Effects of staking, nitrogen and phosphorus fertilizer rates on yield and yield components of African yambean (*Sphenostylis stenocarpa*)

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SUMMARY

Two field experiments were conducted between 1989 and 1991, in the derived savanna environment of south-eastern Nigeria to study the effects of staking, nitrogen fertilizer rates (0, 25, 50, 75 and 100 kg N/ha) on seed yield of yambean. The number of pods per plant, seed weight and seed yield were significantly higher in staked than in unstaked yambean. The number of pods per plant and seed yield were also significantly increased by increasing nitrogen rate from 0 to 50 kg N/ha. Phosphorus application, similarly, increased the number of pods per plant and seed yield as the rate increased from 0 to 40 kg P_2O_5/ha. Interactions between nitrogen and phosphorus significantly influenced seed yield with optimum seed yield obtained when the crop was staked and fertilized at 50 kg N/ha and 40 kg P_2O_5/ha.

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RÉSUMÉ

OKPARA, D.A. & OMALIKO, C.P.E.: *Effets de tuteurage et de proportions d'engrais azoté et phosphoré sur le rendement et les composants de rendements d'igname de l'haricot africain* (Sphenostylis stenocarpa). Deux expériences sur terrian se sont déroulées entre 1989 et 1991, dans l'environment de savane-dérivée du sud-ouest Nigéria afin d'étudier les effets de tuteurage, les proportions d'engrais azoté (0, 25, 50, 75 et 100 kg N/ha) et les proportions de' engrais phosphoré (0, 20, 40, et 80 kg P_2O_5/ha) sur le rendement de graine d' igname de l'haricot. La quantité de cosses par plante, le poids de graine et le rendement de graine étaient considérablement plus élevés dans les tuteurés que dans les non-tuteurés d' igname de l' haricot. La quantié de cosses par plante et le rendement de graine ont été égalemenl augmentés considérablement par l'augmentation de la proportion d' azote de 0.0 à 50 kg N/ha. De la même façon, l' application de phosphore, a augmenté la quantité de cosses par plante ains. que le rendement de graine comme la proportion augmentait de 0.0 à 40 kg P_2O_5/ha. L'Interaction entre azote et phosphore a influencé considérablement le rendement de graine avec l' obtention de l'optimum du rendement de graine quand le culture était tuteurée et fécondée à 50 kg N/ha et 40 kg P_2O_5/ha.

Introduction

The African yambean (*Sphenostylis stenocarpa*) is a long-duration legume crop which is grown in several African cropping systems. The crop is cultivated mainly for its seed in Nigeria where, in the south-eastern states, it serves as an important substitute for cowpea. Elsewhere, the tuber is reported to be the most valuable part, resembling and tasting like potato (Ezueh, 1984). The seed protein content of yambean is higher than that of cowpea while its methionine and lysine content is superior or equal to that of soybean (National Academy of Science, 1979). The protein level of the seed of yambean ranges from 21 to 29 per cent as against 22 to 24 per cent found in cowpea.

Despite its major dietary roles and long existence from ancient times, little is known about the agronomy of yambean (National Academy of Science, 1979). Under the traditional system, yambean is usually intercropped with yams (*Dioscorea* spp.) for which support is provided for the climbing vines. Staking has been shown to significantly influence the yield of some crops, especially yam in the humid tropics (Coursey. 1967; Onwueme,

1978) while Noda & Kerr (1983) have shown that staking is not essential for increasing root production in yambean. Information concerning the effect of staking on seed yield in yambean is, however, very limited. There is also dearth of information on the effects of nitrogen and phosphorus fertilizer rates on seed yield of yambean. Of all nutrient amendments made to soils, nitrogen and phosphorus fertilizer applications have been shown to have had the most outstanding effects in the production and quality of legumes (Ezedinma, 1961, 1965; Graham, 1981; Peck & MacDonald, 1984). The present paper, therefore, examines the effects of staking, nitrogen and phosphorus on yield and yield components of yambean (Nsukka Brown cultivar).

Materials and methods

The experimental site

Two field experiments were conducted between 1989 and 1991 on the fine sandy loam ultisol of the University of Nigeria farm at Nsukka (latitude 06° 52' N, longitude 07° 24' E), to study the response of yambean to staking and fertilizer (nitrogen and phosphorus) rates. The soil has N content of 0.06 per cent, *p*H of 4.8, cation exchange capacity of 6.4 mequiv./100g soil, and fine earth composition of 79.4, 2.2 and 18.4 per cent sand, silt and clay respectively. The meteorological data of the farm are shown in Table 1, with 1989 and 1991 experiencing early heavy rainfall when compared to 1990. The location falls within the derived savanna ecological zone of Nigeria, which is a transition ecosystem developed as a result of poor nanagement of the ecosystem. It lies between the humid tropical forest zone and the true savanna.

Experiment 1: Staking experiment

The experiment was performed in the 1989 and 1990 cropping seasons (from May to December). The land was prepared (ploughed and harrowed) and laid out in nine plots measuring 8 m × 4 m (32 m^2) each. The whole plot size was 328 m^2 with each plot separated from the other by a 1 m path. The treatments were staked and unstaked yambean plants with nine replications. Treatments were achieved by staking plants in one-half of each plot at 6 weeks after sowing (WAS) while leaving plants in the second-half unstaked. The erect single trailing staking method (a stake per plant) was adopted using 2.5 m high bamboos, similar to those used for yams in the given agro-ecological zone. The experiment was evaluated by use of a *t*-test.

Yambean seeds (Nsukka Brown cultivar) were hand-sown on the flat in May at a spacing of 1 m × 1 m. The wider spacing of 1 m× 1 m was used for

TABLE 1

Meteorological Data of Experiment Station (Nsukka) during 1989, 1990 and 1991 Cropping Seasons

	Mean monthly rainfall (cm)			*Mean monthly earth temperature (°C)*			*Relative humidity (%)*			*Evapotranspiration (cm)*			*Solar radiation (Gcal/cm²/day)*		
Month	*1989*	*1990*	*1991*	*1989*	*1990*	*1991*	*1989*	*1990*	*1991*	*1989*	*1990*	*1991*	*1989*	*1990*	*1991*
May	217.5	96.6	214.2	29.5	26.2	29.2	82	80	82	101.6	82.4	110.2	272.9	274.2	275.1
June	213.4	206.4	208.6	28.3	28.5	29.6	84	82	84	88.9	86.8	89.4	243.6	251.5	249.6
July	177.9	264.8	228.4	26.9	28.4	27.8	84	84	84	81.3	80.2	82.0	214.3	216.0	208.2
Aug	238.4	185.5	218.2	24.9	26.5	29.2	84	82	84	81.3	81.5	82.0	208.8	204.5	200.1
Sep	325.3	235.6	310.8	26.7	28.2	29.2	86	84	86	81.3	80.6	82.0	232.6	230.2	230.8
Oct	216.8	210.6	227.5	28.2	28.4	29.8	85	85	86	94.0	96.9	96.7	250.9	255.0	251.7
Nov	5.3	6.1	18.4	29.4	28.0	29.4	80	80	78	114.3	116.8	118.3	300.3	298.9	300.0
Dec	0.0	36.1	22.8	29.8	29.4	29.6	74	78	78	139.7	141.2	140.0	285.7	287.1	282.5

this experiment to enable the plants to express full genetic potentials. Okpara & Omaliko (in press) found no significant yield differences in yambeans spaced in the range from 1 m× 1 m to 0.75 m ×0.5 m. Each plot received the equivalent of 300 kg/ha 15:15:15 NPK mixed fertilizer as basal dressing (broadcast) 6 WAS. Three hoe-weedings were done at a regular 4-week interval from the time of crop emergence. Harvesting was done at full maturity (when green pods turned brown) from October to December. At harvest, 9 plants per plot, each for staked and unstaked plants (avoiding discards/border plants) were sampled and observations were taken on the number of pods per plant, number of seeds per pod, one thousand-seed weight (g) and seed yield (kg/ha).

Experiment 2: Fertilizer (N and P) experiment

The experiment was conducted first in 1990 and repeated in 1991. Each year, the experiment was carried out on a fresh area (to avoid nematode infestation) of the same soil series in the University of Nigeria farm at Nsukka. The layout was a randomized complete block factorial design with three replications. The land was laid out into three blocks measuring 8 m × 3 m each (240 m^2). Each block was divided into 20 experimental plots of 3 m × 3 m (9 m^2) each. Treatments consisted of all combinations of five levels of nitrogen (0, 25, 50, 75 and 100 kg N/ha) applied as urea and four levels of phosphorus (0, 20, 40 and 80 kg P_2O_5/ha) applied as single super phosphate. The fertilizer rates (N and P) rates were broadcast on the appropriate plots (flats) at seed bed preparation. Each plot also received 30 kg K_2O/ha as muriate of potash at the same time as the N and P fertilizers. Yambean seeds were hand-sown at a spacing of 0.75 m × 0.5 m (26, 666 plants/ha) on June 28 in 1990 and 1991. Yambean plants were staked (2.5 m high bamboos) with the single trailing method of one stake per plant. Three hoe-weedings were done at a regular 4 week-interval beginning from time of crop emergence. Harvesting was done as in Experiment 1 and the attributes measured were number of pods per plant, number of seeds per pod, one thousand-seed weight (g) and seed yield (kg/ha).

Results and discussion

Staking effects

Staking or providing support for some crops is an important agronomic practice that influences crop yields especially in the humid tropics where insolation is low, particularly during the annual cropping season. In this study, the staked yambeans maintained significantly higher number of pods per plant, 1000-seed weight and seed yield than yambeans grown without support (Table 2). Chapman (1965), Coursey (1967) and Lyonga, Fayemi & Agboola (1973) have also shown staking to be beneficial to the production of yam (*Dioscorea* spp.). The superior performance of the staked yambeans over the unstaked plants is primarily due to a better display of leaves and thus more efficient utilization of incident light by staked plants; it is of interest to note the striking differences in yields for the 1989 and 1990 crop (staked and unstaked). The early heavy rainfall of the wetter year (1989) encouraged excessive vegetative growth and a build up of insect pests and fungal diseases to the detriment of pod development and seed yield (Tables 1 & 2). On the contrary, yambean plants in the less wet year (1990) were smaller and less

TABLE 2

Effect of Staking on Yield and Yield Components of Yambean

Treatment	*Number of pods per plant*		*Number of seeds per pod*		*1000-seed weight (g)*		*Seed yield (kg/ha)*	
	1989	*1990*	*1989*	*1990*	*1989*	*1990*	*1989*	*1990*
Staked yambean	13.1	17.5	11.4	12.8	213.6	228.0	321.4	515.2
Unstaked yambean	8.9	9.6	11.4	12.2	186.0	211.5	189.6	251.7
LSD (0.05)	3.1	6.4	NS	NS	17.7	14.9	98.1	207.4

vegetative but yields were higher compared to the 1989 plants. This result is consistent with the observations of Gyansa-Ameyaw &Doku (1983) on bambara groundnut.

When averaged over both years, the number of pods per plant, seed weight and yield of staked yambean were higher than those of unstaked ones by 65, 11 and 90 per cent respectively. Among the components of seed yield, the number of pods per plant showed the most change in response to staking, followed by seed weight while number of seeds per pod remained unaffected. An extra dimension to the problem of unstaked yambeans is that their pods make direct contact with the ground and therefore are easily subject to termite attack since pod development and harvest coincide with the period of serious termite activities(from November to December). High risk of yield loss (up to 50 per cent) in unstaked yambeans is, therefore, likely, especially when harvest is delayed.

Nitrogen and phosphorus effects

The number of pods per plant increased as nitrogen rate increased from 0 to 50 kg N/ha and phosphorus from 0 to 40 kg P_2O_5/ha in both years (Table 3). The number of seeds per pod was also significantly increased by increasing phosphorus application from 0 to 40 kg P_2O_5/ha in 1990 and 0 to 20 kg P_20_5/ha in 1991. Beyond these phosphorus rates (40 and 20 kg P_20_5/ha), no significant changes occurred. Nitrogen fertilizer application did not significantly influence the number of seeds per pod in both years but increased seed weight when fertilizer rate was increased from 0 to 100 kg N/ha in 1991. Seed yield increased with increasing fertilizer rate from 0 to 50 kg N/ha and 0 to 40 kg P_20_5/ha after which reductions or no significant changes occurred (Table 3). Similar trends in yield responses to nitrogen (Ezedinma, 1965; Johnson & Evans, 1975; Ziska & Hall, 1982) and phosphorus (Tewari, 1965; Rhodes, 1981; Kang & Nangju, 1983) fertilization have been reported for cowpea. Above the 50 kg N/ha treatment, the number of pods, plant and seed yield dropped because the luxuriant vegetative growth that existed in those treatments (75 and 100 kg N/ha) was detrimental to pod development. Averaged over both years, seed yield at 50 kg N/ha was higher than the values obtained at 0, 25, 75 and 100 kg N/ha by 156, 78, 14 and 47 per cent, respectively. Similarly, seed yield at 40 kg P_2O_5/ha was higher than that at 0.20 and 80 kg P_2O_5/ha by 121,74 and 30 per cent, respectively.

Interactions between nitrogen and phosphorus significantly affected the number of pods per plant

TABLE 3

Main Effects of Nitrogen and Phosphorus on Yield and Yield Components of Yambean

Treatment	*Number of pods per plant*		*Number of seeds per plant*		*1000-seed weight (g)*		*Seed yield (kg/ha)*	
	1990	*1991*	*1990*	*1991*	*1990*	*1991*	*1990*	*1991*
Nitrogen rate (kg/ha)								
0	2.9	3.0	10.6	10.3	210.5	202.8	173.9	167.9
25	4.3	3.6	10.3	11.1	215.3	225.7	255.2	238.0
50	6.7	5.9	10.7	11.6	227.9	228.5	454.1	421.6
75	5.5	5.2	10.5	13.4	221.8	226.7	365.6	400.8
100	3.7	4.8	10.8	11.3	223.3	230.0	247.6	348.1
LSD (0.05)	1.1	1.1	NS	NS	NS	16.0	92.2	94.4
Phosphorus rate (kg P_2O_5/ha)								
0	3.1	3.6	9.1	10.2	216.4	214.6	163.1	210.2
20	4.5	4.6	10.6	12.2	220.9	228.4	234.9	240.3
40	5.8	5.4	11.6	11.8	225.4	228.0	418.5	406.7
80	5.1	4.6	10.9	11.9	216.3	219.9	331.7	303.3
LSD (0.05)	0.9	1.0	1.2	1.3	NS	NS	82.5	84.4

and seed yield in both years (Table 4). The number of pods per plant was maximum when fertilizer was applied at 50 kgN and 40 kg P_2O_5/ha and minimum when no fertilizer was applied. Similarly, seed yield was optimum at 50 kg N/ha and 40 kg P_2O_5/ha and minimum when no fertilizer was applied. The above findings clearly indicate that high seed yield in yambean would be achieved by application of 50 kg N/ha and 40 kg P_2O_5/ha. Greater benefits from nitrogen treatment was obtained when phosphorus was also applied, in line with the observations of Ezedinma (1961) for cowpea. The yambean variety (Nsukka Brown cultivar) used in this investigation apparently stores better than some other local varieties due probably to its relatively greater resistance to weevil infestations. This largely accounts for its popularity in the agriculture of some parts of eastern Nigeria, especially during famine periods (April to June). However, the yield obtained appeared low (optimum: 731 kg/ha in 1990 and 5 kg/ha in 1991) when compared with some results (National Academy of Science, 1979 and Madukife, 1991) from a germplasm collection at International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. In this collection, the most productive accessions gave yields of 1860 kg/ha and over 2000 kg/ha. The search for genetically high yielders that store well in the given agro-ecosystem would appear very necessary.

TABLE 4

Effect of Interaction of Nitrogen and Phosporus on the Number of Pods per Plant and Seed Yield of Yambean

Treatment kg N/ha × kg P_2O_5/ha	*Number of pods per plant*		*Seed yield (kg/ha)*	
	1990	*1991*	*1990*	*1991*
0 × 0	2.2	2.6	113.3	142.4
0 × 20	2.8	2.9	169.6	149.4
0 × 40	3.1	3.0	205.7	172.5
0 × 80	3.5	3.5	207.0	207.1
25 × 0	2.8	3.7	144.0	227.8
25 × 20	4.5	3.0	268.4	219.2
25 × 40	5.1	4.2	323.6	303.6
25 × 80	4.8	3.6	284.7	201.4
50 × 0	3.6	3.9	192.7	242.8
50 × 20	6.2	5.1	374.3	407.0
50 × 40	9.7	7.2	731.6	512.8
50 × 80	7.1	7.2	517.6	523.6
75 × 0	3.6	4.7	188.7	261.0
75 × 20	5.4	6.0	362.2	512.0
75 × 40	7.2	5.8	531.9	491.0
75 × 80	5.9	4.3	379.6	289.1
100 × 0	3.2	3.1	176.9	176.9
100 × 20	3.7	5.0	243.9	363.8
100 × 40	3.8	6.8	299.9	514.4
100 × 80	4.2	4.2	269.9	264.8
LSD (0.05)	2.1	2.2	184.4	188.8

REFERENCES

Chapman, T. (1965) Some investigations into factors limiting yields of the white Lisbon yam (*Dioscorea alata* L.) under Trinidad conditions. *Trop. Agric. Trin.* **42**, 145-151.

Coursey, D. C. (1967) *Yams*, London: Longmans, 203 pp.

Ezedinma, F. O. C. (1961) Research on cowpea (*Vigna* sp.) in Nigeria before 1960 (Memorandum No. 68), 31pp. Ibadan, Nigeria: Federal Deparment of Agriculture.

Ezedinma, F. O. C. (1965) Fertilizer placement for sole-crop cowpeas in southern Nigeria. *Exp. Agric.* **1**, 299-303.

Ezueh, M. I. (1984) African yambean as a crop in Nigeria. *Wld Crops* **39**, 199-200.

Graham, P. H. (1981) Some problems of nodulation and symbiotic nitrogen fixation in common beans (*Phaseolus vulgaris* L.): A review. *Field Crops Research* **4**, 93-112.

Gyansa-Ameyaw, C. E. & Doku, E. V. (1983) Effects of soil miosture stress on reproductive efficiency and yield of bambara groundnut. *Trop. Grain Legume Bull.* **28**, 23-29.

Johnson, W. A. & Evans, D. E. (1975) Nitrogen, phosphorus and potassium fertilization of southern peas for one-time harvest on a sandy soil. *J. Am. Soc. hort. Sci.* **100**, 216-263.

Kang, B. T. & Nangju, D. (1983) Phosphorus responses of cowpea (*V. unguiculata* L. Walp). *Trop. Grain Legume Bull.* **27**, 11-26.

Lyonga, S. N., Fayemi, A. A. & Agboola, A. A. (1973) Agro-nomic studies on edible yams (*Discorea* spp.) in the grassland plateau region of the United Republic of Cameroon. *3rd International Symposium on Tropi-*

cal Root Crops. Ibadan, Nigeria. 1973.

Madukife, S. (1991) *Biology and genetic variability in yambean* (MSc Thesis), Nigeria: Nsukka, University of Nigeria.

National Academy of Science (1979) *Tropical legumes: Resources for the future.* Washington D.C.: NAS.

Noda, H. & Kerr, W. E. (1983) The effects of staking and of infloresceme pruning on root production of yambean (*Pachyrhizus erosus* urban). *Trop. Grain Legume Bull.* **27**.

Okpara, D. A. & Omaliko, C. P. E. (in Press). Responses of African yambean to sowing date and plant density. *Indian J. Agric. Sci.*

Onwueme, I. C. (1978) *The tropical tuber crops.* New York: John Wiley and Sons Limited.

Peck, N. H. & MacDonald, G. E. (1984) Snap bean plant responses to nitrogen fertilization. *Agron. J.* **76**, 247-253.

Rhodes, E. R. (1981) The economics of fertilizing cowpea (*V. unguiculata*) with basic slag on an exisol in Njala and the effects of the fertilizer on leaf lamina N, P, Zn contents and nodulation. *Trop. Grain Legume Bull.* **22**, 6-10.

Tewari, C. P. (1965) Effects of nitrogen, phosphorus and potassium on nodulation of cowpea. *Exp. Agric.* **1**, 257-259.

Ziska, I. H. & Hall, A. E. (1982) Seed yields and water use of cowpeas (*V. unguiculata* (L.) Walp) subjected to planned water- deficit irrigation. *Irrig. Sci.* **3**, 237-246.