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Influence of Different Levels of Phosphorus and Potassium on Growth, Yield Attributes and Economics of Finger Millet in Low Phosphorus and Potassium Soils of Eastern Dry Zone of Karnataka, India

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A B S T R A C T

A field experiment was carried out in farmer's field where soil was deficient in available phosphorus and potassium at Kodihalli village, Magaditaluk, Ramanagara district of Karnataka during *kharif*-2015 to study the influence of different levels of phosphorus and potassium on growth, yield and economics of finger millet. The experiment was laid out in randomized block design comprising 16 treatments replicated thrice. The results revealed a significantly higher plant height, number of tillers hill^{-1} and higher 1000 grain weight in T_{16} (100: 75:75 kg NPK ha^{-1}) at 90 DAS and at harvest stage respectively. Whereas significantly higher number of leaves hill^{-1}, number of productive tillers hill^{-1}, ear head weight, higher grain (52.03 q ha^{-1}) and straw (87.57 q ha^{-1}) yield was obtained in T_{15} (100:75:62.5 kg NPK ha^{-1}) compared to T_6 (100:50:50 kg NPK ha^{-1}) which received nutrients as per package of practice which recorded 39.76 q ha^{-1} of grain and 58.78 q ha^{-1} of straw yield. Significantly higher 1000 grain weight was recorded in T_{16}. Significantly the higher B: C ratio of 2.88 was recorded in treatment T_{15}, Concluding that application 100:75:62.5 kg NPK ha^{-1} is helpful for getting higher yield of finger millet as well as higher economic benefit compared to the present RDF (100:50:50 kg NPK ha^{-1}) in low phosphorus and potassium soils of Ramanagara district of Karnataka.

Introduction

Productive agriculture is dependent upon sound soil nutrient management practices. Over years of intensive cultivation and imbalanced fertilizer use, Indian soils have become deficient in several nutrients among seventeen nutrients and organic matter which are essential for growth and productivity of crops. Yields of various crops have reached a plateau and are on the decline. This is of serious consequence due to increasing population and diminishing per capita land availability. Several methods of nutrient management have been practiced on farms. However, the best option for the farmer is an integration of organic and inorganic approaches of nutrient management. However, current studies across India have shown a gradual and alarming depletion of potassium and phosphorus and also increase in phosphorus fixation leading to sustainability concerns for these two nutrients. Finger millet (*Eleusine coracana* L. Gaertn) is an important dry landmillet crop and ranks third in importance among millets in India after sorghum and pearl millet. Finger millet is a staple food for working class and diabetic patients due to its better nutritional quality. The grains are rich in calcium and iron, and known for its slow releasing pattern of sugar in to blood stream, thereby it is recommended for diabetic patients. Phosphorus plays a key role in energy transfer and is essential for photosynthesis and other chemico-physiological processes in plants.

Application of phosphorus to soils low in available phosphorus promotes root growth and winter hardiness, stimulates tillering, and often hastens maturity. Potassium is required for the activation of over 80 enzymes throughout the plant.

It's important for plant's ability to withstand extreme cold and hot temperatures, drought, pests and lodging. Potassium increases water use efficiency and transforms sugars to starch in the grain-filling process. Balanced fertilization ensures that the plant has access to adequate amount of each nutrient and is essential to optimize yields.

Research information on response of crops to phosphorus and potassium levels generated very scanty and as such generating further information is very much essential specially in low phosphorus and potassium containing soils to combat the present situation. With this in view, the present study was initiated in low phosphorus and potassium soils to assess the effect of phosphorus and potassium levels on growth, yield and economics of finger millet in *Alfisols* of Ramanagara district of Karnataka.

Materials and Methods

The field experiment was conducted in farmer's field at Kodihalli village, Magaditaluk, Ramanagara district where available phosphorus and potassium content in soil was low. It is located in Eastern Dry Zone of Karnataka at 13° 01′ 42.4″ N latitude, 77° 17′ 49.3″ E longitude with an altitude of 868 meters above Mean Sea Level (MSL). Soil of the experimental site was sandy loam in texture and slightly acidic in reaction (pH 6.28). Electrical conductivity was 0.068 dS m^{-1} and organic carbon content was 5.80 g kg^{-1}. Available nitrogen was 261.38 kg ha^{-1}, available phosphorus was low (16.85 kg P_2O_5 ha^{-1}) and available potassium was low (108.70 kg K_2O ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) having sixteen treatment combinations and replicated thrice on a net plot size of 3.9 m × 3.2 m. The details of the treatments are indicated below

T1 – 100 % RDN + 0 % RDP + 0 % RDK.

T2 – 100 % RDN + 0 % RDP + 100 % RDK.

T3 – 100 % RDN + 0 % RDP + 125 % RDK.

T4 – 100 % RDN + 0 % RDP + 150 % RDK.

T5 – 100 % RDN + 100 % RDP + 0 % RDK.

T6 – 100 % RDN + 100 % RDP + 100 % RDK. (RDF*)

T7 – 100 % RDN + 100 % RDP + 125 % RDK.

T8 – 100 % RDN + 100 % RDP + 150 % RDK.

T9 – 100 % RDN + 125 % RDP + 0 % RDK.

T10 – 100 % RDN + 125 % RDP + 100 % RDK.

T11 – 100 % RDN + 125 % RDP + 125 % RDK.

T12 – 100 % RDN + 125 % RDP + 150 % RDK.

T13 – 100 % RDN + 150 % RDP + 0 % RDK.

T14 – 100 % RDN + 150 % RDP + 100 % RDK

T15 – 100 % RDN + 150 % RDP + 125 % RDK.

T16 – 100 % RDN + 150 % RDP + 150 % RDK.

RDN – Recommended dose of nitrogen, RDP- Recommended dose of phosphorus,

RDK – Recommended dose of potassium, RDF- Recommended dose of fertilizer (100: 50: 50 kgNPK ha^{-1})

A composite soil sample was drawn from the experimental site by collecting samples from 0- 15cm depth before initiation of experiment. After layout of the experimental site, calculated quantities of FYM was applied at the rate of 10 t ha^{-1} before two weeks of sowing. Fertilizers were added to the soil on the day of sowing seeds as per the treatment. Nitrogen was applied as urea as 50 percent basal dose, entire quantity of phosphorus as single super phosphate and potassium as muriate of potash was added and mixed with soil and then top dressing with 50 per cent nitrogen after one month of sowing finger millet.

Finger millet variety GPU-28 was used as a test crop under protective irrigation, growth parameters like plant height (cm), number of leaves $hill^{-1}$ and number of tillers $hill^{-1}$ observations were recorded at 30 days interval. Yield attributes like number of productive tillers $hill^{-1}$, earhead weight (g) and 1000 grain weight (g) were recorded at the time of harvest. Grain yield (q ha^{-1}) and straw yield (q ha^{-1}) were recorded after harvest of the crop.

The cost of inputs that were prevailing at the time of their use was considered for working out the economics of various treatment combinations. Net returns $ha^{-1}$was calculated by deducting the cost of cultivation from gross income per hectare. Benefit cost ratio was calculated by using the following formula.

$$\text{Benefit cost ratio (B: C ratio)} = \frac{\text{Gross returns (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

Experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by Gomez and Gomez (1984). The level of significance used in 'F' test was given at 5 per cent. Critical difference (CD) values are given in the table at 5 per cent level of significance, wherever the 'F' test was found significant at 5 per cent level.

Results and Discussion

The plant height was significantly influenced by various treatment combinations both at 90 DAS (Days after sowing) and at harvest. Significantly higher plant height of 109.92 cm at 90 DAS and 116.08 cm at harvest was recorded due to application of 100 per cent RDN (100 kg N ha^{-1}) and 150 per cent of RDP (75 kg P_2O_5 ha^{-1}) and RDK (75 kg K_2O ha^{-1}) along with FYM at 10 t ha^{-1} (T_{16}) compared to 100 per cent RDF (100: 50: 50 kg NPK ha^{-1}). However, it was found to be on par with T15 (100 % RDN + 150 % RDP + 125 % RDK) at all the growth intervals. This clearly indicated the role of phosphorus and potassium in enhancing the crop growth due to better root growth and better translocation of photosynthates resulting in vigorous plant growth. The similar findings were also reported by Prakash Maurya *et al.*, (2014) and Muhammad Bilal Khan *et al.*, (2010) in case of wheat crop (Table 1).

The number of leaves $hill^{-1}$ significantly differed at 90 DAS and at harvest. Significantly higher number of leaves of 56.66 at 90 DAS and 49.42 at harvest were recorded in T_{15} which received 150 per cent RDP + 125 per cent RDK along with 100 per cent RDN compared to all other treatments except T_{16}which was on par at 90 DAS. However, decrease in number of leaves hill^{-1} was noticed at harvest in all the treatments compared to 90 days after sowing. The lower number of leaves observed at harvest compared to 90 DAS was due to translocation of photosynthates from older leaves to grain at harvest subsequently the older leaves dried and fall out.

The number of tillers hill^{-1} significantly differed in all the treatments at 90 DAS and at harvest. At all the growth stages application of 100 per cent RDN + 150 per cent of RDP and RDK (T16) has recorded higher number of tillers hill^{-1}. However, at harvest minimum of 3.13 tillers hill^{-1}was recorded in control (T_1) where no phosphorus and potassium fertilizers were applied except 100 per cent RDN, which significantly increased to 6.07 tillers hill^{-1}(T16) due to application of different levels of phosphorus and potassium fertilizers. There was an improvement in growth parameters of finger millet due to integrated application phosphorus and potassium fertilizer along with FYM compared to no P or K application or both. This was due to important role of phosphorus and potassium in nutrient and sugar translocation in plant and turgor pressure of plant cells. In addition potassium activates numerous enzyme systems involved in formation of organic substances and buildup of compounds such as carbohydrates. It also involved in cell development, triggering young tissues and involved in plant mersitematic growth (Prakash Maurya *et al.*, 2014). Also due to maximum availability of phosphorus which established more root establishments. These facts would ultimately maximized availability of mineral nutrients for optimum cell growth, more uptake, reproduction, photosynthesis and transformation of sugars and starches. (Muhammad Bilal Khan *et al.,* (2010) in case of wheat crop and Dakshina Murthy *et al.*, (2014) in rice crop) (Table 2).

With respect to yield attributes, number of productive tillers hill^{-1} differed significantly due to application of different levels of phosphorus and potassium in low phosphorus and potassium soil. Application of 100 per cent RDN + 150 per cent RDP + 125 per cent RDK (T_{15}) recorded higher number of productive tillers hill^{-1} (4.47) compared to all the treatments where no phosphorus was applied irrespective of the levels of potassium applied, similarly where no potassium was applied irrespective of the levels of phosphorus applied. However, it was on par with T_6 (4.00) which received 100 per cent RDF and also with T_{16} (4.33) which received 100 per cent RDN and 150 per cent of RDP and RDK followed by T_{14} (4.33) which received 100 per cent RDN + 150 per cent RDP + 100 per cent RDK. This was due to increase in phosphorus application resulting in better root growth and increased photosynthetic activity along with optimum irrigation at critical growth stages (Mumtaz *et al.*, 2014 and Basavaraja *et al.*, 2015). Finger millet has considerable capacity to produce more number of tillers per hill under adequate phosphorus and potassium fertilization specially in low P and K soils. Number of tillers per hill increased with increase in fertilizer level most probably phosphorus and potassium in the present investigation.

Ear head weight hill^{-1} has recorded significantly higher values of 24.10 g in T15 where 150 per cent RDP and 125 per cent RDK was applied along with 100 per cent RDN compared to T6 (18.01 g) where 100 per cent RDF was applied and T1 (10.98 g) which received 100 per cent RDN without P and K fertilizers.

Table.1 Influence of different levels of phosphorus and potassium on growth parameters of finger millet

Treatment details	Plant height (cm)		No. of leaves		No. of tillers hill $^{-1}$	
	90 DAS	At harvest	90 DAS	At harvest	90 DAS	At harvest
T_1: 100 % RDN + 0 % RDP + 0 % RDK.	87.06	90.67	26.73	25.19	2.93	3.13
T_2: 100 % RDN + 0 % RDP +100 % RDK.	92.77	96.68	30.80	28.70	3.33	3.47
T_3: 100 % RDN + 0 % RDP + 125 % RDK.	92.87	98.85	34.07	29.30	3.53	3.53
T_4: 100 % RDN + 0 % RDP + 150 % RDK.	92.94	100.17	34.87	30.12	3.60	3.67
T_5: 100 % RDN + 100 % RDP + 0 % RDK.	99.21	103.93	42.00	33.99	4.27	4.33
$T_{6:}$ 100 % RDN + 100 % RDP + 100 % RDK *(RDF)	105.36	105.69	42.87	41.49	4.40	4.60
T_7: 100 % RDN + 100 RDP + 125 % RDK.	106.08	107.24	44.87	42.00	4.47	4.67
$T_{8:}$ 100 % RDN +100 % RDP +150 % RDK.	106.26	108.69	45.00	43.80	4.60	5.00
T_9: 100 % RDN +125 % RDP + 0 % RDK	105.37	107.33	45.40	42.82	4.73	4.87
T_{10}: 100 % RDN + 125 % RDP + 100 % RDK.	106.76	108.58	48.47	43.97	5.20	5.47
T_{11}: 100 % RDN + 125 % RDP + 125 % RDK.	108.79	110.18	50.25	44.53	5.47	5.60
T_{12}: 100 % RDN + 125 % RDP + 150 % RDK.	109.05	112.28	50.10	44.27	5.47	5.60
T_{13}: 100 % RDN + 150 % RDP + 0 % RDK.	105.57	109.58	45.07	43.27	4.80	5.33
T_{14}: 100 % RDN + 150 % RDP+100%RDK.	107.61	113.42	49.93	47.53	5.33	5.60
T_{15}: 100% RDN + 150% RDP + 125 % RDK.	109.67	116.01	56.66	49.42	5.80	6.00
T_{16}: 100 % RDN +150 % RDP + 150 % RDK.	109.92	116.08	55.34	49.39	5.87	6.07
S Em±	**1.34**	**1.41**	**1.66**	**1.20**	**0.22**	**0.25**
C. D. (*P = 0.05*)	**4.00**	**4.22**	**4.96**	**3.59**	**0.66**	**0.76**

Table.2 Influence of different levels of phosphorus and potassium on yield parameters of finger millet

Treatment details	No. of productive tillers hill $^{-1}$	Ear head weight hill $^{-1}$ (g)	1000 grain weight (g)
T_1: 100 % RDN + 0 % RDP + 0 % RDK.	2.42	10.98	2.44
T_2: 100 % RDN + 0 % RDP +100 % RDK.	2.87	11.67	2.91
T_3: 100 % RDN + 0 % RDP + 125 % RDK.	3.09	15.51	3.05
T_4: 100 % RDN + 0 % RDP + 150 % RDK.	3.19	19.09	3.23
T_5: 100 % RDN + 100 % RDP + 0 % RDK.	3.57	17.11	2.83
$T_{6:}$ 100 % RDN + 100 % RDP + 100 %RDK.*(RDF)	4.00	18.01	3.11
T_7: 100 % RDN + 100 RDP + 125 % RDK.	4.13	18.87	3.30
$T_{8:}$ 100 % RDN +100 % RDP +150 % RDK.	4.20	20.71	3.39
T_9: 100 % RDN +125 % RDP + 0 % RDK	3.53	18.25	2.86
T_{10}: 100 % RDN + 125 % RDP + 100 % RDK.	4.13	18.73	3.14
T_{11}: 100 % RDN + 125 % RDP + 125 % RDK.	4.20	19.67	3.35
T_{12}: 100 % RDN + 125 % RDP + 150 % RDK.	4.27	21.97	3.39
T_{13}: 100 % RDN + 150 % RDP + 0 % RDK.	3.67	19.36	3.07
T_{14}: 100 % RDN + 150 % RDP+100%RDK.	4.33	20.92	3.44
T_{15}:100% RDN + 150% RDP + 125 % RDK.	4.47	24.10	3.49
T_{16}:100 % RDN + 150 % RDP + 150 % RDK.	4.33	24.01	3.51
S Em ±	**0.22**	**1.79**	**0.12**
C. D. (*P = 0.05*)	**0.65**	**5.35**	**0.35**

Table.3 Influence of different levels of phosphorus and potassium on grain and straw yield of finger millet

Treatment details	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1: 100 % RDN + 0 % RDP + 0 % RDK.	25.24	46.20
T_2: 100 % RDN + 0 % RDP +100 % RDK.	28.55	50.96
T_3: 100 % RDN + 0 % RDP + 125 % RDK.	33.51	53.33
T_4: 100 % RDN + 0 % RDP + 150 % RDK.	34.97	54.87
T_5: 100 % RDN + 100 % RDP + 0 % RDK.	33.81	56.99
T_6: 100 % RDN + 100 % RDP + 100 %RDK.*(RDF)	39.76	58.78
T_7: 100 % RDN + 100 RDP + 125 % RDK.	40.24	64.07
T_8: 100 % RDN +100 % RDP +150 % RDK.	41.28	65.38
T_9: 100 % RDN +125 % RDP + 0 % RDK	35.14	59.05
T_{10}: 100 % RDN + 125 % RDP + 100 % RDK.	40.91	63.54
T_{11}: 100 % RDN + 125 % RDP + 125 % RDK.	42.11	73.39
T_{12}: 100 % RDN + 125 % RDP + 150 % RDK.	43.85	75.00
T_{13}: 100 % RDN + 150 % RDP + 0 % RDK.	37.76	61.93
T_{14}: 100 % RDN + 150 % RDP+100%RDK.	50.37	81.62
T_{15}:100% RDN + 150% RDP + 125 % RDK.	52.03	87.57
T_{16}:100 % RDN + 150 % RDP + 150 % RDK.	51.25	86.64
S Em ±	**1.37**	**2.40**
C. D. ($P = 0.05$)	**4.11**	**7.18**

Table.4 Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by the levels of phosphorus and potassium application

Treatment Details	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C
T_1: 100 % N + 0 % RDP + 0% RDK	29,868	49,619	19,752	1.66
T_2: 100 % N + 0 % RDP + 100 % RDK	31,201	55,866	24,665	1.79
T_3: 100 % N + 0 % RDP + 125 % RDK	31,534	64,288	32,754	2.04
T_4: 100 % N + 0 % RDP + 150% RDK	31,867	66,921	35,053	2.10
T_5: 100 % N + 100 % RDP + 0% RDK	32,189	65,489	33,300	2.03
T_6: 100 % N + 100 % RDP + 100% RDK	33,523	75,378	41,855	2.25
T_7: 100 % N +100 % RDP + 125 % RDK	33,856	77,203	43,347	2.28
T_8: 100 % N + 100 % RDP + 150 % RDK	34,189	79,118	44,929	2.31
T_9: 100 % N + 125 % RDP + 0% RDK	32,770	68,039	35,269	2.08
T_{10}: 100 % N + 125 % RDP + 100% RDK	34,103	78,169	44,065	2.29
T_{11}: 100 % N + 125 % RDP + 125 % RDK	34,436	82,060	47,624	2.38
T_{12}: 100 % N + 125 % RDP + 150 % RDK	34,770	85,159	50,390	2.45
T_{13}: 100 % N + 150 % RDP + 0% RDK	33,350	72,803	39,452	2.18
T_{14}: 100 % N + 150 % RDP + 100% RDK	34,684	96,910	62,226	2.79
T_{15}: 100 % N + 150 % RDP + 125 % RDK	35,017	1,00,757	65,740	2.88
T_{16}: 100 % N + 150 % RDP + 150 % RDK	35,350	99,328	63,978	2.81

Treatment which received 150 per cent RDP and RDK along with 100 per cent RDN (T16) has recorded significantly higher 1000 grain weight (3.51 g) compared to T6 (3.11g) where 100 per cent RDF was applied and T1 (2.44g) where 100 per cent RDN was applied without phosphorus and potassium fertilizers. Significant increase in test weight was attributed to better grain filling due to improved supply of potassium, which regulates enzyme activities and translocation of photosynthates (Anil Kumar, 2000).

Application of 100 per cent RDN + 150 per cent RDP + 125 per cent RDK recorded more grain (52.03 q ha^{-1}) and straw (87.57 q ha^{-1}) yield compared to 100 per cent RDF as per package of practice (T6)which recorded 39.76 q $ha^{-1}$of grain and 58.78 q ha^{-1} of straw yield. Increase in grain yield in T15 (100 % RDN + 150 % RDP + 125 % RDK) was due to more number of productive tillers $hill^{-1}$, ear head weight $hill^{-1}$and number of fingers ear $head^{-1}$. This clearly indicates that the response of finger millet with respect to grain and straw yield was more due to application of phosphorus at 150 per cent RDP and potassium at 125 per cent RDK along with 100 per cent RDN compared to application of phosphorus and potassium both at 150 per cent of their recommended dose (T16) along with 100 per cent RDN. The lowest grain (25.24 q ha^{-1}) and straw (46.20 q ha^{-1}) yield were recorded in treatments where 100 per cent RDN applied without P and K (T_1).This clearly indicated that the blanket recommendation of 100 per cent RDF for finger millet crop is of no use in enhancing the yield specially in low P and K soils, where modification in the RDF is required through soil test and LMH approach. These results are in conformity with Cheema *et al.,* (1999) in maize and Dakshina Murthy *et al.,* (2015) in rice (Table 3).

In the present investigation application of phosphorus at 150 per cent RDP (75 kg P2O5 ha^{-1}) increased the yield of finger millet irrespective of potassium application. However, as the potassium levels increased from 100 per cent to 125 per cent of recommended dose, at 150 per cent of RDP increased grain and straw yield was noticed. Because phosphorus involved in several energy transformation and biochemical reactions for plant growth and development and also for early flowering. Because phosphorus supply increases cytokinins synthesis and supply of photosynthates for flower formation. Ultimately it increases the grain yield of finger millet.

The benefit cost ratio (B: C ratio) has been calculated to evaluate the economics of irrigated finger millet production under different treatments imposed. The higher gross returns were recorded (Rs. 1, 00,757) in treatment (T15) receiving 100 per cent N + 150 per cent RDP + 125 per cent RDK followed by T16 (Rs.99, 328) which received 150 per cent of RDP and RDK along with 100 per cent RDN. The least gross returns were recorded in T1 (Rs. 49,619) which received 100 per cent RDN without P and K fertilizers. Higher B: C ratio (2.88) observed in T15 was due to more grain (52.03 q ha^{-1}) and straw yield (87.57 q ha^{-1}) in that treatment due to application of phosphorus and potassium at 50 per cent and 25 per cent more than the recommended doses along with 100 per cent RDN and FYM. The highest gross and net income was also recorded in the same treatment. This was due to the fact that crop has not experienced nutrient stress at any growth stages, even though soil was low in available P and K because of balanced nutrition due to higher doses of P and K, improved vegetative growth and increased number of productive tillers which resulted in good grain and straw yield. These results are in line with Mudalagiriyappa *et al.,* (2015) who reported that application of 125 per cent customized fertilizer dose recorded higher net returns and B: C ratio (Table 4).

Even though treatment T16 which received 150 per cent RDP and RDK along with 100 per cent RDN and FYM has recorded a slightly lower B: C ratio (2.81) compared to T15due to slightly higher potassium levels. This clearly indicated that application of 50 per cent more potassium (75 kg K_2O ha^{-1}) than the recommended dose of potassium (50 kg K_2O ha^{-1}) was uneconomical due to higher cost and lower net returns compared to T15.

The present study evidently concluded that application of 100 per cent RDN, 150 per cent RDP and 125 per cent RDK along with FYM at 10 t ha^{-1}(100:75:62.5 kg NPK ha^{-1}) under protective irrigation is beneficial for getting higher yield of finger millet as well as higher benefit cost ratio (2.88) as compared to the present RDF (100:50:50 kg NPK ha^{-1}) in low phosphorus and potassium soils of Ramanagara district of Karnataka.

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