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FERTILITY STATUS OF MULBERRY (*MORUS ALBA* L.) GARDEN SOILS OF BIVOLTINE SERICULTURAL AREAS AND THEIR IMPACT ON COCOON PRODUCTION IN KARNATAKA

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ABSTRACT

It is a well-known fact that availability of organic manures are very much limited in the present day agriculture but demand for organic and inorganic nutrient supply to the soils ever growing due to intensive cropping systems. Therefore, the application of nutrients needs to be increased to keep the soil fertile and to make agriculture sustainable, but the cost of inorganic fertilizers escalating day by day making any farming is expensive. Therefore, it is essential to provide soil analysis based prescription for suitable amelioration of mulberry gardens for enhanced quality leaf and cocoon production thereby minimizing the cost of cultivation. In the present study a total of 2067 composite soil samples were collected from the traditional bivoltine sericultural areas spread over in 13 districts of Karnataka and subjected for their chemical analysis to determine the soil fertility status viz. soil type, reaction, salinity and nutrient status. Out of the soils analysed it was observed that 52% of the soils were recorded as loamy, 28% red, 12% black and 8% were lateritic indicating that large number of soils are most suitable for mulberry cultivation. In regard to the soil reaction (pH), 59% of the soils showed desirable pH (6.5-7.5), 18% low (<6.5) and 23% soils were recorded with higher pH (>7.5). Soil salinity (EC) was recorded ideal in 99% soils indicating that most of the soils bearing ideal salinity for mulberry growth (<1.0 dS/m). Organic carbon (OC) was recorded low (<0.65%) in higher number of soils (76%), desirable range (0.65-1.0%) in 23%, however negligible number of soils showed higher OC content (>1.0%). Organic carbon is considered as the fertility indicator of any soil and the same was found low in mulberry soils. Available nitrogen (N) and phosphorous (P) were recorded low (<250kg/ha; <15kg/ha) in 98% and 45% soils, respectively, whereas P was in medium level (15-25kg/ha) in 23% and higher (>25kg/ha) in 32% soils. Desirable range (120-240kg/ha) of available potassium (K) was recorded in 49% soils, low (<120kg/ha) in 20% and 31% soils are in high (>240kg/ha). Available sulphur (S) was recorded high (>15ppm) in 54% soils followed by 41% desired level (10-15ppm), whereas 5% soils shown low level (<10). In case of available boron (B) it was noticed that 44% soils recorded as low (<0.5ppm), 43% are desired level (0.5-1.0), whereas 13% soils exhibited high content of B (>1.0ppm).

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INTRODUCTION

Soil may be defined as a thin layer of earth's crust which serves as a natural medium for the growth of plants. The word "fertile" means "bearing abundantly" and a fertile soil is considered to be one that produces abundant crops under suitable environmental conditions. 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

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8-10 mt of NPK per annum in India. Blanket recommendation 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 depletion of 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). Essential plant nutrients such as N, P, K, Ca, Mg and S are called macronutrients, while Fe, Zn, Cu, Mo, Mn and B are called micronutrients. It is necessary to assess the capacity of a soil to supply nutrients in order to supply the remaining amounts of needed plant nutrients. Soils may have large amounts of nutrient reserves but all or a part of these reserves may not be of any use to crops because of their non-available farm existence. Therefore, soil needs continuous replenishment of these plant nutrients through the application of manures and fertilizers.

The selection of right kind of nutrient to be replenished and the proper quality to be applied is based on the nutrient requirement of the crop and the nutrient supplying capacity of the soil. 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 (Anonymous, 2011, 2015; Sellamuthu *et al*., 2015). Mulberry being a perennial plant trained and cultivated as seasonal crop for its foliage for decades since its plantation (>10-15 years) to feed silkworm. So, as it is cultivated for its foliage imparting hectic harvesting schedules (@5times/year) to feed silkworm demands high doses of manure and inorganic fertilizers.

Accordingly, mulberry gardens are replenished with recommended doses of NPK @350:140:140kg/ha/yr along with 20mt 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 (250-500kg/ha), P (15-25kg/ha), K (120-240kg/ha), S (10-15ppm) and B (0.5-1.0ppm) in the soils. Due to frequent harvesting of leaf shoot biomass @ 80-100mt/ha/yr it is imperative that depletion of soil reaction 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 (Basavaraja *et al.,* 2015; Bongale *et al.,* 1998; Fang Chen *et al,* 2009; Sarmah *et al*., 2013; Thimmareddy *et al*., 1999). 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

Under a research project programme entitled ***"Soil health cards for sericulture farmers in Southern States"*** soil samples of 2067 were received during the year 2016-17 from various traditional sericultural Districts of Karnataka (at 0-30cm depths) and analysed for their pH, EC and other macro and micronutrients (available N, P, K, S & B) at Soil Testing Laboratory, Regional Sericultural Research Station, Central Silk Board, Kodathi, Bangalore. Basing on the soil analysis results soil amelioration recommendations were served to the sericulturists in the form **'**Soil Health Cards' for suitable correction of their gardens for enhance quality mulberry leaf production thereby improving the quality cocoon production was the objective. Under the programme 13 important traditional sericultural Districts of Karnataka *viz.* Bangalore Rural (12º58'N-77º38'E), Bellari (15º09'N-76º55'E), Bidar (16º50'N-75º47'E), Bijapur (16º50'N-75º47'E), Chikkaballapur (13º26'N-77º46'E), Chitradurga (14º14'N-76º42'E), Gadag (15º30'N-76º36'E), Haveri (14º33'N-75º41'E), Kolar (13º16'N-78º39'E), Koppala (15º20'N-76º13'E), Ramanagaram (12º54'N-78º02'E), Tumkur (13º20'N-77º08'E) and Yadagiri (15º5'N-74º34'E) situated in varied geo-climatic tropical zones were considered for the present study. Though the study was undertaken in the same state but soil type, reaction, salinity and nutrient parameters of all the soils under the study had great variability. The soils received (2067) from the said districts includes red, lateritic, loamy and black soils. Soil samples of the mulberry farming gardens existing in various districts collected by following the standard procedures (Dandin *et al.,* 2003). Soil samples were air-dried in shade, powdered, passed through a 10µ mesh sieved and stored in a fresh polythene covers with proper labelling. Soil characters like pH, EC, OC (%), available N, P, K (kg/ha) and S, B (ppm), respectively were determined by using the standard methods (Subbaiah and Asija, 1956; Jackson, 1973).

RESULTS AND DISCUSSION

The perusal of the data presented in the Fig. 1 and Table 1 mentioned the mean values of 13 Districts as enlisted above showed heterogeneity in case of soil type and nutrient status. Maximum number of soils recorded as clay loamy soils (52%) indicating as the most favourite soils for mulberry because of their richer in plant nutrients, humus and will retain more water. This may be the reason sericulture has become main cultivation and flourishing in Karnataka. Whereas, red soils in 28% followed by 12% black soils and only 8% of soils recorded as lateritic. In case of soil pH, 59% of the soils showed desired level (6.5 to 7.5%) for mulberry, 23% high (>7.5) and 18% were with low (<6.5) pH. Large number of soils (99%) recorded with normal salinity (EC <1.0dS/m) indicating that their suitability for mulberry farming. Organic carbon (OC %) was considered as the soil fertility indicator of mulberry gardens. But the same was recorded low (<0.65%) in 76% soils and only 23% soils recorded desired level of OC% (0.65-1.0%). It is surprising to know that neglected level (1%) of mulberry gardens showed higher OC (>1.0%) indicating that Karnataka soils are deficient in OC content needs suitable amelioration measures.

Table 1. District wise distribution of soil reaction, salinity and nutrient status of bivoltine sericultural farmer's mulberry garden soils in Karnataka

Soil nutrient Parameters	*Status*	*Desired level*	*Districts wise soil reaction, salinity and nutrient status of Karnataka state*												
			Blr Rural (%)	*Be-llari (%)*	*Bidar (%)*	*Bija-pur (%)*	*Ch.Balla-pur (%)*	*Chitra Durga (%)*	*Gad-ag (%)*	*Hav-eri (%)*	*Kolar (%)*	*Kop-pal (%)*	*Rama-nagaram (%)*	*Tum-kur (%)*	*Yada-giri (%)*
No of soils	2067	--	567	134	311	203	70	35	35	79	146	67	78	210	132
pH	Low	<6.50	28	7	15	9	1	--	71	1	32	5	24	20	2
	Medium	6.50-7.50	42	87	73	72	--	74	29	61	55	74	76	70	49
	High	>7.50	30	5	12	19	99	26	--	38	13	21	--	10	49
EC (dS/m)	Low	<1.00	100	100	100	95	100	100	100	91	100	100	100	100	99
	High	>1.00	--	--	--	5	--	--	--	9	--	--	--	--	1
OC (%)	Low	<0.65	75	81	81	81	74	63	83	86	85	75	70	58	76
	Medium	0.65-1.00	25	19	18	17	26	37	17	14	13	25	30	42	22
	High	>1.00	--	--	1	2	--	--	--	--	2	--	--	--	2
Avl. N (kg/ha)	Low	<280	97	100	100	95	94	100	100	100	100	100	100	96	96
	Medium	280-560	3	--	--	5	6	--	--	--	--	--	--	4	4
	High	>560.0	--	--	--	--	--	--	--	--	--	--	--	--	--
Avl. P (kg/ha)	Low	<15	46	28	32	54	57	86	6	37	46	48	71	66	23
	Medium	15-25	18	25	29	19	19	14	26	27	16	40	19	29	24
	High	>25	36	47	39	27	24	--	69	37	38	9	10	5	53
Avl. K (kg/ha)	Low	<120	16	14	23	20	14	14	14	25	23	18	18	28	24
	Medium	120-240	26	71	65	50	57	72	57	50	49	37	60	56	58
	High	>240	58	15	12	30	29	14	29	24	27	45	22	16	18
Avl. S (ppm)	Low	<10	6	--	4	6	13	6	--	9	10	--	--	1	8
	Medium	10-20	45	46	45	51	37	71	6	19	33	30	37	27	42
	High	>20	49	54	51	43	50	23	94	72	57	70	63	72	50
Avl. B (ppm)	Low	<0.5	39	27	49	42	39	63	77	29	34	39	49	64	47
	Medium	0.5-1.0	41	57	48	41	44	26	23	23	49	60	51	32	51
	High	>1.0	20	16	3	17	17	11	--	48	17	02	--	4	2

Similarly 98% soils recorded with low (<250kg/ha) available N whereas only 2% soils showed desired level (280-560kg/ha) alarming that mulberry soils of Karnataka are deficient in available N. Available P was low (<15kg/ha) in 45% soils followed by high in 32% (>25kg/ha) and the same was recorded medium level in 23% soils (15-25kg/ha). Potassium content was medium in 49% soils (120-240kg/ha) followed by 31% high (>240kg/ha) and the same was least in 20% soils (<120kg/ha). Nitrogen and phosphorous are the plant growth limiting nutrients, which are commonly applied to mulberry gardens for effective crop production. 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. Whereas, 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) and ultimately biomass production. Absorption of phosphorous in plants depends on the source of nitrogen. Under P-deficient conditions, even if sufficient nitrogen is applied, argentine is accumulated in plants, which lead to reduced protein synthesis (Subbaswamy *et al.,* 2001).

Kurose (1966) opined that silkworms fed on P-deficient mulberry leaves exhibited inhibitory growth. 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 (Aruga, 1994). In case of micro nutrients, sulphur was high (>15ppm) in 54% soils followed by 41% soils at desired level (10-15ppm) and 5% soils are low (<10ppm). However, boron (B) was low (<0.5ppm) in 44% soils followed by 43% soils desired level (0.5-1.0ppm), whereas the same was showed high (>1.0ppm) in 13% soils. The presence of K and S were observed to be either high are moderate indicating their presence is congenial for mulberry, but boron presence was deficient. District wise distribution of soil fertility status of sericulturists mulberry gardens in Karnataka also resulted similar trend as depicted earlier (Table 2). Most of the districts exhibited ideal pH, EC, low level of OC, available N, P and Sulphur where as increased level of potassium and Boron. In case of minimum, maximum and mean values of soil pH, EC and other macro and micro nutrients (N,P,K,S & B) among the respective districts revealed that all the district soils indicated desired levels of mean values of soil reaction, salinity and nutrient status. However, higher levels of K, S and B was noticed, however the other soil reaction and nutrient

Table 2 District wise soil reaction, salinity and nutrient status of bivoltine farmers mulberry garden soils of Karnataka

Districts	*No of Soils*	*Range*	*Soil reaction, salinity & nutrient status*							
			pH	*EC*	*OC%*	*Avl N*	*Avl P*	*Avl K*	*Avl S*	*Avl B*
Bangalore Rural	567	Min	5.49	0.048	0.055	62.72	0.45	89.6	6.85	0.02
		Max	7.55	0.97	1.596	602.1	127.68	941.0	265.2	1.19
		Avg	6.52	0.34	0.450	322.3	20.3	378.9	22.8	0.75
Bellari	134	Min	6.19	0.50	0.06	175.6	4.26	101.2	10.83	0.09
		Max	7.94	0.90	0.87	276.0	79.7	873.1	124.3	1.52
		Avg	7.07	0.41	0.45	231.8	27.1	367.2	26.1	0.72
Bidar	311	Min	5.38	0.01	0.06	125.44	2.24	87.2	7.2	0.09
		Max	6.87	0.92	1.01	213.21	166.2	748.2	213.0	1.64
		Avg	6.13	0.17	0.40	154.2	27.2	213.3	26.9	0.49
Bijapur	203	Min	5.92	0.181	0.229	175.6	16.8	224.0	35.9	0.32
		Max	8.73	1.863	1.049	539.39	135.5	986.0	123.5	10.28
		Avg	7.33	0.29	0.39	212.0	21.2	236.4	25.72	0.73
Chikkaballapur	70	Min	5.49	0.033	0.058	163.1	0.45	73.1	8.44	0.09
		Max	8.86	0.416	0.981	439.4	199.8	817.2	82.09	1.52
		Avg	7.18	0.20	0.46	235.6	23.2	162.5	21.05	0.63
Chitradurga	35	Min	6.88	0.10	0.06	25.09	2.73	107.5	9.24	0.04
		Max	8.30	0.76	6.0	235.9	22.18	698.8	35.11	1.71
		Avg	7.59	0.37	0.88	229.4	10.9	398.9	16.99	0.49
Gadag	35	Min	6.08	0.217	0.16	175.6	12.9	161.3	12.82	0.19
		Max	7.1	0.52	0.98	255.9	68.5	752.6	82.09	0.83
		Avg	6.59	0.39	0.50	203.93	35.6	326.2	30.3	0.42
Haveri	79	Min	6.16	0.085	0.112	138.0	1.57	137.0	7.2	0.15
		Max	8.29	1.45	0.923	225.8	126.56	254.0	265.2	2.44
		Avg	7.23	0.49	0.45	180.9	25.6	365.2	45.5	0.89
Kolar	146	Min	5.89	0.041	0.059	100.35	4.26	5.15	8.8	0.09
		Max	7.91	0.863	0.881	276.0	96.54	582.0	213.1	2.49
		Avg	6.90	0.32	0.35	211.7	24.8	104.5	26.1	0.69
Koppala	67	Min	6.25	0.113	0.094	125.44	7.39	92.1	12.0	0.16
		Max	7.75	0.841	0.962	200.7	59.36	643.2	231.0	1.22
		Avg	7.00	0.40	0.49	158.9	17.77	213.1	32.64	0.55
Ramanagaram	78	Min	5.49	0.105	0.055	175.6	4.7	83.4	8.3	0.09
		Max	7.55	0.97	0.958	276	127.68	753.2	178.0	1.41
		Avg	6.52	0.36	0.51	217.58	15.98	232.8	24.67	0.55
Tumkur	210	Min	5.75	0.12	0.06	175.6	2.33	83.2	9.2	0.04
		Max	7.93	0.52	1.14	338.7	103.0	412.3	163.3	1.5
		Avg	6.84	0.32	0.6	223.0	15.2	224.8	33.5	0.4
Yadagiri	132	Min	6.20	0.11	0.06	213.2	2.69	179.0	6.98	0.02
		Max	8.22	1.29	1.14	263.4	147.62	371.9	67.20	1.36
		Avg	7.21	0.36	0.48	179.5	32.8	583.3	23.7	0.50

EC = dS/m, **Avl.N, P & K** = kg/ha; **Avl. S & B** = ppm.

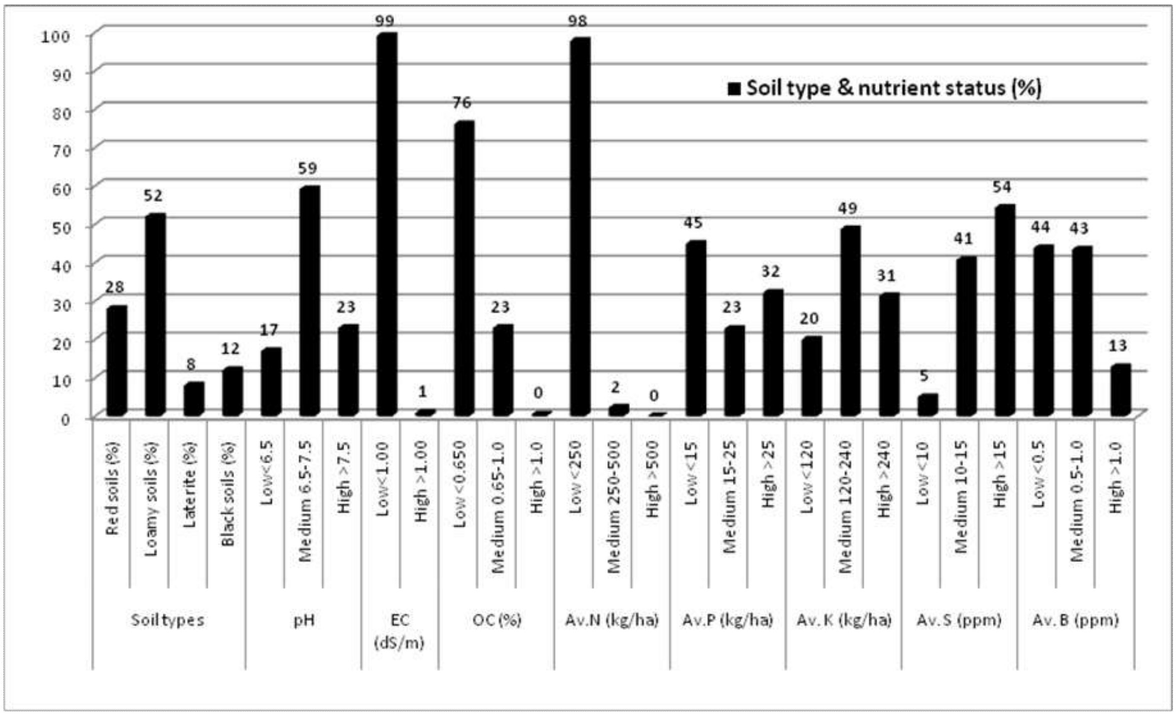

Fig. 1. Soil type, recation, salinity and nutrients status of the mulberry gardens in Karnataka

Table 3. District wise soil reaction, salinity and nutrient status of bivoltine farmers mulberry garden soils of Karnataka

Districts	No of soils	Soil reaction & nutrient status								Rearing performance			
		pH	EC (dS/m)	OC (%)	Avl. N (kg/ ha)	Avl. P (kg/ha)	Avl. K (kg/ha)	Avl. S (ppm)	Avl. B (ppm)	DFLs bru-shed (Lakh)	Yield/ 100 DFLs (kg)	Rate/ (Rs/ kg)	Est.Raw silk (MT)
Bangalore (R)	567	6.52	0.34	0.45	322	20	379	23	0.8	5.2	68.3	381	54.1
Bellari	134	7.07	0.41	0.45	232	27	367	26	0.7	5.3	62.6	381	51.0
Bidar	311	6.13	0.17	0.40	154.	27	213	27	0.5	3.4	67.2	320	30.2
Bijapur	203	7.33	0.29	0.39	212	21	236	26	0.7	4.4	67.4	365	43.0
Chikkaballapur	70	7.18	0.20	0.46	235	23	163	21	0.6	1.9	66.6	352	14.5
Chitradurga	35	7.59	0.37	0.88	229	11	399	17	0.5	2.1	65.8	398	21.7
Gadag	35	6.59	0.39	0.50	204	36	326	30	0.4	2.2	63.9	370	22.3
Haveri	79	7.23	0.49	0.45	181	26	365	46	0.9	3.0	70.3	315	29.1
Kolar	146	6.90	0.32	0.35	212	25	105	26	0.7	4.7	70.8	420	46.4
Koppala	67	7.00	0.40	0.49	159	18	213	33	0.6	1.4	64.7	340	14.5
Ramanagaram	78	6.52	0.36	0.51	218	16	233	25	0.6	2.8	64.4	404	24.3
Tumkur	210	6.84	0.32	0.60	223	15	225	34	0.4	12.6	71.2	392	124.4
Yadagiri	132	7.21	0.36	0.48	180	33	583	24	0.50	0.7	61.6	279	6.4
Total/ Avg	2067	--	--	--	--	--	--	--	--	49.61	67.1	363	481.7

EC = dS/m, **Avl.N, P & K** = kg/ha; **Avl. S & B** = ppm.

parameters were recorded in the admissible ranges indicating congenial conditions for mulberry cultivation (Table 3).No correlation was drawn in regard to soil reaction and nutrient parameters compared to the performance of silkworm rearing i.e. cocoon yield, silk production and market rate among the 13 District soil samples of sericultural farmers garden soils. Irrespective of soil nutrient status all the Districts have yielded appreciable cocoons ranging from 61.6kg to 71.2kg/100dfls with a market rate of Rs. 279/- to Rs. 404/- per kg. Further out of all the Districts of Karnataka Tumkur District has contributed in brushing of highest no. of DFLs (12.56 lakhs) with 124.35mt raw silk production where as Yadagiri District has performed in brushing of least no. of DFLs (0.68 lakhs) with 6.43mt raw silk production (Table 3).

Soil test based fertilizer prescription necessitates avoiding over use or under use of fertilizers for crop requirement. Therefore, the present investigation is an attempt to provide support and assist the sericultural farming community to improve their mulberry gardens for enhanced quality mulberry leaf production. In any farming farmers have to adopt give and take mechanism with their farming practices. Frequent harvesting of a crop is directly proportional to up taking of that much nutrients from soil. Therefore, it is an imperative to supplement additional quantity of nutrient in the farm of organic manures (FYM) and inorganic fertilizers (NPK & other secondary and micro nutrients basing on the requirement (Dandin *et al*., 2003). Soil analysis based advisories are necessary to improve crop productivity and to increase nutrient use efficiency. Judicious application of fertilizer targeting both high yields and nutrient efficiency will benefit farmers, society, and the environment alike. Therefore, the sericultural farming community is 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 leaf and flourishing with enhanced quality cocoon production.

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