American Journal of Experimental Agriculture
3(4): 731-739, 2013

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Evaluating the Effects of Staking and Planting Dates on the Yields of African Yam Bean, *Sphenostylis stenocarpa* in Nigeria

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Author's contribution

The only author performed the whole research work, made the statistical analysis, wrote the first draft of the paper, read and approved the final manuscript.

Research Article

Received 16th March 2013
Accepted 8th May 2013
Published 1st June 2013

ABSTRACT

Aims: To evaluate the effects of staking and planting dates on the seed/tuber yields of African yam bean (AYB).
Study Design: The fields were laid out in split-plots in randomized complete block design
Place and Duration: Field experiments were conducted at Ebonyi State University, Abakaliki, Nigeria during 2009/10 farming seasons.
Methodology: Three different planting dates were used as the main-plot treatments, while staking and non-staking formed the sub-plots. Seven accessions of AYB were planted in the sub-plots. Five plants were randomly selected from each accession/treatment and tagged for data collection. Each seedling was staked independent after germination, while the non-staked plants were allowed to trail on the ground guided. Collected data were subjected to analyses of variance. Mean separation was carried out by Fisher's protected LSD test. Pearson correlation coefficient (r) was used to determine the relationship between yields, planting dates and staking.
Results: The results indicated that all the AYB accessions performed better when they were staked and planted earlier in May of each season with greater seed/tuber yields, which differed significantly ($P < 0.028$) from those that were not staked and planted later in each of the season. Of all the accessions assessed, TSs86 was the most productive with the highest seed yield and differed significantly ($P < 0.015$) from the rest except TSs48 that even gave better seed yield during 2010, while TSs84 had the least seed yields. Results on

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the tuber yields showed the same trend in relation to the treatments. The tuber yield showed that some accessions could produce above 2 Mg ha^{-1} of tubers per hectare; however tuber yield showed inverse relationship to that of the seed yield across the accessions with the highest tuber yield recorded in TSs93 and least in TSs86.
Conclusion: For increased seed/tuber yields of AYB in Nigeria, it has to be staked and planted early in May of each season.

Keywords: Sphenostylis stenocarpa; staking; planting dates; yields.

1. INTRODUCTION

Nigeria is one of the African countries that are endowed with varieties of grain leguminous plants that are required for sustainable food security. Unfortunately, one major causes of food insecurity experienced in many African countries and Nigeria in particular is the underutilization of some potential food security crops in the continent [1,2]. Amongst the underutilized crops with high food potential in Nigeria is African yam bean (*Sphenostylis stenocarpa,* Hochst. Ex. A. Rich). African yam bean (AYB) is one of the most important grain and tuberous legumes of tropical Africa. It is cultivated as a secondary crop with yam (Dioscorea spp) and other crops in many parts of Africa mainly by subsistence farmers despite its nutritional values [3,4,5]. The seed and tuber are the two major organs of immense economic importance as food for Africa with regional preferences [3,5,6,7,8]. While the seeds are preferred in the West African countries, the tubers are preferred both in the east and central Africa. AYB has huge potential for food security in Africa. According to [9], AYB is well balanced in essential amino acid and has higher amino acid content than *Cajanus cajan*, *Vigna unguiculata* and *Vigna subterranea*. The grain is a good source of proteins, fibre and carbohydrate. It is rich in minerals such as phosphorus, iron and potassium. However, the under-exploitation of the crop has subjected it to be classified as minor grain legumes [1].

Of all the factors militating against increased AYB production in Nigeria is its low seed yield, when compared with other legumes (cowpea) and tuber crops (sweet potatoes) under monocrop conditions [2]. Several factors have been reported to be responsible for the low seed yield recorded in the field. Of all the factors that challenges increased AYB production, the most important one is the cultural practices involved in its production. AYB is a vigorously climbing herbaceous vine whose height can reach 1.5–3 m or more with many branches which twines on any available stake [7]. Hence the believe that AYB requires a stake in its production and no wonder the practice of intercropping it with other crops that either requires stake too, like yam or with a crop that may provide a stake like cassava or millet [5,10]. According to [10], AYB requires staking under monocropping for improved seed yield. To provide stakes for a better growth and yield requires extra effort and cost.

Although several references have been made to the use of the AYB tubers as a source of starch and proteins in West Africa [3,7,8], unfortunately many AYB farmers do not even know that it produces tubers talk less of harness the potential in supplementing their protein requirements. Others on the other hand attach no importance to the bean tubers as their yields were considered very poor compare to that of yam [5].

Furthermore the appropriate time of planting for enhanced yields has not been ascertained. The knowledge of these factors is necessary in guiding rural farmers that may want to

engage in its production. Hence the objective of this study was to evaluate the effect of staking and date of planting on the seed/tuber yields of AYB in Nigeria.

2. MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University Abakaliki during 2009 and 2010 farming seasons under rain fed conditions. Abakaliki lies within 7º 30'E, 5º 45'N with a mean annual rainfall of 2000 mm. The fields were laid out in split-plots in randomized complete block design. Three different planting dates (May 4th, June 2nd and July 1st) for 2009/10 were used as the main-plot treatments, while staking and non-staking formed the sub-plots. Seven promising accessions of AYB (TSs 9, TSs 48, TSs84, TSs86, TSs93, TSs94 and TSs166) collected from International Institute of Tropical Agriculture (IITA) genetic bank were randomly planted in the sub-plots. The AYB accessions seeds were planted in rows in each plot with an accession occupying a row. The seeds were sown at 2 seeds per hole at a planting spacing of 1 m x 0.7 m inter and intra spacing. Each treatment was replicated three times. Thinning was done after three weeks of planting to one seedling per stand. Five plants were randomly selected from each accession/treatment and tagged for data collection. Forty kilograms per hectare of compound fertilizer 15: 15: 15 NPK was added to all the plots at three weeks after germination to boost growth. Staking was done three weeks after germination using strong stake each measuring about 3 m high. Each seedling was staked independent of another to avoid mixing the accessional yields, while the non-staked plants were allowed to trail on the ground and were guided to avoid mixing with other accessions. The experimental plots were weeded at three weeks intervals.

At harvest, data were collected on the total seed yield of individual plants based on the treatments and assessed per accession from the tagged plants. Estimate of seed yield per unit area was done when the seeds were dry using the tagged plants. The pods were threshed and winnowed. The results were extrapolated to kilogram per hectare for each accession and treatment. Equally the estimate of tuber yield per unit area was done when the plants were mature and leaves dried using the tagged plants. The tubers were harvested using a hoe, weighed and the results were extrapolated to tons per hectare for each accession and treatment. Daily meteorological data were collected from the Ebonyi State University meteorological station (Table 1).

Table 1. Monthly meteorological data of the experimental site for 2009 and 2010

	2009			2010		
Month	**Rain fall (mm)**	**Temp (ºC)**	**Humidity**	**Rain fall (mm)**	**Temp (ºC)**	**Humidity (%)**
January	92.00	30.5	55.44	No rain	27.8	55.8
February	No rain	31.4	8.39	No rain	32.6	29.8
March	202	32.2	83.45	176	32.5	58.5
April	127.1	31.5	81.15	134	30.0	58.9
May	361.70	30.2	70.37	282.5	27.3	56.2
June	216.13	28.8	86.04	394.8	28.6	64.5
July	381.21	27.8	83.5	159.8	28.3	84.3
August	475.1	28.3	94.17	397.3	28.7	91.7
September	386.30	28.6	93.36	432.1	28.5	93.2
October	438.2	29.2	93.93	420.7	30.1	92.5
November	91.3	30.5	91.9	78.3	30.2	89.2
December	No rain	30.1	66.76	No rain	30.3	54.6
Total	2771	359.1	908.5	2475.5	354.9	829.2
Mean	203.9	29.9	75.7	206	29.6	69.1

2.1 Statistical Analyses

Collected data were subjected to analyses of variance through computer software [11]. The mean separation was carried out by Fisher's protected LSD test. Pearson correlation coefficient (r) was used to determine the relationship between yields, planting dates and staking.

3. RESULTS

The results indicated that staking and date of planting significantly affected the seed/tuber yields of African yam bean (Table 2). Highest seed yields were observed when AYB accessions were staked compared to the accessions that were planted non-staked, which gave the lowest seed yields across the accessions and years (Fig. 1). Amongst the accessions assessed, TSs86 when staked gave the highest seed yields during 2009 and differed significantly ($P< 0.015$) from the rest except TSs48. However during 2010 farming season the reverse was the case with TSs48 having the highest seed yield that differed significantly from the rests except TSs86 and TSs9 accessions. On the contrary, TSs84 gave the poorest seed yield both when staked and non-staked.

Similarly, the highest seed yields were recorded when AYB were planted earlier in May of each season, which differed significantly ($P<0.028$) from those planted later in the season (Table 2). It was observed that AYB planted later than May had more infestation of post-flowering insect pests attack resulting in more destruction of pods and reduced seed yield.

In the two planting seasons, the highest seed yields were recorded during the 2009 farming season than in 2010 across the accessions and planting dates (Fig. 1).

Table 2. Effect of planting dates on seed yield (kg ha^{-1}) of AYB during 2009/2010

	Planting dates 2009				
S/N	Varieties	May	June	July	Mean
1	TSs9	566.8	466.0	383.8	472.2
2	TSs48	604.7	526.9	421.2	517.6
3	TSs84	434.2	328.8	286.2	349.7
4	TSs86	640.5	529.1	470.1	546.6
5	TSs93	521.2	450.7	321.3	431.1
6	TSs94	553.9	500.7	352.5	469.0
7	TSs166	534.7	403.0	362.7	433.5
	Mean	550.9	457.9	371.1	

LSD (P<0.05) for comparing two accessions of AYB means = 49.1
LSD (P<0.05) for comparing two planting dates means = 91.2

	Planting dates 2010				
1	TSs9	520.2	471.3	352.1	447.9
2	TSs48	600.1	501.3	393.1	498.2
3	TSs84	428.3	412.6	213.9	351.6
4	TSs86	530.7	471.7	353.9	452.1
5	TSs93	500.1	375.5	352.8	409.5
6	TSs94	457.2	320.9	299.1	359.1
7	TSs166	400.7	353.1	300.7	351.5
	Mean	491.0	415.2	323.7	

LSD (P<0.05) for comparing two accessions of AYB means = 55.6
LSD (P<0.05) for comparing two planting dates means = 69.3

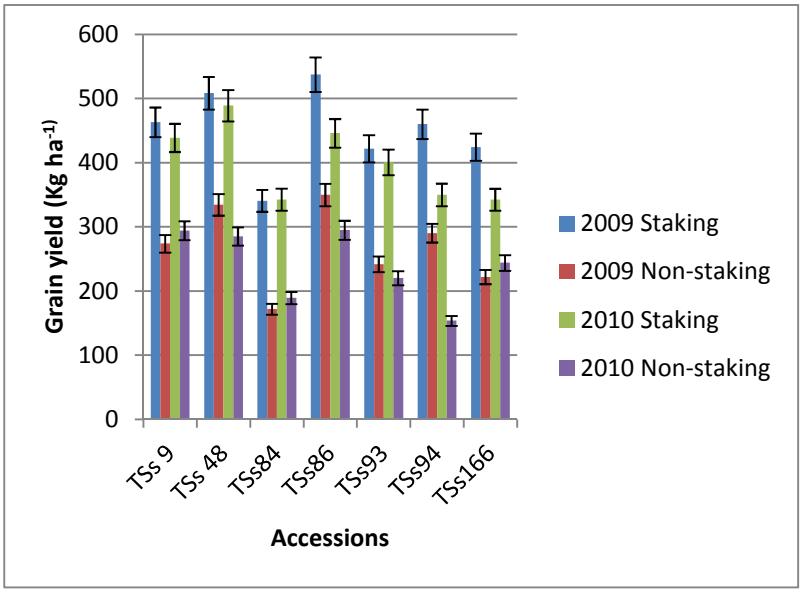

Fig. 1. Effect of staking on seed yield (kgha^{-1}) of African yam bean

The results of the tuber yields indicated that the fresh tuber yield per plant varied across the accessions and planting dates throughout the experimental periods. In overall, TSs86 gave

the least fresh tuber yield across the experimental periods and differed significantly from others, while TSs84 gave the highest tuber yield indicating an inverse relationship between tuber yield and seed yield (Table 3 and Fig. 2). Similarly AYB accessions planted earlier gave higher tuber yield across all the accessions and differed significantly (P <0.001) from those planted later with the highest tuber yield recorded in May of each season while the least was gotten in July of each season.

Table 3. Effect of planting dates on fresh tuber yield (Mg ha^{-1}) of AYB during 2009/2010

		2009			
S/N	**Accessions**	**May**	**June**	**July**	**Mean**
1	TSs 9	1.52a	1.42a	1.31b	**1.42**
2	TSs 48	1.44a	1.22b	1.01c	**1.22**
3	TSs84	2.13a	2.03a	1.73a	**1.96**
4	TSs86	1.32a	1.31a	0.71b	**1.11**
5	TSs93	1.93a	1.82a	1.52b	**1.76**
6	TSs94	1.73a	1.42b	1.22c	**1.46**
7	TSs166	1.93a	1.63b	1.32c	**1.63**
Mean		**1.71**	**1.55**	**1.26**	

LSD (P<0.05) for comparing two planting dates Means = 0.13
LSD (P<0.05) for comparing two AYB accessions means = 0.15

		2010			
1	TSs 9	1.22a	1.21a	1.02b	**1.15**
2	TSs 48	1.42a	1.12b	1.11b	**1.22**
3	TSs84	1.93a	1.62b	1.42b	**1.66**
4	TSs86	1.42a	0.61b	0.41b	**0.81**
5	TSs93	1.73a	1.62a	1.63a	**1.66**
6	TSs94	1.24a	1.32a	1.22a	**1.26**
7	TSs166	1.52a	1.52a	1.41b	**1.48**
Mean		**1.50**	**1.29**	**1.17**	

LSD (P<0.05) for comparing two planting dates Means = 0.11
LSD (P<0.05) for comparing two AYB accessions means = 0.17

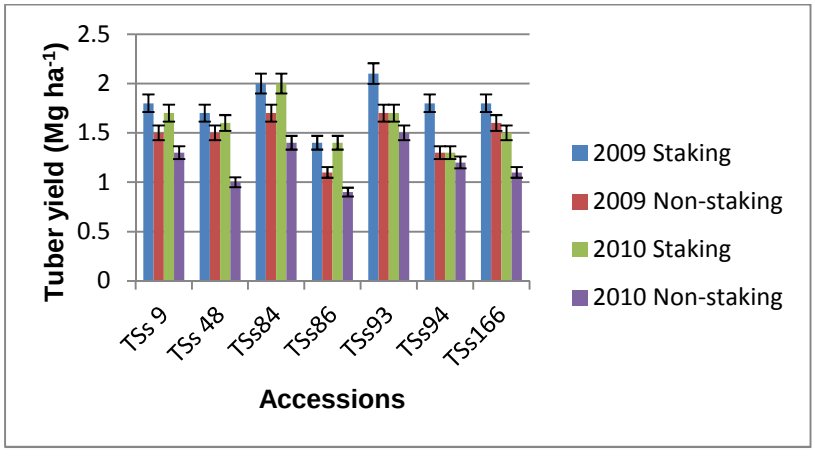

Fig. 2. Effect of staking on fresh tuber yield ((Mg ha^{-1})) of African yam bean

There were significance mean positive correlations between dates of planting, seed yield and tuber yields (r = 0.67 and 0.45, P<0.001) respectively; staking and seed yield (r = 0.56, P<0.001); staking and tuber yield (r = 0.51, P<0.001) for 2009 and 2010 respectively. There was significant negative correlation between seed yield and tuber yield (r = 0.69, P<0.0001).

4. DISCUSSION

The highest seed yield observed when AYB were staked under this study could be due to the importance of staking on the yields of AYB. The yield increase might probably be due to the advantageous effects of staking which provided support for the numerous branches of the crop. Similar results have been reported by [10]. According to them when AYB was intercropped with maize/kenaf, the maize/kenaf served as life stakes for the AYB which in turn gave higher seed yield compared to sole AYB that was not staked. It has been reported that AYB is a vigorous, herbaceous, climbing leguminous plant whose height could be up to 1.5-2 m. Hence, as a climbing crop, it needs a stake for proper vegetative growth. The vegetative growing stage is characterized with the profuse production of trifoliate leaves which is required for an enhanced seed yield [12]. The variation on yield recorded across the planting dates may be also attributed to frequent number of rain days and amount of rain with moderate temperature that were observed at the period of the flowering stage which also may influence other biotic activities that may influence seed yield in AYB (Table 1).

Yield reductions observed on all the accessions under non-staking condition has been reported by earlier researchers [10]. According to them, when AYB is not staked it lacks the support given by the stake material which assist it in repositioning the leaves for adequate sunlight it require for proper growth. It has equally been reported that staking plays a significant role in tuber formation of most climbing plants like yam [13,14].

Similarly, the significant increase in seed yield recorded early in the season may be attributed to reduced pests infestation on the crop. AYB has been reported to be attacked by several flower and post flower pest that results in low yield of the crop [15]. However it has been reported that such pests do not infest the crop early in the season [16]. According to them such serious pest of AYB like *M. vitrata* and thrips were observed to have low infestation of the early planting crops. This is also in agreement with [17,18] who reported that cowpea planted in June or July in Southern Nigeria usually escape severe *M. vitrata* infestation while those planted late in August coincide with the peak population densities of the major post-flower pests resulting in considerable reduction of grain yield. Conversely the low grain yield observed later in the season may also be attributed to increased pest build up in the field thereby destroying the crop [16]. Similar results have been reported in cowpea in Uganda by [19]. The agronomic practices of planting crops at different dates are used in different parts of the tropics especially in Africa [20]. This is evident in the present result that showed significant differences on both the seed and tuber yield of AYB recorded across the three planting dates. Improved crop cultivars and alteration in planting dates of crops have been reported as an effective strategy in reducing pest damage and increasing crop yields by a number of researchers [21].

It has been reported that seed formation/yield in some legumes affect the development of tubers. This is in line with the inverse tuber yield recorded in the present study. Accession that gave higher seed yields were the accessions that gave the least tuber yield and this explains the significant negative correlation observed under the study. The higher seed/tuber yields recorded in some accessions compared to others may also be due to differential genetic make of the different accessions.

5. CONCLUSION

The results presented showed that AYB has high potential in contributing to food security in Nigeria. The high yield gain advantage recorded when AYB was staked over the non-staked cropping calls for its cultural practices improvement. Furthermore, the tuber yield potential of the crop indicated that if improved upon could stand to replace most of the tuber crops grown in Nigeria whose yield have been dwindling following the current low soil fertility observed virtually in all the ecologies in Nigeria. Thus, for improved growth and total yields of AYB, staking and early plant are paramount cultural practices to be observed.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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