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Influence of cow manure and row spacing on growth, flowering and seed yield of Centro (*Centrosema pubescens Benth.*) on ferralitic soils of Benin (West Africa)

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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. The site is located at latitude 6° 30' N and longitude 2° 40' E with elevation of 50 m above sea level. The area is characterized by ferralitic soils with low fertility, rainfall range of 1200 mm with relative humidity from 40 to 95 % and means annual temperature varying between 25 and 26 °C. Field experiments were conducted during 2014, 2015 and 2016 seasons. Five cattle manure rates (0, 4 tons, 8 tons, 12 tons and 16 tons/ha) and 40 kg P2O5/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). Each treatment was replicated 4 times. The growth and flowering characteristics measured in the field included number of branches 90 days after sowing, number of leaves 90 days after sowing, plant girth 90 days after sowing, flower initiation, date of first flower appearance, date of 50% flowering, pod ripping time and efficiency

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of flower for pod production. Seed components evaluated are pod length, pod wide, number of seed/pod, 100 seed-weight and seed weight/pod weight ratio. Seed yield were evaluated each year by harvesting pods from 4 randomly plants per plot. Pods were shelled and seed collected were weighed for seed yield calculation. Analysis of variance (ANOVA) was used to determine degree of variability at 5% probability level. Result obtained from data analysis showed that there was a significant influence of cropping season, row spacing, fertilizer 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) than the first (153.8 kg/ha). Influence of row spacing was observed on seed yield and plants established and 80 cm × 80 cm gave significantly more seed 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). Seed yield was significantly increased due to application of cattle manure and application of 12 tons cattle manure yielded better than others. Neither row spacing nor fertilizer had significant effect on plant phenology. In contrast, efficiency of flower for seed production was influenced by fertilizer and cropping season. According to these results, 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: *Centrosema pubescens*, organic fertilizer, plant density, growth, development, seed, West Africa

INTRODUCTION

In Benin, the productivity of ruminant livestock is limited by poor nutrition. The shortage of forages is a major constraint to ruminant livestock production, especially in the dry season (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, the improvement of ruminant livestock production will need the development of forage productivity compatible to the subsistence farmer conditions in this region. In these conditions, legume forages can play an important role as they can contribute to not only increase forage nutritive value but also to improve soil fertility via air nitrogen fixation (Ajayi *et al*. 2006).

Centrosema pubescens (centro) originated from Central America and belongs to the genus *Centrosema* which comprises about 35 recognized species of herbaceous tropical legumes. Of these, essentially only *C. pubescens* has attained economic importance as a forage plant (Clements and Williams, 1980). Centro is a vigorous, trailing, twining, climbing perennial legume with trifoliate leaves that is drought tolerant. It has been identified by Cook *et al*. 2005, Adjolohoun *et al*. 2008a; Houndjo *et al.* in press) as potential forage legume for tropical region. In grass-centrosema association, the legume can fix annually an amount of 72-280 kg of N/ha (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 very 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 from 0.27-0.37% and 0.71-1.05%, 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 green manure or as a ground cover in 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 (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 alternating 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). Cattle 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, cattle manures sustain cropping systems through better nutrient recycling and improvement in soil physical, chemical and biological properties (Ojeniyi, 2000; Gambo *et al*., 2008).

On other hand, 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). An optimum combination of 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 should not only result in higher yield but it will also reduce the price per unit weight of the seed.

Therefore, the objectives of this research were to determine:

1. the optimum rate of cow manure application and plant row spacing for *C. pubescens* seed production;

2. the flowering and fruiting phenologies of the plant;
3. Make recommendations that ensure sustainable management of *C. pubescens* seed production in particular eco-geographical Guinean 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 has a low water capacity with a relatively high leaching of elements. The main chemical characteristics of the experimental soil are: $pH_{(2/5water)}$ 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.

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 m^2) with 2 m spacing between plots and 3 m between blocks. Each plot 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). 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

Two weeks after sowing, 1 randomly 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 wide (mm) of the widest 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 served 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 flower that produced pod.

Pods, seeds characteristics and seed yield measurements

For seed yield evaluation, pods were hand-picking separately for each plant. Harvested pods from the same plot were pooled and 20 randomly pods were taken per plot and sun dried for 15 days. Seeds from those 20 pods per plot were after shelled and the number of seeds was counted for the following data: (1) Number of seeds/pod; (2) Seeds and shells from those 20 pods were weighed separately (using electronic weighing balance). Seed weight/husk weight ratio was calculated. Seed yield/ha per treatment was calculated thereafter by seed components by multiplying the weight of seed 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. For plant growth, plant flowering and fruiting characteristics, seed yield, seed characteristics and seed cost measurements, the plot was used as the experimental unit. Data were analysed 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* = year effect, row spacing effect, *Fj* = fertilizer effect, *(D*F)ij, (D*Y)jk, (F*Y)jk,* and *(D*F*Y)ijk Yk* 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 significant was declared at P<0.05.

RESULTS

Plant Growth

Plants growth parameters were presented in Table 2. 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 wide. Fertilizer applied had significant effect on these parameters. Results indicated that the different fertilizers had significant ($P < 0.05$) effect on number of branches, plant girth, number of leaves, main leaflet length and wide (Table 2). At 90 days after sowing, plots that received 16 tons cattle manure per ha produced the longest plants (61 cm) followed by treatment of 12 tons per ha. The shortest plants were recorded from the control which in apart with treatment of 4 tons per ha. For four other parameters (plant girth, number of leaves, main leaflet length and wide), treatments with 12 or 16 tons per ha or mineral fertilizer application produced similar plant growth.

Plant flowering and fruiting

Table 3 shows data on *C. pubescens* 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. During three cropping seasons, *C. pubescens* began flower initiation around 125-132 days after sowing. The first flowers bloomed 150-159 days after sowing and pod repining started 169-180 days after sowing. On the other hand, statistical analysis showed that both year and fertilizer have significant effect ($P < 0.05$) on flower efficiency for pod production with also significant interaction between year and fertilizer ($P < 0.05$). Generally, efficiency of flower for pod production was higher in the second and third years than the first one (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 second year, the ranking was: P_2O_5 = 16 tons = 12 tons = 8 tons > 4 tons = control.

Seed yield

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

DISCUSSIONS

Morphological growth parameters

There was no significant influence of row spacing on *C. pubescens* growth characteristics after 90 days age during 3-year study. But fertilizer had significantly influenced growth parameters. In 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 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 indicates that plant nutrients added to the soil from application of 4 tons of manure are not sufficient to induce a sensitive increase in *C. pubescens* growth. In the second year trial, plants established on plot which have receive 12 and 16 tons cattle manure per ha or which that were fertilized with phosphore had produced significantly more number of branches and leaves per plant. The 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.

Plant phenology

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 from 18 and 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.

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 used and found that seed yield of *C. pubescens* ranged from of 408 to 1343 kg/ha. 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. 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 (168.8-176.0 kg/ha) was significantly higher than those of control (39.8-167.5 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 $12×(1.44/1000)×2.29 = 39.57 ≈ 40$ 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 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.

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 90 days after sowing				
	Number of branches	Plant girth (mm)	Number of leaves	Main leaflet length (mm)	Main leaflet wide (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
P fertilizer**	44c	7a	200b	45a	26a
Mean	**46**	**6**	**190**	**41**	**23**

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

** 40 kg P/ha/year

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			
	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
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**
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

Table 5. Effect of plant density, cow manure and phosphore fertilizer on seed yield of *Centrosema pubescens* on ferruginous 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**
P_2O_5*	168.8ααC	216.3ααA	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**
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**
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 line, 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 $p < 0.05$. ** 40 kg P/ha/year.

Table 6. *Centrosema pubescens* pods and seeds characteristics as influenced by fertilizer levels on ferruginous 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)	6.54	2.44	4.55	1.06	3.55
4 tons/ha	8.08	2.61	7.39	1.86	3.19
8 tons/ha	14.98	3.75	13.75	2.09	3.89
12 tons/ha	15.66	3.34	18.09	3.46	3.31
16 tons/ha	15.55	3.59	17.74	3.58	3.45
P_2O_5*	13.77	3.40	14.80	2.27	3.66
Mean	**12.43**	**3.19**	**12.72**	**2.39**	**3.51**

** 40 kg P/ha/year.

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