experimental units were formed.The experimental field measured 19 m × 18 m (342 m^2). Randomized complete block design with 05 treatments (03 monocrops: maize; *Stylosanthes guianensis* and *Brachiaria ruziziensis*; 02 intercropping: maize-*S. guianensis* and maize–*B. ruziziensis*) (figure 2) and 03 replications were used. Each elementary plot measured 5 mx 3 m (15 m^2). Two consecutive elementary plots are spaced at 50 cm as well as two consecutive blocks. In monocrop and in intercropping, space between two consecutive plants of maize was 50 cm. Space between two consecutive plants of *Brachiaria ruziziensis* or *Stylosanthes guianensis* in monocrop was 30 cm, while in intercopping *B. ruziziensis* and *S. guianensis* are spaced of maize at 25 cm.

a)Maize monocrop b)*Stylosanthes guianensis* **monocrop** **c)***Bracharia ruziziensis* **monocrop**

d) Intercropping maize-*Stylosanthes guianensis* **e)Intercropping maize-***Bracharia ruziziensis*

Figure 2: Cropping systems based on maize and fodder plants at 70 days after sowing

I.3.2. Seedling and plants management

Seeding was on July 26, 2018. The sowing method adopted is direct seeding and seeds are sown at 4 cm depth. 30 maize seeds and 20 seeds of *Stylosanthes guianensis* or *Bracharia ruziziensis* are sown per hole. The experimental field is maintained by hand weeding every 2 weeks. Mating took place two weeks after plants emergence so as to leave one plant per hole for *Zea mays* and ten plants per hole for *S. guianensis* and *B. ruziziensis*. Each experimental unit is tagged to facilitate data capture in the field.

I.3.3. Data recorded, sample and statistical analysis

Stages of plants development were determinated. During the vegetative phase, growth parameters such as plants height and number of leaves per plant were evaluated at regular intervals of 14 days. Production parameters (dry biomass of *Stylosanthes guianensis* and *Bracharia ruziziensis*; maize seeds yield) were evaluated at maturity. 30 plants are sample.

Comparison of the performance of each farming systems was made on the basis of the Land Equivalent Ratio (LER) according to Nouri and Reddy (1991) which is basically defined as the ratio of the surface productivity in associated culture to that in monoculture in accordance with follow equation : $LER = Pia/Pim$ $LER\ System = P1a/p1m + p2a/p2m + ... + Pia/Pi$ where, *Pia* and *Pim* are the production of crop *i* respectively in association and monoculture.

Means and confidence intervals were determined from repeated data. Data were subjected to analysis of variance following by the Duncan multiple test range analysis. The statistical package "statgraphics plus" was used for this propose.

II. Results

II.1. Stage of plants development

The study of stage of *Zea mays* development, *Brachiaria ruziziensis* and *Stylosanthes guianensis* revealed that monocrop and intercropping did not affect the dates of seeds germination. Indeed, mays emergence was observed at 6 days after sowing (DAS) and that of forage plants used in this work took place at 8 DAS in monocrop and intercrop. On the other hand, the dates of 50% flowering and fruiting vary according to treatments (Table 1). Maize growth in monocrop and in intercropping with *B. ruziziensis* flowered and fructify early compared to maize intercropped with B. *ruziziensis.* Treatments used in this work had no influence on flowering and fruiting dates of *B. ruziziensis* and *S. guianensis.*

Table 1: Stage of plants development according to treatment

Stage of plants development	*Zea mays*			*Brachiaria ruziziensis*		*Stylosanthes guianensis*	
	M	**MB**	**MS**	**B**	**MB**	**S**	**MS**
Germination (DAS)	6	6	6	8	8	8	8
Flowering (DAS)	77	84	77	84	84	87	87
Fruiting (DAS)	84	92	84	94	94	112	112

DAS : days after sowing ; M : *Zea mays* monocrop ; B : *Brachiaria ruziziensis* monocrop ; S : *Stylosanthes guianensis* monocrop; MB : intercropping *Zea mays–Brachiaria ruziziensis* ; MS : intercropping *Zea mays-Stylosanthes guianensis.*

II.2.1. Effects of intercropping of plants productivity

II.2.1. Effects of intercropping on maize growth and seeds yield

II.2.1.1. Effects of intercropping on maize growth

Growth parameters of maize such as plants height, number of leaves per plant, diameter of stem and plants dry bioimass were evaluated at 70 days after sowing. The analysis of variance (ANOVA) revealed that globally, there is a significant effect (P <0.05) between treatments on studied growth parameters. Maize monocrop exhibited the highest values of maize growth parameters while the smallest values of these parameters are from intercropping *Z. mays – B. ruziziensis* (table 2).

Maize plants height varied from 83.4 ± 21.6 cm for intercropping mays-*B. ruziziensis* to 102.2 ± 23.3 cm for maize monocrop. In this study, maize plants height from monocrop and from intercropping with *S. guianensis* were respectively 1.22 and 1.20 fold higher than that from intercropping with *B. ruziziensis.*

In the present work, the number of leaves per plant of maize ranged from 15.4 ± 0.50 for intercropping *Z. mays-B. ruziziensis* to 16.50 ± 0.50 for maize monocrop. Foliar production of maize from monocrop and from intercropping with *Stylosanthes guianensis* is respectively 1.03 and 1.20 fold greater than that from intercropping with *Brachiaria ruziziensis*.

The diameter of stem diameter ranged from 11.97 ± 2.36 mm for intercropping *Z. mays-S. guianensis* to 14.43 ± 3.09 mm for *Z. mays* monocrop. Intercropping *Z. mays-B. ruziziensis* exhibited an intermediate value (12.26 ± 3.02 mm) of diameter of stem. In this study, the stem diameter of maize from monocrop is respectively 1.17 and 1.20 fold higher than that from maize intercropped with *B. ruziziensis* and *S. guianensis*.

The highest value of maize dry biomass (85.00 ± 17.19 g/plant) is observed on maize monocrop while the smallest value (57.44 ± 10.04 g/plant) of this parameter is from intercropping *Z. mays-B. ruziziensis.* Intercropping *Z. mays-B. ruziziensis* exhibited an intermediate value (60.55 ± 25.01 g/plant) of maize dry biomass. The maize dry biomass from monocrop is respectively 1.47 and 1.40 fold higher than that from maize intercropped with *B. ruziziensis* and *S. guianensis*.

Table 2: Growth parameters of *Zea mays* according to treatment

Parametes	**Treatments**		
	M	**MB**	**MS**
Plants height (cm)	102.2 ± 23.30	83.4 ± 21.60	100.68 ± 22.13
Number of leaves per plant	16.50 ± 0.50	15.4 ± 0.50	16.3 ± 0.48
Diameter of stem (mm)	14.43 ± 3,09^{b}	12,26 ± 3.02^{a}	11.97 ± 2,36^{a}
Dry Biomass of plants (g/plant)	85.00 ± 17,19^{b}	57.44 ± 10,04^{a}	60.55 ± 25,01^{a}

M : *Zea mays* monocrop ; MB : intercropping *Zea mays–Brachiaria ruziziensis ;* MS : intercropping *Zea mays–Stylosanthes guianensis.* Values of lines affected by the same letter are not significantly different (P < 0,05).

II.2.1.2. Maize seeds yield

The analysis of variance (ANOVA) shown that there is a very significant difference (P <0.001) between studied cropping systems on maize seeds yield (figure 3). The highest maize seeds yield (4.32 ± 1.02 t/ha) was from maize monocrop and the lowest maize seeds yield (2.88 ± 0.45 t/ha) was from intercopping *Zea mays-Brachiaria ruziziensis*. The maize seeds yield from intercropping *Z. mays-S. guianensis* exhibited an intermediate value (4.15 ± 0.60 t/ha). In this study, maize seeds yields from monocrop and intercropping with *S. guianensis* were 1.5 and 1.44 fold higher than that from intercropping *Z. mays-B. ruziziensis.*

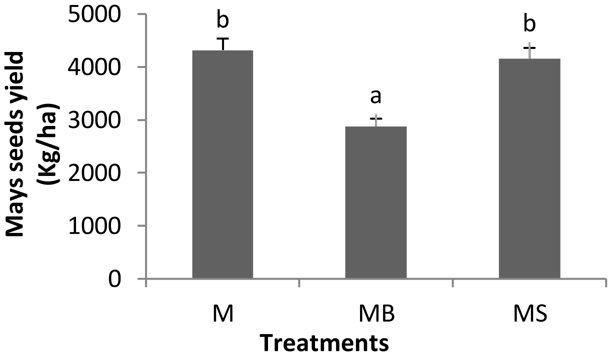

Figure 3 : Maize seeds yield according to treatment
M : *Zea mays* monocrop ; MB : intercropping *Zea mays–Brachiaria ruziziensis ;* MS : intercropping *Zea mays–Stylosanthes guianensis.* Values of bands affected by the same letter are not significantly different (P < 0,05).

II.2.2. Effects of intercropping on forage plants productivity

II.2.2.1. Height and foliar production of *Brachiaria ruziziensis* and *Stylosanthes guianensis*

At 70 days after sowing, the analysis of variance (ANOVA) revealed a very significant difference (P <0.01) between cropping systems on plants height of *Brachiara ruziziensis*. However, there is no significant difference between cropping systems on foliar production of *B. ruziziensis.* Furthermore, *Stylosanthes guianensis* intercropped with maize no affected significantly plants height as well as number of leaves per plant of *S. guianensis.*

At 70 days after sowing, plants height of *B. ruziziensis* ranged from 25.7 ± 5.5 cm for monocrop to 21.1 ± 4.1 cm for intercropped with maize (figure 4). Plants from *B. ruziziensis* monocrop are 1.22 fold taller than that from intercropped with maize. The numbers of leaves of *B. ruziziensis* per plant from monocrop and from intercropping with maize were 7.2 ± 0.8 and 7.1 ± 0.8 respectively (figure 5). Foliar production of *B. ruziziensis* from monocrop was 1.01 fold greater than from intercropping with maize.

At 70 DAS, the highest *Stylosanthes guianensis* plant height (14.79 ± 1.04 cm) was from intercropping *Zea mays-S. guianensis* and the smallest (13.46 ± 1.06 cm)) was observed on *S. guianensis* monocrop (figure 6). At 70 days after sowing, the number of leaves per plant of *S. guianensis* ranged from 15.6 ± 0.49 in intercropping *Z. mays-S. guianensis* to 18.8 ± 0.34 for *S. guianensis* monocrop (figure 7). In this work, foliar production of *S. guianensis* from monocrop is 1.20 fold higher than that from intercropping *Z. mays-S. guianensis*

.

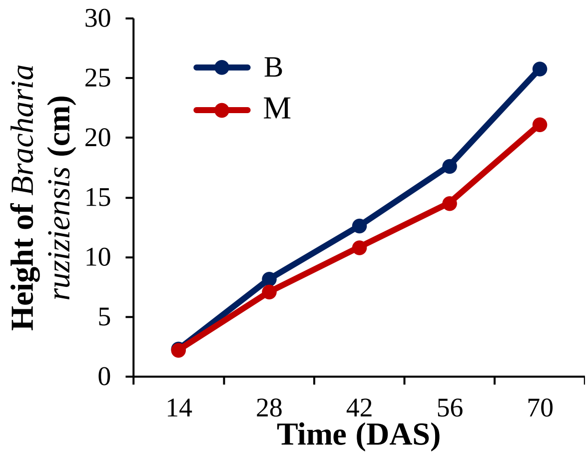

Figure 4: Variation on height of *Bracharia ruziziensis*

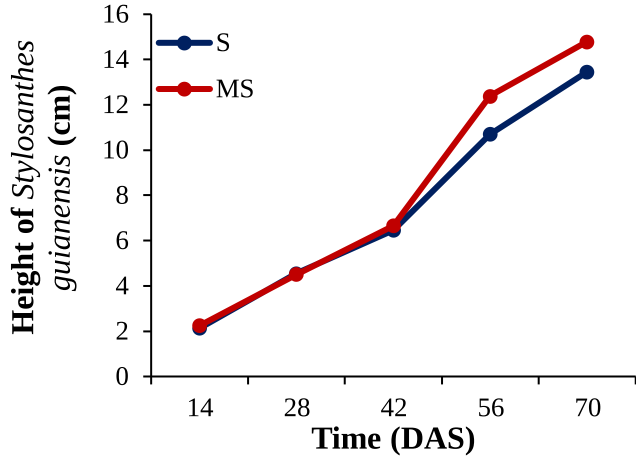

Figure 6: Variation on height of *Stylosanthes guianensis*

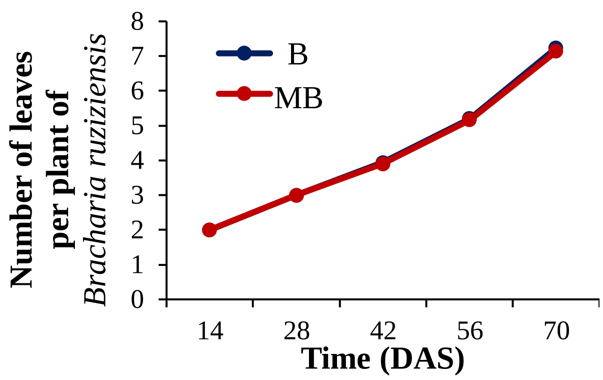

Figure 5: Variation on Number of leaves per plant of *Bracharia ruziziensis*

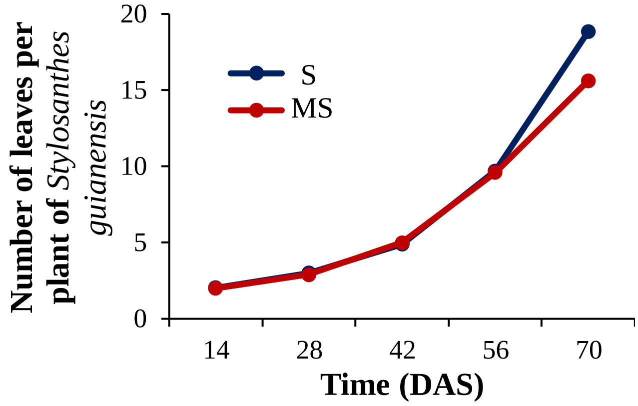

Figure 7: Variation on number of leaves per plant of *Stylosanthes guianensis*

B : *B. ruziziensis* monocrop ; MB : Intercropping maize- *B. ruziziensis* ; S : S. guianensis monocrop ; MS :Intercropping maize-*S. guianensis*

II.2.2.2. Number of bunches per plant, diameter of stem and dry biomass of forage plants

Growth parameters as well as number of bunches per plant, diameter of stem and dry biomass of plants of *Brachiara ruziziensis* and *Stylosanthes guianensis* were assessed at 70 days after sowing. Analysis of variance (ANOVA) revealed that there is no significant difference between *B. ruziziensis* monocrop and intercropping *maize-B. ruziziensis* on studied growth parameters *of B. ruziziensis*. *B. ruziziensis* from monocrop exhibited no signicantly the greater values of growth parameters. However the values of studied growth parameters of *S. guianensis* from monocrop was signicantly ($p<0.05$) higher than those from *S. guianensis* intercropped with maize (table 3).

Plants biomass of *B. ruziziensis* from monocrop is 1.02 fold higher than that from intercropping *B. ruziziensis-Zea mays*. Furthermore, *S. guianensis* biomass is from monocrop is 1.23 fold higher than that of *S. guianensis* intercropped with maize.

In the present study, globally correlation test revealed that there is a positive and significative correlation between studied growth parameters of forage plants used. Concerning *S. guianensis*, there is a positive and significative correlation between plants height and foliar production ($r = -0.90$; $p < 0.05$) ; plants height and number of ramification ($r = 0.87$; $p < 0.05$) ; plants height and plants biomass ($r = 0.93$; $p < 0.05$) ; diameter of stem at collar and plants biomass ($r = 0.62$; $p < 0.05$) and between number of ramifications per plant and plants biomass (r = 0.97 ; p < 0.05). About *B. ruziziensis*, there is a positive and significative correlation between plants height and foliar production (r = 0.52; p > 0.05); plants height and number of ramification (r = 0.84; p < 0.05) ; plants height and plants biomass (r = 0.84 ; p < 0.05) ; foliar production and number of ramifications per plant (r = 0.70 ; p<0.05) and between number of ramifications per plant and plants biomass (r = 0.97 ; p < 0.05).

Table 3 : Growth parameters of forage plants according to cropping systems

Parameters	Cropping systems			
	B	MB	S	MS
NBP	2.4 ± 0.49[a]	2.26 ± 0.44[a]	6.63 ± 0.76[b]	4.86 ± 0.68[a]
DSC (mm)	2.86 ± 0.71[a]	2.95 ± 0.55[a]	4.02 ± 0.73[a]	3.87 ± 0.46[a]
DBP (g/plant)	1.34 ± 0.76[a]	1.30 ± 0.71[a]	5.65 ± 1.70[b]	4.72 ± 1.51[a]
DBP (t/ha)	2.91	1.86	14.50	8.06

B : *B. ruziziensis* monocrop ; MB : Intercropping maize- *B. ruziziensis* ; S : S. guianensis monocrop ; MS :Intercropping maize-*S. guianensis* ; NBP : Number of bunches per plant ; DSC : Diameter of stem at collar ; DBP : Dry biomass of plants. Values of line for a intercropped forage plant affected by the same letter are not different significantly (p<0.5)

II.3. Performance of intercroppings *Zea mays–Brachiaria ruziziensis* and *Zea mays–Stylosanthes guianensis*

Values of Land Equivalent Ratio (LER) of intercroppings *Zea mays-Brachiaria ruziziensis* and *Z. mays-Stylosanthes guianensis* are recorded in Table 4. LER of each of the both studied intercropping systems is greater than 1, and LER of intercropping *Z. mays-S. guianensis* is 1,16 fold higher than that of intercropping *Z. mays-B. ruziziensis*.

Table 4 : Land Equivalent Ratio depending to intercropping system

Intercropping system	Intercropping *Zea mays–Brachiaria ruziziensis*
Land Equivalent Ratio	1.30

III. Discussion

In this study, flowering of *Bracharia ruziziensis* is observed at 84 DAS and is early compared to data from Tendonkeng *et al.* (2009) who reported that unfertilized *B. ruziziensis* flower at 155 DAS. *Z. mays-S. guianensis* intercropping presented no influence on flowering and fruiting periods of associated plants, whereas *Z. mays-B. ruziziensis* intercropping delays flowering and fruiting of maize and presented no effect on *B. ruziziensis* development. This result can be justify by that *Z. mays* and *B. ruziziensis* belongs to Poaceae Family and would have the same nutrient requirements. The beneficial effect of intercropping *maize-S. guianensis* on maize development could be explained by the fact that *S. guianensis is a Legume* and it fixed the atmospheric nitrogen necessary for maize development, but this need to be investigated.

Values obtained on maize height in this study are lower than that reported by Minengu *et al.* (2015); these authors studied the intercropping *Z. mays-S. guianensis* on plants productivity and revealed that average maize plants height was 1.3 m. In addition, data obtained on maize height are inferior to data reported by Tchuenteu *et al.* (2013) who studied the intercropping maize with castor bean under Sudano-Guinean climate of Adamawa Cameroon and found that maize plants height from monocrop was 190.17 ± 31.39 cm.

The number of leaves plant of maize obtained in this study is greater than data reported by Tchuenteu (2014) who found that the number of leaves per plant of maize from monocrop was 11.87 ± 1.63 at 18 weeks after sowing. The increase of foliar production could play a very important role in the region of Adamawa-Cameroon in that it could limit sunstroke, increase soil moisture, reduce erosion and sequester a CO_2 and contributes to reduction of greenhouse gases. These leaves represent a biomass that can be recycled into organic matter and can release the mineral elements needed for plant nutrition (Bunch, 2004). In this study, maize plants from monocrop exhibited the greatest foliar production, thus suggesting that plants grown on this cropping systems would provide the highest maize seeds yield, but this remains to be studied.

The values of maize seeds yield from maize monocrop obtained in this work corroborate the studies of Tchuenteu (2014) who reported that seeds yield of maize monocrop in the Sudano-Guinean savannahs of Cameroon was 4.26 ± 0.013 t/ha. Yeganehpoor *et al*. (2015) studied the effect of maize intercropped with some cover crops in Iran and revealed that maize seeds yield were respectively 3317.8 and 3671.3 kg/ha after synchronized sowing and lagged sowing. In addition, Addo-Kwafo *et al*. (2011) revealed that maize seeds yield from intercropping with *S. guianensis* was 5.27 t/ha.

It was reported in this stidy that the productivity of maize intercropped with *Stylosanthes guianensis* is higher than that of maize interrcropped with *Brachiaria ruziziensis*. This result is in conformity to data found in littérature. Indeed, Bado (2002 studied the role of legumes on soil fertility in Burkina Faso and revealed that legumes (cowpeas and beans) fix greater amounts of nitrogen, thus increasing yield of 70 to 100% compared to non-fixing cultures. Similarly, Konate *et al*. (2013) study the effect of soybean and cowpea crops on rice productivity in Gagnoa (Ivory Coast) and reported that these Legumes significantly ($P < 0.05$) improve rice yield. In fact, Legumes live in symbiosis with *Rhizobium* bacteria. These bacteria fix atmospheric nitrogen in the soil. This helps to increase soil nitrogen content, thus justifying the high productivity of maize when it is intercropped with *S. guianensis*. However, the comparative study of nitrogen amounts fixed by *S. guianensis* monocrop and intercropped with maize needs to be investigated.

The negative effect of maize productivity when it is intercropped with *B. ruziziensis* has been demonstrated: the works of Nchoutnji *et al*. (2010) on intercopping maize-*B. ruziziensis* in North Cameroon revealed that seeds yield of maize intercropped with *B. ruziziensis* is lower than maize monocrop. In addition, Asongwed *et al*. (2011) studied the increasing of cereal and forage biomass in Garoua (North Cameroon) and revealed that *B. ruziziensis* decreases grain yield of sorghum. Indeed this negative effect of *B. ruziziensis* on maize growth observed in this study would be due to competition between the both plants for hydromineral nutrition and light. Since maize and *B. ruziziensis* belong to the same family (Poaceae), they would have the same requirements for mineral nutrition. During flowering and fruiting stage of maize plants intercropped with *B. ruziziensis*, the both plants did not benefit from a sufficient amount of soil nutrients, thus justifies the negative effect of maize.

Data obtained on plants height of *B. ruziziensis* in this work are less than that reported by Mboko *et al*. (2013) who studied the intercropping *B. ruziziensis*-*Arachis glabrata* and reported that average plants height of *B. ruziziensis* was 42.2 cm.

It was observed in this study *B. ruziziensis* productivity decreased when it grown intercropped with maize. This negative effect of intercropping on *B. ruziziensis* growth could be justify by that maize and *B. ruziziensis* belong to the same Family (Poaceae) and would present the same exigency on mineral elements, also these both plants would compete for water and light. However space bewteen *B. ruziziensis* and maize which would limit competition between the both plants needs to be investigated. Crop growth and development is closely linked to the availability of resources (water, mineral elements) in soil and light (Balde, 2011).

In this study, the number of ramifications of *S. guianensis* ranged from 4.86 ± 0.68 for monocrop to 6.63 ± 0.76 for intercropping *Z. mays – S. guianensis*, which is significantly lower than data recorded by Butoto (2010) who studied the intercropping *S. guianensis-Manihot esculenta* and found that the number of ramifications varied from 17.66 to 19.16 for *S. guianensis* plants spaced at 12.5 and 25 cm of cassava.

The higher growth parameters values of *S. guianensis* from monocrop would be due to the fact that in monocrop, *S. guianensis* do not compete with other plants for light, water and all mineral elements present in the soil. It was observed in this work that dry biomass yield of *S. guianensis* monocrop (14.50 ± 1.47 t / ha) is higher than *S. guianensis* associated with maize (8.06 ± 1.49 t / ha). This negative effect of intercropping on *S. guianensis* productivity would be justified by that when *S. guianensis* is associated with maize, the shading created by maize would have limited the photosynthetic activities of *S. guianensis*, thus causing a slowing of *S. guianensis* growth as well as biomass production.

It was observed in this work that Land Equivalent Ratio (LER) of each of the both studied intercropping systems is greater than 1, thus suggesting that these intercropping systems are effective. However, LER of intercropping *Z. mays-S. guianensis* is higher than that of intercropping *Z. mays-B. ruziziensis*, suggesting that maize intercropping with *S. guianensis* is more benefit than intercropping *Z. mays-B. ruziziensis*. This benefit effect of intercropping *Z. mays-S. guianensis* is justified by that *S. guianensis*, being a legume, has fixed the atmospheric nitrogen, which contributes to enrichment of the study site in nitrogen, thus consequently the improvement of plant growth. Indeed, several authors (Parr *et al*., 2004; Teasdale, 2008; Tchuenteu *et al*., 2013, Derogoh *et al*., 2018) have shown that growing plants is improved when these plants are intercropped with legumes. Moreover, in intercropping *Z. mays-B. ruziziensis*, the both plants belong to the same Poaceae family and would have the same requirements for hydromineral nutrition. This could increase the competition between these plants, resulting a reduction of metabolic activities and therefore the growth of intercropped plants, this would justify the inferiority of performance of intercropping *Z. mays-B. ruziziensis* compared to intercropping *Z. mays-S. guianensis*.

CONCLUSION

Intercropping Z. *mays-S. guianensis* has no effect on flowering and fruiting periods of intercropped plants, while intercropping *Z. mays-B. ruziziensis* delays flowering and fruiting of maize and has no effect on *B. ruziziensis* development. Maize seeds yields from monocrop and from maize intercropped with *S. guianensis* are respectively 1.5 and 1.44 fold higher than that from maize intercropped with *B. ruziziensis*. Overall, there is no significant effect on growth of *B. ruziziensis* from monocrop and from intercropped with maize. Biomass yield of *S. guianensis* from monocrop is 1.75 fold higher than that from *S. guianensis* intercropped with maize. Land Equivalent Ratio (LER) of the both studied intercropping systems is greater than 1 and LER of maize-*S. guianensis* intercropping is greater than that of maize–*B. ruziziensis* intercropping (1.30). The both studied intercropping systems are advantageous, but maize-*S. guianensis* intercropping system is the most benefic. By practicing maize-*S. guianensis* and maize–*B. ruziziensis* intercropping systems in Adamawa Cameroon, we contribute not only to ensure food security, but also the rational management of cultivable land, the availability of forage and reduction of agropastoral conflicts while ensuring sustainable agriculture.

References

Addo-Kwafo A, Birteeb P T, Addah W and Naandam J (2011). Effects of intercropping cereal-legume on biomass and grain yield in the savannah zone. *Livestock Research for Rural Development,* 23 (9): 1-4.

Asongwed A A, Ko Awono P M D, Ngo T A C and Olina J P (2011). Augmentation de la biomasse céréalière et fourragère par l'utilisation des plantes de couverture locale, IRAD de Garoua, *Rencontres autour des Recherches sur les Ruminants* 18: 130 p.

Bado B V (2002). Rôles de légumineuses sur la fertilité des sols ferrugineux tropicaux des zones guinéenne et soudanienne du Burkina Faso. *Thèse PhD.* Faculté des Sciences de l'Agriculture et de l'Alimentation. Université Laval-Québec (Canada), 176 p.

Balde A B (2011). Analyse intégrée du partage des ressources (eau, azote et rayonnement) et des performances dans les systèmes de culture en relais sous semis direct en zone tropicale subhumide. *Thèse PhD.* Centre International d'Etudes Supérieures en Sciences Agronomiques Montpellier, 161 p.

Bellefontaine R, Petit S, Pain-Orcet M, Deleporte P and Bertault J G (2001). Les arbres hors forets : vers une meilleure prise en compte. Archives de documents de FAO, département des forets. Paris. 16 p.

Bunch R (2004). Engrais verts et culture de couverture. Agridape, 19 (1): 16-148.

César J, Ehouinsou M and Gouro A (2004). Production Fourragère En Zone Tropicale Et Conseils Aux Eleveurs. Conseils et formation en appui à la production laitière, Rapport Procordel, CIRDES, Bobo-Dioulasso, 47 p.

Coulibaly S (2016). Intégration de la culture fourragére aux systémes de cultures à base de céréales dans la province de la Comoe : cas du niébé fourrager dans un systéme de culture à base du maïs dans le village de Bole. *Mémoire de fin de cycle.* Université polytechnique de Bobo-Dioulasso, Institut du Développement Rural (IDR), 57p.

Derogoh N A N, Megueni C and Tchuenteu T L (2018). Effet de l'association culturale de trois légumineuses à grains (soja, niébé et haricot) et une accession locale de ricin (*Ricinus communis* L.) sur la productivité des plantes cultivées en champs dans deux zones agroécologiques du Cameroun. *Thèse doctorat PhD.* Université de Ngaoundéré. 146 p.

FAO, FIDA and PAM (2015). L'état de l'insécurité alimentaire dans le monde 2015. Objectifs internationaux 2015 de réduction de la faim: des progrès inégaux. Rome.

Ghanbari A, Dahmardeh M, Siahsar B A and Ramroudi M (2010). Effect of maize (*Zea mays* L.) - cowpea (*Vigna unguiculata* L.) intercropping on light distribution, soil temperature and soil moisture in arid environment. *Journal of Food, Agriculture & Environment* 8 (1): 102-108.

Harchies M, Binot A and Wolff E (2007). Impacts mutuels de la conservation et de l'élevage transhumants sur l'occupation des sols et les ressources environnementales. *VertigO - la revue électronique en sciences de l'environnement* Hors-série 4, 14 p.

Husson O, Charpentier H, Razanamparany C, Moussa N, Michellon R, Naudin K, Razafintsalama H, Rakotoarinivo C, Rakotondramanana and Seguy L (2008). *Stylosanthes guianensis***.** Fiches techniques plantes de couverture : Légumineuses pérennes. *Ed.* GSDM/CIRAD, *Manuel pratique du semis direct à Madagascar*, (3): 12 p.

ICRAF (2003). Annual Report. Nairobi. Kenya. La gestion durable des produits forestiers non ligneux (PFNL): cas du District d'Abala, 76 p.

Kasongo L M E (2008). Système d'évaluation des terres à multiples échelles pour la détermination de l'impact de la gestion agricole sur la sécurité alimentaire au Katanga R.D.Congo. *Thèse de doctorat PhD.* Université de Gand Belgique, 336 p.

Konate Z, Yao-Kouame A, Messoum F G, Camara M and Keli-Zagbahi J (2013). Effets des cultures de soja (*Glycine max*) et de niébé (*Vigna unguiculata*) sur la densité apparente et la teneur en eau des sols et sur la productivité du riz pluvial de plateau sur ferralsol hyperdystrique : cas de Gagnoa, au Centre-Ouest de la Côte d'Ivoire. *International Journal of Biological and Chemical Sci*ences, 7 (1): 47-59.

Liba'a N K, Dugué P and Torquebiau E (2011). Eleveurs et agriculteurs du nord du Cameroun faces à la violence et aux insécurités : entre adaptation et impuissance. *Cahiers de géographie du Québec*, 55(155): 175-195.

Martin I (2002). Appui aux groupements de producteurs laitiers de la zone périurbaine de Ngaoundéré-Cameroun. *Mémoire DESS* : Productions animales en régions chaudes, 66 p.

Mboko A V, Tendonkeng F, Matumuini N E F, Zougou T G, Miegou E, Boukila B and Pamo T E (2013). Effet comparé de l'enfouissement de deux légumineuses fertilisées au molybdène sur la croissance et le rendement de *Brachiaria ruziziensis* à différentes périodes de fauche dans l'Ouest Cameroun. *International Journal of Biological and Chemical Sciences*, 7 (6): 2513-2525.

MINCOOP (Ministère de la Coopération) (1993). *Mémento de l'Agronome*. 4[e] éd. Paris.

Minengu J D, Mobambo P and Mergeai G (2015). Etude des possibilités de production *Jatropha curcas* L. dans un couvert permanent de *Stylosanthes guianensis* (Aublet) Swartz en association avec le maïs (*Zea mays* L.) et le soja (*Glycine max* (L.) Merr.) dans les conditions du plateau des Batéké à Kinshasa. *Tropicultura*, 33 (4): 309-321.

MINEPIA (2011). Amélioration du Contrôle des maladies transfrontalières objet des échanges commerciaux, DSV/SDISSPV/AN18/09.

MINEPIA (2016). Cadre de Gestion Environnementale et Sociale (CGES) du Projet de Développement de l'Elevage (PRODEL) : Rapport définitif. 161 p.

Mpairwe D R, Sabiiti E N, Ummuna N N, Tegegne A and Osuji P (2002). Effect of intercropping cereal crops with forage legumes and source of nutrients on cereal grain yield and fodder dry matter yields. *African Crop Science Journal*, 10: 81-97.

Nchoutnji I, Dongmo A L, Mbiandoun M and Dugué P (2010). Accroître la production de la biomasse dans les terroirs d'agro-éleveurs: cas des systèmes de culture à base de céréales au Nord Cameroun, *Tropicultura*, 28(3): 133-138.

Nouri M and Reddy K G (1991). Utilisation de l'eau par le mil et le niébé en association et en culture pure. *In Soil Water Balance in the Sudano Sahelian Zone* (Proceedings of the Niamey Workshop, February 1991). IAHS Publ. no. 199.

Pamo T E, Yonkeu S and Onana J (1997). Evaluation des principales espèces fourragères introduites dans l'Adamaoua camerounais. *Cahiers Agricultures*, 6 : 203-207.

Pamo T E (1989). Rangeland response to low levels of nitrogen fertilization and cutting intensities on the Adamawa Plateau, Cameroon. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux*, 42(4), 591-598.

Pinchinat, A M, Soria J and Bazan R (1976). Multiple cropping in tropical America. In "Multiple cropping" Papendick, R. I. *et al.*, (ed.), ASA Special Publ. 27, *American Society Agronomy, Madison, WI.*, 51-63 p.

Tchuenteu T L (2014). Caractérisation agronomique des accessions locales de ricin (*Ricinus communis* L.) cultivées en champ dans le Grand Nord Cameroun et évaluation des propriétés physico-chimiques des graines. *Thèse de doctorat PhD*. Faculté des sciences, Université de Ngaoundéré, 135 p.

Tchuenteu T L, Megueni C, Tchobsala and Njintang Y N (2013). Effect of Intercropping Systems of Castor Bean, Maize and common bean on their Growth and Seed Yield in the Soudano Guinea Zone of Cameroon. *Journal of Agricultural Sciences and Technology, B.* 3(8): 582-590.

Tendonkeng F, Pamo E T, Zogang B F, Boukila B., Mboko A V and Matumuini F N E, (2009). Effet de différents niveaux de fertilisation azotée et du stade phénologique sur la croissance et le rendement de *Brachiaria ruziziensis* dans l'Ouest-Cameroun. *International Journal of Biological and Chemical Sci*ences, 3 (4): 725-735.

Yeganehpoor F, Saeed Z S, Ghassem A, Farideh S and Vahid B (2015). Effects of cover crops and weed management on corn yield. *Journal of the Saudi Society of Agricultural Sciences*, 14: 178–181.

Yonkeu S (1993). Végétation des pâturages de l'Adamaoua (Cameroun) : écologie et potentialités pastorale. *Thèse doctorat PhD*. Université de rennes I, France, pp 155-190.