RESIDUAL EFFECT OF NITROGEN MANAGEMENT ON YIELD AND QUALITY OF RATOON BANANA

by

Patil Kranti Balasaheb
(Reg.No. 06/051)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
POST GRADUATE INSTITUTE
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2008

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part there of has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

Place : M.P.K.V., Rahuri

Dated : 04/06/2008

(Miss. K.B. Patil)

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CERTIFICATE

This is to certify that the thesis entitled, "**RESIDUAL EFFECT OF NITROGEN MANAGEMENT ON YIELD AND QUALITY OF RATOON BANANA"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the results of a piece of *bona fide* research work carried out by **MISS. PATIL KRANTI BALASAHEB,** under my guidance and supervision and that no part of this thesis has been submitted for any other degree, diploma or publication in other form.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Dated : 04 / 06/2008

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Place : MPKV, Rahuri
Dated : 4/6/2008

(R.S. Patil)

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Place : M.P.K.V., Rahuri (Miss. K.B. Patil)

Dated : 04/ 06/2008

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LIST OF ABBREVIATIONS

^{o}C	:	Degree celcisius
µM'P'	:	Micromole of phosphorus
µg TPF	:	Microgram of tripheny formazan
LAI	:	Leaf area index
Mgm^{3}	:	Mega gram per meter cube
Ca	:	Calcium
DAP	:	Days after planting
Kg $plot^{-1}$	:	Kilogram per plot
CD	:	Critical difference
CEC	:	Cation exchange capacity
cm	:	Centimetre
dSm^{-1}	:	Deci siemens per meter
DTPA	:	Diethylene triamine pentaacetic acid
EC	:	Electrical conductivity
et al.	:	Any others (et alli)
Fe	:	Iron
Mn	:	Manganese
Zn	:	Zinc
Cu	:	Copper
Fig.	:	Figure
FYM	:	Farm yard manure
g	:	Gram
ha	:	Hectare
INM	:	Integrated nutrient management
K	:	Potassium
kg	:	Kilogram
me L^{-1}	:	Miliequivalent per litre
mg kg^{-1}	:	Milligran per kilogram
mg pot^{-1}	:	Milligran per pot
mg $plant^{-1}$	:	Milligran per plant
t ha^{-1}	:	Tone per hectare
N	:	Nitrogen
NH_4-N	:	Ammonical nitrogen
NS	:	Non-significant
P	:	Phosphorus
RDF	:	Recommended dose of fertilizers
S.E.	:	Standard error
%	:	Per cent

ABSTRACT

RESIDUAL EFFECT OF NITROGEN MANAGEMENT ON YIELD AND QUALITY OF RATOON BANANA

BY

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A candidate for the degree

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Research Guide	:	Dr. A.R. Dhage
Department	:	Soil Science and Agricultural Chemistry

The present investigation was carried out by studying residual effect of nitrogen management during *rabi* 2006-07 to assess the yield and quality of ratoon banana. There were ten treatments consisting nitrogen substitution through FYM, neem cake and vermicompost along with chemical fertilizers in various proportions. The field experiment was conducted at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri on Inceptisol soil order belonging to Sawargaon (Pather) soil series.

The studies revealed that bunch weight and yield of ratoon banana were significantly higher in 25 % N- FYM + 75 %

Abstract contd... **Miss. K.B. Patil**

N-RDF (15.43 kg and 72.92 t ha^{-1}). The nitrogen management and its residual effect by application of 50 % N- FYM + 50 % N-RDF was effective to produce higher dry matter production at harvest in ratoon banana. Total uptake of nitrogen phosphorus, potassium and micronutrients in leaves, shoot and fruit were found significant by residual fertility of nutrient management through organics and chemical fertilizers.

The reducing sugar content of ratoon banana was increased upto 21st days of ripening by chemical fertilizers application as per soil test values. Titrable acidity of ratoon banana was increased by recommended dose of fertilizers. The ratoon banana harvested from all the nitrogen management treatment showed significant and consistent increase in pulp : peel ratio of banana at all the ripening periods.

The substitution of nitrogen management and it's residual fertility in ratoon banana by application of 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost maintains nitrogen status, phosphorus, potassium and micronutrients of the soil.

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INTRODUCTION

1. INTRODUCTION

Banana (*Musa paradisiaca*) is one of the most important fruit crop grown in India. The banana cultivation in India is as old as the Indian civilization. In India, bananas are so predominant and popular among people that both poor and rich like it. Considering the nutritive value and fruit value of banana, it could be considered as the 'poor man's apple' being cheapest among all fruits in the country. Considering the year round availability of fruits, unlike the availability of other seasonal tree fruits, it has become an inevitable necessary in any house hold in India, for all functions.

Banana is blended with the Indian culture and referred in the ancient scriptures. Banana is combination of energy value, tissue binding element proteins, vitamins and minerals. Banana is known for it's both nutritive value and medicinal properties. It is also used in management of many physiological disorders of kidney, digestive system, urinary track, heart and throat. It also helps and promotes consumption and retention of calcium, phosphorus and nitrogen which regenerate tissues. Banana contains 1.2 per cent proteins, 27 per cent carbohydrates and gives about 104 calorie energy 100 g^{-1}. Moreover, the banana also contains vitamin 'A', riboflavin and B_6. Special nutritional feature of banana is the low sodium and high potassium content which is of great significance in diet (Tiwari, 2002).

Banana is globally important fruit crop with 976.5 million tonnes of production. In India, it supports livelihood of millions of people, with total annual production of 14.21 million tonnes from 0.47 million hectares with national average of 30.5 tonnes per hectare. Banana occupies 20 per cent area among the total area under fruit crops, which contributes 37 per cent to total fruit production in India (Anonymous, 2004).

The major banana growing states in the country are Maharashtra, Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Bihar and West Bengal. Tamil Nadu has the largest area (0.76 lakh hectares) followed by Maharashtra (0.70 lakh hectares) and Karnataka (0.52 lakh hectares) under banana. However, Maharashtra ranks first in production (48.2 lakh tonnes) followed by Tamil Nadu (28.30 lakh tonnes). The Maharashtra has the highest productivity during 2002-03 (68 tonnes ha^{-1}) as against the national productivity 33.50 tonnes ha^{-1}. The higher productivity in Maharashtra lies due to adoption of improved planting material like tissue cultured seedling and efficient nutrient management (INM) with drip irrigation. In Maharashtra about 62 per cent banana area is under drip irrigation (Mulay and Wankhede, 2004).

The nutrient requirement of banana is very high which is mainly exploited from a very limited soil due to shallow root system of the crop. Being heavy feeder, proper manuring and fertilization has to be resorted in obtaining good yields. The choice of fertilizers, the dosages of nutrients, time of application etc. varies widely with respect to agro climatic regions and varieties. The effect of proper fertilization in banana are (i) Increase in crop yield, (ii) Improvement in grade and weight of marketable good quality bunches per hectare and (iii) Improvement in quality with physical and chemical characters leading to high returns to the farmers.

As banana is a heavy feeder, it requires a large amount of chemical fertilizers to be applied in soil. Use of chemical fertilizers alone for increasing the crop production is not sustainable on long term basis as it may lead to imbalance of nutrients. On the other hand total nitrogen requirement of the crop is too large to meet through organic manures. Thus, it is being increasingly realized that integrated nutrient supply system by using organic manures, chemical fertilizers and biofertilizers is essential to maintain and improve soil fertility and productivity (Panda, 2005). It is estimated that the expenses on manures and fertilizers amount to 20 and 30 per cent of the total cost respectively. A recent trend in farming with organic inputs is beneficial for improving quality and taste of produce, preventing soil deterioration and production in economically sound manner has resulted in renewed interest in the organic farming. Many small scale banana growers are facing increasing difficulty in competing in a free market economy. For export purpose growers have been looking for production and diversification alternatives. One such possibility is the organic production of banana which has attracted considerable interest in both producer and consumer of different countries.

Organic manures have a great potential to supply macro as well as micronutrients in a balanced way. Lahav (1977) reported that application of FYM upto 80 tonnes per hectare per year enhanced growth, hastened flowering, shortened flowering to harvest period and increased yield by 33 per cent in banana. Application of organic manures in addition to inorganic manures improves the qualitative characters of the fruit. Athani and

Hulamani (1999) observed the longest shelf life (7.67 days), highest total soluble solids (27.6^{0}B) in plants treated with vermicompost and in situ vermiculture in Rajapuri banana. Ray and Yadav (1996) observed increase in yield of banana when NPK was applied as 25 per cent FYM + 75 per cent inorganic fertilizer and cowpea as green manuring crop.

Integrated nutrient management not only to help to get economic yield and quality fruits but also helps in maintaining the soil health (Reddy, 2002). The residual effect of Integrated Nutrient Management on yield as well as fruit and soil quality will be beneficially enhanced, with this view the experiment is planned to study the residual effect of integrated nutrient management through organic source *viz.,* FYM, neem cake, vermicompost, biofertilizer and inorganic nitrogen on yield and quality of ratoon banana (*Musa paradisiaca*) with an objectives.

The study has been framed with the following objectives

1. To study the residual effect of nitrogen management on yield and nutrient uptake of ratoon banana and
2. To study the residual effect of nitrogen management on quality of ratoon banana.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Several factors like fertility of the soil and judicious application of fertilizers during the cropping period, availability of moisture, climatic conditions type and kind of variety grown and management practices govern the growth and yield of banana.

Information pertaining to the efficiency of organic sources in supplying to the nitrogen requirement of banana and it's residual effect is limited rather inadequate. An attempt has been made to present herewith the literature pertaining to the research work done on this aspect in various fruit crops. The research work carried out in respect of residual effects of nitrogen management on yield and quality of ratoon banana on inceptisol during recent past is reviewed in this chapter.

2.1 Residual effect of nitrogen management on yield contributing attributes of ratoon banana

2.1.1 Days for flowering

Badgujar *et al.* (2004) found that significantly higher pseudostem height (215.52 cm), girth (68.99 cm), number of leaves at harvest (31.25), and less days required for flowering (265.02 DAP) and harvest (363.35 DAP) were obtained by the application of 200:40:200 g N,P_2O_5 and K_2O plant^{-1}.

The less duration for shooting after planting (287.4 DAP) and total crop duration (404.50 DAP) were recorded in AM inoculated plants alongwith vermicompost @ 1 kg plant^{-1} and inorganic fertilizer as compare to non-AM fungi plants, the corresponding values of duration were 307.54 and 422.78. The highest yield was recorded in vermicompost @ 1 kg plant^{-1} alongwith 75 per cent recommended dose of fertilizer and AM fungi inoculation (32.41 t ha^{-1}) (Sabarad *et al.,* 2004).

Tirkey *et al.* (2003) studied the response of nitrogen levels and split application of N, P and K on growth, yield and quality of tissue culture raised banana (cv. Dwarf Cavendish) at HRF, Indira Gandhi Agricultural University, Raipur (Chhattisgarh) during 1994-95. They reported that 300g nitrogen applied with 5 splits of NPK alongwith their treatment combination showed significant increase in plant height (3.07, 3.04 and 3.11 m respectively) and pseudostem girth (61.99, 61.43 and 65.05 cm respectively) at 240 DAP. Similarly, higher levels of nitrogen (300g plant^{-1}) showed an increase in number of leaves (20.90 and 22.67) at 180 and 240 DAP. The banana plants received 250g N plant^{-1} induced early flowering (276.53 days) followed by 300g N plant^{-1} (277.17 days). Moreover, they noticed that the application of 250 g N plant^{-1} treatment required less crop duration.

Athani *et al.* (1999) studied the effect of vermicompost on maturity and yield on banana cv. Rajapuri (*Musa* AAB) at Arabhavi, Dharwad during 1995-97. They reported minimum number of days for shooting (236.30 DAP) and total crop duration (369 DAP) were recorded in 75% RDF (180:108:225 g NPK plant^{-1}) alongwith 2 kg vermicompost plant^{-1}. While maximum number of days for shooting (290.02 DAP) and total crop duration (409.50 DAP) were recorded in the treatment of *in-situ* vermicomposting @ 25,000 worms ha^{-1}.

Ray and Yadav (1996) studied the effect of combined use of organic manures and chemical fertilizers on growth and productivity of banana on calcareous sandy loam soil during 1990-93 at HRS, Birauly, Bihar. They reported that a combination of 25% inorganic fertilizers not only produced taller plants but also shortened the time required for emergence of bunch. Addition of 25% neem cake with 75% inorganic fertilizers was not as effective as use of FYM. Further, they concluded that green manuring with cowpea, in addition to application of 25% FYM and 75 % inorganic fertilizers produced higher plant height and pseudostem circumference. This was statistically at par with the treatment consisting of 25% FYM and 75% inorganic fertilizers.

Effect of N and K fertilization under basin and drip irrigation on growth, yield and nutrient uptake was studied by Hegde and Srinivas (1991) at IIHR, Bangalore on sandy clay loam soil. They reported that among three levels of nitrogen (100, 200 and 300 g $plant^{-1}$) and potassium levels (100, 200 and 300 g $plant^{-1}$) the 200 g N and 200 g K_2O produced taller plants (214 and 209.70 cm), pseudostem girth (85 and 81.90 cm) and early flowering (293 and 271 DAP) in both plant and ratoon crop respectively.

Singh *et al.* (1990) studied the response of banana to nitrogen and potassium grown on a sandy loam soil at Ranchi, Bihar during 1980. They reported the plant height, girth and index leaf area were increased by the application of N but not by

K. Further, they indicated that the number of days from planting to harvest of crop was decreased by N application.

Chattopadhyay and Bose (1986) reported the early flowering in 283 days in plant crop and 420 days in ratoon banana due to the application of 240 g N and 480 g K plant^{-1}.

2.1.2 Number of fingers, finger girth and weight

Suresh and Surya Prabha (2005) studied the properties of vertisol as influenced by inorganics under cotton-bajra sequence at TNAU, Kovilpatti during 1997-2001. They reported the higher availability of nitrogen was in combined application of 20 kg inorganic N + 20 kg N through composted coir pith (129 kg ha^{-1}) over only 40 kg inorganic N (115 kg ha^{-1}). The application of recommended dose of NPK alongwith *Azatobacter* and PSB significantly increased the available N content (369.43 kg ha^{-1}) of post harvest soil of banana over the control (267.21 kg ha^{-1}) (Gogoi *et al.* 2004).

Shakila and Manivanna (2003) reported the highest number of hands bunch^{-1} (10.46), higher fingers bunch^{-1} (177.92) and high finger weight (174.02 g) was obtained in 200 g N and 400 g K at 3rd, 5th and 7th month after planting over all other treatments.

Tirkey *et al.* (2002) conducted the field experiment on the effect of organic manures @ 15, 30 and 45 kg FYM plant^{-1} alongwith 100:100:150 g NPK plant^{-1} as inorganic fertilizers on growth, maturity and yield of banana cv. Dwarf Cavendish at Raipur during 1996-97. They reported that the maximum bunch weight (21.12 kg plant^{-1}) and total number of fingers bunch^{-1}

(129.25) were observed in 10 kg plant^{-1} poultry manure + 100:100:150 g NPK plant^{-1}. While, the lowest bunch weight (15.78 kg plant^{-1}) was obtained in 300:200:300 g NPK plant^{-1}.

Sooriannathasundaram *et al.* (2001) studied the influence of organic nutrition on the productivity of banana cv. Nendran at TNAU, Coimbatore. They reported that the mean bunch weight (10.80 kg), number of hands per bunch (5.0), number of fingers per bunch (50.5) were higher in 100% N through urea followed by 25%N through FYM + 75% N through urea and 25% N through (FYM + green manure) + 75%N through inorganic N as urea. The highest average bunch weight (19.90 kg), number of hands bunch^{-1} (7.4) and number fingers bunch^{-1} (96) and average finger weight (207 g) were obtained with 200g N and 200g K_2O plant^{-1} (Srinivas *et al.,* 2001).

Ushakumari *et al.* (1997) studied the efficiency of vermicompost on yield and quality of banana (AB) cv. Njalipoovn at college of Agriculture, Vellayani, Kerela. They reported that application of vemicompost @ 13 kg plant^{-1} to supply the recommended dose of nitrogen (200 g N plant^{-1}) significantly recorded higher number of hands bunch^{-1} (12), number of fingers bunch^{-1} (194) and higher mean weight of hands (1.05 kg) followed by the plots received 10 kg vermicompost plant^{-1} alongwith recommended inorganic nitrogen.

The addition of 25 % N-FYM + green manuring + 75 % N inorganic fertilizers produced significantly higher yields in plant crop (74.60 t ha^{-1}), ratoon Ist (30 t ha^{-1}) and ratoon IInd (73.30 t ha^{-1}) followed by the treatment consisting of addition of 25% N-

FYM + 50% N neem cake + 25% N-inorganic fertilizers which was produced 71.70 t ha^{-1}in plant crop, 77.90 t ha^{-1}in ratoon first and 67.10 t ha^{-1} in second ratoon (Ray and Yadav, 1996).

The effect of nitrogen, potassium and their split applications on the yield and yield components of Nendran banana grown in rice fields was studied by Nair *et al.* (1990). They reported the best results regards to number of hands $bunch^{-1}$, number fingers $bunch^{-1}$ and length of finger with the application of 400 g N and 600g K_2O $plant^{-1}$ applied in 4, 6 and 8 month wise splits with equal doses alongwith 10 kg FYM ha^{-1}.

Mustaffa (1988) reported that application of 250: 75:225 g N, P_2O_5 and K_2O $plant^{-1}$produced significantly highest number of hands $bunch^{-1}$ (8.89), number of fingers $bunch^{-1}$ (143), length of fruit (22 cm) and girth of fruit (14.34 cm).

Holder and Gumbs (1983) reported that among the different three N levels 280, 560 and 840 kg ha^{-1} were produced higher bunch weight (21.70 kg), hands $bunch^{-1}$ (7.68) and higher fingers $bunch^{-1}$ (129.70) for plant crop. The second and third ratoon crop, yield contributing characters were found to be non-significant at three levels of nitrogen.

2.1.3 Bunch weight

Gogoi *et al.* (2004) studied the effect of biofertilizers on productivity and soil characteristics in banana at Assam Agricultural University, Jorhat during 2001-2002. They reported significantly the highest banana yield (74.91 t ha^{-1}) and harvest index (0.35) due to the application of half recommended N + P and K alongwith *Azospirillum* + PSB followed by (71.10 t ha^{-1})

and half dose of recommended N + P and K alongwith *Azotobacter* + PSB over inorganic NPK (53.93 t ha^{-1}). The application of vesicular arbuscular mycorrhiza @ 30-50 g $plant^{-1}$ alongwith recommended dose of NPK (300:150:300 g $plant^{-1}$) significantly resulted in the highest bunch weight (17.63 and 17.83 kg) in both the years (1999-2000 and 2000-2001) Singh and Singh (2004).

Tirkey *et al.* (2002) conducted the field experiment on the effect of organic manures (@ 5, 10 and 15 kg FYM $plant^{-1}$ and poultry manure @ 5, 10 and 15 kg $plant^{-1}$ alongwith 100:100:150 g NPK $plant^{-1}$ as inorganic fertilizer on growth, maturity and yield of banana cv. Dwarf Cavendish at Raipur during 1996-97. They reported that higher yields were obtained when inorganic fertilizers @ 100:100:150 g NPK $plant^{-1}$ alongwith poultry manure 10 kg $plant^{-1}$ were applied as against only inorganic fertilizers 300:200:300 g NPK $plant^{-1}$.

Efficiency of vermicompost on yield and quality of banana (AB) cv. Njalopoovan studied by Ushakumari *et al.* (1997) at College of Agriculture, Vellayani, Kerela and reported that the highest bunch weight in 13 kg $plant^{-1}$ vermicompost (15 kg) followed by the vermicompost application @ 10 kg $plant^{-1}$ alongwith inorganic source nitrogen (14.5 kg) bunch weight.

Lahav (1977) studied the effect of manure and fertilizer on yield of banana on clay soil. He observed non-significant differences in yield. However, the addition of chicken manure @ 45 and 60 m^3 ha^{-1} produced 26.6 and 25.8 kg mean bunch weight and 47.40 and 47.90 t ha^{-1} banana yield. While application of FYM @ 90 and 120 m^3 ha^{-1} obtained 25.70 and 24.90 kg mean bunch weight and 46.30 and 47.30 t ha^{-1} yields, respectively.

2.2 Residual effect of nitrogen management on yield of ratoon banana

Hegde and Srinivas (1991) studied the banana performance under drip and basin irrigation alongwith N and K_2O fertilization, at IIHR, Hissarghata, Bangalore on sandy clay loam soil. They reported the significant increase in banana yield under drip irrigation in both plant (83.90 t ha^{-1}) and ratoon crop (72.5 t ha^{-1}) as compared with that under basin irrigation (73.5 and 65.7 t ha^{-1}). Further, they indicated that there was significant improvement in yield with the application of 200g K_2O $plant^{-1}$ over 100g K_2O $plant^{-1}$.

Mustaffa (1988) reported that application of 250: 75:225 g N, P_2O_5 and K_2O $plant^{-1}$produced significantly highest number of hands $bunch^{-1}$ (8.89), number of fingers $bunch^{-1}$ (143), length of fruit (22 cm) and girth of fruit (14.34 cm).

2.3 Residual effect of nitrogen management on total dry matter yield of ratoon banana

Effect of three levels of N (50, 100 and 150 g $plant^{-1}$) and three levels of P_2O_5 (15,30 and 45 g $plant^{-1}$) with a constant dose of 300g K $plant^{-1}$on the dry matter were studied by Bhavani Sankar and Rao (1993) on clay loam soil at Coimbatore during 1991-92. They obtained higher dry matter with 50:30:300 g $plant^{-1}$ N, P_2O_5 and K_2O (78.06 kg $plant^{-1}$).

Sheela and Arvindakshan (1990) studied the production of dry matter and uptake of nutrients as influenced by different levels of K at College of Agriculture, Trisur. They reported that total dry matter production was increased with higher levels of K at all the stages of sampling (vegetative, shooting and harvest). However, the uptake of nitrogen increased from early vegetative growth stage to shooting and declined thereafter, in all the levels of K. While, the uptake of potassium in plant was higher than nitrogen and phosphorus. The uptake and dry matter production of banana as influenced by NPK combinations in loamy soil was studied by Chattopadhyay and Mallik (1977) at Nadia, West Bengal during 1975-1976. They reported that balanced application of fertilizers @ 72 g N, 25g P and 68 g K plant^{-1} increased dry matter in leaves, pseudostem and rhizome. Further, they reported the dry matter in leaves increased with a double dose of NPK. As regards nutrient uptake the application of double dose of P highly increased the uptake of phosphorus. Higher application of potassium or balanced NPK significantly increased the K uptake. They concluded that balanced application of NPK has paramount importance for higher uptake of nitrogen.

Dave *et al.* (1990) studied the nutritional requirements of banana cv. Basrai at two locations with graded levels of N, P and K on *Typic Chromusterts* at Fruit research Station, Navsari during 1982-83. They reported that the dry matter accumulation enhanced rapidly upto shooting stage and shooting to harvest. It was found very slow in all the levels of inorganic fertilizers. Further, they concluded that the total uptake of major nutrients at harvest with F_1 (45:45:45 g NPK plant^{-1}), F_2 (180:180:180 g NPK plant^{-1}) and F_3 (270:270:270 g NPK plant^{-1}) were 45.8, 64.29 and 65.09 g plant^{-1}for N, 6.44, 7.26 and 9.09 g plant^{-1} for P and 131.22, 154.04 and 163.52 g plant^{-1} for K respectively. They concluded that the higher levels of NPK obtained higher nutrient concentration in lamina.

Twyford and Walmsely (1973) studied the dry matter production of the organs and whole plant of the Robusta banana at various growth stages at different locations during 1965-70 at Banana Research Station, Trinidad. They reported the highest dry matter of whole plant of Robusta banana at harvest (15.20 kg) grown on clay loam soil by 1.2 kg of 11:11:33: grade NPK fertilizer per stool per year. Further, they indicated the changes in dry matter from flowering of other organs.

2.4 Residual effect of nitrogen management on nutrient concentration and nutrient uptake of ratoon banana

Alfonso Vergas *et al.* (2005) studied the effect of removing and leaving the suckers at flowering on bunch weight and foliar nutrient content of banana on clay loam and silty clay soil. They noticed the foliar N, P, K, Mg, S, Cu and B concentration diminished from flowering to harvest. They reported the concentration of N (2.87 and 2.60%), P (0.25 and 0.23%), K (3.92 and 2.87%), Ca (0.53 and 1.26%), Mg (0.36 and 0.28%) and S (0.23 and 0.21%) at shooting and harvest respectively. The micronutrient concentration of Fe (75 and 76 mg L^{-1}), Cu (8 and 7 mg L^{-1}), Zn (20 and 40 mg L^{-1}), Mn (140 and 320 mg L^{-1}) and B (14 and 8mg L^{-1}) at shooting and harvest stage respectively.

The distribution of secondary and micronutrients in different parts of banana plant including the fruit at different stages of maturity as influenced by application of N and K @ 50,100,150 and 200 g plant^{-1}through drip and conventional soil application was studied by Raghupati *et al.* (2003) at IIHR, Bangalore on sandy loam soil. They reported that pseudostem was the greatest repository for Cu and Mg. While, sulphur was evenly distributed in plant. However, the Fe concentration was higher in root and stem and sizable amount of Mn, Zn and Cu were found mobilized to leaves. Further, they indicated that concentration of N and K @ 100 g plant^{-1}through drip was found significantly superior.

Srinivas and Raghupati (1997) studied the nutrient partitioning in 'Ney Poovan' banana under nitrogen fertilization at IIHR, Bangalore on sandy loam soil during 1993-94. They reported that nitrogen and phosphorus content in leaf was the highest at 180 days after planting but declined later up to harvest. Further, the leaf N and P concentration was increased with 100g N applied through drip. The leaf K was higher at harvest and N accumulation in leaf, stem and root increased up to 240 DAP and declined later. Whereas, P and K accumulation decreased after 180DAP. The experiment was conducted during 1991-93 to study comparative efficiency of nitrogen absorption and utilization in Robusta banana which was applied in four equal splits of 50g plant^{-1} at 45th, 90th, 155th days and shooting stage on red sandy loam soil (*Udic Paleustalf*) by Murthy *et al.* (1995). They reported the application of N at bud differentiation and shooting stage maintained higher N in leaves till harvest of bunch. However, uptake and utilization of fertilizer N increased with delayed stage of application while the highest utilization (38.87%) was obtained when applied at shooting stage and least when applied at early vegetative stage (11.37%).

Hegde and Srinivas (1991) studied the growth, yield and nutrient uptake of banana under drip and basin irrigation with N and K fertilization on sandy clay loam soil of IIHR, Hessaraghatta during 1990. They reported that increasing K application from 100 to 200 g K_2O plant^{-1} significantly increased the total dry matter production and its distribution in to pseudostem and fruit in both plant and ratoon crops. But further, increase in K to 300g plant^{-1} had non-significant effect except in fruit dry matter. Further, they summarized that increasing N fertilization significantly increased the uptake of N, K and Mg and the trend generally followed the changes in dry matter production. However, the K fertilization significantly increased the uptake of N, K and Ca. It was mainly the consequence of increased dry matter production.

Sheela and Arvindakshan (1990) studied the production of dry matter and uptake of nutrients as influenced by different levels of K at College of Agriculture, Trisur. They reported that total dry matter production was increased with higher levels of K at all the stages of sampling (vegetative, shooting and harvest). However, the uptake of nitrogen increased from early vegetative growth stage to shooting and declined thereafter, in all the levels of K. While, the uptake of potassium in plant was higher than nitrogen and phosphorus. The uptake and dry matter production of banana as influenced by NPK combinations in loamy soil was studied by Chattopadhyay and Mallik (1977) at Nadia, West Bengal during 1975-1976. They reported that balanced application of fertilizers @ 72 g N, 25g P and 68 g K plant^{-1} increased dry matter in leaves, pseudostem and rhizome. Further, they reported the dry matter in leaves increased with a double dose of NPK. As regards nutrient uptake the application of double dose of P highly increased the uptake of P. Higher application of K or balanced NPK significantly increased the K uptake. They concluded that balanced application of NPK has paramount importance for higher uptake of N.

Twyford and Walmsely (1974) studied the mineral composition, uptake and distribution pattern in Robusta banana at Banana Research Station, Trinidad during 1970-74. They reported that from the total composition, 58% N, 53% P, 105% K, 43% Ca and 13.3% of Mg concentration were observed at shooting. While 46% N, 31% P, 80.3% K, 45% Ca and 15.3% Mg content were at harvest stage. They noticed the higher nutrient uptake for N, P, K, Ca and Mg with higher rate of fertilizer application. Further, they reported that the uptake of K was higher (1400 kg ha^{-1}) followed by N (400 kg ha^{-1}) and P (63 kg ha^{-1}) in 3500 plants ha^{-1}density.

2.5 Residual effect of nitrogen management on quality of ratoon banana

2.5.1 Total sugar

The effect of rate and time of nitrogen and potassium fertilization on yield and quality of banana cv. Poovan was studied by Meena and Somasundaram (2004) at ARS, Virinjipuram, Coimbatore during 1998-99 and 2000-2001 on red sandy loam soil. They indicated the highest TSS in terms of brix (21.10) was recorded in the fruits which received 150% of recommended N and K in three and four splits respectively than that of control TSS (16.40). Further, they reported the highest total sugar content (12.95%) in the treatment where 150% N and K than recommended dose of fertilizer in three and four splits. While the lowest value of total sugar was recorded in control (11.28%). However, the acidity of the fruit was marginally lowered with increased rate of N and K application (150% of the recommended).

Sabarad *et al.* (2004) reported that AM inoculated (mycorrhiza) banana fruits recorded higher values of reducing sugars (17.99%), non-reducing sugar (1.68%) and total sugars (19.77%) as compared to uninoculated plants. Further, they observed higher values of TSS (25.38^0), TSS/acid ratio (302.75), reducing sugars (18.29%), non-reducing sugars (1.73%) and total sugars (20.07%) in banana fingers obtained from *in-situ* vermiculite treatment.

Studies on the response of nitrogen levels and split application of NPK on quality of banana (cv. Dwarf Cavendish) was done by Tirkey *et al.* (2003) at Indira Gandhi Agricultural University, Raipur during 1994-95. An increasing trend of TSS was reported with increasing levels of nitrogen. Higher TSS (22.58^0) value was obtained with 300g nitrogen level. Total sugar percentage clearly indicated that 300 g nitrogen with 5 splits produced maximum total sugar (17.48%). They reported the markedly increased total sugar content of banana fruit might be due to more accumulation of photosynthesis due to higher nitrogen level alongwith split application, enhanced the height, girth, leaf number and leaf area. The banana plants fertigated with 75% of recommended dose of NPK (450:90:675 g NPK plant^{-1}) accumulated higher TSS (23%), higher reducing sugars (13.70%), non-reducing sugars (2.33%) and total sugar (17.21%) as against the 100 % of recommended dose of NPK (900:90:900 g NPK plant^{-1}) on sandy loam soil (Kavino *et al.* 2003). The response of Robusta banana to N and K fertigation was studied by Reddy *et al.* (2002) at Hessarghata, Bangalore on well drained sandy loam soil during 1996-97. They reported that total soluble solids was significantly higher with 150 g N and K application through 50% drip and 50% soil (22.3%) as against through full soil (20.90%). The quality of banana under drip and basin irrigation alongwith N and K fertilization was studied by Hegde and Srinivas (1991) at IIHR., Hessarghata, Bangalore on sandy clay loam soil. They reported that increasing N application increased the total soluble solids in the pulp although the effect was significant only in the plant crop. Further, an increased level of K-fertilization significantly increased the TSS in the ratoon crop and decreased the pulp: peel ratio. The highest TSS (24 %) and pulp: peel ratio (2.76) of banana was obtained when the plants were supplied 200g each of N and K plant^{-1} in a study on yield and nutrient uptake of Robusta banana in relation to N and K fertilization conducted at IIHR, Bangalore on sandy loam soil by Srinivas *et al.* (2001). The quality of banana in terms of banana as influenced by organic and inorganic manures was studied by Soorianathasundaram *et al.* (2001) at TNAU, Coimbatore. They observed that there were non significant differences in TSS but higher values were recorded in plots received 25% N-FYM + 75% N-urea N and 25% N-FYM + green manure + 75% N- urea (26%).

Chattopadhayay and Bose (1986) studied the effect of NPK nutrition on growth, yield and quality of Dwarf Cavendish banana at HRS, Nadia, West Bengal during 1979-81. They were indicated that application of K appreciably increased the TSS and total sugar over other treatments while the acidity of fruit increased with nitrogen level. The reduction was noted due to potassium. They also reported the progressive increase in reducing sugars and pulp: peel ratio with ripening.

2.5.2 Reducing sugar and non-reducing sugar

Sabarad *et al.* (2004) reported that AM inoculated (mycorrhiza) banana fruits recorded higher values of reducing sugars (17.99%), non-reducing sugar (1.68%) and total sugars (19.77%) as compared to uninoculated plants. Further, they observed higher values of TSS (25.38^{0}), TSS/acid ratio (302.75), reducing sugars (18.29%), non-reducing sugars (1.73%) and total sugars (20.07%) in banana fingers obtained from *in-situ* vermiculite treatment.

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Efficiency of vermicompost on yield and quality of banana (AB) cv. Njalipoovan studied by Ushkumari *et al.* (1997) at College of Agriculture, Vellayani, Kerela and reported that application of vermicompost @ 13 kg plant^{-1} (having N content 1.5% to supply 200g N solely from vermicompost) produced 18.30% reducing sugars while vermicompost application @ 10 kg plant^{-1} alongwith inorganic source of nitrogen obtained 17.50% of reducing sugars. However, the non-reducing and total sugars in banana obtained higher values 5.5% and 23% in the treatment of vermicompost application @ 10 kg plant^{-1} alongwith inorganic source of nitrogen.

2.5.3 Pulp : peel ratio

Narayana *et al.* (2002) studied the effect of packaging and storage on shelf life and quality of banana cv. Karpuravalli at NRC on banana at Tirchy. They reported that the shelf life of fruits in unvented polybags was maximum (19.33 days) at 13^{0}C followed by zero energy cool chamber (7.33 days). Further, they reported the non-significant variation in TSS of fruits in unvented, vented and control treatments. The acidity increased gradually throughout storage period.

Debnath *et al.* (2001) studied the bunch management for profitable production of banana at HRS, Mondouri, Nadia, West Bengal during 1996-97 and 1997-98. They reported that application of 300:100:400g plant^{-1} N, P_2O_5 and K2O+10kg FYM along with blue polythene cover on bunches had significantly higher pulp and peel weight. The highest pulp: peel ratio (2.37:1) was recorded with blue polythene cover than black polythene cover (2.27:1).

Pathak and Sanwal (1999) studied the ripening of banana fruits as influenced by chemicals at Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad. They were reported that pulp: peel ratio of banana was significantly increased with ripening period and it was maximum in banana fingers dipped in 0.2 % inorganic pyrophosphate (3.05) and 0.2% calcium chloride (3.05). The pH of fruit pulp was decreased gradually as indicated by increase in acidity. The total sugar content was slowly increased initially but on 5 days onwards remarkable increase was noticed.

Bhargava *et al.* (1993) studied the influence of different levels of potassium on banana fruit quality and reported that higher level of potassium @ 480 g plant^{-1} enhanced the total sugar, total soluble solids and reduced the acidity. The chemical and physical changes in plantains during ripening at a temperature of 26^{0}C ere examined by Aboua Firmin (1991). He reported that the acidity of banana as the malic acid significantly enhanced from 2.55 meq 100g^{-1} in mature green banana to 5.13 meq 100g^{-1} in ripe fruits.

Almazan (1991) studied the chemical changes in some cooking banana and plantain cultivars during ripening and reported the increase in pulp: peel ratio, total soluble solids and hydrolysis of starch in banana during ripening.

Ram and Prasad (1988) reported that higher level of total soluble solids (21.21^{0}) in banana was obtained with 200:80:200g N, P_2O_5 and K_2O plant^{1}. Physicochemical changes in plantain during ripening was studied by Asiedu (1987) and reported that the ratio of flesh to peel was in the range of 1.22 to1.68 in the green unripe fruit and it was increased to 2.3 to 2.6 at advanced ripening and it was related to changes in the sugar concentration in the two tissues. Sugar increase more rapidly in the flesh than in the peel and this difference is reflected in a differential changes in osmotic pressure.

Patil and Magar (1976) examined physicochemical changes in banana fruits of different varieties and concluded that the gradual increment in pulp: peel ratio was higher in harichal banana than other cultivars under study.

2.6 Residual effect of nitrogen management on soil fertility status

2.6.1 Soil pH and EC

Islam *et al.* (2003) studied the long term effect of urea-N and organic residue on *Aeric haplaquept* with double rice (wet-dry-fallow) cropping pattern at Rice Research Institute, Gazipur, Bangladesh. They were reported that long term use of inorganic N and organic residues increased soil pH from it's initial (6.70) by 0.09 units in no organic residue, 0.13 units in rice straw while 0.18 units in cow dung. Three organic manures *viz.,* olive oil mill waste compost, municipal solid waste compost and paper mill sludge were used in a field experiment on sandy loam soil involving orange production (Madejon *et al.,* 2003). They reported increase in soil pH in all organic manures. The paper sludge application showed the higher pH (7.61) value than all other organic amendments and control (6.68). The higher pH value could be due to high levels of Ca in paper sludge causes buffer effects. Further, they reported that soil salinity was unaffected after three years of organic amendments. A field experiment at Gandhi Krishi Vigyan Kendra, Bangalore was carried out by Srikant *et al.* (2000) to study the direct and residual effects of enriched composts in comparison with FYM, vermicompost and inorganic fertilizers on ragi and cowpea in alfisol. They reported that incorporation of FYM and vermicompost increased the soil pH. However, the highest pH was recorded in FYM (6.90 and 7.08) followed by vermicompost (6.88 and 7.04) after the harvest of ragi and cowpea over the initial soil pH (6.20).

Eghball (2002) found that the surface soil (0-15 cm) pH and EC significantly increased with N based manure or compost application but decreased with NH_4-N fertilizer application.

Anand Swarup and Yaduvashu (2000) conducted field experiments from 1994 to 1996 to study the effect of integrated nutrient management on soil properties and yield of rice in gypsum amended alkali soil. The continuous cropping for three years during rice-wheat rotation decreased soil pH was higher in inorganic fertilizer as compared to NPK + in situ green manuring of FYM application @ 10 t ha^{-1}.

Dixit and Gupta (2000) observed that there was little variation in soil pH of inceptisol which ranged from 7.70 to 7.80 under different NPK combinations along with FYM, blue green algae as against initial soil pH of 7.80.

Misra and Das (2000) conducted an incubation study on acid sandy loam soil of Bhubaneswar to find out the influence of organic amendments of P availability and soil properties. They reported the increase in pH due to addition of FYM or green manure and attained the highest value between 15-30 days and decreased thereafter.

2.6.2 Soil available nitrogen

Suresh and Surya Prabha (2005) studied the properties of vertisol as influenced by inorganics under cotton-bajra sequence at TNAU, Kovilpatti during 1997-2001. They reported the higher availability of nitrogen was in combined application of 20 kg inorganic N + 20 kg N through composted coir pith (129 kg ha^{-1}) over only 40 kg inorganic N (115 kg ha^{-1}). The application of recommended dose of NPK alongwith *Azatobacter* and PSB significantly increased the available N content (369.43 kg ha^{-1}) of post harvest soil of banana over the control (267.21 kg ha^{-1}) (Gogoi *et al.* 2004).

At the end of two years crop cycle with different commercial manures in alfisol, Prakash *et al.* (2002) found that availability of major nutrients was higher in the treatments with organic nutrient sources like FYM, vermicompost and FYM + microbial cultures as compared to inorganic fertilizers.

After twenty eight years of continuous intensive cropping along with organic and inorganic fertilization resulted in increased available nitrogen. The highest value of available nitrogen (290 kg ha^{-1}) was recorded by integrating the use of recommended dose of fertilizer with FYM (Tiwari *et al.,* 2002).

Suresh and Hasan (2002) studied the soil nutrient status of a banana (Musa AAA cv. Gaint governer) plantation in relation to nitrogen and potassium nutrition at HRS, Mandouri, West Bengal during 1996-97 and 1997-98 on sandy loam soil. They reported that application of nitrogen at higher levels on combination with potassium substantially increased the soil nitrogen status. However, the reduction in soil nitrogen recorded during shooting and harvest.

According to Singh *et al.* (2001) the continuous conjunctive use of fertilizer nitrogen with organic manure increased the total hydrolysable nitrogen, conjunctive use of 90 kg N ha^{-1} + 5 t FYM ha^{-1} or 6 t ha^{-1} green manure increased the total hydrolysable nitrogen from 1256 to 1350 kg ha^{-1} after three years, 1356 to 1395 kg ha^{-1} after five years and 1395 to 1525 kg ha^{-1} after seven years.

Higher available N content of soil under FYM addition could be due to favourable microbial activity and enhanced biomass addition to the soil and also as a result of improved soil physical properties (Muthuvel *et al.*, 1990).

Adhikari and Ganguly (1971) reported that there was an increase in nitrate formation with the increase in organic matter fraction.

2.6.3 Soil available phosphorus

Tolanur and Badanur (2003) observed that available phosphorus content of soil was increased significantly with FYM increased the available phosphorus might be because of solubalization of the native phosphorus in the soil through release of various organic acids.

Sharma *et al.* (2001) studied the long term (1985-97) effect of integrated nutrient management with rice-wheat sequence on inceptisol of Jammu and Kashmir and found that continuous application of organics through FYM, green manure and crop residues resulted significantly higher available phosphorus. The increase in phosphorus might be due to decomposition of organic material accompanied by the release of appreciable quantity of CO_2.

The field experiment at Gandhi Krishi Vigyan Kendra, Bangalore was carried out by Srikanth *et al.* (2000) to study the direct and residual effect of enriched compost in combination with FYM, vermicompost and inorganic fertilizers on ragi and cowpea in alfisol. They concluded higher available phosphorus (72.30 and 54.31 kg ha^{-1}) after the harvest of ragi and cowpea in the soil amended with enriched compost of industrial waste.

Mathur (1997) studied the long term effect of fertilizer and manure on soils of Sriganganagar, Rajasthan. They reported that there was a significant increase in the available P status of the soil in plots receiving fertilizer P in both the seasons and in those getting FYM application over rest of the treatments.

Continuous application of FYM to sierozem soil into the semi-arid region of Haryana resulted in built up of soil available P (Singh and Singh, 1980).

Chellamuthu *et al.* (1978) found that application of FYM registered the highest available P content of the soil.

2.6.4 Soil available potassium

Babhulkar *et al.* (2000) studied the residual effect of long term application of FYM and fertilizers on soil properties (vertisol) and yield of soybean at College of Agriculture, Nagpur. They were reported that significantly higher available potassium was observed in 7.5 t ha^{-1} FYM plus half dose of NP.

Lal *et al.* (2000) concluded the effect of plant residue incorporation of *Lantana camera* tops, *Ipomoea cornea* tops, water hyacinth, karanj leaves, subabhul leaves, lentil straw, maize stover and rice straw in alfisol of Ranchi on microbial population and nutrient availability. They reported that the highest K availability (182.70 mg kg^{-1}) was recorded in subabhul incorporation soil, which was on par with water hyacinth treated soil (180.20 mg kg^{-1}).

Gopal Reddy and Suryanarayan Reddy (1998) studied the effects of organic manures and nitrogen levels on available nutrient status of sandy loam soil of Hyderabad with maize-soybean cropping system. They reported that 100 per cent level of each manure (FYM, vermicompost, poultry manure and biogas slurry) recorded higher availability of K. It was on par with 75 and 50 per cent levels of manure.

Santhy *et al.* (1998) observed the long-term (1982-1992) effects of continuous cropping and fertilization on sandy clay loam soil at Coimbatore. They reported that available K content of the soil was increased (765, 605 and 590 kg ha^{-1} in 1982, 1987 and 1992 respectively) over the initial value (490 kg ha^{-1}) under 100 % NPK + FYM treatment.

Mathur (1997) studied the long term effect of application of fertilizers and manures on soil properties under cotton-wheat rotation on sandy loam soil of Sriganganagar and Rajasthan. They reported that full dose of FYM [100 % FYM (0.5% N) was applied @ 16 and 24 t ha^{-1} for cotton and wheat respectively] recorded significantly the higher availability K (630 kg ha^{-1}), which was followed by 50% FYM + 50 % NPK (552.5 kg ha^{-1}).

2.6.5 Soil organic carbon

Bhattacharrya *et al.* (2004) studied the long-term effect of manuring on soil organic carbon and reported that both oxidisable and nonoxidisable soil organic carbon content of the soil were significantly higher in FYM at the first two depths (1.31 and 10.44 g C kg soil^{-1} in 0-15, 1.87 and 8.44 g C kg soil^{-1} in 15-30cm for NPK + FYM treatment) than all other treatments.

Selvi *et al.* (2004) indicated the gradual increase in the biomass carbon content of the soil with the treatment of graded levels of NPK from 50 to 150 per cent. However, application of 100 per cent NPK + FYM recorded significantly the highest biomass C followed by 150 per cent NPK application.

Islam *et al.* (2003) found the long term effect of urea-N and organic residues on *Aeric Haplaquept* with double (wet-dry-fallow) cropping pattern at Rice Research Institute, Gazipur, Bangladesh. They reported that application of 210 kg N ha^{-1} alongwith rice straw @ 5 t ha^{-1} increased the organic carbon content from 1.07 to 1.11% while cow dung enhanced the organic carbon from 1.11 to 1.15 %.

Organic carbon content of surface soil increased significantly with the incorporation of FYM (0.47 to 0.55%), vermicompost (0.43 to 0.50%) and subabhul (0.47 to 0.54%) alongwith 50% inorganic fertilizers (Tolanur and Badanur, 2003). The highest organic carbon content (0.54 to 0.64 %) reported in 50% N through compost + 50% N through RDF.

Prakash *et al.* (2002) reported that the vermicompost and FYM was responsible for significantly higher organic build up in soil over other commercial manure at the end of two year crop cycle.

Anand Swarup and Yaduvanshi (2000) studied the effects of integrated nutrient management on soil properties and yield of rice in gypsum amended alkali soil of Karnal. They were reported that continuous use of NPK along with *in-situ* green manuring or FYM @ 10 t ha^{-1} increased the organic carbon from 3.20 to 3.70 g kg^{-1} in 0-15 cm soil depth. However, continuous cropping for three years reduced organic carbon from initial level of 3.20 to 3.00 g kg^{-1} in control and inorganic fertilizer treated plots. Residual effects of long-term use of fertilizer alone and in combination with FYM on properties of vertisol and yield of soybean were studied after five years of soybean based cropping system at College of Agriculture, Nagpur by Babhulkar et al. (2000). They were reported that the organic carbon content of soil significantly increased in the plots where FYM was applied. The higher value of organic carbon (6.2 g kg^{-1}) was obtained in plots received 7.5 t ha^{-1} FYM along with half dose of NP followed by 5 t ha^{-1} FYM + half dose of NP.

A field experiment at Gandhi Krishi Vigyan Kendra, Bangalore was carried out by Srikanth *et al.* (2000) to study the direct and residual effects of enriched composts in comparison with FYM, vermicompost and inorganic fertilizers on *Alfisol.* They reported that enriched compost of agro-industrial waste recorded higher organic carbon content after harvest (7.10 and 6.90 kg^{-1}) of first crop ragi and second crop cowpea.

2.6.6 Soil DTPA – Fe, Mn, Cu and Zn

Malewar (2005) reported the available Fe, Mn, Zn and Cu in soil were increased with the addition of organic manures and balanced fertilization. The long-term (1997-2001) application of organic residues alone equivalent to 40 kg N ha^{-1} recorded significantly higher DTPA-Zn (0.90 kg ha^{-1}) and Fe (2.8 kg ha^{-1}) over

50% substitution with inorganic fertilizers (Suresh and Surya Prabhu, 2005).

Agbenin and Henningsen (2004) studied the dynamics of copper fraction and solubility in a *Typic Haplustalf* (dominated by kaolinite and traces of illite) as influenced by organic manures, inorganic fertilizers and noticed that long-term application of FYM and FYM + NPK significantly increased the DTPA extractable Cu in surface horizon while in the subsurface horizon in FYM fertilized soil. Further, fertilization with FYM and FYM + NPK increased the organically complexed Cu in the surface layer as compared to NPK-fertilization.

The micronutrients like Fe, Cu and Zn availability was significantly higher in FYM treatment in a two year crop cycle with different commercial manures tested (Prakash *et al.* 2002).

Mukhopadhyay and Das (2001) recorded the higher amount of extractable Fe and Mn in inceptisol and alfisol with the application of organic matter. The magnitude was more with the levels of organic matter indicated its positive relationship with the extractability of Fe and Mn in the soils. In a long term experiment (1985-97) on integrated nutrient management on rice-wheat sequence on inceptisol of Jammu and Kashmir studied by Sharma *et al.* (2001). They were noticed that reduction in DTPA- extractable Fe, Mn, Zn, and Cu in the inorganic fertilizers over control. Incorporation of organics (FYM, green manure and crop residues) alongwith inorganic fertilizers registered higher micronutrients (Zn, Fe, Mn and Cu) status of soil over 100% recommended dose. The magnitude of increase was significantly higher in 50 % N supplied through FYM, green manure and crop residues.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The present investigation was carried out to study the "Residual effect of nitrogen management on yield and quality of ratoon banana on inceptisol" in field. The details of materials used and methods adopted are described in this chapter.

The investigation was carried out during *rabi* October 2006 to June 2007.

3.1 Climate

Geographically, the location of Rahuri campus is situated between $19^{0}47'$-$19^{0}57'$ N latitude and $74^{0}19'$ E longitude. The altitude varies from 495 to 569 m above mean sea level. The experimental field was in semi arid subtropical zone, with an average annual rain fall receiving through Southwest monsoon.

The climatic conditions during crop growth *viz.*, average maximum and minimum temperature, rain fall and morning and evening humidity were recorded and presented in Table 1.

The maximum and minimum temperature ranged between 40.6-9.2^{0}C during the crop growth. The relative humidity during morning and evening ranged from 94.00 to 18.00 per cent. Rainfall received during the crop growth was 507.5 mm in 27 rainy days.

Table 1. Meteorological data recorded during experimental period

Met. Week No.	Temp. (°C)		RH (%)		Rain fall (mm)	No of rainy days	Evaporation (mm)
	Max.	Min.	7.30 hrs	14.30 hrs.			
2006							
Oct.							
40	29.8	22.2	88	74	45.2	4	2.4
41	31.7	17.9	80	44	0.0	-	3.5
42	32.8	18.0	70	35	0.0	-	3.9
43	31.2	16.5	75	35	7.2	1	3.2
44	29.8	18.0	84	51	0.0	-	3.1
Nov.							
45	29.4	16.3	81	48	33.7	1	2.3
46	28.9	13.3	77	39	0.0	-	2.6
47	30.0	16.5	77	49	15.0	1	2.0
48	30.8	17.9	77	45	08.8	1	2.0
Dec.							
49	30.8	13.7	81	37	0.0	-	2.2
50	28.9	12.1	82	39	0.0	-	2.2
51	28.2	9.2	83	35	0.0	-	2.3
52	29.6	12.3	79	37	0.0	-	2.4
2007							
Jan.							
1	28.5	10.1	75	36	0.0	-	2.7
2	29.1	11.3	81	38	0.0	-	2.9
3	30.1	11.0	72	33	0.0	-	3.0
4	31.2	12.2	54	35	0.0	-	3.6
5	31.9	14.6	59	35	-	-	3.7
Feb.							
6	31.5	12.5	51	27	0.0	-	4.6
7	28.9	12.2	70	32	0.0	-	5.4
8	32.6	14.1	64	23	0.0	-	4.5
9	32.3	12.3	71	26	0.0	-	5.3
March							
10	33.3	13.3	62	23	0.0	-	6.2
11	33.6	15.2	58	24	0.0	-	6.3
12	35.8	17.3	50	25	0.0	-	7.4
13	37.7	18.3	53	18	0.0	-	7.8

Table 1. contd...

Met. Week No.	Temp. (°C)		RH (%)		Rain fall (mm)	No of rainy days	Evapor-ation (mm)
	Max.	Min.	7.30 hrs.	14.30 hrs.			
April							
14	38.8	18.4	87	19	0.0	-	10.9
15	38.2	18.8	89	22	0.0	-	12.0
16	36.9	20.7	92	30	9.1	1	11.3
17	39.3	19.9	86	19	0.0	-	12.9
18	41.3	22.0	81	20	0.0	-	15.0
May							
19	40.6	22.0	82	22	0.0	-	15.9
20	38.5	21.7	86	26	83.6	2	12.9
21	37.2	21.7	89	28	0.0	-	11.1
22	36.7	23.2	87	36	44.1	2	9.1
June							
23	34.4	23.1	92	50	74.1	4	4.8
24	34.8	23.4	91	62	18.8	2	5.7
25	31.7	22.7	94	72	143.2	4	3.9
26	29.5	22.6	94	76	07.8	1	5.0
July							
27	28.6	23.0	95	74	15.5	3	4.2
28	29.8	22.7	94	71	1.4	-	4.2
29	31.0	21.8	93	72	0.0	-	5.0

3.2 Experimental material

3.2.1 Experimental site and location

The present investigation was carried out at Post Graduate Institute Research Farm of Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra.

3.2.2 Soil

The soil of experimental area was grouped under Inceptisol order belonging to Pather (Sawargaon) soil series, which comprises of type montmorillionitic, hyperthermic family of *Vertic haplustepts*. The soil was medium black with 70 cm depth and dolomite type of clay mineral having high swell shrink property. The soil samples were collected randomly from different sites of experimental plots. These samples were analysed for physical and chemical properties. The physico-chemical properties of soil are given in Table 2.

3.2.3 Glass wares

Glass wares used for analytical work were of Borosil, Pyrex and Corning (India) made.

3.2.4 Chemicals

All the chemicals used for analysis of soil and plant samples were analytical (A.R.) grade.

3.3 Experimental methods

The experiment was laid out in Randomized Block Design comprised with three replications (Fig. 1).

Table 2. Initial physical and chemical properties of soil

Sr. No.	Soil property	Value
A.	**Physical properties**	
1.	Bulk density (Mgm^{-3})	1.28
2.	Particle size analysis	
	1. Sand (%)	20.38
	2. Silt (%)	27.50
	3. Clay (%)	50.40
3.	Textural class	Clay

chemical properties

Tr. No.	pH	E.C. (dSm^{-1})	O.C. (%)	Available nitrogen ($kg\ ha^{-1}$)	Available P_2O_5 ($kg\ ha^{-1}$)	Available K_2O ($kg\ ha^{-1}$)	Soil DTPA micronutrients ($mg\ kg^{-1}$)			
							Fe	Mn	Zn	Cu
T_1 : RDF: 200:40:200 g $plant^{-1}$ N, P_2O_5 and K_2O + 10 kg FYM $plant^{-1}$	8.55	0.16	0.733	166.0	17.34	799	7.28	8.31	1.34	2.86
T_2 : 25% N- FYM + 75% N- RDF	8.43	0.16	0.740	173.0	20.21	632	6.36	9.66	1.43	2.33
T_3 : 25% N- Neem cake + 75% N- RDF	8.49	0.18	0.688	147.0	20.55	652	6.70	8.54	0.70	2.83
T_4 : 25% N- Vermicompost + 75% N- RDF	8.61	0.17	0.713	155.0	19.31	492	5.96	8.29	1.03	2.84
T_5 : 50% N- FYM + 50% N- RDF	8.16	0.19	0.820	154.0	21.72	748	6.26	8.29	1.26	2.79
T_6 : 50% N- Neem cake + 50% N- RDF	8.63	0.16	0.663	152.0	19.13	643	6.14	8.39	1.08	2.91
T_7 : 50% N- Vermicompost + 50% N- RDF	8.53	0.15	0.705	150.0	22.09	554	6.03	8.20	0.91	2.38
T_8 : Inorganic fertilizers as per soil test	8.58	0.17	0.608	151.4	14.14	532	5.77	6.64	0.84	2.06
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	8.32	0.18	0.838	157.4	22.26	860	7.59	7.16	1.20	2.63
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	8.50	0.18	0.715	151.0	19.22	757	6.64	6.48	0.86	2.07
SE±	0.031	0.003	0.010	2.641	1.270	4.288	0.108	0.256	0.055	0.111
CD at 5 %	0.092	0.010	0.031	7.843	3.771	12.735	0.320	0.761	0.164	0.330

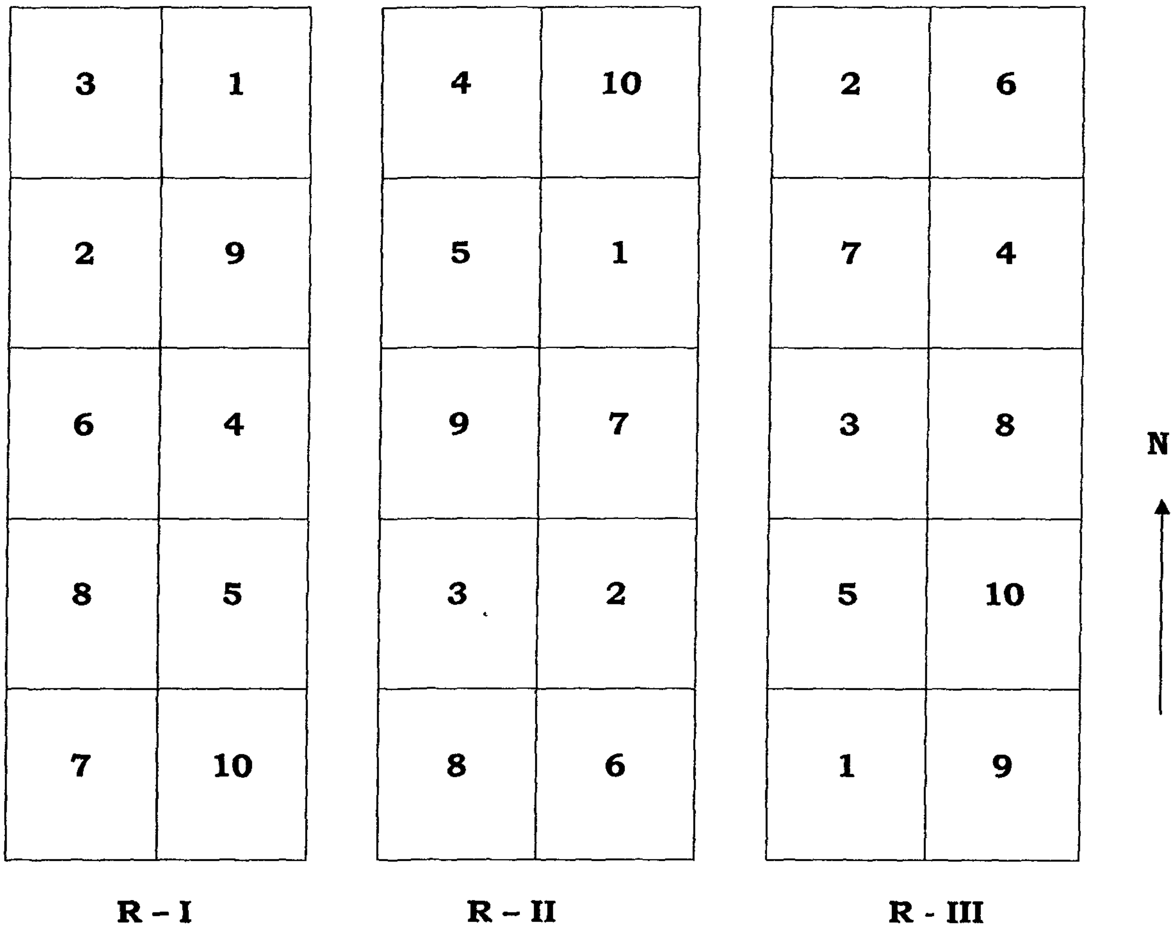

Fig. 1. Plan of layout

Plot size	: Gross plot - 10.5 X10.5 m^2
	: Net plot - 8.5 X 7.54 m^2
Spacing	: 1.5 m x1.5 m
Design	: Randomized block design
Replication	: 3
Treatment	: 10
Variety	: Grand naine

Treatment details

Sr. No.	Treatments
1	Recommended dose of fertilizer (200:40:200 g plant^{-1} N, P_2O_5 and K_2O) + 10 kg FYM plant^{-1} (Control)
2	25% N- FYM + 75 % N- RDF
3	25% N- neem cake + 75 % N- RDF
4	25% N- vermicompost + 75 % N- RDF
5	50% N- FYM + 50 % N- RDF
6	50% N- neem cake + 50 % N- RDF
7	50% N- vermicompost + 50 % N- RDF
8	Inorganic fertilizer as per soil test
9	33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost
10	25% N- FYM + 25% N- neem cake + 25% N- vermicompost + 25% N- RDF

3.4 Observations recorded

All the plants of each of the treatment were catered to with equal care in each of their growth and development stages. For recording various growth observations five plants were randomly selected from each of the thirty plots. The observation *viz*; pseudo stem height, stem girth and number leaves were recorded at the time of harvest.

3.4.1 Vegetative parameters

3.4.1.1 Number of functional leaves

The number of fully emerged leaves were counted and last emerged leaf was tied with sutali. During each subsequent observations same method was followed and leaf count was made above the marked leaf.

3.4.1.2 Height of pseudostem

The height was measured in meters from the base of pseudostem up to the throat.

3.4.1.3 Stem girth of pseudostem

The girth of the pseudostem of each plant under observation was measured at 15 cm above the base of the plant in centimeters.

3.5 Plant analysis

3.5.1 Plant analysis at harvest

Five plants from each plot were selected randomly by assessing the physiological maturity of bunches. The bunches were harvested from the plant. After harvest of bunches the plants were cut down from the ground level and weighed. The selected plants were then partitioned in to three parts *viz.,* total leaves and shoot (Table 3).

3.5.2 Leaf analysis

The total fresh weight of leaves was recorded for five randomly selected plants from each plot, air-dried and oven dried at 70^{0}C temperature till constant weight. Dry matter yield was recorded. The third youngest leaves of five plants were cut at center for 20 cm strip along with midrib and lamina and processed for nutrient assessment.

3.5.3 Shoot analysis

The total fresh weights of randomly selected five shoots from each plot were recorded. The shoot then partitioned in equal parts and a representative composite sample was air-dried and oven dried at 70^{0}C temperature till constant weight. Dry matter yield was recorded and analysed for nutrient concentration in shoot.

Table 3. Standard analytical methods

Sr. No.	Parameter	Method	Reference
A] Soil analysis – Physical			
1.	Bulk density	Clod method	Blake and Hartge (1986)
2.	Particle size analysis	Bouyoucos hydrometer	Gee and Bauder (1986)
B] Soil analysis – Chemical			
1.	pH (1:2.5)	Potentiometric	Jackson (1973)
2.	EC (dSm^{-1})	Conductometric	Jackson (1973)
3.	Organic carbon	Wet oxidation – Walkley and Black (1934)	Nelson and Sommer (1982)
4.	Available nitrogen	Modified alkaline permanganate	Subbiah and Asija (1956)
5.	Available phosphorus	0.5 M $NaHCO_3$ (pH 8.5)	Olsen *et.al.,*(1954)
6.	Available potassium	Neutral N NH_4OAc	Knudsen *et.al.,* (1982)
7.	DTPA –Fe, Mn, Zn and Cu	Atomic Absorption Spectrophotometry	Lindsay and Norvell (1978)
C) Plant analysis (shoot, leaf and fruit analysis)			
1.	Leaf sampling	International Reference Method	Matin- Prevel (1983)
2.	Total nitrogen	Micro-kjeldahl	Jackson (1973)
3.	Total phosphorus	Vanadomolybdate yellow colour method in Nitric acid system	Jackson (1973)
4.	Total potassium	Flamephotometery	Chapman and Pratt, (1961)
D) Fruit quality analysis			
1.	Reducing sugars	Hydrolysis	Lane and Eynon (1923)
2.	Total soluble sugars	Hydrolysis	Lane and Eynon (1923)
3.	Acidity	Neutralization	A.O.A.C. (1990)

3.5.4 Fruit analysis

The physiologically matured fruit samples were drawn from the five selected plants. The middle three fruits of third hand from the top were selected and cut into small slices. These fruit slices were air dried and then oven dried at 70^0 C temperatures till constant weight. The dried fruit samples were ground in mortar and pestle and used for their nutrient concentration (Table 3).

3.5.5 Uptake of nutrients

The uptake of major and micronutrients were determined by using dry matter percent and nutrient concentration at harvest in partitioned banana. The uptake of each nutrient was calculated separately for shoot, leaves and fruit. The total uptake at harvest was calculated by summing the nutrient uptake by shoot, leaves and fruit.

3.6 Yield contributing characters

3.6.1 Days for flowering

When most of the fingers from the bunch started changing their colour from dark green to light green, when edges of individual fruit disappeared and when tapped gave metallic sound was considered as physiological maturity stage. The days counted from ratooning to physiological maturity stage at which banana were harvested and worked out as days for harvesting.

3.6.2 Number of hands

Number of hands from individual bunch were counted and recorded.

3.6.3 Number of fingers

Total number of fingers per hand were counted and recorded.

3.6.4 Finger length (cm)

Middle two fingers of second hand from base were taken to measure the length of fruit. The length was measured from the attached portion pedicel and fruit up to apex, along the curved surface in centimeters.

3.6.5 Finger girth (cm)

Middle circumference of the same selected fruits was measured in centimeters.

3.6.6 Bunch weight

Bunch weight was recorded with the help of spring balance in kilogram (kg).

3.6.7 Yield per hectare (q ha^{-1})

The yield per hectare was calculated from average yield of individual plot in tonnes per hectare.

3.7 Post harvest study

The manual of INIBAP Technical Guidelines on Routine Post-Harvest screening of Banana/plantain Hybrids; Criteria and Methods by Dadzie and Orchard (1997) were used for banana fruit sampling and post harvest studies.

The banana plants of Grand Naine variety were tagged on the first day of their inflorences in the experimental plot. The uniformity was maintained in each treatment during tagging. The ready to harvest or physiologically mature bunches were picked and hands were separated and brought to laboratory in corrugated boxes. The maturity of banana bunches were judged by using colour chart given by Dadzie and Orchard (1997) middle three hands were selected from each bunch excluding top and bottom hands to reduce the variation in physiological maturity of fruits within the bunch.

Three bunches were harvested from each replication for post harvest studies. Five fruits were randomly selected from three hands representing single replicate of a treatment at 0, 7th, 14th and 21st days of ripening for fruit observations and chemical analysis for quality parameters. A desired quantity of fresh pulp (20g) was rapidly weighed, cut into slices and thoroughly mixed with water in a blender and centrifuged at 3000 x g to obtain water soluble sugars and filtered to 250ml volume. The suitable aliquot was used for different quality parameters *viz.*, total sugar, reducing and non-reducing sugars by following standard method.

3.7.1 Pulp: peel ratio

The pulp and peel was separated from each other for individual fruit. The weight of pulp and peel were weighed on electronic balance and the ratio was calculated as weight of pulp divided by peel weight.

3.7.2 Titrable acidity

Titrable acidity was determined at 0, 7, 14 and 21st days of ripening by diluting 20g of homogenized banana pulp with distilled water and neutralized the acidity with N/10 NaOH and excess NaOH was back titrated with N/10 HCL using phenolphthalein indicator (A.O.A.C., 1990). The data were expressed in meq. acidity 100g $^{-1}$ NaOH.

3.7.3 Reducing sugars (%)

The reducing sugars from ripened fruits were estimated by felhling (A) and felhing (B) Nelson and Sommers method which is modified by Ranganna.

3.7.4 Total sugars (%)

The non-reducing sugars from ripened fruit were estimated by Benedicts method.

3.8 Soil analysis

Composite soil samples were collected from each plot upto 15 m depth after harvest of ratoon banana and analysed for the pH, EC, organic carbon, N, P_2O_5, K_2O, Fe, Mn, Zn and Cu by adopting standard methods of analysis (Table 3).

3.9 Statistical analysis

The data generated during investigation are processed tabulated and statistically analysed for their test of significance by using standard statistical method Randomized block design (Panse and Sukhatme, 1985).

Chapter Opener Page

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The residual effect of nitrogen management as influenced by use of farm yard manure, vermicompost and neem cake along with different ratios of recommended dose of chemical fertilizers was examined. The effect of nitrogen management on yield and quality as well as nutrient uptake of ratoon banana during *rabi* October, 2006 to June, 2007 were studied. The observations recorded during the investigation were statistically analysed and results obtained are discussed in this chapter.

4.1 Residual effect of nitrogen management on growth parameters of ratoon banana at harvest

Influence of residual effect of nitrogen management on growth parameters at harvest in ratoon banana are presented in Table 4.

The number of functional leaves, pseudostem height and girth of pseudostem at harvest were not responded significantly. The non-significant differences in growth parameters at harvest may be due to slow uptake pattern of nutrients.

Similar results were obtained by Hegde and Srinivas (1991), Soorianathasundaram *et al.* (2002), Jeyabaskaran *et al.* (2003), Trikey *et al.* (2002), Babu and Sharma (2005).

Table 4. Influence of residual effect of nitrogen management on growth parameters of ratoon banana at harvest

Treatment	**No. of leaves**	**Pseudostem girth (cm)**	**Pseudostem height (cm)**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	15.80	59.70	206.00
T_2 : 25% N- FYM + 75% N- RDF	16.82	60.32	206.46
T_3 : 25% N- Neem cake + 75% N- RDF	16.50	55.30	206.16
T_4 : 25% N- Vermicompost + 75% N- RDF	16.95	56.35	208.83
T_5 : 50% N- FYM + 50% N- RDF	17.01	55.42	212.50
T_6 : 50% N- Neem cake + 50% N- RDF	15.96	55.33	204.30
T_7 : 50% N- Vermicompost + 50% N- RDF	16.23	55.07	206.30
T_8 : Inorganic fertilizers as per soil test	16.40	56.06	207.00
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	16.12	54.66	203.00
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	16.30	57.32	202.94
S.E. $\pm$	1.234	1.213	2.138
C.D. at 5 %	N.S.	N.S.	N.S.
Mean	16.409	56.55	206.35

4.2 Residual effect of nitrogen management on yield and yield contributing characters of ratoon banana

The integrated nitrogen management treatment and it's residual effect significantly influenced the banana yield and yield contributing characters are presented in Table 5 and Fig. 2. Number of fingers per bunch and bunch height of banana were significantly influenced. Whereas, number of hands per bunch were statistically non-significant.

Amongst all the treatments the treatment receiving 25 % N- FYM + 75 % N- RDF showed significant increase in number of fingers per bunch, bunch weight, yield (116.36, 15.43, 72.92 t ha^{-1}) followed by 50 % N- FYM + 50 % N- RDF (113.06, 14.56 kg, 69.14 t ha^{-1}) and inorganic fertilizer application based on soil test (112.03, 14.12 kg, 66.62 t ha^{-1}), 50 % N- vermicompost + 50 % N- RDF (113.90, 14.11 kg, 66.45 t ha^{-1}) and 25 % N- neem cake + 75 % N- RDF (112.41, 13.82 kg, 64.43 t ha^{-1}).

The results on number of hands per bunch were statistically non significant. However, an application of 25 % N Neem cake + 75 % N- RDF recorded numerically higher number of hands per bunch (7.66).

The application of nitrogen through FYM or vermicompost or neem cake in the proportion of either 25 or 50 per cent and it's residual effect on ratoon crop reported higher number of fingers per bunch, number of hands per bunch, bunch weight and yield of banana. This might be because of adequate supply of both macronutrients and micronutrients to banana. The integrated nutrient management and it's residual effect resulted

Table 5. Yield and yield contributing characters of ratoon banana as influenced by residual effect of nitrogen management

Treatment	Bunch wt. (kg)	Yield (t ha^{-1})	No. of hands/ bunch	No. of fingers/ bunch	Length of finger (cm)	Girth of finger (cm)
T_1 : RDF: 200:40:200 g $plant^{-1}$ N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	12.87	57.91	7.26	111.94	16.26	11.80
T_2 : 25% N- FYM + 75% N- RDF	15.43	72.92	7.66	116.36	20.33	15.63
T_3 : 25% N- Neem cake + 75% N- RDF	13.82	64.43	7.58	112.41	17.63	13.66
T_4 : 25% N- Vermicompost + 75% N- RDF	13.70	64.52	7.54	114.10	17.30	13.60
T_5 : 50% N- FYM + 50% N- RDF	14.56	69.14	7.60	113.06	18.53	14.60
T_6 : 50% N- Neem cake + 50% N- RDF	13.19	62.94	7.60	105.93	18.53	12.83
T_7 : 50% N- Vermicompost + 50% N- RDF	14.11	66.45	7.52	113.90	17.50	13.06
T_8 : Inorganic fertilizers as per soil test	14.12	66.62	7.40	112.03	19.43	13.43
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	10.35	48.61	7.52	106.06	16.63	11.50
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	13.32	64.14	7.50	106.50	18.66	12.33
S.E. ±	0.224	0.476	0.318	0.518	1.237	0.696
C.D. at 5 %	0.666	1.414	N.S.	1.537	N.S.	N.S.
Mean	**13.551**	**63.77**	**7.519**	**111.232**	**18.083**	**13.247**

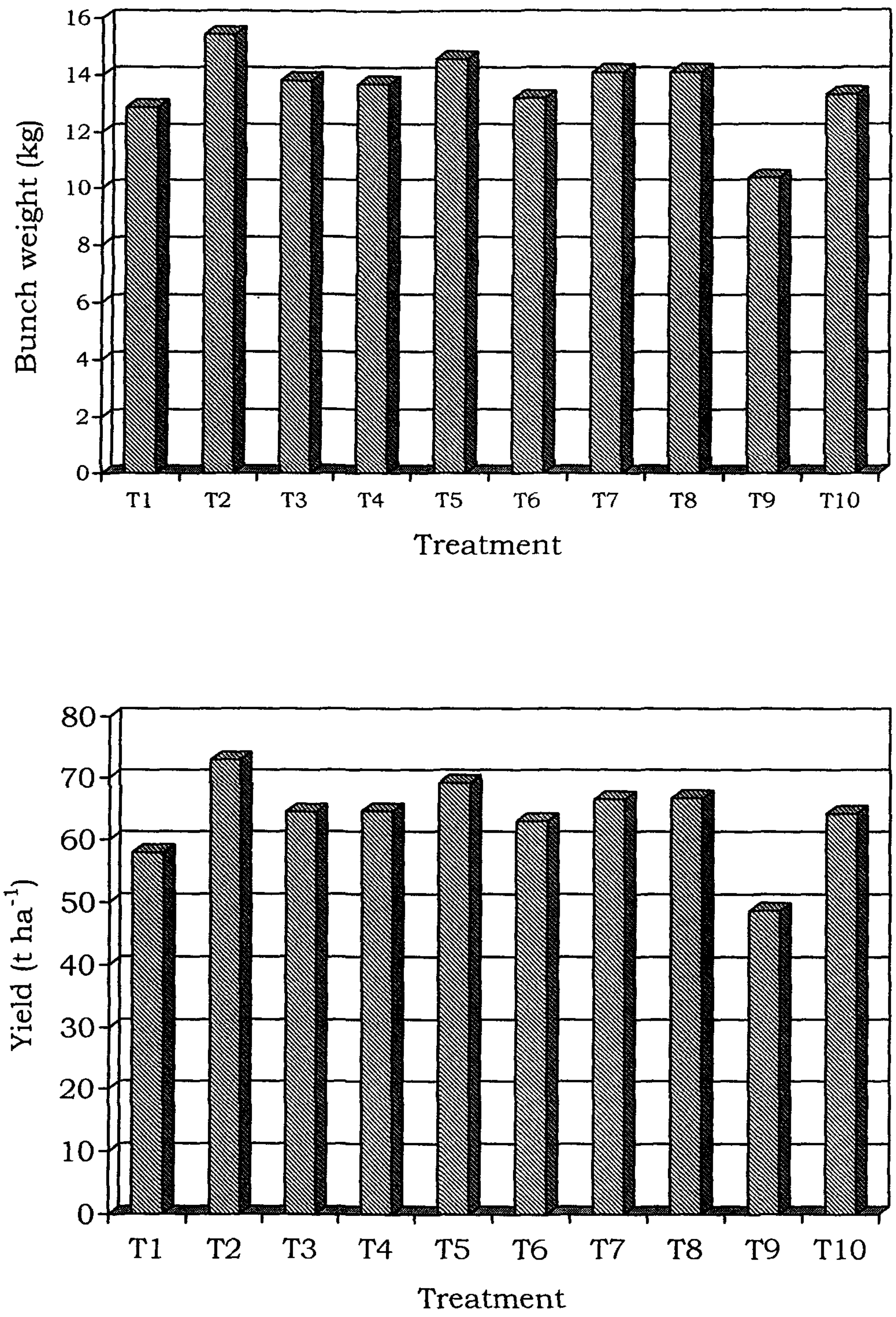

Fig. 2. Bunch weight and yield of ratoon banana as influenced by residual effect of nitrogen management in ratoon banana

on profuse growth of banana leads to higher synthesis of photosynthates and biomass accumulation.

The length of finger and girth of finger of banana as influenced by residual effect of nitrogen management was noted after harvest.

The length of finger and girth of finger were not responded significantly. However, an application of 25 % N- FYM + 75 % N- RDF recoded numerically higher length and girth of finger (20.33 and 15.63 cm, respectively). The application of chemical fertilizers based on soil test values are on par with the each other.

Similar trend of results were also recorded by Meena and Somasundaram (2004), Sabard *et al.* (2004), Singh and Singh (2004), Jayebaskaran *et al.* (2003), Tirky *et al.* (2002), Geetha and Nair (2000), Hegde and Srinivas (1991), Chattopadhaya and Bose (1986).

4.3 Residual effect of nitrogen management on dry matter yield of ratoon banana

The dry matter production of banana shoot, leaf and fruit at harvest as influenced by nitrogen management and residual effect on dry matter yield of ratoon banana are presented in Table 6 and Fig. 3.

All treatments significantly influenced the dry matter production of banana shoot, leaf and fruit. The results revealed that dry matte production of banana shoot, was significantly higher in 50 % N- FYM + 50 % N- RDF (8.56 t ha^{-1}) which was at par with 25 % N- vermicompost + 75 % N- RDF (8.46 t ha^{-1})

Table 6. Dry matter yield of ratoon banana as influenced by residual effect of nitrogen management

Treatment	Shoot	Leaf	Fruit
	(t ha^{-1})		
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	7.44	12.92	9.57
T_2 : 25% N- FYM + 75% N- RDF	7.50	14.63	13.27
T_3 : 25% N- Neem cake + 75% N- RDF	7.89	13.85	14.08
T_4 : 25% N- Vermicompost + 75% N- RDF	8.46	13.76	12.16
T_5 : 50% N- FYM + 50% N- RDF	8.56	14.14	13.61
T_6 : 50% N- Neem cake + 50% N- RDF	7.67	13.57	11.81
T_7 : 50% N- Vermicompost + 50% N- RDF	7.63	16.23	13.36
T_8 : Inorganic fertilizers as per soil test	7.31	12.18	13.39
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	5.83	12.61	12.02
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	7.16	13.66	12.32
S.E. $\pm$	0.092	0.125	0.147
C.D. at 5 %	0.274	0.372	0.437
Mean	**7.54**	**13.75**	**12.56**

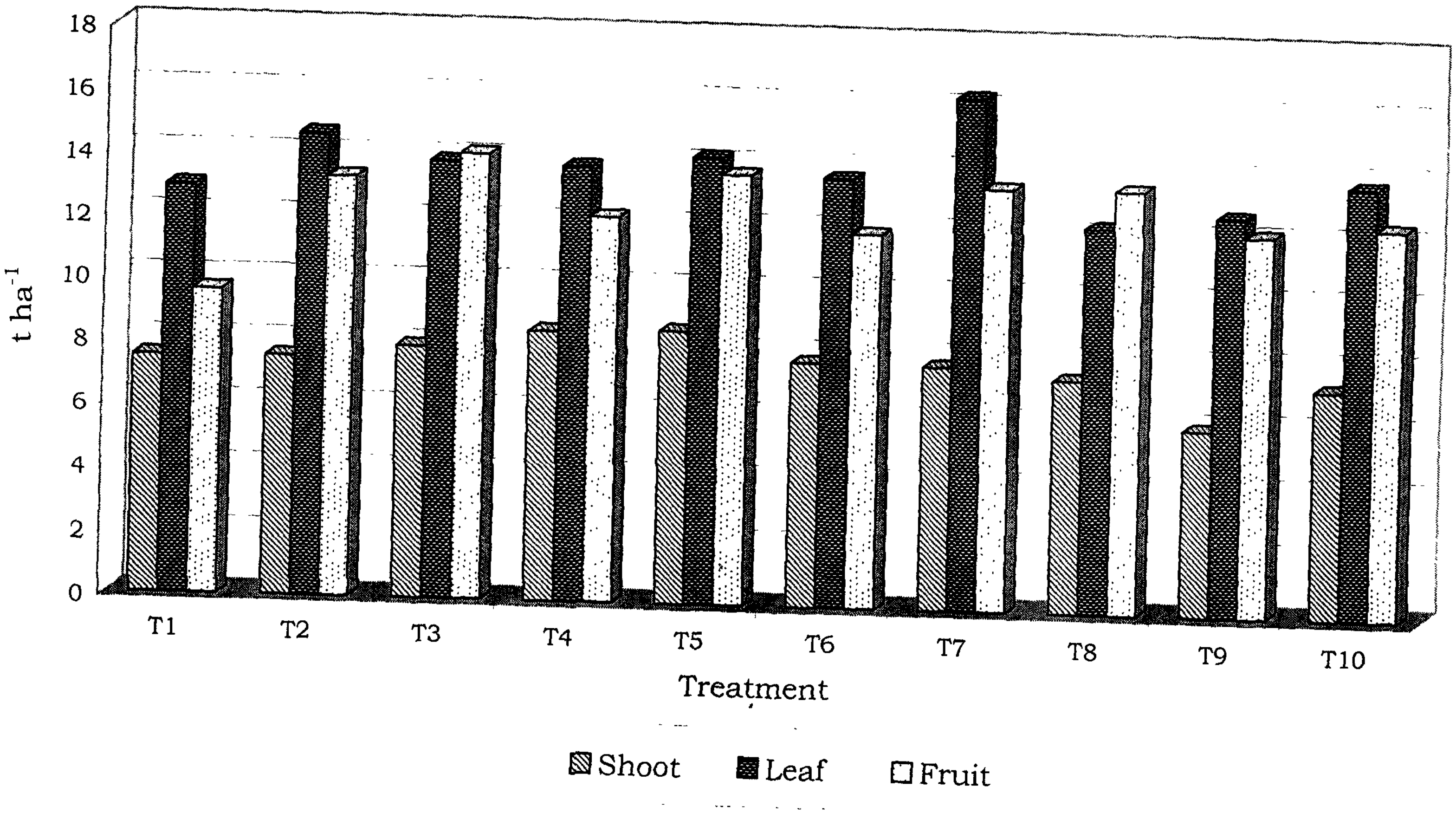

Fig. 3. Dry matter yield of ratoon banana as influenced by residual effect of nitrogen management

treatment. The remaining nitrogen management treatment were found at par with each other for shoot dry matter production except 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (5.83 t ha^{-1}) and 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (7.16 t ha^{-1}).

The leaf dry matter yield of banana was significantly higher in 50 % N- vermicompost + 50 % N- RDF (16.23 t ha^{-1}) followed by 25 % N- FYM + 75 % N- RDF (14.63 t ha^{-1}) and 50 % N- FYM + 50 % N- RDF (14.14 t ha^{-1}). Inorganic fertilizers applied as per the soil test values (12.18 t ha^{-1}) recorded the lowest leaf dry matter yield.

Residual effect of nitrogen management were significantly influenced the fruit dry matter yield. The banana fruit dry matter yield was found significantly higher by the application of 25 % N- neem cake + 75 % N- RDF (14.08 t ha^{-1}) followed by inorganic fertilizer application as per soil test (13.39 t ha^{-1}), 50 % N- neem cake + 50 % N- RDF (13.36 t ha^{-1}) and 25 % N- FYM + 75 % N- RDF (13.27 t ha^{-1}). It was on par with each other.

The higher dry matter accumulation was obtained in leaf and fruit followed by shoot of banana. These results are in agreement with Hegde and Srinivas (1989) as they reported higher dry matter accumulation in fruit (46 %) followed by leaf (29 %) and shoot (24 %) with application of 200:240:200 g N, P_2O_5 and K_2O $plant^{-1}$. The nitrogen substitution through FYM, neem cake or vermicompost in the proportion of either 25 or 50 per cent resulted in higher dry matter production of banana leaf and fruit. This might be the cumulative effect of applied organic manures which helped to keep soil porous and reduce moisture saturation leads to the physical, chemical and biological soil environment higher nutrient availability which resulted in more leaf area and leaf area index of banana. Similar trend of results were also obtained by Raghupati *et al.* (1996), Shankar and Rao (1993), Dave *et al.* (1990), Sheela and Arvindakshan (1990), Chattopadhyay and Mallik (1977).

4.4 Residual effect of nitrogen management on crop duration of ratoon banana

The integrated nitrogen management to banana and it's residual effect on crop duration in ratoon banana significantly affected the days required for shooting and shooting to harvest are presented in Table 7 and Fig. 4.

The variation in the days required for shooting of banana were 15 days. However, less number of days were required for shooting with 25 % N- FYM + 75 % RDF (269) followed by the treatments of nitrogen application based on 25 % N – Neem cake + 75 % N- RDF (271) inorganic nitrogen application based on soil test (273) and RDF (273), which were statistically at par with each other.

Further, days for shooting of banana were reported in treatment 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (284) and followed by 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (282) and 50 % N- neem cake + 50 % N- RDF (280).

Table 7. Influence of residual effect of nitrogen management on crop duration of ratoon banana

Treatment	Days required for shooting	Days required shooting harvest	Crop duration
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	273	117	390
T_2 : 25% N- FYM + 75% N- RDF	269	119	388
T_3 : 25% N- Neem cake + 75% N- RDF	271	124	395
T_4 : 25% N- Vermicompost + 75% N- RDF	274	123	397
T_5 : 50% N- FYM + 50% N- RDF	272	120	392
T_6 : 50% N- Neem cake + 50% N- RDF	280	108	388
T_7 : 50% N- Vermicompost + 50% N- RDF	275	123	398
T_8 : Inorganic fertilizers as per soil test	273	123	396
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	282	117	399
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	284	119	403
S.E. $\pm$	1.143	0.648	1.374
C.D. at 5 %	3.393	1.925	4.082
Mean	275.60	119.533	395.267

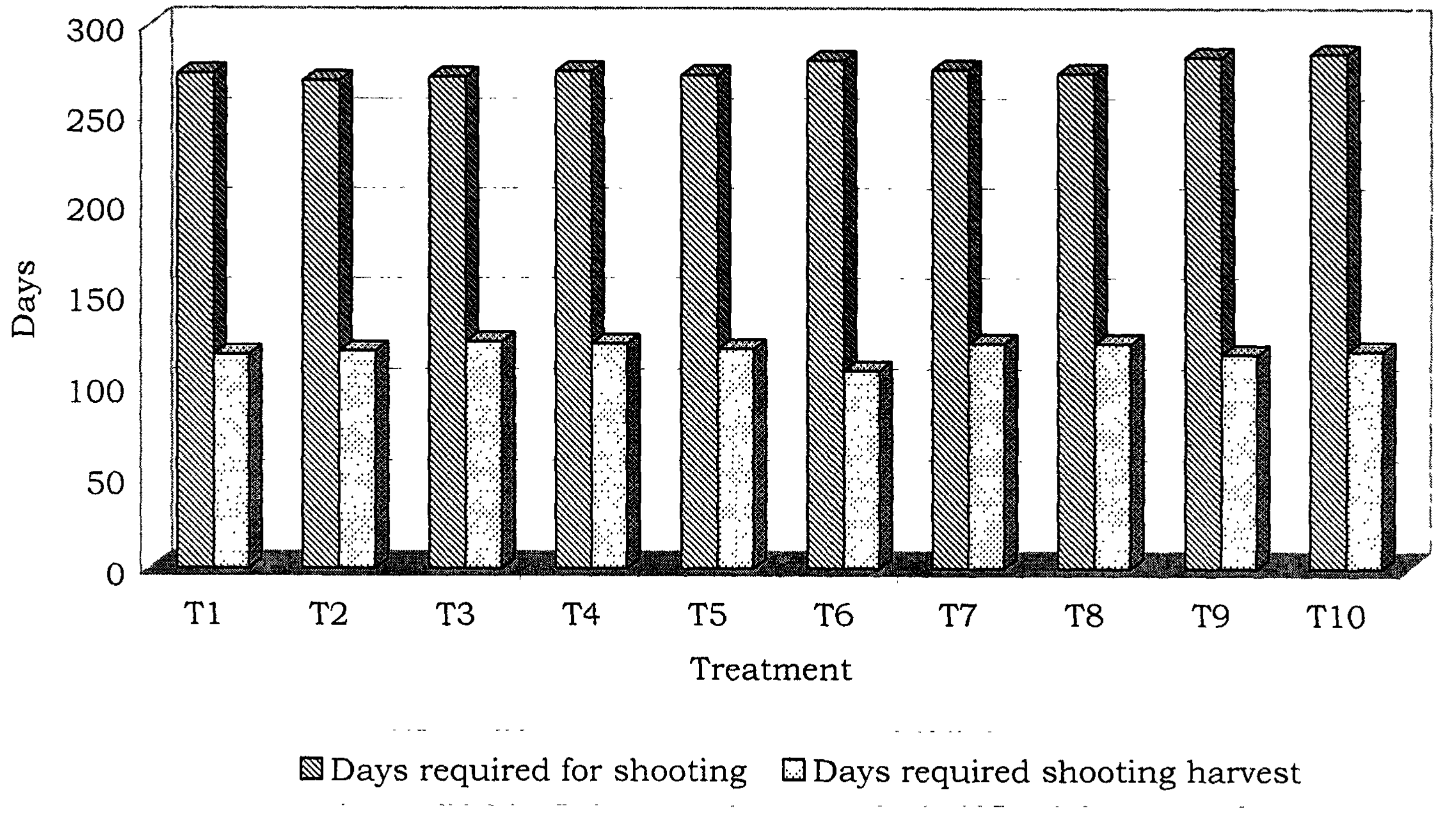

Fig. 4. Crop duration in ratoon banana as influenced by residual effect of nitrogen management

The delay in shooting of banana due to the higher quantity of organic manure and it's residual effect leads to the microbial decomposition and enhanced the immobilization of soil available nutrients. The days required for bunch development of shooting to harvest was significantly influenced by the residual effect of nitrogen management in ratoon banana.

An application of 25 % N- FYM + 75 % N- RDF required significantly less period (388) followed by 50 % N- neem cake + 50 % N- RDF and RDF (390).

The shooting of banana depends upon the soil available nutrients, climatic condition and water supply. These results are in agreement with the findings of Badgujar *et al.* (2003), Trikey *et al.* (2002), Soorianthasundaram *et al.* (2001), Ray and Yadav (1996), Chattopadhyay and Bose (1986) ad Lahav (1977), Trikey *et al.* (2003) conducted that application of 250 g N $plant^{-1}$ produced the earliest shooting followed by 300 g N plant with dwarf Cavendish banana cultivar.

4.5 Residual effect of nitrogen management on nutrient concentration in ratoon banana at harvest

4.5.1 Banana shoot

The concentration of nitrogen, phosphorus and potassium as influenced by the residual effect of nitrogen management are presented in Table 8.

The concentration of N, P and K in shoot at harvest of ratoon banana are significantly influenced by the residual effect of nitrogen management. The concentration of nitrogen varies

Table 8. Nutrient concentration of ratoon banana in shoot as influenced by nitrogen management at harvest

Treatment	**N**	**P**	**K**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	1.12	0.217	2.43
T_2 : 25% N- FYM + 75% N- RDF	1.40	0.253	3.15
T_3 : 25% N- Neem cake + 75% N-RDF	1.44	0.293	2.60
T_4 : 25% N- Vermicompost + 75% N- RDF	1.07	0.267	2.55
T_5 : 50% N- FYM + 50% N- RDF	1.52	0.333	2.85
T_6 : 50% N- Neem cake + 50% N-RDF	1.40	0.310	3.16
T_7 : 50% N- Vermicompost + 50% N- RDF	1.26	0.307	2.91
T_8 : Inorganic fertilizers as per soil test	1.26	0.337	3.21
T_9 : 33% N- FYM +33% N- Neem cake + 33% N-Vermicompost	1.26	0.330	2.70
T_{10} : 25% N- FYM + 25% N-Neem cake + 25% N-Vermicompost + 25% N-RDF	1.17	0.277	3.21
S.E. $\pm$	0.192	0.023	0.042
C.D. at 5 %	N.S.	0.069	0.124
Mean	1.291	0.292	2.880

from 1.07 to 1.52 per cent, 0.217 to 0.337 per cent for phosphorus and 2.43 to 3.21 per cent for potassium. The higher concentration of leaf nitrogen was obtained with the application of 50 % N FYM + 50 % N- RDF (1.52).

The treatment of fertilizers applied on the basis of soil test values was statistically significant over all other treatment combinations (0.337 %) of phosphorus followed by 50 % N- FYM + 50 % N- RDF, 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost and 50 % N- neem cake + 50 % N- RDF (0.333, 0.330 and 0.310 per cent, respectively). This treatments are statistically on par with each other.

At harvest of ratoon banana the potassium content in shoot was significantly influenced by the residual effect of nitrogen management treatment and it was ranged between 2.70-3.21 per cent of potassium. The substitution of 25 % FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF chemical fertilizers applied on the basis of soil test. The treatment 50 % N- neem cake + 50 % N- RDF, 25 % N- FYM + 75 % N- RDF (3.16 and 3.15 per cent, respectively) are statistically on par.

Similar trends of results were reported by Sheela and Arvindakshan (1990), Srinivas *et al.* (2001), Robert and Fox (1977). Dave *et al.* (1990) reported the concentration of N (2.87 and 2.60 %), phosphorus (0.25 and 0.23 %) and potassium (3.92 and 2.87 %) at harvest.

4.5.2 Banana leaf

The concentrations of nitrogen, phosphorus and potassium as influenced by the residual effect of nitrogen management are presented in Table 9.

The concentrations of nutrient in the index leaf of banana was ranged between 1.45-2.05 per cent for nitrogen, 0.18 to 0.38 per cent for phosphorus and 2.21 to 3.51 per cent for potassium. The higher concentration of leaf nitrogen was obtained with the application of 25 % N neem cake + 75 % N-RDF (2.05 per cent) followed by 25 % N- FYM + 75 % N- RDF (2.05 %) and 50 % N- vermicompost + 50 % N- RDF (1.82 %).

The higher phosphorus concentration in third leaf of ratoon banana at harvest was noticed in the treatment received 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (0.38 %) followed by the application 50 % N- neem cake + 50 % N- RDF (0.37 %). Remaining treatments were at par with each other.

At harvest of ratoon banana the potassium content in third leaf was significantly influenced by the residual effect of nitrogen management treatments and it was ranged between 2.21-3.51 per cent. The substitution of 25 % N- neem cake + 75 % N- RDF, 33 % N- FYM + 33 % N- neem cake + 33 % N-vermicompost and 25 % N- FYM + 25 % N- neem cake + 25 % N-vermicompost + 25 % N- RDF were obtained (3.51, 3.45 and 3.38 %, respectively) potassium in leaves, respectively. However, the lower potassium concentration was noticed in 25 % N substitution through vermicompost along with 75 % N- RDF (2.21 %).

Table 9. Nutrient concentration in ratoon banana leaf as influenced by residual effect of nitrogen management at harvest

Treatment	**N**	**P**	**K**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	1.77	0.34	3.26
T_2 : 25% N- FYM + 75% N- RDF	2.05	0.35	2.86
T_3 : 25% N- Neem cake + 75% N- RDF	2.05	0.34	3.51
T_4 : 25% N- Vermicompost + 75% N- RDF	1.58	0.18	2.21
T_5 : 50% N- FYM + 50% N- RDF	1.59	0.36	3.00
T_6 : 50% N- Neem cake + 50% N- RDF	1.54	0.37	3.10
T_7 : 50% N- Vermicompost + 50% N- RDF	1.82	0.33	2.70
T_8 : Inorganic fertilizers as per soil test	1.63	0.35	3.25
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	1.45	0.38	3.45
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	1.54	0.35	3.38
S.E. $\pm$	0.093	0.022	0.043
C.D. at 5 %	0.276	0.064	0.126
Mean	1.703	0.344	3.07

Similar trend of result were reported by Sheela and Arvindakshan (1990), Srinivas *et al.* (2001), Robert and Fox (1977). Dave *et al.* (1990) reported the concentration of N (2.87 and 2.60 %), phosphorus (0.25 and 0.23 %) and potassium (3.92 and 2.87 %) at shooting and harvest.

4.5.3 Banana fruit

The residual effect of nitrogen management were significantly influenced the concentrations of nitrogen, phosphorus and potassium in banana fruit at harvest which is presented in Table 10.

The concentration of nitrogen varied from 0.82 to 1.21 per cent and phosphorus ranged from 0.150 to 0.223 per cent. The higher concentration of fruit phosphorus was found in the treatment 50 % N- neem cake + 50 % N- RDF, 25 % N- FYM + 25 % N- neem cake +25 % N- vermicompost + 25 % RDF followed by 50 % N- FYM + 50 % N- RDF (0.223, 0.223 and 0.200 per cent, respectively).

At harvest of ratoon banana the potassium content in third leaf was significantly influenced by the residual effect of nitrogen management and it was ranged between 1.01 to 2.91 per cent. The substitution of recommended dose of fertilizer, 25 % N- FYM + 75 % N- RDF had 2.91 and 2.65 per cent potassium. However, lower potassium concentration was noticed in 50 % N- vermicompost + 50 % N- RDF (1.01 per cent).

Similar trend of result were obtained by Sheela and Arvindakshan (1990), Srinivas *et al.* (2001), Robert and Fox (1977), Dave *et al.* (1990).

4.6 Residual effect of nitrogen management on nutrient uptake of ratoon banana at harvest

4.6.1 Banana shoot

The nutrient uptake of banana shoot at harvest as influenced by residual effect of nitrogen management are presented in Table 11.

The uptake of nitrogen, phosphorus and potassium in banana shoot at harvest were significantly influenced by nitrogen management through organic manures and chemical fertilizers. The nitrogen uptake in banana shoot was significantly higher by the nitrogen management in treatment 50 % N- vermicompost + 50 % RDF (72.78 kg ha^{-1}). This might be because of slow and adequate release of nitrogen through vermicompost and which provided the secondary and micronutrients. Vermicompost also improved the biological and physical environment of soil. The chemical fertilizers contain nitrogen in available form which was easily taken by banana at their grand growth stage. Hence, this nitrogen management treatment showed higher uptake of nitrogen. Similar trend of results were also obtained by Prakash *et al.* (2002), Shrikanth *et al.* (2000), Gopal and Suryanarayan (1998).

However, 25 % N- vermicompost + 75 % N- RDF, 50 % N- FYM + 50 % N- RDF and inorganic fertilizers as per soil test were at par with each other for shoot nitrogen uptake (62.90, 65.84 and 62.58 kg ha^{-1}, respectively).

The uptake of phosphorus by shoot of banana at harvest was significantly superior in nitrogen management

Table 11. Nutrient uptake of ratoon banana shoot as influenced by residual effect of nitrogen management

Treatments	N	P	K
	(kg ha^{-1})		
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	41.40	16.72	291.42
T_2 : 25% N- FYM + 75% N- RDF	48.07	15.93	296.70
T_3 : 25% N- Neem cake + 75% N-RDF	37.01	17.80	321.54
T_4 : 25% N- Vermicompost + 75% N- RDF	62.90	18.42	284.85
T_5 : 50% N- FYM + 50% N- RDF	65.84	18.08	336.09
T_6 : 50% N- Neem cake + 50% N-RDF	39.36	16.96	221.12
T_7 : 50% N- Vermicompost + 50% N- RDF	72.78	15.40	261.14
T_8 : Inorganic fertilizers as per soil test	62.58	15.32	275.89
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	35.87	21.30	239.46
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N-RDF	51.56	17.90	203.28
S.E. $\pm$	0.080	0.039	0.068
C.D. at 5 %	0.237	0.116	0.202
Mean	51.74	17.385	273.151

through 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (21.30 kg ha^{-1}). This might be associated with decomposition of added organics which released certain organic acids and helped to increase the phosphorus availability in soil.

In treatment 25 % N- FYM + 75 % N- RDF, 50 % N- vermicompost + 50 % N- RDF and inorganic fertilizer application based on soil test values were recoded less phosphorus uptake (15.93, 15.40 and 15.32 kg ha^{-1}, respectively). This was ascertained by phosphorus fixation with clay complexes. The phosphorus uptake by remaining treatment was at par with each other. Similar results for availability of phosphorus from soil was also reported by Lal *et al.* (2000), Srikanth *et al.* (2000), Vasanthi and Kumaranswamy (2000), Sharma *et al.* (2001).

The potassium uptake of banana shoot at harvest ranged between 203.28 to 336.69 kg ha^{-1} by various nitrogen management and it's residual effect. In the treatment 50 % N- FYM + 50 % RDF to banana was significantly superior for potassium uptake (336.09 kg ha^{-1}). It was followed by 25 % N- neem cake + 75 % RDF (321.54 kg ha^{-1}) and recommended dose of fertilizers (296.7 kg ha^{-1}).

4.6.2 Banana leaf

Residual effect of nitrogen management on nutrient uptake of ratoon banana leaf at harvest is presented in Table 12.

The nitrogen uptake in banana leaf was significantly higher in 25 % N- FYM + 75 % N- RDF (245.95 kg ha^{-1}). The nitrogen in banana leaf was significantly less in the treatment 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost

Table 12. Nutrient uptake of ratoon banana leaf as influenced by residual effect of nitrogen management

Treatments	N	P	K
	(kg ha^{-1})		
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	179.96	44.15	293.52
T_2 : 25% N- FYM + 75% N- RDF	245.95	55.56	291.18
T_3 : 25% N- Neem cake + 75% N-RDF	203.65	48.34	290.34
T_4 : 25% N- Vermicompost + 75% N- RDF	134.62	48.86	326.74
T_5 : 50% N- FYM + 50% N- RDF	151.79	52.52	311.92
T_6 : 50% N- Neem cake + 50% N-RDF	120.56	51.40	331.69
T_7 : 50% N- Vermicompost + 50% N- RDF	118.46	66.53	301.02
T_8 : Inorganic fertilizers as per soil test	105.35	52.63	277.24
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	79.56	56.40	338.07
T_{10} : 25% N- FYM + 25% N-Neem cake + 25% N-Vermicompost + 25% N- RDF	98.48	60.07	160.63
S.E. $\pm$	0.123	0.124	0.068
C.D. at 5 %	0.364	0.368	0.202
Mean	**143.84**	**53.648**	**292.23**

(79.56 kg ha^{-1}) and 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % RDF (98.48 kg ha^{-1}). This might be because of addition of nitrogen through neem cake. Vermicompost and FYM leads to wider C:N ratio which predominant the process of immobilization and reduced nitrogen uptake by banana in their leaves.

The application of nitrogen as 50 % N- FYM + 50 % N- RDF, 25 % N- vermicompost + 75 % N- RDF and 50 % N- neem cake + 50 % N- RDF recorded leaf nitrogen uptake as 151.79, 134.62 and 120.56 kg ha^{-1}, respectively. However, nitrogen management and it's residual effect through 25 % N- neem cake + 75 % N- RDF and general recommended dose of fertilizers (200:40:200 g N, P_2O_5 and K_2O + 10 kg FYM $plant^{-1}$) were recorded 203.65 and 179.96 kg ha^{-1} nitrogen uptake in leaf. The use of FYM as source of nitrogen and it's residual effect reduced nitrogen losses and enhanced use efficiency of added nitrogen through inorganic fertilizers.

The phosphorus uptake of banana leaf at harvest was significantly more due to 50 % N- vermicompost + 50 % N- RDF (66.53 kg ha^{-1}). This might be because of residual effect of vermicompost in second crop. It was closely followed by the treatment through 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (60.07 kg ha^{-1}).

The potassium uptake in banana leaf at harvest was numerically highest by residual effect in the treatment where ermicompost, FYM and neem cake in equal proportion applied

(338.07 kg ha^{-1}) which reflected in higher leaf potassium uptake by banana.

Similar results for higher availability of potassium from soil was also reported by Lal *et al.* (2000), Anand Swarup and Yaduvanshi *et al.* (2000), Sharma *et al.* (2001), Gogoi *et al.* (2004) and Wandile *et al.* (2005).

4.6.3 Banana fruit

Residual effect of nitrogen management to banana by use of organics and inorganics in various proportions significantly influenced the fruit nitrogen uptake at harvest presented in Table 13.

In treatment as 25 % N- neem cake + 75 % N- RDF recorded significantly higher nitrogen uptake by banana fruit (138.02 kg ha^{-1}) followed by 50 % N- FYM + 50 % N- RDF (111.36 kg ha^{-1}) and 25 % N- FYM + 75 % N- RDF (106.23 kg ha^{-1}). The higher nitrogen uptake in banana fruit with 25 % nitrogen addition through neem cake might be because nitrification inhibitor action of neem cake.

However, integrated nitrogen management and it's residual effect on treatment as 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (68.87 kg ha^{-1}), 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % RDF (77.63 kg ha^{-1}) 50 % N- vermicompost + 50 % N- RDF (81.06 kg ha^{-1}) were found at par with each other.

Application of 50 % N- FYM + 50 % N- RDF recorded significantly higher phosphorus uptake (27.40 kg ha^{-1}) followed by treatment as 25 % N- FYM + 25 % N- neem cake + 25 % N-

Table 13. Nutrient uptake of ratoon banana fruit as influenced by residual effect of nitrogen management

Treatments	N	P	K
	(kg ha^{-1})		
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	74.17	16.28	258.69
T_2 : 25% N- FYM + 75% N- RDF	106.23	26.44	387.22
T_3 : 25% N- Neem cake + 75% N- RDF	138.02	25.04	384.47
T_4 : 25% N- Vermicompost + 75% N- RDF	79.42	21.96	324.15
T_5 : 50% N- FYM + 50% N- RDF	111.36	27.40	391.02
T_6 : 50% N- Neem cake + 50% N- RDF	82.64	24.07	384.26
T_7 : 50% N- Vermicompost + 50% N- RDF	81.06	26.64	369.73
T_8 : Inorganic fertilizers as per soil test	84.46	23.05	390.62
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	68.87	19.12	269.02
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	77.63	27.06	347.28
S.E. $\pm$	0.093	0.121	0.096
C.D. at 5 %	0.277	0.360	0.286
Mean	**100.38**	**23.709**	**350.649**

vermicompost + 25 % N- RDF (27.06 kg ha^{-1}) and 50 % N- vermicompost + 50 % N- RDF (26.64 kg ha^{-1}). These treatments were at par with each other for fruit phosphorus uptake of banana.

Blake *et al.* (2000) reported the effect of FYM application on the availability, uptake, leaching and fixing of phosphorus. They reported that consistent and stable phosphorus availability in soil was noticed during vegetative and reproductive growth phases of banana, which might be ascribed due to the release of organic acids during microbial decomposition with narrow C/P ratio (0.73).

Application of all the treatments *viz.*, 50 % N- FYM + 50 % N- RDF (391.02 kg ha^{-1}), chemical fertilizers as per soil test (390.62 kg ha^{-1}), 25 % N- neem cake + 75 % N- RDF (384.47 kg ha^{-1}), 25 % N- FYM + 75 % N- RDF (387.22 kg ha^{-1}) and 50 % N- neem cake + 50 % N- RDF (384.26 kg ha^{-1}) were found to be on par with each other for potassium uptake of banana. However, lower potassium uptake was noticed in recommended dose of fertilizers (258.69 kg ha^{-1}). Similar results were obtained by Lal *et al.* (2000), Anand Swarup and Yaduvanshi *et al.* (2000) and Sharma *et al.* (2001).

4.6.4 Total nutrient uptake

The total uptake of nitrogen, phosphorus and potassium of ratoon banana at harvest as influenced by the residual effect of nitrogen management are presented in Table 14 and Fig. 5.

Table 14. Total nutrient uptake of ratoon banana as influenced by residual effect of nitrogen management at harvest

Treatments	Total nutrient uptake (kg ha^{-1})		
	N	P	K
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	295.54	77.15	843.66
T_2 : 25% N- FYM + 75% N- RDF	400.56	97.94	975.18
T_3 : 25% N- Neem cake + 75% N- RDF	378.69	91.20	996.36
T_4 : 25% N- Vermicompost + 75% N- RDF	376.94	89.23	935.76
T_5 : 50% N- FYM + 50% N- RDF	328.99	98.00	1039.60
T_6 : 50% N- Neem cake + 50% N- RDF	242.57	92.43	937.40
T_7 : 50% N- Vermicompost + 50% N- RDF	272.30	108.58	931.56
T_8 : Inorganic fertilizers as per soil test	252.39	91.01	943.96
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	184.30	96.82	846.86
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	227.68	105.05	711.53
S.E. $\pm$	0.180	0.160	0.272
C.D. at 5 %	0.535	0.479	0.808
Mean	**295.99**	**94.74**	**912.092**

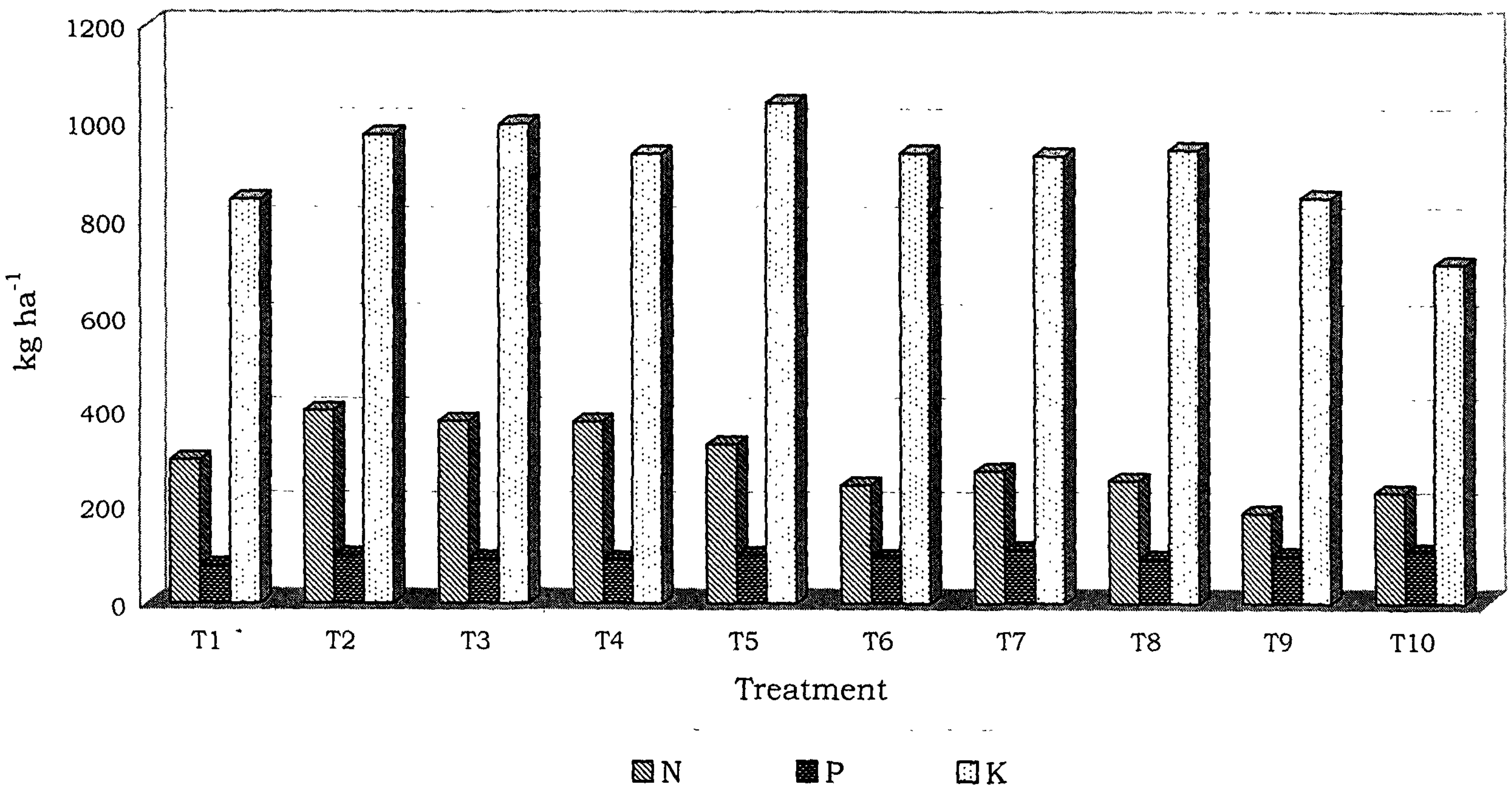

Fig. 5. Total nutrient uptake of ratoon banana as influenced by residual effect of nitrogen management

The application of 25 % N- FYM + 75 % N- RDF treatment recorded higher total nitrogen uptake (400.56 kg ha^{-1}). It was also evidenced by the higher nitrogen uptake in leaves and fruit of banana at harvest. It was followed by 25 % N- neem cake + 75 % N- RDF (378.69 kg ha^{-1}). There was slow release of nitrogen by blending of neem cake. Hence, the higher uptake of nitrogen in banana crop was observed.

The nitrogen management through 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost and 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF recorded lower nitrogen uptake (184.30 and 227.68 kg ha^{-1}). The use of organics as a source of nitrogen to banana crop decreased the nitrogen uptake because of the immobilization process in soil dominates initially and slowly enhanced the mineralization there by increased the availability of nutrients to ratoon banana.

The phosphorus uptake of banana at harvest was significantly influenced by nitrogen management and it's residual effect. It was significantly superior in treatment 50 % N- vermicompost + 50 % N- RDF (108.58 kg ha^{-1}). It was closely followed by treatments of 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (105.05 kg ha^{-1}) and 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (96.82 kg ha^{-1}) and 50 % N- FYM + 50 % N- RDF (98 kg ha^{-1}).

The results of phosphorus uptake by banana at harvest revealed that use of organic manures as source of nitrogen through FYM, neem cake and vermicompost in combination with recommended dose of fertilizers were beneficial for enhanced phosphorus uptake.

The potassium uptake of banana was significantly higher by the combined use of 50 % N- FYM + 50 % N- RDF (1039.60 kg ha^{-1}) followed by 25 % N- neem cake + 75 % N- RDF (996.36 kg ha^{-1}) followed by 25 % N- FYM + 75 % N- RDF (975.18 kg ha^{-1}). However lower potassium uptake was noted in the 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (711.53 kg ha^{-1}).

Twyford and Walmsely (1974) observed that total nutrient uptake was much more associated with potassium than with high uptake of other nutrients. It is observed that lower yields were always associated with lower potassium uptake.

Murthy *et al.*, (1995), Srinivas *et al.* (2001) reported the higher uptake of N in leaves (47.70 %) followed by fruits (30.40 %) and shoot (21.40 %) while higher uptake of P and K were in fruits (40 and 37 %) followed by leaves (30 and 37 %) and shoot (28 and 26 %), respectively. Among the major nutrients higher uptake potassium (35 %) followed by nitrogen (48 %) and phosphorus (26 %) in ratoon banana leaves were reported with the application of 200:100:200 g N, P_2O_5 and K_2O $plant^{-1}$ (Raghupathi *et al.*, 1996). Similar results were also reported by Sheela and Arvindakhan (1990) and Chattopadhyay and Mallik (1977).

The total uptake of nitrogen, phosphorus and potassium were higher in banana leaf followed by fruit and shoot. However, total potassium uptake was higher than nitrogen and phosphorus. Similar trend in uptake was reported by Srinivas *et al.* (2001), Sheela and Arvindakshan (1990).

4.7 Residual effect of nitrogen management on micronutrient uptake in ratoon banana

4.7.1 Banana shoot

The micronutrient uptake of banana shoot at harvest are presented in Table 15.

The uptake of iron in banana shoot was significantly higher by the 50 % N- neem cake + 50 % N- RDF (1617.92 mg kg^{-1}) followed by 50 % N- vermicompost + 50 % N- RDF. In the treatment 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (685.13 mg $plant^{-1}$) as well as in treatment of recommended dose of fertilizer (802.83 mg $plant^{-1}$) had obtained lower uptake of iron in banana shoot at harvest.

The nitrogen management and it's residual effect on uptake of manganese in banana shoot at harvest the treatment 50 % N- FYM + 50 % N- RDF recorded higher uptake of manganese (398.27 mg $plant^{-1}$). However, in treatment 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (387.52 mg $plant^{-1}$) and 25 % N- neem cake + 75 % N- RDF (370.30 mg $plant^{-1}$) were found at par with each other.

In treatment 50 % N- FYM + 50 % N- RDF shows significant (181.96 mg $plant^{-1}$) zinc uptake followed by 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF, 50 % N- neem cake + 50 % N- RDF, 25 % N- vermicompost + 25 % N- RDF 170.94, 169.27 and 175.58 mg $plant^{-1}$, respectively recorded substantial zinc uptake in banana shoot at harvest.

Table 15. Micronutrient uptake of ratoon banana shoot as influenced by residual effect of nitrogen management

Treatments	Shoot micronutrient uptake (mg plant^{-1})			
	Fe	Mn	Zn	Cu
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	802.83	265.32	141.36	58.54
T_2 : 25% N- FYM + 75% N- RDF	1037.87	305.18	158.52	60.34
T_3 : 25% N- Neem cake + 75% N-RDF	972.58	370.30	160.15	64.95
T_4 : 25% N- Vermicompost + 75% N- RDF	1100.18	348.88	175.58	67.25
T_5 : 50% N- FYM + 50% N- RDF	911.64	398.27	181.96	72.51
T_6 : 50% N- Neem cake + 50% N-RDF	1617.92	312.56	169.27	69.61
T_7 : 50% N- Vermicompost + 50% N- RDF	1326.55	293.83	152.61	78.18
T_8 : Inorganic fertilizers as per soil test	1224.87	288.38	160.54	84.02
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	685.13	337.56	126.53	37.98
T_{10} : 25% N- FYM + 25% N-Neem cake + 25% N-Vermicompost + 25% N- RDF	811.61	387.52	170.94	49.48
S.E. $\pm$	0.430	0.167	1.049	0.047
C.D. at 5 %	1.278	0.495	3.114	0.138
Mean	**1049.11**	**330.781**	**159.74**	**64.288**

In case of copper uptake by banana shoot at harvest it ranged between 37.98-84.02 mg plant^{-1} due to residual effect of integrated nutrient management. In treatment 25 % N-vermicompost + 75 % N- RDF (67.25 mg plant^{-1}) and 50 % N-vermicompost + 50 % N- RDF (78.18 mg plant^{-1}) recorded significantly higher copper uptake in banana shoot. Moreover, the application of 25 % N- FYM + 75 % N- RDF and 50 % N- FYM + 50 % N- RDF (60.34 and 72.51 mg plant^{-1}) reported substantial uptake of copper in ratoon banana shoot.

The higher availability of soil DTPA extractable iron, manganese and zinc were reflected at harvest. Similar trend of results were also reported by Alfonso Vergas *et al.* (2005), Twyford and Walmsely (1968). Dave *et al.* (1991) leaf content of Fe, Mn, Zn and Cu were increased with the addition of 180:180:180 g N, P_2O_5 and K_2O plant^{-1} and correlated with banana yield. The higher uptake of manganese and substantial amount of iron, zinc and copper by leaves with 200:100:200 g N, P_2O_5 and K_2O plant^{-1} was reported by Raghupati *et al.* (1996).

4.7.2 Banana leaf

Residual effect of nitrogen management on micronutrient uptake of banana leaf at harvest are presented in Table 16.

The higher banana leaf iron uptake at harvest was obtained in treatment 50 % N- neem cake + 50 % N- RDF (2471.13 mg plant^{-1}). However, the application of 50 % N-vermicompost + 50 % N- RDF was recorded significantly higher uptake of manganese (4113.28 mg plant^{-1}), zinc (362.89 mg plant^{-1})

Table 16. Micronutrient uptake of ratoon banana leaf as influenced by residual effect of nitrogen management

Treatments	Leaf micronutrient uptake (mg plant^{-1})			
	Fe	Mn	Zn	Cu
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	1868.30	2190.93	300.79	90.21
T_2 : 25% N- FYM + 75% N- RDF	2199.13	2543.12	318.40	101.00
T_3 : 25% N- Neem cake + 75% N- RDF	2115.03	3301.03	308.15	102.13
T_4 : 25% N- Vermicompost + 75% N- RDF	2017.16	2544.08	306.62	96.30
T_5 : 50% N- FYM + 50% N- RDF	1990.02	2429.06	312.31	100.22
T_6 : 50% N- Neem cake + 50% N- RDF	2471.13	2761.92	321.91	107.63
T_7 : 50% N- Vermicompost + 50% N- RDF	1771.20	4113.28	362.89	116.32
T_8 : Inorganic fertilizers as per soil test	1852.08	2731.67	282.52	88.87
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	2328.66	2299.24	269.91	81.30
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	2374.13	2684.68	328.37	94.86
S.E. $\pm$	0.385	10.513	0.136	0.064
C.D. at 5 %	1.143	31.221	0.404	0.189
Mean	**2098.90**	**2759.90**	**311.19**	**97.887**

and copper (116.32 mg plant^{-1}). It could be revealed from the data that substitution of 25 % nitrogen through FYM (2199.13 mg plant^{-1}) or neem cake (2115.03 mg plant^{-1}) or vermicompost (2017.16 mg plant^{-1}) along with 75 % N- RDF recorded substantial leaf iron uptake of banana than the nitrogen through only chemical fertilizers based on soil test values (1852.08 mg plant^{-1}). The higher iron uptake in organic manure substituted treatments might be because of synergistic effect of nitrogen and iron. The nitrogen and iron are the integral component of chlorophyll plant pigment and utmost importance in photosynthetic activity of banana. This might be the reason for higher uptake of micronutrients in banana leaf.

The zinc uptake of ratoon banana leaf was found at par for nitrogen management treatment as 25 % N- FYM + 75 % N- RDF (318.4 mg plant^{-1}), 50 % N- FYM + 50 % N- RDF (312.31 mg plant^{-1}) and 25 % N- vermicompost + 75 % N- RDF (308.15 mg plant^{-1}). However, lower uptake of zinc was noticed in treatment where equal proportion of FYM, neem cake and vermicompost were used (269.91 mg plant^{-1}).

The application of nitrogen and it's residual effect through 25 % N- neem cake + 75 % N- RDF (102.13 mg plant^{-1}) and 25 % N- FYM + 75 % N- RDF (101 mg plant^{-1}) recorded on par results for copper uptake of banana leaf at harvest.

Higher availability of DTPA extractable micronutrients in the soil might be because of intensified microbial and chemical reduction. Walmsely and Twyford (1976) reported higher uptake of manganese than Fe, Zn and Cu.

4.7.3 Banana fruit

The uptake of iron, manganese, zinc and copper in banana at harvest were significantly influenced by residual effect of nitrogen management to banana (Table 17).

In treatments 25 % N- neem cake + 75 % N- RDF (947.75 mg plant^{-1}), 50 % N- vermicompost + 50 % N- RDF (862.73 mg plant^{-1}), 50 % N- FYM + 50 % N- RDF (236.59 mg plant^{-1}), 25 % N- neem cake + 75 % N- RDF (79.74 mg plant^{-1}) showed higher iron, manganese and zinc uptake in ratoon banana, however other treatments were found at par with each other for micronutrient uptake in the fruit.

In general, the uptake of all the micronutrients were higher in banana leaf followed by shoot and fruit. The uptake pattern of micronutrients in banana leaf and fruit were followed in the order of Mn > Fe > Zn > Cu. However, in shoot it was followed by Fe > Mn > Zn > Cu. Similar trends of results were also reported by Alfonso Vergas *et al.* (2005), Twyford and Walmsely (1968), Dave *et al.* (1991).

4.7.4 Total micronutrient uptake

The total uptake of iron, manganese, zinc and copper by banana shoot, leaf and fruit at harvest were significantly influenced by residual effect of nitrogen management to banana presented in Table 18 and Fig. 6.

The data revealed that the total uptake of iron, manganese, zinc and copper by banana plant ranged between 3156.3 to 4897.7, 2833.60 to 3566.00, 566.82 to 745.73, 172.89 to 267.71 mg kg^{-1}, respectively.

Table 17. Micronutrient uptake of ratoon banana fruit as influenced by residual effect of nitrogen management

Treatments	Fruit micronutrient uptake (mg plant^{-1})			
	Fe	Mn	Zn	Cu
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	485.19	579.71	174.88	55.99
T_2 : 25% N- FYM + 75% N- RDF	710.86	822.51	225.05	72.14
T_3 : 25% N- Neem cake + 75% N- RDF	947.75	849.69	223.92	79.74
T_4 : 25% N- Vermicompost + 75% N- RDF	752.80	768.95	205.95	70.15
T_5 : 50% N- FYM + 50% N- RDF	682.12	843.72	236.59	73.64
T_6 : 50% N- Neem cake + 50% N- RDF	808.47	760.04	200.73	66.00
T_7 : 50% N- Vermicompost + 50% N- RDF	651.57	862.73	230.22	72.87
T_8 : Inorganic fertilizers as per soil test	754.20	861.07	231.20	77.96
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	529.79	633.17	170.38	53.60
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	581.59	803.69	208.69	68.62
S.E. $\pm$	10.573	0.192	0.118	0.208
C.D. at 5 %	31.401	0.572	0.350	0.617
Mean	**690.43**	**778.53**	**210.76**	**69.073**

Table 18. Total micronutrient uptake of ratoon banana as influenced of residual effect of nitrogen management

Treatments	Total micronutrient uptake (mg plant^{-1})			
	Fe	Mn	Zn	Cu
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	3156.30	2833.60	617.03	204.75
T_2 : 25% N- FYM + 75% N- RDF	3948.06	3326.90	701.90	233.48
T_3 : 25% N- Neem cake + 75% N- RDF	4035.60	3335.60	692.20	246.82
T_4 : 25% N- Vermicompost + 75% N- RDF	3870.80	3135.90	688.15	233.72
T_5 : 50% N- FYM + 50% N- RDF	3584.10	3232.80	731.20	246.37
T_6 : 50% N- Neem cake + 50% N- RDF	4897.70	3544.00	691.92	243.24
T_7 : 50% N- Vermicompost + 50% N- RDF	3749.40	2928.30	745.73	267.71
T_8 : Inorganic fertilizers as per soil test	3831.60	3001.40	674.26	250.85
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	3543.60	3299.90	566.82	172.89
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	3767.50	3566.00	708.00	212.96
S.E. $\pm$	10.555	37.971	1.089	0.264
C.D. at 5 %	31.347	112.76	3.233	0.783
Mean	**3838.50**	**3220.49**	**681.73**	**231.28**

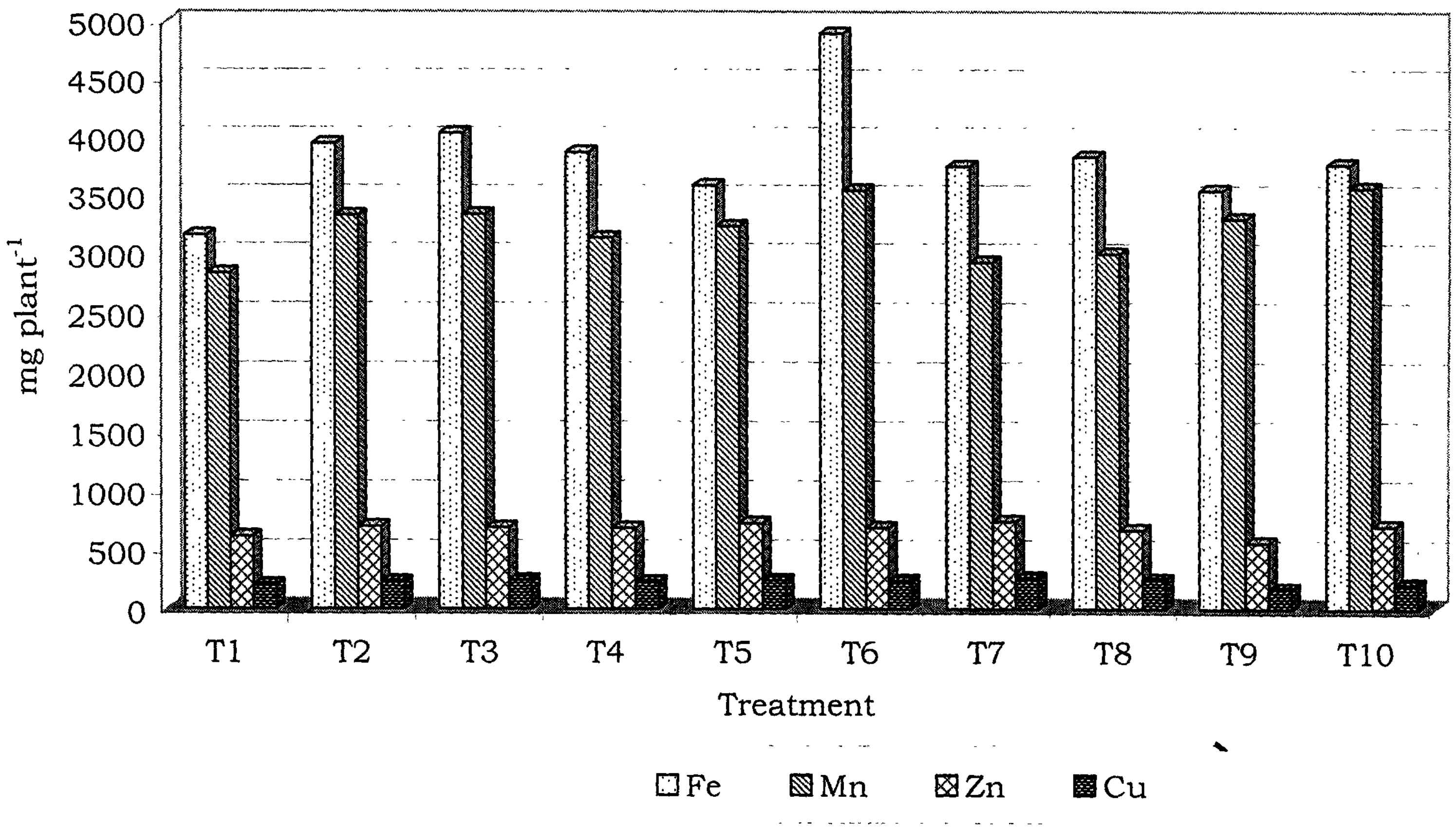

Fig. 6. Total micronutrient uptake of ratoon banana as influenced of residual effect of nitrogen management

The treatment 50 % N- neem cake + 50 % N- RDF recorded significantly higher iron uptake (4897.7 mg kg^{-1}) followed by the substitution of 25 % N- neem cake + 75 % N- RDF (4035.6 mg kg^{-1}).

The uptake of manganese by banana plant was significantly higher in treatment 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (3566 mg kg^{-1}) followed by 50 % N- neem cake + 50 % N- RDF (3544 mg kg^{-1}) and 25 % N- neem cake + 75 % N- RDF (3326.9 mg kg^{-1}).

The substitution of 50 % N- vermicompost + 50 % N- RDF (745.73 mg $plant^{-1}$) responded significantly higher zinc uptake followed by 25 % N- vermicompost + 75 % N- RDF (688.15 mg kg^{-1}) and 50 % N- FYM + 50 % N- RDF (731.20 mg kg^{-1}).

Significantly lower zinc uptake was noticed in the nitrogen management as 100 % N substituted equally through FYM, neem cake and vermicompost (566.82 mg $plant^{-1}$) which may be associated to the formation of complexes with organic ligands leads to the immobilization of zinc.

The total copper uptake by banana plant was significantly influenced by residual effect of nitrogen management and revealed that application 50 % N- vermicompost + 50 % N- RDF recorded significantly higher copper uptake (267.71 mg kg^{-1}) followed by treatment where inorganic fertilizers were applied as per soil test value (250.85 mg kg^{-1}). The 100 % N substitution through FYM, neem cake and vermicompost in equal proportion reported lower copper uptake

(172.89 mg $plant^{-1}$) which may be ascribed to complete formation of metal cation.

Similar trend of results were also reported by Alfonso Vergas *et al.* (2005), Twyford and Walmsely (1968), Twyford and Walmsely (1976), Dave *et al.* (1991) leaf content of Fe, Mn, Zn, Cu were increased with addition of 180:180:180 g N, P_2O_5 and K_2O $plant^{-1}$ and correlated with banana yield.

Thus, among the micronutrients the banana takes more or less similar iron and manganese from soil followed by zinc and copper.

4.8 Residual effect of nitrogen management on post harvest quality of ratoon banana during ripening

4.8.1 Total sugar

The periodical total sugar content of ratoon banana as influenced by the residual effect of nitrogen management are presented in Table 19.

The total sugar content of banana fruits were increased significantly at zero day of ripening. The magnitude of increase in total sugar was faster at 0 day to 7^{th} days and 14^{th} days of ripening. Whereas, it was slightly increased at 21^{st} days of ripening.

The total sugar content of banana during ripening of fruits was mainly governed by the rate of respiration and temperature at which banana fruits were stored and physiological maturity at which banana fruits were harvested, this might be the reasons to show the variation in periodical total sugar content of banana fruits during ripening.

Table 19. Influence of residual effect of nitrogen management on periodical total sugar content during ripening in ratoon banana

Treatment	Total sugar (%)			
	0 day	7th day	14th day	21st day
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	3.03	7.08	17.25	18.70
T_2 : 25% N- FYM + 75% N- RDF	4.28	6.56	18.08	19.48
T_3 : 25% N- Neem cake + 75% N- RDF	2.84	6.96	17.65	19.60
T_4 : 25% N- Vermicompost + 75% N- RDF	4.81	6.90	18.10	19.31
T_5 : 50% N- FYM + 50% N- RDF	4.17	6.45	17.30	19.23
T_6 : 50% N- Neem cake + 50% N- RDF	3.11	6.50	17.90	19.39
T_7 : 50% N- Vermicompost + 50% N- RDF	5.03	6.66	18.07	19.66
T_8 : Inorganic fertilizers as per soil test	3.07	6.42	17.36	18.71
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	4.35	7.51	19.30	20.33
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	5.29	7.55	17.97	19.77
S.E. $\pm$	0.303	0.307	0.338	0.377
C.D. at 5 %	0.899	N.S.	N.S.	N.S.
Mean	**3.998**	**6.860**	**17.898**	**19.410**

The total sugar at 0 days showing significant result in 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (5.29 %) which was on par with 50 % N- vermicompost + 50 % N- RDF, 25 % N- vermicompost + 75 % N- RDF (5.03, 4.81 % respectively). However, at 7, 14, 21 days there was no statistical variation amongst the treatments.

In general, the nitrogen management and residual effect through organic sources and recommended dose of fertilizers were more beneficial for total sugar content of banana fruits. Amongst the organic sources vermicompost was the best source for nitrogen management for total sugar in banana fruit followed by FYM and neem cake. Similar results were also reported by Jaykumar *et al.* (2003), Bauri *et al.* (2002).

4.8.2 Reducing sugars

The residual effect of nitrogen management through FYM, neem cake and vermicompost with chemical fertilizers significantly influenced the reducing sugars in fruits during ripening at an ambient condition (Table 20).

The application of chemical fertilizers as per soil test values recorded higher reducing sugars (0.83 %) at harvest followed by recommended dose of fertilizers (0.79 %). Similar results also found at 7^{th} days of ripening.

The highest peak of reducing sugars in banana was reported at 14^{th} days of ripening, but thereafter small increment was reported up to 21^{st} days of ripening.

Table 20. Influence of residual effect of nitrogen management on periodical reducing sugars content during ripening in ratoon banana

Treatment	Reducing sugars (%)			
	0 day	7th day	14th day	21st day
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	0.795	5.490	16.44	18.31
T_2 : 25% N- FYM + 75% N- RDF	0.722	4.537	16.52	18.65
T_3 : 25% N- Neem cake + 75% N- RDF	0.684	4.937	15.79	18.50
T_4 : 25% N- Vermicompost + 75% N- RDF	0.730	4.830	16.75	18.46
T_5 : 50% N- FYM + 50% N- RDF	0.673	4.417	15.51	18.34
T_6 : 50% N- Neem cake + 50% N- RDF	0.731	4.800	16.39	18.50
T_7 : 50% N- Vermicompost + 50% N- RDF	0.733	4.857	16.38	18.72
T_8 : Inorganic fertilizers as per soil test	0.832	5.700	16.64	17.96
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	0.632	5.393	17.21	19.24
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	0.682	5.340	16.34	18.68
S.E. $\pm$	0.002	0.035	0.144	0.061
C.D. at 5 %	0.005	0.103	0.428	0.181
Mean	**0.721**	**5.030**	**16.400**	**18.538**

At the end of ripening (21st days) the higher amount of reducing sugars (19.24 %) in banana was obtained with the application of 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost followed by 50 % N- vermicompost + 50 % N- RDF (18.72 %).

In general, banana is a climacteric fruit which produces endogenous ethylene from methionine. At harvest, starch was the most abundant constituent of the banana. It's breakdown slow at first (0 to 7th days) and accelerate as the climacteric peak was attained (7th to 14th days). Corresponding to the breakdown of starch there was rise in the content of total soluble solids and sugar. Wall *et al.* (2004) confirmed these results of ethylene synthesis and starch hydrolysis peak was at 12th days of banana ripening. Similar results were also reported by Jaykumar *et al.* (2003), Bauri *et al.* (2002).

4.8.3 Non-reducing sugar

The non-reducing sugar in banana fruits during ripening was significantly influenced by the residual effect of nitrogen management (Table 21).

Significantly higher non reducing sugar in banana was reported at 0 days of ripening in treatment 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (4.60 %) and 50 % N- vermicompost + 50 % N- RDF treatment.

The consistent decrease in non-reducing of banana in all the ripening periods noticed in all the nitrogen management treatment. At 7th-14th days there was no significant variation in non reducing sugar. However at 21st days the treatment 50 % N-

Table 21. Influence of residual effect of nitrogen management on periodical non-reducing sugars content during ripening in ratoon banana

Treatment	**Non-reducing sugars (%)**			
	0 day	**7^{th} day**	**14^{th} day**	**21^{st} day**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	2.23	1.59	0.80	0.41
T_2 : 25% N- FYM + 75% N- RDF	3.55	2.02	1.55	0.82
T_3 : 25% N- Neem cake + 75% N-RDF	2.15	2.03	1.50	0.90
T_4 : 25% N- Vermicompost + 75% N- RDF	4.07	2.07	1.35	0.85
T_5 : 50% N- FYM + 50% N- RDF	3.49	2.03	1.78	0.88
T_6 : 50% N- Neem cake + 50% N-RDF	2.37	1.70	1.50	0.89
T_7 : 50% N- Vermicompost + 50% N- RDF	4.29	1.80	1.68	0.94
T_8 : Inorganic fertilizers as per soil test	2.23	0.82	0.74	0.75
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	3.71	2.11	2.09	0.90
T_{10} : 25% N- FYM + 25% N-Neem cake + 25% N-Vermicompost + 25% N- RDF	4.60	2.21	1.62	0.89
S.E. $\pm$	0.303	0.308	0.292	0.030
C.D. at 5 %	0.900	N.S.	N.S.	0.088
Mean	**3.271**	**1.840**	**1.465**	**0.825**

vermicompost + 50 % N- RDF was significant in non reducing sugar content (0.94 %) followed by equal substitution of FYM, neem cake, vermicompost (0.90 %), 25 % N- neem cake + 75 % N- RDF (0.9 5).

Substitution of nitrogen through vermicompost either in 25 or 50 % proportion reported significantly higher non reducing sugar which might be associated with higher fruit potassium uptake and rate of inversion at harvest. Bhargava *et al.* (1995) reported higher levels of potassium enhances the total soluble solids, sugars and starch content of banana fruit.

The consistent and higher decrease in the non reducing sugar at 0, 7, 14 and 21st days of ripening was noticed in the nitrogen management treatment of 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (4.60, 2.21, 1.62, 0.89 %) respectively.

The consistent rise in the total sugar content in banana was corresponding to the breakdown of starch. Similar trend of results were also reported by Martin-Prevel (1983). The sugars have been identified as sucrose the most at harvest while fructose and glucose was maximal in full ripened banana. These results are in close conformity with those reported by Jaykumar *et al.* (2003), Bauri *et al.* (2002), Narayana *et al.* (2002).

4.8.4 Residual effect of nitrogen management on periodical study of pulp: peel ratio of ratoon banana during ripening

The mean pulp: peel ratio of banana fruit during ripening period presented in Table 22 and Fig. 7.

Table 22. Influence of residual effect of nitrogen management in ratoon banana on periodical pulp:peel ratio during ripening

Treatment	**Pulp : Peel ratio**			
	0 day	**7th day**	**14th day**	**21st day**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	1.03	1.32	2.32	3.07
T_2 : 25% N- FYM + 75% N- RDF	1.31	1.53	2.40	2.72
T_3 : 25% N- Neem cake + 75% N- RDF	1.20	1.56	2.26	2.92
T_4 : 25% N- Vermicompost + 75% N- RDF	1.04	1.40	2.11	2.93
T_5 : 50% N- FYM + 50% N- RDF	1.11	1.22	1.82	3.10
T_6 : 50% N- Neem cake + 50% N- RDF	1.01	1.61	1.87	3.05
T_7 : 50% N- Vermicompost + 50% N- RDF	1.03	1.48	2.40	3.12
T_8 : Inorganic fertilizers as per soil test	1.11	1.55	2.46	3.18
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	1.02	1.37	2.01	2.61
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	1.15	1.54	2.35	3.11
S.E. $\pm$	0.037	0.033	0.019	0.036
C.D. at 5 %	0.109	0.099	0.056	0.108
Mean	**1.103**	**1.459**	**2.201**	**2.985**

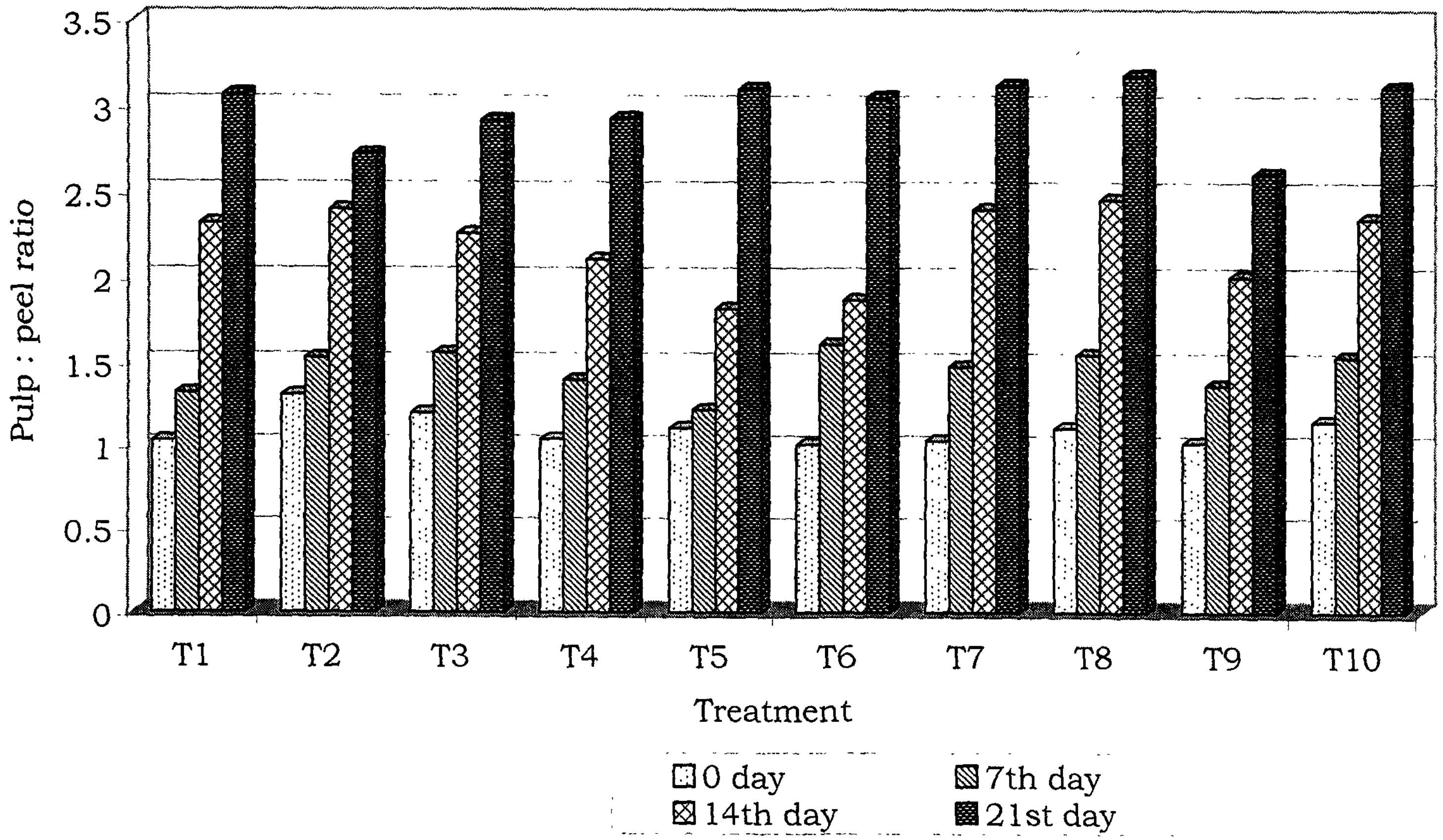

Fig. 7. Residual effct of nitrogen management in ratoon banana on priodical pulp : peel ratio during ripening

Residual effect of integrated nutrient management significantly influenced the pulp: peel ratio of banana at all the period of ripening *viz* 0, 7, 14 and 21days.

The banana harvested from the treatment 25 % N- FYM + 75 % N- RDF (1.31) followed by 25 % N- neem cake + 75 % RDF (1.20) showed significant pulp: peel ratio at 0 day of ripening. Significantly higher increment in the pulp: peel ratio was reported in the treatment 50 % N- neem cake + 50 % N- RDF (1.01-1.61) followed by 25 % N- FYM + 25 % N- neem cake + 25 % vermicompost +25 % RDF (1.15-1.54) during 0-7th day of ripening.

The highest magnitude of increment in pulp: peel ratio of banana was obtained at 14th day of ripening in all the integrated nitrogen management treatment except 50 % FYM + 50 % N- RDF. Further, the rate of increment in the pulp: peel ratio of banana between 7 to 14th day of ripening was reported significantly higher in 50 % N- neem cake + 50 % N- RDF (1.61 to 1.87).

At the end of ripening (21st day) higher pulp: peel ratio of banana were noticed in chemical fertilizers application based on soil test value (3.18) followed by 50 % N- vermicompost + 50 % N- RDF (3.12).

The higher pulp: peel ratio of banana during ripening recorded in the nitrogen management treatment through FYM, neem cake and vermicompost in the proportion of either 25 or 50 % alongwith 75 or 50 % recommended dose of chemical fertilizers.

The increment in the pulp: peel ratio of banana might be attributed to the changes in sugar concentration in both the tissues. As sugar increases more rapidly in the pulp than peel leads to the differential change in osmotic pressure and water was with drawn from the peel by the pulp and ratio changes accordingly. These results are in accordance with those reported by Patil and Magar (1976), Asiedu (1987), Hegde and Srinivas (1991).

4.8.5 Residual effect of nitrogen management on titrable acidity in ratoon banana during ripening

The mean periodical titrable acidity of banana during ripening as influenced by residual effect of nitrogen management are depicted in Table 23 and Fig. 8.

The treatment combinations showed significant variation. The titrable acidity was significantly higher at harvest (0 day of ripening) in recommended dose of fertilizer (2.81 meq 100 g^{-1} fresh pulp) and it was on par with inorganic fertilizers as per soil test value (2.72 meq 100^{-1} g^{-1} fresh pulp).

The application of recommended dose to banana reported higher magnitude of increase in the titrable acidity (2.81, 4.57, 5.83, 4.87 meq 100^{-1} g fresh pulp) at 0, 7th and 14th days of ripening than 25 % N- FYM + 25 % N- RDF (2.36, 3.92, 5.25, 4.43 meq 100^{-1}g fresh pulp) respectively.

Chattopadhayay and Bose (1986) concluded that acidity of banana fruit increased with nitrogen levels and reduction was noticed with higher potassium content.

Table 23. Influence of residual effect of nitrogen management in ratoon banana on periodical titrable acidity (meq 100 g^{-1} fresh weight) during ripening

Treatment	Titrable acidity (meq 100 g^{-1} fresh weight)			
	0 day	7^{th} day	14^{th} day	21^{st} day
T_1 : RDF: 200:40:200 g $plant^{-1}$ N, P_2O_5 and K_2O + 10 kg FYM $plant^{-1}$	2.81	4.57	5.83	4.87
T_2 : 25% N- FYM + 75% N- RDF	2.26	3.92	5.25	4.43
T_3 : 25% N- Neem cake + 75% N- RDF	2.37	4.13	5.63	4.62
T_4 : 25% N- Vermicompost + 75% N- RDF	2.41	3.55	5.09	4.46
T_5 : 50% N- FYM + 50% N- RDF	2.41	3.93	5.11	4.56
T_6 : 50% N- Neem cake + 50% N- RDF	2.33	4.64	5.80	4.82
T_7 : 50% N- Vermicompost + 50% N- RDF	2.57	4.97	5.21	4.44
T_8 : Inorganic fertilizers as per soil test	2.72	4.82	5.42	4.61
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	2.42	4.36	5.38	4.52
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	2.40	3.81	5.22	3.86
S.E. $\pm$	0.029	0.067	0.125	0.037
C.D. at 5 %	0.086	0.198	0.372	0.111
Mean	**2.285**	**4.273**	**5.379**	**4.521**

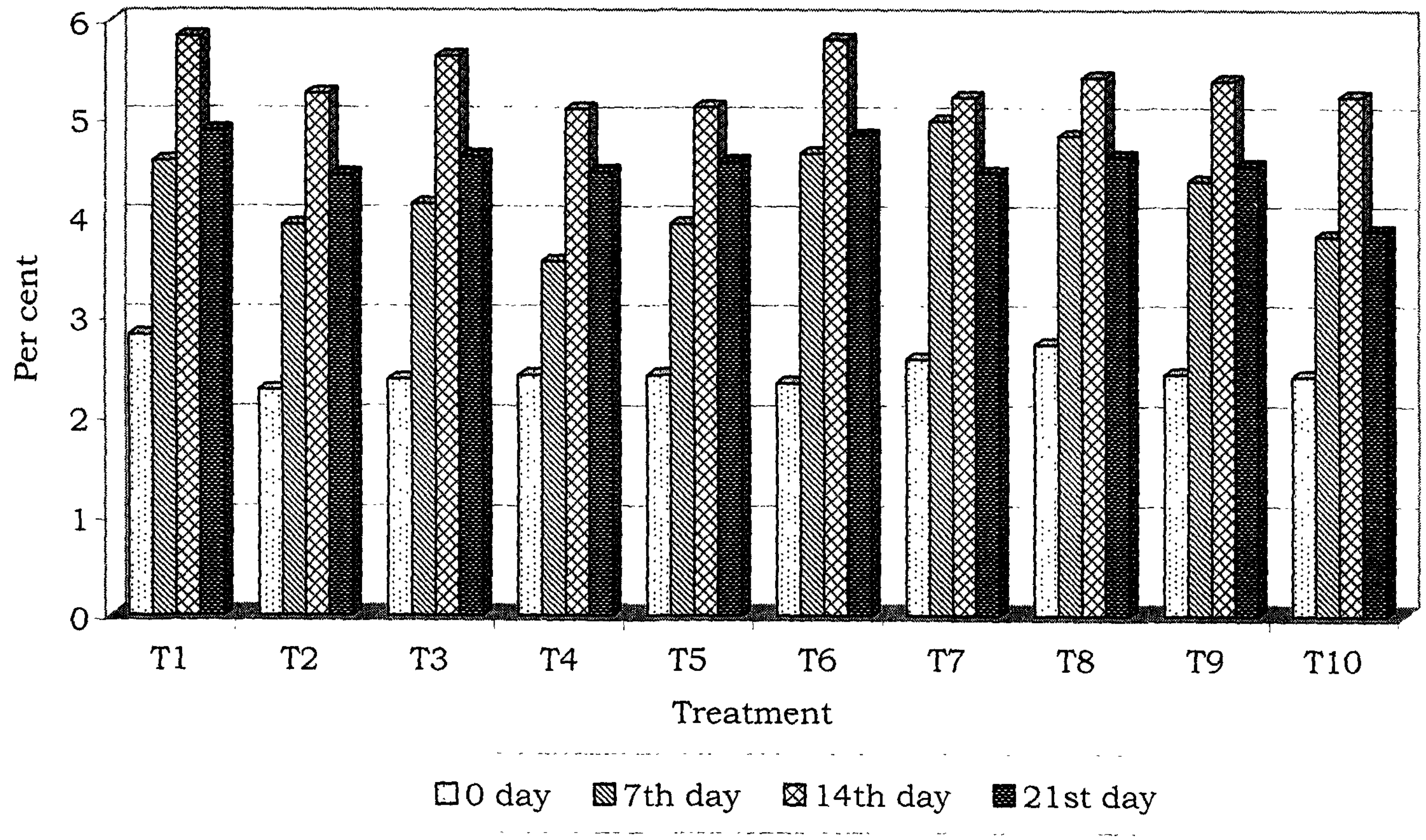

Fig. 8. Residual effect of nitrogen management in ratoon banana on titrable acidity of ratoon banana during ripening

The titrable acidity in banana at harvest (0 day) by nitrogen management as 25 % N either through FYM, neem cake or vermicompost + 75 % N through RDF, 50 % N through FYM, neem cake or vermicompost + 75 % N through RDF or only organic in an equal proportion were at par with each other during 7th, 14th, 21st days of ripening.

Similar trend of results were also reported by Sabard *et al.* (2004), Narayana *et al.* (2002), Almazan (1991), Ram and Prasad (1988). The gradual increase in acidity during ripening was attributed to the organic acids assimilation and it's oxidation to carbonic acid and water. Thus, combined application of organic manures and recommended dose of fertilizers were useful for restricted acidity in banana during ripening.

4.9 Residual effect of nitrogen management on soil properties in ratoon banana

The residual fertility in relation to soil pH, electrical conductivity and organic carbon at harvest of ratoon banana as influenced by the nitrogen management of plant banana is presented in Table 24.

The soil pH and electrical conductivity at harvest of ratoon banana was not found significantly influenced, however the addition of 50 % N- neem cake + 50 % N- RDF to plant banana was recorded numerically higher soil pH and lower electric conductivity (8.62, 0.16 dSm^{-1}) at harvest of ratoon banana.

The addition of nitrogen only through organics, 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost to plant banana was found significantly superior for residual soil fertility at

Table 24. Influence of residual effect of nitrogen management on soil properties at harvest of ratoon banana

Treatment	**pH (1:2.5)**	**EC (dSm^{-1})**	**Organic carbon (%)**
T_1 : RDF: 200:40:200 g $plant^{-1}$ N, P_2O_5 and K_2O + 10 kg FYM $plant^{-1}$	8.51	0.19	0.733
T_2 : 25% N- FYM + 75% N- RDF	8.40	0.19	0.735
T_3 : 25% N- Neem cake + 75% N- RDF	8.42	0.20	0.661
T_4 : 25% N- Vermicompost + 75% N- RDF	8.60	0.19	0.703
T_5 : 50% N- FYM + 50% N- RDF	8.09	0.22	0.790
T_6 : 50% N- Neem cake + 50% N- RDF	8.62	0.17	0.640
T_7 : 50% N- Vermicompost + 50% N- RDF	8.50	0.16	0.682
T_8 : Inorganic fertilizers as per soil test	8.55	0.16	0.582
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	8.30	0.20	0.820
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	8.48	0.21	0.685
S.E. $\pm$	0.123	0.022	0.004
C.D. at 5 %	N.S.	N.S.	0.012
Mean	**8.447**	**0.191**	**0.703**

harvest of ratoon banana in respect to soil organic carbon (0.82 %). Similar, observations also observed by Deshmukh *et al.* (2005), Bhattacharya *et al.* (2004) and Wandile *et al.* (2005).

4.10 Residual effect of nitrogen management on soil available nutrients at harvest

4.10.1 Major nutrients

The residual soil available nitrogen, phosphorus and potassium content at harvest of ratoon banana as influenced by the residual soil fertility of plant banana are presented in Table 25 and Fig. 9.

The residual soil fertility of plant banana are significantly influenced the soil available nitrogen, phosphorus and potassium at harvest of ratoon banana. The addition of nitrogen only through organics to plant banana was found significantly superior for residual soil fertility at harvest of ratoon banana in respect of nitrogen, phosphorus and potassium (156.73, 21.39 and 857 kg ha^{-1} respectively). The sustained soil fertility from plant banana to harvest of ratoon banana was might be as certained that the addition of organic sources to plant banana initially mineralize and termeterniorally immobililize the plant nutrients during plant banana growth. These mineralized and immobilized plant nutrients slowly released to ratoon banana. Similar results were also obtained by Santhy *et al.* (1998), Vyas *et al.* (2003), Tolanur and Badanur (2003) and Suresh and Surya Prabha (2005).

Table 25. Soil fertility in ratoon banana as influenced by residual effect of nitrogen management at harvest

Treatment	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant $^{-1}$	144.67	15.32	797
T_2 : 25% N- FYM + 75% N- RDF	142.03	19.43	629
T_3 : 25% N- Neem cake + 75% N- RDF	144.23	18.45	648
T_4 : 25% N- Vermicompost + 75% N- RDF	153.18	17.89	488
T_5 : 50% N- FYM + 50% N- RDF	152.26	18.17	744
T_6 : 50% N- Neem cake + 50% N- RDF	151.00	17.34	640
T_7 : 50% N- Vermicompost + 50% N- RDF	148.63	20.20	551
T_8 : Inorganic fertilizers as per soil test	148.33	11.88	527
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	156.73	21.39	857
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	148.66	18.23	754
S.E. $\pm$	0.963	0.705	27.184
C.D. at 5 %	2.860	2.094	80.731
Mean	**153.976**	**17.833**	**663.50**

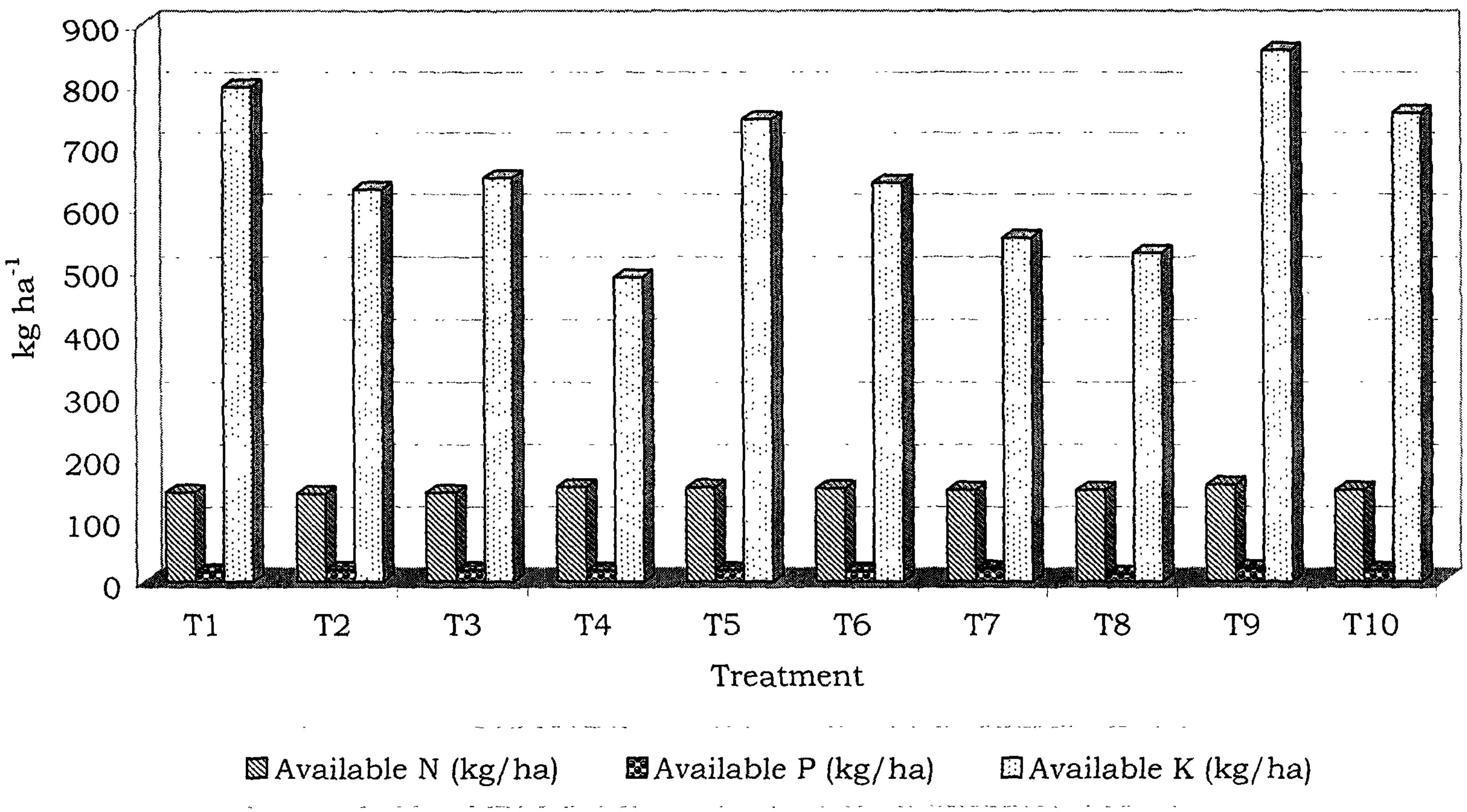

Fig. 9. Soil fertility in ratoon banana as influenced by residual effect of nitrogen management at harvest

4.10.2 Soil DTPA extractable micronutrient

The residual soil DTPA extractable micronutrients at harvest of banana as influenced by the residual soil fertility of plant banana are presented in Table 26.

The residual soil fertility by plant banana are significantly influenced the soil DTPA extractable micronutrients at harvest of ratoon banana. The addition of nitrogen only through organics to plant banana was found significantly superior for residual soil fertility at harvest of ratoon banana in respect of DTPA extractable Fe, Mn, Zn and Cu (6.39, 8.46, 1.04 mg kg^{-1}). The higher availability of DTPA extractable Fe, Mn and Zn in residual soil fertility might be due to release of organic acids and humus which act as chelating agents thereby preventing from precipitation, fixation leaching and oxidation of micronutrients.

The substitution of residual soil fertility due to addition of 50 % N- neem cake + 50 % N- RDF showing significant result for soil DTPA extractable Cu (1.71 mg kg^{-1}) it might be due to organic and it's inherent capacity to add good amount of organic carbon content to the soil which hastens the process of mineralization of organically bound Cu present in native soil.

Significant increase in DTPA extractable micronutrients with the addition of organic manures had also reported by Gopal and Suryanarayana (1998), Babhukar (2000), Suresh and Prabha (2005).

Table 26. Soil DTPA extractable micronutrient as influenced by residual effect of nitrogen management in ratoon banana at harvest

Treatment	**Soil DTPA (mg kg^{-1})**			
	Fe	**Mn**	**Zn**	**Cu**
T_1 : RDF: 200:40:200 g plant^{-1} N, P_2O_5 and K_2O + 10 kg FYM plant^{-1}	6.07	7.08	1.01	1.66
T_2 : 25% N- FYM + 75% N- RDF	5.16	5.96	1.23	1.13
T_3 : 25% N- Neem cake + 75% N- RDF	5.50	7.34	0.52	1.63
T_4 : 25% N- Vermicompost + 75% N- RDF	4.77	7.09	0.89	1.64
T_5 : 50% N- FYM + 50% N- RDF	5.06	7.08	1.02	1.59
T_6 : 50% N- Neem cake + 50% N- RDF	4.94	7.29	0.92	1.71
T_7 : 50% N- Vermicompost + 50% N- RDF	4.83	7.02	0.75	1.08
T_8 : Inorganic fertilizers as per soil test	4.57	5.44	0.64	1.01
T_9 : 33% N- FYM +33% N- Neem cake + 33% N- Vermicompost	6.39	8.46	1.04	1.43
T_{10} : 25% N- FYM + 25% N- Neem cake + 25% N- Vermicompost + 25% N- RDF	5.42	5.28	0.73	1.02
S.E. $\pm$	0.080	0.061	0.02	0.055
C.D. at 5 %	0.238	0.181	0.06	0.162
Mean	**5.272**	**6.805**	**0.875**	**1.391**

4.11 Residual effect of nitrogen management on nutrient balance at harvest of ratoon banana

The residual soil nutrient balance at harvest of ratoon banana as influenced by residual soil fertility of plant banana are presented in Table 27.

The soil nutrient balance in respect of nitrogen balancing at harvest of ratoon banana were showed positive signs. The nitrogen balancing at harvest of ratoon banana was considerably higher application of 33 % N- FYM + 33 % N- neem cake + 33 % N- vermicompost (198.83 kg ha^{-1}) followed by 25 % N- FYM + 25 % N- neem cake + 25 % N- vermicompost + 25 % N- RDF (156.92 kg ha^{-1}). Residual nitrogen management and residual soil fertility through organics *viz.*, FYM, neem cake and vermicompost might have immobilized the nitrogen due to higher quantity of manures.

The phosphorus and potassium balancing at harvest of ratoon banana showed negative signs. The negative signs indicated that the ratoon banana had luxurious uptake of phosphorus and potassium from residual soil fertility.

Table 27. Residual effect of integrated nitrogen management on soil nutrient balance at harvest of ratoon banana

Treatment	Initial nutrient status (kg ha^{-1})			Nutrient added in the soil (kg ha^{-1})			Plant uptake (kg ha^{-1})			Residual fertility (kg ha^{-1})			Nutrient balance		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	165.6	17.34	799.5	382.46	75.58	418.74	295.54	77.15	843.66	144.67	15.32	797	107.85	0.45	-422.4
T_2	173.0	20.21	632.0	382.46	75.58	418.74	400.56	97.94	975.18	142.03	19.43	629	12.87	-21.58	-555.4
T_3	147.3	20.55	652.0	382.46	75.58	418.74	378.69	91.20	996.36	144.23	18.45	648	42.83	-13.32	-573.6
T_4	154.5	19.31	492.2	382.46	75.58	418.74	376.94	89.23	935.76	153.18	17.89	488	6.84	-12.23	-512.8
T_5	153.3	21.72	748.9	382.46	75.58	418.74	328.99	98.00	1039.60	152.26	18.17	744	54.71	-18.87	-615.6
T_6	151.6	19.13	643.1	382.46	75.58	418.74	242.57	92.43	937.40	151.00	17.34	640	140.49	-15.06	-515.5
T_7	149.7	22.09	554.5	382.46	75.58	418.74	272.30	108.58	931.56	148.63	20.20	551	111.23	-31.11	-509-3
T_8	151.4	14.14	532.9	382.46	75.58	418.74	252.39	91.01	943.96	148.33	11.88	527	133.17	-13.17	-519.3
T_9	157.4	22.26	860.3	382.46	75.58	418.74	184.30	96.82	846.86	156.73	21.39	857	198.83	-20.37	-424.8
T_{10}	150.8	19.22	757.0	382.46	75.58	418.74	227.58	105.05	711.53	148.66	18.23	754	156.92	-28.98	-289.7

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SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSIONS

The present investigations on residual effect of nitrogen management in Inceptisol were carried out at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri to study "Influence of residual effect by nitrogen management on yield and quality of ratoon banana on Inceptisol" during *rabi* 2006-07. The field experiment was carried out in randomized block design with three replications.

The results emerged out are summarized.

5.1 Residual effect of nitrogen management on yield and yield contributing characters of ratoon banana

The residual fertility of application of 25 % N FYM + 75 % N RDF was the most effective and beneficial treatment for obtaining higher bunch weight (15.43 kg) and yield (72.92 t ha^{-1}) which was followed by the treatment of 50 % N FYM + 50 % N RDF (14.56 kg and 69.14 t ha^{-1}).

5.2 Residual effect of nitrogen management on shooting and duration of ratoon banana

The application of 25 % N FYM + 75 % N RDF and recommended dose of fertilizers (200:40:200 g $plant^{-1}$ N, P_2O_5 and K_2O $plant^{-1}$) + 10 kg FYM $plant^{-1}$ for plant crop and residual effect in ratoon banana were found significantly less period (388 days) followed by the treatment 50 % N neem cake + 50 % N RDF (390 days).

5.3 Residual effect of nitrogen management on dry matter production of ratoon banana

The residual effect of application of 50 % N FYM + 50 % N RDF and 25 % N vermicompost + 75 % N RDF were effective for dry matter production of shoot (8.56 and 8.46 t ha^{-1}) at harvest. The leaf dry matter at harvest was significantly higher in 50 % N vermicompost + 50 % N RDF and 25 % N FYM + 75 % N RDF (16.23 and 14.63 t ha^{-1}). The highest fruit dry weight was obtained in 25 % N neem cake + 75 % N RDF (13.27 t ha^{-1}).

5.4 Residual effect of nitrogen management on nutrient concentration of ratoon banana at harvest

The concentrations of nitrogen, phosphorus and potassium were significantly higher in treatments of 25 % N neem cake + 75 % N RDF (2.05 %); 33 % N FYM + 33 % N neem cake + 33 % N vermicompost (0.38 %) and 25 % N neem cake + 75 % N RDF (3.51 %).

5.5 Residual effect of nitrogen management on nutrient uptake of ratoon banana

Major nutrients

Residual effect of application of 50 % N vermicompost + 50 % N RDF was the most effective for higher uptake of nitrogen (72.78 kg ha^{-1}); 33 % N FYM + 33 % N neem cake + 33 % N vermicompost for phosphorus (21.30 kg ha^{-1}) and 50 % N FYM + 50 % N RDF for potassium uptake (321.54 kg ha^{-1}) by banana in ratoon shoot at harvest.

The uptake of nitrogen in ratoon banana leaf was higher in 25 % N FYM + 75 % N RDF (245.95 kg ha^{-1}) and 50 % N vermicompost + 50 % RDF (60.07 kg ha^{-1}) of phosphorus uptake and vermicompost, FYM and neem cake in equal proportion (338.07 kg ha^{-1}) was beneficial for potassium uptake by banana leaf.

The application of 25 % N neem cake + 75 % N RDF and it's residual effect reported higher uptake of nitrogen (138.02 kg ha^{-1}) by ratoon banana fruit, whereas in treatment 50 % N FYM + 50 % N RDF had higher phosphorus and potassium uptake (27.06 and 391.02 kg ha^{-1}).

Micronutrient

Residual effect of nitrogen management by application of 50 % N FYM + 50 % N RDF was most effective for the higher uptake of iron (1617.92 mg kg^{-1}) and 50 % N FYM + 50 % N RDF (398.27 mg kg^{-1}) for manganese and zinc (181.96 mg kg^{-1}) in ratoon banana shoot at harvest.

The substitution of 50 % N neem cake + 50 % N RDF and it's residual effect on higher uptake of leaf iron (2471.13 mg kg^{-1}) and 50 % N vermicompost + 50 % N RDF for higher leaf manganese (4113.28 mg kg^{-1}) and 25 % N FYM + 75 % N RDF for zinc (318.4 mg kg^{-1}) and 25 % N neem cake + 75 % N RDF for zinc (318.4 mg kg^{-1}) and 25 % N meek cake + 75 % N RDF (102.13 mg kg^{-1}).

The uptake of iron, manganese, zinc and copper by banana fruit at harvest were significantly influenced by nitrogen management and it's residual effect of 25 % N FYM + 75 % N

RDF for iron (947.75 mg kg^{-1}), manganese 50 % N vermicomopst + 50 % N RDF (236.59 mg kg^{-1}), 25 % N neem cake + 75 % N RDF (79.74 mg kg^{-1}) for zinc in ratoon banana fruit was obtained.

Total nutrient uptake for iron found significantly higher in 50 % N neem cake + 50 % N RDF (4897.7 mg kg^{-1}) for manganese 25 % N FYM + 25 % N neem cake + 25 % N vermicompost + 25 % N RDF (3566 mg kg^{-1}), 50 % N vermicomopst + 50 % N RDF (745.73 mg kg^{-1}) and 100 % N substitution equally through FYM, 50 % N neem cake + 50 % N RDF.

5.6 Residual effect of nitrogen management on post harvest quality of ratoon banana during ripening

Reducing sugars

During ripening in all the integrated nitrogen management treatment the reducing sugars content in banana were gradually increased upto last week of ripening (21^{st} days).

The magnitude of increment in the reducing sugars was higher with the chemical fertilizers application based on soil test (0.83 and 5.70 %), which was also higher for nitrogen (400.56 kg ha^{-1}), phosphorus (105.58 kg ha^{-1}) and potassium (1039.60 kg ha^{-1}) uptake.

Titrable acidity

The application of recommended dose of fertilizers (200:40:200 g N, P_2O_5, K_2O $plant^{-1}$) + 10 kg FYM $plant^{-1}$ recorded higher increase in titrable acidity at 0, 7^{th}, 14^{th} and 21^{st} days of ripening (2.81, 4.57, 5.83 and 4.87 %, respectively).

5.7 Residual effect of nitrogen management on soil fertility at harvest

The integration of nitrogen through 33 % N FYM + 33 % neem cake + 33 % vermicompost was recorded highest available nitrogen, phosphorus and potassium (156.73, 21.39 and 857 kg ha^{-1}) at harvest.

5.8 Residual effect of nitrogen management on soil DTPA micronutrients

The DTPA-extractable micronutrients at harvest of ratoon banana as influenced by residual fertility by application of nitrogen through only organics found significantly superior i.e. in application of 33 % N FYM + 33 % N neem cake + 33 % N vermicompost for Fe, Mn and Zn (6.39, 8.46 and 1.04 mg kg^{-1}) and 50 % N neem cake + 50 % N RDF for Cu (1.71 mg kg^{-1}).

Conclusions

- The study of nitrogen management and residual effect on ratoon banana indicated that an application of 25 % N through FYM + 75 % N RDF was the most effective and beneficial treatment for obtaining higher bunch weight (15.43 kg) and yield (72.92 t ha^{-1}).
- The total uptake of nitrogen in leaves at harvest was higher in 25 % N FYM or neem cake + 75 % N RDF and phosphorus in 50 % N vermicompost + 50 % N RDF.
- The nitrogen management and its residual effect to ratoon banana as 50 % N vermicompost + 50 % N RDF recorded higher uptake of manganese, zinc and copper at harvest.

The iron uptake was higher in 50 % N neem cake + 50 % N RDF.

- ❖ The reducing sugar content of ratoon banana was increased at the time of ripening by chemical fertilizer application as per soil test values.
- ❖ The substitution of nitrogen and it's residual effect by 33 % N FYM + 33 % N neem cake + 33 % N vermicompost maintained N status of the soil as well as phosphorus.

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6. LITERATURE CITED

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9. VITA

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