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Effects of age and plant location on agronomic indices, dry matter yield and nutrients composition for *Mucuna pruriens* (L) Var. Cream established under silvopastoral system

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Abstract

Forage legume has been used to improved pasture for livestock production. Integration of pasture and forest tree has been advocated, this study investigated the agronomic performance, dry matter yield and proximate composition for velvet beans (Mucuna pruriens) established under silvopastoral system in humid tropics were assessed. The experiment was a 2 x 3 factorial arrangement fitted into a completely randomize design, comprising of two stages of growth and three different plant location (plain plot i.e. control, Annona muricata plantation and Irvingia gabonensis plantation). Agronomic indices, dry matters yield (DMY) and proximate composition were monitored. Results showed no significant (P>0.05) differences in all the agronomic indices (plant height (PH), leaf number (LN), leaf length (LL), leaf breath (LB) and leaf area (LA) across the plant locations. Significant (P<0.05) influence was observed for PH, LN, LL,LB and LA across the stages of growth. Mucuna established on Annona muricata plantation had higher (P<0.05) DMY (6.66 t/h) but similar (P>0.05) to the mucuna established on plain plot (control) (6.14 t/h). Similar (P>0.05) DMY was also recorded for plain plot (6.14 t/h) and Irvingia gabonensis plantation (5.74 t/h). The mucuna harvested at 16 weeks after sowing (WAS) had highest (P<0.05) DMY (8.54 t/h) compared to 10 WAS (3.84 t/h). There were no significant effects plant locations on dry matter(DM) content, crude protein (CP), ether extract (EE) and ash. More so, similar (P>0.05) contents of DM, CP and EE were observed across the stages of growth. Higher (P<0.05) ash content (8.95%) was recorded at 10 WAS, least (8.15%) was observed at 16 WAS. Conclusively, establishment of forage legume Mucuna pruriens within forest plantation does not negatively affect the agronomic performance, dry matter yield and proximate composition, it is therefore recommended for famers to established Mucuna pruriens alongside with forest plantation i.e. silvopastorial farming system, harvesting is also encouraged at 16 WAS.

Keywords: Agronomic-performance, dry-matter-yield, mucuna, proximate-composition

Effets de l'emplacement de l'âge et de l'usine sur les indices agronomiques, le rendement de la matière sèche et la composition des nutriments pour MucunaPruriens (L) Var. Crème établie sous Système Silvopastoral

Résumé

Le légumineux de fourrage a été utilisé pour améliorer les pâturages pour la production de bétail. L'intégration du pâturage et de l'arbre forestier a été préconisée, cette étude a examiné la performance agronomique, le rendement en matière sèche et la composition proximité des haricots de velours (Mucunapruriens) établis dans un système sylvopastoral dans des tropiques humides ont été évaluées. L'expérience était un arrangement de 2 x 3 facteurs intégré dans une conception complètement randomisée, comprenant deux étapes de

croissance et trois emplacements d'usine différents (parcelle uni.e. Contrôle, plantation d'AnnonaMuricata et plantation d'IrvingiaGabonensis). Les indices agronomiques, le rendement des questions sèches (RQS) et la composition proximité ont été surveillés. Les résultats n'ont montré aucune différence significative (p> 0,05) dans tous les indices agronomiques (hauteur de la plante (HP), nombre de feuilles (NF), longueur de la feuille (LP), souffle de feuilles (SF) et zone de la feuille (ZF) à travers les emplacements des plantes. Une influence significative (p <0,05) a été observée pour HP, SF, LF, SF et LA part des étapes de la croissance. Le mucuna créé sur AnnonaMuricata Plantation avait plus haut (p <0,05) RQS (6,66 t / h) mais similaire (p> 0,05) au mucuna établi sur une parcelle unie (6,14 t / h). Similaire (p> 0,05) RQS a également été enregistré pour une parcelle unie (6,14 t / h) et plantation d'irvingiagabonensis (5,74 t / h). Le mucuna récolté à 16 semaines après l'ensemencement (8,54 t / h) (P <0,05) par rapport à 10 était (3,84 t / h). Il n'y avait pas d'effets significatifs des emplacements d'usine sur la teneur en matière sèche (MS), brut protéine (BP), extrait d'éther (EE) et cendres. Plus d'informations similaires (P> 0,05) de MS, BP et EE ont été observées à travers les étapes de la croissance. La teneur en cendres supérieure (p <0,05) (8,95%) était enregistré à 10 WAS, le moins (8,15%) était observé D à 16 WAS. Conclusivement, la mise en place de la légumineuse fourragère Les pruriens au sein de la plantation forestière ne touchent pas négativement la performance agronomique, le rendement de la matière sèche et la composition proximité, il est donc recommandé aux familles de créer des pruriens de Mucuna, ainsi que de plantation forestière, c'est-à-dire du système d'agriculture sylvopastoriale, la récolte est également encouragée à 16 semaines après le semis.

Mots-clés: performance agronomique, rendement sec, mucuna, composition proximité

Introduction

Ruminants in Nigeria are mostly managed by nomadic, semi-nomads and pastoral famers who solely depend on natural pasture. Natural pasture is known to be the main source of feed in livestock production in Nigeria, as most the famers can hardly afford to keep their animals on concentrate feed (Lamidi *et al*., 2019). The natural pasture, though cheap but it is limited both in quantity and quality. In order to mitigate the problem of poor nutrition for ruminants because of theirnatural dependence on the natural pasture, the use of sown and purposely managed pastures have been widely suggested (Olanite, 2003). Efforts have been made by government in the past to introduce improve forage species into Nigeria, with the aim of improving the quality and quantity of feed for sustainable livestock production, one of such forages introduced is velvet (*Mucuna pruriens*). Hassan *et al*. (2015) observed *M. pruriens* as one of the promising forage legumes identified for its diverse use worldwide. It is used for treatment of Parkinson's disease in man, soil cover, and ruminant livestock feed and intercropping with maize(Hassan *et al*., 2015).

Farmland for the establishment of pasture has been an issue considering the pressure on the farmland due to ever increases in population which resulted to the expansion of infrastructural facilities, consequently farmland has been a great concern and serious challenge to pasture establishment. Forest plantation would be a solution or means of mitigating the establishment of pasture be it grazing or on cut and carry systems, especially with the “young forest plantation” i.e. that is the forest that has not fully formed canopy, forage legume which has ability to fix atmospheric nitrogen can be perfectly cultivated or established with the forest plantation. Cultivation of forage along with established forest plantation

will ensure maximal utilization of land.
Silvopastoral systems combine fodder plants such grass and leguminous herb with shrubs and trees for animal production and environmental evinces. Under humid, tropical conditions, the silvopastoral systems can sequester more carbon and fix atmospheric than traditional monocrop pasture system (Nair *et al*., 2009). This study was intended to investigate the effects of plant location and age on theagronomic indices, dry matter yield and nutrients composition for velvet beans (*Mucuna pruriens*) established under silvopastoral system in humid tropics.

Materials and methods

Experimental site and land preparation

The study was carried out at the Teaching and Research Farm, University of Port Harcourt, Rivers State, Nigeria. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria within latitudes 6° 58' – 7° 60'E and longitudes 4° 40' – 4°55'N. The monthly rainfall in Port Harcourt follows a sequence of increase from March to October before decreasing in the dry season months of November to February (Lamidi and Ogunkunle, 2016). The routine soil analysis of 0 - 15 cm depth (Udom and Lale, 2017) showed that it had pH (H_2O) 4.5, total nitrogen (g kg^{-1}) 0.94, organic carbon (g kg^{-1}) 16.94, exchangeable K (cmol kg^{-1}) 0.24, Mg^{2+} (cmol kg-1), Ca^{2+}(cmol kg^{-1}) 6.1, sand (g kg^{-1}) 710, silt (gkg^{-1})152, clay (g kg^{-1}) 138. The land was cleared and prepared into seed beds 12m by 4m and latter divided into four equal parts on three different plant locations and plain plot as control, five years old *Annona muricata* plantation and *Irvingia gabonensis* plantation.
Seeds of *Mucuna pruriens* used for the experiment were obtained from the National Animal Production Research Institute (NAPRIL), Ahmadu Bello University, Zaria, Kaduna State, Nigeria. The seeds were dressed with fungicide (Apron star ^{R}). Planted two seeds per hill in 25cm x 75cm according to Hassan *et al*. (2015). The experiment was laid out in complete randomized design, factorial design 2 x 3 factorial design two different stages of growth and three plots, replicated three times. Plots were weeded manually using hand hoes as at when due. Five randomly tagged plants at middle of each plot were used in recording the plant height (cm) with tape rule, leaf length and breadth with ruler and the numbers of leaves were counted, also dry matter yield were determined according to Ojo *et al*. (2018) at two different stages of growth.

Chemical analysis

Proximate composition: The dry matter, crude protein, ether extract and ash contents of the milled sample were determined according to A.O.A.C. (2000). Non-fibre carbohydrate was calculated as NFC = 100 - (CP + Ash + EE + NDF)**.**

Statisticalanalysis

The experiment was a 2 x 3 factorial scheme (2 different stages of growth) and threedifferent plant locations fitted into a completely randomize design (CRD). All data obtained were subjected to the analysis of variance (ANOVA). Means were separated using Duncan's Multiple Range Test SAS (2002) package.

Results and discussion

Table 1 shows the average weather condition of the experimental site during the experimental period. The range of maximum temperature was between 30 – 33°C, decreases towards the progression of the mouth of experiment. Amount of rainfall (mm), rainfall in days and sunshine ranged from 136 – 345mm, 9 – 28 days and 2.5 – 4.5 hrs., respectively.
Weather and climate data play a significant role in agricultural activities. The metrological condition of the experimental site was favorable,rainfall was increasing throughout the experimental period, and the weather was conducive for effective and efficient establishment of pasture and other agronomic practices.

Table 1: Average metrological condition for the experimental site during the experimental period (March – July, 2018)

	Months				
Parameters	**March**	**April**	**May**	**June**	**July**
Temperature max. (^{0}C)	33	32	31	30	30
Temperature min. (^{0}C)	23	23	23	23	23
Rainfall (mm)	136	188	285	288	345
Rainfall days	9	12	14	17	28
Sunshine (hrs.)	3.7	4.4	4.5	3.4	2.5

Source:weather.atlas.com

Effects of plots and age on agronomic indices of *Mucuna pruriens* established under silvopastoral system were indicated in Table 2. There was no significant difference (P>0.05) in all the agronomic indices across the plots. There was a significant different in the agronomic indices across the stages of growth. The four weeks after sowing (WAS) had highest (P<0.05) plant height (PH) (260.30 cm), leaf number (LN) (48.24), leaf length (LL) (12.57cm), leaf breath (LB) (8.34 cm) and leaf area (LA) (1.04) compared to 2 WAS with PH (124.58 cm), LN (24.63), LL (10.37 cm), LB (6.44 cm) and LA (0.60).

The agronomic indices of the *Mucuna pruriens* was increasing across the stages of growth, this is similar to the report of Mbahi *et al*. (2010; 2015) that legumes exhibit slow growth at early stages of growth and increases with time in the season. Progressive increase in the plant height, leaf number, leaf length, leaf breath and leaf area across the stages of growth recorded in this study is in line with the report of Lamidi and Aina (2013). The plant height as a plant growth indicator is very important and has a direct effect on other agronomic parameters and dry matter yield. Higher leaf number must have resulted from increasing photosynthetic activities of the plants as the plants mature in age, since higher leaf number is desirable for photosynthesis activities of the plants and well as livestock production (Lamidi and Aina, 2013). The higher the plant height, leaf number, leaf length, leaf breath and leaf area the higher the herbage yield, the more materials available for livestock.

Table 2: Effects of plots and age on Agronomic indices of *Mucuna pruriens* established under silvopastoral system

	Agronomic indices				
Factors	**PH**	**LN**	**LL**	**LB**	**LA**
Plots					
Plain plot	119.81	48.45	7.53	9.40	1.61
Annona muricata plantation	119.45	46.20	6.88	9.34	1.59
Irvingia gabonensis plantation	119.48	45.90	6.52	9.30	1.58
SEM	9.53	6.91	0.75	0.52	0.39
LOS	NS	NS	NS	NS	NS
Age					
2 weeks of sowing	124.58^b	24.63^b	10.37^b	6.44^b	0.60^b
4 weeks of sowing	260.30^a	48.24^a	12.57^a	8.34^a	1.04^a
SEM	9.53	6.91	0.75	0.52	0.39
LOS	**	**	**	**	**

$^{a, b}$ Means on the same column with different superscripts differ significantly (P<0.05)

SEM= Standard error of mean; LOS= Level of significant; NS= Values not significant; **= Significantly different; PH= plant height; LN= leaf number; LL= leaf length; LB= leaf breath; LA= leaf area

Table 3 showed the effects of plots and age on the dry matter yield (DMY t/h) of *Mucuna pruriens* established under silvopastoral system. The dry matter yield was significantly influenced (P<0.05) by the plots. The mucuna established on *Annona muricata* plantation had higher (P<0.05) but similar (P>0.05) to the plain plot (control) (6.14 t/h). Similar (P>0.05) DMY was recorded for plain plot (control) (6.14 t/h) and *Irvingia gabonensis* plantation (5.74 t/h). There was a significant difference (P<0.05) in DMY across the stages of growth. The 16 weeks after sowing had highest (P<0.05) DMY (8.54 t/h) compared to 10 WAS (3.84 t/h).

Higher DMY observed at higher stages of growth (i.e. 16 WAS) could be attributed to the fact that as the forage plants increase in age, the nodes of the plants are elongated, leading to an increase in the production of leaves and stem component. The present observation corroborates the finding of Omokanye *et al*. (1996) who also reported that plant dry matter increases with maturity of the plat from an increase in stem proportions at the expense of leaf production leading to more DMY produced by the plants. The DMY produced in the present study was higher than the value of 1.48t ha-1 reported by Muir (2002) for some herbaceous legumes and browse plants compared. Higher DMY is desirable in forage production since it will provide sufficient quantity of feeds for animals. The observed linear increase in DMY with increasing age i.e. 3.84 t/h for 10 WAS and 8.54 t/h for 16 WAS observed in the study corroborate earlier report that extended harvesting time of tropical forages encourages high DM yield (Chheda and Akinola, 1971). The DMY obtained in the present study was higher than 2.21 t/h-1 reported in the previous studies (Ojo *et al*., 2018), 2.060kg reported by Malunga *et al*. (2008) in maize intercrop while Carsky *et al*. (1998) and Eilitta and Sollenberger (2002) reported higher range values of 7 to 9 kg and 4.900kg to 7.900kgDM/ha, respectively in Zimbabwe by Maasdrop and Titterton (1997). The differences between the yield values obtained in the present study and the previous studies could be due to differences in the species used, soil nutrients statues, season of harvest, age of harvest and other agronomic practices.

Similar DMY recorded forplain plot (control) and *Annona muricata* plantation, also plain plot and *Irvingia gabonensis* plantation, was an indication that *Mucuna pruriens* established in a plain plot or with other forest plantations will not affect the DMY of the forage legume, meaning that this forage legume (*Mucuna pruriens*) can be integrated with forest plantations especially the "young" plantation i.e. silvopastoral system without affecting the DMY.

Table 4 showed the effects of plots and age on the proximate composition of *Mucuna pruriens* established under silvopastoral system. There were no significant (P>0.05) effects of plots onDM, CP, EE and ash, it ranges from 87.94 – 88.66%, 14.08 – 15.38%, 3.23 – 3.48% and 8.40 – 8.64%, respectively. Similar (P>0.05) contents of DM, CP and EE were observed across the stages of growth for *Mucuna pruriens*. The CF and NFC was influenced (P<0.05) by the plots and stages of growth. Mucuna established on irvingia plantation had higher (P<0.05) contents of CF (24.97%) and NFC (23.97%) compared to mucuna established on plain plot and plantation which were similar in CF and NFC.Ash was influenced by the stages of growth. Higher (P<0.05) ash content (8.95%) was recorded at 10 WAS, least (8.15%) was observed at 16 WAS.

The value recorded for dry matter (87.94 – 88.66%) is above 87.50% reported by Ezeokonkwo and Okafor (2015) but within what Lamidi and Ogunkunle (2015)

catalogued for feed stuffs used for small ruminant animal production is South-west, Nigeria. Crude protein contents (14.08 – 15.38%) recorded in this study is below 16.3%, 16.6%, 17.5% and 22.94% CP reported by Muinga *et al*. (2003), Mbuthia and Gahuiri (2003), Nyambati and Sollenberger (2003) and Ezeokonkwo and Okafor (2015), respectively. Meanwhile, fall within what was catalogued (13.57 – 16.63% CP) by Adebayo *et al*. (2019) for some selected forages. The variation might be associated with difference in the species (Lamidi, 2004), the season Lamidi and Aina (2013) and soil fertility Mbahi *et al*. (2018). The CP content (14.08 – 15.38%) observed in the current study was above the critical lower limit (7% CP) which forage intake by ruminants and rumen microbial activity could be negatively affected (Van Soest, 1994 and Norton, 2003). The CP content recorded for *Mucuna pruriens* was also above the 7 to 8 % CP suggested as threshold for sufficient utilization of feed by McDonald *et al*. (1995). However, *Mucuna pruriens* irrespective of the plots or stages of growth (10 and 16 WAS) would provide adequate nitrogen requirement for rumen micro-organism to maximally digest the main components of dietary fiber leading to the production of volatile fatty acid (Trevaskis *et al*., 2001; Lamidi, 2009) which in turn facilitates microbial protein synthesis (Lamidi and Aina. 2013). The consistent increase of CF across the stages of growth is in line with the findings of Omokanye *et al*. (1996) who reported plant maturity has been associated with the structural build-up of fibre constituents in plants. The ash content of mucuna reported by Mbahi *et al*. (2018) and Nyaambati and Sollenberger (2003) were 5.74 – 9.01 % and 9.4% which falls within the range values (8.15 – 8.95%) obtained in this study. Ash content is generally taken to be a measure of the mineral content of the original food (Onwuka, 2005). The higher level of ash content inherent in the forages is an indication that the forage is rich in minerals which are essential in the formation and function of bloods and bones (Animashahun *et al*., 2006).

Table 3: Effects of plots and age on the dry matter yield (t/h) of *Mucuna pruriens* established under silvopastoral system

Factors	**Dry matter yield (t/hectare)**
Plots	
Plain plot	6.14^{ab}
Annona muricata plantation	6.66^{a}
Irvingia gabonensis plantation	5.74^{b}
SEM	0.01
P value	0.038
LOS	**
Age (weeks after sowing)	
10	3.84^{b}
16	8.54^{a}
SEM	0.12
p-value	0.000
LOS	**

[a, b] Means on the same column with different superscripts differ significantly (P<0.05)
SEM= Standard error of mean; LOS= Level of significant; NS= Values not significant; **= Significantly different

Table 4: Effects of plots and age on the proximate composition of *Mucuna pruriens* established under silvopastoral system

	Proximate composition					
Plots	DM	CP	EE	CF	Ash	NFC
Plain plot	88.00	15.38	3.48	17.09[b]	8.64	20.57[b]
Annona plantation	87.94	14.98	3.32	17.20[b]	8.61	20.55[b]
Irvingia plantation	88.66	14.08	3.23	24.97[a]	8.40	23.97[a]
SEM	0.78	0.50	0.19	1.47	0.14	0.61
P-value	0.94	0.61	0.89	0.00	0.67	0.00
LOS	NS	NS	NS	**	NS	**
Ages						
10 weeks after sowing	87.87	14.78	3.52	16.66[b]	8.95[a]	20.50[b]
16 weeks after sowing	88.50	14.82	3.16	22.85[a]	8.15[b]	22.87[a]
SEM	0.78	0.50	0.19	1.47	0.14	0.61
P-value	0.73	0.97	0.42	0.00	0.01	0.00
LOS	NS	NS	NS	**	**	**

[a, b] Means on the same column with different superscripts differ significantly (P<0.05)
DM=Dry matter; CP= Crude protein; EE= Ether extract: NDF= Neutral detergent fibre; NFC= Non -fibre carbohydrate; SEM= Standard error of mean; LOS= Level of significant; NS= Values not significant; **= Significantly different.

Conclusion

Conclusively, establishment of *Mucuna pruriens* within forest plantation did not affect the agronomic indices, dry matter yield and nutritive quality. The highest dry matter yield was guarantee at 16 weeks after sowing, similar dry matter, crude protein and ether extract was observed for 10 and 16 weeks after sowing, best ash content was noted at 10 weeks after sowing, higher crude fibre and non-fibre carbohydrate were encouraged at 16 week after sowing. It is therefore recommended for famers to establish or plant *Mucuna pruriens* alongside with forest plantation i.e. silvopastorial farming system, harvesting can also be done at 16 WAS.

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