PRODUCTIVITY ENHANCEMENT OF BAMBARA GROUNDNUT (*Vigna subterranean* (L.) Verdc.) THROUGH SPRAYING WITH BRASSINOLIDE^R AT DIFFERENT PHENOLOGICAL STAGES IN CALABAR, NIGERIA

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Abstract

Two experiments were conducted in Calabar (4.5 – 5.2^0 N, 8.3^{0}E, about 39 m above sea level) to evaluate the effectiveness of Brassinolide^R plant hormone sprayed at different growth stages on the performance of Bambara groundnut (*Vigna subterranean* (L.) Verdc.) Under field and screenhouse conditions. Spraying was done at the seedling, vegetative and flowering growth stages which corresponded to 3, 6, and 9 WAS respectively, while the plants that were not sprayed constituted the control treatment. Results obtained showed that Brassinolide^R significantly (p = 0.05) influenced the yield parameters evaluated under both screenhouse and field conditions but the growth hormone was more effective in the screen house crop than in the field at the corresponding stages of spraying. Irrespective of where the crop was planted, plants sprayed at the seedling growth stage had the best yielded followed by those sprayed at the vegetative stage and at flowering, while the control plants showed the least performance. Spraying Bambara groundnut with Brassinolide^R at the seedling produced more pods, large seed size, high dry matter yield and high seed yield per hectare irrespective of the growth conditions. The highest seed yield of 1.92 t/ha and 1.80 t/ha was obtained in the screen house and field experiments respectively, giving a seed yield difference of 0.12 t/ha. The seed yield in the screen house and field was in the order: Seedling stage (1.92/1.80 t/ha) > vegetative stage (1.56/1.43 t/ha) > flowering stage (1.12/1.02 t/ha) > control (0.85/0.78 t/ha), respectively.

Introduction

Bambara groundnut also known as Bambara nut (*Vigna subterranea* (L.) Verdc.; *syn: Voandzeia subtermnea* Thousars) is an annual crop in the family *Fabaceae.*It is known by various local names as 'Ntoyo cibemba' in the Republic of Zambia, 'Nyimo' in Zimbabwe and 'Jugo' beans in South Africa. In Nigeria the crop has several names in the different tribes such as 'Epa-Roro', 'Okpa' and 'Kwaruru' or 'Gurjiya' in Yoruba, Ibo and Hausa languages, respectively (Bamshaiye *et al.,* 2011; Mahbudhi *et al*. 2013). The crop is a high quality food legume with high socioeconomic impact and consumption in the semi-arid Africa where it ranks third after groundnut *(Arachis hypogaea*) and *cowpea (Vigna unguiculata*) as the most important grain legume in the peasant production systems (Rowland, 1993).

Bambara groundnut is a pulse crop of immense potential in enhancing food security especially in drought prone agricultural systems where the environment is too harsh for crops like maize, groundnut and even sorghum to grow well (Ntundu *et al.,* 2006). The increasing food shortages experienced across Nigeria indicate that the production of the popular staples be stepped up and thehitherto neglected crops like bambara groundnut be accorded priority

research attention to enhance their productivity and ensure food security for all citizens particularly in the arid areas.

The cultivation of the crop is confined to the hot dry areas covering the Northern Guinea savanna and Sudan Savanna in northern Nigeria with commercial cultivation in Benue, Taraba, Adamawa, Nasarawa, and Niger states (Muhammad *et al*., 2020). The crop can also tolerate humid conditions if managed appropriately with effective growth stimulatorsto enhance its performance but such work has not been carried out in the humid agroecology.

Brassinolide^{R} micronutrient complex is a plant growth hormone manufactured as a foliar fertilizer. The effectiveness of plant growth hormones largely depends on the crop environment as well as the growth stage of the crop (Wareing, 1974). The growth stage to apply the foliar nutrient to maximize the effectiveness of the fertilizer for optimal crop performance is critical and needs to be determined accurately.The objective of this work was therefore to provide information on the best growth stage to apply Brassinolide^{R} for enhanced productivity of Bambara groundnut under field and screen house conditions in Calabar.

Materials and Methods

Experimental site

Screen house and field experiments on Bambara groundnut were conducted at the University of Calabar during the 2015 late cropping season (August - December). Calabar is located in the southeastern rainforest agro-ecological zone of Nigeria on Latitude 04° - 57'N and Longitude 08° - 19'E, 37 metersabove sea level. The area has a bimodal annual rainfall distribution that ranges from 3,000 - 3,500 mm with mean minimum and maximum temperatures of 27 °C and 35 °C, respectively and relative humidity of between 75 and 88 % (Effiong, 2011).

The Screenhouse Experiment

The screenhouse experiment was undertaken at the Department of Crop Science screen house, University of Calabar. Medium size plastic buckets with brim circumference of 96 cm wide, bottom circumference of 73cm and depth of 32 cm were used to plant Bambara groundnut seeds in the screen house. The buckets were perforated at the bottom and filled with 6.5 kg of top soil collected from the site of the field experiment, leaving about 5cm to the brim of the buckets.

Field Experiment

The field experiment was located at the Crop Science Research Farm behind the Faculty of Biological Sciences building. A total plot size measuring 14.0 m x 11.5 m (161 m^2) was used for the field experiment with unit plot size of 2 m x 3 m (6.0 m^2) with alley alleyways of 1 m wide. The site had been under intensive cultivation for some years and the vegetation as a mixture of grasses and broad leaf weeds. The predominant weeds observed during bush clearing included yellow nutsedge (C*yperus rotundus),* cover crop (*Calopogonium mucunoides),* purple nutsedge (*Cyperus esculentus), Tridax procumbens,* stubborn grass (*Eleusine indica*),*African marigold (Aspilia africana*),Sensitive plant(*Mimosa pudica),* Milk weed *(Europhobia heterophylla*),Broom weed (*Sida acuta*),Goat weed *(Ageratum conyzoides*), *and* Morning glory *(Ipomoea involucrata*), etc.

Land Preparation for Sowing

The vegetation in the area was manually cleared with machete and the debris packed. The land was then tilled manually using a spade after which three blocks were mapped out and unit plots within the blocks demarcated. Each block consisted of four unit plots separated by border of 1.0 m wide pathways. There were 16 experimental plots in all.

Sources of Experimental Materials

The experimental materials were seeds of a cream coloured Bambara groundnut landrace ('Black eye') which consistently had higher seed yield than other landraces in the experimental area. Seeds were obtained from the Department of Crop Science, Federal University of Agriculture Makurdi, Benue State, Nigeria. The micronutrient growth hormone used was a growth promoter, Brassinolide^{R} sourced from Japan. The nutrient complex contained Zinc, Manganese, Boron, Ferrum (Iron), Molybdenum and Copper.

Treatments and Experimental Design

There were four treatments comprising the control, where Brassinolide^{R} was not applied and spraying at different growth stages namely: spraying at the seedling, vegetative, and flowering stages which corresponding to 3, 6 and 9 weeks after sowing (WAS), respectively. Treatments were laid out in Randomized Complete Block Design and Completely Randomized (RCB) Design for the field and screen house experiments, respectively, and replicated three times.

Planting of Bambara Seeds

Clean and healthy seeds were planted at 30 cm x 30 cm spacing, two seeds per hole and later thinned to one plant per stand one week after emergence, giving plant population of 111,111 plants per hectare. Four tagged plants in the net plot at centre of each unit plot constituted the sample population. In the screen house experiment, two seeds were sown in each bucket and thinned to one per bucket one week after emergence. The buckets were watered adequately with twenty liters of water and left overnight before sowing the Bambara seeds the following day. A group of six buckets arranged in three rows of two buckets each constituted a unit plot in the screenhouse experiment and the middle row was used for sampling. Regular watering with twenty-five liters of water once a week, was carried out in the screenhouse to prevent moisture stress since the experiment was not exposed to natural rainfall.

Preparation and Application of Brassinolide^{R}

A solution of Brassinolide^{R} was prepared and applied according to the manufacturer's specification. A spray solution was made by dissolving 12.5g of the nutrient in 10 litres of clean tap water. Spraying of both field and screenhouse plants was done between 8 and 9 am each time using a Knapsack sprayer. Spraying was done in such a way that sprayed plants were completely drenched and the time of spraying was according to the recommendation of the manufacturer to have good result.

Weeding

First weeding was carried out at 2 WAS and subsequently weeding was done at two weeks interval in the screen house and field.

Data collection.
Data were collected on seed yield parametersand these were recorded at harvest. Six plants in the net plot in each replicate were tagged and used for data collection. The data collected was analyzed statistically using analysis of variance (ANOVA) and means were tested for significance using the Fisher-LSD at 5 % level.

Result and Discussion
The stage of spraying Brassinolide^{R} significantly ($p<0.05$) influenced all the yield parameters exceptnodule production and seed number per plant in both experiments (Table 1).Plants that were sprayed at the seedling stage (3WAS) were outstanding in all the parameters evaluated. Plants treated with the growth stimulator at the seedling growth stage grew more rapidly and attained early flowering and also produced more flowers than those in other treatments. Nodule count was similar in all treatments while more pods were also produced in plants sprayed at 3 WAS and delayed spraying at 6 WAS produced similar pods with the plants that were not sprayed. The number of seeds per pod was similar at all stages of spraying the growth hormone indicating that this parameter might be genetically determined. Values for seed size, seed length and seed weight were highest in plants treated with Brassinolide^{R} at 3 WAS after which decreased as the plants aged, and lowest values were recorded in the untreated plants.

Like other parameters, dry matter production was highest in plants sprayed at the young age of 3 WAS in both the screenhouse and field trials. The difference in the respective DM content of the plants were 1.19, 1.78 and 2.11 t/ha when the plants were sprayed at 6 and 9 WAS and in zero treatment plants, respectively. Similarly, the highest seed yield was recorded at 3 WAS after which the yield reduced by 0.34, 0.80 and 1.07 t/hain plants treated at 6 and 9 WAS and in untreated plants, respectively.

A comparism between the screenhouse and field experiments shows variation in the values of the parameters evaluated across the spraying stages with values obtained being higher at 3 WAS than other treatments in both experiments. Some parameters were better in the screenhouse plants while others were higher in the plants grown under field conditions. The values for pod number/plant, pod length and dry matter content were higher in the field while values for seed size and weight and seed yield per hectare were higher in the screenhouse.

The variation in crop performance under different environments is a clear indication that Brassinolide^{R} was more effective under protected conditions than in the open field where the crop was exposed to the vagaries of the weather. The enhanced effectiveness of the growth promoter in the screenhouse which was evidenced by the luxuriant growth of the screenhouse plants could be due to possible increased absorption of the plant hormone and the additional protection against inclement weather conditions enjoyed by the plants which further enhanced their growth and development which intandem with the previousobservations by (Sairam, 1994). The screenhouse environment probably also guaranteed effective protection against pests and diseases and other pathogens thereby providing favourable conditions necessary for rapid crop growth. These conditions were obviously lacking in the field experiment and this certainly limited crop performance under such conditions contrary to what was obtained in the

screenhouse experiment.

Spraying Bambara groundnut with Brassinolide[R] early at the seedling stage obviously afforded the plants enough time to utilize the nutrients more effectively than when the nutrients were provided at later growth stages. This probably explains why the plantssprayed early performed better than those in treatments that sprayed beyond the seedling stage and those that were not sprayed. Brassinolide[R]-induced plant growth has been reported to be associated with increased metabolic activities like the photosynthetic process (Sairam, 1994), protein synthesis and nucleic acid production (Sengupta *et al.,* 2011). The superior performance exhibited by early sprayed plants is an indication that young plants absorb and utilize growth hormones more effectively than old plants. Enhanced performance of crops treated with Brassinolide[R] at the early growth stage has been reported in other crops such as maize (Hola *et al.,* 2010), cucumber (Faridudin *et al*, 2011), sunflower (Kurepin, *et al.* 2012), mustard seed (Latha and Vardhini, 2016). Spraying Bambara groundnut with Brassinolide[R] at the seeding growth stage could be adopted for enhanced productively of the crop.

Table 1. Effect of spraying stages of Brassinolide (plant hormone) on flowering and yield parameters of Bambara groundnut *(Vigna subterranean* (L) Verdc.) Calabar, Nigeria

Treatments	D50% (days)	NF/P	NOD	NOP	SS (mm)	NSP	PL (mm)	SW/P (g)	DM (g)	SY (t/ha)
Screen house experiment										
Control (no spray)	50.60	3.6	5.20	3.00	8.20	1.00	12.54	2.93°	17.70	0.85 /
Spraying % 3wap	48.10	5.8	6.60	5.80	10.08	1.40	13.25	11.36	19.81	1.92
Spraying @ 6wap	49.20	3.2	4.60	4.50	8.56	1.40	12.80	6.18	18.62	1.58
Spraying @ 9wap	50.80	3.2	5.20	3.40	8.54	1.40	12.68	4.06	18.03	1.12
$LSD_{0.05}$	1.80	0.90	NS	1.42	1.47	NS	0.40	2.03	0.80	0.25
Field experiment										
Control (no spray)	59.80	4.40	7.20	4.00	8.22	1.00	12.44	4.82	33.36	0.78
Spraying @ 3wap	56.60	4.00	8.00	9.60	9.60	1.40	13.48	9.93	34.03	1.80
Spraying @ 6wap	58.60	4.40	7.60	6.90	8.34	1.20	13.20	7.24	33.75	1.43
Spraying @ 9wap	60.20	4.60	7.20	5.00	7.68	1.40	13.14	4.95	33.65	1.02
LSD 0.05	0.97	NS	NS	1.40	1.66	NS	0.23	2.16	0.50	0.20

Key:
D50% = days to 50 % flowering.NF/P = number of flower per plant, NOD = number of nodules per plant, NOP = number of pods per plant, PL = pod length, NSP = number seed per pod, SS = size of seed, SW/P = seed weight per plant, DW = dry matter yield SY = seed yield per hectare

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