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Effect of different levels of N and P on ratoon banana (*Musa* spp. AAA)

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In India, banana is the important and highly remunerative fruit crop grown in tropical and subtropical region. It represents the second most important fruit crop after mango in India. Banana is grown throughout Asian countries but it is commercially cultivated on a large scale in the Indo-china region. A field experiment was carried out in the College Orchard, College of Agriculture, Punjab Agricultural University, during 2009. The objective of the study was to determine the proper rate of N and P fertilizers that would maximize the potential yield of commercially-grown banana Grand naine. Different levels of chemical fertilizers were applied, *viz.,* N (150, 200, 250 and 300 g/tree), P (60 and 90 g/tree) in addition to non-fertilized control (no N and P applied) treatment. The results indicated that vegetative growth parameters (that is, pseudostem height, pseudostem girth, number of leaves, leaf area index) of fertilized plants neither were significantly different nor produced better vegetative growth when compared to non-fertilized control plants. The fertilizer treatment T5 consisting of N (200 g N in 5 split doses and 60 g P_2O_5) numerically influenced the yield and fruit characteristics like bunch weight, number of hands per bunch, hand weight and number of fingers per hand of 'Grand naine' banana as compared to other treatments. Hence, this fertilizer dose of N and P was recommended for cultivation of 'Grand naine' banana in northern region (Punjab) of India.

Key words: Fruit yield, bunch weight, banana, nitrogen and phosphorus.

INTRODUCTION

Banana (*Musa* spp.) belongs to the family Musaceae and originated from South East Asia. It is the fourth important global food commodity and is grown in 4.5 million ha area with an annual production of about 73 million tons in the world (Anonymous, 2005). Banana is the leading fruit crop of India, ranks third in area (0.647 million ha) and first in production (23.20 million tons) among fruit crops (Anonymous, 2008) and grown in variety of soils provided with soil moisture, deep, well drained, friable loamy soil with adequate organic matter is ideal for its cultivation. In plains it is grown in well drained black cotton soil. The medium black and lighter soils of East Khandesh are also suitable. Banana is one of the fruit which has a restricted root zone. Therefore, two soil factors are important namely depth and drainage. In banana it is essential to induce quick growth and produce more leaves with larger area. So it is a gross feeder of nutrients and responds well to nitrogen and phosphorus.

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As Indian soils are deficient in nitrogen and phosphorus - these two plant nutrients together with organic manure play an important role to get good crop returns. The choice and dosage of nutrients to be applied depends on the cultivar, inherent soil fertility, stage of plant growth, climate etc.

The better vegetative growth ensures better bunch development. High fertilization requirement of banana is mainly due to its rapid and vigorous growth and high fruit yield. Grand Naine is a popular variety of banana grown mostly in all export oriented countries of Asia, South America and Africa. This is a superior selection of Giant Cavendish which was introduced to India in 1990's. Due to many desirable traits like excellent fruit quality, immunity to fusarium wilt etc, it has proved better variety (Singh and Chundawat, 2002). However, its requirement of nutrients through organic sources along with inorganic fertilizers is not well documented. Keeping this in mind, the present investigation was undertaken to find out the suitable combination of nitrogen (N) and phosphorus (P) fertilizers for Grand Naine banana. Banana being a new crop for Punjab, requisite information on nutrient management for optimum growth and fruiting is lacking. So there is an urgent need was felt to generate this valuable information for optimum production of banana under sub-tropical conditions of Punjab. Thus, the present studies were planned to gather the much needed information on nutrient management in banana.

MATERIALS AND METHODS

The present investigation was carried out at New Orchard of the Department of Horticulture, Punjab Agricultural University, Ludhiana during 2009. Nutrients (Nitrogen and Phosphorus) were applied to the ratoon crop. All plants were given uniform cultural practices, except the fertilizers treatments.

Layout of the experiment

Treatments

Main treatments - 2 (Phosphorus at 60 g and 90 g/plant)
Sub treatments - 6 (Nitrogen detailed below)
Number of replications - 3, Treatment unit - 8
Total number of experimental plants - 6 × 2 × 3 × 8 = 288
Design: Split plot design

Treatment details

T1 - 150 g N (5 split doses) + 60 g P_2O_5
T2 - 150 g N (5 split doses) + 90 g P_2O_5
T3 - 200 g N (4 split doses) + 60 g P_2O_5
T4 - 200 g N (4 split doses) + 90 g P_2O_5
T5 - 200 g N (5 split doses) + 60 g P_2O_5
T6 - 200 g N (5 split doses) + 90 g P_2O_5
T7 - 250 g N (4 split doses) + 60 g P_2O_5
T8 - 250 g N (4 split doses) + 90 g P_2O_5
T9 - 250 g N (5 split doses) + 60 g P_2O_5
T10 - 250 g N (5 split doses) + 90 g P_2O_5
T11 - 300 g N (5 split doses) + 60 g P_2O_5
T12 - 300 g N (5 split doses) + 90 g P_2O_5

Nitrogen application was in the form of urea
Phosphorus application was in the form of single superphosphate
Potassium application was in the form of muriate of potash

Time of application

Nitrogen - Urea in 4 split doses - April, May, June, and July; Urea in 5 split doses - May, June, July and August.
Phosphorus - Single superphosphate was applied at the time of planting along with farmyard manure. Potassium - Muriate of potash 200 g/plant was applied uniformly in 5 split doses at monthly intervals starting from June onwards (till September).Different NP combinations comprised of six levels of Nitrogen and two levels of Phosphorus.

Observations

Pseudostem height

The pseudostem height was measured from June to September at monthly intervals by using a steel measuring tape from the base of pseudostem to the emergence point of the peduncle and was recorded in centimeters.

Pseudostem girth

The pseudostem girth was measured from June to September with a steel measuring tape from 90 cm above the ground and was recorded in centimeters.

Leaf area index (Length × Breadth)

The length and breadth of leaves was recorded by using a steel measuring tape and expressed in centimeters. Leaf area was calculated with formula L × B × Constant factor. Constant factor 0.8 was developed by using calculated area with the help of graph paper.

Span of harvesting

The date of harvesting of each plant was judged by the criteria given by Dhillon et al. (2002), that is, the fruits were harvested when fruit colour changed from deep green to green and ridges on the skin change from angular to round.

Bunch weight

The bunch of each plant was weighed and recorded in kilograms per plant.

Number of hands per bunch

The number of hands per bunch was recorded and an average of eight plants was pooled.

Hand weight

The 2nd and 3rd hand of the bunch was weighed and recorded in

Table 1. Effect of various combinations of N and P fertilizers on pseudostem height (cm) of banana ratoon crop *cv* Grand Naine.

Treatment	June	July	August	September
T1 - 150 g N (5 split doses) + 60 g P_2O_5	41.00	49.93	111.95	200.75
T2 - 150 g N (5 split doses) + 90 g P_2O_5	40.00	48.40	111.35	199.37
T3 - 200 g N (4 split doses) + 60 g P_2O_5	43.24	52.66	118.50	209.48
T4 - 200 g N (4 split doses) + 90 g P_2O_5	42.50	51.08	116.86	207.00
T5 - 200 g N (5 split doses) + 60 g P_2O_5	43.80	53.16	119.58	210.64
T6 - 200 g N (5 split doses) + 90 g P_2O_5	42.44	51.91	118.52	208.45
T7 - 250 g N (4 split doses) + 60 g P_2O_5	42.09	51.68	117.16	207.02
T8 - 250 g N (4 split doses) + 90 g P_2O_5	41.30	50.91	115.49	205.57
T9 - 250 g N (5 split doses) + 60 g P_2O_5	41.93	50.58	115.71	204.19
T10 - 250 g N (5 split doses) + 90 g P_2O_5	40.27	49.42	113.30	200.46
T11 - 300 g N (5 split doses) + 60 g P_2O_5	41.85	51.96	117.00	206.28
T12 - 300 g N (5 split doses) + 90 g P_2O_5	41.18	49.64	115.16	202.57
CD at 5% (N × P)	NS	NS	NS	NS

kilograms.

Number of fingers per hand

The number of fingers per hand was recorded as an average of 3 randomly selected hands that is, upper, lower and middle.

Finger length

Finger length was recorded by measuring the length of mature fruits with scale. Fingers were taken from randomly selected hands.

Statistical analysis

The data recorded during the course of studies were statistically analyzed as per split plot design method (Chao and Lincoln, 1969).

RESULTS AND DISCUSSION

Effect of nitrogen and phosphorus fertilizers on growth parameters

The effect of various combinations of N and P treatments on vegetative growth was observed in terms of pseudostem height, girth, number of leaves and leaf area index. The uniform sized plant selection was done in the month of May and the data were recorded at monthly intervals starting from June till September, one month after the application of fertilizers. The results obtained are presented and discussed below:

Pseudostem height

The data pertaining to the effect of N and P fertilizers on pseudostem height is presented in Table 1, the various combinations of N and P treatment means was found to be non significant in all the months from June to September. However it is clear from the data that the Treatment T5 (200 g N in 5 split doses and 60 g P_2O_5) recorded maximum pseudostem height, but it was at par with all other treatment combination means.

It is also evident from the Table 2 that the pseudostem height is significantly influenced by various N Treatments. In the month of June, the mean maximum pseudostem height (43.12 cm) was observed with the application of 200 g N in 5 split doses (N3), followed by 200 g N in 4 split doses (N2) with the mean height of (42.87 cm). During the month of July, application of 200 g N in 5 split doses (N3) had significantly higher mean pseudostem height (52.53 cm) than all the other N Treatments. Likewise, in the months of August and September maximum mean pseudostem height (119.05 cm) and (209.54 cm) respectively, was recorded by application of 200g N 5 split doses (N3). The applications of different P Treatments (Table 3) also indicate significant effect on pseudostem height. It is clear from the data that the Treatment P1 (60 g P_2O_5) per plant had resulted in significantly higher mean pseudostem height from the month of June to September (42.32, 51.66, 116.65 and 206.39 cm), respectively, as compared to the Treatment P2 (90 g P_2O_5).The result of the experiment also did not record much difference in height of banana plants due to application of P at the rate of 60g and 90g P_2O_5 per plant, but lower dose of 60 g P_2O_5 was significantly better than 90 g P_2O_5.

Pseudostem girth

The data on the effect of different doses of N and P Treatments and their combinations on pseudostem girth are presented in Tables 4, 5 and 6. The application of

Table 2. Effect of various doses of applied N fertilizers on pseudostem height (cm) of banana ratoon crop *cv* Grand Naine.

N (g/tree)	June	July	August	September
N1 - 150 g N (5 split doses)	40.50	49.16	111.65	200.06
N2 - 150 g N (4 split doses)	42.87	51.87	117.68	208.24
N3 - 200 g N (5 split doses)	43.12	52.53	119.05	209.54
N4 - 250 g N (4 split doses)	41.70	51.29	116.32	206.29
N5 - 250 g N (5 split doses)	41.10	50.00	114.50	202.33
N6 - 300 g N (5 split doses)	41.52	50.80	116.08	204.43
CD 5%	0.45	0.60	0.78	1.49

Table 3. Effect of two different doses of applied P fertilizers on pseudostem height (cm) of banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90 g P_2O_5)	CD 5%
June	42.32	41.28	0.87
July	51.66	50.22	1.32
August	116.65	115.11	1.53
September	206.39	203.90	1.66

Table 4. Effect of various combinations of N and P fertilizers on pseudostem girth (cm) of banana ratoon crop *cv*Grand Naine.

Treatment	June	July	August	September
T1 - 150 g N (5 split doses) + 60 g P_2O_5	20.54	25.05	39.91	53.19
T2 - 150 g N (5 split doses) + 90 g P_2O_5	19.89	24.90	39.55	52.56
T3 - 200 g N (4 split doses) + 60 g P_2O_5	21.42	26.86	43.13	58.35
T4 - 200 g N (4 split doses) + 90 g P_2O_5	20.87	26.11	42.38	57.20
T5 - 200 g N (5 split doses) + 60 g P_2O_5	21.78	27.82	44.25	58.54
T6 - 200 g N (5 split doses) + 90 g P_2O_5	20.96	26.32	43.04	57.40
T7 - 250 g N (4 split doses) + 60 g P_2O_5	21.11	26.58	42.41	58.09
T8 - 250 g N (4 split doses) + 90 g P_2O_5	20.52	25.36	41.10	56.50
T9 - 250 g N (5 split doses) + 60 g P_2O_5	20.86	26.31	42.43	56.76
T10 - 250 g N (5 split doses) + 90 g P_2O5	20.63	25.01	40.01	54.44
T11 - 300 g N (5 split doses) + 60 g P_2O_5	21.31	26.57	41.92	57.41
T12 - 300 g N (5 split doses) + 90 g P_2O_5	20.10	26.03	40.26	55.73
CD at 5% (N × P)	NS	0.38	0.88	NS

Table 5. Effect of various doses of applied N fertilizers on pseudostem girth (cm) of banana ratoon crop *cv* Grand Naine.

N (g/tree)	June	July	August	September
N1 - 150 g N (5 split doses)	20.22	24.97	39.73	52.87
N2 - 150 g N (4 split doses)	21.14	26.48	42.75	57.77
N3 - 200 g N (5 split doses)	21.37	27.07	43.64	57.97
N4 - 250 g N (4 split doses)	20.81	25.97	41.75	57.29
N5 - 250 g N (5 split doses)	20.74	25.66	41.22	55.60
N6 - 300 g N (5 split doses)	20.70	26.30	41.09	56.57
CD 5%	0.45	0.27	0.62	0.57

Table 6. Effect of two different doses of applied P fertilizers on pseudostem girth (cm) of banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90 g P_2O_5)	CD 5%
June	21.17	20.49	0.19
July	26.53	25.62	0.19
August	42.34	41.06	0.58
September	57.05	55.63	0.77

various combinations of N and P Treatments had shown a significant effect on the pseudostem girth in the months of July and August, but in the month of June and September it was found to be non-significant.

However, in the month of July, different N and P Treatments and their combinations significantly influenced the pseudostem girth. The maximum pseudostem girth (27.82 cm) was recorded in treatment combination 200 g N 5 split doses and 60g P_2O_5 (T5) which was at par with combination 200 g N 4 split doses and 60g P_2O_5 (T3) with the height (26.86 cm) significantly higher than all the other combinations. The minimum pseudostem girth (24.90 cm) was recorded in NP Treatment T2 (150 g N 5 split doses and 90 g P_2O_5). Similarly in the month of August, the maximum pseudostem girth (44.25 cm) was recorded with the application of 200 g N 5 split doses and 60g P_2O_5 (T5) followed by Treatment 200g N 4 split doses and 60g P_2O_5 (T3) having pseudostem girth of 43.13 cm. The pseudostem girth of these treatments was significantly higher than all the other treatment combinations. The minimum pseudostem girth (39.55 cm) was recorded in T2 (150 g N 5 split doses and 90 g P_2O_5).

The data presented in Table 5 reveal that the application of different doses of N significantly influenced the pseudostem girth during June. The application of 200g N in 5 split doses (N3) per plant had maximum mean pseudostem girth (21.37 cm) however, it was at par with the treatment were 200 g N in 4 split doses (N2) was applied. The lowest mean pseudostem girth was recorded in Treatment N1 (150 g N in 5 split doses). It is quite evident from the data that in the month of July, the Treatment N3 (200 g N in 5 split doses) had the highest mean pseudostem girth (27.07 cm) which was at par with Treatment N2 (200 g N in 4 split doses) which had mean pseudostem girth of 26.48 cm. Similarly in the months of August and September the Treatment N3 (200 g N in 5 split doses) had the maximum mean pseudostem height that is, 43.64 cm, and 57.97 cm respectively. The lowest mean pseudostem girth was recorded in Treatment N1. The data presented in the Table 6 reveal that the applied P Treatments also has a significant effect on pseudostem girth, but among the phosphorus treatments, the Treatment P1 (60 g P_2O_5) had significantly higher mean pseudostem girth (21.17, 26.53, 42.34 and 57.05 cm) respectively, in all the months than the Treatment P2 (90 g P_2O_5). Tirkey et al. (2003) also reported similar results, as the growth rate of banana during May and June (initial stages) were not affected by the different nitrogen levels, split applications of NPK and their interactions. They further explained that non-significant difference in growth parameters during early months may be due to slow nutrient uptake at initial growth phase due to the reason that tissue cultured plants take time to get acclimatized under field conditions. The significant results at later stages may be due to better utilization of nutrients.

Number of leaves per plant

Data on number of leaves per plant is presented in Tables 7, 8 and 9. Like other growth parameters (height and girth) the effect of applied N and P Treatment combinations significantly influenced the number of leaves per plant during the months of June, August and September. However, in the month of July, it was found to be non-significant. In the month of June the maximum number of leaves per plant (9.10) were recorded (Table 7) in treatment where 200 g N 5 split doses and 60 g P_2O_5 (T5) was applied, however the number of leaves obtained where at par with the treatment where 200 g N 4 split doses and 60 g P_2O_5 (T3) were applied, while the minimum number of leaves per plant (7.30) were recorded in T2 (150 g N 5 split doses and 90g P_2O_5) combination. In the month of August, the maximum number of leaves per plant (13.05) were recorded in Treatment T5 (200 g N 5 split doses and 60g P_2O_5) followed by Treatment T6 (200 g N 5 split doses and 90 g P_2O_5) and the minimum number of leaves per plant (11.70) were recorded in T2 (150 g N 5 split doses and 90 g P_2O_5).

Similarly in the month of September the maximum number of leaves per plant (15.55) were recorded in Treatment T5 (200 g N 5 split doses and 60 g P_2O_5) which was however at par with T6 (200 g N 5 split doses and 90 g P_2O_5) and the minimum number of leaves per plant (13.68) were recorded in Treatment T1 (150 g N 5 split doses and 60 g P_2O_5). The perusal of data presented in Table 8 revealed that the various doses of N have significant influence on number of leaves per plant in all the months. During the month of June, the

Table 7. Effect of various combinations of N and P fertilizers on number of leaves per plant of banana ratoon crop *cv*Grand Naine.

Treatment	June	July	August	September
T1 - 150 g N (5 split doses) + 60 g P_2O_5	7.38	9.17	12.16	13.68
T2 - 150 g N (5 split doses) + 90 g P_2O_5	7.30	9.02	11.70	14.08
T3 - 200 g N (4 split doses) + 60 g P_2O_5	9.06	9.97	12.68	15.26
T4 - 200 g N (4 split doses) + 90 g P_2O_5	8.33	9.56	12.76	15.26
T5 - 200 g N (5 split doses) + 60 g P_2O_5	9.10	10.38	13.05	15.55
T6 - 200 g N (5 split doses) + 90 g P_2O_5	8.31	9.94	12.96	15.50
T7 - 250 g N (4 split doses) + 60 g P_2O_5	8.12	9.85	12.40	15.32
T8 - 250 g N (4 split doses) + 90 g P_2O_5	7.89	9.71	12.53	14.82
T9 - 250 g N (5 split doses) + 60 g P_2O_5	7.91	9.71	12.30	14.81
T10 - 250 g N (5 split doses) + 90 g P_2O_5	7.75	9.52	12.35	13.98
T11 - 300 g N (5 split doses) + 60 g P_2O_5	7.82	9.78	12.45	14.86
T12 - 300 g N (5 split doses) + 90 g P_2O_5	7.88	9.66	12.50	14.91
CD at 5% (N × P)	0.27	NS	0.24	0.30

Table 8. Effect of various doses of applied N fertilizers on number of leaves per plant of banana ratoon crop *cv* Grand Naine.

N (g/tree)	June	July	August	September
N1 - 150 g N (5 split doses)	7.34	9.09	11.93	13.88
N2 - 150 g N (4 split doses)	8.69	9.77	12.72	15.26
N3 - 200 g N (5 split doses)	8.70	10.16	13.00	15.52
N4 - 250 g N (4 split doses)	8.00	9.78	12.46	15.07
N5 - 250 g N (5 split doses)	7.83	9.61	12.32	14.39
N6 - 300 g N (5 split doses)	7.85	9.72	12.47	14.88
CD 5%	0.19	0.15	0.17	0.21

Table 9. Effect of two different doses of applied P fertilizers on number of leaves per plant of banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90 g P_2O_5)	CD 5%
June	8.23	7.91	0.18
July	9.81	9.57	0.73
August	12.50	12.46	NS
September	14.91	14.76	NS

Treatment N3 (200 g N in 5 split doses) had maximum mean number of leaves per plant (8.70) which however was at par with Treatment N2 (200 g N in 4 split doses) with (8.69) mean number of leaves per plant. Whereas the lowest mean number of leaves per plant (7.34) were recorded in Treatment N1 (150 g N in 5 split doses). Similarly in the month of July, Treatment N3 (200 g N in 5 split doses) had significantly higher mean number of leaves per plant (10.16). The lowest mean number of leaves (9.09) were recorded in Treatment N1 (150 g N in 5 split doses). Table 8 further revealed that in the months of August and September the Treatment N3 (200 g N in 5 split doses) had the higher mean number of leaves per plant (13.00 and 15.52), respectively. Whereas, the lowest mean number of leaves per plant (11.93 and 13.88) were recorded in the Treatments N1 (150 g N in 5 split doses), in the months of August and September, respectively.

The data pertaining to the effect of P fertilizers on number of leaves per plant is presented in the Table 9. It is clear from the data that in the early months viz., June and July the P treatments was significant, but in the later months it was found to be non-significant. The data further revealed that in both these months, Treatment P1 (60 g P_2O_5) had significantly higher mean number of leaves (8.23 and 9.81) per plant.

Table 10. Effect of various combinations of N and P fertilizers on leaf area index (cm^2) of banana ratoon crop *cv* Grand Naine.

Treatment	June	July	August	September
T1 - 150 g N (5 split doses) + 60 g P_2O_5	2018	3660	5605	6873
T2 - 150 g N (5 split doses) + 90 g P_2O_5	1961	3586	5491	6801
T3 - 200 g N (4 split doses) + 60 g P_2O_5	2619	4476	6283	7324
T4 - 200 g N (4 split doses) + 90 g P_2O_5	2562	4312	6218	7214
T5 - 200 g N (5 split doses) + 60 g P_2O_5	2718	4623	6393	7423
T6 - 200 g N (5 split doses) + 90 g P_2O_5	2702	4518	6389	7414
T7 - 250 g N (4 split doses) + 60 g P_2O_5	2365	4303	6104	7161
T8 - 250 g N (4 split doses) + 90 g P_2O_5	2268	4243	5983	7044
T9 - 250 g N (5 split doses) + 60 g P_2O_5	2047	3768	5796	6936
T10 - 250 g N (5 split doses) + 90 g P_2O_5	1965	3755	5825	6943
T11 - 300 g N (5 split doses) + 60 g P_2O_5	2176	3960	5934	7112
T12 - 300 g N (5 split doses) + 90 g P_2O_5	2114	3919	5891	6998
CD at 5% (N × P)	NS	NS	NS	NS

Table 11. Effect of various doses of applied N fertilizers on leaf area index (cm^2) of banana ratoon crop *cv* Grand Naine.

N (g/tree)	June	July	August	September
N1 - 150 g N (5 split doses)	1989	3623	5548	6837
N2 - 150 g N (4 split doses)	2590	4394	6250	7269
N3 - 200 g N (5 split doses)	2710	4570	6391	7418
N4 - 250 g N (4 split doses)	2316	4273	6044	7103
N5 - 250 g N (5 split doses)	2006	3761	5810	6939
N6 - 300 g N (5 split doses)	2145	3939	5912	7055
CD 5%	95.6	97.4	102.1	85.9

Table 12. Effect of two different doses of applied P fertilizers on leaf area index (cm^2) of banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90 g P_2O_5)	CD 5%
June	2324	2262	59.1
July	4131	4055	NS
August	6019	5966	NS
September	7138	7069	59.3

Leaf area index

The data pertaining to leaf area index are presented in Tables 10, 11 and 12. The different N and P combinations did not significantly influence this trait. However, the maximum leaf area index (2718, 4623, 6393 and 7423 cm^2) was recorded by application of Treatment T5 (200 g N 5 split doses and 60 g P_2O_5) however, it was at par with all other treatment combinations.

The data presented in Table 11, has revealed that the application of different doses of N have a significant effect on leaf area index in all the months. In the month of June, the Treatment N3 (200 g N in 5 split doses) resulted in significantly higher mean leaf area index (2710 cm^2) followed by Treatment N2 (200 g N in 4 split doses) with mean leaf area index of 2590 cm^2. Whereas the lowest leaf area index (1989 cm^2) was recorded in Treatment N1 (200 g N in 5 split doses). In the month of July, Treatment N3 (200 g N in 5 split doses) had the highest mean leaf area index (4570 cm^2) followed by the Treatment N3 (200 g N in 5 split doses) with mean leaf area index of 4394 cm^2. Whereas the lowest leaf area index of (3623 cm^2) was recorded in Treatment N1 (150 g

Table 13. Effect of various combinations of N and P fertilizers on Bunch weight (kg) and Mean no of hands per bunch of banana ratoon crop *cv* Grand Naine.

Treatment	Bunch weight (kg)	Mean no. of hands per bunch
T1 - 150 g N (5 split doses) + 60 g P_2O_5	15.88	7.19
T2 - 150 g N (5 split doses) + 90 g P_2O_5	15.37	7.08
T3 - 200 g N (4 split doses) + 60 g P_2O_5	17.57	10.08
T4 - 200 g N (4 split doses) + 90 g P_2O_5	17.17	9.41
T5 - 200 g N (5 split doses) + 60 g P_2O_5	18.11	10.61
T6 - 200 g N (5 split doses) + 90 g P_2O_5	17.65	9.98
T7 - 250 g N (4 split doses) + 60 g P_2O_5	16.83	9.09
T8 - 250 g N (4 split doses) + 90 g P_2O_5	16.51	8.50
T9 - 250 g N (5 split doses) + 60 g P_2O_5	16.08	7.51
T10 - 250 g N (5 split doses) + 90 g P_2O_5	15.79	7.30
T11 - 300 g N (5 split doses) + 60 g P_2O_5	16.42	8.11
T12 - 300 g N (5 split doses) + 90 g P_2O_5	16.12	7.62
CD at 5% (N × P)	NS	NS

Table 14. Effect of various doses of applied N fertilizers on Bunch weight (kg) and Hands per bunch in banana ratoon crop *cv* Grand Naine.

N (g/tree)	Bunch weight (kg)	Hands per bunch
N1 - 150 g N (5 split doses)	15.63	7.13
N2 - 150 g N (4 split doses)	17.37	9.75
N3 - 200 g N (5 split doses)	17.88	10.29
N4 - 250 g N (4 split doses)	16.67	8.80
N5 - 250 g N (5 split doses)	15.93	7.40
N6 - 300 g N (5 split doses)	16.27	7.86
CD 5%	0.22	0.35

N in 5 split doses). Similarly in the months of August and September, Treatment N3 (200 g N in 5 split doses) resulted in higher mean leaf area index of (6391 and 7418 cm^2, respectively) was followed by N2 (200 g N in 4 split doses) with mean leaf area index of (6250 and 7269 cm^2). Whereas the lowest leaf area index (5548 and 6837 cm^2) was recorded in Treatment N1 (200 g N in 5 split doses). The perusal of data presented in Table 12 revealed that the P treatments were non-significant in the month of July and August, but it had shown a significant effect in June and September. In the months of June and September, among phosphorus treatments the maximum leaf area index (2324 and 7138 cm^2) has been recorded in the Treatment P1 (60 g P_2O_5) as compared to the Treatment P2 (90 g P_2O_5).

These results showed a close relationship between temperature and number of leaves and leaf area index. During the months of July and August the range of temperature remained closer to the optimum growth temperature that is, 27°C which along with humidity were most favorable for the better growth of banana leaves. Arumugam and Manivannan (2001) also reported similar results with (200 g) nitrogen per plant.

Effect of nitrogen and phosphorus on fruit yield parameters

Bunch weight (kg/plant)

The data pertaining to the effect of different N and P Treatment and their combinations on bunch weight is presented in the Tables 13, 14 and 15. This revealed that N and P treatments significantly affected the yield but the effects of NP combinations were not-significant. The perusal of data presented in Table 5a, indicated that the plants with Treatment N3 (200 g N in 5 split doses) had significantly higher mean bunch weight (17.88 kg/plant) followed by the Treatment N2 (200 g N in 4 split doses) with bunch weight of 17.37 kg/plant and was significantly higher than all other treatments. The minimum mean bunch weight (15.63 kg/plant) was recorded in Treatment N1 (150 g N in 5 split doses). In case of phosphorus Treatments P1 (60 g P_2O_5) had significantly higher mean bunch weight (16.81 kg/plant) than P2 (90 g P_2O_5).

The increase in bunch weight by increasing N dose from (150 to 200 g/plant) could be attributed largely to increased growth, higher bunch weight, more number of

Table 15. Effect of two different doses of applied P fertilizers on Bunch weight (kg) and Hands per bunch in banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90g P_2O_5)	CD 5%
Bunch weight (kg)	16.81	16.43	0.32
Hands per bunch	8.76	8.31	0.25

fingers per hand and more number of hands per bunch, which might have been increased by timely availability of the nutrients at critical growth stages, which enhanced photosynthesis that lead to accumulation of more carbohydrates and other metabolites ultimately translocations towards the fruit tissue. Nitrogen is a constituent of nucleoproteins, amino acids, amines, amino sugars, polypeptides and many other organic compounds which are associated with all vital plant processes like photosynthesis, respiration, building plant structure and fatty acid synthesis etc. Where a yield decrease had occurred, it was due to an adverse effect of higher N dose on the availability of other nutrients, notably P or due to the toxicity caused by the release of excessive amounts of some other elements such as copper etc.

The results of the present study are in accordance with the findings of Naresh and Sharma (2004) reported that N application up to 240 g N/plant increased yield and above this dose it reduced the fruit yield significantly, due to possible toxic effects of N at higher levels in Jahajee Banana. P increased the growth and foliar status of tree which improved ATP formation thus providing more physiological efficiency to the tree which indirectly helped in better yield.

Number of hands per bunch

The data pertaining to number of hands per bunch is presented in Tables 13, 14 and 15. The data indicates that interaction between N and P Treatments is non-significant. The highest number of hands per bunch (10.61) were recorded by the application of Treatment T5 (200 g N 5 split doses and 60 g P_2O_5), while the lowest number of hands per bunch (7.08) were recorded in T2 (150 g N 5 split doses and 60 g P_2O_5). The data presented in Table 14. Further revealed that with the Treatment N3 (200 g N in 5 split doses) the significantly highest mean number of hands per bunch (10.29) were obtained followed by the Treatment N2 (200 g N in 4 split doses) with (9.75) mean number of hands per bunch. While the lowest mean number of hands per bunch (7.13) were recorded in Treatment N1 (150 g N in 5 split doses). In phosphorus treatments, P1 (60 g P_2O_5) resulted in significantly higher mean number of hands per bunch (8.76) and fingers per hand than Treatment P2 (90 g P_2O_5). The results on above said yield attributing characters like number of fingers per hands and number of hands per bunch in this experiment are in agreement with findings of Naresh and Sharma (2004) reported that N dose from 60 to 240 g/plant was effective in increasing the number of fingers per hand and number of hands per bunch and reduction in these characters were noticed beyond this nitrogen dose in Jahajee banana. This increase in yield attributing traits may be due to the availability of N during critical growth phase and increase in N supply resulted in translocation of more N to the top and this resulted in vigorous protein synthesis, utilizing the photosynthates produced by leaves for production of fingers and hands.

Hand weight (kg/bunch)

The effects of applied N and P on hand weight (kg/bunch) are presented in the Table 16. The data has revealed that the applied N and P Treatment combinations had not significantly influenced the hand weight (kg/bunch). It is evident from the data presented in Table 17. that with Treatment N3 (200 g N in 5 split doses) maximum mean hand weight of (2.14 kg/bunch) was obtained which however was at par with Treatment N2 (200 g N in 4 split doses) and N4 (250 g N in 5 split doses) with hand weight of (2.02 and 1.90 kg/bunch, respectively). The minimum mean hand weight of (1.65 kg/bunch) were recorded in Treatment N1 (150 g N in 5 split doses). Among phosphorus treatments as presented in Table 18 the Treatment P1 (60 g P_2O_5) had significantly higher mean hand weight of (1.92 kg/bunch).

Number of fingers per hand

The effect of applied N and P on number of fingers per hand is presented in the Table 16. The data revealed that the applied N and P treatment combinations did not significantly affect number of fingers per hand. However, it is evident from the data presented in Table 17, that various N doses have shown a significant effect on number of fingers per hand. The significantly higher mean number of fingers per hand (19.58) were recorded in Treatment N3 (200 g N in 5 split doses) followed by the Treatment N2 (200 g N in 4 split doses) with 18.99 fingers per hand. The minimum mean numbers of fingers per hand (16.14) were recorded in Treatment N1 were150 g N in 5 split doses was applied. The data presented in Table 16 reveal that P has a significant

Table 16. Effect of various combinations of N and P fertilizers on Hand weight (kg), Mean no fingers per hand and finger length (cm) of banana ratoon crop *cv* Grand Naine.

Treatment	Hand weight (kg)	Mean no of fingers per hand	Finger length (cm)
T1 - 150 g N (5 split doses) + 60 g P_2O_5	1.66	16.51	18.25
T2 - 150 g N (5 split doses) + 90 g P_2O_5	1.64	15.77	17.92
T3 - 200 g N (4 split doses) + 60 g P_2O_5	2.04	19.19	19.24
T4 - 200 g N (4 split doses) + 90 g P_2O_5	2.01	18.80	18.74
T5 - 200 g N (5 split doses) + 60 g P_2O_5	2.20	19.75	20.30
T6 - 200 g N (5 split doses) + 90 g P_2O_5	2.08	19.40	19.40
T7 - 250 g N (4 split doses) + 60 g P_2O_5	1.96	18.14	19.00
T8 - 250 g N (4 split doses) + 90 g P_2O_5	1.84	17.92	18.36
T9 - 250 g N (5 split doses) + 60 g P_2O_5	1.76	16.98	17.85
T10 - 250 g N (5 split doses) + 90 g P_2O_5	1.64	16.07	17.59
T11 - 300 g N (5 split doses) + 60 g P_2O_5	1.88	17.74	18.55
T12 - 300 g N (5 split doses) + 90 g P_2O_5	1.78	17.21	17.98
CD at 5% (N × P)	NS	NS	NS

Table 17. Effect of various doses of applied N fertilizers on Hand Weight (kg), Fingers per hand and Finger length

N (g/tree)	Hand weight (kg)	Fingers per hand	Finger Length (cm)
N1 - 150 g N (5 split doses)	1.65	16.14	18.08
N2 - 150 g N (4 split doses)	2.02	18.99	18.99
N3 - 200 g N (5 split doses)	2.14	19.58	19.85
N4 - 250 g N (4 split doses)	1.90	18.03	19.68
N5 - 250 g N (5 split doses)	1.70	16.52	17.72
N6 - 300 g N (5 split doses)	1.83	17.47	18.26
CD 5%	0.57	0.37	0.37

Table 18. Effect of two different doses of applied P fertilizers on hand weight (kg), Fingers per hand and Finger Length (cm) in banana ratoon crop *cv* Grand Naine.

P (g/tree)	P1 (60 g P_2O_5)	P2 (90 g P_2O_5)	CD 5%
Hand weight (kg)	1.92	1.83	0.16
Fingers per hand	18.05	17.53	0.82
Finger length (cm)	18.86	18.33	NS

effect on mean number of fingers per hand. Among phosphorus treatments, P1 (60 g P_2O_5) recorded significantly higher mean number of fingers per hand (18.05).

Finger length

The data on finger length as affected by different N and P treatments and their combinations is presented in Table 16. From perusal of data, it is clear that the finger length was significantly affected by different N treatments but P however the interaction between N and P combinations failed to show any significant effects. It is evident from the data presented in Table 17, that the different levels of applied N significantly influenced the finger length. The highest mean finger length (19.85 cm) was recorded by the application N3 (200 g N in 5 split doses) which was at par with N4 (250 g N in 4 split doses) having mean finger length of (19.68 cm) and significantly higher than the all other N treatments. The minimum mean finger length (17.75 cm) was recorded in Treatment N5 (250 g N in 5 split doses). The highest finger length with Treatment N3

(200 g N in 5 split doses) than all other N and P combinations may be due to significant effect of this treatment on vegetative characters like pseudostem height, girth, number of leaves, leaf area index etc which might have augmented photosynthesis and formation of more carbohydrates, thereby resulted in better finger size.

Conclusion

Application of four levels of N and two levels of P fertilizer greatly influence vegetative growth studied, which is pseudostem height, pseudostem girth, number of leaves and leaf area index. Application of fertilizers influenced the reproductive characteristics of 'Grand Naine' banana including total bunch weight, number of hands per bunch, hand weight and number of fingers per hand. However, long-term studies are needed to determine the residual effects of fertilizer application on soil and plants as well as its interaction with other factors such as irrigation, desuckering and management practices.

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