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ORIGINAL ARTICLE **OPEN ACCESS**

Effect of Phosphorus And Potassium Levels on Phosphatase Activity And Potassium Fractions In Post-Harvest Soils Of Finger Millet

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ABSTRACT

A field experiment was conducted under loamy soil (Alfisols), during kharif 2013 at Doddabelavangala village of Doddaballapura (T), Bangalore Rural district, Karnataka to study the effect of reduced phosphorus (P) and potassium (K) level on K fractions and phosphatase activity (acid and alkaline phosphatase activity) in post-harvest soils of finger millet. The result revealed that, all fractions of K recorded significantly higher values in treatments received 100 % of NPK fertilizers and FYM along with bio-fertilizers compared to only NPK added and control treatment.The activity of acid phosphatase was significantly high (17.21 µ g PNP g^{-1} soil hr^{-1}) in the treatment received 100% NPK and FYM along with P and K solubilizer. Whereas alkaline phosphatase activity was higher (36.39 µ g PNP g^{-1} soil hr^{-1}) in 100 % NPK alone added treatment than the FYM and bio-fertilizer treatment.

***Key words**: Phosphorus, Potassium, Fractions, Post-harvest Soils, Finger Millet, phosphatase activity*

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INTRODUCTION

In the earlier days use of fertilizer for finger millet was very limited. With the introduction of high yielding varieties, farmers started using fertilizers to finger millet mainly to achieve higher yield. However, balanced fertilization is not a practice and it led to high P and K imbalance due to application of only chemical fertilizers. P and K are costly nutrients and being used in India, where few million tones are being imported annually to India. Fertilizer application by farmers in India is skewed towards nitrogen and very less of P and K are added. P on addition undergoes transformation leading to build up; whereas K is either fixed or leached. Thus, successful use of an elite microbial strain capable of solubilizing insoluble P and K from minerals quickly in large quantity can conserve our existing resources and helps to avoid environmental pollution hazards caused by heavy application of chemical fertilizers [10]. In order to sustain the reduce the dependency on inorganic fertilizers and imbalance application of fertilizers, conjunctive use of organic manures, bio fertilizers and reduced doses of chemical fertilizers are very much essential. In view of the above facts, the present investigation was carried out to study the effect of reduced P and K level on K fractions in post harvest soil.

MATERIALS AND METHODS

Composite soil sample was collected and analyzed for physical and chemical properties. According to USDA soil textural classification chart, the soil is categorized as red loamy. The pH of the soil was 7.39, low in nitrogen, high in phosphorus and high in potassium content with 180.12 kg N ha^{-1}, 67.39 kg P_2O_5 $ha^{-1}$and 345.36 kg K_2O ha^{-1}respectively.

Sl.No.	Particulars	Value obtained
I	Physical properties of soil	
1	Sand (%)	45.5
2	Silt (%)	28.0
3	Clay (%)	26.3
4	Texture	Red loamy
II	Chemical properties of soil	
1	pH (1:2.5)	7.39
2	Electrical conductivity (d Sm^{-1})	0.30
3	OC (%)	0.47
4	Avail N (kg ha^{-1})	180.12
5	Avail P_2O_5 (kg ha^{-1})	67.39
6	Avail K_2O (kg ha^{-1})	345.36
III	Potassium fractions of soil (mg kg^{-1})	
1	Water soluble potassium	20.95
2	Exchangeable potassium	158.93
3	Non-exchangeable potassium	422.90
4	Total potassium	1692.03
IV	Soil enzyme activity (µg PNP/g soil/ hr)	
1	Acid phosphatase activity	11.4
2	Alkaline phosphatase activity	26.57

The experiment was laid out in randomized complete block design having eleven treatment combinations and replicated thrice on a gross plot size of 2.7 m × 3.0 m and net plot size of 1.8 m × 2.4 m.

Crop	Finger millet
Variety	GPU-28
Recommended dose of fertilizer (NPK kg ha^{-1})	100:50:50
Spacing	22.5cm ×10cm
Date of sowing	11-07-2013
Date of harvest	01-11-2013

Treatments	
T_1	100% NPK POP (+FYM)
T_2	100% NPK POP (-FYM)
T_3	T_1 + P and K solubilizer
T_4	T_2 + P and K solubilizer
T_5	100% NP + 50% K + FYM + K solubilizer
T_6	100% NP + 50% K - FYM + No K solubilizer
T_7	100% N + 50% P + 100% K + FYM + P solubilizer
T_8	100% N + 50% P + 100% K - FYM + No P solubilizer
T_9	100% N + 50% P + 50% K + FYM + P and K solubilizer
T_{10}	100% N + 50% P + 50% K – FYM + No P and K solubilizer
T_{11}	Absolute control

Note: FYM: Applied at the rate of 15 t ha^{-1}

P solubilizer (*Bacillus megaterium*): Applied at the rate of 5 kg ha^{-1}

K solubilizer (*Frateuriaaurantia):* Applied at the rate of 5 kg ha^{-1}

Bio-fertilizer cultures were obtained from Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bangalore.

Determination of various forms of soil potassium

Water-soluble potassium

Water-soluble potassium was determined in 1:2 soil water suspensions after shaking for two hours and allowing the suspension to stand for an additional 16 hours [8]. The potassium in the extract was determined by flame photometer.

Exchangeable potassium

Exchangeable potassium was determined by extracting with neutral N NH_4OAc solution as outlined by Knudsen *et al*. [6]. Ten gram of soil sample was shaken with 25 ml of neutral N NH_4OAc solution for ten minutes and then centrifuged.

The clear supernatant liquid was decanted into 100 ml volumetric flask. Three more additional extractions were made in the same manner and the combined extract was diluted to volume with NH_4OAc. The K content in the extract was determined, by flame photometer. The water-soluble potassium content was subtracted from NH_4OAc-K to get the exchangeable potassium content of the soil.

Non exchangeable potassium

The boiling 1N HNO_3 method as outlined by Knudsen *et al.* [6] was followed for the determination of non-exchangeable K in the soil.

Two and half gram of finely ground soil was boiled gently with 25 ml of 1N HNO_3 for 10 minutes. The content was filtered and the filtrate was collected in a 100ml volumetric flask. The soil was then washed four times with 15 ml portions of 0.1N HNO_3. After making up volume and mixing, the potassium content in the extract was determined using flame photometer. The quantity of K obtained with the NH_4OAc extract was subtracted to get the non-exchangeable potassium content in the soil.

Total potassium

Total potassium content was determined by digesting the samples with hydrofluoric acid in a closed vessel [7]. 200 mg of finely ground soil sample was transferred into 250 ml wide mouth polypropylene bottle. Two ml of aqua regia was added to disperse the samples. Later 10 ml of hydrofluoric acid was added by means of plastic pipette and after capping the bottle the contents were shaken to dissolve the sample for a period of 8 hours. The white residue remaining after the treatment was dissolved in 100ml of saturated H_3BO_3 solution. The contents were diluted and final volume was made to 250 ml and subsequently used for analysis of total potassium by flame photometer.

Phosphatase activity

Acid and alkaline phosphatase activity

Acid and alkaline phosphatase activities were estimated as per the procedure given by Eivazi and Tabatabai [2]. For this one gram of soil sample (<2mm) was placed in wide mouth test tube and 0.2ml of toluene, 4ml of modified universal buffer (pH 6.5 for assay of acid phosphatase or pH 11.0 for assay of alkaline phosphatase), 1ml of p-nitro phenyl phosphate solution made in the same buffer were added. Tubes were swirled for a few seconds to mix the contents. Then tubes were stoppered with cork and placed in an incubator at 30^0 C. after 1 hr stoppers were removed and 1ml of 0.5 M $CaCl_2$, 4ml of 0.5 M NaOH was added. The suspension was centrifuged at 3000 rpm, filtered and the intensity of yellow colour of the supernatant was measured using spectrophotometer at 420 nm wavelength.

p-nitro phenol content of the supernatant was calculated by referring to a calibration graph plotted from the results obtained with standards containing 0, 10, 20, 30, 40 and 50 µg of p-nitro phenol. Control was performed with each soil analyzed to allow for colour not derived from p-nitro phenol released by phosphatase activity.

Statistical analysis

The methods outlined by Panse and Sukhatme [12] were made used for statistical analysis of the data for drawing conclusion on the effect of various treatments on different parameters studied.

RESULTS AND DISCUSSION

The data pertaining to different fractions of potassium in soil as influenced by various treatments are presented in Table 1.

Water soluble potassium

Water soluble K content in soil after the harvest of finger millet crop showed significant difference among the various treatments. The water soluble potassium content was recorded highest in treatment which received chemical fertilizer, FYM and microbial culture *i.e*T_3 of 28.99 mg $kg^{-1}$and T_5 of 28.28 mg kg^{-1}. The lowest water soluble K was recorded in control (T_{11}: 18.27 mg kg^{-1}).The higher level of water soluble potassium was observed under 100 % NPK+ FYM + P and K solubilizer. Production of organic acids by added P and K solubilizer and organic matter that would have released the potassium from fixed forms into available pool. Continuous application of FYM and NPK fertilizer enhanced the water soluble potassium to a considerable extent. The results are similar to Pannu *et al.* [11], Gurumurthy and Vagheesh [4] and Divya [1].

Exchangeable potassium

The exchangeable K represents much of the available potassium to crop. The results were showed significant difference among the various treatments. The exchangeable K content was higher in treatment T_3 of 352.75 mg kg^{-1} followed by $T_4$of 334.74 mg kg^{-1}, T_9 of 329.13 mg kg^{-1} and T_5 of 326.63 mg kg^{-1}due to application of biofertilisers. The lowest content (T_{11}: 165.76 mg kg^{-1}) of exchangeable K was recorded in treatment where no fertilizers were added. Addition of organic manures enhanced the soil exchangeable K by supplying K into soil solution and ultimately acted as strong sink for K added [13]. A significant decrease in the soil exchangeable K was noticed in the plots T_2, T_6, T_8 and T_{10} which was mainly because of the depletion of K due to crop removal [1].

Non exchangeable potassium

Non exchangeable K content in soil after the harvest of finger millet crop showed significant differences among the various treatments. The non exchangeable K content was recorded highest in treatment which received chemical fertilizer, FYM and microbial culture *i.e*T_3 of 1056.63 mg kg^{-1}, T_4 of 932.10 mg kg^{-1}, $T_9$of 931.54 mg kg^{-1} and T_5 of 930.71 mg kg^{-1}. Among these treatments where chemical fertilizer, FYM and single inoculation of either P or K solubilizer were added, the treatment which received K solubilizer along with chemical fertilizer and FYM was recorded higher (T_5: 930.71 mg kg^{-1}) non exchangeable K.The lower amount of non exchangeable K might be due to release of fixed K to compensate the removal of water soluble and exchangeable K by plants and leaching losses and the non-exchangeable K was increased due to presence of unweathered mineral lattice. The results are in conformity with Divya [1].

Table 1: Effect of levels of phosphorus and potassium on fractions of potassium in soil after the harvest of finger millet

Treatments	Water soluble K	Exchangeable K	Non-Exchangeable K	Total K
	(mg kg^{-1})			
T_1: 100% NPK POP (+FYM)	25.21	303.40	779.19	3167.76
T_2: 100% NPK POP (-FYM)	23.78	292.30	788.60	2179.97
T_3: T_1 + P and K solubilizer	28.99	352.75	1056.63	3847.06
T_4: T_2 + P and K solubilizer	27.27	334.74	932.10	3132.55
T_5: 100% NP + 50% K + FYM + K solubilizer	28.28	326.63	930.71	3260.96
T_6: 100% NP + 50% K - FYM +no K solubilizer	22.93	302.39	542.46	2809.77
T_7: 100% N + 50% P + 100% K + FYM + P solubilizer	26.29	298.95	688.99	2378.88
T_8: 100% N + 50% P + 100% K - FYM + No P solubilizer	20.26	190.39	436.51	1929.88
T_9: 100% N + 50% P + 50% K + FYM + P and K solubilizer	28.97	329.13	931.54	3214.46
T_{10}: 100% N + 50% P + 50% K – FYM + No P and K solubilizer	17.27	175.94	442.19	1632.09
T_{11}: Absolute control	18.27	165.76	410.02	1549.00
S.Em±	**1.28**	**20.36**	**20.80**	**88.76**
CD @ 5%	**3.79**	**60.05**	**61.37**	**261.8**

Total potassium

The total K content in soil after the harvest of finger millet crop showed significant differences among the various treatments. The total K content was recorded highest in treatment T_3 of 3847.06 mg kg^{-1} (T_1+ P and K solubilizer) and it was on par with treatment T_5 (3260.96 mg kg^{-1}), T_4 (3132.55 mg kg^{-1}) and T_9(3214.46 mg kg^{-1}) where chemical fertilizers with FYM and biofertilizers were added. The highest total potassium recorded because of the presence of substantial quantities of K bearing minerals as a reserve since the treatment received sufficient amount of K from external application to meet out the crop demand [3].The amount of total K which depended largely upon the clay content and type of clay mineral present in the soils [9] might be the cause for huge amount of total potassium.

Table 2: Effect of levels of phosphorus and potassium on phosphatase activity in soil after the harvest of finger millet

Treatments	Acid phosphatase	Alkaline phosphatase
	(µg PNP g^{-1} soil hr^{-1})	
T_1: 100% NPK POP (+FYM)	14.97	34.62
T_2: 100% NPK POP (-FYM)	12.65	31.70
T_3: T_1 + P and K solubilizer	17.21	29.53
T_4: T_2 + P and K solubilizer	15.73	30.43
T_5: 100% NP + 50% K + FYM + K solubilizer	14.57	30.81
T_6: 100% NP + 50% K - FYM +no K solubilizer	11.31	31.36
T_7: 100% N + 50% P + 100% K + FYM + P solubilizer	14.43	29.29
T_8: 100% N + 50% P + 100% K - FYM + No P solubilizer	12.61	33.80
T_9: 100% N + 50% P + 50% K + FYM + P and K solubilizer	16.70	28.26
T_{10}: 100% N + 50% P + 50% K – FYM + No P and K solubilizer	11.44	36.39
T_{11}: Absolute control	10.32	35.43
S.Em±	**1.00**	**1.03**
CD @ 5%	**2.95**	**3.04**

The activity of acid phosphatase was significantly high (17.21 µ g PNP g^{-1} soil hr^{-1}) in the treatment T_3 (T_1 + FYM + P and K solubilizer) than in plots receiving only fertilizers and control. This is because the fertilizer alone treatment registered relatively much lower acid phosphatase activity than the FYM and bio-fertilizer treatment. Whereas alkaline phosphatase activity was higher (36.39 µ g PNP g^{-1} soil hr^{-1}) in 100 % NPK alone added treatment than the FYM and bio-fertilizer treatment. The conversion of organic P in to inorganic P forms is mainly governed by soil phosphatase activity. It is dependent on pH, organic carbon and P compounds of soil [5]. The enzyme activities are regulated by the soil characters like organic carbon, pH and nutrient status [10].

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