

Site Specific Fertilizer Recommendation for Tea: A Case Study

S. M. T. J. Senanayake, and R. B. Mapa
Uva Wellassa University, Badulle, Sri Lanka

and

A. Wijsekere
CIC Laboratory, Pelwehera, Dambulle, Sri Lanka

Introduction

The average productivity of the tea sector in Sri Lanka remains low compared to competitors mainly due to the decline of soil fertility. Total tea production in 2011 declined marginally by 0.3% accounting to 328.6 million kg over 2010. Fertilizer and its application account for about 8-12% of the total cost of production in tea. Generally, a blanket fertilizers recommendation is used on the basis of made tea yields for different tea growing regions in the country. Plant nutrient reserves or deficiencies in the soil are not considered in such recommendations. Therefore, less application or over application of certain plant nutrients could occur. Less application of plant nutrients creates reduction of yield and soil fertility decline, while over application results in increased cost of production and environmental problems. Proposing fertilizer recommendations based on soil nutrient data for a given field is called Site-Specific Fertilizer Recommendation (SSFR). SSFR optimizes crop yield and thereby increase profits while reducing the loss of nutrients. The main objective of this study was to propose a Site Specific Fertilizer Recommendation for No-16 field, Balagalle Division of Glen Alpin Estate in Badulle. This was achieved by characterizing soil chemical properties of the given field such as pH, EC, macro-nutrients (P, K, Mg and Ca). The measured data were used to propose SSFR and a sampling scheme for future studies for the given site.

Methodology

A field of 2ha in extent with vegetatively propagated tea was selected from No-16 field, Balagalle Division, Glen Alpin Estate at Badulle in Uva region of Sri Lanka. It is in the Intermediate zone, mid country Agro-ecological Region (IM -3) and the soil belongs to Red Yellow Podzolic Great Soil Group classified as Rhodudults according to USDA Soil Taxonomy. To adopt the site specific approach, the following steps were followed. Collecting and tabulation of past information about the given field (extent, type of tea, fertilizer practices, monthly yield records), soil sampling, analyzing and interpretation of data to assess specific nutrient inputs using TRI circular No: 01/08 (Anonymous, 2008).

Vegetatively propagated TRI 2025 is cultivated in this field and the potential yield above 3500 (kg/ha/yr) made tea. Thirty soil samples were collected randomly and the following analysis were conducted at the CIC - Laboratory at Pelwehera, Dambulla.

Electric conductivity was determined by using EC meter for a soil: water suspension of 1:5, soil pH was determined by using glass electrode method and exchangeable cations (K, Ca, Mg) were determined using Atomic Absorption Spectrophotometer (Bigham, 1996). Extractable P was determined using BORAX method (Zoysa, 2008). Trace elements (Zn, Cu, Mn, Fe) were determined using DTPA (diethylenetriaminepenta acetic acid) with the Atomic Absorption Spectrophotometer (Bigham, 1996).

Results and Discussion

Results of exploratory data analysis for soil EC, pH & macro-nutrients are given in Table 1.

Table 1: Results of exploratory data analysis for soil EC, pH and macro-nutrients

Property	Mean	±SD	Min	Max
EC ($\mu\text{s}/\text{cm}$)	45.2	131.8	37.7	594
pH	4.77	1.08	0.75	6.95
P (ppm)	88.89	47.31	17	201
Ca(ppm)	28.42	21.73	3.12	79
Mg(ppm)	150.1	95.0	21	334.6
K (ppm)	88.35	32.97	28.87	170.3

(SD = Standard Deviation, Min= Minimum, Max=Maximum)

The recommendations given in TRI circular No: 01/08 (Anonymous, 2008) for available P, exchangeable K and Mg for Uva region for different yield categories are given in Table 2. The mean soil analysis values for macro-nutrients given in Table 1 were used to arrive at site specific fertilizer recommendation for the given field. Tea Research Institute (TRI) has recommended to apply 60ppm of Mg, 200ppm of K and 20ppm of P for 3000-3500 and above 3500 kg/ha/yr potential yield. The available amounts were 20.96 ppm of Mg, 50.5 ppm of K and 17 ppm of P in No-16 field, Balagalle Division, Glen Alpin Estate, Badulle. Therefore, the deviations were 39.04ppm of Mg, 149.5 ppm of K and 3ppm of P. Potassium deficiency was comparatively higher than the other two macronutrients according to optimum requirements. These are indicated in Figure 1.

Table 2: Recommendations of available P, exchangeable K and exchangeable Mg according to TRI circular

Region	Potential Yield	Recommended ppm levels (P, K, Mg)	Recommended quantity of (P_2O_5 , K_2O and Kieserite) (kg/ha/yr)
Uva	Above 3500	20: 200: 60	35: 140: 125

Region	Potential Yield	Resulted ppm levels (P, K, Mg)	Additional quantity of (P_2O_5 , K_2O and Kieserite) (kg/ha/yr)	Recommended quantity of (P_2O_5 , K_2O and Kieserite) (kg/ha/yr)
Uva	Above 3500	17: 50.5: 20.96	5.25: 104.65: 81.33	40.25: 244.65: 206.33

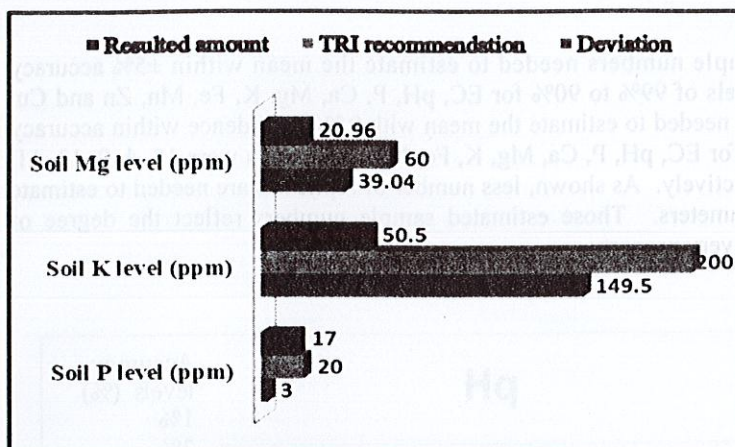


Figure 1: Mean values of macro-nutrients for the given field with TRI recommendations and the deviation between the two

The mean soil pH value was 4.77 for the given field (Table 1) and the recommended rates of liming material was obtained according to information supplied by TRI as given in Table 3. Accordingly, 1000 kg/ha/yr of dolomite is recommended to maintain the optimum pH level for tea.

Table 3: The quantity of dolomite needed to be applied according to pH levels for tea soils in Uva region

Soil pH	Dolomite (kg/ha)
Below 3.9	2500
From 3.9 up to 4.2	2000
From 4.2 up to 4.5	1500
Above 4.5	1000

Source: Hand Book on Tea, 2008

Using the summary statistics given in Tables 1 and 3 the sample size required to obtain an estimate of the mean for a given precision level at a specified confidence level was estimated using the equation given bellow (Petersen and Calvin, 1986)

$$N = T_{\alpha}^2 S^2 / D^2$$

N – the sample size required

t^2 – the t with $(n-1)$ degrees of freedom at the specified probability level α

S^2 – the variance obtained from measured samples

D^2 – the specified confidence interval at a given accuracy level (%)

Figure 2 gives a visual picture for the sample number needed to any future experimenter to decide on the accuracy level that could be maintained for soil pH according to the resources available. The three accuracy levels selected for pH which showed the lowest variation were $\pm 1\%$, $\pm 3\%$ and $\pm 5\%$ within the true mean.

Table 5 shows the sample numbers needed to estimate the mean within $\pm 5\%$ accuracy with the probability levels of 99% to 90% for EC, pH, P, Ca, Mg, K, Fe, Mn, Zn and Cu. The number of samples needed to estimate the mean with 95% confidence within accuracy levels of $\pm 5\%$ of mean for EC, pH, P, Ca, Mg, K, Fe, Mn, Zn and Cu were 15, 4, 9, 13, 11, 6, 6, 11, 12 and 6, respectively. As shown, less number of replicates are needed to estimate pH than for other parameters. Those estimated sample numbers reflect the degree of variability of each and every property.

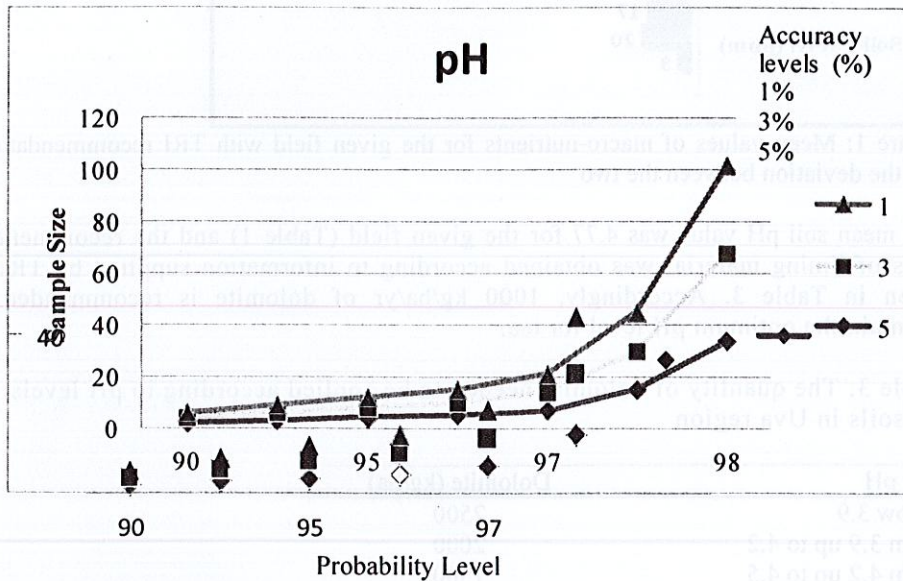


Figure 2: Estimated sample numbers for pH for a given accuracy level for 90% to 99% probability levels.

Table 5: The minimum sample numbers required to estimate the mean with an accuracy level of $\pm 5\%$ at given probability level for different soil properties for the given site.

Probability levels	EC	pH	P	Ca	Mg	K	Fe	Mn	Zn	Cu
90	3	1	2	2	2	1	1	2	2	2
95	15	4	9	13	11	6	6	11	12	9
98	137	34	81	116	96	57	55	100	112	86
99	690	172	404	581	481	283	278	502	562	430

The main purpose of a soil sampling scheme is to estimate the properties with an accuracy level that can estimate the mean at the least possible cost.

Conclusions

Available amounts of macro-nutrients were 21ppm of Mg, 50.5ppm of K and 17ppm of P in field No-16 in Glen Alpin Estate, Badulle. According to TRI recommendations the deficiencies are 39.04ppm of Mg, 149.5ppm of K and 3ppm of P for this soil, Therefore the site specific recommendation is 40.25 kg/ha/yr of P₂O₅, 244.65 kg/ha/yr of K₂O and 206.33 kg/ha/yr. Phosphorus was recommended as Eppawela Rock phosphate (ERP), K was recommended as Muriate of Potash (MOP) and Mg was recommended as Kieserite. The measured available micro-nutrient levels were 0.9 ppm of Zn, 1.41 ppm of Mn, 1ppm of Fe and 0.25 ppm of Cu for the given field. According to pH value the lime requirement was estimated as 1000 kg/ha/yr. The number of samples needed to estimate the mean with 95% confidence at ± 5% accuracy level for EC, pH, P, Ca, Mg, K, Fe, Mn, Zn and Cu in future experiments were estimated as 15, 4, 9, 13, 11, 6, 6, 11, 12 and 9, respectively. This shows that varying numbers of replications are required, and any sampling schemes should take into account the differences in the variability in soil properties.

References

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