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Growth and Forage Production of Four Arachis Pintoi (Kaprovickas & Gregory) Genotypes in Two Contrasting Ecological Regions of Benin (West Africa)

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Abstract **– The agronomic performance of plants is influenced by their genetic potential and the interactions of complex ecophysical factors, as well as by management practices. A 3-year field experiment was set up in order to examine the adaptability of four *Arachis pintoi* varieties (CIAT 17434, CIAT 18744, CIAT 22160 and AFT 495) in two different ecological sites (humid and subhumid zones) of Benin in West Africa. *A. pintoi* varieties were planted at three sowing densities (9, 18 and 36 plants/m^2). The objective of the trial was to identify the most interesting variety and sowing density which could be used in agricultural system in those regions. Twelve treatments (2 sites × 4 varieties × 3 densities) with four replicates per treatment arranged in a split-block design with randomised complete block where varieties were main plot and sowing densities were subplots. Data Stolon number (SN), stolon density (SD), dry matter production (DM), soil coverage (SC) and plant dry season survival (SS) were monitored for 3 years after establishment and were analysed with the General Linear Model procedure of SAS.**

Data indicated that plant (SN) and (SD) varied from 8 to 512 units/m^2 and from 3 to 110 m/m^2, respectively. The proportion of the plants that remained green after the 3-year trial varied from 10 to 80%. (DM) varied from 9 to 3153 kg/ha. For (SN), (SD), (DM), (SC) and (SS), there was a significant difference between sites, varieties, densities and years with a significant site×variety interaction (P<0.01). In general, under humid conditions, varieties ranged in the following order: CIAT 17434 = CIAT 18744 > CIAT 22160 > ATF 495. Under subhumid conditions the ranking was: CIAT 22160 > CIAT 18744 > CIAT 17434 > ATF 495. Sowing density of 36 plants/m^2 gave higher (SC) and (DM). Sowing density had no influence on plant dry season survival.

Keywords **– Cover, Density, Dry Matter, Peanut, Stolon.**

I. Introduction

Arachis pintoi Krapov. & W.C. Greg is a perennial herbaceous legume native from South America and has demonstrated its adaptability to a wide range of rainfall regimes (650-3500 mm rainfall) in ecosystems whose dry season lasts less than six months (Bowman and Wilson, 1996 ; Adjolohoun *et al.*, 2013a ; Adjolohoun *et al.*, 2013b). This forage legume can be intensively managed in combination with grasses and was effective against soil erosion (Cook, 1992). It had High tolerance to shade, where it often appears more vigorous than in full sunlight (Cook *et al.*, 2005). *A. pintoi* could be a valuable ley pasture species for the evolving agricultural systems of West Africa (Adjolohoun *et al*., 2008) for both grazing and cutting particularly when combined with grasses.

These ecological and agronomic attributes of *A. pintoi* are influenced by the environment and by management practices (Gobbi, 2011) including the plant density at establishment (Perin *et al*., 2003), but they also depend on the selected variety. Researches on the effects of plant density on the agronomic parameters of Arachis plants have produced variable results. Studying the effect of density on the growth and development of *A. hypogaea*, Cahaner and Ashri (1974), and Giayetto *et al*. (1998) found that increased planting density led to increased vegetative growth and dry matter production. Thoma (1994) had reported that 8 plants/m^2 was the recommended sowing density for *A. pintoi* species. Perin *et al.* (2003) found that a sowing density of 16 plants/m^2 was the best compromise for high *A. pintoi* DM production combined with a high nutritive value, while for optimum plant growth, Kendrick (2004) and Huang *et al.* (2004) recommended between 30 and 100 plants/m^2 for the same species. Since *A. pintoi* seed is expensive for smallholders, finding the right sowing density to ensure the best results is a challenge for forage scientists in West-Africa. *A. pintoi* was recently introduced in this region and no research was carried out on this species until 1990, when it was distributed from CIAT (Centro Internacional de Agricultura Tropical) to agronomists via the RABAOC (Recherche en alimentation du bétail en Afrique occidentale et centrale) project (Stür and Ndikumana, 1994). To date, CIAT 17434 was only *A. pintoi* variety which has been tested in the region. It showed little success: its DM production ranged from 580 to 3230 kg/ha over the span of the rainy season but the plant was severely affected by drought (Stür and Ndikumana, 1994). Unlike in South-America or Australia, few data are available on the suitability of different *A. pintoi* variety to the environmental conditions prevailing in West Africa or on the influence of sowing density on productive traits such as total forage production, , ground cover and dry season survival.

This study therefore aimed to (1) provide some quantitative information on the vegetative growth of four *A. pintoi* varieties (CIAT 17434, CIAT 18744, CIAT 22160 and AFT 495) in West Africa, (2) compare those varieties in two different agro-ecological regions for their dry season plant survival and dry matter production.

II. Materials and Methods

Site description

The experiment was carried out on two sites. The first was located in the humid region of Benin (coastal Atlantic Ocean) at 6°05'N, 1°32'E and 0-20 m altitude. The area is covered by savannah vegetation with grasses dominated by *Panicum maximum* and *Brachiaria* sp. Soils are ferralitic, which are red in colour, characterised by a deep profile (> 2 m) with no gravel (Table 1). The rainfall follows a quadrimodal distribution. The rainy season extends from March until the beginning of November, with a short dry season in July and August. Annual precipitations during the three experimental years (2008, 2009, 2010) were 1211, 1147 and 1232 mm, respectively. Average monthly minimum and maximum temperatures were 22 and 30 °C, respectively. The second experimental site was located in the subhumid region of Benin (12° 45'N, 2° 28'E, altitude 400 m) with a grass savannah dominated by *Andropogon gayanus*, *Rottboellia cochinchinensis* and *Pennisetum polystachion*. The soil on the second experimental site contained a high proportion of gravel (> 50%) with a lower deepth (40 – 80 cm) (Table 1). The climate is characterized by strongly contrasting seasons with a single rainy season from May to mid-October followed by a dry season of 6 to 7 of months. Annual precipitation during the three experimental years (2008, 2009, 2010) were 894, 902 and 932 mm, respectively. Average monthly minimum and maximum temperatures were 21 and 33 °C, respectively. A general trend of the rainfall and temperature in both sites is a slightly decrease of rainfall and the increase of temperature during the last three decades.

A. pintoi varieties

Four *A. pintoi* varieties were used in this trial: CIAT 17434, CIAT 18744, CIAT 22160 and AFT 495. They were selected on the basis of their outstanding performances in terms of DM production, soil cover and plant dry season survival. variety CIAT 17434 was reported to have a slow growth but to produce many seeds (Rojas *et al*., 2005). CIAT 18744 is reported to be more efficient for phosphorus utilisation than CIAT 17434 (Gweyi-Ongnango *et al.* 2011) and in some areas it has greater growth rate and is more productive, covers the soil faster and has denser stolon than CIAT 17434 (Ngome and Mtei, 2010). CIAT 22160 was reported for its fair drought tolerance and the ability to produce of green sprouts during the dry season. It has a better forage quality and showed more aggressiveness in association with grasses as well as a better resistance to pest and deseases than CIAT 17434 (Castillo, 2003). Variety ATF 495 is more erect and performed better in South-East Asia than CIAT 17434. It produces more flowers and bigger seeds than other CIAT varieties. Its upper leaves are normally paler than those of CIAT 17434.

Land preparation, treatments and sowin.

Prior to the study (year 2007), both sites were covered by the previously described savannah vegetation. Soil sites were sampled and analysed for physical and chemical properties (Table1). After that, sites were manually cleared, weed residues were burnt on site, and ash spread over the field in conformity with local practices. This was followed by conventional peasant's practice tillage at a depth of approx. 40 cm. For each site, the design was a randomised complete block arranged in a split-block where varieties were main plot and sowing densities were subplots replicated four times per treatment of four blocks. The experimental scheme was as follows: 2 sites × 4 varieties × 3 sowing densities × 4 blocks. Elementary plot size was 6 m × 5 m (30 m²) with 2 m spacing between plots. These spaces were maintained by regular hand hoeing. Seeds were sown on April 01 and April 15 2008 in the humid and the sub humid region respectively with 50-cm spacing between lines (Perin *et al*., 2003) and 22, 11, and 5.5 cm between plants in the same line, yielding sowing densities of 9, 18 and 36 plants/m^2, respectively. 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. Varieties were planted without *Rhizobium* inoculation or any fertilizer treatment in conformity with smallholder practices in the area. Plots were weeded manually 8 weeks after establishment, after this only shrub regrowth was controlled.

Table 1: Physical and chemical properties of the soils on the experimental site

Soil property	Experimental Region		Analysis method
	Humid site	Sub humid site	
Sand (%)	70-80	75-95	Hydrometer method
Silt (%)	15-25	4-10	
Clay (%)	3-7	2-14	
pH	5.8 – 6.0	6.2 – 6.5	Laroche and Oger (1999), H_2O (2:5) (pH-meter PHM82)
Organic carbon (%)	0.30-40	0.4-0.6	Springer and Klee, 1954
Total N (%)	0.02-0.06	0.06-0.10	Kjeldahl (method 981.10, AOAC 1990)
Available P (ppm)	2-4	4-8	Cottenie *et al.* (1982) (spectrophotometer, CE 373) using the Scheel method

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Ca (meq/100g)	2.0-4.0	4.2-5.6	
Mg (meq /100g^{-1})	0.9-1.3	1.0-1.8	
K (meq /100g)	0.3-0,5	0.4-0.6	Cottenie *et al.* (1982)
Na (meq /100g)	0.1	0,1-0.3	
CEC (meq /100g)	4.0-5.2	6.0-8.0	

Measurements and calculation

Two weeks after sowing, 2 randomly located 1-m^2 quadrats were permanently marked in each plot. Five plants per quadrat (10 plants per block) were chosen randomly for the following measurements: (1) Day after emermence of first primary and secondary stolons; (2) stolon number; (3) stolon density (total stolon length in m^2). The quadrats were also used to measure the percentage soil cover. Dry season survival was considered through plant survival assessed via the presence of green stolons and expressed as the percentage of surviving plants in each plot. Dry season plant survival was evaluated at the onset of the first rain following the dry season on the above-selected 10 plants. Stolon number and density were measured on September 30 and October 15 in 2009, 2010 and 2011 for the humid and subhumid sites, respectively. Soil cover was measured weekly using a 1 m × 1 m measurement frame sub-divided into 25 (20 cm × 20 cm squares) (Njarui and Wandera, 2004). This measurement allowed identifing the number of weeks after sowing (the first year) and after the beginning of the growing season (the following years) to acheve 50% soil coverage.

Forage yield (kg dry matter/ha) was determined over the three years on each permanent quadrat at the end of October. After each harvest the residual biomass of the plots was cut and discarded. At plant harvest, five other plants per block (out of quadrat) were randomly chosen and gently excavated to access root nodulation status. The number of nodule per plant was counted.

Statistical Analysis

Twelve treatments (2 sites × 4 varieties × 3 densities) were considered in the trial. For all measurements, the plot was used as the experimental unit and the value of the plot was calculated as the average of the measurements performed on the 2 permanent quadrats of each plot. This yielded 4 replicates per treatment per year. Data were analysed with the GLM (General Linear Model) procedure of SAS 8.02 software (SAS Inc., Cary, NC) using the following model : $Yij = \mu + Si + Ej + Dk + Yl + (S{*}E)ij + (S{*}D)jk + (S{*}Y)il + (E{*}D)ik + (E{*}D)jk + (EY)jl + (D{*}Y)kl + (S{*}E{*}D)ijk + (S{*}E{*}Y)ijl + (E{*}D{*}Y)jkl + (S{*}E{*}D{*}Y)ijkl + eijkl$. In this model, repeated measurement option was considered to take into account that data in year 2 and 3 depend on the data collected the previous years.

Where μ = mean, *Si* = fixed site effect, *Ej* = fixed variety effect, *Dk* = fixed density effect, *Yl* = random year effect and two, three or four way interactions, *eijkl* = experimental error. When significant interaction was observed, data were reanalyzed separately by two- or one-way analysis of variance. A significant was declared at P<0.05. Soil coverage data (in percentage) were transformed to arcsine values to normalize the error distribution before GLM analysis. Means were compared by Least Significant Difference method.

III. Results

Stolon appearance date, stolon number and density: For both sites and in the first year trial, the first primary stolons appeared from the two cotyledonary positions almost simultaneously at approximately 18, 25, 30 and 35 days after sowing for CIAT 17434, CIAT 18744, CIAT 22160 and ATF 495, respectively. The second primary stolons began to sprout 30, 35, 38 and 45 days, respectively after emergence (data not shown), inducing differences (P<0.05) between varieties in primary stolon emergence in the following order: CIAT 17434 > CIAT 18744 > CIAT 22160 > ATF 495. The first secondary stolons of CIAT varieties began to sprout between 2 and 2.5 months after sowing and those of ATF 495 began to emerge between 2.5-3 months. No difference was observed between CIAT varieties for the first secondary stolon emergence dates (P>0.05), but the three CIAT varieties emerged faster (P<0.05) than variety ATF 495. Site, density, year or their interactions had no significant influence (P>0.05) on the first primary or secondary stolon emergence dates.

Ground cover and dry season resistance

Site, variety and density all had a marked influence (P<0.001) on ground cover (Fig. 1). As previously stated for stolon production, under humid conditions, CIAT 17434 and CIAT 18744 performed similarly but their ground cover was higher (P<0.001) than that of CIAT 22160 and ATF 495. Under sub humid conditions, CIAT 17434 covered the ground faster than CIAT 18744. After the first year, ATF 495 growth was very slow and 50% soil cover could not be reached (Fig. 1). Sowing densities of 36 plants/m^2 induced higher ground covers in the first year but no effect was observed in the subsequent years. For all varieties and for both sites, plant surface coverage rate decreased with time. Differences in dry season survival were observed between sites, varieties and years (P<0.01) but sowing density had no influence on this parameter (P>0.05). Interactions between variables were also no significant. Therefore only averages over sites and varieties are presented in Table 5. Unsurprisingly, varieties survived better under humid than subhumid conditions but, interestingly, variety differences were higher under subhumid conditions. This is logical as the more extreme the growing conditions, the more selective pressure there is, and more the varieties can express their differences.

Edible dry matter production

Forage yield followed similar trends as ground cover (Table 6) (Pearson correlation: 0.72 ; p<0.01). Differences between sites and varieties were observed (P<0.001). Density significantly influenced (P<0.001) edible dry matter production in the first year and 36 plants/m^2 yielded the highest dry matter production but this influence was not shown the two subsequent years (P>0.05). This result

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sugested that widely spaced seedings need more time to cover the soil, but once covered, there is no difference anymore. DM yield under humid conditions was higher than that under suhumid conditions (P<0.01). In the humid site, CIAT 17434 and CIAT 18744 yields where similar but in the subhumid site, CIAT 18744 produced more DM than CIAT 17434 (P<0.01) and CIAT 22160 yielded the highest DM. On both sites, variety ATF 495 yielded (p<0.01) the lowest DM and for all varieties, DM yield decreased with time

Table 2: Effects of site (humid and sub humid), varieties (CIAT 17434, CIAT 18744, CIAT 22160, AFT 495), density (9, 18 and 36 plant.m^{-2}), year (2008, 2009, 2010) and their interactions on stolon number, stolon density production, ground cover, forage production and dry season survival (N=4)

Parameter	Stolon number	Stolon density	Ground cover	Forage yield	Dry season resistance	Plant* nodulation
Site	< 0.001	< 0.001	< 0.001	< 0.001	< 0.000	0.041
Variety	< 0.001	< 0.001	0.003	< 0.001	< 0.000	0.001
Density	0.002	0.005	< 0.001	< 0.001	0.234	0.390
Year	< 0.001	< 0.001	< 0.001	< 0.001	0.003	-
Site×variety	< 0.001	< 0.001	< 0.001	< 0.001	0.585	0.018
Site×density	0.169	0.252	0.062	< 0.074	0.444	0.321
Site×year	0.018	0.023	0.010	0.019	0.892	-
variety×density	0.065	0.950	0.071	0.068	0.354	0.255
variety ×year	< 0.001	< 0.00	< 0.001	< 0.001	0.966	-
density×year	0.010	0.015	0.021	0.031	0.877	-
Site×year× variety	0.017	0.022	0.003	0.007	0.267	-
Site×year×density	0.123	0.163	0.017	0.008	0.588	-
Site× density× variety	0.267	0.462	0.011	0.724	0.098	0.118
variety × density ×year×site	0.434	0.113	0.022	< 0.044	0.696	-

* For nodulation access, count was done only in first year (2008).

Table 3: Stolon number per m^2 of four tested varieties six months after sowing in humid and sub humid sites (N = 4)

Site	Year	Varieties: CIAT 17434			CIAT 18744			CIAT 22160			ATF 495		
		Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)		
		9	**18**	**32**	**9**	**18**	**32**	**9**	**18**	**32**	**9**	**18**	**32**
Humid	2008	379 Aβa(1)	512 Aαa	313 Aγa	341Aβa	507 Aαa	356 Aγa	271 Aβb	298 Aαb	289 Aγb	79 Aβc	116 Aαc	62 Aγc
	2009	256 Bαa	301 Bαa	245 Bαa	232 Bαa	259 Bαa	225 Bαa	177 Bαb	197 Bαb	148 Bαb	53Bαc	65 Bαc	45 Bαc
	2010	134 Cαa	145 Cαa	130 Cαa	128 Cαa	126 Cαa	131 Cαa	105 Cαb	117 Cαb	121 Cαb	23 Cαc	27 Cαc	23 Cαc
Sub humid	2008	176 Aβc	199 Aαc	158 Aγc	216 Aβb	248 Aαb	196 Aγb	248 Aβa	284 Aαa	217Aγa	37 Aβd	74 Aαd	41 Aγd
	2009	77 Bαc	80 Bαc	88 Bαc	97 Bαb	101 Bαb	109 Bαb	130 Bαa	124 Bαa	139 Bαa	23 Bαd	35 Bαd	22 Bαd
	2010	58 Cαc	63 Cαc	59 Cαc	83 Cαb	89 Cαb	77 Cαb	90 Cαa	101 Cαa	107 Cαa	8 Cαd	9 Cαd	10 Cαd
SEM(2)		27	33	20	22	32	21	17	18	16	13	8	5

(1) For the same line and for the same sowing density, means followed by different lower Latin letters are significantly different for $p < 0.05$
For the same site and for the same column, means followed by the different upper Latin letters are significantly different for $p < 0.05$
For the same variety and for the same line, means followed by different Greco letters are significantly different for $p < 0.05$.

Table 4: Stolon density (m/m^2) of four tested varieties six months after sowing in humid and sub humid sites (N = 4)

Site	Year	Varieties: CIAT 17434			CIAT 18744			CIAT 22160			ATF 495		
		Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)		
		9	**18**	**32**	**9**	**18**	**32**	**9**	**18**	**32**	**9**	**18**	**32**
Humid	2008	82 Aβa(1)	110 Aαa	70 Aγa	79 Aβa	99 Aαa	68 Aγa	57 Abβ	78 Aαb	49 Aγb	26 Aβc	32 Aαc	17 Aγc
	2009	54 Bαa	52 Bαa	62 Bαa	49 Bαa	45 Bαa	54 Bαa	37 Bαb	30 Bαb	38 Bαb	16 Bαc	37 Bαc	23 Bαc
	2010	38 Cαa	41 Cαa	39 Cαa	36 Cαa	38 Cαa	32 Cαa	25 Cαb	22 Cαb	21 Cαb	9 Cαc	16 Cαc	7 Cαc
Sub humid	2008	18 Aβc	16 Aαa	36 Aγc	29 Aβb	45 Aαb	25 Aγb	49 Aβa	59 Aαa	37 Aαa	14 Aβd	12 Aαd	8 Aγd
	2009	20 Bαc	18 Bαa	15 Bαc	19 Bαb	25 Bαb	28 Bαb	38 Bαa	31 Bαa	39 Bαa	5 Bαd	9 Bαd	7 Bαd
	2010	9 Cαa	10 Cαa	11 Cαc	15 Cαb	16 Cαb	18 Cαb	21 Cαa	23 Cαa	25 Cαa	3 Cαd	4 Cαd	3 Cαd
SEM(2)		5.67	7.42	5.71	5.54	6.06	4.41	3.57	5.41	3.44	1.96	2.93	1.64

(1) For the same line and for the same sowing density, means followed by different lower Latin letters are significantly different for $p < 0.001$
For the same site and for the same column, means followed by the different upper Latin letters are significantly different for $p < 0.001$
For the same variety and for the same line, means followed by different Greco letters are significantly different for $p < 0.001$.

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Table 5: Plant dry season survival (% of surviving plants) of four tested varieties (N = 4)

Year	Humid site				Sub humid site			
	CIAT 17434	CIAT 18744	CIAT 22160	AFT 495	CIAT 17434	CIAT 18744	CIAT 22160	AFT 495
2008	65 Abα(1)	75 Abα	80 Aaα	45 Acα	50 Acβ	60 Abβ	75 Aaβ	30 Adβ
2009	45 Bcα	55 Bbα	65 Baα	35 Bdα	35 Bcβ	45 Bbβ	60 Baβ	20 Bdβ
2010	35 Ccα	45 Cbα	55 Caα	20 Cdα	20 Ccβ	35 Cbβ	50 Caβ	10 Cdβ
SEM(2)	5.98	6.76	4.45	4.33	7.33	7.03	4.91	3.52

(1) For the same variety and for the same colon, means followed by different Latin upper letters are significantly different for $p < 0.01$.
For the same year and for the same site, means followed by different Latin lower letters are significantly different for $p < 0.001$.
For the same year and for the same variety, means followed by different Greco letters are significantly different for $p < 0.001$.

Table 6: Leaf yields (kgDM/ha) according to varieties and densities in humid and sub humid sites (N = 4)

Site	Year	Varieties											
		CIAT 17434			CIAT 18744			CIAT 22160			ATF 495		
		Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)			Sowing density (plant number per m²)		
		9	18	32	9	18	32	9	18	32	9	18	32
Humid	2008	2023 Aγa(1)	2321 Aβa	3153 Aαa	2037 Aγa	2798 Aβa	3463 Aαa	1401 Aγb	2118 Aβb	2889 Aαb	541 Aβc	862 Aαc	1025 Aγc
	2009	1988 Bαa	1707 Bαa	1889 Bαa	1884 Bαa	1831 Bαa	1629 Bαa	887 Bαb	1097 Bαb	1148 Bαb	318 Bαc	452 Bαc	510 Bαc
	2010	972 Cαa	959 Cαa	837 Cαa	1286 Cαa	1395 Cαa	1225 Cαa	405 Cαb	417 Cαb	521 Cαb	107 Cαc	106 Cαc	124 Cαc
Sub humid	2008	472 Aγc	751 Aβc	983 Aαc	681 Aγb	884 Aβb	1064 Aαb	816 Aγa	1399 Aβa	1977 Aαa	114 Aγd	253 Aβd	418 Aαd
	2009	467 Bαc	496 Bαc	414 Bαc	684 Bαb	670 Bαb	680 Bαb	878 Bαa	891 Bαa	949 Bαa	81 Bαd	105 Bαd	159 Bαd
	2010	185 Cαc	154 Cαc	159 Cαc	316 Cαb	231 Cαb	332 Cαb	521 Cαa	566 Cαa	507 Cαa	16 Cαd	10 Cαd	9 Cαd
SEM(2)		159	167	216	142	186	217	73	121	181	40	64	72

(1) For the same line and for the same sowing density, means followed by different lower Latin letters are significantly different for $p < 0.001$
For the same site and for the same column, means followed by the different upper Latin letters are significantly different for $p < 0.001$
For the same variety and for the same line, means followed by different Greco letters are significantly different for $p < 0.001$.
(2)*SEM* : Standard error of means.

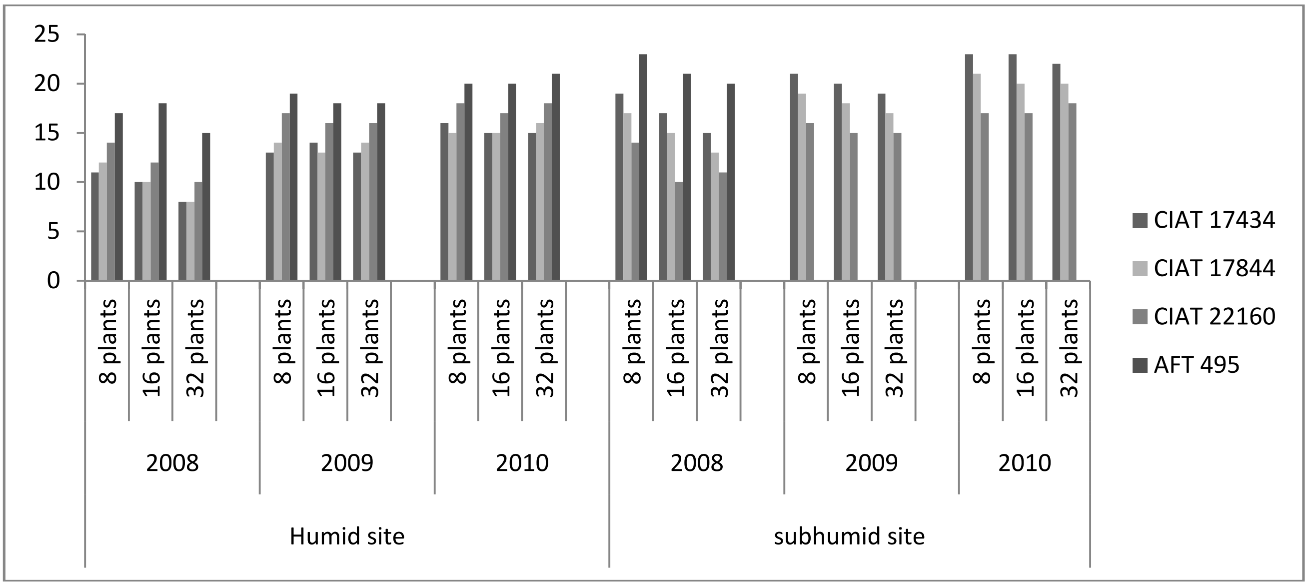

Fig.1. Number of weeks required for reaching 50% soil coverage by different tested varieties in humid and sub humid sites

Table 7: Number of nodule per plant (6 months after sowing) for four tested *Arachis pintoi* varieties in first experimental year (2008) (N = 12)

Experimental site	Varieties			
	CIAT 17434	CIAT 18744	CIAT 22160	AFT 495
Humid site	12.8aAB(1)	18.3aA	9.5aBC	8.4aC
Subhumid site	15.3aA	11.5bAB	10.3aB	2.5 bC
SEM(2)	1.0	1.9	0.9	1.2

(1) For the same line, means followed by different upper letters are significantly different for $p < 0.05$. For the same column, means followed by different lower letters are significantly different for $p < 0.05$.
(2)*SEM* : Standard error of means.

IV. Discussion

This study compared the performances of four *A. pintoi* varieties under three sowing densities in two agro-ecological regions of Benin. The differences between varieties for first primary and first secondary stolon emergence dates and the similarity between

sites for these parameters suggest that first primary stolon emergence date is related to genetic characteristics of each variety and that the differences between sites in environmental conditions such as soil moisture and temperature during establishment have no influence on emergence. The ability of varieties to sprout faster and develop dense stolon is a desirable characteristic as it can contribute effectively to ground cover, competition against weeds and reduced soil erosion. To our knowledge, there is no information in the literature that shows any *A. pintoi* stolon sprouting date data comparison. After 6 months the average stolon number per unit area recorded in this study was lower than that observed by Villarreal and Vargas (1996) in Costa Rica (stolon density of 73 and 188 m/m^2 and stolon number of 514 and 1386 stolons/m^2 for CIAT 17434 and CIAT 18744 varieties, respectively). Their superior results when compared to those reported in this study could be due probably to higher soil fertility and the above 2000 mm annual rainfall conditions prevailing in Costa Rica, which are more suitable to *A. pintoi* than the ones in Benin.

Most of plots reached 50% soil coverage between 14 to 16 weeks after sowing showing that the plants displayed slow growing rates during establishment. This is well documented through South and Central America, and Australia (Castillo, 2003). In this trial, sowing density of 36 plants/m^2 showed better soil cover. Kendrick (2004) reported a similar conclusion for the species and recommended 30-40 plants/m² as a suitable density. Nevertheless, 36 plants/m² was the highest density in this study and the question remains whether planting at even higher densities could be attempted without prohibitive establishment costs. It is possible that a more equal distribution of the seed could reduce the within-row competition at high seed densities. The decrease in ground cover over time could be related to a decrease soil nutrient quality as plots were cut and biomass was removed without any nutrient restitution. The competition with weeds could also explain this decrease. The 6-months dry season prevailing in the subhumid zone, the sandy structure of the soil and its shallow depth (Table 1) considerably reduce the water holding capacity of the soil and plants suffered of water deficiency during the dry season as shown by the differences in dry season resistance. Variety×density interaction was not significant on each site for dry season survival indicating that the ability of individual variety to remain green during the dry season was similar for all 3 tested densities. Conversely, significant site×variety interactions suggest that it might be necessary to select different varieties for cropping according to the site moisture and soil conditions. In this regard, variety CIAT 22160 and to some extent CIAT 18744 showed better dry season survival than CIAT 17434 and AFT 495 in both humid and sub humid environments. They are therefore interesting candidates in improving diet quality of ruminants in West Africa not only during the growing season but also during the dry season (Peters *et al.*, 1997). In conditions where farmers are unable to establish *A. pintoi* each year, varieties CIAT 22160 and CIAT 18744 would be more useful as persistence is a major issue with forage legumes. Such results have never been reported in West Africa regions where only CIAT 17434 has been tested so far (Stür and Ndikumana, 1994).

In the first year, an increase in forage dry matter yield was observed with increasing plant sowing density, as reported by Giayetto *et al*. (1998) who noted similar trends of plant density on *A. hypogaea* dry matter production. The two outstanding varieties in terms of dry matter production were CIAT 17434 and CIAT 18744 in the humid site. But, in the subhumid environment, variety CIAT 22160 performed better than the 3 others. A decrease in dry matter production was observed for all varieties but the extent of this reduction varied largely according to the variety. CIAT 22160 was the most reliable for dry matter production over the years in the subhumid site. This result highlights that the choice of CIAT 17434 in the 1990's was not the best in terms of plant survival and that CIAT 22160 is more suited for subhumid regions in West Africa. With an average rainfall of 828 mm/year, Bowman *et al*. (1998) recorded in Australia only 510 – 550 kg DM/ha/year for CPI 58113 which is considered genetically close to CIAT 17434. The results recorded in this trial can be stated as well. Trends between these two varieties in subhumid area (CIAT 18744 > CIAT 17434) found in our evaluation agree with reports of CIAT (1996) who noted 230 and 500 kg DM/ha for *A. pintoi* cv. Maní Mejorador which is considered genetically as similar to CIAT 17434 and *A. pintoi* cv. Porvenir which is considered to be close to CIAT 18744, respectively. On the other hand, *A. pintoi* is known to have highly specific *rhizobia*. In this experiment, no *rhizobium* inoculant has been applied. Native *rhizobia* may not have been effective and it is possible that, with specific *rhizobium*, all varieties would have been more productive. The number of nodule per plant varied about 3 to 18. Thomas (1994) had studied influence of type and amount of nitrogen fertilizer on CIAT 17434 nodule production and found that plant produced between 2 and 47 nodules par plant. Legume plant nodulation could depend on many factors particularly on the interaction between soils, rhizobia and legume plant. In some soils, populations of appropriate rhizobia may be absent or too small for nodulation to occur. The available N of the soil at plant establishment can also play an important role. At sowing, *A. pintoi* varieties were deliberately not inoculated in order to favour varieties that could nodulate with native *Rhizobia* and survive under the conditions prevailing in the experimental area as suggested by Tarawali *et al.* (1995).

V. Conclusion

This study highlighted varieties performance differences in the environmental conditions found in humid and sudhumid Benin. The most common variety grown in the area CIAT 17434 (Stür and Ndikumana 1994 ; Carvalho 2004) was not the best candidate. The most suitable varieties for Benin humid and subhumid regions appear to be CIAT 18744 and CIAT 22160. Although none of the 4 tested varieties could maintain a year-round ever-green biomass, their contribution in ruminant diet in the regions would be valuable due to the low nutritive value of the native pastures. Sowing density of 36 plants/m^2 allows better plant ground cover but has no influence on long term production. Therefore, 9 plant/m² densities might be regarded as suitable for the smallholders in order not to increase cost and work-load for establishment.

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