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RESEARCH ARTICLE

SOIL FERTILITY STATUS OF MULBERRY (*MORUS ALBA L.*) SOILS UNDER BIVOLTINE SERICULTURAL AREAS OF NORTH, SOUTH AND EASTERN REGIONS OF KARNATAKA.

P. Sudhakar¹, V. Sobhana², M. R. Swamy Gowda¹, Jalaja S Kumar¹ and V. Sivaprasad².

1. Regional Sericultural Research Station, Central Silk Board, Kodathi, Beangaluru-560 035 (Karnataka).
2. Central Sericultural Research and Training Institute, Central Silk Board, Mysuru-570 008 (Karnataka).

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Abstract

Soil analysis based prescription to suitable amelioration of mulberry gardens for enhanced quality leaf and bivoltine cocoon production is the priority of sericulture industry in Karnataka. With the above objective in the present study a total of 2067 composite soil samples were collected from traditional sericultural vicinity under 13 districts situated in North (1066), South (855) and Eastern (146) parts of Karnataka and subjected for their chemical analysis. The soil samples were characterized and analysed for their soil type, reaction (pH), salinity (EC) and nutrient status like available nitrogen (N), phosphorous (P), potassium (K), sulphur (S) and boron (B), respectively. The soils received were observed to be 52% were loamy (clay), 28% red, 12% black and 8% lateritic indicating that large numbers of soils are most suitable for mulberry cultivation. In regard to the soil reaction and salinity status, 59% of the soils showed desired optimal category of pH (6.5-7.5) for mulberry, 18% acidic (<6.5) and 23% were of very high pH (>7.5). Electrical conductivity (EC) was normal with desirable soil salinity in 99% soils indicating congenial for mulberry (<1.0dS/m²). Organic carbon (OC) was low (<0.65%) in 76% soils, 23% desirable range (0.65-1.0%) whereas negligible number of soils showed higher OC content (>1.0%) alarming that maximum soils were falling under low fertility category. Available Nitrogen (N₂O) and Phosphorous (P₂O₅) was recorded low (<250kg/ha; <15kg/ha) in 98% and 45% samples. Medium level (15-25kg/ha) of, P₂O₅ was recorded in 23% soils and higher side (>25kg/ha) in 32% samples. Optimal range (120-240kg/ha) of available Potassium (K₂O) was recorded in 49%, low (<120kg/ha) in 20% and 31% soil showed high level (>240kg/ha). Available Sulphur (S) was recorded high (>15ppm) in 54% soils followed by 41% desired level (10-15ppm), whereas mere 5% soils shown low level (<10) of sulphur. In case of available Boron (B) 44% soils recorded as low (<0.5ppm), 43% are desired level (0.5-1.0), whereas 13% soils exhibited high content of available Boron

results can be inferred that majority of the soils are optimal for mulberry growth, low in organic carbon, low to medium in available N_2O and P_2O_5 , whereas moderate to high of available K_2O , S and low to moderate in available Boron (B).

(>1.0ppm) in bivoltine mulberry garden soils of Karnataka. The

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Introduction:-

Soil fertility is concerned with the inherent capacity of the soil to provide nutrients in adequate amounts and in proper balance when the other growth factors such as light, moisture, temperature and other physical conditions of the soil are favourable. Under a given situation, the system of farming, soil management and manuring practices etc. influence the productivity of soils and yields obtained from them. Even highly fertile soils get exhausted of reserve nutrients as crops are grown harvested continuously. Due to crop intensification and high yielding varieties grown, it has reported that a net negative balance of 8-10mt of NPK per annum in India. It is also estimated that the different agricultural crops in India remove about 4.27m.ton of nitrogen, 2.13m.tons of phosphorous, 7.42m.ton of potassium and 4.88 mil.ton of lime per year. Blanket recommendations of fertilisers lead to over or under use of fertilisers ultimately deterioration of soil health (Anonymous, 2011, Sellamuthu *et al.*, 2015). Frequent cultural operations, inorganic fertilizer applications, imparting of diseases and pest control measures and industrial emissions and effluents are not only altering and depleting the soil nutrient status but also polluting ground water resources (Deo *et al.*, 1994; Ambika *et al.*, 2011; Das *et al.*, 2003; Debasish Saha *et al.*, 2003).

Therefore, soil needs continuous replenishment of these plant nutrients through the application of manures and fertilizers. The assessment of nutrient supplying capacity of the soil is carried out by soil fertility evaluation. Growing plants are reliable indicators of the fertility status of the soil. If a soil is deficient in any nutrient it exhibits its deficiency symptoms and so it is essential that the crop plants should be fed with all nutrients (Rana *et al.*, 2014). Thus, it is important to know which plant nutrient lacking in the soil. Simple and elaborate tests have been developed by the agricultural scientists to estimate the nutritional requirement of soils and crops. A study of soil profile supplemented by physical, chemical and biological properties of the soil will give full picture of soil fertility and productivity (Rana *et al.*, 2014; Sellamuthu *et al.*, 2015). Soil Test Crop Response Correlation (STCR) studies targeted yield approach in many agricultural crops has been found to be beneficial which recommends balanced fertilization considering the soil available nutrient status and crop needs (Basavaraja *et al.*, 2015; Ramamoorthy *et al.*, 1967). These methods are known as diagnostic techniques. Soil Testing is well recognized as a sound scientific tool to assess inherent power of soil to supply plant nutrients. The benefits of soil testing have been established through scientific research, extensive field demonstrations, and on the basis of actual fertilizer use by the farmers on soil test based fertilizer use recommendations. One of the objectives of soil tests is to sort out the nutrient deficient areas from non-deficient ones (Anonymous, 2015).

Mulberry (*Morus alba* L.) being a perennial plant cultivated as seasonal crop for its foliage and maintained for decades since its plantation (>10-15 years). As it is cultivated for its foliage by imparting hectic crop schedules for its leaf @ 5 times/year and harvested 60-70MT/ha/yr for feeding silkworm demands high doses of manure and inorganic fertilizers. Accordingly mulberry gardens were replenished with recommended NPK @ 350:140:140 kg/ha/yr along with 20mt of FYM/ha/yr, respectively for irrigated mulberry gardens (Dandin *et al.*, 2003). It is established that mulberry cherish under desirable levels of pH (6.5-7.5), electrical conductivity (EC-<1.00dS/m), organic carbon (OC: 0.65-1.0%), available N (280-560kg/ha), P (15-25kg/ha), K (120-240kg/ha), Sulphur (S;10-15ppm) and Boron (B:0.5-1.0ppm). Due to frequent harvesting of leaf shoot biomass @ 80-100mt/ha/yr it is imperative that depletion of soil reaction, salinity and nutrient status of mulberry gardens is a regular phenomenon. Therefore, frequent supplementation of essential nutrients along with manuring for conditioning soils and enriching nutrient status for enhanced quality mulberry leaf production is essential. Earlier workers emphasized on the need of balanced fertilization and their impact on quality mulberry leaf and cocoon production in India and else where (Bongale *et al.*, 1998; Fang Chen *et al.*, 2009; Sarmah *et al.*, 2013; Thimmareddy *et al.*, 1999). In the recent past, Karnataka being highly traditional and unique in India that produces large quantity of bivoltine silk needs improvement of the mulberry garden soils for production of enhanced quality leaf and graded cocoons. Therefore, in the present study an effort was made to assess the recent trends of soil nutrient status of the traditional sericultural areas of Karnataka and their impact on bivoltine sericulture development. Further, the farmers were extended soil

analysis based amelioration recommendation through the issue of Soil Health Cards (SHCs) in improving their mulberry soils for enhanced quality mulberry and cocoon production.

Materials and Methods:-

A total of 2067 soil samples were received from 9 districts of North, 3 districts of South and one district of Eastern Karnataka during the year 2016-17 under a research programme entitled “*Soil health cards for sericulture farmers in Southern States*” at 0-30cm depths and analysed for their soil reaction (pH), electrical conductivity (EC) and other macro, secondary and micronutrients such as like available N, P, K, S & B at this Soil Testing Laboratory, Regional Sericultural Research Station, Central Silk Board, Kodathi, Bangalore and soil analysis based suitable soil amelioration recommendations were served to the sericulturists for suitable correction of their garden soils to enhance quality mulberry leaf production thereby improving the quality cocoon production. The soil samples (1066) received from North Karnataka includes the districts viz. Bellari, Bidar, Bijapur, Chikkaballapur, Chitradurga, Gadag, Haveri, Koppala, Yadagiri, South Karnataka (855) includes Bangalore Rural, Ramanagaram, Tumkur and Eastern Karnataka (146) includes Kolar district. Though all the districts are falling under the same tropical sericultural zones of Karnataka but the soil texture, soil reaction (pH), salinity (EC) and soil nutrient parameters of all the soils under the study had great variability. The received soils include Red, Lateritic, Loamy and Black soils. Soil samples were received from the sericulture farmers’ mulberry gardens existing in various districts collected by following the standard procedures (Dandin *et al.*, 2003). The soil samples received were air-dried in shade, powdered, passed through a 10 μ mesh sieved and stored in a fresh polythene covers with proper labelling. Soil characters like pH, EC, Organic carbon (OC%), available nitrogen (N/ha), phosphorous (P/ha), potassium (K/ha), Sulphur (S-ppm) and Boron (B-ppm) were determined by using the standard methods (Subbaiah and Asija, 1956; Jackson, 1973).

Results and Discussion:-

The perusal of the soil characterization and nutrient analysis data presented in the **Table 1, 2 & Fig. 1, 2 & 3** from the soils received from North, South and Eastern Karnataka bivoltine sericulturist’s soils existing in 13 Districts as enlisted above revealed the following:

Soil types received:-

The soils received from the sericultural farming gardens of Karnataka showed marked variability. Maximum number of soils characterised as clay loamy soils (52%) indicating as the most suitable soils for plants because of their richness in plant nutrients, humus and water absorption and moisture retaining habit. It may be the reason that sericulture has become predominant farming and flourishing cultivation in Karnataka. Red soils were noticed 28% followed by 12% black soils and only 8% of soils as lateritic (**Table 1, 2 & Fig. 1**).

Soil Reaction (pH):-

Out of the soils received, the soil reaction varied from 5.59 to 8.23 with an average pH of 7.27. Among the soils 61% showed desired level of pH (6.5 to 7.5%), 21% high and 18% are with low pH. Though the acidic soils with liming and alkaline soils with gypsum were ameliorated to bring the soil reaction at desired level for mulberry but instead chemical correction it is better to impart eco-friendly inputs such as enhanced manure (FYM), adopting eco-friendly farming with green manuring crops followed by trenching and mulching during monsoon not only improve the soil health but also bring the soil reaction to normal range thereby improving the nutrient availability of these soils (Table 1, 2 & Fig. 1).

Total soluble salts (EC):-

The total soluble salt content (EC) of these soils ranged from 0.05 to 1.23 dS/m² with a mean value of 0.39dS/m². Most of the soils (99%) have recorded desired levels of electrical conductivity (<1.0 dS/m²) for mulberry indicating as no harmful EC prevailed in the soils. However, negligible number of soils (1%) recorded harmful EC for which no amelioration recommendation is required. The results indicated that mulberry growing soils of Karnataka bivoltine area were normal with respect to soil salinity.

Organic Carbon (OC):-

Organic carbon content varied from 0.06 to 1.05% with an average value of 0.52%. Organic carbon is considered as the soil fertility indicator of mulberry gardens. But, the same was recorded low (<0.65%) in $\frac{3}{4}$ of the soils received (2067) i.e. 74% soils and only 24% soils recorded desired level of OC% (0.65-1.0%). However, it is surprising to know that neglected number (2%) of mulberry gardens showed higher OC (>1.0%) indicating that Karnataka soils

are deficient in OC content (Table 1 & Fig. 1). Soil organic carbon appears to be an important parameter that controls sustainability of crop production (Lal, 2004) through conditioning of soil physical properties (Mishra and Sharma, 1997) and acting as a reservoir of essential nutrients and promote maximum utilization of the inorganic fertilizers supplemented converting into available form (Anonymous, 2011a). Therefore, the Karnataka soils of bivoltine area are advised to enhance organic inputs (manures) application followed by the regular imparting of green manuring crops and trenching & mulching during monsoon.

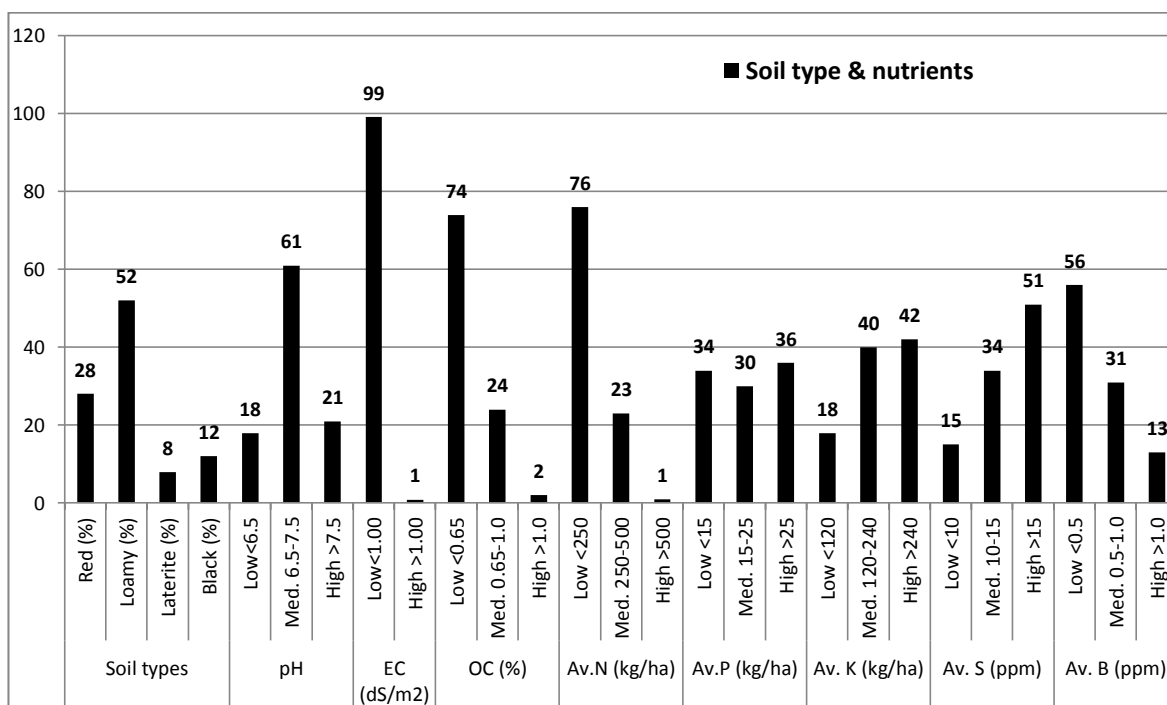


Fig. 1:- Soil texture, rection and nutrients distribution of the mulberry gardens of Karnataka.

Table 1:-Soil reaction, salinity and nutrient status of bivoltine farmers gardens under North, South and Eastren states of Karantaka.

Soil Parameters	Range	Soil reaction & nutrient status			
		North	South	East	Average
No of soils	2067	1066	855	146	--
1. Soil reaction (pH)	Min	5.38	5.49	5.89	5.59
	Max	8.86	7.93	7.91	8.23
	Avg	7.68	7.15	6.98	7.27
2. Electrical Conductivity (EC dS/m ²)	Min	0.01	0.105	0.041	0.05
	Max	1.863	0.97	0.863	1.23
	Avg	0.49	0.36	0.32	0.39
3. Organic Carbon (OC%)	Min	0.05	0.06	0.059	0.06
	Max	1.14	1.14	0.881	1.05
	Avg	0.62	0.6	0.35	0.52
4. Available Nitrogen (N kg/ha)	Min	25.09	175.6	100.35	100.35
	Max	539.39	338.7	276	384.70
	Avg	203.93	223	211.7	212.88
5. Available Phosphorous (P kg/ha)	Min	2.24	2.33	4.26	2.94
	Max	199.8	127.68	96.54	141.34
	Avg	32.8	15.98	24.8	24.53
6. Available Potassium (K kg/ha)	Min	92.1	83.2	5.15	60.15
	Max	986	753.2	582	773.73
	Avg	583.3	232.8	104.5	306.87

7. Available Sulphur (S ppm)	Min	7.2	8.3	8.8	8.10
	Max	265.2	178	213.1	218.77
	Avg	45.5	33.5	26.1	35.03
8. Available Boron (B ppm)	Min	0.04	0.04	0.09	0.06
	Max	10.28	1.41	2.49	4.73
	Avg	0.89	0.55	0.69	0.71

Available Nitrogen (N₂O):-

Nitrogen recorded 100.4kg/ha minimum and 384.7kg/ha maximum with 212.9kg/ha mean value. Available nitrogen was noticed low (<250kg/ha) in maximum number of soils (76%) where as desired medium level N (250-500kg/ha) in 23% soils only 1% soils showed high quantity of available N (>500kg/ha) indicating that mulberry soils of Karnataka bivoltine area are deficient in available N. Nitrogen and phosphorous are the plant growth limiting nutrients, which are commonly applied to mulberry gardens for effective crop production. Subbaswamy *et al.*, (2001) has given a detailed account on the importance of nitrogen on crop plants and prospects and problems of nitrogen deficiency in the mulberry soils. Optimum quantity of nitrogen from an appropriate source increases the crop yield (Pradhan *et al.*, 1992). Prasad *et al.* (1992) opined that efficiency of nitrogen is affected by the availability of other plant nutrients, and the maximum benefits from N application can only be obtained when adequate supply of other essential plant nutrients assured.

Available Phosphorous (P₂O₅):-

Majority of the soils were low (2.94kg/ha) to high (141.3kg/ha) with a mean value of 24.5kg/ha. Out of the soils tested 36% soils exhibited high level of available P (>25kg/ha) followed by 34% low (<15kg/ha) and 30% soils recorded desired levels of available P (15-25kg/ha). Only marginal level of soils showed in higher with available P. Phosphorous is a major constituent of important organic compounds, which are, in addition to inorganic phosphorous, involved in energy utilization and storage reactions (Maschner, 1983; Dwivedi *et al.*, 1999) and ultimately biomass production. Absorption of phosphorous in plants depends on the source of nitrogen (Miller, 1970). Blair *et al.* (1970) reported that when N was supplied in NH₄⁺ form, uptake of P and sulphate ions increased. Under P-deficient conditions, even if sufficient nitrogen is applied, arginine is accumulated in plants, which lead to reduced protein synthesis (Stewart and Larher, 1980; Achtuv and Bar-Akiva, 1978). Further, silkworms fed on P-deficient mulberry leaves exhibited inhibitory growth (Kurose, 1966). These observations are of special significance since mulberry leaves are the sole food of silk producing caterpillar, *Bombyx mori* L. and the stability of silkworm crop greatly depends on the quality of mulberry leaves (Arug, 1994; Subbaswamy *et al.*, 2001).

Table 2:- Distribution (%) of soil reaction, salinity and nutrients status of mulberry garden soils of bivoltine sericultural farmers in North, South and Eastern Karnataka.

Soil Parameters	Status	Desired levels	Soil nutrient status of Karnataka			
			North (%)	South (%)	East (%)	Average (%)
No of soils	2067	--	567	134	311	--
1. Soil reaction (pH)	Low	<6.50	28	9	16	18
	Medium	6.50-7.50	39	79	66	61
	High	>7.50	38	12	12	21
2. Electrical Conductivity (EC dS/m²)	Low	<1.00	98	100	100	99
	High	>1.00	1	2	1	1
3. Organic Carbon (OC%)	Low	<0.65	71	76	76	74
	Medium	0.65-1.00	26	24	21	24
	High	>1.00	2	--	1	2
4. Available Nitrogen (N kg/ha)	Low	<280	78	72	73	74
	Medium	280-560	24	22	26	24
	High	>560.0	2	3	1	2
5. Available Phosphorous (P kg/ha)	Low	<15	44	28	31	34
	Medium	15-25	29	28	32	30
	High	>25	34	39	36	36
6. Available Potassium (K kg/ha)	Low	<120	16	14	23	18
	Medium	120-240	28	47	45	40

	High	>240	42	38	45	42
7. Available Sulphur (S ppm)	Low	<10	15	14	16	15
	Medium	10-20	33	38	32	34
	High	>20	49	54	51	51
8. Available Boron (B ppm)	Low	<0.5	54	55	60	56
	Medium	0.5-1.0	31	29	32	31
	High	>1.0	20	16	3	13

Available Potassium (K₂O):-

Available K content of Karnataka bivoltine areas varied from 60.2-773.7kg/ha with a mean value of 306.9kg/ha. Of the total, 42% soils exhibited higher level of K (>240kg/ha) was recorded followed by 40% soils with desired level of K (120-240kg/ha), whereas only 18% soils recorded lower available K (<120kg/ha) indicating that the Karnataka bivoltine farming soils showed equal number of soils with higher and required level K. The results are in conformity with the finding of earlier workers (Perur and Mityantha, 1985; Shivaprasad *et al.*, 1995; Thimmareddy *et al.*, 1999) confirming that being red and lateritic in nature Karnataka soils are medium and high in some cases with respect to available K.

Available Sulphur (S):-

In case of secondary nutrients available sulphur was prevailing in 8.10 to 218.8ppm with an average value of 35.0ppm. Further, 51% soils showed higher level S (>15ppm) followed by 34% soils with medium (10-15ppm) level of S. However, 15% of soils were recorded with low level of S (<10ppm). The results indicated that maximum Karnataka soils are either high or moderate level of S indicating congenial for mulberry.

Available Boron (B):-

Available level of boron recorded 0.06-4.73ppm with an average value of 0.71ppm in Karnataka soils. Of the total 56% soils recorded lower level of boron (<0.5ppm) followed by 31% of soils recorded with medium range of B, whereas, the same was recorded high (>1.0ppm) in 13% soils indicating the Karnataka bivoltine areas are deficient in boron and needs enrichment of the same.

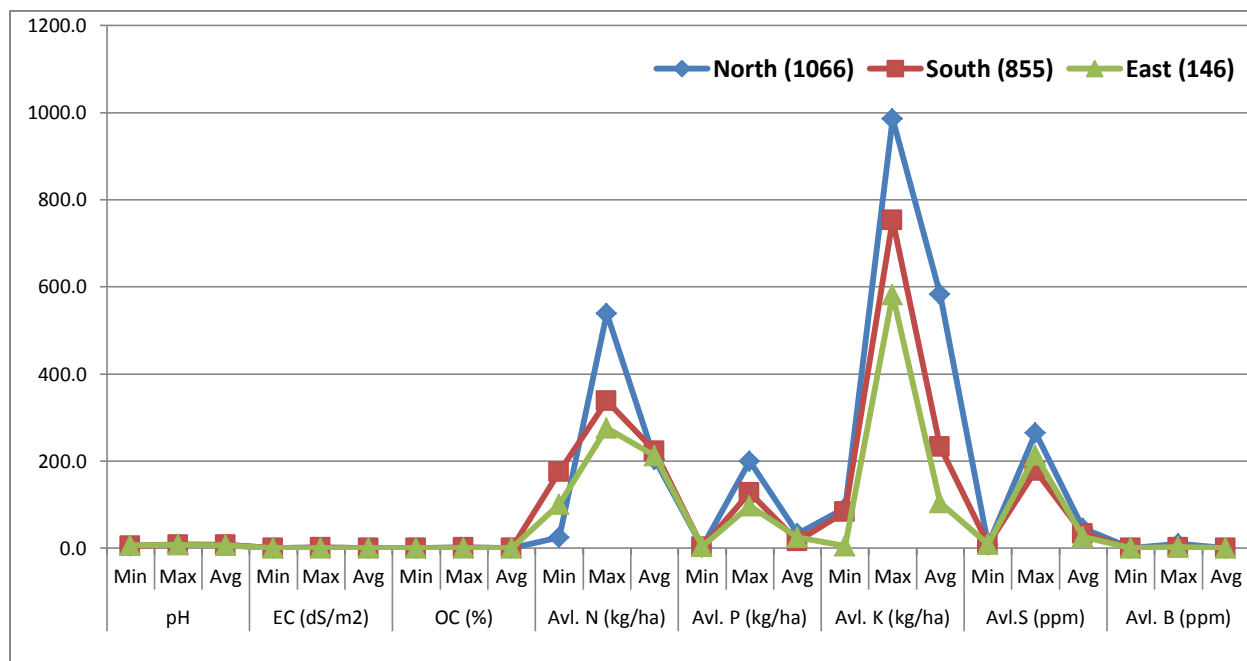


Fig. 2:- Soil reaction, salinity and nutrient status of North, South & Eastern regions of Karnataka.

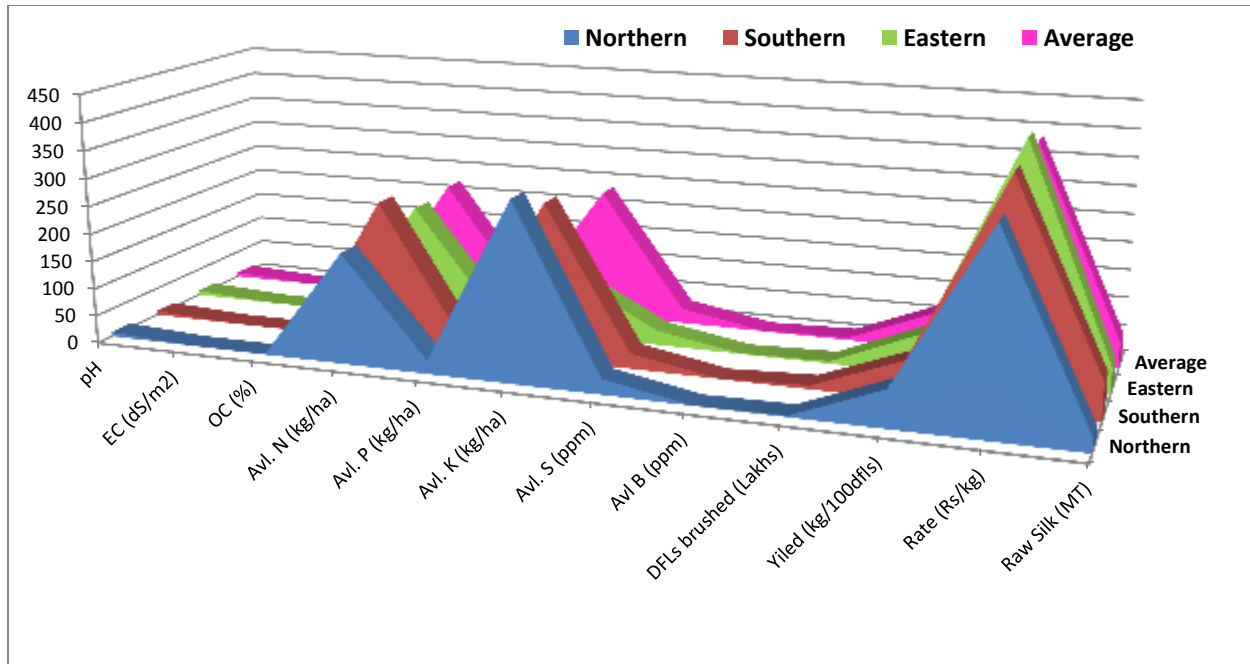


Fig. 3:- Soil reaction, salinity and soil nutrient status of mulberry soils and performance of bivoltine silkworm rearing in Karnataka.

No correlations were drawn in regard to soil reaction, salinity and nutrient parameters compared to the performance of silkworm rearing i.e. cocoon yield, silk production and market rate among the 3 regions of Karnataka as because it is imperative that, soil fertility and productivity is directly proportional to the enhanced quality cocoon production. However, irrespective of soil fertility status of the 3 regions Eastern Karnataka recorded enhanced cocoon yield (70.8kg/100dfis) with increased market rate (Rs. 420/-per kg) compared to other regions (**Fig. 3**).

Thus the compilation of soil test results showed that majority of the mulberry growing bivoltine sericultural areas were optimal for mulberry growth, low in organic carbon content, low to medium in available N₂O and P₂O₅, whereas moderate to high in available K₂O and Sulphur (S) whereas low to moderate in available Boron (B) content (**Table 2 & Fig. 2**). Hence, the sericulture farming community of Karnataka are advised to enhance application of >20-25% of the present doses of organic manures viz. FYM, compost, green manuring followed by the imparting of trenching and mulching for enhancing soil organic carbon (OC) and organic matter (OM) for improving and retaining the soil fertility and heath. Further the farmers also advised to broadcast higher doses of nitrogen, phosphatic fertilizer along with recommended dose of K is a must to maintain the soil fertility and to meet the requirement of plant. Further last but not the least the bivoltine sericultural farming community of Karnataka are also advised to take up time to time soil chemical testing of their garden soils at least once in a year or once in two years and impart soil analysis based (Soil Health Cards) soil amelioration recommendations for correcting the soil health and maintaining desired levels of soil nutrient status for cherishing mulberry with enhanced quality mulberry leaf production flourishing with enhanced cocoon production.

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