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Influence of NPK on crop performance and leaf nutrient status of banana under sub surface drip fertigation system

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Field experiment was carried out at AICRP- Water Management block, Agricultural College and Research Institute, Madurai during 2010 - 2011. The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of T_1-Surface irrigation with soil application of recommended dose of fertilizers, T_2- Subsurface drip fertigation of 100% RDF (P as basal, N and K through drip as urea and white potash), T_3- Subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3), T_4- Subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF), T_5- Subsurface drip fertigation of 75% RDF (P as basal, N and K through drip as urea and white potash) + LBF, T_6- Subsurface drip fertigation of 75% RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF, T_7- Subsurface drip fertigation of 75 per cent RDF (50% P and K as basal, remaining N, P and K as WSF) + LBF, T_8- Subsurface drip fertigation of 100% RDF (P as basal, N and K through drip as urea and white potash)+LBF, T_9- Subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3)+ LBF, T_{10}- Subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF)+LBF and T_{11}-Subsurface drip irrigation with LBF alone (no inorganic). Banana cv. Rasthali was used as test crop. Subsurface drip irrigation was scheduled at 100% PE once in three days and fertigation was given once in six days starting from 15 days after planting to 300 days after planting. For surface method, irrigation was scheduled at 5.0 cm depth with IW / CPE ratio of 0.8. Estimates of total water use, soil available nutrients, nutrient mobility in soil and economic returns were also recorded. Banana leaf samples should normally be taken either just before or following floral emergence and when all female hands are visible. However, the age of the tissue to be sampled depends on the nutrients being diagnosed. In most banana producing countries, the laminar structure of third leaf is sampled for tissue analysis. However samples of the central vein of third leaf and the petiole of seventh leaf are also used. The laminar structure of third leaf is sampled by removing a strip of tissue 10 cm wide, on both side of the central vein and discarding everything but the tissue that extends from the centrals vein to the centre of the lamina.

Key words: Banana, leaf analysis, nitrogen, phosphorus, potassium.

INTRODUCTION

Plant analysis has been considered a very practical approach for diagnosing nutritional disorders and formulating fertilizer recommendations (Kelling et al., 2000). Plant analysis, in conjunction with soil testing, becomes a highly useful tool not only in diagnosing the nutritional status but also an aid in management decisions for improving the crop nutrition (Rashid, 2005). Plant analysis is the quantitative analysis of the total nutrient content in a plant tissue, based on the principle that the amount of a nutrient in diagnostic plant parts indicates the soil ability to supply that nutrient and is directly related to the available nutrient status in the soil (Malavolta, 1994; Havlin et al., 2004). It is a very practical and useful technique for fruit trees and long duration crops (Rashid, 2005). Hence, it seems quite convenient and appealing for bananas also.

Bananas are heavy feeder of nutrients (Jones, 1998) and thus need to balanced nutrition for optimum growth and fruit production, and in turn potential yields. A deficiency or excess of nutrients can cause substantial damage to the plant (Memon et al., 2001). The early (until the mid-1960s) researches on banana nutrition had concentrated on the description of symptoms of nutrient imbalance and the conduct of field experiments comparing response to rates of applied fertilizer on a range of soil types. During last three decades, scientists attempted to understand more clearly the role of nutrients in the growth and development of bananas. Field studies of fertilizer response are still being conducted, but attempts to relate nutrient concentrations in the soil and plant to yield have complemented this work.

MATERIALS AND METHODS

The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of T_1-Surface irrigation with soil application of recommended dose of fertilizers, T_2- Subsurface drip fertigation of 100% recommended dose of fertilizer RDF (P as basal, N and K through drip from the source of urea and white potash), T_3- Subsurface drip fertigation of 100% RDF by Water Soluble Fertilizer (WSF – Urea, 13: 40: 13, Pottasium nitrate (KNO_3), T_4- Subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K through WSF), T_5- Subsurface drip fertigation of 75% RDF (P as basal, N and K through drip from and white potash) + LBF, T_6- Subsurface drip fertigation of 75% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + Liquid Bio Fertilizer (LBF), T_7- Subsurface drip fertigation of 75 per cent RDF (50% P and K as basal, remaining N, P and K by WSF) + LBF, T_8- Subsurface drip fertigation of 100% RDF (P as basal, N and K through drip from urea and white potash) +LBF, T_9- Subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF, T_{10}- Subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K by WSF) + LBF and T_{11}-Subsurface drip irrigation with LBF alone (no inorganic).

The leaf samples were taken from the third upper leaf from the top of the plant at different growth stages by Mitra and Dhue (1988). Ten plants were selected at random and the samples of the index tissue comprising 10 cm wide stripes of leaf blade in the centre of the leaf and on either side of the mid rib were collected from recently matured leaf. A composite sample was prepared for by combining the leaf stripes obtained from 10 plants for each treatment. Decontamination of samples was done by washing them with distilled water (Chapman and Parker, 1961). The samples were dried in shade and then in air oven at 60^oC and were ground in a Willey mill using stainless steel grinder and stored in labeled container for the analysis of total N, P and K by following the procedures. Total nitrogen analyzed by micro kjeldahl distillation method by Humphries (1956). Total Phosphorus by Vanadomolybdate colour method of Jackson (1973) and Total Potassium by Flame photometry in triple acid extract of Piper (1966).

RESULTS AND DISCUSSION

Leaf nutrient concentration

Effect of subsurface drip fertigation on leaf N content (percent)

The leaf N steadily increased from 3 MAP to shooting stage and thereafter it decreased. At 3 MAP, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) recorded the highest leaf N content of 2.97%. This treatment was on par with subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) +LBF (T_{10}) and subsurface drip fertigation of 100% RDF (P as basal, N and K through drip as urea and white potash) + LBF (T_8). The treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}) recorded the lowest leaf N content.

At 5 MAP, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) ranked best by registering higher leaf N content of 3.42%. The lowest leaf N content was recorded in the treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}).

At shooting stage, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) recorded the highest leaf N content of 3.99% which was on par with subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) (T_3). The treatment LBF subsurface drip irrigation with alone (No inorganic) (T_{11}) recorded the lowest leaf N content.

At harvesting stage, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) (T_3) was found to maintain higher leaf N content of 3.62%. This treatment was on par with subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9), subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) +LBF (T_{10}) and subsurface drip fertigation of 100% RDF (P as basal, N and K through drip as urea and white potash) +

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Table 1. Effect of subsurface drip fertigation levels on leaf N content (per cent) of banana.

Treatment	3 MAP	5 MAP	At harvest
T_1	2.43	3.16	3.01
T_2	2.40	2.73	3.15
T_3	2.74	3.17	3.62
T_4	2.70	3.05	3.18
T_5	2.65	3.19	3.13
T_6	2.75	3.11	3.26
T_7	2.41	3.15	3.31
T_8	2.85	2.83	3.47
T_9	2.97	3.42	3.58
T_{10}	2.85	3.20	3.43
T_{11}	2.30	2.71	3.20
SE d	**0.06**	**0.09**	**0.13**
CD(P=0.05)	**0.14**	**0.20**	**0.27**

MAP, Months after planting.

Table 2. Effect of subsurface drip fertigation levels on leaf P content (per cent) of banana.

Treatment	3 MAP	5 MAP	At harvest
T_1	0.24	0.28	0.23
T_2	0.26	0.28	0.25
T_3	0.21	0.29	0.24
T_4	0.29	0.31	0.23
T_5	0.31	0.30	0.22
T_6	0.27	0.28	0.23
T_7	0.25	0.26	0.20
T_8	0.28	0.29	0.22
T_9	0.30	0.31	0.23
T_{10}	0.28	0.30	0.24
T_{11}	0.20	0.22	0.21
SE d	**0.01**	**0.01**	**NS**
CD(P=0.05)	**0.02**	**0.02**	

MAP, Months after planting.

LBF (T_8). The lowest leaf N content was record in surface irrigation with soil application of RDF (T_1) (Table 1).

Effect of subsurface drip fertigation on leaf P content (percent)

At 3 MAP, higher P content (0.31%) was observed under subsurface drip fertigation of 75% RDF + LBF (P as basal, N and K through drip as urea and white potash) (T_5) which was on par with subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) and subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) (T_4).

The lowest leaf P content was recorded in the treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}). At 5 MAP, subsurface drip fertigation 100 per cent RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) and subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) (T_4) were comparable and recorded the highest leaf P content of 0.31%. These treatments were closely followed by subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) + LBF (T_{10}) and subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) (T_3). The lowest leaf P content was recorded in the treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}).

At shooting stage, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) recorded the higher leaf P content of 0.33. This treatment was on par with subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) (T_3) and subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) + LBF (T_{10}). The lowest leaf P content was recorded in the treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}).

The leaf P content at harvesting stage was not significantly by fertigation treatments (Table 2).

Effect of subsurface drip fertigation on leaf K content (percent)

At 3 MAP, the highest leaf K content (3.46%) was recorded in subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) and it had similar effect with subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) (T_{10}). The lowest leaf K content was observed in surface irrigation with soil application of RDF (T_1).

As the crop stage advanced from 5 MAP to shooting, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) showed its superiority by registering the highest leaf K content. The treatment subsurface drip irrigation with LBF alone (No inorganic) (T_{11}) recorded the lowest leaf K content.

At harvesting stage, subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9) maintained the highest leaf K content (3.61%). This treatment was on par with subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) +LBF (T_{10}), subsurface drip fertigation of 75% RDF + LBF (P as basal, N and K through drip as urea and white potash) (T_5) and subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K

Table 3. Effect of subsurface drip fertigation levels on leaf K content (per cent) of banana.

Treatment	3 MAP	5 MAP	At Harvest
T_1	2.19	2.83	2.95
T_2	2.93	2.88	3.18
T_3	3.15	3.48	3.31
T_4	3.04	3.65	3.48
T_5	3.02	3.53	3.41
T_6	2.64	3.33	3.40
T_7	2.98	3.17	3.32
T_8	2.95	3.40	3.21
T_9	3.46	3.91	3.61
T_{10}	3.33	3.69	3.45
T_{11}	2.45	2.39	3.11
SE d	**0.09**	**0.09**	**0.10**
CD(P=0.05)	**0.19**	**0.20**	**0.21**

MAP, Months after planting.

as WSF) (T_4). The lowest leaf K content was noted in surface irrigation with soil application of RDF (T_1) (Table 3).

DISCUSSION

The leaf NPK was affected significantly by subsurface drip fertigation treatments under this investigation. The highest NPK percentage in leaf was recorded by plants received subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF. In general, there was an increase in NPK contents in all the treatments up to shooting and thereafter the values declined. This shows a heavy loading of NPK in leaves during vegetative and shooting stage followed by a decrease in the concentration due to rapid increase in dry matter caused by faster growth of banana crop. Mitra and Dhue (1988) reported a continuous uptake of N up to shooting in banana. Ram and Prasad (1985) observed an increase in the content of N up to flowering in banana.

It was further observed that the content of NPK was always higher when drip fertigation is integrated with liquid bio fertilizers. Application of nutrients at six interval up to 300 days maintained the NPK content of the third youngest leaf always at a higher level, when compared to surface irrigation with soil application of recommended dose of fertilizers. This indicates that nutrients are more efficiently absorbed and distributed within the plant when the frequency of application increases. Therefore, more frequent application of NPK could be beneficial for growing banana. However, at the other stages of growth, the NPK content in leaf should be maintained at 3.0% for N, 0.30% for P and 3.50% for K. Different workers have proposed different critical levels of nutrients in third leaf of banana which range from 1.80 to 4.0% for N (Angeles et al., 1993), 0.17 to 0.29% for P (Lahav and Turner, 1983) and 1.66 to 5.40% for K (Noor-Un-Nisha Memon et al., 2010).

Conclusion

Plant analysis is on authoritative tool for evaluating nutrient deficiency, toxicities and imbalances, identifying hidden hunger, deciding fertilization plants, studying nutrient interaction and determining the availability of element for which reliable soil tests have not been developed. The highest NPK content at shooting stage was recorded in plants received subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) + LBF (T_9). This was followed by subsurface drip fertigation of 100% RDF as WSF (WSF - Urea, 13: 40: 13, KNO_3) (T_3), subsurface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) + LBF (T_{10}) and subsurface drip fertigation of 100% RDF (P as basal, N and K through drip as urea and white potash) + LBF (T_8). The treatment subsurface drip irrigation with LBF alone (no inorganic) (T_{11}) recorded the lowest NPK content in leaves.

Conflict of Interest

The authors have not declared any conflict of interest.

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