Mapping soil chemical properties and leaf quality parameters relation to tobacco production in Sri Lanka: a GIS approach

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Introduction

Tobacco (*Nicotianatabacum L*) holds an unparalleled position among crop plants and in overall terms, the status achieved by this single species is truly remarkable (Akehurst, 1981). This crop significantly influences on world trade as a leaf basis product and is also a commercially widely grown crop as a non–food field crop (Akehurst, 1981).The chemistry and fertility of soils greatly influence the tobacco plant growth, leaf size, yield and physical, chemical and manufacturing properties of tobacco leaf.Among factors that influence on tobacco productivity, soil fertility and fertilizer use contribute nearly 50% of the yield and quality improvement of tobacco crop (Krishnamurthy and Deosingh, 2002).

Thus, by changing the soil properties and water quality, the yield and the quality of the final product can be greatly changed. Identifying lands with suitable soil propertiesfor the cultivation will help to understand the correct fertilizer application. Fertilizer recommendation based on soil test is important for improving the fertilizer use efficiency and thereby to increase the yield and quality of tobacco.

An understanding of spatial distribution of soil properties in the field is important for refining agricultural management practices. Soil variability is the outcome of many processes acting and interacting across a continuum of spatial and temporal scales and inherently scale-dependent (Cambardella et al., 1994).

Therefore, the study of relationship between the soil chemical properties and leaf quality can provide a scientific basis to find potential lands for quality tobacco production.This research presents the future potential tobacco growing areas based on the tobacco leaf quality distribution.

Materials and methodology

In this study,Galewala and Mahiyanganaya tobacco growing areas were chosen as sample area.Data were collected from primary and secondary sources. Soil property data which wererecorded Ceylon tobacco company's (CTC) lab reports were collected as secondary data. Global Positioning System (GPS) coordinates were taken fromthe field as primary data. Soil analysis was undertaken by collecting soil samples in studyareas from 15 cm deep from the soil surface. The soil samples were collected from ten different places of one land with approximately 1kg of weight. Soil samples were analyzed for pH, organic matter, electrical conductivity, soil texture, calcium, magnesium, potassium, sodium, calcium/magnesium ratio, magnesium/potassium ratio, phosphorous, acid saturation, cupper, ferrus, manganese and zinc. Leaf quality data were taken from the CTC lab reports and identified the leaf nicotine percentage, chloride percentage and sugar percentages from the plants in selected locations.

Major soil chemical properties which affectontobacco leaf quality were identified by correlation analysis in MINITABstatistics. Soil chemical property and tobacco leaf quality distribution maps were processed using interpolation technique in ArcGIS. Interpolated leaf quality maps were reclassified in four suitability rankings i.e. most suitable, suitable, moderately suitable and fairly suitable as shown in Table 01. Finally all leaf quality layers were integrated in a GIS environment to generate the potential map.

Table 01: Suitability factors for identifying potential areas tobacco cultivation

Factor	Most Suitable	Suitable	Moderately Suitable	Fairly Suitable
Leaf Nicotine%	>3.5	3.0 – 3.5	2.5 – 3.0	< 2.5
Leaf Sugar %	< 10	10 – 14	14 – 18	> 18
Leaf Chloride %	< 0.6	0.6 – 0.8	0.8 – 1.0	>1.0

Results and Discussion

According to correlation analysissoil pH and magnesium affected on nicotine, chloride and sugar levels in tobacco leaves. Low soil pH and low soil magnesium levels result in lower chloride level and sugar level in tobacco leaves.Acid saturation of the soil basically affected on the nicotine level of tobacco leaves. High acid saturation in soil result in high nicotine level in tobacco leaves. Soil potassium level affected on the chloride level of tobacco leaves. When potassium level of soil was lower chloride level of tobacco leaves was also lower. Sugar level of the tobacco leaves is affected by soil nitrogen level. Lower the nitrogen level in soil; lower the sugar level in tobacco leaves.

With lower soil pH levels, acidic cations; Mn^{+2}, Fe^{+3} and Al^{+3} are more available, however Cd^{+2} like heavy metals are also available at lower pH values. Availability of these cations can be a reason for the reduction of chloride level and sugar level of tobacco leaves.Magnesium is a part of the chlorophyll in all green plants and essential for photosynthesis. It also helps to activate plant enzymes needed for growth. This may results for the difference of nicotine, chloride and sugar levels in tobacco leaves.Acid saturation is the percentage of the cation exchange capacity occupied by H ions. Increasing the acid saturation will reduce the pH.Having too much of potassium in soil, it can lead to salt damage and acid fixation of the root system. It may result in increasing the leaf chloride level.Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. According to the results, leaf sugar levels can be affected directly by soil nitrogen.

Therefore soil with low pH, low nitrogen, low magnesium, low potassium and high acid saturation are favorable for quality tobacco production as shown in Table 02.

Table 02: Relationship between composition of soil chemical properties and tobacco leaf quality

Factors	Mean value		
Leaf Nicotine %	pH	Mg (Kg/ha)	Acid Saturation%
2 - 2.5	4.7	428.1	7.05
2.5 – 3	4.96	392.3	8.72
3 - 3.5	5.57	296.1	12.6
3.5 – 4	5.61	226.0	16.33
Leaf Chloride %	pH	Mg (Kg/ha)	K (Kg/ha)
0 - 0.625	4.95	290.4	219.9
0.625 - 1.25	5.31	344.8	237.1
1.25 - 1.875	5.862	470.3	345.2
1.875 - 2.5	6.35	573.5	332.5
Leaf Sugar %	pH	Mg (Kg/ha)	N (Kg/ha)
0 – 10	4.925	299.5	15.5
10 – 15	5.321	359.4	16.53
15 – 20	5.638	408.7	20.54
20 – 25	5.533	435.7	28.67

Mahiyanganaya area is the most suitable area for quality tobacco production. Mahiyanganaya; Rideela, Dehiaththakandiya, Sandunpura, NawaMadagama and Diyawiddagama were identified as most suitable areas for tobacco cultivation. Polonnaruwa; Siripura, Pallegama and Selasumgama were identified as the most suitable areas. Galewela; Tholombagolla and Kalawewa are the most suitable areas for quality tobacco production as shown in Figure 01.

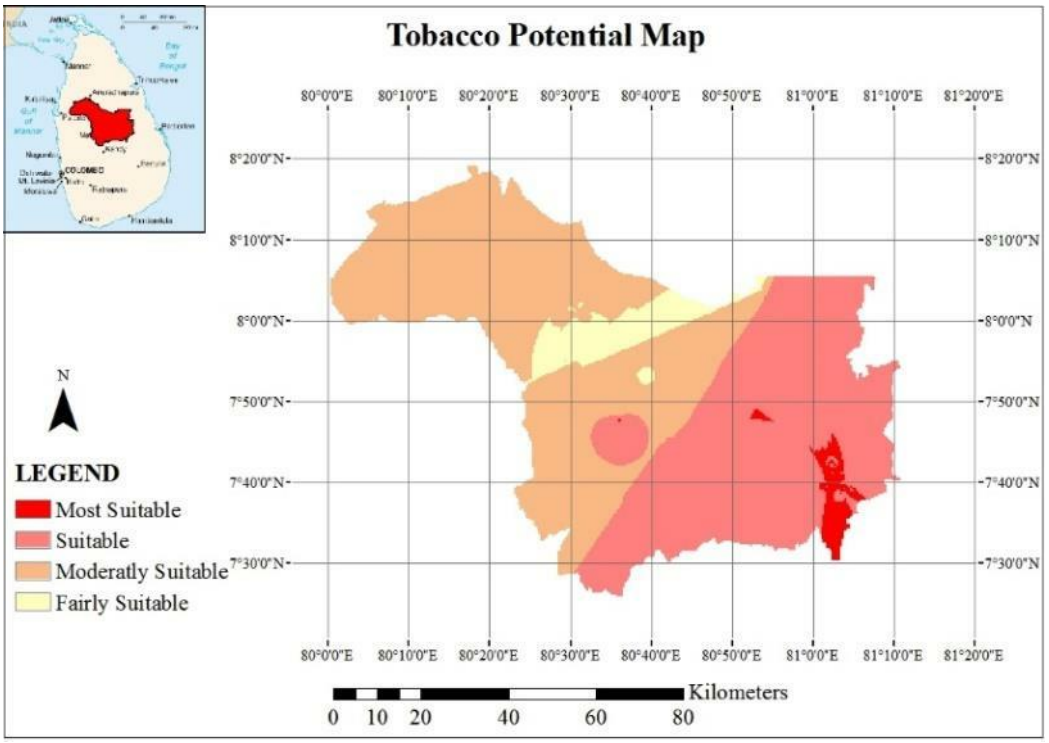

Figure 01: Tobacco Potential Map

Conclusion

GIS based approach is a useful tool for assessing tobacco potential areas. Mahiyanganaya area is the most suitable area for quality tobacco production. Soil with low pH, low Nitrogen, low Magnesium, low Potassium and high Acid saturation are favorable for quality tobacco production.

Results of the study can be improved by adding evenly distributed sample locationsand analyzing with agro ecological conditions.

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