PERFORMANCE OF GREEN BEANS (*Phaseolus vulgaris* L.) AS AFFECTED BY FRUIT SETTING HORMONES AND TIME OF APPLICATION IN MINNA, NIGERIA

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ABSTRACT

This study evaluated the performance of green beans (Phaseolus vulgaris L.) as affected by fruit setting hormones and time of application in Minna, Suthern guinea savanna Nigeria. The treatments were three levels of fruit setting hormones (Control, Cytokinin and Beta Naphth Oxy-acetic Acid (BNOA)) and four periods of application (seed priming for 8 hours + application at vegetative and flowering stage, application at vegetative and flowering stage only, application at flowering stage only and application at two weeks interval throughout the experiment). These were factorially H combined to give twelve treatments combinations which were arranged in a randomized complete block design with three replicates. Data were collected on growth, flowering and yield parameters. Data collected were subjected to analysis of variance using General Linear Model procedure of Minitab software. Differences between the means were separated using least significant difference (LSD) at 5% level of probability. The results revealed that seeds primed with cytokinin were the fastest to emerge while those primed with BNOA did not emerge. Plants that received BNOA at 2 weeks interval and plants that received Cytokinin both at vegetative + flowering stage had the longest vine, fattest stem and largest leaf area. Plants that received BNOA were the earliest to approach 50% flowering (33 days) compared to other treatments (34-40 days). Plants that received Cytokinin at two weeks interval throughout the experiment had the longest pod, fattest pod, heaviest fresh and dry pod weights as well as the highest number of pods per plant. Application of cytokinin at 2 weeks interval throughout the growth stages of green beans can therefore be recommended to improve the productivity of the crop.

Keywords: *Fruit setting hormone, time of application, Cytokinin, Beta Naphth Oxy-Acetic Acid, green beans*

INTRODUCTION

Green Bean (*Phaseolus vulgaris* L.) is an annual vegetable of the legume family (Fabaceae). Fabaceae ranks second in economic importance after the Poaceae family (Husham and Ali, 2020). They serve as major source of protein, minerals and vitamins for many households in Nigeria. *Phaseolus*is a large genus of annual plants that can be grown in many different climates (Savita, 2020). China is the world largest producer of green beans (14 million metric tons), followed by Indonesia (1.4 million metric tons) and Turkey (0.6 million metric tons) (FAOSTAT, 2021b). It is an important vegetable crop in Nigeria, providing a significant source of nutrition and income for farmers. Nigeria produced apparently 178,550 metric tons of green beans in 2020 (FAOSTAT, 2021a). It is predominantly grown in Jos, plateau state and in Kaduna states (Rashida *et al.*, 2022).

Fruit setting hormones (FSHs) are synthetic hormones that are applied to enhance fruit setting and yield in crops. They are also known as plant growth regulators (PGRs). They play an essential role in the development and ripening of fruit. There are several types of hormones involved in fruit setting, including auxins, cytokinins, gibberellins, abscisic acid and ethylene. Auxins play a crucial role in the early stages

of fruit development by controlling cell division and differentiation in the ovary (Huang *et al.,* 2020). Beta Naphth Oxy-Acetic Acid (BNOA) stimulates the growth of reproductive organs and promotes fruit development. Gibberellins are involved in the regulation of fruit size, shape, and quality (Pan *et al.,* 2020). Cytokinins are involved in the regulation of cell division and enlargement, and they play a critical role in determining fruit size and shape (Osorio *et al.,* 2020) .

Many crops experience sub-optimal yields and low fruit quality due to inadequate pollination, low fruit set and poor crop nutrition (De Silva *et al.,* 2022). Fruit yields can be constrained by the percentage of flowers that are pollinated and fertilized, the percentage of fruit that develop to maturity, and the mass of the fruit components that contribute to yield (Alcaraz & Hormaza, 2021). The final size of the remaining fruit that reach maturity can be affected by environmental conditions, crop nutrition and fruit paternity (De Silva *et al.,* 2022). Despite the potential of green beans, the average yield obtained by African farmers (1.48 tons/ha) is much lower than the potential yield (2.5-3 tons/ha) (Melkamu *et al.,* 2023). Low fruit setting have been identified as one of the major factor responsible for the poor yield in green beans (FAOSTAT, 2021a).

One approach to increase crop yield is the use of plant growth regulators such as fruit setting hormones (FSHs). Oloyede *et al.* (2021) investigated the effect of FSHs and planting dates on yield and yield components of two cowpea cultivars in southwest Nigeria. The author reported that application of FSHs at flowering stage significantly increased yield and yield components of the bean cultivars. Previous studies have suggested that fruit setting hormones such as gibberellins, auxins and cytokinins can enhance fruit set and yield in various crops like oil palm (Edison *et al.,* 2021), tomatoes (Satoshi, 2012; Yoshihito *et al.,* 2020), pear (Caixi *et al.,* 2008) etc. However, the effectiveness of these hormones may depend on the timing of their application. This study therefore aimed to evaluate the effect of FSHs at different time of application on the performance of green beans.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural Nursery, Federal University of Technology, (9.^{0}46.8' N, 6^{0}57.9' E) Minna, Niger State in the southern Guinea savanna of Nigeria under rain fed condition. The climate of Minna is sub humid with mean annual rainfall of about 1284 mm and a dry season of about 5 months duration occurring from November to March. The mean maximum temperature (about 33.5 ºC) remains high throughout the year (Adediran *et al.,* 2019)

The treatmentsconsisted of three levels of fruit setting hormones (control, Cytokinin (100ppm) and Beta Naphth Oxy-Acetic Acid (200ppm)) and four periods of application (seed priming for 8 hours + application at vegetative and flowering stage, application at vegetative and flowering stage only, application at flowering stage only and application at two weeks interval throughout the experiment). These were factorially combined to give twelve treatmentscombinations which were arranged in a randomized complete block design replicated three times.Net plot size was consisting2m x 2m (4m^2) consisting of three ridges, with 75 cm between rows. Inter and intra row spacing of 75cm x 40 cm was maintained by three seeds per hole which was later thinned to two plants per stand. Data were collected from five randomly tagged plants at six weeks after planting on vine length, stem diameter, leaf area, number of leaves, pod length, pod weight, pod diameter and number of pods/plant. Data collected were subjected to analysis of variance using General Linear Model procedure of Minitab software. Where significant interaction exists between hormone and time of application, tables of main effects are not presented. Differences between the means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

Vine length

The vine length was significantly affected ($P<0.01$) by hormone, time of application and interaction between the two (Table 1). Plants that received Cytokinin at vegetative + flowering stage had the longest vine (31.77 cm) and were at par with plants that received BNOA every two weeks throughout the

experiment (32.26 cm) and plants that received cytokinin every two weeks throughout the experiment (29.87 cm). The shortest vine was recorded from plants that received Cytokinin at priming + vegetative + flowering stages (23.56 cm) similar to the control plants (24.35 cm) (Table 2)

Table 1: Mean square values for response of green beans to fruit setting hormone and time of application

Source of variation	Vine Length (cm)	Stem Diameter (mm)	Leaf Area (cm^2)	Number of Leaves	Number of Branches
Hormone (H)	120.37**	0.08**	92.87*	46.06**	31.74**
Time of application (T)	162.39**	0.10**	2793.25**	64.00**	24.65**
H X T	262.39**	0.06**	1294.63**	123.65**	33.00**
SME ±	2.34	0.0002	26.87	3.43	0.34

*, **- significant at 5 and 1 percent probabilitylevel respectively

Table 2: Vine length (cm) of green beans as affected by fruit setting hormone and time of application

Hormone	Priming+ Vegetative + Flowering	Vegetative + Flowering	Flowering	Every two weeks
Control (no hormone)	24.35de	24.35cde	24.35de	24.35de
Cytokinin	23.56e	31.77a	24.28de	29.87ab
BNOA	0.00f	26.25cd	27.04c	32.26a
SE±		0.883		

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Stem diameter

The stem diameter was significantly (P<0.01) affected by hormone, time of application and interaction between the two (Table 1). The fattest stem was obtained in plants that received cytokinin at vegetative + flowering stages (0.59 mm). The least value (0.50 mm) was obtained in plants the received BNOA only at flowering similar to the control plants (0.51 mm). (Table 3)

Table 3: Stem diameter (mm) of Green beans as affected by fruit setting hormone and time of application

Hormone	Priming+ Vegetative + Flowering	Vegetative + Flowering	Flowering	Every two weeks
Control (no hormone)	0.51cd	0.51cd	0.51cd	0.51cd
Cytokinin	0.54b	0.59a	0.54b	0.50cd
BNOA	0.00e	0.54b	0.50d	0.54b
SE±	0.009			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Leaf area

The leaf area was significantly affected ($P \leq 0.01$) by the hormone, time of application and interaction between the two (Table 1). The highest leaf area was recorded in plants that received Cytokinin at vegetative + flowering stages (84.57 cm^2) which was at par with values obtained in plants that received BNOA every two weeks throughout the experiment (84.09 cm^2), and those that received BNOA at vegetative + flowering stages (76.53 cm^2). The least leaf area value was obtained in plants that received BNOA at flowering alone similar to the control plants (Table 4).

Table 4: Leaf area (cm^2) of green beans as affected by fruit setting hormone and time of application

Hormone	Priming + Vegetative + Flowering	Vegetative + Flowering	Flowering	Every two weeks
Control (no hormone)	49.57de	49.57de	49.57de	49.57de
Cytokinin	59.86bc	84.57a	46.47e	50.23de
BNOA	0.00f	76.53a	58.28bcd	84.09a
SE±	2.99			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Number of leaves

The number of leaves was significantly affected ($P \leq 0.01$) by the hormone, time of application and interaction between the two (Table 1). The interaction between hormone and time of application in respect of number of leaves is shown in Table 5. The highest number of leaves was recorded in plants that received BNOA at flowering stage only (20.87 leaves). This was statistically similar to the other treatments except those primed in the hormones and control plants which produced the least number of leaves (16.87) (Table 5).

Table 5: Number of leaves of green beans as affected by fruit setting hormone and time of application

Hormone	Priming + Vegetative + Flowering	Vegetative + Flowering	Flowering	Every two weeks
Control (no hormone)	16.87c	16.87c	16.87c	16.87c
Cytokinin	17.73bc	18.53abc	18.67abc	20.07ab
BNOA	0.00d	20.13ab	20.87a	19.20abc
SE±	1.07			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Table 6: Mean square values for response of green beans to fruit setting hormone and time of application

Source of variation	Pod Length (cm)	Pod Diameter (mm)	Fresh Pod Weight (g)	Dry Pod Weight (g)	Number of Pods
Hormone (H)	32.72**	0.15**	667.23**	100.26**	30.94**
Time of application (T)	33.63**	0.14**	54.14**	11.16	3.02
H X T	40.06**	0.18**	260.41**	29.63**	14.74**
SME ±	0.42	0.002	60.69	4.28	3.40

*,**- significant at 5 and 1 percent respectively

Pod length

Highly significant difference ($P \leq 0.01$) exists between the hormone, time of application and interaction between the two in respect of pod length (Table 6). The longest pod was recorded in plants that received cytokinin at two weeks intervals throughout the experiment similar to other treatment combination except those primmed in the hormone which had the shortest pod similar to control plants (Table 7).

Table 7: Pod length (cm) of green beans as affected by fruit setting hormone and time of application

Hormone	Priming + Vegetative + Flowering	Vegetative + Flowering	Flowering	Every two weeks
Control (no hormone)	11.05bc	11.05bc	11.05bc	11.05bc
Cytokinin	10.91c	12.01ab	11.96abc	12.67a
BNOA	0.00d	12.07ab	12.13ab	12.21a
SE±	0.372			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Pod diameter

The pod diameter was significantly (P<0.01) affected by response to hormone, time of application and interaction between the two (Table 6). Table 8 shows the interaction effect of hormone type and time of application on pod diameter. Plants whose seeds were primed in the hormone prior to sowing produced significantly slimmer pods than plants which received the hormones at vegetative, flowering and those who received at two weeks interval throughout the growth period (Table 8).

Table 8: Pod diameter (mm) of green beans as affected by fruit setting hormone and time of application

Hormone	Priming + vegetative + flowering	Vegetative + flowering	Flowering	Every two weeks
Control (no hormone)	0.77ab	0.77ab	0.77ab	0.77ab
Cytokinin	0.70b	0.82a	0.81a	0.83a
BNOA	0.00c	0.79a	0.84a	0.78a
SE±	0.027			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Fresh pod weight

Highly significant difference (P ≤ 0.01) exists between the hormone, time of application and interaction between the two in respect of fresh pod weight (Table 6). The interaction effect of hormone and time of application on fresh pod weight is presented in Table 9. The result shows that plant that received Cytokinin at two weeks interval throughout the experiment had the heaviest pod (33.33 g). This was similar to the values obtained in plants that received cytokinin at vegetative + flowering stage (25.24 g), at flowering stage alone (21.76 g), and plants that received BNOA at two weeks interval throughout the growth period (20.30 g). The least pod weight was recorded in plants that received BNOA at flowering only (11.27 g) similar to the control plant (15.67 g) (Table 9).

Table 9: Fresh pod weight (g) of green beans as affected by fruit setting hormone and time of application

Hormone	Priming + vegetative + flowering	Vegetative + flowering	Flowering	Every two weeks
Control (no hormone)	15.67bcd	15.67bcd	15.67bcd	15.67bcd
Cytokinin	11.46de	25.24abc	21.76abcd	33.33a
BNOA	0.00e	12.33cde	11.27de	20.30abcd
SE±	4.50			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

Number of pods/plant

Highly significant difference ($P \leq 0.01$) exists between the hormone, time of application and interaction between the two in respect of number of pod/plant (Table 6). The interaction between hormone and time of application in respect of number of pod per plant is presented in Table 10. The highest pods were recorded in plants that received Cytokinin at every two weeks throughout the experiment (8 pods/plant). This was at par with the number of pods recorded in other cytokinin treated plants except those whose seeds were primmed in the hormone prior to planting (3.40 pods/plant) and also similar to plants that received BNOA at two weeks interval throughout the experiment (5.83 pods/plant). The least pods/plant was recorded in plants that received BNOA at flowering stage only (2.87 pods/plant).

Table 10: Number of pods/plant of Green beans as affected by fruit setting hormone and time of application

Hormone	Priming + vegetative + flowering	Vegetative + flowering	Flowering	Every two weeks
Control (no hormone)	4.53bcd	4.53bcd	4.53bcd	4.53bcd
Cytokinin	3.40cd	5.73abcd	6.13abc	8.00a
BNOA	0.00e	4.10bcd	2.87de	5.83abcd
SE±	1.06			

Means followed by similar alphabets are not significantly different at P = 0.05 using DMRT

DISCUSSION

This study found that FSHs significantly affected the growth and yield of green beans. This is in agreement with the findings of Oloyede *et al*. (2021) who investigated the effect of FSHs and planting dates on yield and yield components of two cowpea cultivars in southwest Nigeria. The authors reported that the application of FSHs significantly increased the growth, number of pods and seeds per plant as well as the total seed yield of cowpea. The growth components (vine length, stem diameter, leaf area and number of leaves) were highest in plants that received Cytokinin at vegetative and flowering stages. This was followed by plants that received BNOA at vegetative and flowering stages had a higher growth component than the control (no hormone). Cytokinin increases cell division and enlargement. Osorio *et al*. (2020) similarly reported that cytokinins improved the development of tomato fruits resulting in larger fruits. Oloyede *et al*. (2021) reported that application of FSHs at flowering stage significantly increased yield and yield components of cowpea cultivars. Investigation on the effect of BNOA on the growth and yield of two cowpea cultivars in Nigeria by Adekiya *et al*., (2020) Shows that the application of BNOA significantly increased the plant height, number of branches, number of pods and seeds yield of the cowpea cultivars. These studies suggest that the application of fruit setting hormone at the appropriate time can significantly improve the performance of bean production in Nigeria. BNOA stimulates the growth of reproductive organs and promotes fruit development. Furthermore, Debi (2022) reported that foliar application of growth regulators and chemicals at the flowering stage may improve the physiological efficiency and may play a significant role in raising the productivity of crop. Wamiq *et al*., (2020) studied the effect of GA3 and NAA on yield of bottle gourd (*Lagenaria siceraria*) (MGH-4) and reported that application of 40 ppm gibberellin at 2, 4 leaf stage was found most effective in terms of number of female flowers per vine, fruit per plant, fruit yield per plant, fruit yield per hectare.

The yield components were higher in plants that received Cytokinin at every two weeks throughout the experiment. Zhang *et al*. (2021) reported that the application of cytokinin increased fruit set and yield in cowpea, while also improving the quality of the fruit. This was followed by plants that received BNOA at every two weeks throughout the experiment which had a higher yield component than the control (no hormone). This was in line with the study of Manish *et al*., (2020) who concluded that foliar application

of Ethrel at 300 ppm sprayed at different stages of growth i.e., at two true leaf stage, four true leaf stage and flower initiation stage was beneficial for higher seed yield and better growth of bottle gourd.

CONCLUSIONS AND RECOMMENDATION

The study revealed that hormones and time of application significantly influenced green beans growth and yield. Plants that received cytokinin at vegetative + flowering stages had the longest vine, fattest stem and largest leaf. Plants that received BNOA at flowering stage only had the highest number of leaves. Plants that received cytokinin at two weeks interval throughout the growth stageshad the longest pod, fattest pod, highest number of pods/plant as well as highest pod yield. Based on the result of this study, it is recommended that farmers should apply cytokinin at two weeks intervals for maximum pod yield.

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