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Influence of vegetative and seed establishment methods on seed yield and quality of *Arachis pintoi* CIAT 17434 in Soudanian region of Benin

S. Adjolohoun[9], F. Houndonougbo[9], C. Adandedjan[9], S. S. Toleba[9], M. Houinato[9], W. R. Nonfon[9] et B. A. Sinsin[10]

Abstract

Arachis pintoi is a valuable forage legume in tropical savannas. However, seeds are expensive, so that, vegetative planting is an option particularly for smallholder farmers. During 3-year, *A. pintoi* CIAT 17434 seed yield and quality were studied in northern Benin (West Africa). Two treatments (establishment from stolons and from seeds) were tested under a randomised bloc design with 4 replications per treatment. Mean annual rainfall was 1,200 mm with mean annual temperature of 27 °C. Seed yield/ha, 100 pods and 100 kernels weight, pod and kernel length and wide, pod distribution in soil profile, seed germination percentage and germination speed were parameters assessed. Mean value of each treatment were compared using the Least Squares Mean method. Plants established by seeds produced significantly ($p<0.01$) more pod (309-407 kg/ha) than those established from stolons (125-181 kg/ha). 1000 pods weight varied from 12.2 to 15.8 g and 100 kernel weight varied from 8.8 to 10.9 g. Both, pod and kernel weights were influenced by establishment methods. Most of the seeds were produced in 0-6 cm soil layer but plants established from seeds showed a higher pod depth than plants established by stolons. Harvested seeds had higher germination percentage for both treatments (75-92%) which decreased quickly 6 months after storage to nil before 9 months after harvesting. High correlations ($r = -0.97$; $p < 0.01$) were found between seed germination percentage and storage duration which can be used to predict seed germinative quality.

Key words: Forage peanut, pod, germination, West Africa.

Influence des méthodes d'installation par voie végétative ou par graines sur le rendement et la qualité des semences de *Arachis pintoi* CIAT 17434 en région soudanienne au Bénin

Résumé

Arachis pintoi est une importante légumineuse fourragère des savanes tropicales. Toutefois, les semences coûtent chères au point où les petits exploitants agricoles font recours au mode végétatif pour l'installation de la culture. Un essai visant la détermination du rendement et de la qualité des semences d'*Arachis pintoi* CIAT 17434 a été conduit au Nord-Bénin au cours de trois années. Deux traitements (installation de la plante par les stolons et par graines) ont été testés. Ces traitements ont été installés suivant un dispositif en bloc complètement aléatoire comportant 4 répétitions par traitement. La pluviométrie annuelle moyenne a été d'environ 1.200 mm de pluie avec une température moyenne annuelle de 27 °C. Les mesures réalisées ont concerné le rendement en semences de la plante, la répartition des gousses dans le sol, les poids de 100 gousses et de 100 graines, la longueur et la largeur des gousses et des graines, le pourcentage et la vitesse de germination des graines. Les traitements ont été comparés par la méthode des moindres carrés. Les données relatives au pourcentage de germination et la répartition des gousses dans le sol ont connu

[9] Dr Ir. Sébastien ADJOLOHOUN, Département des Productions Animales (DPA), Faculté des Sciences Agronomiques (FSA), Université d'Abomey-Calavi (UAC), 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 97 89 88 51, E-mail : s.adjolohoun@yahoo.fr, République du Bénin

Prof. Dr Ir. Fréderic HOUNDONOUGBO, DPA/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 97 89 88 51, E-mail : fredericmh@gmail.com, République du Béni

Prof. Dr Ir. Claude ADANDEDJAN, DPA/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 96 14 29 65, E-mail : claude.adandedjan@gmail.com, République du Bénin

Prof. Dr Ir. Séibou Soumanou TOLEBA, DPA/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 97 01 05 68, E-mail : seiboutoleba@yahoo.fr, République du Bénin

Prof. Dr Ir. Marcel HOUINATO, DPA/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 97 69 65 64, E-mail : mrhouinat@yahoo.fr, République du Bénin

Dr Ir. René NONFON, DPA/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 66 62 99 22, E-mail : wren@yahoo.fr, République du Bénin

[10] Pr. Dr Ir. Brice Augustin SINSIN, DAGRN/FSA/UAC, 01 BP 526 Recette Principale, Cotonou 01, Tél. : (+229) 97 01 61 36, E-mail : bsinsin@gmail.com, République du Bénin

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une transformation de la forme arcsin afin de les normaliser avant la comparaison des moyennes. Les résultats ont montré que les plants installés par graine ont produit significativement (p<0,01) plus de gousses (309-407 kg/ha) que ceux installés par stolon (125-181 kg/ha). Les poids de 100 gousses ont varié de 12,2 à 15,8 g et ceux de 100 graines ont varié de 8,8 à 10,9 g. Ces poids ont été influencés par le type d'organes utilisés lors du semis. La plupart (>75%) des gousses sont formées dans les 6 premiers cm du sol mais les plants installés par graines ont produit plus de gousses en profondeur que les stolons. Les semences récoltées ont montré une forte germination (75-92%) au cours des 3 premiers mois après la récolte. La germination est pratiquement nulle, 9 mois après la récolte. De fortes corrélations (r = -0.97 ; p<0,01) ont été observées entre la germination et la durée de stockage des semences. Ces corrélations peuvent être utilisées pour prédire la qualité germinative des semences.

Mots clés : arachide fourragère, gousse, germination, Afrique de l'Ouest.

INTRODUCTION

Arachis pintoi (Kaprovickas & Gregory) is a valuable forage legume for tropical savannas, persisting under different management systems. The plant is used for several purposes such as ornamental use, soil coverage, animal feed and soil fertility improvement. In association with tropical grasses, *A. pintoi* had showed great potential to improve cattle production in grazing systems. Some accessions can spread through swards of the aggressive growing grass species with high resistance to heavy grazing and trampling (Cook *et al.,* 1994). This legume which could be grown from seed is frequently propagated vegetatively due to its high seed cost for rural people in West Africa. This was reported by the extension services as serious barrier for a wide-scale adoption. Thus, there is a need for increasing seed production of this species in West Africa. Most of the agronomic data published on *A. pintoi* seed production were obtained in studies conducted in Central America countries and are exclusively from the originated area of the plant. Furthermore, seed yield depends on environmental factors such as soil fertility, rainfall conditions, agronomic practices and crop age. A seed yield of 0.123 and 1.4 t/ha has been reported in Australia by Gallegos (2003) and Cook and Franklin (1988), respectively. Seed yield of 7.2 and 9 t/ha have been documented by Ferguson *et al.* (1992) and Cook *et al.* (1994), respectively. *A. pintoi* plant can be established from seed or stolon and little data are available on vegetative establishment (stolon) and seed yield in field conditions. In West Africa, seed production and management techniques are limited and there is lack of information on the assessment of *A. pintoi* seed yield from seeds or stolons.

The objectives of the study are to 1) compare the potential seed yield of two different organs of *A. pintoi* and 2) to access seed characteristics (weight, length and wide) and seed quality through germination and longevity in West Africa's environment.

MATERIALS AND METHODS

Site description

The experimental site was located in the northern region of Benin (12° 05'N, 2° 06'E, altitude 300 m) with a grass savanna dominated by *Andropogon, Rottboellia* and *Pennisetum* species. The soil contained a high proportion of gravel (> 50%) with relative a shallow layer profile (40 – 80 cm depth). The climate is characterized by strongly contrasted seasons with a single rainy season from May to mid-October followed by a 5 to 6 months dry season. Annual precipitations during the three experimental years (2009, 2010, 2011) were 1,210, 1,190 and 1,200 mm, respectively. Average monthly minimum and maximum temperatures were 21 and 33 °C, respectively.

Land preparation and sowing

Land of 1,000 m^2 was slashed and ploughed. Soil physical and chemical characteristics were presented in Table 1. Two treatments (planting material) were used for the trial: plant established from seeds and from stolons. For both treatments, *A. pintoi* CIAT 17434 were planted on 15 April 2009, 10 April 2010 and 20 April 2011in 50 cm between lines and 8 plants per m in the line (Perin *et al.,* 2003) giving 16 plants per square meter. Four seeds per hole at 2 cm depth were observed during the sowing. Two weeks after emergence, plantlets were thinned to one vigorous. For vegetative material establishment, 0.30 m length of the stolon with 8 nodes was used for planting. A randomized block design was used, with 4 replications per treatment. Each sub-plot consisted of 40 m^2 (8 m × 5 m).

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Table 1. Some physical and chemical properties of soils used in the study

Soil property	Value	Analysis method
Sand (%)	82.00	Hydrometer method
Silt (%)	10.00	
Clay (%)	8.00	
pH	6.40	Laroche and Oger (1999), H_2O (2:5) (pH-meter PHM82)
Organic carbon (%)	0.50	Springer and Klee, 1954
Total N (%)	0.05	Kjeldahl (method 981.10, AOAC 1990)
Available P (ppm)	0.40	Cottenie *et al.* (1982) (spectrophotometer, CE 373) using the Scheel method
Ca (Cmol/kg)	3.60	Cottenie *et al.* (1982)
Mg (Cmol/kg)	1.80	
K (Cmol/kg)	0.70	
Na (Cmol/kg)	0.20	
CEC (Cmol/kg)	6.80	

Assessment of pod seed yield and Pod seed distribution through soil profile

Seeds were harvested on 12 November 2009, 07 November 2010 and 17 November 2011. Two randomized quadrats of 0.5 m × 0.5 m corresponding to 0.25 m^2 were chosen. At each harvest date, above material (leaves and stolons) was removed per quadrat and after that, soil was dug at 30 cm deep and screened on a sieve of 0.2 x 0.2 cm mesh to remove all the pods from the soil. The pods that were still attached to plants and those that were detached were separately harvested, carefully washed with abundant tape water and then sun-dried until seed moisture was approximately 8% and then weighed. Mean of the two quadrats per plot was considered for pod seed yield. Pod seeds from each plot were separately stocked given 4 repetitions (4 seed lots) per planting material and per year.

On each plot, two other quadrats were randomly identified and 30 cm soil depth split into 10 successive layers of 3 cm intervals each was taken with an auger of 8.9 cm diameter. A number of pods from each layer were counted and reported as a percentage of total number of each quadrat. For each soil layer, mean of the two quadrats per plot was considered with 4 replications for statistical analysis considering each sowing method per year.

Assessment of pod and seed characteristics

Pod seeds used for yield determination were used for assessing pod and seed characteristics. 20 pods were randomly taken from each of the 4 seed lots per planting material and per year, the length and wide were measured with caliper. After that, they were shelled and kernel length and wide also were measured with caliper. For the assessment of 100 pods weight and pure seed, 10 replications of 100 pods from each seed lot were randomly selected, weighted separately and thereafter shelled. The number of kernels from each replication were then counted and weighed separately. Pure seed set (%) was assessed as percentage of pod number having kernel. Kernel weight/shell weight ratio was also calculated. Ten replications per treatment were considered during statistical analysis of pod or seed quality characteristics.

Seed germination test

Seed lots were packed in polyethylene bags and stored in aerated room conditions (according to local practices for *A. hypogaea* seed conservation). Average minimum and maximum room temperature during seed storage were 20 and 33 °C respectively. Mean relative humidity ranged from 30-35% (December-February) to 80-95% (Mai-October). Before the beginning of the germination test, pods were preheating at 40 °C with free air circulation for a period of 14 days (Ferguson, 1993; ISTA, 1993). Germination tests were carried out at 0, 3, 6, 9 and 12 months after harvesting using “Between Paper” (BP) method, with incubation at alternating temperature 20-30 °C according to ISTA (1993) prescriptions for *A. hypogaea*. Four replications of 100 kernels each were used. Paper was watered prior with 4% bleach solution to delay fungal growth. Germinated seeds were daily counted and removed from the paper. A seed was considered as germinated when the rootlet had at least 1 mm length. Germination was recorded up to 15 days after planting. The following parameters were assessed and analysed: final germination percentage (G%) and germination speed measured as mean germinated time *(MGT)* defined as follows:

$$G(\%)\frac{\sum_{i=1}^{15} ni}{100} \quad \text{and} \quad MGT(days/seed) = \left[\frac{\sum_{i=1}^{15} nidi}{\sum_{i=1}^{15} ni}\right]$$

Where n_i = number of seeds germinated and removed on day *di*, 100 = number of seeds of each repetition placed on each paper at the beginning of germination test and 15 the duration in days of the test.

Statistical analysis

Means and standard deviations were calculated for all variables. Statistical analyses were performed using the statistical package SAS 8.02 software (SAS Institute Inc., 1989). For pod seed yield, pod distribution in soil profile, pod and seed characteristics, treatments were compared by the Least Squares Mean method according to the following equation: $Yij = \alpha + Ai + Bj + A*B(ij) + e(ij)$, where: α is overall mean, *Ai* is the planting material effect, *Bj* is the year effect, *A*B(ij)* is the interaction of planting material and year effect and *e(ij)* is error term.

For seed germination and germination speed, treatments were compared by the Least Squares Mean method according to the following equation: $Yij = \alpha + Ai + Bj + Ck + A*B(ij) + A*C(ik) + B*C(jk) + A*B*C(ijk) + e(ijk)$, where: α is overall mean, *Ai* is the planting material effect, *Bj* is the year effect, *Ck* is the storage duration effect, *A*B(ij), A*C(ik), B*C(jk) and A*B*C(ijk)* their different interaction effects and *e(ijk)* is error term.

For variables which values were comprised between 0 and 1 (pod distribution in soil profile, seed set, proportion of attached pod and final percentage of germinated seed), they were transformed by square arc sinus before being analyzed to satisfy the conditions of normal distribution of data. Pearson correlation coefficients were made on the one hand between pod weight, kernel weight and shell weight and the other hand between percentage of seed germination and storage duration time.

RESULTS

Effect of planting methods on pod seed yield and proportion of pods detached from plant at harvest

Clean pod seed yield for the two sowing materials are presented in Table 2. During the 3 years, significant differences ($p<0.01$) were observed between the sowing materials and years ($p<0.05$) regarding pod seed yields. However, there was no significant interaction between sowing materials and years ($p>0.05$). For the same sowing material, seed pod yield in 2009 was significantly ($p<0.05$) higher than those obtained in 2010 and 2011. There was no significant difference ($p>0.05$) in pod seed yield in 2010 and 2011 for both sowing materials.

Table 2. ***Arachis pintoi*** **CIAT 17434 seed production from two sowing materials (stolon and seed) after 6 months cultivation in South-east region of Benin (West Africa) and the proportion of pods detached from plants at harvest (n= 4)**

Parameters	Year						Mean	
	2009		2010		2011			
	Seed	Stolon	Seed	Stolon	Seed	Stolon	Seed	Stolon
Total pod seed yield (kg/ha)	407 Aa*	181 Ab	328 Ba	125 Bb	309 Ba	165 Bb	348	141
Pods detached from the plant at harvest (%)	82 Aa	88 Aa	85 Aa	87 Aa	69 Ba	72 Ba	79	82

*** For the same line and for the same sowing material, means followed by the same front size alphabetic letters are not significantly different (p>0.05). For the same line and for the same year, means followed by the same front size alphabetic letters are not significantly different (p>0.05).**

During 3-years experimentation, pod seed yields from seed sowing treatment were 2.2 to 2.6 times significantly higher ($p<0.01$) than those obtained from stolons plantation. The different proportions of pods which remained attached to plants at the harvest period (6 months after sowing) are also presented in Table 2. There was no significant difference ($p>0.05$) between the plantation treatment but significant difference was observed between years ($p<0.05$). Interaction between sowing materialxyear was not significant (p>0.05). A significantly lower proportion of pods were detached from plants at harvest in 2011 than those obtained in 2009 and 2010 (Table 2).

Effect of planting methods on pod and seed characteristics

Harvested pod and seed characteristics are presented in Table 3. Pod sets (percentage of pods having kernels) varied from 79 and 95% with mean of 89% for both sowing materials through the 3-years experimentation. The sowing materials had no significant (p>0.05) effect on pod set. However, the year of experimentation has influenced significantly seed set. The seed set recorded in 2009 and 2010 were significantly higher (P<0.05) than that recorded in 2011. Both sowing materials and year of experimentation had influenced significantly (p<0.05) pod and kernel weights. But, their interaction were not significant (p>0.05). The shell weight, kernel/shell ratio and kernel wide are not affected by the sowing materials nor by the year of experimentation. The regression equation between pods weight (y) and kernel weight (x_1) was $y = 1.20 + 1.34*x_1$ (R^2 = 78, p = 0.02 and SED = 1.77). The relationship between pod weight and shell weight (x_2) was not significant: $y = 3.17 + 0.03*x_2$ (R^2 = 0.36, p = 0.20 and SED = 5.2).

Table 3. Pod and seed characteristics of *Arachis pintoi* CIAT 17434 in South-east region of Benin (n= 10)

Characteristics	Years						Mean	
	2008		2009		2010			
	Seed	Stolon	Seed	Stolon	Seed	Stolon	Seed	Stolon
Seed set (%)	95 Aa*	91 Aa	90 Aa	92 Aa	85 Ba	79 Ba	90	87
100 pods weight (g)	15.6 Aa	13.8 Ab	15.8 Aa	14.4 Ab	14.5 Ba	12.3 Bb	15.3	13.5
100 kernels weight (g)	10.7 Aa	9.6 Ab	10.9 Aa	9.8 Ab	9.1 Ba	8.8 Bb	10.2	9.4
100 shells weight (g)	4.9	4.2	4.7	4.5	4,4	4.5	4.7	4.4
Ratio: kernel/shell	2.18	2.29	2.13	2.18	2.30	2.51	2.2	2.3
Pod length (mm)	12 Aa	10.4 Ab	11.3 Aa	10.1 Aa	12.2 Aa	11.0 Aa	11.8	10.5
Pod wide (mm)	8.0 Aa	7.5 Aa	7.8 Aa	7.1 Aa	7.6 Aa	6.5 Bb	7.8	7.0
Kernel length (mm)	9.0 Aa	8.3 Aa	8.4 Aa	7.8 Aa	8.4 Aa	6.9 Bb	8.6	7.7
Kernel wide (mm)	4.5	4.2	4.7	4.2	4.1	3.7	4.4	4.0

*** For the same line and for the same sowing material, means followed by the same upper case letters are not significantly different (p>0.05). For the same line and for the same year, means followed by the same lower case letters are not significantly different (p>0.05).**

Effect of planting methods on pod distribution in soil profile and

The pod seed distribution varied according to the sowing materials (Table 4).

Table 4. *Arachis pintoi* seed pods distribution (Percentage of number basis) in soil layer in the Soudanian zone of South-east Benin

Year	Sowing material	Soil deep (cm)					
		0-3	3-6	6-9	9-12	12-15	15-30
2009	Seed	45 Ab*	30 Aa	16 Aa	6 Aa	3 Aa	0
	Stolon	61 Aa	31 Aa	7 Ba	1 Aa	0 Ab	0
2010	Seed	52 Aa	19 Ba	19 Aa	8 Aa	2 Aa	0
	Stolon	58 Aa	22 Aa	15 Aa	5 Aa	0 Ab	0
2011	Seed	49 Aa	24 ABa	14 Aa	10 Aa	3 Aa	0
	Stolon	50 Aa	35 Aa	11 ABa	4 Aa	0 Ab	0
Overall mean	Seed	49	24	16	8	3	0
	Stolon	56	30	11	3	0	0

*** For the same column and for the same year, means followed by different lower case letters are significantly different (P<0.05). For the same column and for the same sowing material, means followed by different upper case letters are significantly different (P<0.05).**

During the 3-years of experimentation, 49% of pods were concentrated in the first 3 cm of the soil layer with seeds sowing treatment against 56% for stolons plantation treatment. In 2009, pod seed proportion in the 0-3 cm soil layer for plants established from seeds was significantly ($p<0.05$) lower than that of the plants established from stolons plantation. No seed was found in the soil layer below 12 cm for plants established by stolons whereas; plant established from seeds produced 2 to 3% of pods in the 12 - 15 cm soil layer. However, in both treatments, no pods of seeds were found below 15 cm soil layer.

Effect of planting methods on seed germination

Data on final germination percentage G (%) and germination speed measured as mean germinated time MGT (days/germinated seed) are presented in Table 5. Sowing material, year and storage duration had influenced significantly G (%) ($p<0.001$) but had no significant effect ($p>0.05$) on seed germination speed. Relatively high final percentage of seed germination was observed during the first 6 months after harvest. The final percentage of seed germination after 9 months storage varied between 0 and 4%. The final percentage of seed germination in 2010 was significantly lower ($p<0.05$) than that obtained in 2009 and 2011. The final percentage of seed germination (y) decreased during the time (x) and was strongly linear following the equation $y = -7.98x + 89.67$ ($R^2 = 95\%$, $p<0.01$ and SED = 3.725).

Table 5. Effect of planting method and storage on total percentage germination (%) (G) and mean germination time (days/seed) (MGT) of Arachis pintoi CIAT 17434 seed in South-east region of Benin (n = 5)

Duration of Storage (months)	Parameters	Years						Mean	
		2008		2009		2010			
		Seed	stolon	Seed	Stolon	Seed	stolon	Seed	stolon
0	G	92 Aaα*	91 Aaα	75 Baα	78 Baα	92 Aaα	92 Aaα	86	87
	MGT	2.5	2.3	2.1	2.2	2.6	2.4	2.4	2.3
3	G	79 Aaβ	82 Aaβ	53 Baβ	60 Baβ	74 Aaβ	70 Aaβ	69	71
	MGT	2.2	2.4	2.3	2.5	2.2	2.4	2.2	2.4
6	G	68 Aaγ	71 Aaγ	27 Caγ	24 Caγ	55 Baγ	49 Baγ	50	48
	MGT	2.3	2.3	2.5	2.1	2.2	2.3	2.4	2.2
9	G	13 Aaδ	6 Abδ	0 Caδ	0 Baδ	2 Baδ	0 Baδ	5	2
	MGT	2.2	2.1	-(**)	-	-	-	-	-
12	G	0 ε	0 ε	0 δ	0 δ	0 δ	0 δ	0	0
	MGT	-	-	-	-	-	-	-	-

*** For the same sowing material on the same line, means followed by the different upper case Latin letters (A, B and C) are significantly different (P<0.05). For the same year, means followed by the different lower case Latin letters (a and b) are significantly different (P<0.05). For the same column and for the same parameter, means followed by the different Greek letters (α, β, γ, δ and ε) are significantly different (P<0.05). - ** After 6 months storage, (G) was too low and MGT had not been calculated.**

DISCUSSION

Influence of planting methods on pod seed yield

A. pintoi pod seed yield varied between 309-407 and 121-181 kg/ha when plants were established by seeds or by stolons plantation respectively. When established by seeds, *A. pintoi* produced about 2.5 times than when it is established by stolons plantation. To our knowledge, there is no information available in the literature in West Africa to allow data comparison. In Colombia, Ferguson *et al.* (1992) reported that, *A. pintoi* seed yield from plants established by seeds (about 2000 kg/ha) was 8-times higher than that from plants established by stolons plantation (240 kg/ha). Argel and Valerio (1993) observed in Costa Rica that, seed yield from *A. pintoi* CIAT 17434 was between 800 and 960 kg/ha. Seed yield performance from stolons plantation in our study was lower than that recorded by these authors but was in the range 150-250 kg/ha reported by CIRAD (2009). *A. pintoi* CIAT 17434 seed yield depends on rainfall conditions, soil texture and plant density, sowing material and crop age. For the same environment and ecotype, seed yield can depend also on seed components such as flower production, flower efficiency for gynophores production and efficiency for pods production (Adjolohoun *et al.*, 2013). The low seed yield of plant established from stolons plantation would probably be related to the above components. Several reports on *A. pintoi* seed yield in the tropics showed that great variations exist among regions, Cook and Franklin (1988) reported seed yield of 1.4 t/ha after 12 months from plants established by seeds. However, in Colombia, when planted in fertile soils, Ferguson *et al*. (1992) reported yield of 7.3 t/ha from plants established by seeds.

Influence of planting methods on pod distribution in the soil layer and proportion of pods detached from plants

In leguminous seed production, the genus *Arachis* has specific behavior as seeds are produced below ground and are fixed to the plant by structure called gynophores (Simpson *et al.* 1994). The collapse time of these gynophores has been reported as one of the important characteristics between domesticated and wild species (Ferguson, 1994). With *A. hypogaea*, a far most studied *Arachis* species, the structure is sufficiently rigid due to a long period of domestication, and only 75% (Putnam *et al.*, 1991) remain attached to the plants until pod maturity and therefore, the harvest is easier. In opposite with domesticated *A. hypogaea*, wild peanut species such as *A. pintoi* are characterized by gynophores with well-defined abscission layers and collapsed easily after so that, at crop maturity, an important proportion of pods are commonly detached from the plants (Ferguson, 1994). This presents new challenges to seed growers and makes *A. pintoi* seed harvesting very costly. In the present experiment, it was observed that, 69 to 88% of the pods were detached from plants before the harvest date. Argel and Pizarro (1992) reported an average value of 97% for three accessions (CIAT 17434, 18744 and 18748) after 14 months growth in Colombia. Ferguson *et al.* (1992) observed that, 90% of pods were detached from plants at harvest. The relatively lower proportion of detached pods observed in 2011 during the present study could be explained by the shorter rainfall period which did not allow good gynophores growth and therefore pods production.

Pods were produced after gynophores penetration in soil. Most pods 45 – 61%, 71 – 92% and 87 – 99% were concentrated in the 0 – 3 cm, 0 - 6 cm and 0 - 9 cm, respectively of the soil layer. The assessment of 12 accessions of *A. pintoi* at two different locations in Brazil, Carvalho *et al.* (2009) obtained about 60, 99 and 100% of the pods in 0 – 3, 0 – 6 and 0 – 9 cm soil layer, respectively. The proportion of pods (54%) found in this study in the 0-3 cm soil layer compared with that of 60% noted by Carvalho *et al.* (2009). Studying 3 accessions of *A. pintoi* in Costa Rica, Argel and Valério (1993) obtained for the ecotype BRA–015121 only 82% of the pods in the first 10 cm soil horizon. In Colombia, Ferguson *et al.* (1992) observed that 90% of *A. pintoi* CPI 58113 (CIAT 17434) pods were concentrated in this soil layer. Moreover, no pods were found in 15 – 30 cm layer in this study. Argel and Pizarro (1992) observed that 1 to 3% of pods were formed in 15 – 20 cm layer. With seed establishment method, 3% of pods were found in 12 – 15 cm soil layer in our study but no pods were found in this horizon for plant established based on stolon. These results indicated that, even if the pod depth is genetically controlled, soil type would play an important role in pod depth.

Influence of planting methods on pod and seed characteristics

In the same species, seed weight depends not only on plant varieties but also on environmental factors particularly soil nutrients content and rainfall conditions. Pod set, 100 pods and 100 kernels weight were higher in the two first years of experimentation than the third. The plants were grown without nutrient supply. This would probably cause soil nutrient depletion particularly for phosphorus which influences plant seed weight. Furthermore, rainfall distribution in the first two experimental years was more favorable for plant growth than the third and could also contribute to greater plant growth. Pods and kernels characteristics were slightly higher when plants were established from seeds than from stolons plantation but the difference was not significant, except for the third experimental year during which seed produced from plant growth from seeds showed longer pods and kernel. Pods and kernels characteristics in the literature vary. For instance, in Mexico, Enrỉquez and Quero (2001) analyzing the effect of liming and harvest date on *A. pintoi* CIAT 17434 seed yield and quality reported that 100 pods weight and 100 kernels weight were 16.35 and 11.83 g respectively. Ferguson *et al.* (1992) studying *A. pintoi* CIAT 17434 seed yield in various locations in Colombia noted that, 100 pods weight varied from 13 to 20 g and 100 kernels weight varied from 8 to 16 g. Our results reinforce these findings, with 100 pods and 100 kernels weights of 13.5–15.30 and 9.40–10.23 g, respectively.

Influence of planting methods on seed germination

The duration of the experiment has significantly influenced seed germination for both establishment methods. Seeds harvested in the first and third years had germinated significantly more than those of the second year. Environmental conditions prevailing during seed formation can influence physiologically the quality of the harvested seeds and therefore, their germination. Ferguson (1993) studied the physiological quality of different seed lots of *A. pintoi* harvested from Bolivia after six months storage and reported that mean value of seed germination ranged between 39-61%. In our study, after six months storage, the percentage of seed that germinated declined rapidly to nil 9 months after harvest. Recovered seeds were packed in polypropylene bags and stored under ambient conditions. Under such conditions in humid tropical regions, Ferguson (1993) reported that seeds were suggested to air humidity and temperature variation and lost quickly their viability and germination capacity. Sanders *et al.* (1982) indicated that the sum of temperature plus relative moisture should be less than 100 to have optimal Arachis seed storage. Argel and Pizarro (1992) noted that under 10 °C and 30% relative air moisture, the loss of germination capacity of *A. pintoi* seeds was negligible. Under ideal storage conditions, Arachis pod seeds remain viable for 15 years or more (Holbrook and Stalker, 2003). A low temperature and relative air moisture cannot be achieved constantly in West Africa ecosystem under natural conditions.

CONCLUSION

A. pintoi seed yield in Benin agroecosystem ranges from 300 to 400 kg/ha when plants are established from seeds and from 125 to 180 kg when establish from vegetative material. Although, these results of seed yield are relatively low compared to other seed yield levels of the same species, seed yield is satisfactory according to the local conditions of low rainfall and the little period of plant cycle. Seeds loose their germination capacity within less than 9 months. Further research is needed for better understanding of seed viability and germination in older to prevent a rapid seed deterioration of seed lots during the storage

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