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Influence of plant growth regulators on morphological and physiological parameters of groundnut (*Arachis hypogaea* L.) cv. GJG-9

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Abstract
A field experiment was conducted during the *kharif* 2017 at Cotton Research Station, Junagadh Agricultural University, Junagadh to study the effects of different plant growth regulators on morphological and physiological parameters of groundnut cv. GJG-9. The investigation was carried out in RBD design three replications and foliar application of different concentration of growth regulators such as GA_3 (50, 100 ppm), NAA (40, 80 ppm), TRIA (2.5, 5.0 ppm), BR (10, 15 ppm) and water spray (control) at 40 & 55 DAS. The experiment results revealed that foliar application of PGRs increased the plant height, no. of primary branches, no. of leaves and increase was more in GA_3 @ 100 ppm treated plants. Among different treatments, significantly higher LAI (3.71), CGR (24.43 g m^{-2} day^{-1}) and RGR (0.049 g g^{-1} day^{-1}) were observed in GA_3 @ 100 ppm treated plants at 70 DAS as compared to control.

Keywords: BR, CGR, GA_3, LAI, RGR

Introduction
Groundnut is a rich source of edible oil (47-54%), high quality protein (22-30%), starch (6-24%), cellulose (1-2%), minerals (2-3%) and calories (5-6%). It has a distinct position among the oilseeds, as it can be consumed and utilized in diverse ways. Groundnut is commercially cultivated over 100 countries in an area of 26.4 million hectares with a production of 37.1 million metric tons and an average productivity of 1.4 metric tons/ha. The total groundnut production in India during the year 2017 was 7.07 million tons from 4.15 million hectares area with an average productivity 1.70 metric tons/ha. Groundnut is the major oilseed crop of Gujarat with 2.79 million hectare area and 3.05 million tons of production with 1.87 metric tons/ha productivity (Anon, 2017) [1].

The performance of a plant depends not only on the environment, where it is grown but also on the efficiency of the metabolic processes within the plant. It is well known fact that endogenous growth substances play a vital role in regulation of plant metabolism. It has been the endeavour of crop physiology to influence crop growth and production by the exogenous application of the growth regulators.

Several growth regulators differ in regulating plant growth. NAA, an auxin, is known to influence the growth and development of different crops by promoting cell division. Plants treated with GA_3 grow taller as it enhances cell elongation. Triacontanol, a plant growth stimulant, induce plant growth and dry matter accumulation by water incorporation *via* hydrolysis, hydration and oxidation reactions. Brassinosteroids are a new addition to the group of PGRs and have emerged as the sixth group of phytohormones with significant growth promoting activity and they influence varied physiological processes like growth, germination of seeds, senescence (Clouse and Sasse, 1998) [4].

The intent of the present study is to evaluate different morphological and physiological parameters contributory to yield as affected by different growth regulators.

Materials and Methods
The present investigation was conducted at Cotton Research Station, JAU, Junagadh during *kharif* season of 2017. The soil of the experimental plot was clayey in texture and medium black in reaction with pH 7.99 and EC 0.42 dS/m. The soil has available nitrogen (301 N kg/ha) and available phosphorus (34.26 P_2O_5 kg/ha) while available potash (660 K_2O kg/ha). The experiment constituted of 10 treatment combinations were laid out in RBD design with three replications. Solutions of GA_3 (50, 100 ppm), NAA (40, 80 ppm), TRIA (2.5, 5.0 ppm), BR (10, 15 ppm) were prepared and sprayed on the foliage of plants at 40 & 55 DAS with the help of hand sprayer as per treatment while in untreated control distilled water was sprayed.

The crop was fertilized with a uniform dose of nitrogen and phosphorus at the rate of 12.5 kg and 25 kg ha^{-1}, respectively.

Morphological parameters: Plant height, no. of primary branches and no. of leaves per plant were counted from the selected five plants in each treatment from all replications at 50, 70 & 90 DAS.

Physiological parameters

Leaf area index: The leaf area index was calculated by dividing the total leaf area with the corresponding ground area as suggested by Watson (1952) [13] at 50, 70 & 90 DAS.

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Ground area}}$$

Crop growth rate (CGR): By using the total dry matter of the plant, CGR was calculated by using the formula given by Watson (1952) [13] at 50, 70 & 90 DAS and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,
W_1 = Dry weight of the plant (g) at time t_1
W_2 = Dry weight of the plant (g) at time t_2
$t_2 - t_1$ = Time interval in days
A = Land area (m^2)

Relative growth rate (RGR, g g^{-1} day^{-1}): It is the rate of increase in the dry weight per unit dry weight already present and is expressed as g g^{-1} day^{-1} (Blackman, 1919) [3]. Relative growth rate at 50, 70 & 90 DAS was calculated as follows

$$RGR = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$$

Where,
W_1 = Dry weight of plant (g) at time t_1
W_2 = Dry weight of plant (g) at time t_2
$t_2 - t_1$ = Time interval in days
Loge = Natural logarithm

Statistical analysis: The data were analyzed by method of analysis of variance obtained by Panse and Sukhatme (1984) [8]. Significance was tested by "F" value at 5 percent level of probability. Critical differences were worked out for the effects which are significant.

Results and Discussion

Morphological parameters

Plant height (cm): The data summarized in Table 1 showed that the plant height influenced significantly with the different growth regulator treatments at 50, 70 and 90 DAS. The plant height was found significantly higher in treatment T_2 (46.94 cm), which was followed by T_7 (45.22 cm), T_1 (44.97 cm), T_8 (44.95 cm), while control T_{10} (38.99 cm) was recorded the lowest plant height. The promotion of growth in terms of increase in plant height has been thought to be by altering the plasticity of the cell wall. Plasticity changes are mainly contributed by the hydrolysis of starch to sugars which lowers the water potential of cell, resulting in the entry of water into the cell causing elongation. These osmotic driven responses under the influence of GA might have attributed for an increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in growing portion. Similarly increase in plant height was observed in groundnut by Gardner (1988) [6] and Reddy (1984) [10]. The promotive effect of NAA and GA_3 in increasing plant height was attributed to the increased meristematic activity (cell division and cell elongation at the stem apex) by the exogenous application of GA_3 and NAA (Tagawa and Bonner, 1957) [11].

Number of primary branches per plant: The data regarding the effect of different treatments on number of primary branches per plant of groundnut recorded at 50, 70 and 90 DAS are presented in Table 1. No. of primary branches per plant was found higher in GA_3 (5.90) in comparison of control (4.80). An increase in number of branches could be due to inhibition in the auxin activity in the plant due to the application of GA_3. These treatments might have resulted in inhibition of apical bud dominance, thereby diverting the polar transport of auxins towards the basal nodes leading to breaking of lateral bud dormancy and increased branching. Similarly increase in no. of branches was observed in groundnut by Khatun *et al.* (2016) [7].

Table 1: Effect of growth regulators on plant height (cm), no. of primary branches and no. of leaves per plant of groundnut cv. GJG-9

Treatments		Plant height (cm)				No. of primary branches per plant				No. of leaves per plant			
		50 DAS	70 DAS	90 DAS	Mean	50 DAS	70 DAS	90 DAS	Mean	50 DAS	70 DAS	90 DAS	Mean
T_1	GA_3 @ 50 ppm	25.29	34.80	44.97	5.47	5.60	5.70	5.59	57.00	106.23	73.30	78.84	78.84
T_2	GA_3 @ 100 ppm	26.42	36.40	46.94	5.73	5.80	5.90	5.81	55.67	111.07	72.64	79.79	79.79
T_3	NAA @ 40 ppm	22.57	32.15	42.01	5.00	5.13	5.13	5.09	47.67	97.23	62.97	69.29	69.29
T_4	NAA @ 80 ppm	22.60	32.64	42.03	5.00	5.06	5.13	5.06	46.33	97.68	56.64	66.88	66.88
T_5	TRIA @ 2.5 ppm	25.49	34.19	44.73	5.26	5.26	5.26	5.26	48.33	99.08	62.30	69.90	69.90
T_6	TRIA @ 5.0 ppm	24.95	33.57	44.57	5.13	5.20	5.20	5.18	48.67	98.57	59.64	68.96	68.96
T_7	BR @ 10 ppm	25.92	34.78	45.22	5.17	5.33	5.37	5.29	52.33	105.23	67.30	74.95	74.95
T_8	BR @ 15 ppm	25.85	34.69	44.95	5.27	5.40	5.40	5.36	51.67	104.24	66.64	74.18	74.18
T_9	Water spray	20.14	30.32	39.22	4.73	4.80	4.80	4.78	30.33	84.24	46.64	53.74	53.74
T_{10}	Control	19.35	30.03	38.99	4.53	4.60	4.80	4.64	32.00	80.24	43.64	51.96	51.96
S.Em.±		1.19	1.25	1.62	1.35	0.19	0.22	0.22	0.21	2.88	4.01	3.46	3.45
C.D. at 5%		3.53	3.71	4.80	4.01	0.56	0.66	0.64	0.62	8.56	11.91	10.27	10.25
C.V. %		8.62	6.48	6.45	7.18	6.37	7.42	7.11	6.97	10.61	7.06	9.79	9.15

Number of leaves per plant: A perusal of data in Table 1 revealed that different growth regulator treatments showed their significant effect on no. of leaves per plant at 50, 70 and 90 DAS. Over all experimental result showed that no. of leaves was found higher in treatment T_2 (111.07) at 70 DAS. The no. of leaves were increased up to pod development phase and decreased during harvest. Leaves are the essential source from which the photosynthates are channelled to the sink. During pod development phase leaves provides nutrition to pods due to more no. of leaves contribute to higher pod yield. Reddy (1984) [10] observed an increase of 40-50 percent in leaf number and 13-17 per cent in LAI by the application of GA_3 at 10 and 50 ppm concentrations and also Gardner (1988) [6] reported that a 28 percent increase in leaf number and leaf area due to application of GA_3 in groundnut.

Physiological parameters

Leaf area index: Scrutiny of data in Table 2 revealed that the leaf area index influenced significantly with the different growth regulator treatments at 50, 70 and 90 DAS. In compared with control significantly the higher LAI observed in treatment T_2 (3.71) at 70 DAS. Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. The LAI was found a typical sigmoidal pattern with an initial slow increased in leaf area followed by a steep rise. The leaf area index (LAI) increased up to 70 DAS and decreased thereafter due to senescence and ageing of leaves. However, plant growth regulators maintained a higher leaf area at later stage (90 DAS) of the crop growth. Similarly increase in leaf area index was observed by Upadhyay and Ranjan (2015) [12] and Gardner (1988) [6].

Crop growth rate (CGR): A perusal of data in Table 2 revealed that different growth regulator treatments showed their significant effect on crop growth rate during 30-50 DAS, 50-70 DAS and 70-90 DAS. The CGR was found significantly higher in treatment T_2 (24.43 g m^{-2} day^{-1}), in comparison of control T_{10} (16.89 g m^{-2} day^{-1}) at 70 DAS. Crop growth rate (CGR) is used as a character for estimating production efficiency of crop stand, which is influenced by LAI, photosynthetic rate and leaf angle and is an index of amount of light interception. Crop growth increased at pick period 70 DAS there after crop growth was shown steady due to transport of photosynthate towards the pod during pod development phase and pod maturity phase started. Ramesh *et al*. (2013) [9] reported that CGR was observed to increase significantly as compared to control.

Relative growth rate (RGR, g g^{-1} day^{-1}): A perusal of data in Table 2 revealed that different growth regulator treatments showed their significant effect on relative growth rate during 30-50 DAS, 50-70 DAS and 70-90 DAS. Significantly the higher RGR was observed in treatment T_2 (0.0341 g g^{-1} day^{-1}) as compared to control (0.0296 g g^{-1} day^{-1}). RGR represents the increase in dry matter per unit dry matter already present per unit time. The increase in the RGR due to the application of growth regulators might be due to increase in photosynthetic efficiency by increasing leaf thickness, retaining more chlorophyll content and efficient translocation of photosynthates. All the treatments differ significantly for RGR values and showed the highest RGR at 30-50 DAS, which declined after 50-70 DAS. All the treatments showed maximum RGR before pod setting and declined during pod filling period. The decline in RGR during later growth phase in groundnut was reported by Bharud and Pawar (2005) [2] and Deshamukh (1986) [5].

Table 2: Effect of growth regulators on LAI, CGR and RGR of groundnut cv. GJG-9

Treatments		LAI				CGR(g m^{-2} day^{-1})				RGR (g g^{-1} day^{-1})			
		50 DAS	70 DAS	90 DAS	Mean	30-50 DAS	50-70 DAS	70-90 DAS	Mean	30-50 DAS	50-70 DAS	70-90 DAS	Mean
T_1	GA_3 @ 50 ppm	2.60	3.50	2.52	2.87	10.51	22.05	8.02	13.52	0.045	0.039	0.0112	0.0317
T_2	GA_3 @ 100 ppm	2.67	3.71	2.36	2.91	11.80	24.43	6.25	14.16	0.048	0.049	0.0054	0.0341
T_3	NAA @ 40 ppm	2.32	3.22	2.07	2.54	8.81	21.79	5.57	12.05	0.040	0.044	0.0082	0.0307
T_4	NAA @ 80 ppm	2.34	3.23	2.15	2.57	8.22	22.74	5.26	12.07	0.037	0.045	0.0064	0.0295
T_5	TRIA @ 2.5 ppm	2.33	3.26	2.17	2.59	9.82	20.52	4.08	11.48	0.044	0.038	0.0033	0.0284
T_6	TRIA @ 5.0 ppm	2.54	3.26	2.28	2.69	10.38	20.82	4.77	11.99	0.050	0.040	0.0059	0.0320
T_7	BR @ 10 ppm	2.61	3.34	2.21	2.72	10.55	21.19	6.25	12.66	0.045	0.037	0.0095	0.0305
T_8	BR @ 15 ppm	2.58	3.45	2.35	2.79	10.80	21.82	6.97	13.20	0.047	0.039	0.0095	0.0318
T_9	Water spray	2.22	2.88	1.64	2.25	6.79	17.28	5.94	10.01	0.035	0.044	0.0103	0.0298
T_{10}	Control	2.20	2.80	1.60	2.20	6.81	16.89	5.51	9.74	0.036	0.044	0.0087	0.0296
S.Em.±		1.19	0.11	0.15	0.10	0.57	1.48	0.44	0.83	0.003	0.002	0.001	0.0020
C.D. at 5%		3.53	0.32	0.45	0.31	1.69	4.38	1.32	2.47	0.009	0.007	0.002	0.0060
C.V. %		8.62	7.54	8.04	8.46	10.42	12.20	13.10	11.93	12.59	10.10	13.15	11.94

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