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**RESEARCH ARTICLE :**

# Influence of integrated nutrient management practices on nutrient uptake of banana under irrigated conditions

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**SUMMARY :** Nutrient uptake is greatly influenced by combined application of organic manures along with chemical fertilizers in banana. Field investigations were carried out at Northern Block farm, Agricultural Research Station (Tamil Nadu Agricultural University), Bhavanisagar, Erode district of Tamil Nadu during 2010-11 and 2011-12 to study the effect of integrated nutrient management (INM) practices on nutrient uptake of banana under irrigated conditions. The INM treatments had significant effect on nutrient uptake by roots, corm, pseudostem, midrib, petiole, lamina, inflorescence and fruits. Among the treatments, combined applicationof 100 per cent RDF either with 40 per cent *WG organic soil* ($T_3$) or FYM @ 10kg plant$^{-1}$($T_{12}$) recorded the maximum uptake of nitrogen, phosphorus and potassium in different parts of banana as well as total nutrient uptake.During 2010-11, the maximum uptake of nitrogen was observed in $T_3$ (380 and 568 kg ha$^{-1}$) at shooting and at harvest stages, respectively and similar results were found during 2011-12 also (355 and 587 kg ha$^{-1}$) whereas it was at par with $T_{12}$. At harvest stage the maximum uptake of phosphorus was observed with 100 per cent RDF along with 40 per cent *WG organic soil* (87and 84 kg ha$^{-1}$) but it was statistically at par with $T_{12}$. The same trend was noticed in potassium uptake also. Hence, it's concluded that integrated nutrient management practices *i.e.*, application of 100 per cent RDF either with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ recorded the maximum uptake of N, P and K by various parts of banana under irrigated conditions.

**KEY WORDS :**
Organic manures, inorganic fertilizers, Farm yard manure, Nitrogen, Phosphorus, Potassium uptake

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## BACKGROUND AND OBJECTIVES

Banana, an exhaustive user of water and nutrient due to large rhizosphere, rapid growth and high yielding nature, demands large quantities of nutrients through organic and inorganic sources (Lahav, 1973). Farmers apply essential plant nutrients in large quantities as synthetic inorganic fertilizers, since these are cheapest and easily available, when compared to organic manures. The continuous use of inorganic fertilizers leads to undesirable changes in the soil and environment and ultimately endanger the very sustainability of farming (Sharma, 1988). Inclusion of organic manures in nutrient

schedule of banana not only supplies micro-nutrients but also improve physical, chemical and biological properties of soil.

Hence, integrated nutrient management system was introduced with an aim of achieving efficient use of chemical fertilizers in conjunction with organic manures. Integrated nutrient management, a combined application of organic and inorganic sources of nutrients, maintains storage of plant nutrients in soil and improves nutrients-use efficiency which is essential for sustainable crop production, organic matter act as a source and a sink for plant nutrients as well as provides energy substrate for soil microorganisms. Thus, it enhances activities of soil flora and fauna as well as intrinsic soil properties, soil nutrient capital, water-holding capacity and soil structure in turn makes soil less susceptible to leaching and erosion. Therefore, INM practices are essential to maintain or enhance the soil quality and sustainability of an agro-ecosystem (Carter, 2002). Conjunctive use of FYM with recommended levels of inorganic fertilizers improves the soil fertility with increased yield of the crop. The availability of FYM in adequate quantities for integrated and conjunctive use with inorganic fertilizers to meet the requirement of the banana is a major limitation. However, there is scope for supplementing FYM with green manures, vermi-compost, bio-fertilizers and commercial organic formulations (Bhalerao *et al*., 2009).

Estimation of the removal of nutrients by plants is an important aspect to compute the quantity of nutrients to be added to the soil for sustaining higher yields. High and sustained yield could be obtained with judicious and balanced fertilization combined with organic manures (Kang and Balasubramanian, 1990). Keeping these aspects in view, the present research work was undertaken to study the effect of integrated nutrient management practices on uptake of banana under irrigated conditions.

## RESOURCES AND METHODS

Field experiments were carried out to study the effect of integrated nutrient management practices on nutrient uptake of banana under irrigated conditions at Northern block farm, Agricultural Research Station, Bhavanisagar during 2010-11 and 2011-12.The farm is geographically located at 11°29´ N latitude and 77°08´ E longitude at an altitude of 256 m above MSL. The normal weather conditions were prevailed at Bhavanisagar. A mean annual rainfall of 685 mm was received in 57 rainy days. The mean maximum and minimum temperatures recorded were 28-41°C and 18-26°C, respectively. Meanrelative humidity was 69.67 per cent and the bright sunshine hours per day was 4.67 with a mean solar radiation of 453 cal $cm^2$ $day^{-1}$.The soil of the experimental site was sandy loam in texture belonging to *Irugur* series and taxonomically known as *Udicustropepts* under USDA classification. The initial analysis of the experimental sites revealed that the soils were neutral (pH 7.06 and 7.18) with low soluble salts (EC 0.263 and 0.254 $dSm^{-1}$), medium and low in organic carbon content (0.51 and 0.46 %), low in available nitrogen (208 and 232 kg $ha^{-1}$), medium in available phosphorus (14.7 and 15.3 kg $ha^{-1}$) and high in available potassium (611 and 649 kg $ha^{-1}$) for 2010-11 and 2011-12, respectively.

The banana cv. GRAND NAINE (AAA) was used as test crop in both the years of study. *Wellgro* organic manures [*Wellgro soil, wellgro grains* and *Wellgro crops* (liquid organic manure)] were used as organic source of nutrients in integrated nutrient management of banana. *Wellgro* organic manures are a product of Indian Tobacco Company (ITC) and developed for soil application and foliar spray. These products are made from non-timber forest produce. Well decomposed farm yard manure was also used as organic manure. Nitrogen as urea, phosphorus as single super phosphate (SSP) and potassium as muriate of potash (MOP) were used as inorganic sources of nutrients.

Field experiments were laid out in Randomized Complete Block Design (RCBD) and treatments were replicated thrice as suggested by Gomez and Gomez (2010). Plot size was 14.4×5.4 $m^2$ (77.76 $m^2$) and plant spacing adopted was 1.8×1.8 $m^2$. The treatment comprises $T_1$- 100% recommended dose of fertilizer (control), $T_2$- 100% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, $T_3$- 100% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, $T_4$- 75% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, $T_5$- 75% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, $T_6$- 100% RDF + liquid organic manure spray (LOM) on bunches, $T_7$- 75% RDF + liquid organic manure spray (LOM) on bunches, $T_8$- 100% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, $T_9$- 100% RDF + *Wellgro grains* @ 40% w/w of chemical fertilizers, $T_{10}$- 75% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, $T_{11}$- 75% RDF + *Wellgro*

*grains* @ 40% w/w of chemical fertilizers, $T_{12}$- 100% RDF + FYM @ 10kg/plant and $T_{13}$- 75% RDF + FYM @ 10kg/plant.

Method of application: 165: 495 g and 123.7: 371.3 g NK plant$^{-1}$were applied in four equal split doses at 2$^{nd}$, 4$^{th}$, 6$^{th}$and 8$^{th}$ month after planting and total phosphorus (52.5 and 39.4 g P plant$^{-1}$) and FYM @ 10 kg plant$^{-1}$ were applied in a single dose at 2$^{nd}$month after planting. Fertilizers and organic manures (quantity as per the treatment) were applied in the basins which were formed around the pseudostem at distance of 30 cm and closed after the application. Liquid organic manure @ 2% was sprayed twice (*i.e.*, at 15 and 30 days after last hand opening) uniformly on the foliage and developing bunches. The other recommended cultural practices were followed uniformly for raising the crop as per the Crop Production Techniques of Horticultural crops (2004).

**Plant tissue analysis :**

The plant parts such as roots, corm, pseudostem, petiole, midrib, lamina, inflorescence, peduncle and fruits were collected at various growth stages for analysis.

**Nitrogen uptake :**

Nitrogen content in the plant samples was estimated by micro-kjeldhal method as per the procedure given by Bremner (1965). This was expressed as percentage on dry weight basis and computed to g plant$^{-1}$. The uptake of nutrients was worked out using the following formula.

$$\text{Nutrient uptake (g plant}^{-1}) = \frac{\text{Nutrient concentration (\%)}}{100} \text{ x Biomass yield}$$

**Phosphorus uptake :**

Phosphorus content was estimated by using triple acid digestion extract using photoelectric calorimeter with blue filter as described by Jackson (1973). The amount of phosphorus content determined by referring to a standard curve and the uptake computed was expressed in g plant$^{-1}$.

**Potassium uptake :**

Potassium uptake in the plant sample was estimated from triple acid extract using flame photometer (Jackson, 1973) and uptake was expressed in g plant$^{-1}$.

**Statistical analysis :**

The data were statistically analysed by the analysis of variance method as suggested by Gomez and Gomez (2010). Wherever the treatment differences were found significant, critical differences were worked out at 5 per cent probability level and the values are furnished. Non-significant treatment differences were denoted as NS.

## OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

**Table 1 : Effect of integrated nutrient management on nutrient uptake (g plant$^{-1}$)by corm**

| Treatments | 2010-11 | | | | | | 2011-12 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shooting | | | Harvest | | | Shooting | | | Harvest | | |
| | N | P | K | N | P | K | N | P | K | N | P | K |
| $T_1$ | 8.50 | 2.06 | 24.80 | 6.91 | 1.446 | 18.42 | 8.67 | 2.05 | 24.52 | 7.03 | 1.44 | 18.85 |
| $T_2$ | 9.06 | 2.16 | 26.32 | 7.36 | 1.597 | 19.47 | 9.74 | 2.24 | 27.39 | 7.63 | 1.61 | 20.29 |
| $T_3$ | 10.65 | 2.59 | 30.72 | 9.59 | 2.060 | 24.90 | 10.46 | 2.37 | 29.22 | 7.77 | 1.64 | 21.25 |
| $T_4$ | 8.55 | 2.04 | 25.62 | 6.77 | 1.425 | 18.22 | 8.70 | 2.07 | 24.96 | 7.30 | 1.47 | 19.35 |
| $T_5$ | 9.35 | 2.16 | 26.60 | 7.87 | 1.614 | 19.80 | 9.43 | 2.21 | 27.19 | 7.84 | 1.61 | 20.05 |
| $T_6$ | 8.54 | 2.03 | 25.00 | 6.86 | 1.426 | 18.51 | 8.69 | 2.05 | 24.52 | 6.83 | 1.46 | 18.89 |
| $T_7$ | 8.43 | 1.95 | 24.69 | 6.67 | 1.407 | 17.98 | 8.36 | 1.99 | 23.96 | 6.59 | 1.49 | 18.55 |
| $T_8$ | 9.19 | 2.22 | 27.07 | 7.79 | 1.571 | 19.83 | 9.62 | 2.22 | 27.24 | 7.67 | 1.63 | 19.76 |
| $T_9$ | 9.42 | 2.25 | 27.15 | 7.70 | 1.610 | 19.97 | 9.82 | 2.22 | 27.62 | 7.68 | 1.63 | 20.30 |
| $T_{10}$ | 8.76 | 2.06 | 25.28 | 7.05 | 1.507 | 18.95 | 8.86 | 2.08 | 25.07 | 7.32 | 1.48 | 19.16 |
| $T_{11}$ | 9.14 | 2.21 | 26.11 | 7.34 | 1.591 | 19.54 | 9.16 | 2.12 | 26.34 | 7.51 | 1.56 | 18.25 |
| $T_{12}$ | 10.91 | 2.48 | 30.90 | 9.17 | 1.783 | 22.20 | 10.16 | 2.34 | 28.48 | 7.74 | 1.65 | 20.75 |
| $T_{13}$ | 9.15 | 2.16 | 26.62 | 7.64 | 1.574 | 19.90 | 9.40 | 2.19 | 26.80 | 7.47 | 1.58 | 19.20 |
| S.E. $\pm$ | 0.26 | 0.134 | 1.39 | 0.43 | 0.084 | 0.66 | 0.48 | 0.08 | 1.25 | 0.20 | 0.02 | 0.45 |
| C.D. (P=0.05) | 0.54 | 0.277 | 2.87 | 0.89 | 0.174 | 1.37 | 1.00 | 0.16 | 2.59 | 0.41 | 0.04 | 0.94 |

**Nutrient uptake by corm :**

The INM treated plots significantly influenced the N, P and K uptake at both the shooting and harvest stages of banana.

During 2010-11, at shooting stage, the maximum uptake (10.91 g plant$^{-1}$) was observed with application of 100 per cent RDF + FYM @ 10kg plant$^{-1}$ ($T_{12}$). At harvest stage, application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) recorded the maximum uptake (9.59 g plant$^{-1}$) of N. However, both these treatments were statistically at par with each other during these stages. During 2011-12, the treatment $T_3$ registered the maximum N uptake (10.46 g plant$^{-1}$) at shooting stage. At harvest stage, application of 75 per cent RDF + 40 per cent *WG organic soil* ($T_5$) recorded the maximum uptake (7.84 g plant$^{-1}$) but it was statistically at par with $T_{12}$, $T_9$, $T_2$ and $T_8$ at shooting stage and $T_3$, $T_{12}$, $T_9$, $T_8$, $T_2$, $T_{11}$ and $T_{13}$ at harvest stage. The lowest N uptake was recorded with $T_7$ (75% RDF + 2% liquid organic manure spray on bunches) at both the stages of banana.

During 2010-11, at shooting stage, the treatment $T_3$ registeredhigher P uptake (2.59 and 2.060 g plant$^{-1}$ at shooting and at harvest stages, respectively) but it was on par with $T_{12}$ at shooting stage. During 2011-12, application of 100 per cent RDF along with 40 per cent *WG organic soil* ($T_3$) recorded the maximum P uptake (2.37 g plant$^{-1}$) at shooting. At harvest stage, the highest P uptake (1.65 g plant$^{-1}$) was observed with application of 100 per cent RDF + FYM @ 10kg plant$^{-1}$ ($T_{12}$). $T_3$ was statistically on par with $T_{12}$, $T_2$, $T_9$, $T_8$ and $T_5$ at shooting stage while $T_{12}$ was at par with $T_3$, $T_9$, $T_8$ and $T_5$ at harvest stage. The lowest P uptake at both stages was noticed with $T_7$ except at harvest stage during 2011-12 (Table 1).

During 2010-11, the maximum K uptake was registered with $T_{12}$ (30.90 g plant$^{-1}$) and it was on par with $T_3$ at shooting stage while $T_3$ recorded the maximum uptake (24.90 g plant$^{-1}$) at harvest stage. During 2011-12, $T_3$ registered the highest K uptake (29.22 and 21.25 g plant$^{-1}$ at shooting and at harvest stages, respectively) and it was comparable with $T_{12}$, $T_9$, $T_2$, $T_8$, $T_5$ and $T_{13}$ at shooting stage and with $T_{12}$ at harvest stage. The lowest K uptake was observed with $T_7$ at both these stages except at harvest stage during 2011-12.

**Nutrient uptake by pseudostem :**

Data pertaining to uptake by pseudostem at shooting and at harvest stages are presented in Table 2.

Application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) registered the maximum uptake (46.54 and 38.81 g plant$^{-1}$) at shooting and harvest stages, respectively during 2010-11. It was at par with $T_{12}$, $T_8$, $T_9$, $T_{13}$, $T_5$ and $T_2$ at shooting stage and $T_{12}$ at harvest stage. During 2011-12, application of 100 per cent RDF along with 40 per cent *WG organic soil* ($T_3$) recorded the maximum N uptake (42.76 and 37.98 g plant$^{-1}$) at shooting and at harvest stages, respectively. It was comparable with $T_{12}$, $T_4$, $T_2$, $T_9$, $T_5$, $T_{13}$, $T_8$ and $T_{11}$ at shooting stage and $T_{12}$ at harvest stage. The lowest uptake was observed with $T_7$ (75% RDF + 2% liquid organic manure spray on bunches) at two stage of banana growth during both the years.

**Table 2 : Effect of integrated nutrient management on nutrient uptake (g plant$^{-1}$) by pseudostem**

| Treatments | 2010-11 | | | | | | 2011-12 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shooting | | | Harvest | | | Shooting | | | Harvest | | |
| | N | P | K | N | P | K | N | P | K | N | P | K |
| $T_1$ | 34.21 | 5.92 | 101.38 | 29.33 | 4.422 | 46.57 | 35.22 | 6.251 | 102.47 | 31.37 | 4.51 | 45.78 |
| $T_2$ | 39.00 | 6.57 | 108.36 | 33.75 | 4.689 | 49.87 | 40.37 | 6.785 | 109.75 | 35.66 | 4.83 | 51.08 |
| $T_3$ | 46.54 | 7.60 | 128.21 | 38.81 | 5.493 | 58.21 | 42.76 | 7.074 | 113.79 | 37.98 | 5.16 | 53.95 |
| $T_4$ | 34.58 | 5.96 | 101.17 | 29.98 | 4.395 | 46.29 | 40.80 | 6.289 | 103.04 | 32.35 | 4.62 | 46.63 |
| $T_5$ | 39.28 | 6.49 | 112.09 | 34.38 | 4.856 | 51.93 | 39.31 | 6.621 | 107.83 | 35.31 | 4.81 | 50.76 |
| $T_6$ | 34.29 | 5.98 | 102.16 | 29.60 | 4.457 | 47.38 | 35.70 | 6.284 | 102.57 | 31.74 | 4.55 | 46.34 |
| $T_7$ | 33.55 | 5.83 | 100.22 | 28.98 | 4.385 | 46.21 | 35.08 | 6.257 | 101.67 | 31.16 | 4.50 | 45.83 |
| $T_8$ | 40.24 | 6.68 | 112.72 | 34.85 | 4.965 | 52.10 | 39.05 | 6.614 | 107.41 | 35.11 | 4.85 | 49.56 |
| $T_9$ | 39.91 | 6.78 | 114.69 | 33.96 | 4.920 | 51.21 | 40.04 | 6.758 | 110.87 | 36.03 | 4.90 | 51.76 |
| $T_{10}$ | 35.95 | 6.08 | 103.52 | 31.20 | 4.537 | 48.20 | 36.52 | 6.361 | 103.84 | 32.56 | 4.63 | 49.42 |
| $T_{11}$ | 36.43 | 6.32 | 109.30 | 32.16 | 4.718 | 50.10 | 38.37 | 6.517 | 106.05 | 34.92 | 4.77 | 49.97 |
| $T_{12}$ | 46.35 | 7.62 | 130.94 | 38.13 | 5.456 | 59.30 | 42.54 | 7.144 | 114.39 | 37.80 | 5.18 | 54.76 |
| $T_{13}$ | 39.47 | 6.73 | 112.04 | 33.62 | 4.893 | 51.40 | 39.17 | 6.636 | 107.72 | 34.60 | 4.76 | 50.45 |
| S.E. $\pm$ | 4.19 | 0.40 | 5.55 | 1.53 | 0.150 | 1.72 | 2.21 | 0.23 | 1.13 | 0.87 | 0.08 | 1.23 |
| C.D. (P=0.05) | 8.65 | 0.83 | 11.47 | 3.15 | 0.310 | 3.55 | 4.57 | 0.48 | 2.34 | 1.80 | 0.17 | 2.53 |

During 2010-11, P uptake was significantly increased with $T_{12}$ (7.62 g plant$^{-1}$) at shooting stage and $T_3$ at harvest stage (5.493 g plant$^{-1}$). It was statistically on par with $T_3$ at shooting stage and $T_{12}$ at harvest stage. During 2011-12, higher uptake was observed in $T_{12}$ (7.144 and 5.18 g plant$^{-1}$) at shooting and at harvest stages, respectively. However, it was statistically on par with $T_3$, $T_2$ and $T_9$ at shooting stage and $T_3$ at harvest stage. The lowest P uptake was observed with $T_7$ during 2010-11. During 2011-12, it was $T_1$ at shooting stage and $T_7$ at harvest stage.

During 2010-11, $T_{12}$ recorded the maximum uptake of K (130.94 and 59.30 g plant$^{-1}$) at shooting and harvest stages, respectively. It was comparable with $T_3$ at shooting and harvest stages. Similarly, 2011-12 also, application of 100 per cent RDF along with FYM @ 10kg plant$^{-1}$ ($T_{12}$) recorded the highest nutrient uptake (114.39 and 54.76 g plant$^{-1}$)at shooting and at harvest stages, respectively but it was on par with $T_3$ at both the stages of banana growth. The lowest K uptake was also noticed with $T_7$ except at harvest stage during 2011-12.

**Nutrient uptake by lamina :**

During both the years of the study, the integrated nutrient management practices influenced the nutrient uptake at shooting and at harvest stages of lamina (Fig. 1a and b).

During 2010-11, among the treatments, application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) registered the maximum N uptake (45.06 and 20.07 g plant$^{-1}$) at shooting and at harvest stages, respectively. It was comparable with $T_{12}$ at shooting stage and $T_{12}$, $T_5$, $T_{13}$, $T_8$, $T_9$, $T_2$ and $T_{11}$ at harvest stages. The same trend was observed during the second year also. Where, application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) recorded the maximum N uptake (39.28 and 16.84 g plant$^{-1}$) at shooting and at harvest stages, respectively. However, it was statistically on par with $T_{12}$ at both the stages of banana growth. The lowest N uptake was observed with $T_7$ except at harvest during 2010-11.During 2010-11, the treatment $T_3$ registered higher P uptake (4.81 and 2.430 g plant$^{-1}$) at shooting and at harvest stages, respectively, but it was comparable with $T_{12}$ at shooting and $T_8$ and $T_{12}$ at harvest stage. During 2011-12, the treatment $T_{12}$ (100% RDF + FYM @ 10kg plant$^{-1}$) registered the highest P uptake (4.13 and 2.03 g plant$^{-1}$) at shooting and at harvest stages, respectively, but, it was comparable with $T_3$ at shooting and harvest stages. The least P uptake was noticed under $T_7$ at shooting and $T_4$ at harvest during 2010-11 and $T_1$ during 2011-12.During 2010-11, the treatment $T_{12}$ registered the maximum K uptake (67.66 g plant$^{-1}$) at shooting stage and it was $T_3$ (28.16 g plant$^{-1}$) at harvest stage. However, it was comparable with each other at shooting and harvest stages. During 2011-12, the maximum K uptake was observed with $T_{12}$ (56.36 g plant$^{-1}$) at shooting stage and $T_9$ (25.05 g plant$^{-1}$) at harvest stage and it was at par with $T_3$ at shooting stage and $T_{12}$ at harvest stage. The lowest K uptake was observed in $T_7$ at shooting stage and $T_4$ at harvest stage during 2010-11. During the year 2011-12, it was $T_7$ at shooting (42.56 g plant$^{-1}$) and at harvest stages (18. 81 g plant$^{-1}$) of banana.

**Table 3 : Effect of integrated nutrient management on nutrient uptake (g plant$^{-1}$) by fruits**

| Treatments | 2010-11 | | | 2011-12 | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| $T_1$ - 100% RDF (Control) | 71.92 | 10.88 | 179.82 | 77.00 | 11.41 | 186.66 |
| $T_2$ - 100% RDF + 20% WS | 91.11 | 13.85 | 214.15 | 99.45 | 15.12 | 228.61 |
| $T_3$ - 100% RDF + 40% WS | 102.23 | 16.66 | 243.89 | 115.43 | 17.16 | 260.49 |
| $T_4$ - 75% RDF + 20% WS | 71.43 | 11.06 | 179.99 | 78.65 | 11.78 | 191.32 |
| $T_5$ - 75% RDF + 40% WS | 82.52 | 13.44 | 209.24 | 92.04 | 14.25 | 215.00 |
| $T_6$ - 100% RDF + WC spray | 72.60 | 11.42 | 182.83 | 81.38 | 11.88 | 193.87 |
| $T_7$ - 75% RDF + WC spray | 71.00 | 11.11 | 176.94 | 81.00 | 11.44 | 179.30 |
| $T_8$ - 100% RDF + 20% WG | 82.25 | 13.37 | 204.75 | 87.38 | 13.81 | 211.36 |
| $T_9$ - 100% RDF + 40% WG | 87.48 | 14.09 | 211.40 | 96.93 | 14.83 | 224.19 |
| $T_{10}$ - 75% RDF + 20% WG | 74.49 | 11.71 | 192.77 | 80.60 | 12.03 | 196.27 |
| $T_{11}$ - 75% RDF + 40% WG | 80.43 | 13.61 | 202.22 | 90.98 | 14.27 | 215.20 |
| $T_{12}$ - 100% RDF + FYM | 100.87 | 16.30 | 244.59 | 109.55 | 16.57 | 251.03 |
| $T_{13}$ - 75% RDF + FYM | 81.76 | 13.18 | 201.54 | 91.87 | 14.06 | 215.52 |
| S.E.$\pm$ | 3.64 | 0.52 | 4.74 | 1.89 | 0.19 | 2.23 |
| C.D. (P=0.05) | 7.52 | 1.08 | 9.78 | 3.90 | 0.39 | 4.60 |

**Nutrient uptake by fruits :**

Nutrient uptake by fruits was significantly influenced by various combinations of organic and inorganic fertilizers in banana.

Combined application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) recorded the maximum N uptake (102.23 and 115.43 g plant$^{-1}$) during 2010-11 and 2011-12 years, respectively. However, it was at par with $T_{12}$ during 2010-11 and 2011-12. The lowest N uptake was observed with $T_7$ during 2010-11 and $T_1$ during 2011-12 (Table 3).

Similarly, the highest P uptake was observed with $T_3$ (16.66 and 17.16 g plant$^{-1}$) during 2010-11 and 2011-12 and it was statistically at par with $T_{12}$ during 2010-11. The lowest P uptake was observed with $T_1$ during both the years of experimentation.

During 2010-11, the maximum K uptake (244.59 g plant$^{-1}$) was recorded with combined application of 100 per cent RDF + FYM @ 10kg plant$^{-1}$ ($T_{12}$) and it was on par with $T_3$. The treatment $T_3$ registered higher uptake (260.49 g plant$^{-1}$) of K during 2011-12. The lowest K uptake was noted with $T_7$ during 2010-11 and 2011-12.

**Total uptake of nutrients :**

Total uptake was influenced by combined application of recommended dose of fertilizers along with organic manures in both the years. On the whole, combined application of 100 per cent RDF along with either 40 per cent*WG organic soil* ($T_3$) or FYM @ 10kg plant$^{-1}$ ($T_{12}$) recorded the maximum uptake of nutrients at shooting as well as at harvest stages. During 2010-11, the maximum uptake of N was observed in $T_3$ (380 and 568 kg ha$^{-1}$) at shooting and at harvest stages, respectively. Whereas it was statistically at par with $T_{12}$ (372 and 550 kg ha$^{-1}$) in both the stages of banana. During 2011-12 also, application of 100 per cent RDF along with 40 per cent *WG organic soil* ($T_3$) registered the highest N uptake (355 and 587 kg ha$^{-1}$) at shooting and at harvest stages, respectively and it was at par with $T_{12}$ at shooting and harvest stages. The least total N uptake was recorded with $T_7$ at shooting stage and $T_1$ at harvest stage during 2010-11. During the year 2011-12, the treatment $T_7$ recorded the lowest N uptake at shooting and harvest stages of banana. During 2010-11, P uptake was high in $T_3$ (58 and 87 kg ha$^{-1}$) at shooting and harvest stages, respectively but it was statistically on par with $T_{12}$, $T_9$, $T_8$, $T_5$ and $T_{13}$ at shooting stage and $T_{12}$, $T_9$, $T_2$, $T_{11}$, $T_5$ and $T_{13}$ at harvest stage. Similarly, during 2011-12, application of 100 per cent RDF + 40 per cent *WG organic soil* ($T_3$) recorded the maximum P uptake (52 and 84 kg ha$^{-1}$) at shooting and harvest stages, respectively and it was statistically at par with $T_{12}$ at shooting stage and $T_{12}$, $T_9$ and $T_2$ at harvest stage. The lowest P uptake was recorded under $T_7$ at shooting and harvest stages during 2010-11 and $T_1$ during 2011-12.During 2010-11 year, the maximum uptake of K was recorded in $T_{12}$ (880 kg ha$^{-1}$) at shooting stage and $T_3$ recorded higher uptake (1184 kg ha$^{-1}$) at harvest stage and it was at par with each other. During 2011-12, application of 100 per cent RDF along with 40 per cent *WG organic soil* ($T_3$) registered the maximum uptake (792 and 1183 kg ha$^{-1}$) at shooting and at harvest stages,

**Table 4 : Effect of integrated nutrient management on total nutrient uptake (kg ha$^{-1}$)by banana**

| Treatments | 2010-11 | | | | | | 2011-12 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shooting | | | Harvest | | | Shooting | | | Harvest | | |
| | N | P | K | N | P | K | N | P | K | N | P | K |
| $T_1$ - 100% RDF (Control) | 270 | 42 | 660 | 398 | 59 | 874 | 283 | 42 | 670 | 422 | 61 | 893 |
| $T_2$ - 100% RDF + 20% WS | 304 | 46 | 713 | 484 | 72 | 1007 | 326 | 49 | 743 | 517 | 76 | 1055 |
| $T_3$ - 100% RDF + 40% WS | 380 | 58 | 878 | 568 | 87 | 1184 | 355 | 52 | 792 | 587 | 84 | 1183 |
| $T_4$ - 75% RDF + 20% WS | 271 | 42 | 663 | 398 | 60 | 872 | 302 | 43 | 678 | 433 | 63 | 915 |
| $T_5$ - 75% RDF + 40% WS | 311 | 48 | 748 | 464 | 71 | 1011 | 315 | 48 | 729 | 491 | 73 | 1013 |
| $T_6$ - 100% RDF + WC spray | 272 | 42 | 669 | 405 | 62 | 893 | 287 | 43 | 677 | 437 | 63 | 919 |
| $T_7$ - 75% RDF + WC spray | 265 | 40 | 653 | 395 | 60 | 863 | 281 | 42 | 663 | 431 | 62 | 869 |
| $T_8$ - 100% RDF + 20% WG | 317 | 49 | 740 | 463 | 71 | 993 | 312 | 47 | 725 | 476 | 72 | 993 |
| $T_9$ - 100% RDF + 40% WG | 320 | 49 | 758 | 477 | 73 | 1015 | 325 | 49 | 755 | 511 | 75 | 1059 |
| $T_{10}$ - 75% RDF + 20% WG | 283 | 43 | 680 | 416 | 63 | 926 | 293 | 43 | 686 | 442 | 64 | 941 |
| $T_{11}$ - 75% RDF + 40% WG | 303 | 46 | 705 | 444 | 71 | 972 | 311 | 47 | 718 | 485 | 72 | 1001 |
| $T_{12}$ - 100% RDF + FYM | 372 | 56 | 880 | 550 | 84 | 1167 | 348 | 53 | 790 | 565 | 83 | 1158 |
| $T_{13}$ - 75% RDF + FYM | 310 | 48 | 740 | 459 | 70 | 982 | 316 | 48 | 727 | 488 | 72 | 1011 |
| S.E.± | 13 | 5 | 15 | 25 | 6 | 32 | 7 | 4 | 17 | 19 | 4 | 27 |
| C.D. (P=0.05) | 27 | 10 | 31 | 52 | 12 | 65 | 15 | 8 | 34 | 38 | 9 | 56 |

respectively. The least K uptake was recorded with $T_7$ during both the years of experimentation.

**Effect of integrated nutrient management on nutrient uptake by different plant parts of banana :**

Uptake of nutrients is a product between nutrient concentration and dry matter accumulation. The uptake of N, P and K was significantly influenced by the application of organic sources of nutrients. Increased uptake of N, P, and K might be due to mineralization of nitrogen during decomposition of the organic manures, which might have resulted in enhanced availability of N in rhizosphere and ultimately increased the nutrient uptake. *WG organic soil* and FYM recorded the highest N, P and K uptake at shooting and harvest stages. This might be due to improvement in availability of plant nutrients from applied inorganic fertilizer favoring better crop growth and accumulation of biomass which further led to increased uptake of N, P and K. Organic manure also improved microbial activity in soil, which led to better uptake of nutrients by plants. Daniells and Armour (2010) reported that banana plant took only about 50 per cent of applied fertilizers from soil.

**N uptake :**

Better growth of banana due to increased dry matter production and N concentration have enhanced the nutrient uptake. N uptake shall be considered as a valid parameter to establish the efficacy of the quantity and source of applied N to crops. Uptake of nutrients in

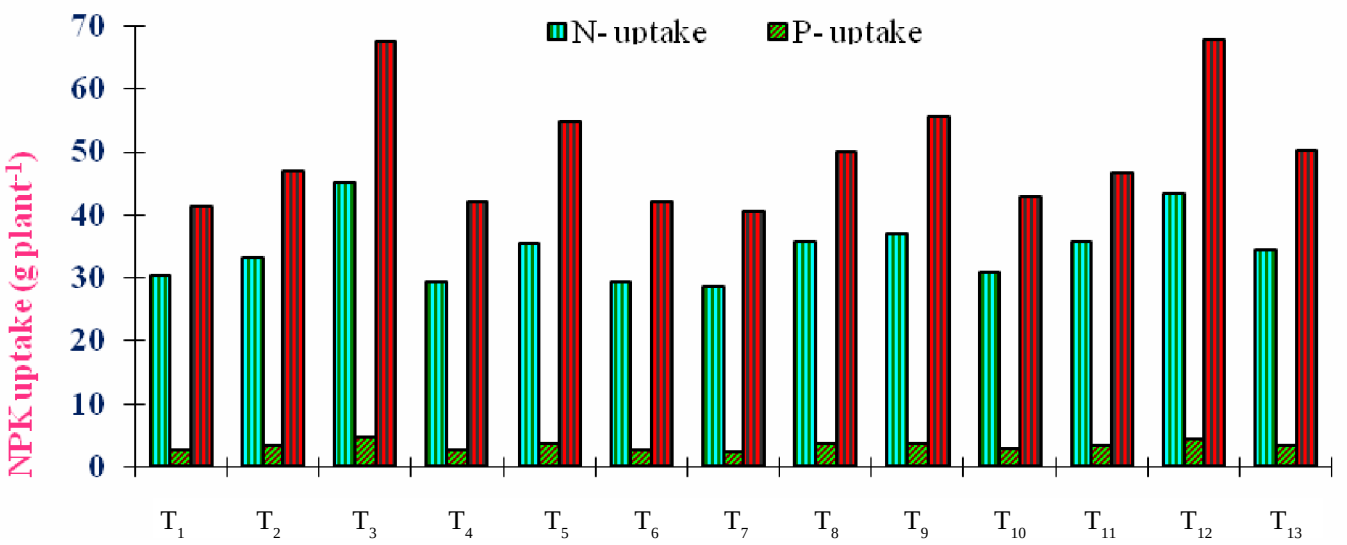


**Fig. 1 : Effect of integrated nutrient management on nutrient uptake (g plant $^{-1}$) of lamina at shooting stage during 2010-11**

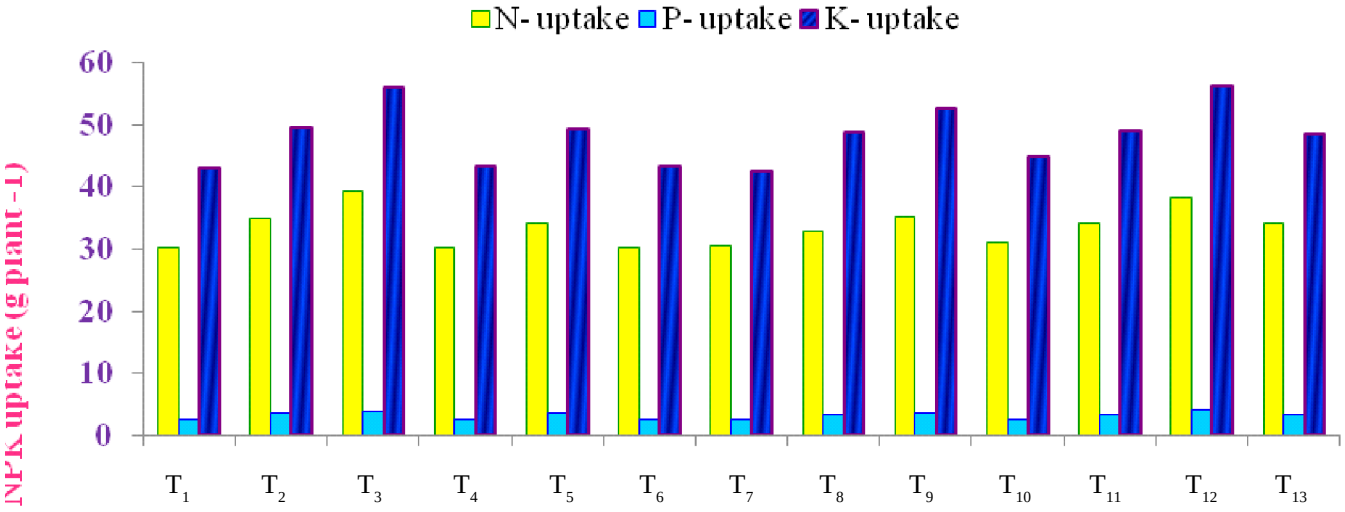


**Fig. 2 : Effect of integrated nutrient management on nutrient uptake (g plant $^{-1}$) of lamina at shooting stage during 2011-12**

different parts at various growth stages revealed that, N uptake increased at shooting stage. Among the various parts, N uptake was highest in lamina. It was attributed by higher number of leaf production resulting in more DMP coupled with higher N content. Among the treatments, 100 per cent RDF with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ recorded the maximum N uptake by vegetative and economic parts. It may be due to the presence of optimum concentration of nitrogen in the soil, which might have provided the available nitrogen supplied through organic and inorganic fertilizers.

The N has a promotive effect on root hair formation (Tien *et al.*, 1979) and absorbing surface which might have resulted in higher uptake and better plant growth (Jeeva, 1987). The increase in available nitrogen due to application of FYM and *WG* organic manure might be attributed to the greater multiplication of soil microbes. These organics during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen to soil. Similar results were reported by Tolanur and Badanur (2003). In general, organic manures are converted through bacterial action into readily usable ammonical and nitrate nitrogen for use by the crops (Sankaranarayanan, 2011).

**P uptake :**

Studies on uptake of phosphorus in different parts at two different stages of banana revealed that P uptake by the vegetative parts increased linearly up to shooting. Among the various parts, the pseudostem removed maximum phosphorus at shooting stage. It is attributable to the higher dry matter production. At harvesting stage, P uptake was maximum with fruits, which is assumed to be due to mobilization of all the assimilates from the vegetative part, higher content of P and DMP. Martin-Prevel (1964) and Walmsley and Twyford (1968) also noted that P was most rapidly taken up from three months after planting until flower initiation. Thus, P fertilizer applied during this period would most effectively be utilized.

The maximum P uptake was found with 100 per cent RDF with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ at all the stages, which recorded higher content of P coupled with the highest DMP. The increase in P uptake with the application of FYM and *WG organic soil* may be attributed to better availability of P in rhizosphere (Shashindra, 2000). The complex organic anions chelate $Al^{+3}$, $Fe^{+3}$ and $Ca^{+2}$, decrease the phosphate precipitating power of these cations and thereby increases the phosphorus availability (Reddy *et al.*, 2005). Also, organic manure might have helped in solubilising immobilized and fixed phosphorus in soil into utilizable form and aided in easy uptake (Krishnamoorthy and Rama, 2004). Moreover, increased root proliferation owing to application of organic manures might also have contributed to the increased uptake of P from the soil. The increased uptake might be due to enhanced phosphorus activities that mobilize sparingly the available nutrient sources and ectozymes resulting in improved phosphate uptake (Dixon *et al.*, 1985). The mechanism involved in solubilizing phosphorus was due to acid production and enzyme activity *viz.*, dehydrogenase, phosphatase and urease activities. Thus, due to transport of solubilized phosphorus through hyphae to the roots led to an efficient increase in phosphorus uptake (Abbolt and Robson, 1977).

In general, organic matter from manure interacts with clay minerals and reduces P sorption by the soil, thereby enhancing P availability to plants (Hue, 1990). Wopereis and Walraven (2009) also reported that phosphorus become more mobile when organic manure is added to the soil.

**K uptake :**

The uptake of K was investigated in different plant parts at shooting and harvest stages of banana and the results revealed that the uptake is increased at shooting in all the vegetative parts. Among the different parts, maximum uptake was found with pseudostem which might be attributed to higher DMP. The uptake of K at harvesting stage was maximum in fruits which could be attributed to higher DMP along with higher K content besides mobilization of assimilates from leaves and other parts to the fruits. Twyford and Walmsley (1974) also shared a similar view.

The uptake of K was also influenced by the treatments. The maximum uptake was recorded in 100 per cent RDF with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ at these stages which could be attributed to higher K content as well as dry matter production. This could be due to application of *WG* organic manure or FYM, which helps in conversion of soil humic substances and mobilization of potassium due to mineralization and exchange reaction with soil particles. This is in corroboration with the previous work of

Adherkhin and Belyayer (1971). Availability of optimum concentration of K in the soil colloids might also have facilitated better absorption by the root system of the plants.

Organic manures in general improved the water stable aggregates, which might have helped in increasing the uptake of potassium. This was in confirmation with the observations made by Roy and Chatterjee (1972). The reason for the increased uptake of K in the crop might also be due to the result of increased availability of K in the soil due to the application of organics (Hangarge *et al*., 2002). Decomposition and liberation of potassium from organic matter into the soil leading to better potassium uptake has also been reported (Randhawa *et al*.,1972). Increased microbial activities resulted in greater uptake of potassium in plants. Moreover, the increased availability of potassium under organics application might be due to the solubilisation action of certain organic acids produced during decomposition of organic manures and its greater capacity to hold K in available form in soil and also due to interaction of organic matter with clay and direct addition of potassium to the available pool of soil. Similar beneficial effects of organic manures were reported earlier (Pawar *et al*., 1997). The minimum uptake of K was registered with 75 per cent RDF with 2 per cent liquid organic manure spray on bunches due to the least nutrient content and DMP.

**Total N, P and K uptake (kg ha$^{-1}$) :**

The total uptake of nitrogen increased linearly with all the treatments from shooting to harvest stages (Table 4).The percentage of uptake of N was increased from shooting stage to harvest stage which indicating that N is required for vegetative growth and photosynthesis which would increase the source for further mobilization to the fruits. Among the treatments, the uptake of N was very high with 100 per cent RDF with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ during both the years. The higher uptake was due to higher total DMP coupled with higher quantity of assimilates accumulated in it.

The total uptake of P increased linearly from shooting to harvest stage. Martin-Prevel (1964), Walmsley and Twyford (1968) also reported maximum uptake of P during the early development stages by pseudostem and leaves and it was by fruit at harvest stage. The highest uptake of P is observed due to application of 100 per cent of NPK along with either 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ during both the years. It was attributed due to higher DMP as a result of optimum availability of phosphate ions in the soil solution.

The total uptake of K increased constantly from shooting to harvest in all the treatments. The K uptake was maximum at harvest showing that absorption and translocation of assimilates to sink was necessary for the finger development. Twyford and Walmsley (1974) also reported maximum content of K was necessary for finger development. The K uptake was also influenced by the treatments and recorded the maximum uptake in 100 per cent RDF with either 40 per cent *WG organic soil* or FYM @ 10 kg plant$^{-1}$ during both the years, which was due to higher K uptake as well as higher DMP.

**Conclusion :**

Nutrient uptake was greatly influenced by combined application of organic manures along with chemical fertilizers in banana. Among the treatments, combined applicationof 100 per cent RDF either with 40 per cent *WG organic soil* or FYM @ 10kg plant$^{-1}$ recorded the maximum uptake of nitrogen, phosphorus and potassium in different parts of banana as well as total nutrient uptake.Hence, the integrated nutrient management practice of 100 per cent recommended dose of fertilizer combined with 40 per cent *WG organic soil* in banana crop has been found to be an ideal option to sustain soil fertility and uptake of nutrients besides being economically competitive and productive under soil and climatic conditions of Western zone of Tamil Nadu.

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## REFERENCES

**Abbolt, L.K.** and Robson, A.D. (1977). The role of vesicular arbuscularmycorrhizae fungi in agriculture and the selection

of fungi for inoculation. *Agric. Res.*, **33** : 389-408.

**Adherkhin, P.G.** and Belyayer, A.B. (1971). Potassium in the organic matter of soils in the central chernoxem belt. *Agrochimica*, **11** : 48-53.

**Bhalerao, N.M.**, Patil, N.M., Badgujar, C.D. and Patil, D.R. (2009). Studies on integrated nutrient management for tissue cultured Grand Naine banana. *Indian J. Agric. Res.*, **43**(2): 107-112.

**Bremner, J.M.** (1965). Inorganic forms of nitrogen. In: Methods of Soil Analysis. Black, C.A. (Ed.), American Soc. Agron., Medison, Wisconsin. 1179-1237.

**Carter, M.R.** (2002). Soil quality for sustainable land management, organic matter and aggregation interactions that maintain soil functions. *Agrnon. J.*, **94**: 38-47.

Crop Production Techniques of Horticultural crops (2004). Published by Directorate of Horticulture and Plantation crops, Chennai and Tamil Nadu Agricultural. University, Coimbatore. pp 4-8.

**Daniells, J.** and Armour, J. (2010). Managing crop nutrition in banana production. QDPI Bull. No. (2): 1-8. Queensland Horticulture Institute, Australia.

**Dixon, R.K.**, Gravelt, H.E. and Cox, G.S. (1985). Cytokinins in the root pressure exudates of *Citrus jambhiri* colonized by vesicular arbuscularmycorrhizae. *Tree Physiol.*, **4** : 9-18.

**Gomez, K.A.** and Gomez, A.A. (2010). *Statistical procedures for agricultural research*. 2nd Ed. John Wiley and Sons, New York, U.S.A.

**Hangarge, D.S.**, Rault, R.S., Malewar, G.V., More, S.D. and Keshbhat, S.S. (2002). Yield attributes and nutrient uptake by chilli due to organics and inorganic on vertisol. *J. Maharashtra Agric. Univ.*, **127** : 109-110.

**Hue, N.V.** (1990). Interaction of $Ca(H_2PO_4)_2$ applied to an Oxisol and previous sludge amendment: Soil and crop response. *Comm. Soil Sci. Plant Anal.*, **21** : 61-73.

**Jackson, M.L.** (1973). *Soil chemical analysis*. Prentice Hall of India private Ltd., New Delhi. p. 495.

**Jeeva, S.** (1987). Studies on the effect of *Azospirllium* on growth and development of banana cv. POOVAN (AAB). M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural. University, Coimbatore (T.N.) India.

**Kang, B.T.** and Balasubramanian, V. (1990). Long-term fertilizer trials on alfisols in West Africa. In: Proceedings of the Transactions 14th International Congress of Soil Science. Kyoto, Japan, pp. 20-25.

**Krishnamoorthy, B.** and Rama, J. (2004). Biofertilizers and their application. Spice India,pp. 5-7.

**Lahav, E.** (1973). Effects and interactions of manure and fertilizers in a banana plantation. *Israel J. Agric. Res.*, **23** : 45-57.

**Martin-Prevel, P.** (1964). Nutrient elements in the banana plant and fruit. *Ferti. News*, **22** : 3-14.

**Pawar, V.P.**, Kathmale, D.K., Deshmuth, Z.V. and More, J.A. (1997). Effect of fertilizers doses and their application on production of Basrai banana. *J. Maharashtra Agric. Univ.*, **22**(2): 166-168.

**Randhawa, G.S.**, Sharma, C.S., Kohli, R.R. and Chacko, E.K. (1972). Studies on nutrient concentration in soil tissue and fruit yield with varying planting distance and nutritional levels in banana cv. ROBUSTA. *Indian J. Hort.*, **30**(1&2): 367-374.

**Reddy, S.S.**, Shivaraj, B., Reddy, V.C. and Ananda, M.G. (2005). Direct effect of fertilizers and residual effect of organic manures on yield and economics of maize (*Zea mays* L.) in groundnut-maize cropping system. *Crop Res.*, **30**(1): 1-5.

**Roy, S.N.** and Chatterjee, P.C. (1972). Use of indigenous materials to enhance the efficiency of nutrients for crops. *Fert. News*, **4**(3): 30-35.

**Sankaranarayanan, K.** (2011). Nutrient potential of organic sources for soil fertility management in organic cotton production. CICR, RS, Coimbatore. In: *www.cicr.org.in*

**Sharma, S.B.** (1988). Effect of different methods and times of manuring on growth and yield of banana. *Fertilizer News*, **32** (10) : 33-35.

**Shashindra, G.B.** (2000). Integrated nutrient management for chilli (*Capsicum annum* L.) in alfisols of Northern transition zone of Karnataaka. M.Sc., (Ag.) Thesis. University Agricultural Science, Dharwad, KARNATAKA (INDIA).

**Tien, T.M.**, Gaskens, M.H. and Hubbell, D.H. (1979). Plant growth substances produced by *Azospirillumbrasilense* and their effect on growth of pearl millet (*Pennisetum americanum* L.). *Appl. Environ. Microbiol.*, **37**: 1016-1024.

**Tolanur, S.I.** and Badanur, V.P. (2003). Changes in organic carbon, available N, P and K under integrated use of organic manure, green manure and fertilizer on sustaining productivity of pearlmillet-pigeonpea system and fertility of an inceptisol. *J. Indian Soc. Soil Sci.*, **5**: 37-41.

**Twyford, I.T.** and Walmsley, D. (1974). The mineral composition of the Robusta banana plant. III. Uptake and distribution of mineral constituents. *Plant & Soil*, **41**: 471-491.

**Walmsley, D.** and Twyford, I.T. (1968). The uptake of $^{32}P$ by the Robusta banana. *Trop. Agric. Trinidad*, **45** : 223-228.

**Wopereis, S.** and Walraven, A. (2009). Plant nutrients. In: PLAR-IRM curriculum: Technical manual. Ref. No. 14: 49-51.