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Optimizing Banana Crop Productivity: Effects of Nitrogen Levels and Plant Growth Regulators on Chlorophyll Dynamics in Ney Poovan Cultivar

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study highlights the Effect of different nitrogen levels and plant growth regulators on Total chlorophyll content and chlorophyll stability index of banana cv. Ney Poovan. A field experiment in banana cv. Ney Poovan was conducted with various levels of nitrogen and plant growth regulators at Orchard, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in the complete Randomized Block Design with four main plot and eight sub plot treatments which are replicated thrice. Significant differences among the different treatments in growth and physiological parameters was observed. The results reveled that application of various levels of

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nitrogen and plant growth regulators 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively + Urea 2% foliar spray + Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP respectively *i.e.* M_4S_5 recorded the highest chlorophyll content (1.40 mg g^{-1}) and chlorophyll stability index (72.58) which was on par with the M_3S_5 : 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively)+ Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP.

Keywords: Plant growth regulators, chlorophyll a, chemical manipulation, physiological efficiency.

1. INTRODUCTION

Banana is one of the important fruit crops of tropical and subtropical countries. In India, banana accounts for higher fruit production among various fruit crops contributing 31 per cent of total fruit production. India is the largest producer of bananas with an area of 8.78 lakh hectares, production of 315.04 lakh metric tonnes and productivity of 36.243 metric tonnes per hectare [1]. It is a significant, nutrient-rich fruit crop grown for both domestic and international trade. The banana is a great lover of essential micronutrients and uses up enormous amounts of both macro- and micronutrients from the soil, it demands continuous supply. It requires a continuous supply of water and nutrients at proper growth stages for enhanced yield and it responds well to applied nutrients. To overcome the production constraints, chemical manipulation could be tried to improve the root system, in proportion to shoot growth. Apart from this, any attempt on improving the physiological efficiency of the crop will also have significant impact. One of the biotechnological approaches to overcome these bottlenecks and to make stupendous contributions in increasing productivity is the use of plant growth regulators (PGRs). At harvest, banana retains a part of the assimilates and nutrients in pseudostem and leaves and so, the crop is relatively less efficient in translocation of assimilation to sink [2]. Farmers that grow bananas use nonscientific management techniques that result in inefficient use of fertilisers and water which results in low output [3]. To overcome this malady, use of a suitable growth regulator may be advantageous

2. MATERIALS AND METHODS

A field experiment in banana cv. Ney Poovan was conducted with various levels of nitrogen and plant growth regulators at Orchard, Tamil Nadu Agricultural University, Coimbatore. The experiment was conducted in split plot design with three replications. In the main plot treatment the levels of nitrogen are as follows, M_1 (Control): 150 g plant^{-1} (45g + 75g +30g N plant^{-1} at 3,5 and 7 MAP, respectively), M2: M_1 + Urea 2% foliar spray, M_3: 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively), M4: M_3 + Urea 2% foliar spray. In sub plot different plant growth regulators were sprayed viz., S_1: Control (water spray), S2: Mepiquat chloride (MC) 500 ppm, S3: Chlormequat chloride (CCC) 100 ppm, S4: Ethrel 500 ppm, S5: Salicylic acid (SA) 100 ppm, S6: Nitrobenzene 100 ppm, S7: Benzyl adenine (BA) 20 ppm, S8: 2,4-Dichlorophenoxy acetic acid (2, 4-D) 25 ppm. Respective foliar spray treatments were given in the early morning hours before 8 AM. Teepol was added to the spray fluid as surfactant @ 1.5ml I-1 for effective absorption of chemicals. Foliar spray of urea in main plots and foliar spray of bioregulators in subplots were imposed at third, fifth and seventh months after planting separately.

Physiological parameters such as, total chlorophyll content, chlorophyll stability index (CSI), chlorophyll fluorescence and soluble protein content were recorded. The content of chlorophyll *a, b* and total chlorophyll were estimated by adopting the procedure of Yoshida et al. (1972) and the contents were expressed as mg g^{-1} of fresh weight. CSI was assessed following the method of Murty and Majumder [4] and expressed as percentage. The fluorescence measurement was done by using Plant Efficiency Analyzer (PEA) (Hansatech, UK), that uses a fast analyzing system capable of recording in 10 s was used to assess the chlorophyll fluorescence. Soluble protein content of leaf was estimated by following the procedure of Lowry et al. [5], by using folin ciocalteau reagent and expressed in mg g^{-1} of fresh weight.

3. RESULTS AND DISCUSSION

3.1 Effect of different Nitrogen Levels and Plant Growth Regulators on Chlorophyll Content

All the treatments were found significantly superior over the control. Among the all the different treatments, the treatment M_4 S_5 (200 g

N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively + Urea 2% foliar spray + Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP respectively) recorded for higher amount of chlorophyll a and b, and total chlorophyll. High nitrogen level appeared to have more impact on chlorophyll b than on chlorophyll a. Being a constituent of chlorophyll, increased nitrogen supply might have accelerated the synthesis of more chlorophyll pigments [6]. Mahadevan [7] also observed higher chlorophyll content in cv. Nendren with foliar application of urea. Among the growth regulators, salicylic acid and benzyl adenine were more efficient in increasing the contents of chlorophyll a and b. The effects of these treatments were obviously high on chlorophyll a. Increase in chlorophyll content by salicylic acid spray was reported by many early workers in different crops [8,9,10]. The reason adduced for enhanced chlorophyll biosynthesis by phenolic substances was that the phenolics inhibited chlorophyllase enzyme which led to higher accumulation of chlorophyll [11]. Duguma et al. [12] claimed that banana fruits treated with GA3 delay the change of green skin color due to the retarding effect of the hormone on the synthesis of ethylene and, hence, reduced the respiration rate of the fruits in concentration dependent manner. Retardation in skin color development in Berangan banana could possibly be associated with the activities of ACS and ACO enzymes that are closely related to the production of ethylene [13]. (Table 1a and 1b).

According to Duarte et al. [14], the repeated spraying within the vegetative-silking stage ensured better nutrient uptake by corn might be the cause of higher chlorophyll content. Besides, banana pseudostem contains bio-active molecules such as amino acids, proline, betaine, and glutamic acid that have stimulatory effects on chlorophyll synthesis which could be promoted a higher total chlorophyll content [15].

3.2 Effect of different Nitrogen Levels and Plant Growth Regulators on Chlorophyll Stability Index

The effect of various levels of nitrogen and plant growth regulators on chlorophyll stability index was tabulated under Table 2a and 2b. Among the different treatments, treatment M_4 S_5 (200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively + Urea 2% foliar spray + Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP respectively) recorded higher amount of Chlorophyll stability index. CSI has been considered as an useful parameter for resisting the degradation of chlorophyll pigments under different stresses [16,4,17,18]. Compared to the effects of growth regulating chemicals, nitrogen levels had low response on chlorophyll stability index [19,20]. Salicylic acid appeared to effect greater stability to chlorophyll pigments than others, which recorded 21.6 per cent increased chlorophyll stability over untreated plant. (Table 2a and 2b) [21,22].

Table 1a. Effect of different levels of nitrogen and plant growth regulators on total chlorophyll (mg g^{-1}) content at different growth stages of banana cv.Ney Poovan (Main effect)

Treatments	3 MAP		5 MAP		7 MAP		Harvest		Mean
				Main Plot					
M_1	1.04	(0.0)	1.27	(0.0)	1.37	(0.0)	1.25	(0.0)	1.23
M_2	1.06	(1.9)	1.35	(6.3)	1.36	(-0.7)	1.27	(1.6)	1.26
M_3	1.10	(5.8)	1.37	(7.9)	1.42	(3.6)	1.29	(3.2)	1.30
M_4	1.12	(7.7)	1.38	(8.7)	1.48	(8.1)	1.31	(4.8)	1.32
Mean	1.08		1.34		1.41		1.28		1.28
CD (p=0.05)	NS		0.007		0.008		0.005		
				Sub Plot					
S_1	0.98	(0.0)	1.25	(0.0)	1.41	(0.0)	1.21	(0.0)	1.21
S_2	1.10	(12.2)	1.31	(4.8)	1.37	(-2.8)	1.30	(7.4)	1.27
S_3	1.08	(10.2)	1.32	(5.6)	1.37	(-2.8)	1.31	(8.3)	1.27
S_4	1.05	(7.1)	1.35	(8.0)	1.37	(-2.8)	1.23	(1.7)	1.25
S_5	1.18	(20.4)	1.45	(16.0)	1.48	(5.0)	1.36	(12.4)	1.37
S_6	1.04	(6.1)	1.32	(5.6)	1.38	(-2.1)	1.24	(2.5)	1.24
S_7	1.17	(19.4)	1.43	(14.4)	1.44	(2.1)	1.35	(11.6)	1.35
S_8	1.07	(9.2)	1.33	(6.4)	1.14	(-19.1)	1.26	(4.1)	1.20
Mean	1.08		1.34		1.38		1.28		1.27
CD (p=0.05)	0.009		0.011		0.012		0.011		

[Values in parentheses are per cent changes over respective control (M_1 and S_1)]

Table 1b. Effect of different levels of nitrogen and plant growth regulators on total chlorophyll content (mg g^{-1}) at different growth stages of banana cv.Ney Poovan (Interaction effect)

Treatments	3 MAP	5 MAP	7 MAP	Harvest	Mean
			Interaction effect		
M_1S_1	0.94	1.21	1.35	1.20	1.18
M_1S_2	1.06	1.26	1.32	1.26	1.22
M_1S_3	1.03	1.23	1.34	1.28	1.22
M_1S_4	1.02	1.26	1.30	1.21	1.20
M_1S_5	1.15	1.36	1.42	1.32	1.31
M_1S_6	0.96	1.27	1.36	1.21	1.20
M_1S_7	1.12	1.37	1.43	1.31	1.31
M_1S_8	1.05	1.23	1.41	1.22	1.23
M_2S_1	0.98	1.22	1.37	1.21	1.20
M_2S_2	1.08	1.31	1.31	1.29	1.25
M_2S_3	1.05	1.37	1.34	1.31	1.27
M_2S_4	1.03	1.34	1.33	1.21	1.23
M_2S_5	1.17	1.45	1.46	1.34	1.36
M_2S_6	0.98	1.34	1.36	1.22	1.23
M_2S_7	1.16	1.46	1.46	1.33	1.35
M_2S_8	1.06	1.33	1.32	1.22	1.23
M_3S_1	0.99	1.28	1.42	1.21	1.23
M_3S_2	1.11	1.34	1.39	1.31	1.29
M_3S_3	1.10	1.31	1.38	1.32	1.28
M_3S_4	1.07	1.39	1.39	1.24	1.27
M_3S_5	1.20	1.53	1.49	1.39	1.40
M_3S_6	1.10	1.32	1.41	1.23	1.27
M_3S_7	1.19	1.47	1.50	1.36	1.38
M_3S_8	1.08	1.31	1.42	1.28	1.27
M_4S_1	1.00	1.28	1.51	1.22	1.25
M_4S_2	1.15	1.34	1.46	1.32	1.32
M_4S_3	1.14	1.37	1.42	1.32	1.31
M_4S_4	1.09	1.39	1.45	1.27	1.30
M_4S_5	1.20	1.47	1.55	1.40	1.40
M_4S_6	1.12	1.36	1.41	1.29	1.30
M_4S_7	1.20	1.41	1.53	1.39	1.38
M_4S_8	1.09	1.37	1.50	1.30	1.31
Mean	1.08	1.34	1.41	1.28	1.28
CD (p=0.05)					
M at S	0.188	0.023	0.024	0.022	
S at M	0.195	0.023	0.023	0.022	

[Values in parentheses are per cent changes over respective control (M_1 and S_1)]

Table 2a. Effect of different levels of nitrogen and plant growth regulators on chlorophyll stability index at different growth stages of banana cv.Ney Poovan (Main effect)

Treatments	3 MAP		5 MAP		7 MAP		Harvest		Mean
					Main Plot				
M_1	61.99	(0.0)	68.55	(0.0)	79.74	(0.0)	64.42	(0.0)	68.67
M_2	62.24	(0.4)	69.04	(0.7)	80.02	(0.4)	64.42	(0.0)	68.93
M_3	62.15	(0.3)	69.27	(1.1)	80.61	(1.1)	64.63	(0.3)	69.16
M_4	62.48	(0.8)	69.71	(1.7)	80.73	(1.2)	64.73	(0.5)	69.41
Mean	62.22		69.14		80.27		64.55		69.05
CD (p=0.05)	NS		0.550		0.640		0.340		
					Sub Plot				
S_1	60.93	(0.0)	67.34	(0.0)	69.06	(0.0)	60.03	(0.0)	64.34
S_2	44.54	(5.9)	69.36	(3.0)	81.66	(18.2)	65.20	(8.6)	65.04

Treatments	3 MAP		5 MAP		7 MAP		Harvest		Mean
S_3	62.45	(2.5)	69.03	(2.5)	81.54	(18.1)	65.16	(8.5)	69.55
S_4	61.72	(1.3)	68.41	(1.6)	79.60	(15.3)	64.74	(7.8)	68.62
S_5	63.63	(4.4)	71.04	(5.5)	83.95	(21.6)	67.14	(11.8)	71.15
S_6	62.21	(2.1)	68.06	(1.1)	79.55	(15.2)	65.07	(8.4)	68.72
S_7	63.30	(3.9)	70.83	(5.2)	83.64	(21.1)	66.85	(11.4)	71.44
S_8	61.63	(1.1)	71.00	(5.4)	82.95	(20.1)	61.61	(2.6)	69.56
Mean	60.20		69.43		80.58		64.55		68.89
CD (p=0.05)	0.520		0.600		0.710		0.560		

[Values in parentheses are per cent changes over respective control (M_1 and S_1)]

Table 2b. Effect of different levels of nitrogen and plant growth regulators on chlorophyll stability index at different growth stages of banana cv. Ney Poovan (Interaction effect)

Treatments	3 MAP	5 MAP	7 MAP	Harvest	Mean
		Interaction effect			
M_1S_1	60.70	67.21	68.65	59.75	64.08
M_1S_2	62.66	68.52	81.40	65.12	69.43
M_1S_3	62.15	68.12	81.44	65.02	69.18
M_1S_4	61.21	68.06	79.16	64.56	68.25
M_1S_5	63.02	69.91	83.15	66.78	70.68
M_1S_6	62.13	68.00	79.16	65.00	68.57
M_1S_7	63.15	69.46	83.20	66.92	70.72
M_1S_8	61.27	68.10	80.01	61.68	67.77
M_2S_1	61.01	67.98	68.20	59.97	64.29
M_2S_2	62.72	69.24	81.46	65.24	69.67
M_2S_3	62.66	69.13	81.25	65.21	69.56
M_2S_4	61.82	68.01	79.24	64.72	68.45
M_2S_5	63.11	69.85	83.20	66.83	71.06
M_2S_6	62.23	68.20	79.95	65.07	68.86
M_2S_7	63.64	70.43	83.48	67.15	70.89
M_2S_8	61.42	68.98	81.12	61.46	68.21
M_3S_1	60.98	67.00	69.65	60.15	64.45
M_3S_2	62.58	69.46	82.00	65.36	69.85
M_3S_3	62.47	69.15	81.58	65.32	69.63
M_3S_4	61.75	68.72	79.58	64.68	68.68
M_3S_5	63.22	72.10	84.10	66.94	71.98
M_3S_6	62.12	68.12	79.75	65.13	68.78
M_3S_7	63.75	71.21	84.70	67.25	71.34
M_3S_8	61.33	68.31	81.58	61.75	68.24
M_4S_1	61.11	67.26	69.86	60.23	64.62
M_4S_2	63.00	70.58	82.21	65.47	70.32
M_4S_3	62.88	70.15	82.40	65.41	70.21
M_4S_4	62.07	68.81	80.40	64.92	69.05
M_4S_5	64.07	73.12	84.40	67.45	72.58
M_4S_6	62.89	68.51	80.05	65.19	69.16
M_4S_7	64.56	72.14	85.15	67.11	71.93
M_4S_8	62.58	68.64	82.32	61.88	68.86
Mean	62.34	69.28	80.44	64.61	69.17
CD (p=0.05)					
M at S	1.090	1.260	1.470	1.111	
S at M	1.051	1.212	1.411	1.123	

[Values in parentheses are per cent changes over respective control (M_1 and S_1)]

4. CONCLUSION

In this present investigation application of various levels of nitrogen and plant growth regulators 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively + Urea 2% foliar spray + Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP respectively *i.e.* M_4S_5 recorded the highest chlorophyll content and chlorophyll stability index which was on par with the M_3S_5 : 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively)+ Salicylic acid (SA) 100 ppm @ 3,5 and 7 MAP respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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