Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 4, Issue, 5, pp. 680 - 686, May, 2013

International Journal of Recent Scientific Research

RESEARCH ARTICLE

GROWTH AND YIELD PARAMETERS AND NUTRIENT UPTAKE OF BANANA AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT PRACTICES

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ARTICLE INFO

Article History:

Received 17th, March, 2013
Received in revised form 14th, April, 2013
Accepted14th, May, 2013
Published online 28th May, 2013

Key words:

Banana, Chemical fertilizers, Wellgro soil, Wellgro grains, Liquid organic manure, FYM, Organic manures.

ABSTRACT

Field investigations were carried out at Northern Block farm, Agricultural Research Station (Tamil Nadu Agricultural University), Bhavanisagar, Erode district of Tamil Nadu during 2010-11 and 2011-12 to study the effect of integrated nutrient management practices on growth, yield and nutrient uptake of banana under irrigated conditions. The banana *cv.* Grand Naine (AAA) was used as a test crop in both the years of study. The experiments consisted of thirteen treatments *viz.,* Control (100% Recommended dose of fertilizer), four treatments consisted of 100 and 75% RDF in combination with *Wellgro soil* @ 20 and 40%, two treatments consisted of 2% liquid organic manure spray on bunches with 100 and 75% RDF, four treatments consisted of 100 and 75% RDF combined with *Wellgro grains* @ 20 and 40% and the last two treatments comprised of FYM @ 10kg plant^{-1} with 100 and 75% RDF combinations. The study revealed that the growth and yield parameters and nutrient uptake were conspicuously higher in integrated nutrient management practices as compared to control (chemical fertilizers alone). During 2010-11 and 2011-12, application of 100% recommended dose of fertilizer along with 40% *Wellgro soil* recorded the highest pseudostem girth (70.1 and 69.9 cm), number of leaves (17.4 and 16.4), and lower phyllochron (6.6 and 7.3 days) at shooting stage and registered shorter crop duration (325.6 and 330.2 days) followed by maximum number of hands (10.2 and 10.3), number of fingers (136.3 and 145.2), bunch weight (23.9 and 25.3 kg/plant) and total yield (72.8 and 77.1 t/ha) respectively. Similarly, nutrient uptake was also influenced by integrated nutrient management practices during both years of study in banana. Hence, integrated nutrient management (100% recommended dose of fertilizer combined with 40% *Wellgro soil*) practices has been found to be an ideal option to improve yield and nutrient uptake of banana under soil and climatic conditions of Western zone of Tamil Nadu.

Banana (*Musa* sp.) is the fifth largest agricultural commodity in the world trade after cereals, sugar, coffee and cocoa and the second largest fruit crop in the world. Banana is a cheap source of energy like vitamins A, C, B_6 and other minerals with traces of fat. At present, banana production in India is 27.0 million tonnes from an area of 0.77 million ha and the productivity is 34.4 tonnes. The major banana growing states in India are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar and West Bengal. Tamil Nadu has the largest area of 0.12 million ha and the production is 6.4 million tonnes while Maharashtra has the second largest area of 0.08 million ha with a production of 5.2 million tonnes (Anon., 2010).

Bananas owing to its large size and rapid growth rate require relatively large amount of nutrients for high yields of quality fruits. It is estimated that 50 tonnes of banana in one hectare removes 320kg N, 32kg P_2O_5 and 925kg K_2O every year (Lahav and Turner, 1983). Application of inorganic fertilizers though increases the yield substantially but could not able to sustain the fertility status of the soil (Bharadwaj and Omanwar, 1994) and have caused several undesirable consequences in the fragile soil eco-system, leading to gradual decline in productivity.

Considering the present situation of soil quality and environmental security, it is necessary to go for an integrated nutrient management, involving various sources of organic manures, organic cakes and bio-fertilizers besides using chemical fertilizers in banana. Integrated nutrient management in banana are being practiced and experimented in various parts of India. Bhalerao *et al.*(2009) observed that combined application of 100% recommended dose of NPK along with organic manures increased the pseudostem height and girth, minimize the days for flowering and total crop duration and yield attributes in banana. Similar trend was also reported by Hazarika and Ansari (2010a); Badgujar *et al.* (2010) and Barakat *et al.* (2011).

In today's cultivation many commercial organic manures are being used because of their application in lesser volume and also enriched with nutrients. One such commercial organic manure used in the study is *Wellgro*. *Wellgro* organic manure is a unique product with a blend of neem and non-timber forest produce and a rich source of nutrients and this organic based farm input addresses soil fertility and crop nutrition in line with the perception of Integrated Nutrient Management (INM). Reddy (2005a) found that application of *Wellgro soil* along with 100% RDF recorded the maximum yield in rice. Similar line of results was also obtained by Reddy (2005b) in cotton,

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Senthurpandian (2007) in tea, Srivastava, (2008) in potato and Prabhakar and Hebbar (2008) in tomato.

The information on effect of integrated nutrient management practices on banana with commercial formulations of organic products (*Wellgro*) is new under the soil and climatic conditions of Western zone of Tamil Nadu. Hence, this study was under taken to find out the influence of INM on growth and yield parameters and nutrient uptake of banana.

MATERIALS AND METHODS

The experiments were laid out at Northern Block Farm, Agricultural Research Station (Tamil Nadu Agricultural University), Bhavanisagar, Erode district of Tamil Nadu. The farm is geographically located at 11°29′ N latitude and 77°08′ E longitude at an altitude of 256 m above MSL.

The experiments were conducted under irrigated conditions. Throughout the experiment, the mean annual rainfall was 538.8 mm in 38 rainy days and 742.8 in 43 rainy days during first and second year, respectively. The mean maximum and minimum temperatures recorded were 33.8°C and 21.9°C in 2010-11 and 34°C and 21.1°C in 2011-12. Similarly, the mean maximum and minimum relative humidity was 87.8 and 50.2% during 2010-11 and 86.2 and 56.3% during 2011-12. Mean bright sunshine hours per day was 4.67 with a mean solar radiation of 453 cal cm^2 day^{-1}.

The soil type was sandy loam in texture. The soils were neutral (pH 7.06 and 7.18) with low soluble salts (EC 0.263 and 0.254 dSm^{-1}), medium and low in organic carbon content (0.51 and 0.46%), low in available nitrogen (208 and 232 kg/ha), medium in available phosphorus (14.7 and 15.3 kg/ha) and high in available potassium (611 and 649 kg/ha) for 2010-11 and 2011-12, respectively. Similarly, soil bulk density was 1.35 and 1.28 g/cc, particle density was 2.27 and 2.31g/cc and porosity was 40.3 and 44.6% during 2010-11 and 2011-12, respectively.

The banana *cv.* Grand Naine (AAA) was used as a test crop during both the years of experimentation. The field was uniformly levelled and the pits were dug out to a dimension of 45x45x30 cm at 1.8m×1.8m spacing and plot size was 14.4m x 5.4m (77.76 m^2). The experiment was laid out in a Randomized Complete Block Design with thirteen treatments and replicated thrice as suggested by Gomez and Gomez (2010). The treatment comprises T_1- 100% recommended dose of fertilizer (control), T_2- 100% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, T_3- 100% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, T_4- 75% RDF + *Wellgro soil* @ 20% w/w of chemical fertilizers, T_5- 75% RDF + *Wellgro soil* @ 40% w/w of chemical fertilizers, T_6- 100% RDF + liquid organic manure spray (LOM) on bunches, T_7- 75% RDF + liquid organic manure spray (LOM) on bunches, T_8- 100% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, T_9- 100% RDF + *Wellgro grains* @ 40% w/w of chemical fertilizers, T_{10}- 75% RDF + *Wellgro grains* @ 20% w/w of chemical fertilizers, T_{11}- 75% RDF + *Wellgro grains* @ 40% w/w of chemical fertilizers, T_{12}- 100% RDF + FYM @ 10kg/plant and T_{13}- 75% RDF + FYM @ 10kg/plant. The following formula was used to calculate the quantity of *Wellgro soil* and *Wellgro grains* @ 20 and 40% w/w of chemical fertilizers.

$$\textit{Wellgro soil/grains}\ (\text{g plant}^{-1}\ \text{split}^{-1}) = \frac{\text{Urea+ super phosphate+ muriate of potash (g plant}^{-1}\ \text{split}^{-1})}{100} \times 20 \text{ or } 40\%$$

The experimental plots consisted of three rows with eight plants in each row. The plots were separated by buffer channels to minimize the movement of nutrients and water. At the time of planting, Furadon granules were applied @ 20g/pit. Applied *Azospirillum* and *Phosphobacteria* 20g each and Vasicular Arbuscular Mycorrhizae (VAM) @ 10kg/ha at planting and 5th month after planting preceding chemical fertilizer application uniformly to all the treatments.

The 100 and 75% recommended dose of fertilizers *i.e.*, 165-52.5-495 and 123.7-39.4-371.3g N-P-K/plant respectively were applied through urea, single super phosphate (SSP) and muriate of potash (MOP). Entire dose of phosphorus and FYM were applied during 2nd month after planting to scheduled treatments. Remaining nitrogen and potash were applied along with *Wellgro* organic manure at 2nd, 4th, 6th and 8th MAP (two months interval). Fertilizers and organic manures were applied in a circular band around the base of the plants. Liquid organic manure @ 2% was sprayed twice (*i.e.*, at 15 and 30 days after last hand opening) uniformly on the foliage and developing bunches. Other cultural practices like weeding, irrigation, pest and disease management and special operations like desuckering, denavelling, pruning of leaves, earthing up and propping were followed uniformly for raising the crop as per the Crop Production Techniques of Horticultural crops (2004).

The following characters were estimated

At all growth stages, pseudostem girth was measured at 15 cm height from the ground level and expressed in cm; phyllochron, the time interval between the appearance of two successive leaves (days $leaf^{-1}$) on the developing pseudostem was recorded (Wilhelm and McMaster, 1995). And the number of functional leaves was also recorded at these stages. Total leaf area was estimated non-destructively by multiplying the product of length and breadth of third leaf by the factor 0.8 and number of leaves and expressed as m^2/plant. At harvest stage, total crop duration (planting to harvest) was recorded and expressed in days.

Bunches were harvested at the green maturity stage. At harvest, the marketable bunch weight (total bunch weight), number of hands and fingers per bunch was recorded. Individual bunch weight was converted in to hectare (3050 plants/ha) and expresses as total yield (t/ha).

The biomass sampling for the banana was made at shooting and harvest stage. During biomass sampling, random plants in each experimental plot were dug up and separated into leaf-lamina, leaf-midrib and petiole, pseudostem, corm, roots and bunch. Before biomass sampling, a composite leaf- lamina was taken from the third uppermost open leaf of all experimental plants in each treatment. Similarly, a composite sample was taken from midrib, petiole, pseudostem, corm, roots and bunch for nutrient analysis.

For each biomass sampling, green and oven-dry weights of the various plant organs were obtained. Sub-samples from these and the composite samples were dried, ground, sieved through a 20mm mesh screen and analyzed for nitrogen, phosphorus and potassium. Nitrogen was determined by the micro-Kjeldhal method; phosphorus, colorimetrically and potassium by the flame photometer. Total nutrient uptake and total dry matter production were calculated by using the product of the dry matter weight and the nutrient concentration in the various

plant organs. *i.e.,* the uptake of nutrients was worked out using the following formula.

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

In banana, data were obtained on growth parameters (pseudostem girth, phyllochron, number of leaves, total leaf area and total crop duration), bunch traits (number of hands and fingers per bunch), bunch weight, total yield and total nutrient uptake during the course of investigation. The data were statistically analyzed by the analysis of variance method as suggested Gomez and Gomez (2010). Wherever the treatment differences were found significant, critical differences were worked out at 5% probability level and the values are furnished. Non-significant treatment differences were denoted as NS.

RESULTS AND DISCUSSION

Growth parameters

Data pertaining to pseudostem girth (cm), phyllochron (days), number of leaves, total leaf area (m^2/plant) and total crop duration of banana under different treatments are presented in Table 1.

The integrated nutrient management (INM) treated plots exerted a positive influence on pseudostem girth over control at shooting stage during both the years. However, plants in the 100% recommended dose of fertilizer along with 40% *Wellgro soil* developed significantly thicker pseudostem girth (70.1 and 69.9cm) than 100% chemical fertilizers alone (59.8 and 57.7cm) during 2010-11 and 2011-12, respectively. However, it was comparable with T_{12}, T_2, T_9 and T_{13} during 2010-11 and T_{12}, T_2, T_{13}, T_9 and T_8 during 2011-12. Application of 75% RDF along with liquid organic manure spray on bunches (T_7) recorded the lowest girth of pseudostem (54.9 and 56.6 cm during the first and second years respectively). Plants with thicker pseudostem are desirable as they reflect on bunch size and other related characters. Besides, they also give better anchorage to the plant. Available NPK status, organic carbon and microbial biomass and dehydrogenase activity were enhanced due to application of inorganic fertilizers along with organic manures which would have helped in increasing pseudostem girth of banana plants. This result is coinciding with the observations of Hazarika and Ansari (2010).

Phyllochron or the rate of leaf production is an important factor to be considered during vegetative growth. The phyllochron was found to differ significantly among the INM treatments at shooting stage of banana.

Table 1 Effect of integrated nutrient management on growth parameters of banana at shooting stage

Treatments	2010-11						2011-12					
	Pseudostem girth (cm)	Phyllochron (days)	No. of leaves	LA (m^2 $plant^{-1}$)	LAI	Total crop duration (days)	Pseudostem girth (cm)	Phyllochron (days)	No. of leaves	LA (m^2 $plant^{-1}$)	LAI	Total crop duration (days)
T_1 - 100% RDF (Control)	59.8	7.1	14.0	11.49	3.72	354.7	57.7	8.4	14.2	12.05	3.55	356.0
T_2 - 100% RDF + 20% WS	68.3	6.6	16.6	16.86	5.42	331.7	66.5	7.6	16.8	17.56	5.20	337.1
T_3 - 100% RDF + 40% WS	70.1	6.6	17.4	19.02	5.17	325.6	69.9	7.3	16.4	16.74	5.87	330.2
T_4 - 75% RDF + 20% WS	55.3	6.9	13.9	11.47	3.76	334.0	61.0	8.6	14.4	12.19	3.54	333.5
T_5 - 75% RDF + 40% WS	63.3	7.0	16.1	15.36	4.43	326.3	62.5	7.9	15.6	14.35	4.74	330.2
T_6 - 100% RDF + LOM	59.2	7.1	14.1	11.59	3.87	346.7	57.0	8.3	14.8	12.54	3.58	350.4
T_7 - 75% RDF + LOM	54.9	6.9	13.8	10.74	3.25	350.4	56.6	8.6	13.6	10.51	3.31	351.5
T_8 - 100% RDF + 20% WG	63.0	6.8	16.1	14.77	4.72	354.2	63.8	7.7	15.7	15.29	4.56	358.3
T_9 - 100% RDF + 40% WG	65.3	6.7	16.3	15.94	4.65	359.0	64.5	7.8	16.1	15.06	4.92	362.2
T_{10} - 75% RDF + 20% WG	60.6	7.2	14.8	12.93	4.11	335.8	62.2	8.1	14.7	13.30	3.99	338.1
T_{11} - 75% RDF + 40% WG	62.0	7.0	15.5	15.15	4.21	349.5	63.2	8.0	14.9	13.64	4.68	362.4
T_{12} - 100% RDF + FYM	68.5	6.9	16.5	17.59	5.65	355.7	67.5	7.7	16.9	18.29	5.43	350.4
T_{13} - 75% RDF + FYM	65.1	6.7	16.3	15.37	4.55	354.7	65.2	7.6	15.5	14.75	4.74	356.7
S.Ed	3.1	0.2	0.8	1.43	0.44	6.4	3.1	0.2	0.7	1.34	0.41	5.8
CD(P=0.05)	6.4	0.4	1.7	2.95	0.91	13.3	6.4	0.4	1.5	2.77	0.85	12.0

Table 2 Effect of integrated nutrient management on bunch characteristics of banana

Treatments	2010-11					2011-12				
	Bunch weight (kg)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)	Bunch weight (kg)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)
T_1 - 100% RDF (Control)	21.2	8.6	125.2	167.3	64.6	21.6	9.6	131.3	173.3	65.8
T_2 - 100% RDF + 20% WS	23.0	9.5	132.0	172.7	70.0	24.5	10.3	139.0	182.3	74.7
T_3 - 100% RDF + 40% WS	23.9	10.2	136.3	175.0	72.8	25.3	10.3	145.2	184.2	77.1
T_4 - 75% RDF + 20% WS	21.0	8.6	123.3	169.3	64.0	21.6	9.5	124.1	178.0	65.7
T_5 - 75% RDF + 40% WS	22.5	9.2	126.4	171.0	68.5	22.5	10.0	128.7	180.3	68.6
T_6 - 100% RDF + WC spray	21.9	8.7	126.5	172.3	66.9	22.3	9.6	130.7	178.0	68.0
T_7 - 75% RDF + WC spray	20.5	8.5	118.6	170.0	62.5	21.0	9.1	124.0	176.3	64.1
T_8 - 100% RDF + 20% WG	22.5	9.8	130.7	173.7	69.3	23.7	10.0	136.1	181.0	72.1
T_9 - 100% RDF + 40% WG	23.3	9.5	133.4	178.7	71.0	24.9	10.2	139.8	184.7	75.9
T_{10} - 75% RDF + 20% WG	21.2	8.9	122.2	172.8	64.6	21.8	10.0	127.3	179.0	66.5
T_{11} - 75% RDF + 40% WG	21.4	9.3	123.1	171.7	65.2	21.7	9.9	129.0	178.3	66.1
T_{12} - 100% RDF + FYM	23.8	10.0	135.4	174.3	72.5	25.3	10.4	141.5	186.3	77.1
T_{13} - 75% RDF + FYM	21.3	9.7	126.3	170.4	65.0	21.9	9.6	130.9	179.0	66.9
S.Ed	0.6	0.5	3.1	5.3	2.1	0.8	0.5	3.4	5.4	2.4
CD(P=0.05)	1.2	1.0	6.3	10.1	4.2	1.6	1.1	7.0	11.2	5.0

Table 3 Effect of integrated nutrient management on total nutrient uptake (kg ha^{-1}) of banana

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

Where, combined application of 100% RDF along with 40% *Wellgro soil* recorded the minimum of 6.6 and 7.3 days leaf^{-1} and also reduced the interval between two successive leaves of banana (0.5 and 1.1 days) over control during 2010-11 and 2011-12, respectively, but it was on par with T_2, T_9, T_{13}, T_8, T_{12}, T_7, T_4 and T_5 during 2010-11 and T_2, T_{13}, T_{12} and T_8 during 2011-12. Whereas, the maximum number of days leaf^{-1} (7.2) was taken in treatment T_{10} during 2010-11. Similarly, T_4 and T_7 registered the maximum number of days leaf^{-1} (8.6) during 2011-12.

This also can be explained that higher vegetative growth in the treatment with organic manures improved the nutrient availability and thereby causing higher protein synthesis resulting in better growth and in turn faster leaf production. This was confirmed from the findings of Sosamma *et al.*(1998). Number of leaves/plant was significantly increased with application of 100% RDF along with either 40% *Wellgro soil* or FYM @10kg/plant. It produced 19.34 and 13.54% higher number of leaves compared to control. It was found that total number of leaves retained at shooting is crucial in determining the yield potential of banana.

Discernible variation in leaf area was observed due to the INM treatments at shooting stage of banana over control. Greater leaf area aids the plant to synthesize more metabolites exhibiting high photosynthetic rate during the period of growth and development in banana (Mahadevan, 1988). In the present investigation, the total leaf area measured at shooting stages revealed that application of 100% RDF either with 40% *Wellgro soil* or FYM @ 10kg/plant continued to register maximum leaf area during both the years of experimentation (Table 1). It could be attributed to the fact that the increase in nutrient levels of NPK along with organic manures especially nitrogen, enhanced the vegetative growth and simultaneously increased the leaf area.

Leaf area index (LAI) is an important source in manufacturing photoassimilates for determining dry matter accumulation and crop yield. An increase in LAI results in better utilization of solar energy. Thus, leading to higher dry matter accumulation through the process of photosynthesis. It is a positive index with direct influence on plant growth. Similar response was observed in the present study due to various integrated nutrient management treatments. At the time of shooting, the treatment 100% recommended dose of fertilizer along with FYM @ 10kg plant^{-1} (5.65) which was on par with T_2 and T_3 during 2010-11and the lowest LAI was observed in T_7.

Application of 100% RDF along with 40% *Wellgro soil* registered the maximum LAI (5.87) during 2011-12 and it was on par with T_{12} and T_2. The lowest LAI was observed in control plot (T_7) at shooting stage of banana. The reason for increasing leaf area index might be due to integrated application of chemical fertilizers along with organic manures, which attributed the increase in nutrient levels of NPK; especially nitrogen enhanced the vegetative growth like number of leaves and leaf area and simultaneously enhanced the leaf area index. This fact was already reported by Hazarika and Ansari (2010b) in banana.

The total crop duration was strongly influenced by various integrated nutrient management practices. The shorter crop duration might be due to the higher net assimilation rate on account of better growth leading to the production of endogenous metabolites earlier in optimum level enabling early flower bud initiation and thereby early shooting in banana (Hazarika and Ansari, 2010b). In the present investigation also, application of 100% RDF along with 40% *Wellgro soil* shortened the crop duration into 325.6 days as compared to control (354.7 days) during the first year. Similarly, second year also it reduced the total crop duration into 25.8 days than control. This might be due to optimum quantity of nutrients available through chemical and organic fertilizers hastened the process of initiation and emergence of inflorescence due to earlier production of leaves with larger leaf area/plant and better disposition of photosynthetic activity resulting in higher required net assimilation.

Yield parameters

Crop had significant effect on bunch traits due to integrated nutrient management practices. However, application of 100% RDF along with either 40% *Wellgro soil* or FYM @ 10kg/plant recorded the maximum marketable weight, number of hands and fingers/bunch and total yield (Table 2). During 2010-11 and 2011-12, the highest bunch weight (23.9 and 25.3kg), number of hands (10.2 and 10.3) and fingers (136.3 and 145.2/bunch), finger weight (175.0 and 184.2 g) and maximum yield response (72.8 and 77.1 t/ha) respectively were obtained with application of 100% RDF along with 40% *Wellgro soil*. However, bunch weight was comparable with T_{12} (23.77 kg), T_9 (23.3 kg) and T_2 (23.0 kg) during 2010-11 and with T_{12} (25.3 kg) and T_9 (24.9 kg), T_2 (24.5 kg) and T_8 (23.7 kg) during 2011-12. Similarly, total yield was on par with T_{12} (72.5 t ha^{-1}), T_9 (71.0 t ha^{-1}), T_2 (70.1 t ha^{-1}) and T_8 (69.3 t ha^{-1})

during first year and T_{12} (77.1 t ha^{-1}), T_9 (75.9 t ha^{-1}), T_2 (74.7 t ha^{-1}) and T_8 (72.1 t ha^{-1}) during second year.

Increase in yield attributes could be due to the increase in morphological traits such as plant height, girth, number of functional leaves, leaf area index, faster rate of leaf production and also higher nutrient uptake by the plants. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher carbohydrates could have promoted the growth rate and in turn increased bunch weight. This was in accordance with the results of Chezhiyen *et al.*(1999) in banana. The increase in finger weight may be due to the increase in production of promoting endogenous and enhancement of nutrient uptake in addition to the role of nitrogen on productivity of banana plants (Nijjar, 1985). Any factor that stimulates higher finger production and favours better finger development leads to better bunch weight.

The increment of yield due to the application of 100% RDF along with 40% *Wellgro soil* was 11.2 and 14.7% as compared to control. Similarly, application of 100% RDF with FYM @ 10kg/plant registered 10.8 and 14.6% higher yield over control during 2010-11 and 2011-12, respectively. Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which in turn led to good crop growth and yield. Humus substance present in organic product could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. These products would help the better availability and utilization of nutrients. All these positive effect might have facilitated quick mobilization and availability of nutrients that would aid in increased plant height, number of leaves, leaf area, leaf area index and photosynthetic rate. This in turn would have assisted for the increased yield of banana. This is in confirmation with the findings of Patel *et al.*(2010) and Aba *et al.*(2011) in banana.

Nutrient uptake

There was a significant difference among the different INM treatments on total nutrient uptake of banana. Total uptake was influenced by combined application of 100% recommended dose of fertilizers along with organic manures in both the years. The uptake of nitrogen increased linearly with all the treatments at shooting and harvest stages (Table 3). Among the various parts, N uptake was highest in lamina (Fig. 1a and Fig 1b). It was attributed by higher number of leaf production resulting in more DMP coupled with higher N content. Among the treatments, 100% RDF with either 40% *Wellgro soil* or FYM @ 10kg/plant recorded the maximum N uptake. The increase in available nitrogen due to application of FYM and *Wellgro* organic manure might be attributed to the greater multiplication of soil microbes. These organics during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen to soil. Similar results were reported by Tolanur and Badanur (2003). In general, organic manures are converted through bacterial action into readily usable ammoniacal and nitrate nitrogen for use by the crops (Sankaranarayanan, 2011).

The highest uptake of P is observed due to application of 100% of NPK along with either 40% *Wellgro soil* or FYM @ 10kg/plant (Table 3). It was attributed due to higher DMP as a result of optimum availability of phosphate ions in the soil solution. The increased uptake might be due to enhanced phosphorus activities that mobilize sparingly the available nutrient sources and ectozymes resulting in improved phosphate uptake (Dixon et al*.,* 1985). The mechanism involved in solubilizing phosphorus was due to acid production and enzyme activity *viz.,* dehydrogenase, phosphate and urenase activities. Thus, due to transport of solubilized phosphorus through hyphae to the roots led to an efficient increase in phosphorus uptake (Abbolt and Robson, 1977). In general, organic matter from manure interacts with clay minerals and reduces P sorption by the soil, thereby enhancing P availability to plants.

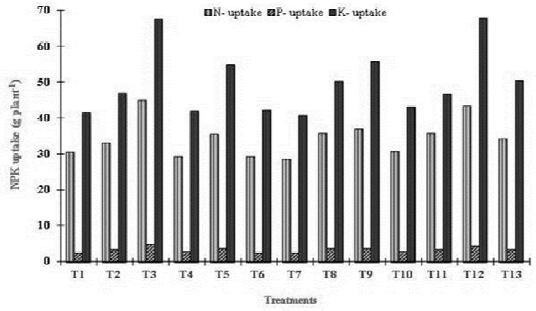

Figure. 1a. Effect of integrated nutrient management on nutrient uptake (g plant $^{-1}$) of lamina at shooting stage during 2010-11

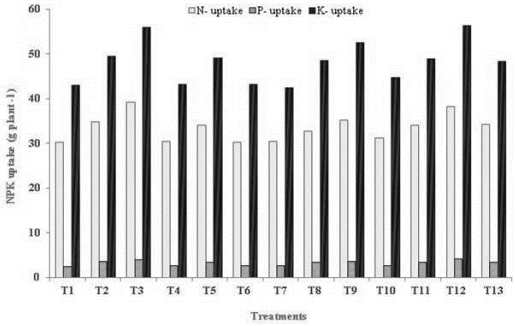

Figure 1b Effect of integrated nutrient management on nutrient uptake (g plant $^{-1}$) of lamina at shooting stage during 2011-12

The total uptake of K increased constantly till harvest in all the treatments (Table 3). The K uptake was maximum at harvest showing that absorption and translocation of assimilates to sink was necessary for the finger development. Twyford and Walmsley (1974) also reported maximum content of K was necessary for finger development. The K uptake was also influenced by the INM treatments and recorded the maximum uptake in 100% RDF with either 40% *Wellgro soil* or FYM @ 10kg/plant. This could be due to application of *Wellgro* organic manure or FYM, which helps in conversion of soil humic substances and mobilization of potassium due to mineralization and exchange reaction with soil particles. This is in corroboration with the previous work of Adherkhin and Belyayer (1971). And also, availability of optimum concentration of K in the soil colloids might have facilitated better absorption by the root system of the plants. Increased microbial activities have resulted in greater uptake of potassium in plants. Moreover, the increased availability of potassium under organics application might be due to the solubilization action

of certain organic acids produced during decomposition of organic manures and its greater capacity to hold K in available form in soil and also due to interaction of organic matter with clay and direct addition of potassium to the available pool of soil. Similar beneficial effects of organic manures were reported earlier (Pawar et al., 1997).

CONCLUSIONS

From the field investigations, it is concluded that banana responded favourably to *Wellgro* organic manure and FYM in combination with chemical fertilizers. Combined application of 100% RDF either with *Wellgro soil* or FYM @ 10kg plant^{-1} positively influenced the growth and yield attributes along with nutrient uptake. Taking into consideration of the growth and yield of banana, it is inferred that application of 100% RDF along with either 40% *Wellgro soil* or FYM @ 10kg/plant could be a viable practice where resources are abundant. Application of 75% RDF along with 40% *Wellgro* organic manures also responded well and recorded high B: C ratio due to less quantity of input (data not shown). It can be considered where resources are limited. Though FYM treated plot was prominent in higher yield and gross income, but, it recorded the lowest net return and benefit cost ratio due to high cost of input. So, it can be recommended to the farmers producing FYM on their own.

Hence, the integrated nutrient management practice of 100% recommended dose of fertilizer combined with 40% *Wellgro soil* in banana crop has been found to be an ideal option to crop productivity besides being economically competitive and productive under soil and climatic conditions of Western zone of Tamil Nadu.

Acknowledgement

Authors are highly thankful to the India Tobacco Company (ITC)- ABD- Ltd, Guntur, Hyderabad for granting scheme.

References

Aba, S.C., Baiyeri, P.K. and Tenkouano, A. 2011. Impact of poultry manure on growth behavior, black sigatoka disease response and yield attributes of two plantain (*Musa* spp. AAB) genotypes. Tropicultura, 29(1): 20-27.

Abbolt, L.K. and Robson, A.D. 1977. The role of vesicular arbuscular mycorrhizae fungi in agriculture and the selection of fungi for inoculation. Agric. Res., 33: 389-408.

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

Anonymous. 2010. National Horticulture Board. Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India, New Delhi.

Badgujar, C.D., Pujari, C.V. and Patil, N.M. 2010. Evaluation of banana cultivars under different fertilizer regimes. Asian. J. Hort., 4(2): 332-335.

Barakat, M.R., Kosary, S.E. and Nafea, M.H.A. 2011. Enhancing Williams banana cropping by using some organic fertilization treatments. J. Hort. Sci. Ornamental Plants, 3(1): 29-37.

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

Bharadwaj, V. and Omanwar, P.K. 1994. Long term effects of continuous rotational cropping and fertilization on crop yields and soil properties- II. Effects on EC, pH, organic matter and available nutrients of soil. J. Indian Soc. Soil Sci., 42(3): 387-392.

Chezhiyen, N., Balasubramani, P., Harris, C.V. and Anandthan, M. 1999. Effect of inorganic and biofertilizers on growth and yield of inorganic banana var. Virupakshi. S. Indian Hort., 47: 1-6.

Crop Production Techniques of Horticultural crops. 2004. Published by Directorate of Horticulture and Plantation crops, Chennai and Tamil Nadu Agrl. Univ., Coimbatore. Pp 4-8.

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

Gomez, K.A. and Gomez, A.A. 2010. Statistical Procedures for Agricultural Research. 2nd Edn. John Wiley and Sons, New York.

Hazarika, B.N. and Ansari, S. 2010a. Effect of integrated nutrient management on growth and yield of banana to organic manuring. Trop. Agric. 133: 117-229.

Hazarika, B.N. and Ansari, S. 2010b. Effect of integrated nutrient management on growth and yield of banana cv. Jahaji. Indian J. Hort., 67(2): 270-273.

Lahav, E. and Turner, D.W. 1983. Banana nutrition. Int. Potash Inst. Bull., No. 7: 33.

Mahadevan, V.C. 1988. Effect of foliar nutrition of NPK on banana cv. Nendran (AAB). M.Sc. (Hort.) Thesis, Tamil Nadu Agrl. Univ., Coimbatore.

Nijjar, G.S. 1985. Banana- role of nitrogen on yield. In: Nutrition of fruit trees. Usha, R. (Ed.), Kalyani Publishers, New Delhi, India, pp. 306-308.

Patel, C.M., Patel, N.L., Gaikwad, S.S. and Patil, S.J. 2010. Effect of post-shooting treatments on yield and it's attributes of banana (*Musa paradisiaca* L.) cv. Grand Naine. J. Plant Dis. Sci., 5(2): 210-212.

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

Prabhakar, M. and Hebbar, S.S. 2008. Evaluation of wellgro-organic manure (soil and foliar application) in selected vegetable crops. In: Evaluation report. Indian Institute of Horticulture Research, Bangalore. pp. 4-6.

Reddy, R.P. 2005a. Evaluation of wellgro brand organic manures (wellgro soil and wellgro crops) on paddy. In: Trial report. Andhra Pradesh Rice Research Institute, Marateru. pp. 2-4.

Reddy, R.P. 2005b. Evaluation of wellgro organic manures on cotton. In: Trial report. Regional Agricultural Research Station, Lam. pp. 8-11.

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

Senthurpandian, V.K. 2007. Report of wellgro crops and wellgro soil on Tea. In: Trial report. UPASI Tea Research Foundation, Valparai. pp, 2-4.

Sosamma, Y.K., Koshy, P.K., Samuel, R. and Mehta, U.K. 1998. Effect of *Glomus mossae* on nematodes infesting banana under coconut based high density multi species cropping system. In. Proc. of the third Int. symp. on 'Nematology - Challenges and opportunities in 21st century', Afro-Asian Society of Nematologist (TISSASN), pp. 94-97.

Srivastava. K. 2008. Studies on the beneficial effects of two organic agri inputs (wellgro soil and wellgro crops) on potato chips varieties. In: Ann. report. Banarus Hindu University, Varanasi. pp. 1-4.

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

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

Wilhelm, W.W. and McMaster, G.S. 1995. Importance of the phyllochron in studying development and growth in grasses. Crop Sci., 35(1): 1-3.t

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