Available online at http://www.ajol.info/index.php/njbas/index
Nigerian Journal of Basic and Applied Sciences (June, 2024), 32(1): 85-89
DOI: http://dx.doi.org/10.4314/njbas.v32i1.12

ISSN 0794-5698

Full Length Research Article

Growth and Yield Response of Soybeans (*Glycine max* (L.) Merr.) Upon Exposure to Gibberellic Acid Concentrations

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ABSTRACT

The aim of the study was to evaluate the response of soybeans exposed to gibberellic acid (GA_3) on the growth and yield of soybeans**.** Field experiments were conducted during the 2019 rainy season at the Botanical Garden of the Federal University of Lafia. Seeds were collected from AGRO TROPICS LTD Lafia, Nasarawa state. The Soybean variety was submerged in various concentrations of GA_3 90mg/m, 120mg/m, and 150mg/m respectively). The experiment was laid in a randomized completely block design (RCBD) with three replicates each and one control. Growth and yield parameters were measured. Results showed that GA_3 at different concentrations both in 1 and 2 hours of treatment increased the number of leaves (19.85), (24.23) at 90 mg/L and 120 mg/L in 1- and 2-hours exposure time respectively. In the same exposure time (1 hour), treatment 90mg/L increased the plant height (19.98cm) while in 2 hours exposure time, treatments 120 and 150mg/L increased the plant height. The leaf area, number of flowers, and number of seeds increased at 90mg/L at the same exposure time (1 hour) but this was so in the 2 hours concentration as leaf area and number of flowers increased at different treatments 150 mg/L,90mg/L respectively while the number of seeds increased 150 mg/L.

Keywords: Soybean, Gibberellic acid, Growth, Variety

INTRODUCTION

Soybean is a grain legume crop. As food and feed soybean plays an important role throughout the different countries of the world (Rahman *et al*., 2011). It provides oil as well as protein to the living beings. This very useful crop is grown in many countries but land coverage is highest in the United States of America. In Africa, soybean is still a minor and new crop continuously growing in average with 1.7 million ha harvested in 2013, particularly in Nigeria and South Africa (FAOSTAT, 2015). Soybean is a vital source of vegetable protein for food and animal feed worldwide. It is predicted to become a major crop in Africa (Sinclair *et al.,* 2014). Soybeans have a short growing season (less than four months) which allows poor farmers access to income. The soybeans' ability to serve as a cover crop when rotated with maize also provides poor farmers with a cheap alternative to synthetic fertilizers to improve soil fertility and productivity (Sinclair *et al.,* 2014; Gasparri *et al.,* 2016). Soybean *Glycine max* (L.) is the world's leading source of oil and protein. It has the highest protein content of all food crops and is second only to groundnut in terms of oil content among food legumes (Fekadu *et al*., 2009; Alghamdi, 2004).

Plant regulators are organic compounds that, in small amounts, somehow modify a given physiological plant process and rarely act alone, as the action of two or more of these compounds is necessary to produce a physiological effect (Solaimalai *et al*., 2001). Gibberellins (GAs) play an essential role in many aspects of plant growth and development, such as seed germination (Haba *et al.,* 1985); stem elongation, and flower development (Yamaguchi and Kamiya, 2000). Plant growth regulators are known to enhance and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit, and seed development, and ultimately enhancing the productivity of the crop. Growth regulators can improve the physiological efficiency including photosynthetic ability in the field crops (Kumar *et al*., 2001). The study aimed to evaluate the growth and yield response of Soybeans (*Glycine max* (L.) Merr.) upon exposure to Gibberellic Acid concentrations.

MATERIALS AND METHODS

Study Area

This study was carried out in the Botanical Garden of the Department of Plant Science and Biotechnology, Federal University Lafia, Nasarawa State. The study area falls within the Guinea Savanna Zone of North Central Nigeria. It lies between Latitude 80.33°N and Longitude 08.33 (NIMET, 2010).

Collection of Planting Materials

A variety of soybean (TGX 1835) was collected from AGRICTROPICS LTD, Lafia, Nasarawa State.

Soil Collection

The soil that was used, was collected from the Botanical Garden of Federal University Lafia, Nasarawa state. The soil was measured into the polythene bags (Planting bags). The bags were then placed at the research garden at a spacing of 60x30cm, as proposed by Okeleye *et al*. (1999). The soil was measured into 24 planting bags, 12 pots for 1-hour gibberellic acid exposure and another 12 pots for 2 hours gibberellic acid exposure time with three (3) replicates each. The poly pots were labeled with masking tape based on the different gibberellic acid concentrations.

Preparation of Plant Hormone Solution.
Three different Gibberellic acid concentrations were prepared on weight basis 90, 120, and 150 mg, respectively, and dissolved in 1 liter of distilled water while the control was just distilled water without any additive.

Sowing of Seeds
The seeds were sown directly into the soil. Planting was done in the evening just beyond the sunset following the method of Ikhajiagbe (2004). Seeds were sown at the rate of 3 per planting bag. Thereafter, constant irrigation was carried out morning and evening all through the experiment until full maturity and yield were attained.

Treatment of Seeds with GA3
The seeds were primed in the various GA3 concentrations viz: 90, 120 and 150mg/L for 1hr and 2hrs exposure time separately

Experimental Design
The experimental design chosen was the Randomized Complete Block Design (RCBD) following the assumption of homogeneity of the experimental plot in use. As a result, treatments were randomized over the whole plot. Each treatment consisted of 3 replicates. In order to avoid bias and misidentification, treatment bags were properly labelled according to a given treatment name and replicate number. Treatment bags were then randomized over the whole plot, each bearing an identification tag.

Parameters Considered
Plant was assessed for both vegetative and yield parameters like plant height, number of leaves, leaf area, number of flowers per plant, the weight of seeds, number of nodules per plant, dry weight of the plant, wet weight of plant, number of days to 50% maturity, number of seed per pod and the weight of 100 seeds (Mshelmbula *et al.,* 2012).

Data Analysis
Data was analyzed using One-way Analysis of Variance (ANOVA and the significant mean was separated using LSD.

RESULTS
Results showed that the highest number of leaves (19.85) was observed among the 90mg/L treatment at 1hr exposure time and was not significantly different from 120 and 150mg/L (Table 1). upon exposure to 2 h exposure time, the number of leaves was not significantly different from the other treatments except for 120 mg/L gibberellic acid concentration which had the highest number of leaves (24.23). No significant difference was observed in the plant heights of all treatments and control for 1hr and 2 h exposure time. Also, there were no significant differences in the girth size in all the treatments and control for both exposure times.

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Table 1: Effects of growth hormone treatments on some growth parameters of soybean variety at 12 weeks after planting (WAP)

TREATMENT (mg/m)	NUMBER OF LEAVES		PLANT HEIGHT		STEM GIRTH	
	1 Hour	2 Hours	1 Hour	2 Hours	1 Hour	2 Hours
Control	$19.31^{a} \pm 1.85$	$12.62^{a} \pm 2.50$	$19.04^{a} \pm 1.53$	$12.22^{a} \pm 2.22$	$0.87^{a} \pm 0.34$	$0.34^{a} \pm 0.08$
90	$19.85^{a} \pm 2.76$	$12.64^{a} \pm 2.61$	$19.98^{a} \pm 2.11$	$12.65^{a} \pm 2.19$	$0.53^{a} \pm 0.08$	$0.38^{a} \pm 0.09$
120	$12.65^{a} \pm 1.85$	$24.23^{b} \pm 3.74$	$17.76^{a} \pm 2.34$	$16.34^{a} \pm 1.91$	$0.65^{a} \pm 0.32$	$0.49^{a} \pm 0.09$
150	$13.74^{a} \pm 2.68$	$14.24^{ab} \pm 2.33$	$14.61^{a} \pm 2.38$	$16.75^{a} \pm 2.25$	$0.75^{a} \pm 0.38$	$0.36^{a} \pm 0.08$
p value	0.058	0.011	0.303	0.299	0.875	0.593

Values represent mean ± standard error of mean, n = 3. The mean values with the same superscripts are not statistically different ($p > 0.05$).

The seed weight at 1hr exposure time showed no significant difference among all the treatments and the control (Table 3). The highest seed weight (24.00 g) was observed in 120 mg/L at 2 h exposure time and was significantly different from others. So also, the dry weight of roots recorded no significant difference among all the treatments and the control in both 1hr and 2 h exposure time. The wet weights of roots among control and all other treatments for both 1hr and 2 h exposure times were not significantly different.

There was no significant difference in the number of nodules and number of days to 50% maturity between the control and all the treatments for both 1hr and 2 h exposure time (Table 4). Also, there was no significant difference in the number of days to full maturity in the control and all the treatments. The exception was in the 2 h exposure time where the treatments were significantly different from the control.

Table 2: Effects of growth hormone treatments on the leaf area, number of flowers and number of seeds of soybean variety at 12 weeks after planting (WAP)

TREATMENT	LEAVE AREA		NUMBER OF FLOWERS PER PLANT		NUMBER OF SEEDS PER PLANT	
	1 Hour	2 Hours	1 Hour	2 Hours	1 Hour	2 Hours
Control (mg/L)	$15.36^{ab} \pm 1.26$	$10.21^{a} \pm 1.88$	$2.69^{a} \pm 1.28$	$2.26^{a} \pm 1.61$	$6.67^{a} \pm 3.76$	$0.00^{a} \pm 0.00$
90	$19.29^{b} \pm 2.20$	$15.00^{a} \pm 2.92$	$3.92^{a} \pm 2.39$	$3.97^{a} \pm 1.95$	$11.33^{a} \pm 9.87$	$8.00^{a} \pm 4.93$
120	$11.65^{a} \pm 1.62$	$12.63^{a} \pm 1.71$	$2.38^{a} \pm 1.20$	$2.64^{a} \pm 1.64$	$8.00^{a} \pm 4.93$	$24.00^{a} \pm 15.87$
150	$11.04^{a} \pm 1.99$	$15.69^{a} \pm 2.26$	$2.95^{a} \pm 1.68$	$3.87^{a} \pm 2.09$	$5.33^{a} \pm 2.73$	$7.33^{a} \pm 3.84$
p value	0.005	0.299	0.928	0.88	0.904	0.31

Values represent mean ± standard error of mean, n = 3. The mean values with the same superscripts are not statistically different ($p > 0.05$).

Table 3: Effects of growth hormone treatments on the weight of 100 seeds, dry weight of the plant and wet weight of soybean variety at 12 weeks after planting (WAP)

TREATMENT	WEIGHT OF 100 SEED		DRY WEIGHT OF PLANT		WET WEIGHT OF PLANT	
	1 Hour	2 Hours	1 Hour	2 Hours	1 Hour	2 Hours
Control (mg/L)	$8.60^{a} \pm 4.55$	$0.00^{a} \pm 0.00$	$0.52^{a} \pm 0.52$	$0.00^{a} \pm 0.00$	$1.78^{a} \pm 0.98$	$0.00^{a} \pm 0.00$
90	$8.28^{a} \pm 4.33$	$10.10^{a} \pm 7.10$	$0.65^{a} \pm 0.33$	$0.42^{a} \pm 0.27$	$0.68^{a} \pm 0.56$	$1.86^{a} \pm 0.94$
120	$7.48^{a} \pm 3.77$	$5.63^{a} \pm 2.96$	$0.76^{a} \pm 0.76$	$1.45^{a} \pm 0.73$	$0.96^{a} \pm 0.96$	$3.63^{a} \pm 2.04$
150	$5.11^{a} \pm 3.32$	$10.80^{a} \pm 1.54$	$0.67^{a} \pm 0.48$	$1.06^{a} \pm 0.57$	$1.16^{a} \pm 0.62$	$2.01^{a} \pm 1.07$
p value	0.924	0.262	0.992	0.223	0.798	0.306

Values represent mean ± standard error of mean, n = 3. The mean values with the same superscripts are not statistically different ($p > 0.05$).

Table 4: The number of nodules, number of days to 50% maturity and number of days to full maturity under different treatments at 12 WAP

TREATMENT	NUMBER OF NODULES		NUMBER OF DAYS TO 50% MATURITY		NUMBER OF DAYS TO FULL MATURITY	
	1 Hour	2 Hours	1 Hour	2 Hours	1 Hour	2 Hours
Control (mg/L)	$3.00^{a} \pm 1.53$	$0.00^{a} \pm 0.00$	$52.67^{a} \pm 26.64$	$0.00^{a} \pm 0.00$	$60.67^{a} \pm 30.33$	$0.00^{a} \pm 0.00$
90	$3.67^{a} \pm 1.86$	$0.42^{a} \pm 0.27$	$52.67^{a} \pm 26.64$	$80.00^{a} \pm 4.16$	$59.00^{a} \pm 29.54$	$88.00^{a} \pm 3.00$
120	$2.33^{a} \pm 2.33$	$1.45^{a} \pm 0.73$	$26.33^{a} \pm 26.33$	$51.33^{a} \pm 25.83$	$27.33^{a} \pm 27.33$	$57.67^{a} \pm 28.95$
150	$4.33^{a} \pm 2.33$	$1.06^{a} \pm 0.57$	$50.00^{a} \pm 25.06$	$48.00^{a} \pm 24.00$	$57.67^{a} \pm 28.95$	$56.00^{a} \pm 28.02$
p value	0.908	0.223	0.867	0.07	0.824	0.079

Values represent mean ± standard error of mean, n = 3. The mean values with the same superscripts are not statistically different ($p > 0.05$).

Plate 1: Soyabeans seeds treated with GA3 at 4WAP

Plate 2: Flowering of soyabeans seeds treated with GA3 at 7WAP at 2 hours exposure time

DISCUSSION

The soybean variety treated with GA_3 at different exposure times expressed different responses depending on the parameter measured. For example, at 1hr exposure time, lower doses of the growth hormone (90mg/L) recorded a decrease in the number of leaves compared to other treatments (Table 1, Plates 1&2).). This is in concert with work done by Mshelmbula *et al*. (2021) who reported a decrease in the number of leaves in Cowpea with lower doses of GA_3. Also, it agrees with the finding of Mshelmbula *et al*. (2015) who reported that lower concentrations of IAA which is also a growth promoter reduced the number of Leaves of Sesame. On the other hand, soybean at an exposure time of 2 h had a different response with increased GA3 concentration where 120 mg/L triggered an increased number of leaves per plant. Findings by Kumar *et al.* (2014) revealed an increased number of leaves in tomato seeds treated with GA_3 at higher doses. Similarly, the same trend was observed in the plant heights of the soybean studied where a lower concentration of GA3 brought about an increase in plant height at 1hr exposure time. At 2 h exposure time, however, the reverse is the case. This finding corroborates with work done by Azizi *et al*. (2012) and Mshelmbula *et al*. (2021) who both reported an increase in plant height of soybeans when exposed to lower doses. There was no significant difference in the stem girth across all treatments of the two-exposure time but it disagrees with Azizi *et al*. (2012) who reported that Foliar application of GA_3 led to an increase in the stem girth of soybeans.

The leaf area of the treatment 90 concentration had the highest leaf area (19.29 cm^2). However, there was no significant difference for 2 hours of exposure in their leaf area (Table 2). This finding agrees with Emongor, (2007); Sarkar *et al*. (2002), and Mshelmbula *et al*. (2021) who worked on cowpeas reported similar results in which lower concentrations of GA3 drastically increased the leaf area. There was no significant difference in the number of flowers at different exposure times to the gibberellic acid solutions (Table 2). This result does not agree with the findings of Sarkar *et al*., (2002) who reported an increased number of flowers in soybeans with increased doses of GA_3. This finding also correlates with Rahman *et al*. (2015) who reported that there was an increase in the number of flowers of tomatoes treated with 4-CPA + GA3 as the concentration increased. There was no significant difference observed between the control and all the treatments in 1 hour in regards to the amount of seeds/plant. However, there was a significant difference in 2 hours exposure time between the number of seeds of control and all the treatments. This quite agrees with the findings of Sarkar *et al*. (2002) who observed that GA_3 increases the number of seeds per plant for 2 hours exposure time but disagrees with the findings in 1 hour exposure time.

The weight of seeds for 1 hour exposure time had no significant difference between the treatments and control. The highest weight of seed was (24.00g) upon exposure to 120mg/L for 2 hours exposure time and was significantly different from other treatments (Table 3). Sarkar *et al*. (2002) reported that GA_3 had a regulatory effect on the enhanced weight of seeds of soybeans; his findings hence agree with the 2 hours exposure time in this study but disagree with 1 hour exposure time. Moreover, the treatments and control were statistically similar in 1 hour exposure time of dry weight of root. There was no significant difference between the treatments for 2 hours exposure time and does not agree with 1 hour exposure time. This result does not agree with the findings of Sharma *et al*. (1988) who reported that *Menthacitrate* indicated that GA_3 increased the dry weight per plant. Furthermore, this finding disagrees with Emongor (2002) who reported that increased Ga4+7 concentration significantly reduced 100 seed weight of cowpea; but agrees with Mohammed and Ismail (2018) and Emongor (2007) who reported that an increase in GA3 brought about increase in the dry weight of groundnut and cowpea respectfully.

The effect of GA_3 on the wet weight of the plant between control and all the treatments of both 1 hour and 2 hours of exposure time is not significantly different. This result does not agree with the findings of Sharma *et al*, (1988) who reported that *Menthacitrate* indicated GA_3 increased the wet weight per plant but agrees with Mshelmbula *et al*. (2021) who worked on cowpea opined that an increase in GA_3 concentration triggered an increase in a wet weight of different accessions of cowpea.

There was no significant difference observed in both 1 hour and 2 hours exposure time. There was no significant difference between the control and all the treatments of both 1 hour and 2 hours exposure time at 50% days to maturity and the number of root nodules (Table 4). Also, the number of days to full maturity of 1 hour exposure time had no significant difference between the control and all the treatments. However, the treatments were significantly different from the control in 2 hours of exposure time which is in agreement with work done by Mshelmbula *et al*. (2021) on cowpea.

CONCLUSION

At the end of this study, it was observed that GA3 had a significant impact on important growth characteristics with 90 concentrations having the highest number of leaves, height, leaf area, number of flowers, number of seeds, and weight of seeds on exposure to 1h exposure time while for 2hrs exposure time, 120 and 150 concentrations had highest number of leaves, height, stem girth, number of flowers, weight of seeds, number of seeds, dry wet of plant and wet weight of seeds.

Acknowledgments

I wish to acknowledge the following people: Dr. Beckley Ikhajiagbe and Prof Mensah for their input and guidance.

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