Agricultural Science Research Journal
ISSN 2026-6073
Sebastien et al, Volume (8) Issue (5): 108 – 116 May - 2018.
RESEARCH PAPER

Cattle dung, phosphorus fertilizer and row planting on Centrosema pubescens (Benth) growth and, seed component attributes in ferralitic soils of Benin (West Africa)

Daniel Bignon Maxime HOUNDJO[1], *Sébastien ADJOLOHOUN[1], Basile GBENOU[1], Aliou SAIDOU[2], Léonard AHOTON[2], Marcel HOUINATO[1], Brice Augustin SINSIN[3]

[1]Département de Production Animale, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Jéricho, Cotonou, Benin

[2]Département de Production Végétale, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Jéricho, Cotonou, Benin

3Département de l'Aménagement et Gestion des Ressources Naturelles, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Jéricho, Cotonou, Benin

Email: GBENOU Basile: gbenoubasile@gmail.com[1], SAIDOU Aliou: saidoualiou@gmail.com[2], AHOTON Léonard: essehahoton@yahoo.fr[2], HOUINATO Marcel: mrhouinat@yahoo.fr[1], SINSIN Augustin Brice: bsinsin@gmail.com[3]

**Corresponding Author's E-mail: s.adjolohoun@yahoo.fr[1], Tél (229) 97 89 88 51*

Corresponding Author

Sébastien ADJOLOHOUN (PhD)

Département de Production Animale, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Jéricho, Cotonou, Benin

Corresponding Author's E-mail: s.adjolohoun@yahoo.fr[1], Tél (229) 97 89 88 51

Abstract

Centrosema pubescens **(Benth) is identified as a tropical forage legume of considerable promise which can improve pasture in West Africa. A study on the influence of rates of cattle manure in combination with plant row spacing on the growth, phenology and seed yield of Centro (*Centrosema pubescens*) was conducted at the Teaching and Research Farm of the Faculty of Agronomy Science of University of Abomey-Calavi in South Benin during 2014, 2015 and 2016 seasons. Five cattle manure rates (0, 4, 8, 12 and 16 tons/ha) and 40 kg P_2O_5/ha in combination with three plant spacings (40cm x 40cm, 80cm x 80cm, 120cm x 120cm) were evaluated in a 6x3 factorial laid out in Randomized Complete Block Design (RCBD). The growth and flowering characteristics measured in the field included: number of branches, number of leaves, plant girth, number of days to flower initiation, number of days to date of first flower appearance, number of days to 50% flowering, pod ripping time and efficiency of flower for pod production. Seed yield and seed components were evaluated each year by harvesting pods from 4 randomly selected plants per plot. Results obtained from data analysis showed that there was a significant influence of cropping season, row spacing, fertilizer rate and their three way interaction on seed production. Apart from the control treatment, seed yield was significantly higher in the second and third years (187.3 and 189.0 kg/ha, respectively) relative to the first year (153.8 kg/ha). Row spacing effect was significant on seed yield. Plants established at 80 cm × 80 cm gave significantly higher seed yield per ha (204.5 kg/ha) followed by 120 cm × 120 cm (179.0 kg/ha) and 40 cm × 40 cm (146.6 kg/ha) spacings. Seed yield was significantly increased due to application of cattle manure, with application of 12 tons/ha cattle manure giving higher yield. Neither row spacing nor fertilizer rate had significant effect on plant phenology. In contrast, efficiency of flower for seed production was influenced by fertilizer rate and cropping season. It can be concluded that row spacing of 80 cm × 80 cm and 12 tons per ha cattle manure can be recommended to farmers for *C. pubescens* seed production in the region.**

Key words: *Centro*, organic fertilizer, plant density, growth, development, seed, West Africa

Introduction

In Benin, the productivity of ruminant livestock is limited by poor nutrition. Several studies showed that shortage of forages is a major constraint to ruminant livestock production, especially in the dry season (Lesse, 2016; Koura, 2015; Adjolohoun, 2008; Gbenou *et al*. in press). Where forages are available, they are usually of low nutritive value. Poor nutrition lowers the resistance of animals to infections and parasitic diseases thus leading to high mortality rates, especially among young animals (30–40% in calves and 50% in lambs and kids) and low fecundity in adult females (60–66%), (Rivière 1991; Gbenou *et al*. in press). In such system, improvement of ruminant livestock production will need the development of forage productivity compatible to the subsistence farmer conditions in the region. In these conditions, legume forages can play an important role as they can contribute not only to increase the forage nutritive value but also to improve soil fertility via air nitrogen fixation (Muhammad, 2015; Ajayi *et al*. 2006).

Centro (*Centrosema pubescens*) originated from Central America and belongs to the genus *Centrosema* which comprises about 35 recognized species of herbaceous tropical legumes. Of these, only *C. pubescens* has attained economic importance level as a forage plant (Clements and Williams, 1980). Centro is a vigorous, trailing, twining, climbing perennial legume with trifoliate leaves that are drought tolerant. It has been identified by Cook *et al*. (2005), Adjolohoun *et al*. (2008a) and Houndjo *et al.* (in press) as a potential forage legume for the tropical region. In grass-centrosema association, the legume can fix annually an amount of 72-280 kg of N/ha (Muhammad, 2015; Sylvester-Bradley *et al*. 1990). Green matter yield of Centro varies from 13.5 to 40.0 t/ha/year (Ajayi *et al*. 2006; Houndjo *et al.* in press). *Centro* forage is rich in protein (19.6%) and can play an important role in overcoming micronutrient deficiencies characteristics of most tropical natural pastures (Adjolohoun 2008; Adjolohoun *et al*. 2008b; Nworgu *et al*. 2001). Forage phosphorous and calcium contents can reach 0.27 to 0.37% and 0.71 to 1.05%, respectively (Keller-Grein *et al*. 2000). Centro can be integrated into crop–livestock farming system from the north to the south of Benin (Muhammed *et al*. 2002; Houndjo *et al*. in press). This legume can be used as a green manure or as a ground cover in coconut and oil palm plantation crop and its forage can be grown for stall feeding, grazing or preserved as hay or silage for use during the dry season when there is a scarcity of grazeable materials (Muhammad, 2015; Ajayi *et al*. 2006). All these features have stimulated interest in improving its cropping in farming system.

Unfortunately, seed availability to promote this species in pastures is generally very low in Benin due to the low seed yield. The limited seed yield is attributed to low soil fertility and management production systems. In such case, mineral fertilizers can be used but these inorganic fertilizers are too expensive to resource-poor farmers. On the other hand, the use of high levels of chemical fertilizers on grasslands has enormous adverse effects on animal health and creates fertility problems. For example, a high potassium load can lead to reduction in fertility, disturbance of carotene metals and reduced feed intake, while a chronic high nitrate level during pregnancy has been linked to milk fever and other diseases (Lampkin, 1990).

There is a need for developing alternative management fertilizer systems that could be adapted to most ecological zones. Also the growing concerns over the environmental problems emanating from indiscriminate use of inorganic fertilizers in intensive production system leading to deterioration of soil fertility and productivity calls for alternative ways to fertilizer input through utilization of organic fertilizers (Akanbi *et al*. 2010; Ayoola and Adediran 2006). Therefore, the use of farm inputs in the form of organic manures has become necessary (Ayoola and Adediran 2006). Animal manure has long been used by ancient farmers as a source of nutrition and its benefits has been fully realized because of its cheapness (Hamma *et al*. 2012). Improvement in environmental conditions with respect to public health has been observed as some of the major reasons for the need to adopt organic farming by farmers in the world (Eifediyi and Remison 2010). Animal manures are a safer source of nutrition as they are environmentally friendly, release their nutrients in a slow and steady manner to crops in the field thereby activating soil microbial activities (Eifediyi and Remison 2010). Also, animal manures sustain cropping systems through better nutrient recycling and improvement in soil physical, chemical and biological properties (Ojeniyi 2000; Gambo *et al*. 2008).

Planting density is another agronomic parameter that influences both plant growth and seed production. Whether the seed should be sown in rows or broadcast is a question often raised in relation to seed production. Seed yield and quality in many crops depend on optimum planting density (Ogbonna *et al*. 2015; da Silva *et al.* 2016; Ngozi and Chidera 2017). A combination of optimum cow manure and plant density can maximize *C. pubescens* plant development. It is expected that *C. pubescens* sown at the appropriate plant spacing with adequate organic fertilizer application would result in higher yield and consequently the possible access to seed for most farmers.

Therefore, the objectives of this research were:

1. to determine the optimum rate of cow manure application and plant row spacing for *C. pubescens* seed production;
2. to determine the flowering and fruiting phenologies of the plant;
3. to make recommendations that ensure sustainable management of *C. pubescens* seed production in the Guinean savanna eco-geographical conditions of West Africa.

Methodology

Experimental site conditions

The experiments were conducted during the rainy seasons of 2014, 2015 and 2016 at the Teaching and Research Farm of the Faculty of Agronomy Science of

University of Abomey-Calavi in South Benin (Latitude 06°30'N, Longitude 2°40'E with an altitude of 50 m above sea level). The soil of the region was typical sandy-ferralitic and analysis conducted on 0-10 cm soil-samples showed that sand, loam and clay represent approximately 84, 8 and 8 %, respectively. The soil had a low water holding capacity with a relatively high leaching of elements. The main chemical characteristics of the experimental soil were: $pH_{(2/5water)}$ of 6.2; N = 0,05 %; organic carbon = 0,4 %; Ca = 60 mg/100 g; Mg = 10 mg/100 g; P(extractable) = 0,2 mg/100 g and K(exchangeable) = 20 mg/100 g. The experimental site was previously cultivated without any organic fertilization, as reflected by the low organic carbon content of the soil. The site is located in the Guinean Soudanian agroecological zone and has a bimodal pattern of rainfall, with a first rainy season commencing from April to July, a dry spell in August followed by a second rainy season, September to November. Annual precipitations during the three experimental years (2014, 2015, 2016) were 1107, 1241, 1238 mm, respectively (Table 1). Average monthly minimum and maximum temperatures were 25 and 30 °C, respectively (Table 1). During the 3-year experiment, irrigation was not used.

Experimental design, manure application, sowing and plant management

The experiment consisted of factorial combinations of six levels of fertilizer (0, 4, 8, 12 and 16 tons/ha of cattle manure (90% dry matter) and 40 kg/ha of P_2O_5 as form of superphosphate). Three levels of plant density (40×40, 80×80 and 120 cm ×120 cm). The eighteen (18) treatment combinations were laid out in a split-plot design with plant row spacing assigned to the main-plot (block), while fertilizer (cattle manure or P fertilizer) was assigned to the sub-plot (elementary plot). Elementary plot size was 6 m × 5 m (30 m²) with 2 m spacing between plots and 3 m between blocks. Each treatment was replicated 4 times. Fertilization with cattle manure took place fifteen days before sowing. The choice of 40 kg P_2O_5/ha was based on phosphorous content of cattle manure (approximately 1.44‰ reported by Gbenou *et al.* in press) and recommendation of Adjolohoun (2008). The four levels of cattle manure were incorporated into the soil according to the experimental design after land preparation and left for two weeks before sowing. *C. pubescens* used in the study was received from Brazil and was described by Cook *et al.* (2005) as training plant having strong tendency to root at nodes. Leaves are trifoliate with leaflets having 3 cm long and 1.3-2 cm broad. One kg of seeds contained approximately 36,000 units. Seeds were sown on March 25, 2014; March 16, 2015 and March 19, 2016. Four seeds per hole were planted (60-80% germination) at a depth of about 2 cm and latter thinned to one vigorous plantlet per hole after emergence. The treatments were established at the same plot each year. Trellis of 2.5 m height was installed for each plant (Keller-Grein *et al.* 2000). Manual hoe weeding was done if necessarily to maintain a weed-free growth environment.

Plants growth and flowering parameters measurements

- **Plant growth parameters**

Three weeks after sowing, 1 randomly selected plant was chosen per plot and marked for the following measurements: (1) Number of leaves 90 days after sowing (unit) by simple counting of leaves on each plant; (2) Length (mm) and the width (mm) of the largest leaflet of the plant; (3) stem girth (mm) at the base of the plant. Border plants were excluded from all measurements.

- **Plant flowering and fruiting phenologies**

For phenology characteristics, plants were daily observed and the following data were collected. (1) Date of flower initiation as the number of days after sowing where flower bud has 0.5 cm in length; (2) Day of first flower (unit): number of days from sowing to the appearance of the first flower; (3) Day of 50% flowering (unit): number of days from sowing to the day where 50% of plants had flowered; (4) Day of the onset of pod maturing; (5) Flower efficiency for pod production as the percentage of flowers that produced pod.

- ***Pods, seeds characteristics and seed yield measurements***

For seed yield evaluation, pods were hand-picked separately for each plant. Harvested pods from the same plot were pooled and 20 randomly selected pods were taken per plot and sun dried for 15 days. Seeds from those 20 pods were shelled and the number of seeds counted for the following data: (1) Number of seeds/pod; (2) Seed and shell weights from those 20 pods that were weighed separately (using electronic weighing balance). Seed weight/husk weight ratio was calculated. Seed yield/ha per treatment was calculated thereafter from seed components by multiplying the weight of seeds per plant by the corresponding plant density for corresponding row spacing.

Statistical analysis

Eighteen treatments (3 row spacing × 6 levels of fertilizers) were considered in the trial. Data were analyzed with the GLM (General Linear Model) procedure of SAS 8.02 software (SAS Inc., Cary, NC) using the following model : $Yij = \mu + Di + Fj + Yk + (D*F)ij + (D*Y)jk + (F*Y)jk + (D*F*Y)ijk + eijk$. Where μ = mean, *Di* = row spacing effect, *Fj* = fertilizer effect, *Yk* = year effect, *(D*F)ij, (D*Y)jk, (F*Y)jk,* and *(D*F*Y)ijk* their two or three ways interactions and *eik* the error term. When significant interaction was observed, data were re-analyzed separately by two- or one way analysis of variance. A significance was declared at P<0.05.

Results

Plant Growth

Statistical analysis showed that there was neither significant influence of year nor row spacing on plant growth parameters such as number of branches, plant girth, number of leaves, main leaflet length and leaf width (Table 2). Fertilizer applied had significant effect on these parameters. The different fertilizers had significant ($P < 0.05$) effect on number of branches, plant girth, number of leaves, main leaflet length and leaf width (Table 2). At 90 days after sowing, plots that received 16 tons cattle dung per ha produced the highest number of branches (61) followed by treatment of 12 tons per ha. The shortest number of branches (36) were recorded from the control (36) which was not statistically different with treatment of 4 tons per ha (38). For four other parameters like plant girth, number of leaves, main leaflet length and leaf width, application of either 12 or 16 tons per ha or mineral fertilizer application of 40 kg/ha of P_2O_5 produced similar plant growth.

Table 1: Average monthly rainfall and mean temperature during the growing seasons of 2015–2016

Months	Temperature (°C)			Rainfall (mm)		
	2014	2015	2016	2014	2015	2016
January	27	26	28	0	27	0
February	26	27	28	0	0	0
March	29	27	28	29	55	11
April	28	29	27	110	155	121
May	27	26	28	132	153	133
April	28	27	27	254	203	276
Jun	25	26	27	154	219	217
July	25	25	26	117	118	110
August	25	25	26	89	55	101
September	26	26	27	123	112	167
October	27	28	26	74	121	99
November	26	25	25	0	23	0
December	27	28	28	0	0	3
Total	-	-	-	**1107**	**1241**	**1238**

Table 2: *Centrosema pubescens* vegetative growth characteristics as influenced by cattle manure and phosphorous fertilization during three growing seasons (2014-2016)

Fertilizer	Growth characteristics at 90 days after sowing				
	Number of branches	Plant girth (mm)	Number of leaves	Main leaflet length (mm)	Main leaflet width (mm)
0 (control)	36d*	3c	158d	32c	15b
4	38d	5b	154d	36b	15b
8	45c	5b	187c	35bc	19b
12	50b	8a	218a	48a	29a
16	61a	8a	221a	50a	31a
40 kg/ha P_2O_5	44c	7a	200b	45a	26a
Mean	**46**	**6**	**190**	**41**	**23**

* For the same column, means followed by different letters are significantly different at $p < 0.05$.

Plant flowering and fruiting

Neither row spacing nor fertilizer have significant influence on plant initiation date, date of first flower, 50% flowering date and pod repining time (Table 3). During the three cropping seasons, *C. pubescens* began flower initiation between 125 and 132 days after sowing. The first flowers bloomed between 150 and 159 days after sowing and pod repining started 169 and 180 days after sowing. Both year and fertilizer had significant effect ($P < 0.05$) on flower efficiency for pod production with also significant interaction between year and fertilizer ($P < 0.05$). Efficiency of flower for pod production was higher in the second and third years than in the first year (Table 4). During the first year, flower efficiency ranged in the following order: P_2O_5 = 16 tons = 12 tons > 8 tons = 4 tons > control and in the second year the range was in the order: P_2O_5 = 16 tons = 12 tons = 8 tons > 4 tons = control. In the third year, the ranking was: P_2O_5 = 16 tons = 12 tons = 8 tons > 4 tons = control.

Table 3: *Centrosema pubescens* flowering and fruiting as influenced by cattle manure fertilizer in Soudano-Guinean region of Benin (West Africa)

Fertilizer	Number of days after sowing to			
	Flower initiation	First flower	50% flowering	Pod repining
0 (control)	132	159	169	180
4 tons/ha	120	150	157	169
8 tons/ha	125	152	160	169
12 tons/ha	128	156	164	176
16 tons/ha	130	159	165	177
40 kg/ha P_2O_5	127	157	165	176
Mean	**127**	**156**	**163**	**175**

Table 4: *Centrosema pubescens* flower for pod production* as influenced by cattle manure fertilizer and year in Soudano-Guinean region of Benin (West Africa)

Fertilizer	Year			
	2014	2015	2016	Mean
0 (control)	17Bc**	22Ab	24Ac	**21**
4 tons/ha	22Ab	25Ab	25Abc	**24**
8 tons/ha	21Bb	33Aa	32Aa	**29**
12 tons/ha	30Aa	34Aa	35Aa	**33**
16 tons/ha	29Aa	31Aa	30Aba	**30**
40 kg/ha P_2O_5	30Aa	32Aa	33Aa	**32**
Mean	**25**	**30**	**30**	**28**

* Efficiency of flower for pod production (%) calculated as the proportion of flowers that produced pod. **For the same column and for the same year, means followed by different lower case letters (a, b and c) are significantly different at $p < 0.05$; For the same line, means followed by different upper case letters (A, B and C) are significantly different at $p < 0.05$

Seed yield

Year, row spacing, fertilizer and their interactions were significant ($P < 0.05$) on seed yield (Table 5). Mean seed yield through the three years was 176.7 kg/ha. During the three trial years, seed yield was higher in the second and third years (187.3 and 189.0 kg/ha, respectively) than in the first year (153.8 kg/ha). In the three years, seed yield produced by 80 cm row spacing (204.5 kg/ha) was significantly higher than seed yield from 120 cm row spacing (179.0 kg/ha) which was significantly higher than that from 40 cm (146.6 kg/ha). Influence of fertilizer was variable, depending on the year.

Table 5: Effect of plant density, cow manure and phosphore fertilizer on seed yield (Kg/ha) of *Centrosema pubescens* on ferralitic soils of Benin (West Africa)

Fertilizer	Row spacing			Mean
	40×40 cm	80×80 cm	120×120 cm	
2014				
Control	95.0αcC*	150.0βdA	121.0αbB	**122.0**
4 tons/ha	98.4βcC	151.1βcdA	128.5βbB	**125.3**
8 tons/ha	145.0γbC	187.7βbcA	164.8βaB	**165.8**
12 tons/ha	147.9βabC	201.7γabA	166.0βaB	**172.6**
16 tons/ha	128.0βbC	170.0βcA	157.3βaB	**151.8**
40 kg/ha P_2O_5	168.8αaC	216.3αaA	172.3βaB	**185.9**
Mean	**130.5**	**179.4**	**151.6**	**153.8**
2015				
Control	64.6βcC	167.5αβdA	145.0αdB	**125.5**
4 tons/ha	160.0αbC	196.3αcA	173.8αcB	**176.7**
8 tons/ha	172.6αbC	223.8αbA	200.0αbB	**198.8**
12 tons/ha	197.6αaC	254.0βaA	233.5αaB	**228.3**
16 tons/ha	173.3αbC	221.6αbA	200.7αbB	**198.5**
40 kg/ha P_2O_5	176.0αbC	213.8αbcA	197.9αbB	**195.9**
Mean	**157.3**	**212.8**	**191.8**	**187.3**
2016				
Control	39.8γdC	170.0αdA	150.1αdB	**119.7**
4 tons/ha	156.0αcC	195.0αcA	179.6αcB	**176.9**
8 tons/ha	175.6ααbC	228.0αbA	198.9αbB	**200.8**
12 tons/ha	200.0αaC	280.0αaA	229.9αaB	**236.9**
16 tons/ha	169.0bC	227.7αbA	210.7αabB	**202.5**
40 kg/ha P_2O_5	172.0αbC	225.9αbA	192.9αbB	**196.9**
Mean	**151.9**	**221.2**	**193.7**	**189.0**
3-year mean	***146.6***	***204.5***	***179.0***	***176.7***

*For the same column and for the same year, means followed by different lower case letters (a, b and c) are significantly different at $p < 0.05$; For the same row, means followed by different upper case letters (A, B and C) are significantly different at $p < 0.05$; For the same year and for the same level of fertilizer, means followed by different alpha numeric letters (α, β, and γ) are significantly different at $p < 0.05$.

Seed components

Table 6 shows data on *C. pubescens* pods and seeds characteristics. During three cropping seasons row spacing have not significant influence on pod length, pod broad, number of seed/pod, 100 seed-weight and seed weight/pod weight ratio. On the other hand, statistical analysis showed that fertilizer have significant effect ($P < 0.05$) on pod length, pod wide, number of seed/pod, 100 seed-weight and seed weight/pod weight ratio (Table 6)**.** During three cropping seasons The 100 seed-weight was highest (3.58 g) with fertilizer application of 16 t ha^{-1} cattle dung and lowest (1.06 g) for the control 0 t ha^{-1}. The variation in mean of number of seeds per pod for fertilizer application was lowest (4.55) for application of 0 t ha^{-1} of cattle dung and highest (18.09) for application of 12 t ha^{-1} (Table 6). For three other parameters (pod length, pod broad and seed weight/pod weight ratio), treatments with 12 or 16 tons per ha or mineral fertilizer application produced similar results.

Table 6: *Centrosema pubescens* pod and seed characteristics as influenced by fertilizer levels on ferralitic soils of Benin (West Africa)

Fertilizer levels	Pods and seeds characteristics				
	Pod length (cm)	Pod broad (mm)	Number of seeds/pod	100 seeds weight (g)	Ratio Seed/shell
0 (control)	6.54b*	2.44b	4.55d	1.06c	3.55a
4 tons/ha	8.08b	2.61b	7.39c	1.86b	3.19b
8 tons/ha	14.98a	3.75a	13.75b	2.09b	3.89a
12 tons/ha	15.66a	3.34a	18.09a	3.46a	3.31b
16 tons/ha	15.55a	3.59a	17.74a	3.58a	3.45b
40 kg/ha P_2O_5	13.77a	3.40a	14.80b	2.27b	3.66ab
Mean	**12.43**	**3.19**	**12.72**	**2.39**	**3.51**

* For the same column, means followed by different letters are significantly different at $p < 0.05$.

Discussions

There was no significant influence of row spacing on *C. pubescens* growth characteristics with 90 days of growth during the 3-year study. However, fertilizer significantly influenced growth parameters. In the first experiment year and after 90 days plant age, phosphorus fertilizer produced generally highest plant growth than organic fertilizers and control (not showed in the tables). Such results are in accordance with those reported by Saha *et al*. (2007) when they found that chemical fertilizer increased more corn growth parameters than farmyard or poultry manure. In the same way, the number of leaves per plant was smaller in the control treatment than organic or phosphore fertilizer in 3-years of the study which indicates that either organic or phosphore fertilizers have a direct effect on leaf emergence, growth and development and these results agree with others studies. The fact that in the first year of trial, for most growth characteristics that were studied, there was no significant difference between application of 4 tons of cattle manure per ha and the control indicated that plant nutrients added to the soil from application of 4 tons of manure were not sufficient to induce a sensitive increase in *C. pubescens* growth. In the second year trial, plants established on plots which received 12 and 16 tons cattle manure per ha or which were fertilized with phosphorous produced significantly more number of branches and leaves per plant. Production of branches and leaves are desirable characteristics as they can contribute effectively to seed production in various ways, for persistence of training legumes such as *C. pubescens* (Keller-Grein *et al*. 2000) and to ground cover particularly on slope lands (Adjolohoun *et al.* 2013) but excessive production of leaves can reduce seed production. This result confirmed that Centro can be used as a ground cover in coconut and oil palm plantation. Crop and deposition of nitrogen by the cover crop will gradually increase the level of soil nitrogen. Also its forage can be grown for feeding, grazing or preserved as hay or silage for use during the dry season when there is a scarcity of grazeable materials (Muhammad, 2015; Ajayi *et al*. 2006).

Results showed that flower initiation (first flower buds having 0.5 cm length) was neither influenced by density nor by plot fertilization although plants of control plots tended to flower approximately 5 days after plants of fertilized plots. Plant flower initiation beginning varied from 120 to 132 days after sowing and flower appeared from 150 to 190 days after sowing. This result agrees with that of 150-180 days reported by Keller-Grein *et al.* (2000). The number of days between flower beginning and blooming is approximately 30 days and agrees with reports of Ison (1984) who noted that the period from beginning to the first blooming for *C. pubescens* was 23-29 days. Results reported in literature about *Centrosema* genus flowering were variable and an evaluation of this genus plants in different sites in tropical and sub-tropical regions revealed that there is great variability in flowering onset time. The control of flowering in *Centrosema* was reviewed by Ferguson *et al*. (1990) and they reported that latitude of the growing site, the temperature of the site and water stress during plant growing can alone or in combination with others, influenced plant to burst into first flowering. Ison and Hopkinson (1985) reported that *C. pubescens* can be classified in short-day plant group and flowering is accelerated when natural day-length is artificially shortened. Others authors concluded an absence of photoperiod of *C. pubescens* flowering. Latitude of the site probably plays an important role in the date of first flower appearance. At different sites situated between 18-27° N, *C. pubescens* flower sprouted from October 1 to November 27 and for sites situated between 18-27°

S, plant flowered from April 4 to May 6 showing the influence of latitude of *C. pubescens* reproductive physiology (Ferguson *et al*. 1990). In this trial, there was no significant difference between flowering dates. The period coincides approximately with the time when rainfall diminished, suggesting that in the study area, soil water stress would have an important influence on *C. pubescens* flowering period confirming field observation of Ferguson (1990).

Seed production

Statistical analysis showed significant influence of year, row spacing and fertilizer on seed production of *C. pubescens* ($p < 0.05$). Over year, row spacing and fertilizer, seed yield was 176.7 kg/ha. It is in the range 140-180 kg/ha reported by Teitzel and Burt (1976). It is also in accordance with the report of Cruz and Simão Neto (1995) who recorded 109- 315 kg/ha. Also, Keller-Grein *et al.* (2000) reported a range of 14 to 253 kg/ha for *C. pubescens* seed yield in different locations. In Ecuador, Farfan (1974) had used hand picking technic and found that seed yield of *C. pubescens* ranged from of 408 to 1343 kg/ha. Also Omokanye (2001) observed that *C. pubescens* seed yields (405 to 776 kg/ha) was obtained by application of 60 kg/ha of P_2O_5. The performance of seed yield found in this experiment was higher than that of 75-98 kg/ha recorded in Peru by Ferguson *et al.* (1990).Those results showed that seed production of *C. pubescens* varied widely depending to region and agronomic management. For any species, seed yield depends on the choice of suitable cropping site and agronomic management involving plant establishment, good agronomic practices during plant growth and development, the use of physical support for training plants, integrated weed control and harvesting technics.

During 3-years, *C. pubescens* seed production on fertilized plots with phosphorous (168.8-225.9 kg/ha) was significantly higher than those of control (39.8-170 kg/ha). This result may suggest an important deficiency of cropping soil in phosphore for *C. pubescens* seed production in those ferralitic soils. Ferguson *et al.* (1990) and Budiman *et al.* (2016) reported that the main obstacles in improving and maintaining productivity of seed crops on marginal lands include lack of availability of soil nutrients, particularly phosphore to support plant life.

Results of plant growth and seed production in second year were significantly more than those of the first year probably because the use of animal manure not only increases the availability of plant nutrients, but also increases the seasonal nutrients available to the crops. Cattle manure applied contains approximately 1.44‰ P. Taking in to account conversion factor between elemental nutrient (P) and the compound oxide (P_2O_5) which is 2.29, 12 tons of manure will contain approximately $12 \times (1.44/1000) \times 2.29 = 39.57 \approx 40$ kg P_2O_5 per ha which means that, plots that received 12 tons of manure (T_{12}) had received the same level of P fertilizer as mineral P fertilizer treatment (T_{mf}). Nevertheless, treatment (T_{mf}) produced in the first year significantly more seed per ha (168.8 kg/ha) than did (T_{12}) (147.9 kg/ha). In the second and third years, treatments (T_{12}) produced significant more seed than (T_{mf}). Those results lead to a conclusion of two statements. First, during the first year, phosphorous contained in manure would not be available to plants due probably to low rate of decomposition. This statement is supported by the finding of Saïdou *et al*. (2016) who reported that in better ecological conditions of ferralitic soils of West Africa, less than 50% of manure are decomposed after 3 months. The second statement is that cattle manure, offers other vital nutrient elements like N, K, Ca, Mg and Na and other micro-nutrients (Zn, Cu, Fe and Mn) that are required for plant growth (which are absent in P_2O_5 fertilizer). The application of phosphorus has been generally found necessary to sustain or improve Centro yields although in some instances, nitrogen, potassium, gypsum and lime have also been found essential in producing yield increases (Bogdan 1977). The increase of seed production on plots that receive 12 tons per ha compared to mineral fertilizer would due to an increase of plant nutrient (Chang et al. 1993; Matsi *et al*. 2003), and probably the improved soil structure (Alves *et al*. 2008; Gbenou et al. in press). Those two statements have a practical implication and lead to recommendation in term of animal manure management for food or forage cropping: for better soil nutrient utilization by plant, animal manure would be dressed sufficiently before sowing. Seed production of Centro in southern Benin on ferralitic soil is a function of seed number and weight of seed produced. Seed number per pod was highest (18.09) for application of 12 t ha^{-1} of cattle dung and decreased ($p<0.05$) as the level of fertilizer decreased. The 100 seed-weight was highest (3.58 g) with fertilizer application of 16 t ha^{-1} cattle dung and lowest (1.06 g) for the control 0 t ha^{-1}. The results of this study agree with an early finding of Omokanye (2001) who noticed that phosphorus application improved weight of seed.

Conclusion

C. pubescens is an important legume herbaceous forage in agro-systems in West Africa. This trial had showed that neither row spacing nor fertilizer had significant effect on plant phenology. A suitable combination of row spacing and animal manure can increase significantly seed production of *C. pubescens*. It can be concluded that plant spacing of 80 cm × 80 cm and 12 tons per ha cattle manure can be recommended to farmers for *C. pubescens* seed production in the region.

References

Adjolohoun S (2008). *Yield, nutritive value and effects on soil fertility of forage grasses and legumes cultivated as ley pastures in the Borgou region of Benin.* Thèse pour l'obtention du Diplôme de Doctorat en Sciences agronomiques et Ingénierie biologique. Faculté Universitaire des Sciences Agronomiques de Gembloux. Belgique. 101 p.

Adjolohoun S, Bindelle J, Adandédjan C, Buldgen A (2008a). Some suitable grasses and legumes for ley pastures in Sudanian Africa: the case of Borgou region in Benin. *Biotechnol. Agron. Soc. Environ*. 12(4) 405-419.

Adjolohoun S, Bindelle J, Adandedjan C, Seibou Toleba S, Houinato M, Sinsin AB (2013). Growth and forage production of four *Arachis pintoi* (Kaprovickas & Gregory) genotypes in two contrasting ecological regions of Benin (West Africa). *Inter. J. Agric. Innov. Res.*, 2(2), 170-176.

Adjolohoun S, Buldgen A, Adandedjan C, Decruyenaere V, Dardene P (2008b). Yield and nutritive value of herbaceous and browse forage legumes in the Borgou region of Benin. *Trop. Grass*. 42, 104-111.

Adjolohoun S, Dahouda M, Adandedjan C, Toleba Séibou S, Kindomihou V, Sinsin AB (2013). Evaluation of biomass production and nutritive value of nine *Panicum maximum* ecotypes in Central region of Benin. *Afric. J. Agric. Res*., 8(17), 1661-1668.

Ajayi FT, Babayemi OJ, Taiwo AA (2006). Effects of supplementation of *Panicum maximum* with four herbaceous forage legumes on performance, nutrient digestibility and nitrogen balance in West African dwarf goats *Anim. Sc. J.* 79**,** 673–679.

Akanbi WB, Togun AO, Adediran JA, Ilupeju EAO (2010). Growth, Dry matter and Fruit Yield components of okra under organic and inorganic sources of nutrients. *American- Eurasian Journal of Sustainable Agriculture*, 4(1), 1-13.

Alves AU, Oliveira AP, Alves AU, Dornelas CSM, Alves EU, Cardoso EA, Oliveira ANP, Cruz ISS (2008). Lima beans production and economic revenue as function of organic and mineral fertilization. *Horticultura Brasileira* 26: 251-254.

Ayoola OT, Adediran ON (2006). Influence of poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in South West Nigeria. *African Journal of Biotechnology,* 5, 1336-1392.

Bogdan AV (1977). Tropical pastures and fodder plants . 1st Edn. (Longman: London, UK).

Budiman N, Tanrigiling R, Muhammed Y (2016). The effects of bio-slurry fertilizer on sorghum bicolor and *Centrosema pubescens* planted with inter-cropping. *Transylvanian Review*, 24(10), 2552-2560.

Chang C, Sommerfeldt TG, Entz T (1993) Barley performance under heavy applications of cattle feedlot manure. Agron. J., 85:1013–1018.

Clements RJ, Williams RJ (1980). *Genetic diversity in Centrosema. In "Advances in Legumes Science"* (eds. R.J. Summerfield and H. Bunting). Royal Botanic Gardens Kew. 559-567.

Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R (2005). *The Production of Tropical Forages : An alternative selection tool.* Available <http://www.tropicalforages.info> accessed on [15/10/2017].

Cruz ED, Simão Neto M (1995). Produção de sementes de *Centrosema* na regiáo Bragantina, Pará, Bresil. Pasturas Tropicales, 17(1), 18-23.

da Silva TJA, Duarte TF, Sousa JVR, Bonfim-Silva EMB, Pacheco AB, de Sousa HHF (2016). Soil moisture and water use efficiency in cotton plants grown in different spacings in the Brazilian Cerrado Region. *Afric. J. Agric. Res*., 11(8): 701-708.

Eifediyi EK, Remison SU (2010). Growth and yield of cucumber (*Cucumis sativum* L.) as influenced by farm yard manure and inorganic fertilizer. *Journal of Plant Breeding and Crop Science* 2(7): 216-220.

Farfán C (1974). Efecto de prácticas culturales en la producción de semilla de plantas forrajeras tropicales. Thesis. Universidad Tecnica de Manabi, Ecuador.

Ferguson JE, Hopkinson JM, Humphreys LR, de Andrade RP (1990). Seed production of *Centrosema pubescens*. In Eds *Centrosema: Biology, Agronomy, and Utilization*. Schultze-Kraft R, Clements RJ CIAT (Centro Internacional de Agricultura Tropical). Cali, Colombia. 668 p.

Ferguson JE, Hopkinson JM, Humphreys LR, de Andrade RP (1990). Seed production of *Centrosema* species. In Eds *Centrosema: Biology, Agronomy, and Utilization*. Schultze-Kraft R, Clements RJ CIAT (Centro Internacional de Agricultura Tropical). 1990. Cali, Colombia. 668 p.

Gambo BA, Magaji MD, Yakubu AI, Dikko AU (2008). Effects of Farm yard Manure and weed interference on the growth and yield of onion (*Allium cepa* L.). *Journal of sustainable Agriculture and Environment* 3(2): 87-92.

Gbenou B, Adjolohoun S, Houndjo DBM, Saïdou A, Houinato M, Ahoton L, Sinsin BA (in press). Animal dung availability and their fertilizer values in a context of low soil fertility conditions for forage seed and crops production in Benin (West Africa).

Hamma IL, Ibrahim U, Haruna M (2012). Effect of poultry manure on the growth and yield of cucumber (*Cucumis sativum* L.) in Samaru, Zaria. *Nigerian Journal of Agriculture, Food and Environment*. 8(1):94-98.

Houndjo DBM, Adjolohoun S, Gbenou B, Saïdou A, Ahoton L, Houinato M, Seibou Toleba S, Sinsin BA (in press). Benin: socio-demographic and economic characteristics, crop-livestock production systems and issues for rearing improvement. *A review*. *Int. J. Biol. Chem. Sc.*

Ison RL (1984). Flowering of *Desmodium uncinatum* cv. Silverleaf, *D. intortum* cv. Greenleaf and *Centrosema pubescens* cv. Common. In: Proceedings of the Australian Seeds Researchers Conference. Gatton, Qld., Australia, p. 65-69.

Keller-Grein G, Schultze-Kraft R, Franco LH, and Ramirez G (2000). Multilocational agronomic evaluation of selected *Centrosema pubescens* Germplasm on acid soils. *Trop. Grass*. 34, 65-77.

Koura B (2015). Improvement of animal productivity by using crop residues in integrated crop-livestock systems in Benin. PhD thesis. University of Abomey-Calavi. Abomey-Calavi. 186 p.

Lampkin N (1990). *Organic farming*. Ipswich, UK: Farming Press. pp 214 – 271

Lesse DPAA (2016). Gestion et modélisation de la dynamique des parcours de transhumance dans un contexte de variabilités climatiques au nord-est du Bénin. Thèse de Doctorat. Université d'Abomey-Calavi. Abomey-Calavi. 305 p.

Matsi T, Lithourgidis AS, Gagianas AA (2003). Effects of injected liquid cattle manure on growth and yield of winter wheat and soil characteristics. *A*gron J 95:592–596.

Muhammad R (2015). Enhancing Germination in Seeds of *Centrosema pubescens. International Journal of Scientific and Research Publications* **5**(10): 2250-3153.

Muhammed IR, Kallah MS, Tanko RJ, Balarabe A (2002). Forage yield of irrigated centro as influenced by stages of maturity in lowland areas of Zaria, Nigeria. In: Aletor VA, Onibi E (eds), *Proceedings of the 27th Annual Conference of the Nigerian Society for Animal Production 17–21 March, 2002, Akure, Nigeria*, pp. 214–216. Nigerian Society for Animal Production, Akure.

Ngozi EA, Chidera VO (2017). The effect of plant density on growth and yield of 'NsukkaYellow' aromatic pepper (*Capsicum annuum* L.). *Afric. J. Agric. Res*. 12(15): 1269-1272.

Nworgu FC, Egbunike GN, Osayomi OJ (2001). Performance of growing rabbits fed a mixture of leaf meals and concentrates. *Tropical Animal Production Investigation* 4**,** 34–48.

Ogbonna PE, Orji KO, Nweze NJ, Opata PI (2015). Effect of planting space on plant population at harvest and tuber yield in taro (*Colocasia esculenta* L.). *Afric. J. Agric. Res*., 10(5), 308-316.

Ojeniyi SO (2000). Effect of goat manure on soil nutrients and okra yield in a rain forest area of Nigeria. *Applied Tropical Agric*.5:20-23.

Omokanye AT (2001). Seed production, herbage residue and crude protein content of centro (*Centrosema pubescens*) in the year of establishment at Shika, Nigeria. Tropicultura 19 (4): 176 - 179.
Rivière R (1991). Alimentation des ruminants domestiques en milieu tropical, La Documentation Française.
Saha S, Appireddy GK, Kundu S, Hari S, Gupta HS (2007). Comparative efficiency of three organic manures at varying rates of its application to baby corn. *Archives of Agronomy and Soil Science*, 53(5), 507-517.
Saïdou A, Bokossa JHK, Fiogbé ED, Kossou D (2016). Kinetic of pigs' manures decomposition and nutrient release pattern in ferralitic soil of Benin (West Africa). J. Soil Sc. Env. Manag., 7(6), 73-80.
Salinas JG, Kerridge PC, Schunke RM (1990). Mineral nutrition of Centrosema. In Eds *Centrosema: Biology, Agronomy, and Utilization*. Schultze-Kraft R, Clements RJ CIAT (Centro Internacional de Agricultura Tropical). 1990. Cali, Colombia. 668 p.
Sylvester-Bradley R, Souto SM, Date RA (1990). Rhizosphere biology and nitrogen fixation of Centrosema. In Eds *Centrosema: Biology, Agronomy, and Utilization*. Schultze-Kraft, R. and Clements, R. J., CIAT (Centro Internacional de Agricultura Tropical). 1990. Cali, Colombia. 668 p.
Teitzel JK, Burt RL (1976). *Centrosema pubescens* in Australia. *Trop. Grass.* 10(1), 5-14.