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Fertility Assessment of Soil and Suitable Amelioration for Sustainable Quality Mulberry Leaf and Cocoon Production in Karnataka

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Abstract

The composite soil samples received from the various cluster sericulture farmer mulberry gardens (2067) of Karnataka state were subjected for their physical and chemical analysis for measuring their nutrient status. It was noticed that 52% soils characterised as clay loamy, 28% red loamy, 12% black cotton and only 8% soils were red lateritic in nature. Soil pH was recorded in the range of 6.10-7.96 with 7.03 average pH. Among them 59% soils comprised with desired pH (6.5 to 7.5%), 21% with high pH (>7.5) and 20% recorded with low pH (<6.5). Soluble salt content (EC) of the mulberry soils ranged from 0.11 to 0.90 with a mean value of 0.69 dS/m. All most all the soils of the state (99%) recorded with desired levels of EC (<1.0 dS/m2) indicating ideal for mulberry. Organic Carbon (OC) was ranged from 0.12-1.06 with a mean value of 0.64%. Out of the soils 74% recorded with low OC (<0.65%) followed by 24% desired (0.65-1.0%) and 2% in rich OC (>1.0%) indicating that soils received were deficient in OC. The macronutrients (N, P & K) presence and distribution revealed that, available Nitrogen (N) registered in 116.4-349.8 with 212.3kg/ha average content. Similarly 76% soils registered with low level of available nitrogen (<250kg/ha), 23% in medium (250-500kg/ha) whereas 1% with high N (>500kg/ha). Phosphorous (P) in the range of 3.69-103.9 with an average value of 30.1kg/ha. However the distribution of available P is in the ratio of 36:34:30 of high (P>25kg/ha), low (P<15kg/ha) and desired levels of P (15-25kg/ha), respectively. Potassium (K) content was ranged in 181.7-905.4 with a mean value of 521.7kg/ha. The K distribution was high (>240kg/ha) in 42% soils followed by 40% in desired level (120-240kg/ha) and 18% soils recorded with lower quantities of available K (<120kg/ha). The micronutrients such as available Sulphur (S) and Boron (B) present in the range of 10.50-117.30 and 0.08-2.87 with a mean value of 63.90 & 1.48 ppm/ha, respectively. Sulphur distribution was noticed that 71% soils registered rich in S (>15ppm), 21% medium (10-15ppm/ha) and 15% soils represent deprived levels of S (<10ppm). Boron was found medium level (0.5-1.0ppm/ha) in 48% soils followed by 30% with low level B (<0.5ppm/ha) and 22% soils with high amount of B (>1.0ppm/ha). Based on the above findings suitable soil amelioration prescriptions were served in the form of 'Soil Health Cards' for correcting their mulberry gardens to minimise the cost of production thereby achieving quality mulberry leaf production for the development of Bivoltine sericulture.

1. Introduction

Mulberry (*Morus alba* L.) being perennial in habit cultivated by training as seasonal crop for its foliage to feed silkworm demands high doses of organic manures and inorganic fertilizers. As it is grown for its foliage 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), Sulphur (S: 10-15ppm/ha) and Boron (B: 0.5-1.0ppm/ha) in the soils. Therefore, for its sustainable growth and leaf production by maintaining desirable levels of soil fertility status it has been prescribed NPK @350:140:140kg/ha/yr and 20MT FYM/ha/yr, respectively for irrigated mulberry cultivated in the tropical

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eco-zones of South India (Dandin *et al*., 2003). Even though use of recommended doses of manures and fertilizers plays a pivotal role in mulberry leaf yield and quality, the adoption of the same is not found up to the satisfaction level at the farmers level resulting in low mulberry yield and soil fertility (Sarkar, 2000). Further, hectic crop schedules and frequent harvesting (5 crops/yr) of leaf shoot biomass @80-100mt/ha/yr it is imperative that depletion of soil fertility status of mulberry gardens is a regular phenomenon. It is also reported that blanket recommendation of fertilisers lead to over or under use of fertilisers ultimately deterioration of soil health (Anonymous, 2011). Frequent cultural operations, inorganic fertilizer applications, imparting of disease 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. Therefore, frequent supplementation of essential macro and micro nutrients along with sufficient manuring of various kinds for conditioning soils and balancing the soil 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 and cocoon production (Fang Chen *et al.,* 2009).

Even though since 4 decades the mulberry soils of Karnataka are utilized for the production of leaf, but efforts to detect the soil fertility status time to time and recommending suitable analysis based soil amelioration prescriptions for enhanced mulberry leaf and cocoon production are limited (Kar *et al.,* 2008; Subbaswamy *et al*., 2001). Cluster Promotion Programme (CPP) was implemented under XI & XII five year plans during 2012-2017 in India for boosting the bivoltine sericulture with a target of >5000MT/yr raw silk production. For which the state and Central Govt. jointly organised 178 clusters all over the India out of which 46 clusters were implemented in Karnataka. Even though with all the above efforts we could successfully achieve the targeted bivoltine raw silk production, but still we are lagging behind in succeeding the 3A & above grade silk production and not gaining anticipated market rates by the sericultural farming community. The reasons are many, but low level adoption of recommended package of practices in mulberry cultivation is the predominant reason. Though the farming community has been extended suitable package of practices for production of quality mulberry leaf, but due to continuous and long term harvesting of mulberry crops (ranging from 10-15 years) & either supplementing or not the required doses of manures and fertiliser leading to depletion of soil nutrient status. Further, draining of soil nutrients due to heavy and untimely rains, drought spell situations limiting the nutrients uptake and lacking the technical knowhow of adoption of soil testing and imparting analysis based amelioration of garden soils are the main reasons. Therefore, it is necessary to assess the current soil nutrient status of prominent bivoltine sericulture areas of Karnataka and extending soil analysis based amelioration recommendation in the form of **'Soil Health Cards'** for improving their mulberry soils for enhanced sustainable quality mulberry leaf and cocoon production.

2. Materials and Methods

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 sericulture 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 following the standard procedure as detailed by Sudhakar *et al*., 2018. 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. The perusal of the analysis results were presented in the results and discussed.

Figure 1: Soil collection and their analysis activities at Soil Testing Laboratory, RSRS, Bangalore

3. Results and Discussion

With the above objective a research programme was initiated entitled ***"Soil health cards for sericulture farmers in Southern States"*** at Central Sericultural Research & Training Institute (CSRTI) Mysore. Under the programme Institute as well as the Regional Sericultural Research Stations (RSRS) of Bangalore (Karnataka), Salem (Tamil Nadu) and Ananthapur (Andhra Pradesh) were assigned to collect as many soils of sericulture areas and assess for their reaction, salinity and major and micronutrients of mulberry soils and issue analysis based amelioration recommendations in the form of **'Soil Health Cards'** for sustainable leaf and cocoon production. Under

the programme 2067 soil samples received during 2016-17 (0-30cm depth) from 20 CPP areas spread over 13 districts under Karnataka and analysed for their status and revealed the below:

3.1. Soil Characterization (types)

Out of the soils received 52% were characterised as clay loamy type of soils indicating as the most suitable for mulberry growth 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 blooming cultivation in Karnataka. However, 28% soils were red loamy type followed by 12% as black cotton soils and only 8% of soils were sorted out as red lateritic (Table 1, 2).

3.2. Soil Reaction (pH)

The soil reaction was recorded with a minimum of 6.10 to maximum level of 7.96 with an average soil pH of 7.03. Among the soils received 59% recorded with desired level of pH (6.5 to 7.5%), 21% with high pH (>7.5) whereas only 20% soils showed low pH level (<6.5). Therefore, the undesired soils such as low & high pH type instead of imparting any type of chemical correction the farmers were advised to impart eco-friendly inputs application such as enhanced manuring (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.

3.3. Total soluble salts (EC)

The total soluble salt content (EC) of the cluster farmers soils of Karnataka were ranged from 0.11 to 0.90 dS/m with a mean value of 0.69 dS/m. All most all the soils of the state recorded (99%) with desired levels of electrical conductivity (<1.0 dS/m) indicating as no harmful EC prevailed in the mulberry soils. The results indicated that mulberry growing soils of Karnataka bivoltine area were normal with respect to soil salinity. Salinity of any farming soils play very important role in mobilizing the plant nutrients and promoting the uptake of supplemented manure and fertilizers.

Table 1: Soil analysis nutrient values of the sericulture farmers mulberry gardens in Karnataka

Soil nutrient parameters	Minimum	Maximum	Mean values of the soil nutrients
Soil pH	6.10	7.96	7.03
Electrical conductivity (EC dS/m)	0.11	0.90	0.51
Organic Carbon (OC%)	0.12	1.06	0.59
Available Nitrogen (N kg/ha)	116.40	349.80	233.10
Available Phosphorous (P kg/ha)	3.69	103.90	53.80
Available Potassium (K kg/ha)	181.70	905.40	543.55
Available Sulphur (S ppm/ha)	10.50	117.30	63.90
Available Boron (B ppm/ha)	0.08	2.87	1.48

3.4. Organic carbon (OC)

OC content varied from 0.12 to 1.06% with an average value of 0.64%. Among the soils 74% were recorded with low (<0.65%) OC content, 24% with desired (0.65-1.0%), however only 2% were with higher OC (>1.0%) indicating that almost ¾ soils are deficient in OC (Table 1, 2). Soil organic carbon is considered as the fertility indicator of any farming soils. Moreover, OC considered as an important parameter that controls sustainability of crop production through conditioning of soil physical properties, acting as a reservoir of essential nutrients and promote maximum utilization of the inorganic fertilizers supplemented converting into available form. Therefore, the Karnataka soils of bivoltine area were advised to enhance organic inputs (manures) application followed by the regular imparting of green manuring and trenching & mulching during monsoon as a mandatory of serifarming.

3.5. Available nitrogen (N)

Macro nutrient Nitrogen was recorded with minimum level of 116.4kg/ha to maximum of 349.8kg/ha with 212.3kg/ha mean value. Available N was noticed low (<250kg/ha) in 76% soils, 23% with medium level (250-500kg/ha) whereas 1% soils showed high in available N (>500kg/ha) indicating that mulberry soils of Karnataka 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) gave a detailed account on the importance of nitrogen on mulberry crop plants. Optimum level 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.

3.6. Available phosphorous (P)

Available P recorded in 3.69kg/ha minimum level to maximum of 103.9kg/ha with an average value of P (30.1kg/ha). Out of the soils analysed more or less all the soils prevailed in equal ratio of available P in Karnataka sericulture areas i.e. 36% soils with high (P >25kg/ha), 34% low (P <15kg/ha) and 30% soils

Table 2: Soil reaction and nutrient distribution ratio among the sericulture farmers mulberry gardens of Karnataka State

Soil type/ nutrient parameters	Soil type/ nutrient ranges	Soil types & Nutrients distribution ratio (%)
Soil type	Red	28
	Loamy	52
	Lateritic	8
	Black	12
Soil pH	<6.5	20
	6.5-7.5	59
	>7.5	21
Electrical conductivity (EC dS/m)	<1.00	97
	>1.00	3
Organic Carbon (OC%)	<0.65	80
	0.65-1.00	19
	>1.00	1
Available Nitrogen (N kg/ha)	<250	70
	250-500	28
	>500	2
Available Phosphorous (P kg/ha)	<10	28
	10-20	28
	>20	44
Available Potassium (K kg/ha)	<110	7
	110-240	31
	>240	62
Available Sulphur (S ppm/ha)	<0.5	30
	0.5-1.0	48
	>1.0	22
Available Boron (B ppm/ha)	<10	8
	10-15	21
	>15	71

recorded in desired levels (P in 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 and ultimately biomass production. Absorption of P in plants depends on the source of nitrogen. It is reported that when N was supplied in NH_4^+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. 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.

3.7. Available Potassium (K)

Available K content of Karnataka bivoltine areas varied from 181.7-905.4kg/ha with a mean value of 521.7kg/ha. Of the total soils distribution, 42% soils exhibited rich in K (>240kg/ha) 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 ratio of potassium in high and medium levels. The Karnataka soils being red and lateritic in nature proved that they are rich in available K.

3.8. Available sulphur (S)

In case of micro nutrients analysed, available Sulphur was recorded with a minimum value of 10.50/ha to 117.30ppm/ha with an average S presence of 63.90ppm/ha. Out of the soils analysed 71% were registered with high in available S (>15ppm), 21% in medium level (10-15ppm/ha) and 15% soils with low level of S (<10ppm) in potassium content. It can be inferred that Karnataka mulberry garden soils are rich in available Sulphur content indicating congenial for mulberry growth.

3.9. Available boron (B)

Available level of Boron (B) was recorded in the range of 0.08-2.87ppm/ha with a mean value of 1.48ppm/ha. Out of the whole soils analysed (2067), 48% soils recorded with medium level of B (0.5-1.0ppm/ha) followed by 30% with low level of B (<0.5ppm/ha) and 22% soils registered with high amount of B (>1.0ppm/ha) showing that Karnataka bivoltine sericulture areas are deficient in Boron and needs Boron enrichment for their mulberry garden soils (Table 1,2).

The soil analysis results were also compiled and compared among the North, South and Eastern Karnataka state eco-climatic sericulture zones but not much variation was noticed among the prevailing of soil reaction and nutrient status and their distribution (Figure 2). Thus the compilation of soil test results showed that majority of the mulberry growing bivoltine sericulture areas were optimal for mulberry growth, low in organic carbon content, low to medium in available N and P, whereas moderate to high in available K and Sulphur (S) whereas low to moderate in available Boron (B) content. Hence, the sericulture farming community of Karnataka state were advised to enhance application of 20-25% of the present recommended doses of organic manure (FYM @ 20MT/ha/yr) followed by the practicing green manuring and imparting of trenching and mulching during the monsoon of every year for enhancing the soil organic carbon (OC) and organic matter (OM) for improving and retaining the soil fertility and

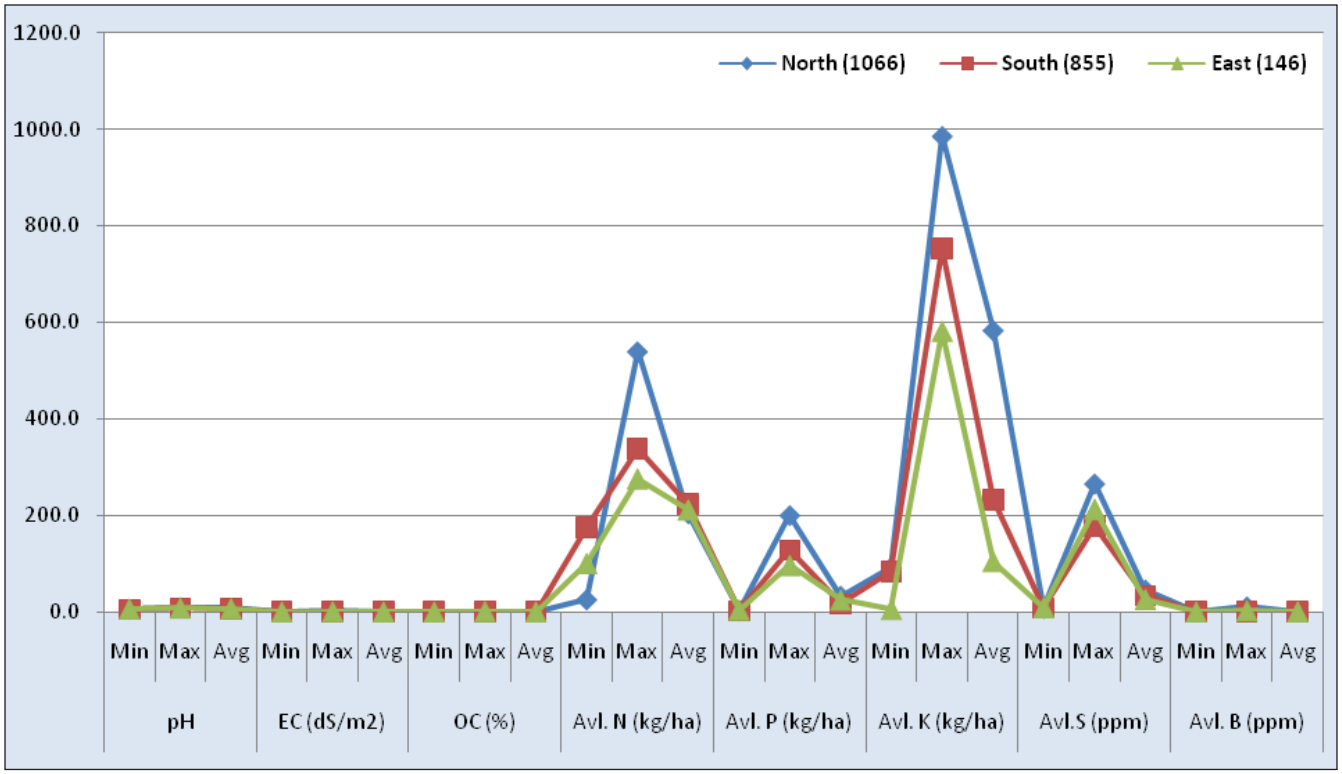

Figure 2: Soil reaction, salinity and nutrient status of North, South & Eastern regions of Karnataka

heath. Further the farmers are also advised to broadcast recommended doses of Nitrogen, Phosphorous and Potassium (NPK @350:140:140kg/ha/yr) as routine practice to maintain the soil fertility and to meet the requirement of mulberry plants nutrition. Further, the bivoltine sericulture 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 and flourishing with enhanced gradable cocoon production.

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