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Standardization of Potassium Requirement for the Foxtail Millet in *Alfisols* of Karnataka

D. K. SRINIVASA AND T. CHIKKARAMAPPA
Department of Soil Science and Agricultural Chemistry, College of Agriculture, GKVK, UAS, Bengaluru - 560 065
E-mail: srinivasa.dk12@gmail.com

ABSTRACT

Assessment of effect of different levels of potassium on foxtail millet performance was studied at the farmer's field of Devapalli village, Chintamani taluk, Chikkaballapur district, which comes under eastern dry zone of Karnataka. The experiment was conducted with twelve treatments, which included different levels (10, 20, 30, 40 and 50 kg K_2O) of potassium with recommended nitrogen and phosphorus (40: 40 kg ha^{-1} respectively and 6 tonnes of FYM) and 25 per cent (50 kg N) and 15 per cent (45 kg P_2O_5) increased recommended nitrogen and phosphorus respectively with same levels of potassium and recommended FYM, only package of practice (40: 40: 0 kg N, P_2O_5 and K_2O ha^{-1} and 6 tonnes of FYM) and absolute control (without fertilizers and FYM). The study was laid out in a randomized complete block design (RCBD) with three replications during *Kharif* 2016 and 2017. Soil properties were determined prior to experimentation and soil was low in available potassium. The test crop was Foxtail millet, variety FIA 136 with 30 cm inter row (row to row) and 10 cm intra row (plant to plant) spacing. The growth parameters were recorded at 30, 60 days after sowing (DAS) and at harvest. Dry matter production was recorded using destructive sampling method. The grain and straw yield was recorded from the each treatment plot at harvest of the crop and calculated benefit cost ratio. The results revealed that significantly higher plant height at 30 DAS, 60 DAS, at harvest and dry matter production during maximum tillering stage and panicle initiation stage of crop recorded with application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} (T_6) followed by 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1} (T_{11}). The higher straw, grain and total NPK uptake by foxtail millet were recorded in treatment T_6 which was on par with treatment T_{11}. The grain yield of foxtail millet was increased by 74.98 per cent in T_6 and 61.17 per cent in T_{11} as compared to other the treatment T_2, POP as per UAS (B). The study showed that application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O + 6 t FYM ha^{-1} is considered as the best treatment to foxtail millet in *Alfisols* of Chikkaballapura district, Karnataka as compared to UAS-B recommendation (40:40 kg N: P_2O_5 ha^{-1}, respectively).

Keywords: Foxtail millet, Potassium, *Alfisols* and uptake of nutrients

THERE has been increasing demand for the importance of millets as a substitute for cereal crops and they have potentiality of increased food production both in developing and developed countries. They can bridge the food gap that can be created by the implementation of a food security law.

Foxtail millet (*Setaria italica* L.) is the second most widely grown species of millet and the most important food crop in East Asia. In India, foxtail millet is an important crop in arid and semi-arid regions. In South India, it has been a staple diet among people for a long time and it is a warm season crop, typically grown in late spring season, which comes to harvest in 75-90 days & yielding 800-900 kg ha^{-1}. Foxtail millet is commonly known as Navane in Karnataka. In India, Andhra Pradesh (4,79,000 ha), Karnataka (2,32,000 ha) and Tamilnadu (20,000 ha) are the major Foxtail millet growing states contributing about 90 per cent of the total area under cultivation. Andhra Pradesh is the major Foxtail millet growing state contributing about 59 per cent of the total area. Foxtail millet has been popular for its wider adaptability, low input requirement and it has good nutritive value as it is rich in protein (12.3 g), carbohydrates (60.9 g), fat (4.3 g), crude fiber (8.0 g), calcium (3.1g), vitamins and thiamin (590 mg) 100 g^{-1}.

Foxtail millet is comparable to that of super cereals like rice and wheat due to adaptability to poor environment and input management. Nutritional demand of crop can be determined by measuring nutrient uptake which may change with changing nitrogen rates and also number of plants per unit area. Potassium is important in the growth of crops and an important ion in the physiology of plant water relations.

Potassium is third most important plant nutrient, vital to many plants by the activation of 60 different enzymes involved in plant growth, important for osmoregulation, cation-anion balance, protein synthesis, water balance, reducing lodging, imparting disease resistance and improving quality and shelf life of crop produce will be increases. Soil test results for K fertility status among Indian agricultural soils are categorized accordingly, 21 per cent low, 51 per cent medium, and 28 percent high. Thus, 72 per cent of India's agricultural area, representing 266 districts, needs K fertilization.

As we know that intensive cropping with high yielding varieties makes considerable demand on the soil nutrient resources and application of nitrogen alone is not a prescription to obtain higher yields. Balanced use of plant nutrients through fertilizers is the only answer. Therefore, quite likely that even those soils which are considered sufficient in available potassium may not be able to maintain soil fertility for long time. However, till recently, little attention was being paid to the K application to field crops. In fact, crop removal of potassium often equals or exceeds that of nitrogen. Fertilizer Association of India (FAI) (2013) estimated that consumption of K_2O was 3514.3 (,000 tonnes) out of 28122.2 (,000 tonnes) of total fertilizer consumption in India to meet the crop demand. After considering all the organic and inorganics addition, a net deficit of 10.00 million tonnes K_2O year^{-1} has been estimated which means a depletion of Indian soils at the rate of 42.5 kg K_2O ha^{-1} year^{-1}. By understanding the soil nutrient status and corrective fertilizer management practices to support high yields of high quality crops require a balanced fertilizer application.

Balanced and adequate fertilization is essential for increasing crop yields and ensuring sustainable agriculture. Foxtail millet being low nutrient demanding crop, but responds well for addition of potassium. Depleted soil potassium status due to higher crop removal as equal as or higher than nitrogen, without application of potassium fertilizers and cultivation of improved varieties of foxtail millet needs balancing of potassium through external fertilizers. The present investigation study was carried out in the farmer's field with the objective of "Standardization of potassium requirement for the foxtail millet in *Alfisols* of Karnataka".

Material and Methods

In order to standardize the potassium requirement for the foxtail millet in *Alfisols* of Chikkaballapura district, Karnataka, the cropping sequence of foxtail millet-field bean for two years were taken at the farmer's field of Devapalli of Chintamani taluk which comes under Eastern dry zone of Karnataka. The experimental field was located at 78° 18' 20.2'' E longitude and 13° 56' 57.8'' N latitude from the mean sea level. To initiate the experiment, the soil samples were collected from the selected locations of Chintamani taluk, Chikkaballapura district of Karnataka and analyzed for the potassium content and the soil low in available potassium was selected for the field experiment for foxtail millet - field bean cropping sequence. The initial properties of the experimental soil are presented in the Table 1. The soil was sandy loam in texture, neutral in reaction (6.59), low organic carbon content (0.47%) and low in available nitrogen (136.42 kg ha^{-1}), phosphorus (16.62 kg ha^{-1}) and potassium (119. 84 kg ha^{-1}). The soil was low in DTPA extractable zinc (0.43 mg kg^{-1}), but no zinc fertilizer was applied, for the foxtail millet. There is no recommendation of potassium and micronutrients. In the group of minor millets, only for the finger millet, there is a recommendation of NPK and Zn. In the recent years, research is being conducted, to work out the recommendation of major and micro nutrients for the millets. Hence the present work was focused on the standardization of potassium for the foxtail millet.

TABLE 1

Initial physico-chemical properties of the experimental soil

Parameters	Values
Sand (%)	64.2
Silt (%)	19.5
Clay (%)	16.1
Textural class	Sandy loam
Maximum Water Holding Capacity (%)	36
pH (1:2.5)	6.59
EC (1:2.5) (dSm^{-1})	0.10
CEC (c mol (p^+) kg^{-1}	24.37
Soil organic carbon (SOC) (%)	0.47
Available N (kg ha^{-1})	136.42
Available P_2O_5 (kg ha^{-1})	16.62
Available K_2O (kg ha^{-1})	119. 84
Exchangeable Ca (meq 100 g^{-1})	8.13
Exchangeable Mg (meq 100 g^{-1})	3.13
Available S (mg kg^{-1})	46.69
DTPA extractable Zn (mg kg^{-1})	0.43
DTPA extractable Fe (mg kg^{-1})	5.40
DTPA extractable Mn (mg kg^{-1})	21.59
DTPA extractable Cu (mg kg^{-1})	1.11

The experiment was laid out in the randomized complete block design with twelve treatments and three replications with plot size of 4.2 m length and 4.0 m width. Test crop taken was foxtail millet, variety FIA 136 and seed rate of 7 kg ha^{-1} with 30 cm inter row and 10 cm intra row spacing under protective irrigated condition for the crop duration of 110 -120 days. The treatments included different levels (10, 20, 30, 40 and 50 kg K_2O) of potassium with recommended nitrogen and phosphorus (40: 40 kg ha^{-1} respectively) and 25 per cent (50 kg N) and 15 per cent (45 kg P_2O_5) increased recommended nitrogen and phosphorus respectively with same levels of potassium, only (POP) package of practice (40: 40: 0 kg N: P_2O_5 and K_2O ha^{-1}) and absolute control. Application of 6 tonnes of farm yard manure (FYM) was common to all treatments except absolute control. Treatment wise recommended dose of N, P_2O_5 and K_2O were given in the form of urea, single super phosphate and muriate of potash, respectively as basal dose at the time of sowing and recommended dose of FYM was applied before 15 days of sowing of the crop. Gap filling was done after one week of sowing in places where seeds failed to germinate and where excess seeds were sown thinning was done 15 DAS to maintain intra row spacing (10 cm). Intercultivation was done using blade hoe at 35 DAS with bullock pair and one hand weeding was done manually at 45 DAS.

The whole crop of Foxtail millet in the net plot was harvested separately from each treatment and were dried separately. Then ear heads of each plot were threshed by beating, winnowed and cleaned separately. The straw in each net plot was harvested separately and sun dried. The grain and straw weight were recorded.

Biometric observations

Growth parameters of Foxtail millet

Observation	Methods followed	Interval
Plant height (cm)	The plant height of five randomly selected plants were measured from the base of the plant to fully emerged leaf. After emergence of panicle, the height was measured from base of plant to tip of the panicle	30 DAS, 60 DAS and at harvest
Dry matter accumulation	Five randomly selected plants from the destructive sampling area were used to record the dry matter production. The sampled plants were dried at 65 °C until they attained constant dry weight. Dry weight was recorded separately at each stage of crop growth. The total dry matter production which was expressed as g $plant^{-1}$.	Dry matter accumulation at tillering stage (45 DAS), panicle initiation stage (60 DAS) and at harvest

Yield and yield components of Foxtail millet

Parameters	Procedure followed
Ear length (cm)	Five ear heads were selected from tagged plants and the length of ear was measured from the base to the tip of the ear and average ear length was expressed in cm.
Test weight (g)	1000 grains were drawn from net plot produce of each treatment for recording test weight and expressed in g.
Grain yield (kg ha^{-1})	The grain yield obtained from each net plot area was air dried and later yield was converted to kg ha^{-1}.
Straw yield (kg ha^{-1})	The straw from net plot area was cut near to the ground level and was left for air drying in the field. Later it was weighed and computed as straw yield in kg ha^{-1}.

Chemical analysis of soil

The post-harvest soil samples were collected from each treatment plot, dried, powdered and used for analysis of pH, EC, OC and available NPK as per the standard procedures.

Chemical analysis of plant samples

Sample preparation	Foxtail millet grain and straw samples were collected and dried, powdered and used for estimating the N, P and K contents.
Nitrogen content (kg ha^{-1})	The nitrogen content in the grain and straw samples was estimated by Micro Kjeldhal method (Jackson, 1967) and expressed in percentage on dry weight basis.
Phosphorus content (kg ha^{-1})	The phosphorus and potassium in the plant sample which was digested in di-acid mixture (900 ml conc. HNO_3 + 400 ml of per chloric acid) as described by Piper (1966). The phosphorus content of the di-acid digested grain and straw samples was determined by Vanado molybdo phosphoric yellow colour method (Jackson, 1967) and expressed in percentage on dry weight basis.
Potassium content (kg ha^{-1})	The potassium content in grain and straw samples was determined by flame photometer method as described by Jackson (1967) and expressed in percentage on dry weight basis.

Nutrient uptake studies

Nutrient content of plant sample (%) and dry weight of plant was considered to calculate nutrient uptake by the crop by using formula.

$$\text{Nutrient Uptake (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%)} \times \text{Dry matter yield (kg ha}^{-1})}{100}$$

Statistical analysis

The experimental data collected on various growth and yield components of plant were subjected to Fisher's method of "Analysis of variance" (ANOVA). Whenever F-test was significant for comparison amongst the treatments means an appropriate value of critical differences (CD) was worked out. Otherwise against CD values abbreviation NS (Non-Significant) was indicated. All the data were analyzed and the results are presented and discussed at a probability level of 0.05 per cent and correlation study was done as given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of different levels of potassium on different growth parameters, yield and uptake of major nutrients by foxtail millet are presented and discussed here under.

A. Plant Height

Plant height of foxtail millet as influenced by potassium levels at 30, 60 DAS and at harvest are furnished in Table 2.

At 30 DAS, plant height differed significantly due to potassium levels. The significantly higher plant height of 54.13 cm was obtained with 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} (T_6) followed by T_{11}, 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1} (53.35 cm) compared to T_2, POP based on UAS (B) package (35.45 cm).

TABLE 2

Effect of different levels of potassium on plant height at different crop growth stages of foxtail millet in *Alfisols* of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017)

Treatments	Plant height (cm)		
	30DAS	60DAS	Harvest
T_1: Absolute control	35.45	97.06	102.42
T_2: POP based on UAS (B) package	44.33	106.97	113.81
T_3: Rec. N P_2O_5 + 10 kg K_2O ha^{-1}	45.54	110.03	114.95
T_4: Rec. N P_2O_5 + 20 kg K_2O ha^{-1}	47.11	110.17	116.12
T_5: Rec. N P_2O_5 + 30 kg K_2O ha^{-1}	47.39	116.22	118.18
T_6: Rec. N P_2O_5 + 40 kg K_2O ha^{-1}	54.13	127.39	131.80
T_7: Rec. N P_2O_5 + 50 kg K_2O ha^{-1}	49.75	121.18	124.84
T_8: 50 kg N + 45 kg P_2O_5 + 10 kg K_2O ha^{-1}	47.16	110.81	115.53
T_9: 50 kg N + 45 kg P_2O_5 + 20 kg K_2O ha^{-1}	48.05	111.44	118.79
T_{10}: 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1}	49.16	115.83	124.59
T_{11}: 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1}	53.35	124.20	129.31
T_{12}: 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1}	50.89	120.83	126.32
SE.m	1.64	1.55	2.32
CD @ 5 %	4.81	4.54	6.81

At 60 DAS, significantly higher plant height of 127.39 cm was recorded in T_6 and was on par with 124.20 cm recorded in T_{11} and 106.97 cm recorded in T_2 (POP based on UAS (B) package). However, the lowest plant height of 97.06 cm was recorded in T_1 (absolute control).

At harvest, the maximum plant height was recorded in T_6 (131.80 cm) followed by T_{11} (129.31 cm), compared to T_2, POP based on UAS (B) package (113.81 cm). It could be attributed to the fact that higher level of nitrogen with potassium might have accelerated the synthesis of more chlorophyll and amino acids and stimulated the cellular activity, which is useful for the process of cell division, meristematic growth coupled with cell enlargement, resulting in higher plant height of the crop. These findings are in confirmation with Jyothi *et al.* (2016).

B. Dry Matter production

Dry matter accumulation at maximum tillering stage, panicle initiation stage and at harvest was significantly higher (2.36, 17.24 and 28.01 g $plant^{-1}$, respectively) with T_6, recommended N P_2O_5 + 40 kg K_2O ha^{-1} + 6 t FYM followed by T_{11}, 50 kg N, 45 kg P_2O_5 + 50 kg K_2O ha^{-1} + 6 t FYM (2.15, 17.01 and 26.04 g $plant^{-1}$), which were significantly superior to rest of the treatments (Table 3). The lowest dry matter production (1.11, 12.73 and 15.41 g $plant^{-1}$) was obtained with control (T_1). This was due to favorable effect of optimum nutrition of potassium with nitrogen and phosphorus resulted in higher dry matter production. Similar findings were also reported by Ambresha (2017).

Higher production of crop attributes *viz* number of tillers $plant^{-1}$, panicle length (cm) and panicle weight (g) (Table 3) was observed with the application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O (T_6). While all these parameters were lowest in control (T_1). It could be attributed to the fact that higher potassium levels might have synergistic effect on nitrogen availability which accelerated the synthesis of more chlorophyll, amino

TABLE 3

Effect of different levels of potassium on dry matter production at different stages of foxtail millet in *Alfisols* of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017).

Treatments	Plant height (cm)		
	Tillering stage	panicle initiation stage	Harvest
T_1: Absolute control	1.11	12.73	15.41
T_2: POP based on UAS (B) package	1.78	13.50	17.65
T_3: Rec. N P_2O_5+ 10 kg K_2O ha^{-1}	1.90	13.79	17.81
T_4: Rec. N P_2O_5+ 20 kg K_2O ha^{-1}	1.91	13.83	20.32
T_5: Rec. N P_2O_5+ 30 kg K_2O ha^{-1}	2.02	14.03	22.06
T_6: Rec. N P_2O_5+ 40 kg K_2O ha^{-1}	2.36	17.24	28.01
T_7: Rec. N P_2O_5+ 50 kg K_2O ha^{-1}	1.94	16.18	21.23
T_8: 50 kg N + 45 kg P_2O_5 + 10 kg K_2O ha^{-1}	1.73	12.67	21.33
T_9: 50 kg N + 45 kg P_2O_5 + 20 kg K_2O ha^{-1}	1.78	15.48	19.91
T_{10}: 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1}	1.86	14.79	22.86
T_{11}: 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1}	2.15	17.01	26.04
T_{12}: 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1}	1.69	15.32	21.47
SE.m	0.09	0.32	0.65
CD @ 5 %	0.26	0.94	1.91

acids and stimulated the cellular activity, which is useful for the process of cell division, meristematic growth coupled with cell enlargement (Jyothi *et al*., 2016).

C. Grain and straw yield

Pooled data pertaining to the grain and straw yield are presented in the Table 4.

Effect of potassium levels

Significant increase in grain and straw yields were observed with increase in potassium levels from 0 to 50 kg K ha^{-1}. The improvement in yield with enhanced potassium application might be attributed to better availability and uptake of nutrients which in turn lead to efficient plant metabolism.

Among the different K levels tested, the higher grain and straw yield were observed in T_6 followed by T_{11}, which is superior to rest of the K levels. The significant increase in grain and straw yield (1918.85 and 3631.61 kg ha^{-1}, respectively) were observed with 40 kg N + 40 kg P_2O_5 + 40 kg K_2O (T_6) which was on par with T_{11} (1882.74 and 3588.29 kg ha^{-1}) and T_5 (1702.02 and 3347.55 kg ha^{-1}) as compare to POP (T_2, 1056.15 and 2382.11 kg ha^{-1}). The lowest grain yield (754.37 kg ha^{-1}) and straw yield (1752.98 kg ha^{-1}) was recorded in T_1 (control), which shows the effect of combined nutrient application. The highest yield associated with the highest application rate represents about 74.98 per cent increased in grain yield with the application of T_6 and 61.17 per cent in T_{11} compared to without application of potassium (T_2, POP of 40:40:0 Kg $N:P_2O_5:K_2O$ ha^{-1}, respectively) and low NPK status of soil limited the yield of foxtail millet in control. The increase in grain and straw yields with enhanced N and K application could be ascribed to increased activity of cytokinin in plant which leads to the increased cell-division and cell elongation thereby better plant growth, dry-matter production and higher photosynthesis. This was further supported by the fact that soil of the experimental field was low in nitrogen (136.42 kg ha^{-1}) and potassium (119.84 kg ha^{-1}). Thus, an increase in potassium and nitrogen supply might have increased the crop growth and yield attributing characters, which ultimately contributed to

TABLE 4

Effect of different levels of potassium on number of tillers, panicle length, panicle weight, grain and straw yield of foxtail millet in Alfisols of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017).

Treatments	Number of tillers plant^{-1}	Panicle length (cm)	Panicle weight (g plant^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	1.33	11.13	4.02	754.37	1752.98
T_2	2.33	14.32	5.19	1056.15	2382.11
T_3	2.20	15.42	5.94	1098.41	2644.08
T_4	2.50	15.88	6.65	1195.63	2831.18
T_5	2.77	15.05	6.72	1702.02	3347.55
T_6	3.47	20.25	8.98	1918.85	3631.61
T_7	2.77	17.23	7.74	1252.98	3061.64
T_8	2.33	15.68	6.92	1187.50	2985.12
T_9	2.57	16.93	7.68	1237.10	2945.47
T_{10}	2.50	17.43	7.54	1523.02	2913.69
T_{11}	3.27	19.60	8.65	1882.74	3588.29
T_{12}	3.17	18.22	7.97	1381.95	2910.71
SE.m	0.18	0.54	0.26	44.54	97.35
CD @ 5 %	0.52	1.59	0.76	130.64	285.52

increase in yields. Increased grain yield due to effect of different levels of potassium with nitrogen and phosphorus have also been reported by Ambresha, (2017).

Effect of different levels of potassium on uptake of N, P and K by Foxtail millet crop

The pooled data pertaining to the uptake of NPK by foxtail millet crop is presented in the Table 5.

Nitrogen

There was a significant increase in uptake of N by foxtail millet with the application of different levels of K, where the highest straw (34.06), grain (32.50) and total uptake of N (66.56 kg ha^{-1}) was noticed with the application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O (T_6) followed by T_{11} (31.54, 31.04 and 62.58 kg ha^{-1} of straw, grain and total uptake, respectively) which was on par with T_5 as compared to rest of the treatments. The least uptake of N in straw (8.37), grain (5.90) and total N (14.27 kg ha^{-1}) was recorded in absolute control. Added fertilizers increased the N content in plant by providing balanced nutrition and higher plant availability, which favored better crop yield (Ghosh *et al*., 2009).

Phosphorus

The best treatment with respect to the different levels of K by highest phosphorus uptake in straw (9.57), grain (8.67) and total P uptake (18.24 kg ha^{-1}) by foxtail millet was with 40 kg N + 40 kg P_2O_5 + 40 kg K_2O (T_6) application followed by T_{11} and T_{10}. The lowest uptake of P by foxtail millet straw (1.77), grain (2.36) and total P (4.13 kg ha^{-1}) was recorded in absolute control. Nitrogen application in the form of urea, upon nitrification forms hydrogen ions besides nitrate ions, thus, modifies the rhizosphere pH. This rhizosphere acidification results in the solubilization of insoluble

TABLE 5

Effect of different levels of potassium on uptake of NPK (kg ha^{-1}) by foxtail millet in *Alfisols* of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017).

Treatments	Nitrogen			Phosphorus			Potassium		
	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total
T_1	8.37	5.90	14.27	1.77	2.36	4.13	15.40	11.29	26.69
T_2	13.55	9.47	23.02	2.75	3.41	6.15	27.32	16.66	43.98
T_3	18.31	11.81	30.12	3.66	3.70	7.36	33.14	26.26	59.40
T_4	22.72	13.80	36.52	4.76	4.20	8.96	38.43	29.34	67.76
T_5	28.20	22.63	50.83	6.99	5.64	12.63	56.08	38.26	94.34
T_6	34.06	32.50	66.56	9.57	8.67	18.24	68.38	51.56	119.94
T_7	23.19	17.57	40.76	6.30	5.15	11.45	47.15	31.35	78.50
T_8	17.75	16.19	33.95	4.19	4.47	8.67	37.96	28.44	66.39
T_9	21.23	17.89	39.12	5.07	4.75	9.83	39.32	30.94	70.27
T_{10}	22.35	26.92	49.27	6.21	6.46	12.67	43.06	43.23	86.29
T_{11}	31.54	31.04	62.58	9.07	7.97	17.04	63.19	50.82	114.01
T_{12}	23.13	20.72	43.85	5.88	5.18	11.06	50.38	35.90	86.28
SE.m	1.02	0.78	1.35	0.22	0.17	0.27	1.53	1.10	2.20
CD @ 5 %	2.99	2.30	3.96	0.65	0.51	0.79	4.47	3.22	6.46

phosphates and releases more orthophosphates into the soil solution for the higher crop availability (Ghosh *et al*., 2009).

Potassium

The increasing trend observed in the uptake of K by different parts of the crop with increased application of potassium from 10, 20, 30, 40 and 50 kg K_2O. The better uptake of K in straw (68.38), grain (51.56) and total K (119.94 kg ha^{-1}) of foxtail millet recorded with application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O (T_6) followed by 50 kg N + 45 kg P_2O_5 + 40 kg K_2O (T_{11}) (63.19, 50.82 and 114.01 kg ha^{-1} by straw, grain and total K uptake, respectively), which was superior as compared to rest of the treatments. Whereas, the lowest uptake by straw (15.40), grain (11.29) and total K (26.69 kg ha^{-1}) was recorded in the control (T_1). Better accumulation of dry matter in shoot and root has led to more uptake of potassium and increased uptake of K due to increased nitrogen and potassium application has been reported by Yadav *et al*., (2011).

Increased uptake of N, P and K by maize crop with increased levels of K application might be due to the synergetic interaction between N and K. Plants deficient in potassium will not produce proteins despite an abundance of available nitrogen. Instead, incomplete proteins such as amino acids, amides and nitrates will accumulate in the cell. This is because of the enzyme nitrate reductase, which catalyzes the formation of proteins, mainly activated by potassium (Ujwala Ranade, 2011). Similar to the present study increase in uptake of different nutrients by wheat crop due to increased levels of potassium was noticed by Sanjeev kumar *et al.,* (2015) and attributed to translocation of nutrients by applied K which plays an important role in increasing nutrient uptake by plants.

Effect of different levels of potassium on soil pH, EC and organic carbon after harvest of Foxtail millet crop

Pooled data pertaining to the influence of different levels of potassium on soil pH, electrical conductivity and organic carbon content of soil are presented in Table 6. Potassium levels had no significant effect on the soil pH. However, the soil pH ranged from 6.09 to 6.29 and the numerically higher value of pH was noticed in the treatment T_4, Recommended N P_2O_5 + 20 kg K_2O ha^{-1} (6.29). Electrical conductivity in soil after harvest of foxtail millet did not show any significant difference due to potassium levels. However, the electrical conductivity ranged between 0.44 to 0.48 dSm^{-1}. Significant differences among the treatments were observed with respect of organic carbon (OC) content of soil. Treatments which received combined application of higher levels of K with FYM recorded significantly higher organic carbon compared to absolute control. Higher OC values recorded with T_7, 40 kg N + 40 kg P_2O_5 + 50 kg K_2O ha^{-1} (0.71%) followed by T_{12}, 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1} (0.70%) which was superior, compared to without K application in T_2, POP based on UAS (B) package (0.61%). Lowest value of 0.49 per cent was recorded in absolute control (T_1) where no fertilizers and FYM was added. Jaison (2018), explained that soil organic carbon significantly improved in the treatments where FYM was incorporated with inorganic fertilizers as compared to NPK application only.

TABLE 6

Effect of different levels of potassium on pH, EC and OC of soil after harvest of foxtail millet in *Alfisols* of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017).

Treatments	Plant height (cm)		
	Tillering stage	panicle initiation stage	Harvest
T_1: Absolute control	6.09	0.44	0.49
T_2: POP based on UAS (B) package	6.11	0.44	0.61
T_3: Rec. N P_2O_5+ 10 kg K_2O ha^{-1}	6.20	0.47	0.64
T_4: Rec. N P_2O_5+ 20 kg K_2O ha^{-1}	6.29	0.45	0.65
T_5: Rec. N P_2O_5+ 30 kg K_2O ha^{-1}	6.26	0.46	0.64
T_6: Rec. N P_2O_5+ 40 kg K_2O ha^{-1}	6.27	0.46	0.67
T_7: Rec. N P_2O_5+ 50 kg K_2O ha^{-1}	6.24	0.48	0.71
T_8: 50 kg N + 45 kg P_2O_5 + 10 kg K_2O ha^{-1}	6.23	0.46	0.61
T_9: 50 kg N + 45 kg P_2O_5 + 20 kg K_2O ha^{-1}	6.22	0.48	0.63
T_{10}: 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1}	6.26	0.44	0.66
T_{11}: 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1}	6.19	0.45	0.66
T_{12}: 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1}	6.15	0.46	0.70
SE.m	0.05	0.01	0.02
CD @ 5 %	NS	NS	0.07

Effect of different levels of K on available N, P_2O_5 and K_2O after harvest of Foxtail millet crop

The pooled data on effect of different levels of K on available N, P_2O_5 and K_2O in soil after harvest of foxtail millet crop is given in Table 7. Among potassium levels, the pooled available nitrogen after harvest of the crops was significantly higher in T_{12}, 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1} (158.11 kg ha^{-1}), which was on par with the T_7, 40 kg N + 40 kg P_2O_5 + 50 kg K_2O ha^{-1} (148.94 kg ha^{-1}) compared to T_2, POP based on UAS (B) package (131.84 kg ha^{-1}). The available phosphorus was significantly higher in T_7, 40 kg N + 40 kg P_2O_5 + 50 kg K_2O ha^{-1} (42.70 kg ha^{-1}) compared to no potassium T_2, POP based on UAS (B) package (20.08 kg ha^{-1}). In contrast to available N and P_2O_5 contents of the soil, increase in available K_2O content of the soil with increased levels of K application was recorded, where the highest potassium content was observed in T_7, 40 kg N + 40 kg P_2O_5 + 50 kg K_2O ha^{-1} (202.46 kg ha^{-1}) which was on par with application of T_{12}, 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1} (202.33

TABLE 7

Effect of different levels of potassium on available N, P_2O_5 and K_2O of soil after harvest of foxtail millet in *Alfisols* of Chikkaballapura region, Karnataka (pooled data of 2016 and 2017).

Treatments	Plant height (cm)		
	Tillering stage	panicle initiation stage	Harvest
T_1: Absolute control	129.37	17.77	134.42
T_2: POP based on UAS (B) package	131.84	20.08	144.87
T_3: Rec. N P_2O_5+ 10 kg K_2O ha^{-1}	136.09	26.49	149.41
T_4: Rec. N P_2O_5+ 20 kg K_2O ha^{-1}	135.32	34.91	153.91
T_5: Rec. N P_2O_5+ 30 kg K_2O ha^{-1}	138.85	33.76	173.91
T_6: Rec. N P_2O_5+ 40 kg K_2O ha^{-1}	138.89	38.03	183.26
T_7: Rec. N P_2O_5+ 50 kg K_2O ha^{-1}	148.94	42.70	202.46
T_8: 50 kg N + 45 kg P_2O_5 + 10 kg K_2O ha^{-1}	138.63	32.43	160.70
T_9: 50 kg N + 45 kg P_2O_5 + 20 kg K_2O ha^{-1}	133.00	30.07	166.70
T_{10}: 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1}	145.08	33.86	190.43
T_{11}: 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1}	146.66	30.12	173.38
T_{12}: 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1}	158.11	38.26	202.33
SE.m	2.28	1.26	4.18
CD @ 5 %	6.69	3.69	12.25

kg ha^{-1}) compared to T_2: POP based on UAS (B) package (144.87 kg ha^{-1}) and lowest value was recorded in absolute control (T_1, 134.42 kg ha^{-1}). This was obviously due to addition of increased application of K to the soil at higher rates, which might have resulted in retention of unused portion of K in the soil itself, after harvest of the crop. These results are in conformity with the findings of Ahmad and Tarence (2016) and Abdel Rahman (2014) who found that there was an increase in available K content in soil with increased levels of K applied after harvest of wheat crop.

Economic analysis of foxtail millet production

The Economic analysis of different treatments with application of potassium in foxtail millet (Table 8) revealed that both net return and BCR increased with application of different levels of potassium. The cost of cultivation was highest for T_{12}, 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1} (22946.68 Rs ha^{-1}) followed by T_{11}, 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1} (22621.32 Rs ha^{-1}) compared to T_2, POP (20916.32 Rs ha^{-1}). The highest gross and net return of `57565.50 ha$^{-1}$ and `34944.18 ha^{-1} was obtained in T_{11} and it also had higher BCR of 2.54 compared to other treatments which received (T_6) 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} (`56482.05 gross return, `34258.41 net return and B:C ratio of 2.53) followed by T_{10}, 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1} with the gross and net returns of `51060.75 and `28766.75 ha^{-1} and BCR of 2.28. The T_2, POP of UAS (B) registered lowest BCR (1.50) compared to all other treatments. Therefore, it is economically feasible for application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} along with 6 tonnes of FYM to the foxtail millet in *Alfisols* of Chikkaballapura region of Karnataka.

Since, the package of practice of UAS (B) is almost 35 years old there is no recommendation of to Foxtail millet. Response of tested crop to higher and balanced fertilization was observed through enhanced crop yield in the present investigation. The inclusion of potassium along with N and P_2O_5 played a major role in enhancing plant growth and crop yield. Therefore considering the soil condition in the region as well as to maintain the proper soil health, the application of 40 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} along with 6 tonnes of FYM is considered as best treatment for the foxtail millet in the Chikkaballapura region of Karnataka.

TABLE 8

Economic analysis of foxtail millet production in *Alfisols* of Chikkaballapura region, Karnataka.

Treatments	Cost of Cultivation	Gross returns	Net returns	B:C ratio
	Rs. ha^{-1}			
T_1: Absolute control	11000.00	22630.95	11630.95	2.03
T_2: POP based on UAS (B) package	20916.32	31684.50	10768.18	1.50
T_3: Rec. N P_2O_5+ 10 kg K_2O ha^{-1}	21243.64	32952.45	11708.81	1.55
T_4: Rec. N P_2O_5 + 20 kg K_2O ha^{-1}	21569.59	35869.05	14299.46	1.66
T_5: Rec. N P_2O_5 + 30 kg K_2O ha^{-1}	21896.32	45690.45	23794.13	2.08
T_6: Rec. N P_2O_5 + 40 kg K_2O ha^{-1}	22223.64	56482.05	34258.41	2.53
T_7: Rec. N P_2O_5 + 50 kg K_2O ha^{-1}	22549.00	37589.25	15040.25	1.67
T_8: 50 kg N + 45 kg P_2O_5 + 10 kg K_2O ha^{-1}	21641.32	35625.00	13983.68	1.64
T_9: 50 kg N + 45 kg P_2O_5 + 20 kg K_2O ha^{-1}	21967.27	37113.00	15145.73	1.68
T_{10}: 50 kg N + 45 kg P_2O_5 + 30 kg K_2O ha^{-1}	22294.00	51060.75	28766.75	2.28
T_{11}: 50 kg N + 45 kg P_2O_5 + 40 kg K_2O ha^{-1}	22621.32	57565.50	34944.18	2.54
T_{12}: 50 kg N + 45 kg P_2O_5 + 50 kg K_2O ha^{-1}	22946.68	41458.35	18511.67	1.80

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