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Effect of Different Nitrogen Levels and Plant Growth Regulators on Stomatal Resistance, Leaf Temperature and Transpiration Rate and Yield of *Banana cv* Ney Poovan

C. Tamilselvi [a], S. Arulselvi [a*], G. Sathish [b], A. Punitha [c], V. A. Vijayashanthi [a], P. Yogameenakshi [d], K. Sivagamy [a], T. L. Preehi [a] and S. Banumathy [a]

[a] ICAR-Krishi Vigyan Kendra, TNAU, Tiruvallur, Tamil Nadu, India.
[b] Regional Research Station, TNAU, Vridhachalam, Tamil Nadu, India.
[c] ICAR-KVK, Tirur, India.
[d] Rice Research Station, TNAU, Tiruvallur, Tamil Nadu, India.

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 was carried out to understand the effects of certain plant growth regulators under different nitrogen levels on different gas exchanging parameters *viz.,* stomatal resistance, leaf temperature, transpiration rate and yield of banana cv. neypoovan. Different levels of nitrogen

**Corresponding author: E-mail: arulselvi.s@tnau.ac.in;*

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*viz.,*150 g Nplant^{-1} (45g + 75g +30g N plant^{-1} at 3,5 and 7 MAP, respectively), M_1 + Urea 2% foliar spray, 200 g N plant^{-1} (60g + 100g + 40g N plant^{-1} at 3,5 and 7 MAP respectively), M_3 + Urea 2% foliar spray and foliar spray of salicylic acid 100 ppm, mepiquat chloride 500 ppm, chlormequat chloride 1000 ppm, nitrobenzene 50 ppm, benzyl adenine 20 ppm and 25 ppm of 2, 4-D at 3rd , 5th and 7th month after planting were given and compared with untreated control.Salicylic acid treated leaves showed high stomatal resistance with low transpiration.

The yield components were favourably influenced by higher level of N application. Soil application of 200 g N plant^{-1} and giving two per cent urea spray on 3rd, 5th,and 7th month after planting distinctly enhanced all the yield components. Salicylic acid spray at 100 ppm improved the number of hands, fingers and finger size. Benzyl adenine at 20 ppm spray also was found beneficial in increasing yield components. More number of fingers per bunch were observed in benzyl adenine treatment. With maximum fruit weight, salicylic acid spray surpassed benzyl adenine by recording maximum bunch weight of 12.58 kg (13.9 % increase over control), while benzyl adenine recorded 12.52 kg (13.4 % increase).

Keywords: Banana; growth regulators; stomatal diffusive resistance; leaf temperature; transpiration rate and yield.

1. INTRODUCTION

One of the major fruit crops grown worldwide, particularly in the tropics, is the banana. Approximately 86 million bananas are produced worldwide each year, with India being the largest producer with 30.5 million tonnes produced annually, albeit the majority of those bananas are consumed locally. With an astounding yearly production of 7.2 million tonnes, Indonesia is the third-largest banana grower in the world, after China, which is the second-largest producer with 12.1 million tonnes annually. The Philippines, Indonesia, Brazil, Ecuador, China, Costa Rica, Mexico, Thailand, and Colombia are some of the other main banana-producing nations. Increasing fruit production is one of the strategies being used in India to address the growing food requirement of the country's ever expanding population. Among horticultural crops, contribution of banana to Agricultural Gross Domestic Product (AGDP) is the highest [1].

In order to realise potential yields in many commercial cultivars for targeted banana production, it is necessary to concentrate on standardising improved production technologies suitable for various cultivation systems. A few key strategies to close the yield gap between actual and potential yield per unit area are the following: selecting high-yielding varieties; planting healthy, disease-free planting material; determining the appropriate planting density; and applying inputs—such as irrigation water and nutrients—as needed and on time. David, [2].

Farmers that grow bananas use nonscientific management techniques that result in inefficient use of fertilizers and water which results in low output. Nisarga et al., [3]. 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 [4].

This study aims to manipulate vegetative growth, source size, and activity by varying nitrogen levels, and to enhance yield by improving assimilate translocation to developing sinks through the application of various growth-regulating chemicals.

2. MATERIALS AND METHODS

A field experiment in banana cv. Ney Poovan was conducted with various levels of nitrogen and plant growth regulators. The main plots are, M_1 (Control-150 g N plant^{-1} (45g + 75g +30g N plant^{-1} at 3,5 and 7 MAP, respectively), M_2 (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), M_4 (M_3 + Urea 2% foliar spray).The sub plot treatments are, S_1(Control (water spray), S_2 (Mepiquat chloride (MC) 500 ppm), S_3(Chlormequat chloride (CCC) 100 ppm), S_4 (Ethrel 500 ppm), S_5 (Salicylic acid (SA) 100 ppm), S_6 (Nitrobenzene 100 ppm), S_7 (Benzyl adenine (BA) 20 ppm), S_8(2,4- Dichlorophenoxy acetic acid (2, 4-D) 25 ppm).The leaf temperature, transpiration rate and stomatal diffusive resistance were estimated during 3rd, 5th and 7th month after planting and at harvest stages of the crop with measuring procedure was given below:

2.1 Leaf Temperature

Leaf temperature was recorded between 10.00 A.M to 12.00 noon at 3rd, 5th and 7th month after planting and at harvest stage using Steady State Porometer (LICOR 1600, Licor Inc, Nebraska, USA) and expressed as °C.

2.2 Stomatal Resistance

Stomatal resistance was assessed at 3, 5, and 7 months post-planting, as well as during harvest, utilising a Steady State Porometer between 10:00 AM and 12:00 noon (LICOR 1600, Licor Inc, Nebraska, USA), and reported in s cm-1.

2.3 Transpiration Rate

Transpiration rate was measured by using Steady State Porometer (LICOR-1600, Licor Inc, Nebraska, USA) at 3^{rd},5^{th},7^{th} month after planting and at harvest and expressed as µg H_2O cm^{-2} s^{-1}.

2.4 Yield and Yield Components

Five plants in each treatment were tagged for recording yield and yield components and the mean values of each treatment were worked out and expressed.

2.5 Bunch Weight

Bunch weight was recorded including the peduncle measuring 20 cm above the first hand and expressed in kg.

2.6 Number of Hands and Fingers Per Bunch

Total numbers of hands and fingers in each bunch were counted and recorded. The mean values were expressed in number.

2.7 Finger Weight

Two middle fingers each from top and bottom rows of the second hand of each bunch were removed with a sharp knife at the point of pedicel attachment with the fruit and the individual finger weight was recorded. The mean value was worked out and expressed in g.

2.8 Fruit Length

Length of the fruit was measured from the base of the pedicel to the tip of the fruit along the outer curvature and expressed as cm.

2.9 Statistical Analysis

The statistical analysis of the data was done by adopting the standard procedure of Gomez and Gomez (1984).

3. RESULTS

3.1 Stomatal Diffusive Resistance

In bananas, stomatal resistance was apparent on the rise up until the shooting stage. At every point, there were notable variations in the main storyline and subplot treatments. At every growth stage, the interaction effects were also discovered to be considerable. M_4 was observed to have lower stomatal resistance than M_3, M_2, or M_1 among the nitrogen dosages; at 5, 7 MAP, and harvest stages, it recorded values that were 12.7, 29.1, and 5.7% lower than the control. Salicylic acid spray (S_5), one of the plant growth regulators, recorded levels of 1.46, 5.18, 6.55, and 1.24 at 3, 5, 7 MAP and at harvest, respectively, representing 19.7, 12.4, 14.3, and 49.4% increase over control while nitrobenzene, benzyl adenine and 2,4-D appeared to reduce the resistance (Table 1).

Maximum values for M_1S_1 and M_2S_5 were reported at 7 MAP (7.98) and harvest (1.37), whereas high values for M4S5 were recorded at 3 MAP (1.59) and M3S4 at 5 MAP (5.49). M_4S_7 and M_4S_8, which combined observations from all stages to record the lowest mean values of 2.66, were mostly associated with very low values.

3.2 Transpiration Rate (µg H2O cm-2 s-1)

Transpiration rate data showed that different plant growth regulators had a considerable effect on transpiration rate at every growth stage. Nevertheless, there were no discernible variations between the nitrogen levels.

In every stage selected for the subplot treatments, control plants showed a high transpiration rate; however, at 3 MAP, 2, 4-D, and benzyl adenine treatments showed higher rates than control. The transpiration rate was much lower in almost every growth regulator treatment than in the control. Salicylic acid spraying at 100 ppm was the least effective at 3 and 7 MAP (21.8 and 21.4 percent lower than control, respectively), whereas mepiquat chloride and CCC showed reduced transpiration rates at 5 MAP and harvest, by 19.5-27.2 percent, respectively, below control values. Nitrobenzene, benzyl adenine, and 2,4-D were the growth regulators that had high transpiration rates that were practically identical to those of the untreated control plants (Fig. 1 and Table 2).

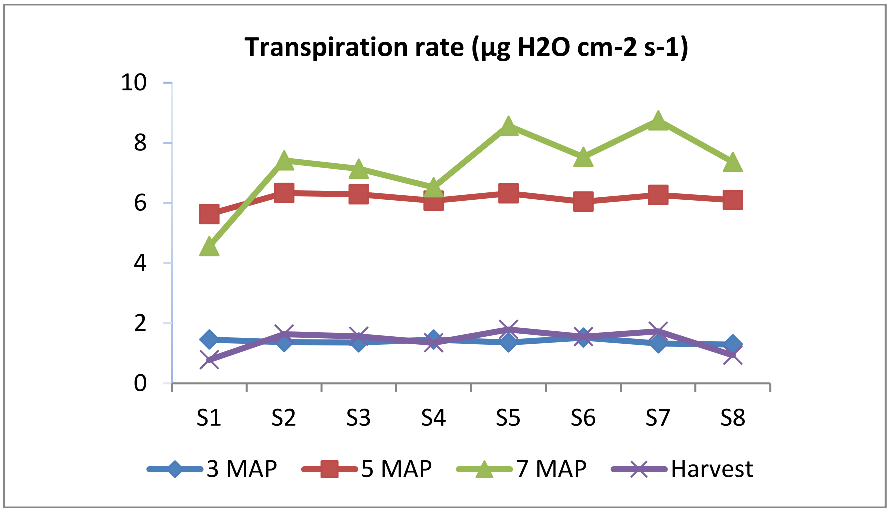

Fig. 1. Effect of different growth regulators and chemicals on transpiration at different growth stages

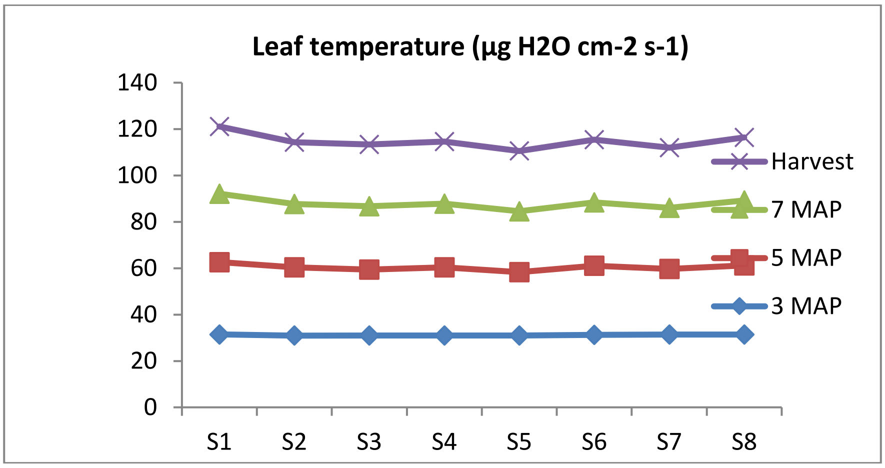

Fig. 2. Effect of different growth regulators and chemicals on transpiration at different growth stages

In the stages of observation, significant interaction effects were noted. At 3 MAP (8.44), M_2S_8 displayed a maximum transpiration rate that was similar to that of M_3S_8. M_1S_7 showed lower rates at 5 and 7 MAP during harvest; the control group recorded the highest rate (8.50); in contrast, M_4S_5 showed lower rates at 5 and 7 MAP (6.91 and 6.14), respectively. If we take the average of all the stages together, M_3S_8 recorded the highest mean value of 6.97, and M1S5 recorded the lowest mean value of 5.10.

3.3 Leaf Temperature (°C)

The temperature of the banana leaf seemed to decline steadily as the crop grew older. Nitrogen doses were not able to cause notable differences in any of the crop growth stages. Nonetheless, there was a little drop in leaf temperature with increased nitrogen dosage.

However, notable variations were noted between the several plant growth regulators at every stage of crop development. Salicylic acid appeared to consistently lower the leaf temperature in all phases, with all growth regulator treatments recording temperatures lower than the control treatment. CCC and mepiquat chloride both significantly lowered the temperature. Conversely, among the compounds tested, 2, 4-D (S8), benzyl adenine (S_7), and nitrobenzene (S_6) all caused elevated leaf temperature. (Table 3 and Fig. 2).

Table 1. Effect of different levels of nitrogen and plant growth regulators on stomatal resistance (s cm^{-1}) at different growth stages of *banana cv*. Ney Poovan

Treatments Main Plot	3 MAP		5 MAP		7 MAP		Harvest		Mean
M_1	1.33	(0.0)	4.89	(0.0)	6.96	(0.0)	6.96	(0.0)	**5.04**
M_2	1.34	(0.8)	4.92	(0.6)	6.58	(-5.5)	6.58	(0.9)	**4.86**
M_3	1.28	(-3.8)	4.84	(-1.0)	5.90	(-15.5)	5.90	(-8.5)	**4.48**
M_4	1.43	(7.5)	4.27	(-12.7)	4.88	(-29.1)	4.88	(-5.7)	**3.87**
Mean	**1.34**		**4.73**		**6.08**		**6.08**		**4.56**
CD (p=0.05)	0.003		0.020		0.020		0.003		
Sub Plot									
S_1	1.22	(0.0)	4.61	(0.0)	5.73	(0.0)	1.12	(0.0)	**4.32**
S_2	1.46	(19.7)	4.96	(7.6)	6.22	(8.6)	1.68	(38.6)	**4.71**
S_3	1.41	(15.6)	4.90	(6.3)	6.48	(13.1)	1.78	(27.7)	**4.82**
S_4	1.33	(9.0)	4.76	(3.3)	6.72	(17.3)	1.38	(44.6)	**4.88**
S_5	1.46	(19.7)	5.18	(12.4)	6.55	(14.3)	1.24	(49.4)	**4.94**
S_6	1.29	(5.7)	4.44	(-3.7)	5.86	(2.3)	1.81	(24.1)	**4.36**
S_7	1.33	(9.0)	4.46	(-3.3)	5.71	(-0.3)	1.13	(0.0)	**4.30**
S_8	1.27	(4.1)	4.54	(-1.5)	5.37	(-6.3)	1.20	(4.8)	**4.13**
Mean	**1.34**		**4.73**		**6.08**		**6.08**		**4.56**
CD (p=0.05)	0.004		0.020		0.020		0.003		
Interaction CD									
CD (p=0.05)									
M at S	0.010		0.030		0.040		0.010		
S at M	0.010		0.030		0.040		0.010		

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

Table 2. Effect of different levels of nitrogen and plant growth regulators on leaf temperature (ºC) different growth stages of banana cv. Ney Poovan (Main effect)

Treatments Main Plot	3 MAP		5 MAP		7 MAP		Harvest		Mean
M_1	30.3	(0.0)	29.6	(0.0)	28.1	(0.0)	27.2	(0.0	**28.8**
M_2	30.3	(0.0)	29.6	(0.0)	28.1	(0.0)	27.4	(0.7	**28.9**
M_3	29.9	(-1.3)	29.6	(0.0)	27.8	(-1.1)	27.0	(-0.7	**28.6**
M_4	29.3	(-3.3)	29.3	(-1.0)	27.9	(-0.7)	27.6	(1.5	**28.5**
Mean	**30.0**		**29.5**		**28.0**		**27.3**		**28.7**
CD (p=0.05)	0.080		0.083		0.081		0.072		
Sub Plot									
S_1	30.7	(0.0)	30.7	(0.0)	29.4	(0.0)	29.0	(0.0)	**29.9**
S_2	29.0	(-5.5)	29.2	(-4.9)	27.2	(-7.5)	26.5	(-8.6)	**28.0**
S_3	29.5	(-3.9)	28.5	(-7.2)	27.2	(-7.5)	27.5	(-5.2)	**28.2**
S_4	29.6	(-3.6)	29.3	(-4.6)	27.4	(-6.8)	26.6	(-8.3)	**28.2**
S_5	29.1	(-5.2)	28.4	(-7.5)	26.9	(-8.5)	26.3	(-9.3)	**27.7**
S_6	30.6	(-0.3)	30.3	(-1.3)	28.7	(-2.4)	27.5	(-5.2)	**29.3**
S_7	30.4	(-1.0)	29.3	(-4.6)	28.1	(-4.4)	27.5	(-5.2)	**28.8**
S_8	30.6	(-0.3)	30.4	(-1.0)	29.0	(-1.4)	27.6	(-4.8)	**29.4**
Mean	**30.0**		**29.5**		**28.0**		**27.3**		**28.7**
CD (p=0.05)	0.080		0.089		0.087		0.079		
Interaction CD									
CD (p=0.05)									
M at S	0.184		0.184		0.171		0.165		
S at M	0.176		0.176		0.164		0.179		

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

Table 3. Effect of different levels of nitrogen and plant growth regulators on transpiration (µg H_2O $cm^{-2}s^{-1}$) different growth stages of *Banana cv*. Ney Poovan

Treatments Main Plot	3 MAP		5 MAP		7 MAP		Harvest		Mean
M_1	6.33	(0.0)	8.04	(0.0)	7.68	(0.0)	2.18	(0.0)	**6.06**
M_2	7.03	(11.1)	8.02	(0.2)	7.68	(0.0)	1.89	(-13.3)	**6.15**
M_3	6.86	(8.4)	8.10	(0.7)	7.35	(-4.3)	2.10	(-3.7)	**6.10**
M_4	6.72	(6.2)	8.07	(0.4)	7.37	(-4.0)	2.01	(-7.8)	**6.04**
Mean	**6.73**		**8.06**		**7.52**		**2.05**		**6.09**
CD (p=0.05)	0.002		0.001		0.001		0.005		
Sub Plot									
S_1	7.35	(0.0)	8.87	(0.0)	8.31	(0.0)	2.24	(0.0)	**6.69**
S_2	6.00	(-18.4)	7.17	(-19.5)	7.02	(-15.5)	1.65	(-26.3)	**5.46**
S_3	6.32	(-14.0)	7.31	(-17.6)	6.91	(-16.8)	1.63	(-27.2)	**5.54**
S_4	6.08	(-17.3)	7.43	(-16.2)	7.37	(-11.3)	2.09	(-6.7)	**5.75**
S_5	5.75	(-21.8)	7.50	(-15.4)	6.53	(-21.4)	1.71	(-23.7)	**5.37**
S_6	7.08	(-3.7)	8.54	(-3.7)	7.71	(-7.2)	2.18	(-2.7)	**6.38**
S_7	7.63	(3.8)	8.86	(-0.1)	8.22	(-1.1)	2.53	(12.9)	**6.81**
S_8	7.66	(4.2)	8.78	(-1.0)	8.09	(-2.6)	2.33	(4.0)	**6.71**
Mean	**6.73**		**8.06**		**7.52**		**2.05**		**6.09**
CD (p=0.05)	0.004		0.002		0.003		0.013		
Interaction CD									
CD (p=0.05)									
M at S	0.002		0.001		0.001		0.011		
S at M	0.003		0.001		0.003		0.011		

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

Among the many interactions of main and subplot treatments, low leaf temperatures were specifically noted in M_4S_2, M_4S_3, and M_4S_5 treatments. When main plot treatments were combined with control (S_1), the leaf temperatures were consistently higher than when they were not combined.

3.4 Yield and Yield Components (Table 4)

Two levels of nitrogen as soil application with or without foliar application of urea were studied in banana cv. Ney Poovan. In each of the above main plot treatments, foliar spray of seven growth regulators in addition to untreated control were tried as sub plots. The effects of these treatments on yield and yield parameters are presented in Table 4.

Data on **finger length** revealed significant differences among main, sub plot and interaction treatments. Finger length ranged from 13.5 cm in M_1 to 14.6 cm in M_3. Both M_3 and M_4 recorded comparable values with 8.1 and 7.4 per cent increased finger length over control. Foliar spray was effective at low nitrogen fertilization of 150 g N plant^{-1} (M_2) with 5.2 per cent increased value over M_1 (soil application of 150 g N plant^{-1}). Foliar application of benzyl adenine (S_7) excelled among the growth regulator treatments (15.0 cm) with 11.9 per cent increased fruit length over control. Salicylic acid (S_5) and 2,4-D (S_8) also produced increased fruit lengths by 11.2 and 10.4 per cent respectively over control.

By increasing nitrogen dose from 150 to 200 g of plant^{-1}, **finger girth** was increased by 5.52 per cent (from 12.7 in M_1 to 13.4 in M_3). However, giving foliar spray of urea in addition to soil application of N at 150 g plant^{-1} showed 5.5 per cent increase, and over 200 g plant^{-1} the foliar spray facilitated 10.2 per cent increase over control. Benzyl adenine spray (S_7) recorded the maximum finger girths of 14.8 cm (22.3 % increase over control), which was closely followed by S_5 with 14.6 cm (20%) increase. Ehrel produced to the least effect (6.6% increases) among the growth regulators. Benzyl adenine and 2, 4-D showed moderate effects in enhancing the fruit girth.

Table 4. Effect of different levels of nitrogen and plant growth regulators on yield and yield components of banana cv. Ney Poovan

Treatments	Finger length (cm)	Finger girth (cm)	Number of hands/bunch	Number of fingers/bunch	Finger weight (g)	Bunch weight (kg)
Main plot						
M_1	13.5 (0.0)	12.7 (0.0)	9.7 (0.0)	152.3 (0.0)	50.1 (0.0)	10.70 (0.0)
M_2	14.2 (5.2)	13.4 (5.5)	10.0 (3.1)	155.7 (2.2)	53.6 (7.0)	11.51 (7.6)
M_3	14.6 (8.1)	13.4 (5.5)	10.0 (3.1)	154.2 (1.2)	56.6 (13.0)	12.20 (14.0)
M_4	14.5 (7.4)	14.0 (10.2)	10.2 (5.2)	158.9 (4.3)	55.4 (10.6)	12.36 (15.5)
Mean	**14.2**	**13.4**	**10.0**	**155.3**	**53.9**	**11.69**
CD (p=0.05)	**0.10**	**0.09**	**NS**	**1.10**	**0.41**	**0.10**
Subplot						
S_1	13.4 (0.0)	12.1 (0.0)	9.1 (0.0)	148.5 (0.0)	52.1 (0.0)	11.0 (0.0)
S_2	14.1 (5.2)	13.0 (7.4)	9.8 (7.7)	157.0 (5.7)	52.4 (0.6)	11.56 (3.8)
S_3	14.3 (6.7)	13.1 (8.3)	10.0 (9.9)	150.7 (1.5)	54.5 (4.6)	11.54 (4.5)
S_4	13.4 (0.0)	12.9 (6.6)	10.1 (11.1)	151.2 (1.8)	51.2 (-1.7)	10.93 (-1.0)
S_5	14.9 (11.2)	14.6 (20.7)	10.6 (11.6)	159.8 (7.6)	57.2 (9.8)	12.58 (13.9)
S_6	14.1 (5.2)	13.1 (8.3)	9.9 (8.8)	153.4 (3.3)	53.1 (1.9)	11.51 (4.3)
S_7	15.0 (11.9)	14.8 (22.3)	10.5 (11.5)	161.8 (9.0)	55.6 (6.7)	12.52 (13.4)
S_8	14.8 (10.4)	13.4 (10.7)	9.8 (7.7)	159.7 (7.5)	55.1 (5.8)	11.97 (8.4)
Mean	**14.2**	**13.4**	**10.0**	**155.3**	**53.9**	**11.69**
CD (p=0.05)	**0.10**	**0.09**	**0.06**	**0.95**	**0.34**	**0.09**

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

The values of **number of hands** ranged from 8.2 in M_1S_1 to 10.8 both in M_3S_5 and M_4S_7. The differences were significant among growth regulator treatments and interactions. N levels failed to reveal significant differences. But, M_4 recorded 10.2 hands per bunch, while M_1 recording 9.7. Among the sub plots, number of hands ranged from 9.1 in control to 10.6 in S_5. Other than S_5, S_7 also performed better with 10.5 hands per bunch.

Number of fingers ranged from 148.5 in S_1 to 161.8 in S_7. Benzyl adenine spray (S_7) increased the number of fingers by 9.0 per cent over that of control. This was followed by S_5 and S_8 with 7.6 and 7.5 per cent increases over control. Though all the growth regulators have performed better than untreated control in terms of finger number, CCC and ethrel treatments showed only negligible increases over control treatment.

Among the interactions, M_4S_7 performed well with maximum finger number of 168.6 followed by M_4S_8 (165.4) and M_4S_5 (165.2). The results indicated that the growth promoters, namely benzyl adenine and 2, 4-D or salicylic acid in collaboration with higher N dose might increase the finger number favourably.

The maximum bunch weight of 12.58 kg was recorded by giving foliar spray of salicylic acid at 100 ppm level, which resulted in 13.9 per cent increase over untreated control. Benzyl adenine treatment also performed better with 12.52 kg bunch weight and 13.4 per cent increase over control. 2, 4-D also revealed its usefulness by enhancing bunch weight by 8.4 per cent. The other growth regulators revealed very low influence in increasing bunch weight. However, ethrel spray adversely affected the bunch yield by reducing the weight by one per cent below that of control.

As higher nitrogen level showed profound influence on bunch weight in the present study, the growth regulator treatments in combination with higher nitrogen levels also performed better. Among the interactions, M_4S_5 recorded the highest bunch weight of 13.65 kg followed by M_4S_7 (13.28 kg) and M_3S_7 (13.16 kg). The results clearly indicated that 200 g N plant^{-1} as soil application in addition to two per cent urea spray, and foliar spray of either 100 ppm salicylic acid or 20 ppm benzyl adenine might result in increased fruit yield in banana cv. Ney Poovan.

4. DISCUSSION

By increasing nitrogen dose or by giving urea spray, stomatal resistance was found to decrease (Tab.1). Among the growth regulators, salicylic acid was found more effective in increasing stomatal resistance, while benzyl adenine performed poorly with low values. Apart from benzyl adenine, nitrobenzene and 2,4-D also showed low stomatal resistance. As stomatal resistance is an useful parameter in identifying drought resistant character, salicylic acid appears to be an useful tool for inducting resistance to drought. Zhu et al. [5] mentioned that increases in CO_2 concentrations will decrease stomata conductance, but carbon assimilation in the intercellular cell could be maintained at levels seen. Eris [6] observed significant increase in stomatal resistance in pepper with salicylic acid treatment. Anitha [7] reported promotary effect of cycocel treatment on stomatal resistance in banana leaves, which is in conformity with the present findings as all growth retarding chemicals including CCC (cycocel) maintained positive influence on stomatal resistance.

The effect of nitrogen application in altering transpiration was not noticed significantly (Fig. 2 and Table 2). However, all the growth regulators chosen for the present study showed their distinct impacts in lowering transpiration rate. Salicylic acid and mepiquat chloride were very effective in lowering rate of transpiration. The known growth promoters namely nitrobenzene, benzyl adenine and 2,4-D, on the other hand, failed to reveal any tangible effects. The effect of salicylic acid in reducing the rate of transpiration was confirmed in previous works [8].

Nitrogen produced only neglible effect on leaf temperature changes in banana. Salicylic acid, mepiquat chloride and cycocel were effective in reducing leaf temperature below that of control. On the other hand, nitrobenzene, benzyl adenine and 2,4-D had higher leaf temperature values. The reduced leaf temperature values in certain growth regulator treatments might be attributed to the maintenance of better water status in leaf tissues. Robinson and Bower [9].

The ultimate aim of any farmer will be to get maximum fruit yield with quality. If all the growth and physiological parameters are favourably settled, then the cumulative response could be manifested in terms of high fruit yield.

Increase in **finger length** was favoured by higher dose of nitrogen but giving urea spray over and above 200 g N plant^{-1} as soil application showed only negative influence on finger length. On the other hand, **finger girth** was substantially increased by urea spray in addition to soil application of N. Satheeshkumar (2002) also stated that urea spray tended to influence fruit circumference as compared to fruit length. Salicylic acid and benzyl adenine, which influenced many of the parameters in the present study, also revealed greater influence on finger girth than on finger length. Except ethrel, the other growth regulators tended to increase both finger length and finger girth. But, ethrel failed to show any influence on finger length, but had a moderate influence in increasing finger girth only.

Nitrogen levels showed only negligible influence on **number of hands per bunch**. But, the number was found high in higher dose of nitrogen. Ashok kumar and Shanmugavelu (1978), and Ramaswamy and Muthukrishnan (1974) obtained significant increases in number of hands by increasing N levels either by foliar application of urea or by soil application. Salicylic acid and benzyl adenine revealed greater influences in increasing the number of hands per bunch. Ethrel spray appeared to have a better influence on number of hands, while the treatment failed to show any positive effect on other yield components.

Number of fingers per bunch and **finger weight** decide the bunch weight and hence, are very valuable yield components in banana. The influence of nitrogen levels was more on finger weight than on finger number. However, maximum values in both the parameters were with high nitrogen dose. Giving urea spray, in addition to soil application, showed beneficial effect on these characters explicitly. Ramaswamy and Muthukrishnan (1974) observed significant correlation between leaf nitrogen and number of fingers. Chattopadhyay *et al,* (1980) also reported that number of fingers were increased significantly with N application. Among the growth regulators, the effect of benzyl adenine was in promoting finger number, while salicylic acid tended to increase finger weight. Ethrel which had very negligible influence on these two parameters.

The regulators had varying degrees of positive influences on these traits. Anitha [7] recorded increased fruit weight in cycocel and mepiquat chloride treated trees. Chattopadhyay *et al*. (1980) attributed increased fruit weight due to high N dose for obtaining greater bunch weights.

There was concomitant increase in **bunch weight** with increase in nitrogen dose.The results revealed the benefit of giving urea spray in addition to soil application, as was seen in bunch weight. Srikul and Turner (1995) observed increased fruit growth rate in banana with the increase in nitrogen dose. Several workers have reported increased bunch yield with high N levels at 200 g N plant^{-1} or nearer to this dose (Ramaswamy and Muthukrishnan,1974; Chattopadhyay *et al.,*1980; Nalina, 2002). As a culmination of favourable effects of major yield components, namely number of hands, number of fingers and finger weight, obtained by salicylic acid treatment, the maximum bunch weight of 12.58 kg was recorded in this treatment. However, Anitha [7] reported higher bunch weight in CCC treated plants than in salicylic acid treatment [10].

CCC treatment also increased the bunch weight by 3.8 per cent over that of control treatment, but the increase was not as high as that of salicylic acid or benzyl adenine, which are the better performing growth regulators as far as the present investigation is concerned.

5. CONCLUSION

The findings of this research also showedthat the leaf temperature, transpiration rate and stomataldiffusive resistance were greatly influenced by different nitrogen levels and plant growth regulators. Net photosynthesis and stomatal conductance revealed very high positive relationship with bunch yield, which were showing high rates at shooting stage in plants receiving nitrogen 200 g plant^{-1} with urea two per cent foliar spray and salicylic acid 100 ppm as combined spray.The yield and yield components were enhanced by high nitrogen fertilization of 200 g N plant^{-1} and foliar spray of urea. Salicylic acid and benzyl adenine spray produced further improvement in fruit yield. The enhancement in fruit yield by these treatments was by increasing finger number per bunch and finger weight. The results indicated that soil application of 200 g N plant^{-1} in three splits along with urea spray at two per cent concentration during third, fifth and seventh month after planting might be advocated for getting high fruit yield in banana cv. Ney Poovan. Additionally, by giving either salicylic acid spray at 100 ppm or benzyl adenine spray at 20ppm could further increase the yielding ability of the cultivar.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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