International Journal of Plant & Soil Science

18(1): 1-9, 2017; Article no.IJPSS.35034
ISSN: 2320-7035

Potassium Dynamics under Sub Surface Drip Fertigation System on Banana cv. Rasthali

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Authors' contributions

This work was carried out in collaboration between both authors. Author MY designed the study, performed the statistical analysis, wrote the protocol, and wrote manuscript. Author PPM guided in this study and gave more suggestion when I am writing manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/35034
Editor(s):
(1) Nasima Junejo, Department of Forest Production, Faculty of Forestry, Universiti Putra Malaysia, Selangor, Malaysia.
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(5) M. Lalitha, National Bureau of Soil Survey and Land Use Planning, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/20470

Original Research Article

Received 25th June 2017
Accepted 3rd August 2017
Published 11th August 2017

ABSTRACT

The soil sampling was done at emitting point (laterals placed at 25 cm depth of soil from surface) and 15 cm horizontally away from the emitting point of the same lateral. Similarly, the soil samples were also collected from 0-25, 25-50 and 50 – 75 cm depth of profile (vertical) between the drippers in 24 hours after fertigation at flowering stage of the crop. The soil was air dried, powdered and passed through a 2 mm sieve and stored in clean polythene bags. The available potassium both in horizontal and vertical dimensions were mapped by using Surfer 7 software. The main aim of this study is to known potassium distribution at different depth in sub surface drip fertigation system in banana.

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Keywords: Subsurface drip fertigation; potassium dynamics; potassium; banana.

1. INTRODUCTION

Potassium is an essential macronutrient for plants by acting, among other functions for the transport of solutes protein synthesis and enzyme activation. Its deficiency affects the metabolism, with negative consequences on the nutritional quality of the product, mechanical stability and resistance to pests and pathogens [1]. The excess can also directly damage the crop by toxicity and indirectly by soil salinization [2]. In modern agriculture potassium used to fertilize crops of high economic value (melon, tomato, cotton) it is almost exclusive applied by fertigation in drip fertigation systems [3,4,5]. Proper management of irrigation using emitters with good hydraulic characteristics and properly sized systems. The movement of nutrients along with irrigation pipes in fertigation primarily occurs through mass flow however at the ends of the laterals lines which hydraulic system is mainly laminar the influence of the diffusion is more effective [6].

2. MATERIALS AND METHODS

The experiment was laid out in Randomized Block Design (RBD) with three replications. Field experiment was carried out at AICRP-Water Management block, Agricultural College and Research Institute, Madurai during 2010 – 2011.

2.1 Treatments Schedule

T1 - Surface irrigation with soil application of RDF

T2 - Subsurface drip fertigation of 100% RDF (P as basal, N&K through drip as urea & white potash)

T3 - Subsurface drip fertigation of 100% RDF as WSF (WSF – urea, 13:40:13, KNO3)

T4 - Subsurface drip fertigation of 100% RDF (50% P&K as basal, remaining NPK as WSF)

T5 - Sub surface drip fertigation of 75% RDF +LBF (P as basal N&K through drip as urea and white potash)

T6 - Subsurface drip fertigation of 75% RDF as WSF + LBF (WSF- urea, 13:40:13, KNO3)

T7 - Subsurface drip fertigation of 75% RDF + LBF (50% P&K as basal remaining NPK as WSF)

T8 - T2+ LBF

T9 - T3 + LBF

T10 -T4 + LBF

T11 -Subsurface drip fertigation with no inorganic + LBF

NOTE:

- Recommended dose of fertilizer (RDF): 200:35:330 gm NPK/plant
- Source of P: Di ammonium phosphate and 13: 40: 13
- Source of K: White potash and KNO_3
- Source of water soluble fertilizers (WSF): Urea, 13:40:13 and KNO3
- Liquid bio fertilizers (LBF): Azospi, Phophofix and Potash Activa @ 2.5 litres/ha each at 2nd,

3rd 4th, 5th and 6th months. Irrigation given once in a three days interval.

The Surfer software developed by Golden Software of USA is a contouring package which includes 3D surface mapping program that runs under Microsoft windows.

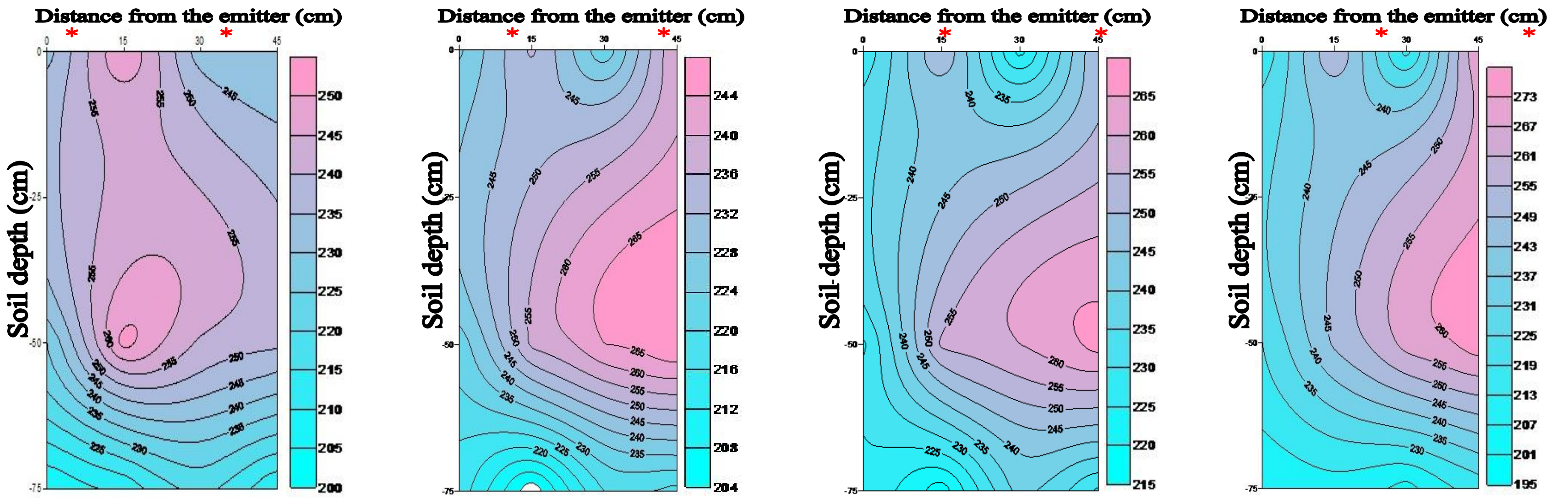
2.2 Experimental Result

2.2.1 Effect of subsurface drip fertigation on nutrient mobility

The mobility of nutrients in soil depends on the source, levels of applied fertilizers and forms of nutrient ions. The moisture content influenced the availability of potassium in the soil. The mobility of the nutrients had been assessed from the soil sample taken 24 hours after fertigation at various distance from dripper both horizontal and vertical directions.

2.2.2 Potassium (Fig. 1a, 1b, 1c)

The distribution of potassium varied both vertically and horizontally from the emitting point. In general, the available soil potassium increased up to a depth of 50 cm and there after it declined. Among the treatments, subsurface drip



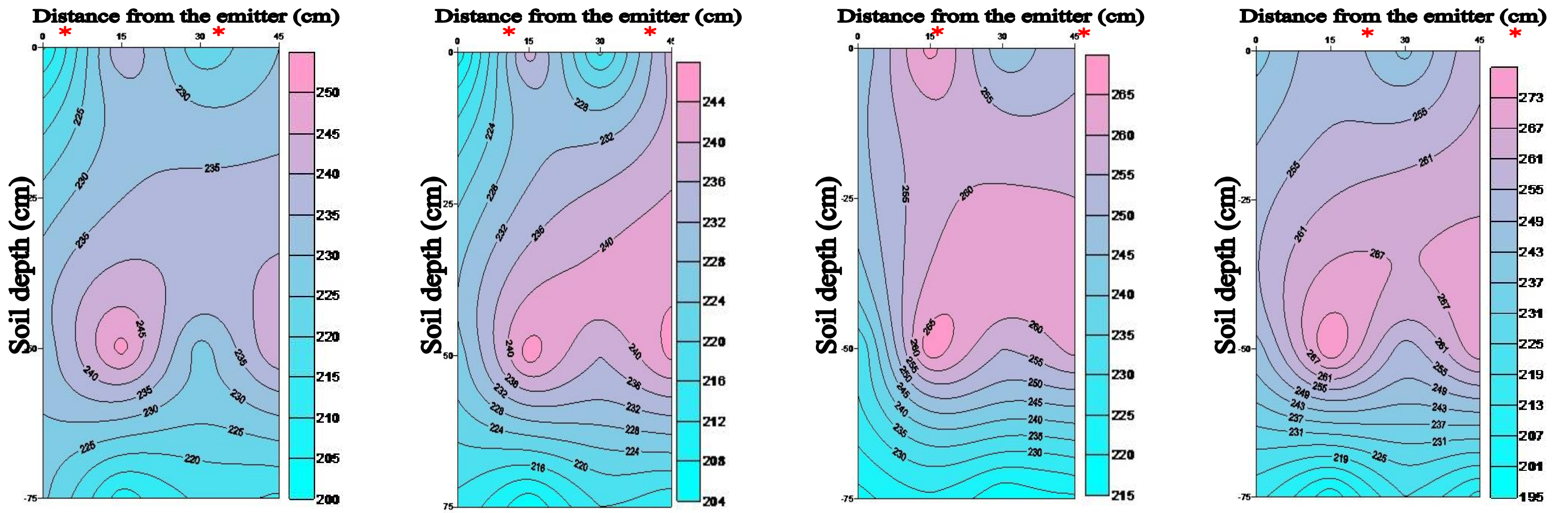
Subsurface drip fertigation of 100 per cent RDF (P as basal, N and K through drip as urea and white potash) (T_2)

Subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) (T_3)

Subsurface drip fertigation of 100 per cent RDF (50% P and K as basal, remaining N, P and K as WSF) (T_4)

Subsurface drip fertigation of 75 per cent RDF + LBF (P as basal, N and K through drip as urea and white potash) (T_5)

Fig. 1a. Potassium mobility and availability (kg ha^{-1}) under subsurface drip fertigation system



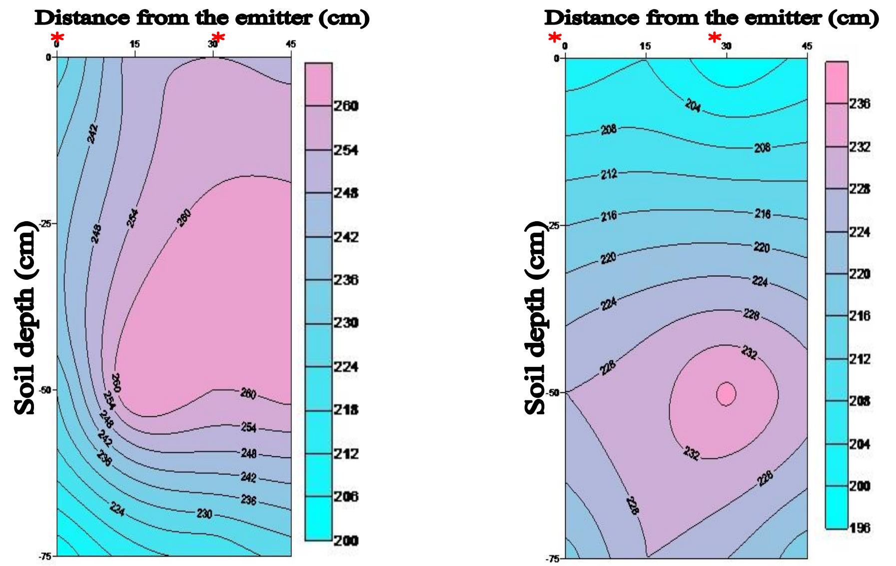
Subsurface drip fertigation of 75 per cent RDF as WSF + LBF (WSF – Urea, 13: 40: 13, KNO_3) (T_6)

Subsurface drip fertigation of 75 per cent RDF + LBF (50% P and K as basal, remaining N, P and K as WSF) (T_7)

Subsurface drip fertigation of 100 per cent RDF (P as basal, N and K through drip as urea and white potash) + LBF (T_8)

Subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF (T_9)

Fig. 1b. Potassium mobility and availability (kg ha^{-1}) under subsurface drip fertigation system



Subsurface drip fertigation of 100 per cent RDF (50% P and K as basal, remaining N, P and K as WSF) + LBF (T_{10})

Subsurface drip irrigation with LBF alone (no inorganic) (T_{11}).

Fig. 1c. Potassium mobility and availability (kg ha^{-1}) under subsurface drip fertigation system

Table 1. Initial soil characteristics of the experimental field

Particulars		
A.	**Mechanical composition**	
	Clay (%)	25.30
	Silt (%)	12.15
	Fine sand (%)	26.10
	Coarse sand (%)	35.61
	Textural class	Sandy clay loam
B.	**Physical properties**	
1.	Bulk density(Mg m^{-3})	1.37
2.	Particle density (Mg m^{-3})	2.65
3.	Water holding capacity (%)	28.50
4.	Pore space (%)	45.80
C.	**Physic chemical properties**	
1.	CEC (c mol (p^+) kg^{-1})	19.5
2.	pH	7.40
3.	EC (dS m^{-1})	0.48
D.	**Chemical properties**	
1.	Loss on ignition (%)	5.16
2.	Acid insoluble (%)	86.51
3.	Sesquioxide (%)	8.73
4.	Total N (%)	0.14
5.	Total P (%)	0.01
6.	Total K (%)	0.62
7.	Available N (kg ha^{-1})	165
8.	Available P (kg ha^{-1})	8.9
9.	Available K (kg ha^{-1})	170
10.	Organic carbon (%)	0.36
11.	Bacterial population (X 10^7CFU g^{-1})	61.27
12.	Fungi population (X 10^3 CFU g^{-1})	52.46
13.	Actinomycetes population (X 10^5 CFU g^{-1})	29.51

fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3)+ LBF (T_9) recorded the highest soil available potassium at 25-50 cm depth of soil at a distance of 15 cm from the emitter point. In surface irrigation with soil application of recommended dose of fertilizers, accumulation of potassium was considerable at a depth of 50-75cm and the surface layer recorded lower available potassium. The accumulation of potassium in surface irrigation with soil application of recommended dose of fertilizers was lower at 0-25 and 25-50 cm depth and the reverse was true at 50- 75 cm depth where entire potassium fertilizers was soil applied, indicating potential leaching risk.

2.2.3 Effect of subsurface drip fertigation levels on leaf K content (per cent) of banana

The leaf K was affected significantly by subsurface drip fertigation treatments under this investigation. The highest K percentage in leaf was recorded by plants received subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF. In general, there was an increase in K contents in all the treatments up to shooting and thereafter the values declined. This shows a heavy loading of K 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 [7] reported a continuous uptake of N up to shooting in banana [8]. observed an increase in the content of N up to flowering in banana (Fig. 2).

2.2.4 Effect of subsurface drip fertigation on yield (Table 2)

Subsurface drip fertigation treatments had favourably influenced the bunch yield of banana. The bunch yield ranged from 11.45 to 44.51 t ha^{-1} in the present investigation. Among the treatments, subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF recorded the highest bunch yield

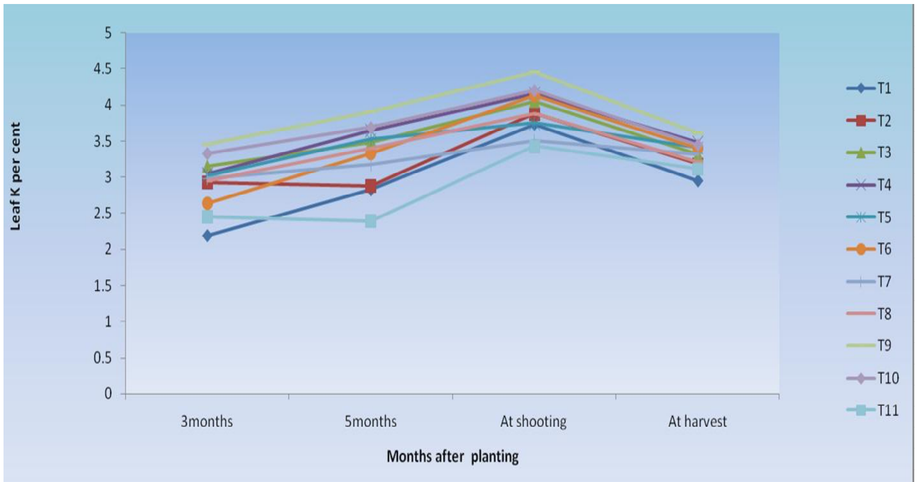


Fig. 2. Effect of subsurface drip fertigation levels on leaf K content (per cent) of banana

(44.51 t ha^{-1}) which accounted to 115 percent yield increase over surface irrigation with soil application of recommended dose of fertilizers. This was followed by subsurface drip fertigation of 100 percent RDF (50% P and K as basal, remaining N, P and K as WSF) +LBF.

Table 2. Effect of subsurface drip fertigation levels on yield of banana

Treatment	Bunch yield (t ha^{-1})
T_1	20.73
T_2	30.25
T_3	41.85
T_4	35.15
T_5	27.06
T_6	34.16
T_7	31.58
T_8	31.36
T_9	44.51
T_{10}	37.67
T_{11}	11.45
SE d	**1.21**
CD (P=0.05)	**2.51**

Marketable fruit yield per hectare was significantly lower in 75 per cent RDF levels compared to 100 per cent RDF. The soil of experimental site was low in available N (165 kg ha^{-1}), available P (8.9 kg ha^{-1}) and available K (170 kg ha^{-1}). Besides, the high yield potential of banana cv. Rasthali tried in the present study was expected to response better at still higher fertilizer rate. Because of these reasons, the yield was significantly lower with 75 per cent fertigation rate over 100 per cent RDF levels.

3. DISCUSSION

This yield increase can be attributed to significantly higher number of hands and fingers per bunch and bunch weight per plant in subsurface drip fertigation over surface irrigation with soil application of recommended dose of fertilizers. The better performance under subsurface drip was attributed to maintenance of favourable soil water status in the root zone, which in turn helped the plants to utilize moisture as well as nutrients more efficiently from the limited wetted area. The leaching aspect under three times soil application of potassium followed by surface irrigation can be related to the study of [9]. On the other hand, fertigation with water soluble fertilizers registered higher available potassium content in root zone layer (0-25 and 25-50 cm). In this sandy clay loam with low CEC and potassium fixation, potassium ions move along with water and thus, it will be prudent to apply potassium fertilizers through drip irrigation in more splits to achieve maximum nutrient use efficiency [10,11]. This suggested that split application of potassium fertilizers through drip would be a better option for banana than soil application with surface irrigation. It was also observed that the drip fertigation has the potential to minimize leaching loss and to improve the available potassium status in root zone for efficient use by the crop. Hence frequent supplementation of nutrients through subsurface drip irrigation increased availability of potassium in the root zone and which in turn increased the yield and quality of banana.

The distinctive yield advantage reflected in subsurface drip fertigation treatments was further amplified by the application of liquid biofertilizers through drip irrigation water. The yield increase was about 8 per cent when compared to uninoculated treatments. Similarly, the direct beneficial effects of *Azospirillum* with recommended dose of fertilizers in increasing bunch yield was reported in tissue cultured grand Naine banana by [12].

This is because of the application of fertilizers through fertigation is restricted to the wetted volume of soil where the active roots are concentrated and hence a better fertilizer utilization is achieved. Savings in the consumption of fertilizers upto 50 per cent by fertigation compared to soil application have been reported by [13] in onion and [14] in tomato.

Further, it was noted that the yield at 75 per cent RDF levels (T_5 to T_7) found superior over surface irrigation with soil application of recommended dose of fertilizers indicating 25 per cent saving in recommended dose of fertilizers.

4. CONCLUSION

The distribution of potassium varied both vertically and horizontally from the emitting point after fertigation. The accumulation of potassium in soil application of recommended dose of fertilizers (T_1) was lower at 0-25 and 25-50 cm depth and the reverse was true at 50-75 cm depth where entire potassium fertilizer was soil applied, indicating potential leaching risk. The subsurface drip fertigation of 100 per cent RDF as WSF (WSF– Urea, 13: 40: 13, KNO_3) + LBF (T_9) recorded the highest soil available potassium at 25-50 cm depth of soil at a distance of 15 cm from the emitter point.

ACKNOWLEDGEMENT

The authors express their sincere thanks and gratitude to International panacea Ltd., New Delhi for sponsoring the research project.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20470