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Chaudhari MS
Main Oil Seed Research Station, JAU, Junagadh, Gujarat, India

Kataria GK
Cotton Research Station, JAU, Junagadh, Gujarat, India

Chandrakant Singh
Wheat Research Station, JAU, Junagadh, Gujarat, India

Bhut JB
Main Oil Seed Research Station, JAU, Junagadh, Gujarat, India

Akbari VR
Main Oil Seed Research Station, JAU, Junagadh, Gujarat, India

Kaluskar SA
Department of GPB, COA, JAU, Junagadh, Gujarat, India

Corresponding Author:
Chandrakant Singh
Wheat Research Station, JAU, Junagadh, Gujarat, India

Response of different plant growth regulators on dry matter accumulation and morpho-physiological parameters of bunch groundnut (*Arachis hypogaea* L.) cv. TG-37A

Chaudhari MS, Kataria GK, Chandrakant Singh, Bhut JB, Akbari VR, and Kaluskar SA

Abstract

An investigation entitled “Effects of plant growth regulators on dry matter production and morpho-physiological parameters of bunch groundnut cv. TG-37A” was carried out at farm of Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, during *kharif* 2020. The experiment was arranged in randomized block design and replicated thrice consisting of eleven treatments of NAA @ 200 & 500 ppm at 70 & 90 DAS, SA @ 500 & 1000 ppm at 70 & 90 DAS, MC @ 150 & 250 ppm at 70 & 90 DAS, CCC @ 5000 ppm at 70 & 90 DAS, CCC @ 10,000 ppm at 90 DAS, PBZ @ 250 & 350 ppm at 70 & 90 DAS and control (water spray) at 70 & 90 DAS. The experiment's findings showed that foliar applications of NAA, SA, MC, CCC, and PBZ at various concentrations increased the production of dry leaf, stem, and root weights as well as total dry matter, with NAA @ 500 ppm treated plants producing more of these dry leaf, stem, and root weights. The leaf area index (LAI) recorded significantly higher in NAA @ 500 ppm at 80 DAS and decreased thereafter due to senescence and ageing of leaves. Significantly the highest mean of LAI observed in NAA @ 500 ppm treatment. Crop growth rate (CGR), which is governed by LAI, photosynthetic rate, and leaf angle and is a measure of quantity of light interception, is utilized as a parameter for measuring production efficiency of crop stands. Finally, it can be concluded that the best concentration of NAA to increase the greatest mean of LA, LAI, LAD, CGR, AGR, and RGR of groundnut is to spray plants with NAA @ 500 ppm at 70 and 90 DAS.

Keywords: AGR, CCC, foliar spray, groundnut, LAI, NAA, PBZ, total dry matter

Introduction

Groundnut is referred to by its botanical name, *Arachis hypogea* (L.). The chromosomal number 2n=40 and gene family Arachis of groundnut are both members of the Leguminosae. The phrase "Arachis hypogea," which describes how pods grow in the soil, is derived from the Greek words "Arachis," which means legumes, and "hypogea," which denotes the earth. The plant is a day-neutral one, and the blooms self-pollinate. One of the most significant field legumes in India is groundnut. Due to its wide range of uses in both home and industrial settings, this oil seed crop is significant to the agricultural economy of the nation. India, China, the United States, Brazil, Senegal, and West Africa are the world's top groundnut producers. India comes in behind China in terms of groundnut output. The total groundnut production in India during the year 2022 was 101.50 lakh tones from 53.67 lakh hectares area with an average productivity 1906 kg/ha. Gujarat's main oilseed crop, groundnut, with a production volume of 44.90 lakh tons and a production area of 19.88 lakh hectares with a productivity of 2259 kg/ha (Anon., 2022) [1]. Given the significance of groundnuts from a nutritional and production perspective, it is imperative to explore growing groundnuts with the goal of increasing productivity. Crop productivity may be increased with the use of physiological methods by organizing plant processes to create dry matter and dividing their main quantities of effective yield-contributing elements. The usage of plant growth regulators (PGRs) can increase crop production for a variety of crops. Groundnut growth characteristics and production may be significantly altered by naphthalene acetic acid (NAA), a chemical that promotes growth. Growth and the generation of dry matter are positively impacted by NAA. According to Raoofi *et al*. (2014) [13], it is essential for fruit setting, blooming, cell elongation, cell division, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, and leaf and fruit abscission.

According to Rademacher and Brahm (2010) [12], chlorocholine chloride (CCC) is an inhibitor of gibberellin biosynthesis and is involved in preventing the cyclization of geranyl-geranyl pyrophosphate into copyallyl pyrophosphate. The physiological performance in a particular environment, such as the partitioning of dry matter to the economic output, will show some of the characteristics that are primarily responsible for raising yield.

Materials and Methods

A field test using bunch groundnut cv. TG-37A was conducted in the kharif season of 2020 at the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat. By a randomized block design in three replications, seeds were sown in rows that were 45 cm apart with a plant to plant spacing of 10 cm. To raise a strong and healthy crop, the suggested practice packages were followed. The treatments *viz*., foliar spray of NAA @ 200 & 500 ppm at 70 & 90 DAS, SA @ 500 & 1000 ppm at 70 & 90 DAS, MC @ 150 & 250 ppm at 70 & 90 DAS, CCC @ 5000 ppm at 70 & 90 DAS, CCC @ 10,000 ppm at 90 DAS, PBZ @ 250 & 350 ppm at 70 & 90 DAS and control (water spray) at 70 & 90 DAS. The physiological characters *viz*., leaf dry weight, stem dry weight, root dry weight and total dry matter production (TDMP) were recorded at 80, 100 and 120 DAS. The various plant components were picked and dried in a hot air oven at 80 °C until they reached a consistent weight in order to determine the TDMP. By using the methods outlined by Watson (1952) [19], Williams (1946) [20], and Power *et al*. (1967) [10], respectively, growth characteristics such as leaf area (cm2/plant), leaf area index (LAI), crop growth rate (CGR), absolute growth rate (AGR), relative growth rate (RGR), and leaf area duration (LAD) were calculated. The least significant difference was computed after the data were statistically examined using the 'F' test (Panse and Sukhatme, 1984) [8].

Result and Discussion

Dry matter accumulation and partioning

Dry matter is the byproduct of assimilations from source organs via a transport pathway to the sink organs. It has been demonstrated that an essential metric that quantitatively indicates an organ's ability to act as a sink is its prospective growth rate and capacity to accumulate assimilates. Table 1 shows how different plant growth regulators affect the physiological characteristics of groundnuts. The findings showed that the physiological characteristics of bunch groundnut, such as leaf dry weight, stem dry weight, root dry weight, and total dry matter production (TDMP), were considerably impacted by the administration of greater concentrations of plant growth regulators. The treatment T2 (NAA @ 500 ppm) had the considerably largest dry leaf weight (4.12 g plant^{-1}), whereas the treatment T7 had the lowest dry leaf weight (2.0 g plant^{-1}).

The treatment with the greatest dry weight of stem was NAA @ 500 ppm (T2), which was statistically comparable to treatments T1, T3, T4, T8, and T11, whereas the treatment with the lowest dry weight of stem was T7 (3.31 g plant^{-1}). The findings show decreasing trends in stem dry weight as a plant matures as a result of the growth regulator treatments considerably partitioning the total dry matter of the stem in reproductive sections of the plant (Faldu *et al*., 2018) [2]. When compared statistically to treatments T1 and T4, treatment T2 (NAA @ 500 ppm) had the significantly largest dry weight of root (4.36 g plant^{-1}), whereas treatment T7 had the lowest (2.95 g plant^{-1}).

Data from Table 2 demonstrated that at 80, 100, and 120 DAS, various plant growth regulator treatments significantly affected the total amount of dry matter produced by each plant. Significantly, treatment T2 (NAA @ 500 ppm) had the highest total dry matter production (24.48 g plant^{-1}), whereas treatment T7 had the lowest total dry matter production (16.78 g plant^{-1}) at 120 DAS. Due to the growth regulator treatments, there were considerable differences in how the total dry matter was distributed across the reproductive, stem, and leaf portions. According to Jeyakumar *et al*. (2008) [4], the increased total dry weight of plants caused by growth regulators is due to higher chlorophyll content and the resulting photosynthetic efficiency, which is demonstrated by higher dry matter accumulation after NAA application and also by efficient assimilation of nutrients from the leaf and stem to reproductive parts.

The dry matter partitioning in the leaf and stem decreased as the crop aged, whereas it increased in the reproductive parts. The redistribution of accumulated photosynthate towards reproductive organs may be the cause of the drop in leaf and stem dry weight during later stages of crop development. Higher yields caused by different PGRs are mostly the result of changed photosynthate distribution patterns within the plant, which are achieved by coordinating plant activities to produce the greatest amount of dry matter and dividing the majority of this added dry matter into elements that effectively contribute to yield. Because of growth regulator treatments, the dry weight of reproductive components increased during the course of the crop's growing season. Growth regulators may raise the dry weight of reproductive parts, which may be a result of the reproductive parts' increased size and number of pods per plant, as well as the assimilation of nutrients from the plant's leaf and stem. The impact of growth regulators on the morpho-physiological parameters and yield in groundnut was examined by Pinjarkar in 2021. According to the results, NAA @ 40 ppm was the treatment that increased leaf dry weight, stem dry weight, and plant dry weight more effectively than the other treatments.

Morpho-physiological and growth characters

The tables 3 and 4 show the impact of several plant growth regulators on the morpho-physiological characteristics of bunch groundnut. The data showed that the application of higher concentrations of plant growth regulators had a significant impact on the morpho-physiological characteristics of bunch groundnut, including leaf area (LA), leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), absolute growth rate (AGR), and relative growth rate (RGR). By managing the sunlight's absorption, a plant's leaf area indicates the activity of photosynthesis. From the vegetative through the reproductive stages, there was a consistent rise in leaf area. As the plant matured, however, there was a decline. The development of the leaf surface determines the crop's production. Data on plant leaf area were determined to be important at 80, 100, and 120 DAS. Treatment T2 (NAA @ 500 ppm) significantly outperformed the control and other treatments in terms of maximum leaf area mean. Due to auxins' active function in cell division and cell elongation in the current study, administration of NAA increased the leaf area. The increase in flexibility caused by auxin stimulating activity weakens the cell wall and increases leaf area. Groundnut researchers Reddy (1978) [14] and Prakash *et al*. (2022) [11] discovered similar results. The yield of a crop is directly influenced by the dry matter output of the crop, which is determined by the leaf area index. The results also showed that different PGR treatments had a substantial impact on the leaf area index during 80, 100, and 120 DAS. The leaf area index (LAI) of the treatments dramatically increased in T2 (NAA @ 500 ppm) at 80 DAS and thereafter dropped as the leaves grew older and senescent. According to Nawalgatti *et al*. (1991) [5] and Saishankar (2001) [15], the stimulatory action of NAA on cell division and cell expansion may be the cause of the rise in leaf area index caused by the administration of NAA. In peanuts, Nazim (2016) [6] and Prakash *et al*. (2022) [11] discovered similar findings.

The application of NAA in the current experiment resulted in an increase in the leaf area duration (LAD) of bunch groundnut, which may have been caused by an increase in the number of leaves and leaf area index per plant, as previously stated by Saishankar (2001) [15] and Shashikumar *et al*. (2013) [16]. Analyzing the data in Table 3 showed that the varied plant growth regulator treatments at 80–100 and 100–120 DAS had a substantial impact on the leaf area duration. T2 (NAA @ 500 ppm) had the significantly longest leaf area duration (25.40 cm^2 day^{-1}), which was statistically comparable to treatments T1 and T4, whereas T7 had the shortest leaf area duration (19.25 cm^2 day^{-1}) between 100 and 120 DAS. This result is similar with the results of Jadhav (2000) [3] in soybean and Tafsira Naz (2006) [17] in groundnut.

The size or mass of crops as they grow over a specific time period is measured as the crop growth rate. Plant dry weight has increased, which has accelerated crop growth. The crop growth rate increased at 80 DAS and subsequently decreased as it approached maturity, generally speaking, as the concentration of the growth regulators increased. Significantly, the highest mean of AGR recorded in T2 (NAA @ 500 ppm) as a result of the application of plant growth regulators may be attributable to an improvement in photosynthetic efficiency through increased leaf thickness, retention of more chlorophyll content, and efficient translocation of photosynthate (Patil, 1994; Upadhyay and Ranjan, 2015) [7, 18]. In terms of groundnut, the current findings are quite similar to those of Tafsira Naz (2006) [17] and Pinjarkar (2021) [9].

According to the information in Table 4, various plant growth regulator treatments had a discernible impact on the relative growth rate of each plant between 80 and 100 and 100 and 120 DAS. The relative growth rate was significantly higher than the control across all PGRS conducted between 100 and 120 DAS. The treatment T2 (NAA @ 500 ppm) recorded the statistically greatest relative growth rate (0.0067 g g^{-1} day^{-1}) and was statistically comparable to the treatment T1, whereas the treatment T7 recorded the lowest RGR (0.0029 g g^{-1} day^{-1}). According to the current experiment, relative growth rate (RGR) decreased as crop growth progressed. The decrease in the rate of dry matter generation is what causes the RGR to decrease in the latter stages of crop development. The rise in RGR caused by the administration of NAA may be attributable to an improvement in photosynthetic efficiency brought on by increased leaf thickness, the retention of more chlorophyll, and effective photosynthetic translocation. Both Nazim (2016) [6] and Prakash *et al*. (2022) [11] in groundnut revealed similar results.

Table 1: Effect of plant growth regulators on dry weight of different parts of bunch groundnut cv. TG-37A

Treatments		**Dry weight of leaf (g plant^{-1})**			**Dry weight of stem (g plant^{-1})**			**Dry weight of root (g plant^{-1})**		
		80 DAS	**100 DAS**	**120 DAS**	**80 DAS**	**100 DAS**	**120 DAS**	**80 DAS**	**100 DAS**	**120 DAS**
T_1	NAA @ 200 ppm	4.16	3.99	3.45	6.47	5.52	5.29	3.23	4.12	4.24
T_2	NAA @ 500 ppm	4.43	4.26	4.12	6.63	5.59	5.47	3.87	4.15	4.36
T_3	SA @ 500 ppm	3.65	3.55	3.15	5.90	5.42	5.09	2.78	2.96	3.49
T_4	SA @ 1000 ppm	4.04	3.96	3.22	6.05	5.52	5.25	2.78	3.89	3.98
T_5	MC @ 150 ppm	3.46	3.14	2.98	5.59	5.27	4.62	2.51	2.80	3.20
T_6	MC @ 250 ppm	3.37	3.04	2.87	5.35	5.18	4.42	2.44	2.79	3.13
T_7	CCC @ 5000 ppm	2.96	2.48	2.00	4.51	3.49	3.31	2.16	2.29	2.95
T_8	CCC @ 10000 ppm	3.58	3.44	3.09	5.75	5.29	4.95	2.63	2.82	3.25
T_9	PBZ @ 250 ppm	3.33	2.96	2.51	5.01	4.81	4.27	2.44	2.79	3.02
T_{10}	PBZ @ 350 ppm	3.27	2.71	2.40	4.89	4.56	4.12	2.34	2.57	2.97
T_{11}	Control (Water spray)	3.60	3.22	3.12	5.87	5.40	4.66	2.56	2.83	3.24
S.Em.±		0.21	0.24	0.14	0.33	0.24	0.28	0.20	0.23	0.22
C.D. at 5%		0.61	0.71	0.42	0.97	0.71	0.83	0.59	0.68	0.65
C.V. %		9.81	12.47	8.28	10.10	8.20	10.42	12.88	12.85	11.05

Table 2: Effect of plant growth regulators on total dry matter production (g plant-1) of bunch groundnut cv. TG-37A

Treatments		**Total dry matter of plant (g plant^{-1})**			
		80 DAS	**100 DAS**	**120 DAS**	**Mean**
T_1	NAA @ 200 ppm	17.66	20.94	22.39	20.33
T_2	NAA @ 500 ppm	19.55	22.42	24.48	22.15
T_3	SA @ 500 ppm	15.59	18.34	20.24	18.06
T_4	SA @ 1000 ppm	16.24	19.93	21.13	19.10
T_5	MC @ 150 ppm	14.73	17.21	18.91	16.95
T_6	MC @ 250 ppm	14.22	16.98	18.50	16.57
T_7	CCC @ 5000 ppm	11.97	14.67	16.78	14.47
T_8	CCC @ 10000 ppm	15.17	17.87	19.72	17.58
T_9	PBZ @ 250 ppm	13.60	16.17	17.52	15.76
T_{10}	PBZ @ 350 ppm	12.99	14.63	16.38	14.66

T_{11}	Control (Water spray)	15.22	17.61	19.29	17.38
S.Em.±		0.54	0.62	0.71	0.62
C.D. at 5%		1.59	1.84	2.08	1.84
C.V. %		6.16	6.04	6.24	6.14

Table 3: Effect of plant growth regulators on morpho-physiological and growth parameters of bunch groundnut cv. TG-37A

Treatments		Leaf area (cm^2/plant)				Leaf area index				Leaf area duration (cm^2 day^{-1})		
		80 DAS	100 DAS	120 DAS	Mean	80 DAS	100 DAS	120 DAS	Mean	80-100 DAS	100-120 DAS	Mean
T_1	NAA @ 200 ppm	1064.33	560.19	525.39	716.64	2.37	1.24	1.17	1.59	36.10	24.12	30.11
T_2	NAA @ 500 ppm	1223.62	606.69	536.09	788.80	2.72	1.35	1.19	1.75	40.67	25.40	33.03
T_3	SA @ 500 ppm	995.74	516.69	506.53	672.99	2.21	1.15	1.13	1.50	33.61	22.74	28.17
T_4	SA @ 1000 ppm	1061.22	528.69	504.58	698.17	2.36	1.17	1.12	1.55	35.33	22.96	29.15
T_5	MC @ 150 ppm	905.43	479.19	466.70	617.11	2.01	1.06	1.04	1.37	30.77	21.02	25.89
T_6	MC @ 250 ppm	832.22	476.19	464.43	590.95	1.85	1.06	1.03	1.31	29.08	20.90	24.99
T_7	CCC @ 5000 ppm	694.06	438.69	427.55	520.10	1.54	0.97	0.95	1.16	25.17	19.25	22.21
T_8	CCC @ 10000 ppm	969.48	501.69	487.41	652.86	2.15	1.11	1.08	1.45	32.69	21.98	27.34
T_9	PBZ @ 250 ppm	792.75	464.19	443.18	566.71	1.76	1.03	0.98	1.26	27.93	20.16	24.05
T_{10}	PBZ @ 350 ppm	758.59	461.19	424.50	548.09	1.69	1.02	0.94	1.22	27.11	19.68	23.39
T_{11}	Control (Water spray)	961.65	494.19	490.58	648.81	2.14	1.10	1.09	1.44	32.35	21.88	27.12
S.Em.±		58.46	31.45	24.32	38.08	0.13	0.07	0.05	0.08	1.58	0.84	1.21
C.D. at 5%		172.44	92.78	71.75	112.32	0.38	0.21	0.16	0.25	4.66	2.49	3.58
C.V. %		10.85	10.83	8.79	10.16	10.86	10.84	8.78	10.16	8.58	6.70	7.64

Table 4: Effect of plant growth regulators on morpho-physiological and growth parameters of bunch groundnut cv. TG-37A

Treatments		Crop growth rate (g m^{-2} day^{-1})			Absolute growth rate (g day^{-1})			Relative growth rate (g g^{-1} day^{-1})		
		80-100 DAS	100 -120 DAS	Mean	80-100 DAS	100-120 DAS	Mean	80-100 DAS	100-120 DAS	Mean
T_1	NAA @ 200 ppm	3.64	1.61	2.63	0.164	0.073	0.118	0.0102	0.0056	0.0079
T_2	NAA @ 500 ppm	3.19	2.29	2.74	0.144	0.103	0.123	0.0103	0.0067	0.0085
T_3	SA @ 500 ppm	3.05	2.12	2.58	0.137	0.095	0.116	0.0088	0.0050	0.0069
T_4	SA @ 1000 ppm	4.10	1.33	2.72	0.185	0.060	0.122	0.0089	0.0050	0.0069
T_5	MC @ 150 ppm	2.75	1.89	2.32	0.124	0.085	0.105	0.0081	0.0045	0.0063
T_6	MC @ 250 ppm	3.06	1.69	2.37	0.138	0.076	0.107	0.0078	0.0044	0.0061
T_7	CCC @ 5000 ppm	3.01	2.34	2.67	0.135	0.105	0.120	0.0059	0.0029	0.0044
T_8	CCC @ 10000 ppm	3.00	2.06	2.53	0.135	0.093	0.114	0.0082	0.0047	0.0065
T_9	PBZ @ 250 ppm	2.86	1.50	2.18	0.129	0.068	0.098	0.0074	0.0040	0.0057
T_{10}	PBZ @ 350 ppm	1.82	1.94	1.88	0.082	0.087	0.085	0.0070	0.0037	0.0053
T_{11}	Control (Water spray)	2.65	1.87	2.26	0.119	0.084	0.102	0.0085	0.0048	0.0067
S.Em.±		0.22	0.15	0.18	0.01	0.01	0.01	0.0007	0.0004	0.0005
C.D. at 5%		0.66	0.43	0.55	0.03	0.02	0.02	0.0020	0.0012	0.0016
C.V. %		12.79	13.59	13.19	14.32	14.72	14.52	13.93	14.83	14.38

Conclusion

This study demonstrated that the use of PGRs improved groundnut growth indices, morphological characteristics, and total dry matter yield. It may be brought on by the plant's accelerated rates of cell division, cell elongation, and dry matter partitioning. At the height of pod filling, the dry weight of the leaves and stem decreased; nevertheless, the dry matter content of the pods grew linearly up until harvest. The PGRs treatment NAA at 500 ppm at 70 & 90 DAS had good LA, LAI, LAD, AGR, CGR and RGR, which resulted in increased photosynthate production because there was more dry matter transferred from leaf to pods, thus promoting pod yield.

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