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Different application methods of nutrients and plant growth regulators enhances the growth and yield of banana cv. Grand Naine

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Abstract
An investigation was carried out in banana cv. Grand Naine with aiming to improve the growth and yield characters. The present investigation consists of foliar application and bunch feeding of nutrients (Banana special 0.5%, KH_2PO_4 0.5% and SOP 2%) and plant growth regulators (GA_3 50 ppm and Brassinosteroids 2 ppm) and their combinations. The foliar application of SOP 2% and BR 2 ppm significantly increased the pseudostem girth, number of leaves, leaf length, leaf area, leaf area index, bunch weight and yield per hectare.

Keywords: Bunch feeding, foliar spraying, sulphate of potash, brassinosteroids, banana special, potassium dihidrogen phosphate

Introduction
Banana plant is supplied with nutrients through soil, foliar spraying and post-shoot feeding of nutrients through the distal stalk end of rachis to achieve high yields (Anitha *et al.*, 2005) [1]. During fruit development, the plant nutrient status and uninhibited flow of nutrients to the developing bunch influence the bunch size and quality of fruits (Mulagund *et al.* 2015) [5]. Soil characters and environmental factors may cause considerable loss to the soil applied nutrients leading to insufficient supply of nutrient after shooting to meet the nutrient demand of developing bunch (Kumar and Kumar, 2009) [2]. Hence, bunch or foliar feeding of nutrients provides a considerable scope not only for the effective utilization of nutrients but also to safeguard the economy of the farmer by improving the yield potential and quality of the produce (Sreekanth *et al.*, 2017) [6].

Material and Methods
The present investigation was carried out at Banana Research Station, Nanded during 2016 - 2017. Four plants per treatment were selected and each plant was performed with above treatments in factorial randomized block design with two replications. Two factors *i.e.* method of application (M) and nutrients/ plant growth regulators (N) were used. Two application methods (M_1 - foliar spraying and M_2- bunch feeding) were used. Different nutrients, plant growth regulators (N_1-banana special, N_2-sulphate of potash, N_3-KH_2PO_4, N_4-GA_3 and N_5-brassinosteroids), their combinations (N_6-banana special + GA_3, N_7- banana special + brassinosteroids, N_8-SOP + GA_3, N_9-SOP + brassinosteroids, N_{10}-KH_2PO_4 + GA_3, N_{11}-KH_2PO_4 + brassinosteroids and N_{12}- control) was used as second factor.

For the foliar spraying, the solution was prepared with water for the required strength of the spray. The first spray will be given after complete emergence of inflorescence and the second spray was given 30 days after first spray the entire plant canopy was sprayed including the developing bunches. The combination was mixed with "sandovit" at the rate of 1 ml per litre of water as a sticking agent.

Bunch Feeding (M_2) was done immediately after the fruit set or bunch formation and shedding of 7-8 flower petals (spathes), the male bud was denavelled at the stalk end of the bunch by cutting with knife at 60^0 in such way that about 15 cm long rachis/ stalk-end is available after the last hand of the bunch. The nutrient/PGR solution was placed in a plastic bag of 200 guage (15cm X 25cm) and tying the bag with strong thread such that about 8-10cm of the distal end of the rachis was immersed in the solution and remaining 8-10cm of the rachis is visible above the tied portion. The data obtained was analyzed statistically as per the method suggested by

Gomez and Gomez (1984). The standard error of mean (S.Em.) was worked out and the critical difference (C.D.) at 5 per cent was calculated whenever the results were found significant.

Result and Discussion

Data presented on girth of pseudostem as influenced by application methods and interaction effect was found to be non-significant however effect of nutrients and plant growth regulators on pseudostem girth was found significant. Significantly maximum pseudostem girth (67.53 cm) was recorded in treatment N_9 *i.e.* application of sulphate of potash (2%) + brassinosteroid (2 ppm) which was at par with treatment N_7 (64.46 cm), N_8 (64.37 cm) and N_6 (63.03 cm). The minimum girth (54.93 cm) was recorded in treatment N_{12}. The increase in pseudostem girth of banana plant might be due to an increase in the absorption of K and additional supply of sulphur, which enhances starch accumulation. Better protein synthesis could have also contributed to higher girth throughout the cropping period (Kumar and Kumar, 2008) [4].

Table 1: Effect of nutrients and plant growth regulators on pseudostem girth of banana

Nutrients/ PGRs	Methods of application		Mean
	M_1	M_2	
N_1	61.01	60.54	60.78
N_2	62.60	62.24	62.42
N_3	61.35	60.95	61.15
N_4	62.19	61.44	61.81
N_5	64.51	60.55	62.53
N_6	63.65	62.40	63.03
N_7	65.70	63.23	64.46
N_8	64.79	63.95	64.37
N9	68.19	66.86	67.53
N_{10}	62.09	61.14	61.61
N_{11}	61.21	62.11	61.66
N_{12}	55.11	54.74	54.93
	62.70	61.68	
(M) S.E N±	0.66	0.79	0.45
C.D. at 5%	NS	NS	NS
(N) S.E N±	1.61	1.93	1.09
C.D. at 5%	4.66	5.57	3.03
(M X N) S.E N±	2.28	2.73	1.55
C.D. at 5%	NS	NS	NS

Significantly maximum number of leaves per plant (11.52) were recorded in treatment M_1 as compared to M_2 (10.53) during the year 2016-17. The significantly maximum number of leaves per plant (12.13) was recorded in treatment N_9 which was at par with N_8 (11.94), N_{11} (11.75), N_{10} (11.69), N_2 (11.56), N_7 (11.50) and N_6 (10.94) during 2016-17. However, minimum numbers of leaves (9.38) were recorded in treatment N_{12}. Significantly maximum number of leaves per plant (13.37) was recorded in treatment combination of M_1N_8 *i.e.* foliar spraying of sulphate of potash (2%) + GA_3 50 ppm. It was at par with treatment combination of M_1N_9 (12.87) and M_1N_{11} (12.50). The minimum number of leaves (9.50) was recorded in treatment M_2N_{12}. It was evident from the result obtained in present investigation, that application of different nutrients; plant growth regulators alone or in combination had significantly influenced on the number of leaves as compared to control. In present investigation it was observed that, foliar spraying of sulphate of potash + GA_3, brassinosteroid + sulphate of potash and KH_2PO_4 + brassinosteroid had significantly increased the number of leaves at harvest in banana plant. This increase in number of leaves per plant in banana might be due to foliar application of nutrients which provided quick and effective augmentation of nutrients and may prevent hidden hunger when properly timed (Kumar and Kumar, 2007) [3].

Table 2: Effect of nutrients and plant growth regulators on number of leaves of banana

Nutrients/ PGRs	Methods of application		Mean
	M_1	M_2	
N_1	10.38	10.00	10.19
N_2	11.63	11.50	11.56
N_3	10.38	10.25	10.31
N_4	10.25	10.63	10.44
N_5	11.88	9.13	10.50
N_6	11.75	10.13	10.94
N_7	12.13	10.88	11.50
N_8	13.25	10.63	11.94
N9	12.75	11.50	12.13
N_{10}	11.88	11.50	11.69
N_{11}	12.50	11.00	11.75
N_{12}	9.50	9.25	9.38
	11.52	10.53	
(M) S.E N±	0.17	0.16	0.10
C.D. at 5%	0.50	0.47	0.27
(N) S.E N±	0.42	0.40	0.24
C.D. at 5%	1.23	1.14	0.67
(M X N) S.E N±	0.60	0.56	0.34
C.D. at 5%	NS	NS	0.94

Significantly maximum leaf length (170.48 cm) was observed in treatment N_9 *i.e.* application of sulphate of potash (2%) + brassinosteroid (2 ppm). The increase in leaf length in brassinsteroid sprayed plants could be due to delay in leaf senescence or abscission which may again be a manifestation of increased chlorophyll content. Increase in leaf length may be due to positive effect on cell division and cell elongation and their by enhanced leaf expansion as reported by Zakaria *et al.* 2018 [7].

Table 3: Effect of nutrients and plant growth regulators on leaf length of banana

Nutrients/ PGRs	Methods of application		Mean
	M_1	M_2	
N_1	143.90	140.33	142.11
N_2	151.71	142.64	147.18
N_3	148.48	144.03	146.25
N_4	146.70	144.66	145.68
N_5	151.81	145.13	148.47
N_6	152.83	149.56	151.19
N_7	156.48	154.55	155.51
N_8	166.33	160.03	163.18
N9	171.65	169.31	170.48
N_{10}	160.86	157.06	158.96
N_{11}	167.51	159.36	163.44
N_{12}	138.13	134.78	136.45
	154.70	150.12	
(M) S.E N±	1.28	1.43	0.89
C.D. at 5%	3.70	4.14	2.46
(N) S.E N±	3.14	3.51	2.17
C.D. at 5%	9.06	10.13	6.03
(M X N) S.E N±	4.44	4.96	3.08
C.D. at 5%	NS	NS	NS

Significantly maximum leaf area of banana was recorded (9.06 cm^2) in treatment M_1 however, minimum leaf area (7.59 cm^2) was observed in treatment M_2. Significantly maximum

leaf area (10.85 cm^2) was recorded by application of treatment N_9 *i.e.* sulphate of potash (2%) + brassinosteroid (2 ppm) whereas minimum leaf area (5.47 cm^2) was observed in treatment control (N_{12}).

Table 4: Effect of nutrients and plant growth regulators on leaf area (m^2) of banana

Nutrients/ PGRs	Methods of application		Mean
	M_1	M_2	
N_1	6.85	6.02	6.44
N_2	8.28	7.49	7.88
N_3	7.34	6.70	7.02
N_4	7.59	7.09	7.34
N_5	9.03	6.46	7.75
N_6	9.42	7.59	8.50
N_7	10.05	8.39	9.22
N_8	11.58	8.44	10.01
N9	11.69	10.01	10.85
N_{10}	9.98	8.95	9.46
N_{11}	11.18	8.68	9.93
N_{12}	5.73	5.22	5.47
	9.06	7.59	
(M) S.E N±	0.18	0.20	0.11
C.D. at 5%	0.53	0.57	0.31
(N) S.E N±	0.45	0.49	0.28
C.D. at 5%	1.29	1.41	0.77
(M X N) S.E N±	0.63	0.69	0.39
C.D. at 5%	NS	NS	1.09

The significantly maximum leaf area index (3.44) was recorded in treatment M_1 and the minimum leaf area index (3.07) was recorded in treatment M_2.

The significantly maximum leaf area index (3.98) was recorded in treatment N_9 which was at par with N_8 *i.e.* sulphate of potash 2% + GA_3 50 ppm (3.80). However, it was followed by N_7 *i.e.* Banana special 0.5% + brassinosteroid 2 ppm (3.49), N_2 *i.e.* sulphate of potash 2% (3.41), N_{11} *i.e.* KH_2PO_4 0.5% + brassinosteroid 2 ppm (3.41) and N_{10} *i.e.* KH_2PO_4 0.5% + GA_3 50 ppm (3.35). The minimum leaf area index (2.49) was recorded in N_{12} *i.e.* control.

Table 5: Effect of nutrients and plant growth regulators on leaf area index (m^2) of banana

Nutrients/ PGRs	Methods of application		Mean
	M_1	M_2	
N_1	2.52	2.56	2.54
N_2	3.87	2.95	3.41
N_3	3.57	2.56	3.06
N_4	3.27	2.84	3.06
N_5	3.36	3.12	3.24
N_6	3.41	3.04	3.22
N_7	3.68	3.30	3.49
N_8	4.10	3.49	3.80
N9	4.18	3.78	3.98
N_{10}	3.30	3.40	3.35
N_{11}	3.57	3.25	3.41
N_{12}	2.44	2.53	2.49
	3.44	3.07	
(M) S.E N±	0.06	0.08	0.05
C.D. at 5%	0.19	0.22	0.13
(N) S.E N±	0.16	0.19	0.12
C.D. at 5%	0.45	0.55	0.32
(M X N) S.E N±	0.22	0.27	0.16
C.D. at 5%	NS	NS	NS

The significant differences were recorded in respect to chlorophyll content of banana leaves with respect to by different application methods. Significantly maximum chlorophyll content (58.12 spad) was recorded under M_1 *i.e.* foliar application over M_2 *i.e.* bunch feeding (56.17 spad).There were significant differences in leaf chlorophyll content between the treatments. The maximum leaf chlorophyll content (69.24 spad) was found in treatment N_9, which was significantly superior over rest of the treatments, which was followed by N_8 (61.68 spad) and minimum values (46.85 spad) was recorded in N_{12}.Significantly maximum leaf chlorophyll content (69.76 spad) was recorded under treatment combination M_1N_9 *i.e.* foliar spraying of sulphate of potash (2%) + brassinosteroid (2 ppm).

Kumar and Kumar (2007) [3] reported that, Neypoovan plants receiving foliar spray had significantly higher leaf chlorophyll content at harvest. Retention of chlorophyll pigment during the post-shooting growth stage helps fruit bunches accumulates photosynthates.

Table 6: Effect of nutrients and plant growth regulators on chlorophyll content of leaf (spad) of banana

Nutrients/ PGRs	Methods of application		Mean
N_1	54.36	51.11	52.73
N_2	57.03	54.55	55.79
N_3	53.69	50.86	52.27
N_4	56.47	52.54	54.50
N_5	56.72	54.96	55.84
N_6	61.36	57.93	59.65
N_7	59.65	59.16	59.41
N_8	61.74	61.63	61.68
N9	69.76	68.73	69.24
N_{10}	60.53	59.23	59.88
N_{11}	59.62	61.03	60.33
N_{12}	46.58	47.13	46.85
	58.12	56.57	
(M) S.E N±	0.22	0.27	0.18
C.D. at 5%	0.65	0.77	0.50
(N) S.E N±	0.55	0.65	0.45
C.D. at 5%	1.58	1.88	1.24
(M X N) S.E N±	0.78	0.92	0.63
C.D. at 5%	2.24	2.76	1.75

Significantly maximum weight of hand (2.92 kg) was recorded in treatment M_1 whereas minimum weight of hand was found in M_2 (bunch feeding). The maximum weight of

hand (3.09 kg) was recorded in treatment N_9 which was 30.38 per cent more as compared to control (2.37 kg). However, it was at par with N_8 (2.99 kg), N_{11} (2.99 kg), N_{10} (2.98 kg) and N_7 (2.97 kg) during the year 2016-17. Nutrients and plant growth regulators given as a foliar spray, the absorption of both SOP and brassinosteroid could have played a key role in assimilate partitioning and diversion to the rapidly developing hands. These results are in accordance with the findings of Mulagund *et al.*, 2015 [5].

Table 7: Effect of nutrients and plant growth regulators on bunch weight (kg) of banana

Nutrients/ PGRs	Methods of application		Mean
N_1	18.75	18.15	18.45
N_2	21.15	18.70	19.92
N_3	18.76	18.78	18.77
N_4	18.25	17.96	18.11
N_5	19.07	18.54	18.80
N_6	20.29	18.69	19.49
N_7	21.42	19.44	20.43
N_8	23.23	22.03	22.63
N9	25.46	23.93	24.69
N_{10}	22.01	21.72	21.86
N_{11}	22.90	21.53	22.21
N_{12}	16.94	16.97	16.96
	20.68	19.70	
(M) S.E N±	0.02	0.02	0.01
C.D. at 5%	0.05	0.05	0.03
(N) S.E N±	0.05	0.05	0.02
C.D. at 5%	0.13	0.13	0.07
(M X N) S.E N±	0.07	0.06	0.04
C.D. at 5%	0.19	0.19	0.10

The maximum yield (91.92 Mt/ha) was found in M_1 *i.e.* foliar application over M_2 *i.e.* bunch feeding of nutrients and plant growth regulators (87.64 Mt/ha) which was (4.88) per cent more as compared to control during year 2016-17. The significantly maximum average yield (109.73 Mt/ha) was recorded in treatment N_9 *i.e.* application of sulphate of potash (2%) + brassinosteroid (2 ppm) over rest of the treatments. The treatment N_9 was 45.63 per cent more as compared to control. The lowest average yield (75.35 Mt/ha) was recorded in treatment N_{12} *i.e.* control in the year 2016-17.

Table 8: Effect of nutrients and plant growth regulators on yield per ha (Mt/ha) of banana

Nutrients/ PGRs	Methods of application		Mean
N_1	83.33	80.66	81.99
N_2	93.99	83.08	88.54
N_3	83.35	83.44	83.39
N_4	81.10	80.82	80.96
N_5	84.73	82.39	83.56
N_6	90.17	83.06	86.62
N_7	95.19	86.39	90.79
N_8	103.24	97.90	100.57
N9	113.15	106.32	109.73
N_{10}	97.79	96.50	97.15
N_{11}	101.75	95.66	98.70
N_{12}	75.28	75.42	75.35
	91.92	87.64	
(M) S.E N±	0.49	0.91	0.60
C.D. at 5%	1.42	2.63	1.74
(N) S.E N±	1.20	2.23	1.48
C.D. at 5%	3.47	6.44	4.27
(M X N) S.E N±	1.70	3.15	2.09
C.D. at 5%	4.92	9.11	6.04

During the 2016-17 the interaction effect of application method of nutrients and plant growth regulators adduced the significant maximum average yield (113.15 Mt/ha) recorded in treatment combination M_1N_9 *i.e.* foliar application of sulphate of potash (2%) + brassinosteroid (2 ppm), which was 50.30 per cent more as compared to control. It was followed by M_2N_9 (106.32 Mt/ha), M_1N_8 (103.24 Mt/ha) and M_1N_{11} (101.75 Mt/ha). The lowest average yield (75.28 Mt/ha) was recorded in treatment combination M_1N_{12} *i.e.* control.

Mulagund *et al.* (2015) [5] also reported that, increase in length of finger, circumference of finger, weight of bunch and yield per hectare is due to sulphur present in the sulphate of potash (SOP) might be responsible for the formation of ferridoxin in plants which might have direct impact in activating the catalase and perodoxidase enzymes Presence of sulphur in SOP had a synergistic effect with zinc, which is essential for carbon dioxide absorption and utilization, synthesis of RNA and auxin. Zinc is also essential for chlorophyll formation, which improves the photosynthetic activity of the crop. The present findings are in close conformity with the findings of Kumar and Kumar (2007) [3] in cv. Neypoovan and Kumar *et al.* (2008) [4] in cv. Robusta

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