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Nutrients availability in soil and yield improvement through balanced crop nutrition in tribal settlements of Karnataka

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Abstract
To study the availability of soil nutrients and crop response through balanced crop nutrition in tribal settlement of Karnataka the present experiment was undertaken under the Tribal Sub Plan programme. About 120 tribal families were selected in various tribal clusters of Malai Mahadeshwara Hills and Biligiri Rangana Hills (Western Ghats) of Chamarajanar district of Karnataka. The soil samples were collected from the fields of tribal families and were analyzed for available nutrients status. About 90 percent of soils are acidic and nine percent are neutral, organic carbon content in soil was high (78%) in majority of soils. Most of the soils (97%) are deficient in available nitrogen, available phosphorus and potassium status were medium (63 & 64% respectively), about 27 and 17 per cent of soils were low in P and K status. Sulphur deficiency was not observed in these soils. Micronutrients availability in these soils were sufficient, except in two samples which exhibited below the critical limit of DTPA zinc. About 120 trials were conducted in famers field on yield improvement through balanced crop nutrition with finger millet ad maize crops. The experimental results revealed that about 24.90% and 22.73% increase in yield of finger millet and maize respectively was recorded due to balance application of fertilizers over farmers practice (50 kg DAP/ acre/ 1-2 t FYM/acre).

Keywords: Tribal settlement, nutrients, soil, low, medium and high

Introduction
Karnataka state is the home to 42, 48,987 tribal people, of whom 50,870 belong to the primitive group. Although these people represent only 6.95 per cent of the population of the State, there are as many as 50 different tribes notified by the Government of India, living in Karnataka, of which 14 tribes including two primitive ones, are primarily natives of this State (Subarna Roy *et al*. 2015) [1]. The general belief that soils in the tribal regions are rich in organic carbon and fertility status as a result of less intensive cropping with low yield, was found to be untrue. The tribal regions are intensively cultivated for the last two decades without much input with highly exhaustive crops like cotton and vegetables. Thus, soils showed multiple nutrient deficiencies. Addition of deficient nutrients increased yield and benefits to farmers in a spectacular manner (Srinivasarao *et al*. 2010) [2].

The depletion of soil nutrients, imbalanced and nonjudicious use of nutrients might be the possible cause for low crop yield and declined soil fertility over the years. Application of nutrients through organic and inorganic sources, therefore, will be essential to improve and sustain crop yields and maintain soil fertility. Effects of imbalanced fertilizer application led to loss of productivity arising from the soil exhaustion of certain primary and secondary nutrients (Yadvinder Singh *et al*. 2004) [3].

The concept of balanced fertilization: Balanced fertilization (BF) is one of the keys to improving fertilizer use efficiency. In principle, the concept of BF aims at a dynamic balance between *nutrient requirement* and *nutrient uptake by crops*. This is achieved by maintaining the equilibrium between nutrients available at different growth stages; between the supply of nutrients from fertilizers and from natural nutrient pools in accordance with conditions relevant to the effectiveness of fertilizer nutrient uptake (e.g. soil properties, water regimes, weather conditions, *etc*.). Balanced fertilization also improves nutrient use by crops in crop rotations and farming systems.

Balanced fertilization is normally defined as the timely application of all essential plant nutrients (which include primary, secondary and micronutrients) in readily available form, in optimum quantities and in right proportion, suitable for specific soil/crop conditions.

Major constrain in promoting balanced use of fertilizers includes inadequate soil testing facilities, wide gap in dissemination of knowledge, lack of awareness among farmers about benefits of balanced fertilization.

Material and Methods

Participatory soil sampling

Soil samples from 120 farmers' fields covering five tribal clusters of BR. Hills and MM. Hills were collected during 2014-15 with farmer participation in soil sampling.

Soil analysis

The soil samples were subjected to chemical analysis by following standard procedures. The soil pH was measured by using glass electrode using a soil to water ratio of 1:2.5; electrical conductivity (EC) was determined by an EC meter using a soil to water ratio of 1:2.5. Organic carbon was determined by following the Walkley-Black method (Nelson and Sommers, 1996) [4]. Available N was determined by alkaline permanganate method (Subbiah and Asija, 1956) [5]. Available P was estimated by Olsen (Olsen and Sommers, 1982) [6] and Bray methods, respectively in neutral to alkaline and acidic soils, respectively, avail. K by neutral normal ammonium acetate method (Hanway and Heidel, 1952) [7], Available S was measured using 0.15% calcium chloride ($CaCl_2$) as an extractant (Tabatabai, 1996) [8], available micronutrients (Zn, Fe, Cu and Mn) were extracted by DTPA reagent (Lindsay and Norvell, 1978) [9] and available B was extracted by hot water (Keren, 1996) [10].

On farm trials

During 2014-15, a total of 120 on-farm trials were conducted with finger millet (90 trials) and maize (30 trials) in tribal farmer's field at Biligiri Rangana Hills, Chamarajanagar district with the objective of demonstrating the comparative evaluation of farmer's practice (DAP alone/1-2 t FYM/ha) and balanced nutrition. Crops were grown on selected farmers' fields with known fertility status and balanced nutrient application. Balanced nutrition was compared with the farmers' practice in an area of one acre in each of the farmers' field. The balanced nutrition included a recommended dose of fertilizers (100:22:42 kg ha^{-1} NPK and for finger millet 100:33:82 kg ha^{-1} N PK for maize, $ZnSO_4$@ 5 kg ha^{-1}) and 10 tons of farm yard manure per hectare for both the crops.

For statistical analysis of data, Microsoft Excel (Microsoft Corporation, USA) and SPSS window version 10.0 (SPSS Inc., Chicago, USA) packages were employed. The level of significance referred in the results is $P<0.05$.

Critical limits considered for low content

OC<0.5%, Av. N<280 kg ha^{-1}, Av. *P*<22.5 kg ha^{-1}, Av. K<125 kg ha^{-1}, Av. S<10.0 mg kg^{-1}, Zn<0.60 mg kg^{-1}, Cu<0.2 mg kg^{-1}, Fe< 4.5 mg kg^{-1}, Mn< 2.0 mg kg^{-1}, B<0.50 mg kg^{-1}.

Results and Discussion

Soil fertility and nutrients status

Variation of nutrient supply in the soils is a natural phenomenon due to exhaustion of nutrients on account of incessant cropping. In some areas, the status of nutrients may be imbalanced while in other areas nutrient status may be adequate, and; thus evaluation of fertility status would be extremely useful in presenting the nutrient profile and accordingly the corrective measures can be initiated. Maximum yields cannot be obtained without applying judicious level of fertilizers to overcome existing deficiencies (Nagaraj *et al*. 2003) [11]. The soil pH varied from 4.04 to 7.34 with an average of 5.60 and a standard deviation of ±0.60, about 90 percent of soils are acidic and nine percent are neutral in reaction, which was due to the parent material from which these soils were derived and the prevailing climatic conditions (Table 1). The soils exhibited normal soluble salts concentration with no salts accumulation. The organic carbon content in soil ranged between 0.27 to 2.25 per cent with an average of 1.06 per cent and SD of ±0.41, organic carbon content was high (78%) in majority of soils (Fig. 1), this could be attributed to the fact that these soils are cultivated by tribal families and are forest soils under cultivation and the carbon content of virgin soils after deforestation is under mineralization and also due to lower cropping intensity.

Available nitrogen content in soils varied from 75.26 to 313.60 kg ha^{-1}, majority of soils (97%) are deficient in available nitrogen which could be attributed to imbalanced fertilization and also due to cropping which have exhausted and removed from soil. Available phosphorus and potassium status were medium (63 & 64% respectively), about 27 and 17 per cent of soils were low in P and K status (Fig. 1). The available phosphorus varied from 8.79 to 125. 24 kg ha^{-1} and available potassium varied from 59.4 to 807.74 hg ha^{-1}. Sulphur content in soils is sufficient with values varied from 18.57 to 56.14 mg kg^{-1}. Sulphur deficiency was not observed in these soils.

The micronutrients availability in these soils were sufficient, except in two samples which exhibited below the critical limit of DTPA zinc. As these soils are cultivated for a single crop per year the micronutrients deficiency was not noticed but due to imbalanced fertilization the deficiencies could be exhibited by crops, hence the trails were demonstrated on farmer fields to create awareness on importance of balanced fertilizer application.

Table 1: Descriptive statistics for nutrient status of soil collected form tribal clusters (Sample no 120)

Parameter		Range	Average	SD±
Soil pH		4.04-7.34	5.60	0.60
EC (dS m^{-1})		0.03-0.83	0.13	0.12
OC (%)		0.27-2.25	1.06	0.41
Avail. N	kg ha^{-1}	75.26-313.60	208.70	38.38
Avail. P_2O_5		8.79-125.24	35.31	19.84
Avail. K_2O		59.40-807.74	253.11	165.28
Avail. S	mg kg^{-1}	18.57-56.14	29.24	9.45
Avail. Zn		0.53-6.35	1.43	0.75
Avail. Cu		0.23-6.17	2.27	1.21
Avail. Fe		2.46-77.38	28.29	15.96
Avail. Mn		2.77-53.56	30.19	12.58

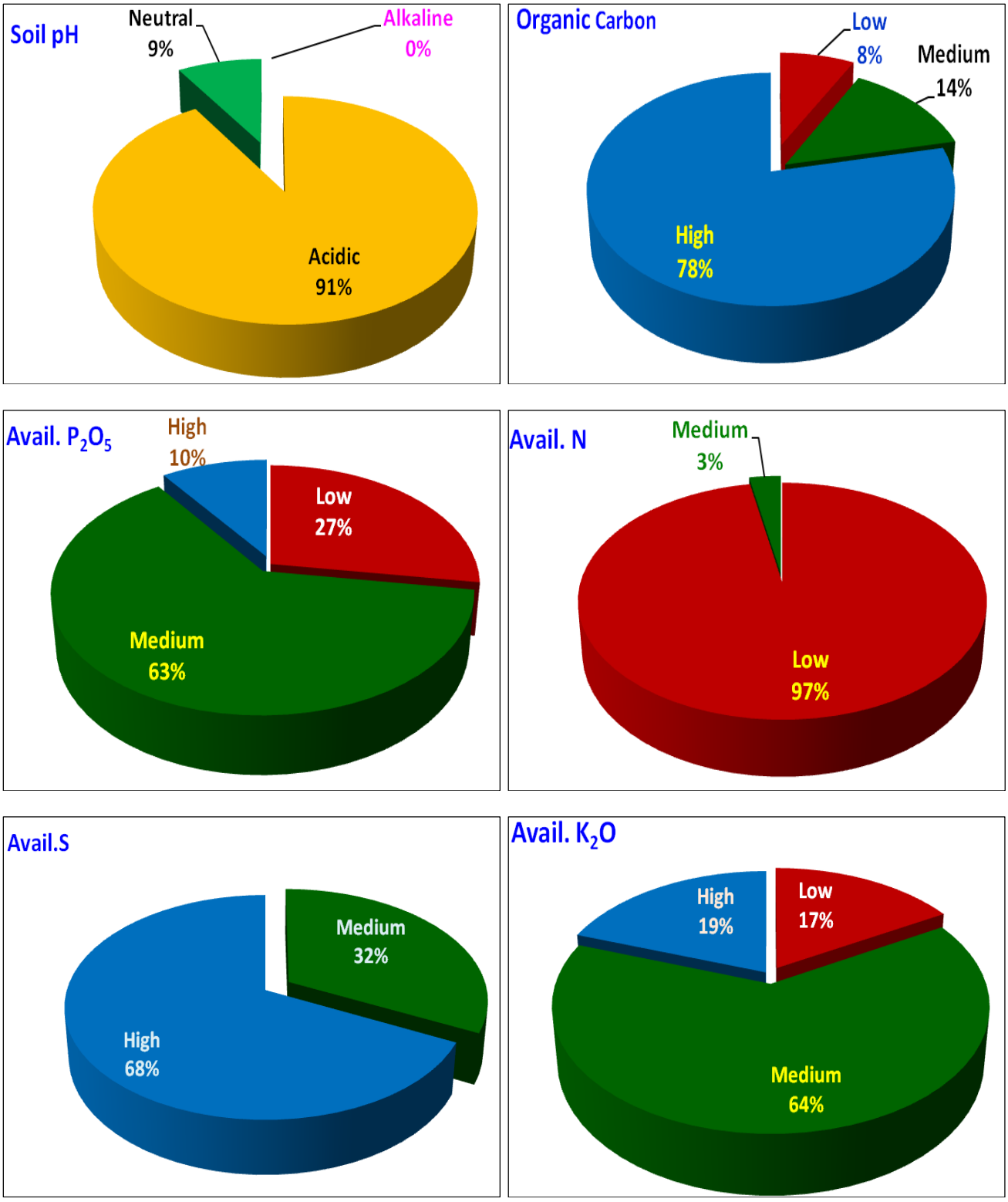

Fig 1: Status of soil pH, organic carbon and available nutrients in selected tribal villages, Chamarajanagar

Critical limits considered for low content: OC < 0.5%, Av. N < 280 kg ha^{-1}, Av. P < 22.5 kg ha^{-1}, Av. K < 125 kg ha^{-1}, Av. S < 10.0 mg kg^{-1}, Zn < 0.60 mg kg^{-1}, Cu < 0.2 mg kg^{-1}, Fe < 4.5 mg kg^{-1}, Mn< 2.0 mg kg^{-1}.

Yield advantage by implementing balanced nutrition

The improvement in yield of finger millet with balanced nutrition was from 25.82 to 32.25 q ha^{-1} in farmer's practice and balanced fertilizer application, the per cent increase in yield was 24.90 over farmers practice (Table 2). The average yield of maize (30 trials) in farmers practice was 65.26 q ha^{-1} in farmer's practice (Table 3) and it was increased to 80.80 65.26 q ha^{-1} with balanced fertilizer application with an increase of 22.73 over farmers practice (Table 4). Higher yield of crops could be associated with the benefits of organics apart from N, P, and K supply, such as improvements in microbial activities, better supply of macro- and micronutrients such as S, Zn, Cu and B, which are not supplied by inorganic fertilizers; and less losses of nutrients from the soil (Yadav *et al*. 2000) [12]. The higher yields obtained on integrated fertilizer application was possibly caused by the better supply pattern of N, P, K and improved soil physical conditions (Yadvinder Singh *et al*. 2004) [3].

Balanced application of NPK in optimum quantities and in right proportion increased rice yield from 32 q ha^{-1} to 60 q ha^{-1} apart improving soil fertility status (Harish Kumar Sharma *et al*. 2013) [13]. The results also corroborated the findings of Praharaj *et al.* (2005) [14] where they have conducted research on effect of balance application of NPK and integrated nutrient management on N recovery in barley, wheat, corn and on yields of crops and indicated that balanced application of NPK increased the N recovery by crop, INM enhanced the yield of crops and quality of the produce.

Table 2: Average yield of finger millet in different tribal clusters as influenced by INM and farmer's practice (90 trials)

S. No	Name of the tribal cluster		Finger millet grain yield (q ha^{-1})	
			Farmers practice	INM
1	B.R. Hills, Yelandur Tq Chamarajanagar Di	PuraniPodu	25.50	33.50
2		KalyaniPodu	24.30	31.50
3	Kollegal Tq Chamarajanagar Di	JeerigeGadde	24.50	30.45
4		HaavinaMoole	26.30	31.25
5		Maavattur	28.50	34.56
Overall Average yield			25.82	32.25

Note: Farmers practice-OnlyDAP @ 50 kg/acre/only FYM @ 1 to 2 tonnes/acre

Table 3: Average yield of maize in different tribal clusters as influenced by INM and farmer's practice (30 trials)

S. No	Name of the tribal cluster		Maizegrain yield (q ha^{-1})	
			Farmers practice	INM
1	BR. Hills, Yelandur Tq Chamarajanagar Di	PuraniPodu	65.20	78.85
2		KalyaniPodu	61.21	77.06
3	Kollegal Tq Chamarajanagar Di	JeerigeGadde	67.12	80.23
4		HaavinaMoole	64.25	81.56
5		Maavattur	68.52	82.82
Overall Average yield			65.26	80.10

Note: Farmers practice-Only DAP @ 50 kg/acre/only FYM @ 1 to 2 tonnes/acre

Table 4: Average yield of finger millet and maize (q ha^{-1})

	Finger millet	% increase	Maize	% increase
1. Farmers practice (50 kg DAP/acre/1-2 t FYM/acre)	25.82	-	65.26	-
2. INM	32.25	24.90	80.10	22.73

Conclusion

Majority of soils are acidic in reaction, soluble salts are normal organic carbon content in soil was high (78%) in majority of soils. Most of the soils (97%) are deficient in available nitrogen, available phosphorus and potassium status were medium, about 27 and 17 per cent of soils were low in P and K status. Sulphur deficiency was not observed in these soils. Micronutrients availability in these soils were sufficient, except in two samples which exhibited below the critical limit of DTPA zinc. About 120 trials were conducted in famers field on yield improvement through balanced crop nutrition with finger millet and maize. The experimental results revealed that about 24.90% and 22.73% increase in yield of finger millet and maize respectively was recorded due to balance application of fertilizers over farmers practice.

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