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Influence of Different Levels of Nutrients on Physiological Characters of Banana cv Ney Poovan (AB)

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Abstract Experiment was conducted to access the influence of different levels of nutrients (N, P_2O_5 and K_2O on physiological parameters. The amount of fertilizer to be applied is calculated based on the fertilizer adjustment equation, which takes into account of the quantity of NPK available in soil and organic inputs. The equation has been worked out at varying soil test value for different target levels (36 t ha^{-1}, 38 t ha^{-1}, 40 t ha^{-1}, 42 t ha^{-1}, 44 t ha^{-1}, 46 t ha^{-1} and 48 t ha^{-1}) target yield of banana has been worked out. The results revealed that the treatment T_5 (42 t ha^{-1}). The results showed that application of 189 g N, 28 g P_2O_5, 259 g K_2O $plant^{-1}$ $year^{-1}$ (T_5 -42 t ha^{-1}) showed that total chlorophyll (1.60 mg g^{-1}), chlorophyll *a* (1.16 mg g^{-1}), chlorophyll *b* (0.44 mg g^{-1}) and soluble protein (2.82 mg g^{-1}) contents were higher in T_5 at all the stages of observation than other treatments. T_5 recorded enhanced nitrate reductase activity (695.95 µg No_2 g^{-1} h^{-1}) during all the observed stages of crop growth.

Keywords Ney Poovan, Chlorophyll, Soluble protein, Nitrate reductase.

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Introduction

Banana (*Musa* spp.) is the second largest fruit crop in the world. It is the fourth most important global food commodity after rice, wheat and milk in terms of gross value of production. Banana is one of the major commodities in international trade, they are more important as starchy staple crops in local food economies. In India, it is one of the most important commercial fruits. Besides being a cheap and easily produced source of energy, it is rich in vitamins A, B6 and is a good source of minerals.

Banana is a fast growing plant requires continuous supply of nutrients and water for high yield. Fertilizer application is generally needed to satisfy plant requirements for obtaining profitable production. Poor

Table 1. Influence of fertilizers levels on chlorophyll *a* (mg g^{-1}), chlorophyll *b* (mg g^{-1}) and total chlorophyll (mg g^{-1}) content in Banana cv Ney Poovan (AB) at 5th month after planting (MAP).

		5 MAP (mg g^{-1})		
Treat-ments	Yield target	Chloro-phyll *a*	Chloro-phyll *b*	Total chloro-phyll
T_1 (Control)	34–35 t/ha	1.63	0.75	2.36
T_2	36 t/ha	1.61	0.71	2.33
T_3	38 t/ha	1.66	0.80	2.42
T_4	40 t/ha	1.68	0.83	2.47
T_5	42 t/ha	1.92	0.97	2.71
T_6	44 t/ha	1.84	0.92	2.57
T_7	46 t/ha	1.70	0.90	2.54
T_8	48 t/ha	1.68	0.86	2.47
SEd	–	0.026	0.014	0.059
CD (p=0.05)	–	0.056	0.030	0.117

Table 2. Influence of fertilizers levels on chlorophyll *a* (mg g^{-1}), chlorophyll *b* (mg g^{-1}) and total chlorophyll) mg g^{-1}) content in Banana cv Ney Poovan (AB) at shooting stage..

		Shooting stage (mg g^{-1})		
Treat-ments	Yield target	Chloro-phyll *a*	Chloro-phyll *b*	Total chloro-phyll
T_1 (Control)	34–35 t/ha	0.91	0.32	1.24
T_2	36 t/ha	0.88	0.31	1.18
T_3	38 t/ha	1.02	0.35	1.37
T_4	40 t/ha	1.05	0.36	1.42
T_5	42 t/ha	1.16	0.44	1.60
T_6	44 t/ha	1.09	0.42	1.52
T_7	46 t/ha	1.08	0.41	1.49
T_8	48 t/ha	1.07	0.37	1.44
SEd	–	0.016	0.013	0.034
CD (p=0.05)	–	0.034	0.026	0.067

agricultural and field management practices, especially over-irrigation, lack of fertilizer application and desuckering in developing countries lead to large losses in yield and fruit quality.

At present a dosage of 110:35:330 g of NPK is recommended for cv Ney Poovan under garden land condition in Tamil Nadu. Judicious nutrient management is often regarded as one of the important aspects to increase the productivity of fruit crops particularly banana. Efficient and rational use of the fertilizers is imperative not only for obtaining more yields per unit area on a sustainable basis, but also to ensure safe food and conserve the environment.

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Materials and Methods

To suggest soil test based balanced fertilization for banana, fertilizer prescription equations under IPNS were developed by NRCB, trichy following the inductive cum targeted yield model of Ramamoorthy et al. [1].

$$FN = (19.0 \times T) - (0.84 \times SN) - (0.28 \times ON)$$

$$FP = (2.41 \times T) - (0.76 \times SP) - (0.20 \times OP)$$

$$FK = (33.10 \times T) - (0.50 \times SK) - (0.45 \times OK)$$

Here, FN, FP, FK are nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) requirement (kg/ha) of banana cultivated in one hectare, respectively, through fertilizers. T is the target (tons/ha) of banana yield. SN, SP and SK are quantity (kg/ha) of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) already existing in the soil, before application of fertilizer. ON, OP and OK are quantity (kg/ha) nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) contributed from the recommended dose of organic manures applied to banana crop. For conducting the experiment, the amount blank proposed by TNAU (i.e, 110:35:330 g NPK per plant) was considered as control for comparison.

The amount of fertilizer to be applied is calculated based on the fertilizer adjustment equation, which takes into account of the quantity of NPK available in soil and organic inputs. The calculated fertil-

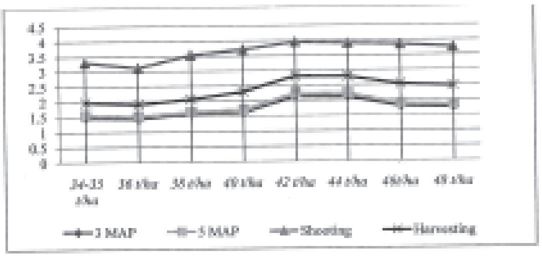

Fig. 1. Influence of different nutrient levels on soluble protein (mg g^{-1}) in banana cv Ney Poovan.

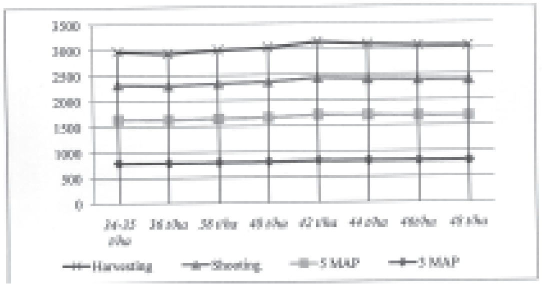

Fig. 2. Influence of different levels of nutrients on nitrate reductase (µg No_2 g^{-1} h^{-1}) in banana cv Ney Poovan.

izer quantities were conventionally applied at three splits in soil at 3rd, 5th and 7th month. One third of nitrogen and potassium along with entire phosphorus from inorganic fertilizer sources were applied at 3rd month while the remaining nitrogen and potassium dose where applied split as applied at 155th and 215th day.

Chlorophyll content in the leaf was estimated at different stages of crop growth namely 3rd MAP, 5th MAP, at shooting and at harvest using 80% acetone and the color intensity was read at 645 and 663 nm for chlorophyll *a* and chlorophyll *b* respectively and expressed as mg g^{-1}. The content of soluble protein was estimated from the leaf samples and expressed in mg g^{-1} fresh weight [2]. The nitrate reductase activity in leaf tissue was estimated and expressed as µg NO_2 $g^{-1}h^{-1}$ [3].

Results and Discussion

Chlorophyll *a* (mg g^{-1})

Significant differences were observed in the chlorophyll *a* content in leaf due to various nutrient levels at 3rd MAP and at shooting stages. The chlorophyll content varied from 1.35 to 1.74 mg g^{-1} at 3rd MAP and the range reached higher levels of 1.61 to 1.92 mg g^{-1} at 5th MAP. Among the various treatments, T_5 recorded significantly maximum values (1.74, 1.92, 1.76 and 1.16 mg g^{-1}) at all the four stages. During 5th MAP treatment T_1 and T_2 did not differ significantly. The chlorophyll *a* recorded by T_7 was on par with T_3, T_4 and T_8 at 5th MAP (Table 1). There was reduction in chlorophyll *a* content after 5th MAP. The chlorophyll *a* recorded by the T_6 (1.09 mg g^{-1}) was on par with T_7 (1.08 mg g^{-1}) and T_8 (1.07 mg g^{-1}) at harvesting stage. The treatment T_2 recorded the least chlorophyll values at 3rd MAP, at shooting and at harvesting stages.

Chlorophyll *b* (mg g^{-1})

Chlorophyll *b* content also varied significantly with the various levels of fertilizers in the different stages. Increasing fertilizer levels increased the chlorophyll *b* content. Among the various treatments, T_5 recorded significantly maximum values at 3rd MAP (0.87 mg g^{-1}), 5th MAP (0.97 mg g^{-1}), at shooting (0.94 mg g^{-1}) and at harvesting stage (0.44 mg g^{-1}). The treatment T_3 and T_4 did not differ significantly during 5th MAP. The value recorded by treatment T_6 was on par with T_7 at 5th MAP. The treatment T_5 and T_6 recorded significantly higher amount of chlorophyll contents at harvesting stage while T_1 and T_2 recorded as lower contents. The treatment T_2 recorded the lesser amounts of chlorophyll *b* at 3rd MAP (*0.57* mg g^{-1}), 5th MAP (0.71 mg g^{-1}), at shooting stage (0.68 mg g^{-1}) and at harvesting (0.31 mg g^{-1}) (Table 2).

Total chlorophyll (mg g^{-1})

The total cglorophyll content ranged from 1.93 to 2.65 mg g^{-1} at 3rd MAP, 2.33 to 2.71 mg g^{-1} at 5th MAP, 2.04 to 2.89 mg g^{-1} at shooting and 1.18 to 1.60 mg g^{-1} at harvesting (Table 3). Varying levels of nutrients at

Table 3. Influence of fertilizers levels on chlorophyll *a* (mg g^{-1}), chlorophyll *b* (mg g^{-1}) and total chlorophyll (mg g^{-1}) content in Banana cv Ney Poovan (AB) at harvesting stage.

Treat-ments	Yield target	Harvesting stage (mg g^{-1}) Chloro-phyll *a*	Chloro-phyll *b*	Total chloro-phyll
T_1 (Control)	34–35 t/ha	1.48	0.73	2.24
T_2	36 t/ha	1.36	0.68	2.04
T_3	38 t/ha	1.52	0.75	2.33
T_4	40 t/ha	1.62	0.79	2.45
T_5	42 t/ha	1.76	0.94	2.89
T_6	44 t/ha	1.70	0.87	2.76
T_7	46 t/ha	1.68	0.85	2.61
T_8	48 t/ha	1.65	0.82	2.55
SEd	–	0.027	0.006	0.061
CD (p=0.05)	–	0.058	0.013	0.122

different stages of plant growth significantly increased the total chlorophyll contents. Treatment T_5 and T_6 recorded significantly higher chlorophyll contents of 2.89, 2.76 mg g^{-1} at shooting stage. The treatment T_5 also recorded significantly maximum values at 5th MAP and at harvesting. Among all treatments T_2 was found to have lower chlorophyll content at all the stages of observation.

Soluble protein (mg g^{-1})

The soluble protein significantly varied among the treatments at different stages of growth (Fig. 1). The soluble protein content was increased up to shooting stage and reduced at harvesting. The treatment T_5 recorded the significantly high soluble protein content (2.14, 2.25, 3.95 and 2.82 mg g^{-1} at all the stages) followed by T_6 (2.12, 2.23, 3.90 and 2.79 mg g^{-1}). The treatment T_2 registered the significantly less soluble protein contents (1.43, 1.51, 3.12 and 1.90 mg g^{-1}) at different stages, followed by treatment T_1 (control) with lesser soluble protein contents of 1.47, 1.55, 3.31 and 1.97 mg g^{-1} in the corresponding stages.

Nitrate reductase activity (NRA) (µg NO_2 $g^{-1}h^{-1}$)

Nitrate reductase activity in leaf tissues significantly differed at all the stage of observation (Fig. 2). The nitrate reductase activity showed a decline after 5th MAP irrespective of the treatments. The treatment T_5 recorded significantly the highest nitrate reductase activities (823.51, 887.69, 727.45 and 695.95 µ g NO_2 $g^{-1}h^{-1}$) at all the four stages as compared to other treatments. The treatment T_2 consistently recorded the less nitrate reductase activity (789.41, 844.37, 664.13 and 625.35 µ g NO_2 $g^{-1}h^{-1}$) at all the stages. The nitrate reductase activity was higher in T_6 and T_7 next to T_5.

Favorable physiological processes will result in higher productivity, and any crop management practice that interrupts the physiological activity will lead to reduced productivity. In the present study, physiological efficiency in different treatments was assessed by estimating chlorophyll contents, soluble protein content and nitrate reductase activity.

The leaf chlorophyll content, a key factor in determining the rate of photosynthesis is also considered as an index of the metabolic efficiency of plants. This pigment, responsible for harnessing solar energy and converting it into chemical energy, exhibits a differential pattern in its accumulation in response to nutrients applied at different levels. A slight fluctuation in chlorophyll content is enough to trigger changes in physiological processes of plants, particularly, photosynthesis. In this present study, higher leaf chlorophyll content was recorded in the plants receiving 189 g N, 28 g P, 259 g K/plant thrice in a year at all stages of growth. This might be due to increase in uptake of nitrogen which stimulated to increased leaf chlorophyll content and in turn photosynthetic activity. Nitrogen is premier of photosynthetic activity directly related to chlorophyll synthesis. The chlorophyll content decreased with leaf nitrogen content might be the probable reasons for varying chlorophyll levels in the treatments [4]. The phenomenon of increased chlorophyll content with increased nutrition, as observed in the present study, was also reported by several workers like Ngugen et al. [5] and Sivakumar [6] in mango and Josefina et al. [7] in citrus. The total chlorophyll content was observed significantly high in plants due to better uptake of N and K. This might be due to increase in uptake of nitrogen which stimulated to increase leaf chlorophyll content and in turn photosynthetic activity. The decreased leaf nitrogen content might be the probable reason for varying chlorophyll levels in the treatments.

The increased chlorophyll *a*, chlorophyll *b* and total chlorophyll contents during 3^{rd} MAP, 5^{th} MAP and reduced in shooting and harvesting stages, as observed in the present study, was due to fact that movement of nutrients to the developing fruits during shooting and harvesting stages, therefore, inadequate level of nutrients leads to reduction in chlorophyll content at the time of fruit development.

Most of the plant leaf tissues are heavily comprised of the photosynthetic CO_2 fixation enzyme ribulose-1, 5-bisphosphate carboxylase/oxygenase (Rubisco) [8]. Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) is present at very high levels in photosynthesizing cells and must therefore be considered as the most abundant protein in the world [9]. Rubisco is the predominant protein in leaves of C_3 plants and may contribute up to 50% to the soluble leaf proteins and 20—30% of total leaf nitrogen [10]. In leaves of C_4 plants, Rubisco still contributes ~30% to the soluble proteins [9] and 5—9% of total leaf nitrogen [10]. In the present study, banana cv Ney Poovan maintained higher soluble protein content due to application of 189 g N, 28 g P_2O_5, 259 g K_2O/plant/year than other treatments. Nitrogen level could enhance the protein synthesis throughout the growth phase by direct participation as an essential constituent of protein [11]. Phosphorus is one of the three essential macronutrients of plants, it is also a pivotal regulator in many metabolisms, including protein activation [12]. High phosphorus levels could also intensify the protein synthesis by way of supplying metabolic energy. The increased level of potassium, however, did not influence the rate of protein synthesis.

Nitrate is the major source of inorganic nitrogen in most plants [13] and is converted to ammonium [14] via the Glutamate synthesis cycle in two successive steps catalyzed by nitrate reductase in the cytosol and chloro plasts of leaves. The acquired ammonia can go into amino acids, proteins, secondary metabolites and other important nitrogenous compounds. Since the reduction of nitrate to nitrite catalyzed by NR is the major rate limiting step; it is supposed to be the key enzyme in the process of nitrate assimilation by plants. Higher nitrate reductase activity was directly correlated with high leaf nitrogen content. In this study, application 189 g N, 28 g P_2O_5, 259 g K_2O/plant/year has improved the nitrate reductase enzyme activity at all the stages of crop growth, after this level reduced activity is noted. Similar trend of results have been documented that nitrogen supply stimulates nitrate reductase activity at low concentrations by positive effects of nitrate on the nitrate assimilation pathway. But at high nitrogen supplies, nitrate metabolites including ammonium and gutamine suppress nitrate assimilation pathway by inhibiting the related rate - limiting enzymes in the biosynthetic pathway. Utilization of N depended upon this enzyme and high activity was related to increased concentration of soluble protein content of the leaves [14]. It could also be understood from the present study that N, applied at higher doses had a greater impact on accelerating the N Rase activity.

Conclusion

Plants respond to different dose of fertilizer through alteration it's physiological and biochemical processes. Our results showed that in banana cultivar Ney Poovan with increasing trend of chlorophyll content, soluble protein and Nitrate reductase activity during shooting stage of the crop upto the treatment T_5 due to different dosage of fertilizer. After that decreasing trend of chlorophyll content, soluble protein and nitrate reductase activity during shooting stage of the crop is noted in remaining treatments. In this study, it could be observed that alteration of physiological parameters is possible by adjusting the dosage of fertilizer levels upto an extent. The physiological parameters for Ney Poovan could not be enhanced beyond 189:28:259 g $plant^{-1}$ NPK/year and at higher nitrogen and potassium levels, there was reduction in chlorophyll content, soluble protein and nitrate reductase activity (T_6, T_7 and T_8).

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