International Journal of Agriculture Innovations and Research
Volume 4, Issue 5, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 17/02/2016 | Accepted on : 03/03/2016 | Published : 11/03/2016

Mapping Soil Chemical Properties and Leaf Quality Parameters in Relation to Tobacco Production

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***Abstract* – Geographic Information System (GIS) can integrate and relate any data with a spatial component regardless of the source of data. It's easy to store, retrieve, manage and analyze geotechnical data. (Burroughs, 1986) This research aims to investigate the development of a Geographic Information System (GIS) to better collect, manage, analyze and visualize soil chemical properties and leaf quality data which obtained from 52 locations of Galewela and Mahiyanganaya tobacco growing areas. This research presents the results of soil chemical properties and leaf quality distribution in selected areas and future potential tobacco growing areas.**

In this study Galewala and Mahiyanganaya tobacco growing areas were chosen as sample area (Figure 2). Major soil chemical properties which affect to tobacco leaf quality were identified by correlation analysis in minitab statistics. Soil chemical property and tobacco leaf quality distribution maps were processed using interpolation technique in ArcGIS. Finally, all thematic layers were integrated in a GIS environment to generate potential map.

Soil pH, Magnesium, Acid saturation, Potassium and Nitrogen are identified as major influencing soil chemical properties for tobacco leaf quality.

In Mahiyanganaya; Rideela, Dehiaththakandiya, Sandunpura, Nawa Madagama and Diyawiddagama are identified as potential areas for tobacco cultivation. In Polonnaruwa; Sirpura, Pallegama and Selasumgama are identified as the most potential areas. In Galewela; Tholombagolla and Kalawewa are the most potential areas for quality tobacco production.

The study thus demonstrates that GIS is a very useful tool for demarcating potential areas for tobacco cultivation.

***Keywords* – Geographic Information System, Interpolation, Potential map, Tobacco.**

I. INTRODUCTION

Tobacco (Nicotiana tabacum L.) contributes significantly to the world market as a leaf crop and is also the main nonfood field crop. In every year, 6.7 million tons of tobacco is produced throughout the world. The top producers of tobacco are China (39.6%), India (8.3%), Brazil (7.0%) and the United States (4.6%) (Food and Agriculture Organization, 2010).

Tobacco has a unique characteristic chemical compound 'nicotine', which is produced in the roots of the plant and then trans located to the leaves. Nicotine is the most abundant of the volatile alkaloids in the tobacco leaf. Nicotine is a colorless, and volatile liquid alkaloid found in smoking and smokeless tobacco which turns brown and acquires the odor of tobacco upon exposure to air. The alkaloid is water-soluble and forms water-soluble salts. Leaves are harvested as the commercial yield and they are mainly used for production of cigarettes, cigars, bidi, and also for chewing. (Akehurst, 1981).

Although, there are many taxations and prohibition rules on tobacco and related products, the consumption of tobacco products has not been fully controlled and prevented yet. In Sri Lanka, at present, the production of tobacco is about 4,750 mt from 2,400 ha (Ceylon Tobacco Company, 2011).At the same time the government receives a large amount of revenue from the tobacco products as taxes; hence the national economy is significantly supported by tobacco. For example, in 2011, the contribution was 7.6% of the country's total tax revenue and 2.2% of Gross Domestic Production (GDP) (Ceylon Tobacco Company, 2012).

Tobacco is cultivated in limited areas in Sri Lanka. As such, in Yala season (May to September) tobacco is cultivated at Galewela, Kalawewa, Dambulla, Naula, Melsiripura, Polonnaruwa and Mahiyanganaya areas whereas in Maha season (November to February), the same is undertaken at Udadumbara, Teldeniya and Haliela areas (Figure 1).

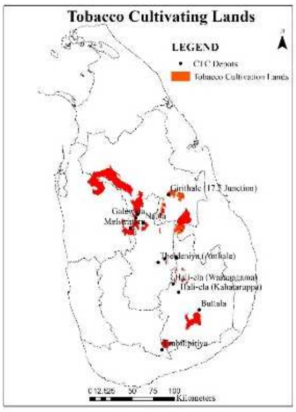

Fig. 1. Tobacco cultivating lands

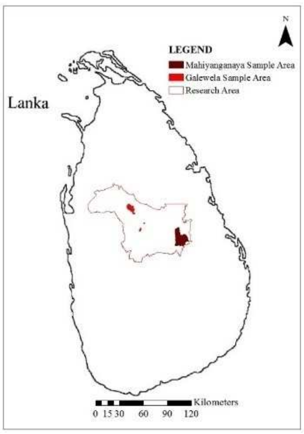

Fig. 2. Sample area

For quality cigarettes production, high nicotine %, and lower chloride & sugar % in the leaves are recommended (Ceylon Tobacco Company, agronomy report 2005). But,

International Journal of Agriculture Innovations and Research
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the level of soil fertility greatly influences on the plant growth, leaf size, yield, and physical, chemical & manufacturing properties of tobacco leaf. According to the geographical distribution of the plant leaf chemical properties are changed even though the farmers cultivate the same species of tobacco in different areas. (Krishnamurthy and Deosingh, 2002) Therefore, identifying lands with suitable soil properties for the cultivation will help to understand the correct fertilizer application and thereby to increase the yield and the quality of tobacco.

However, available methodologies for such works are not up to the requirement. In older method of manual mapping, spatial analysis of the data, data updating, displaying and retrieval get slow, tedious and time consuming. To answer the above problems, there is a possibility to implement Geographical Information System (GIS) for soil and leaf quality data on tobacco cultivation. Therefore, the present study wanted to evaluate the relationship between the soil chemical properties and leaf quality parameters that can provide a scientific basis to find potential lands for quality tobacco production in future.

II. Analysis

Major soil chemical properties that affect on tobacco leaf quality were identified by correlation analysis using MINITAB 14. Maps on soil chemical properties and tobacco leaf quality distribution were processed using interpolation technique in ArcGIS 9.3. Interpolated leaf quality maps were reclassified in four suitability rankings i.e. most suitable, suitable, moderately suitable and fairly suitable (Table 1). Finally, all leaf quality layers were integrated in a GIS environment to generate potential maps.

Lands with higher nicotine level and lower chloride level are more suitable for tobacco cultivation (Tobacco soil analysis report Mahiyanganaya 2013). Within the collected data leaf nicotine sugar and chloride values were categorized in to four category as shown in table 1.

Table 1. Suitability factors for identifying potential areas for 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
Leafchloride%	< 0.6	0.6 – 0.8	0.8 – 1.0	>1.0

Scatter plot diagrams were processed considering the correlations between soil properties and leaf quality data using Minitab 14.Soil chemical properties which have correlation values greater than 0.7 and R squared value greater than 75%, were selected for GIS analysis.

Figure 3 shows the scatterplot of leaf nicotine and soil pH. Low soil pH results in higher Nicotine level in tobacco leaves. With lower soil pH levels, acidic cations; Mn^{2+}, Fe^{3+} and Al^{3+} become 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 increment of nicotine level of tobacco leaves.

Figure 4 shows the scatterplot of Leaf Nicotine and Soil Magnesium. Low soil Magnesium results in higher nicotine level in 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 higher nicotine level in tobacco leaves.

Figure 5 shows the scatterplot of Leaf Nicotine and Soil Acid Saturation. High soil Acid Saturation results in higher nicotine level in tobacco leaves. Acid saturation is the percentage of the CEC occupied by H^+ ions. Increasing the acid saturation will reduce the pH.

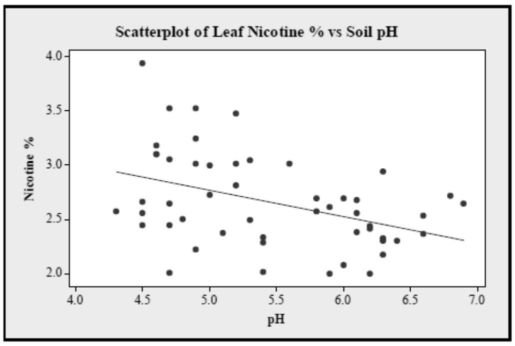

Fig. 3. Scatterplot of Nicotine and pH

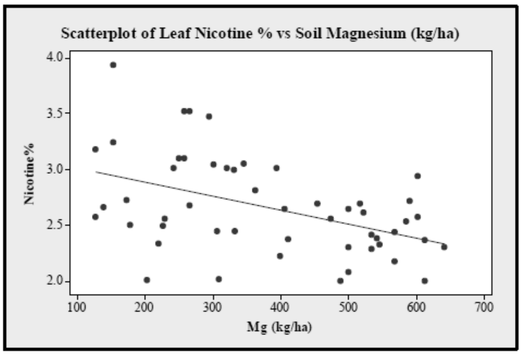

Fig. 4. Scatterplot of Nicotine and Magnesium

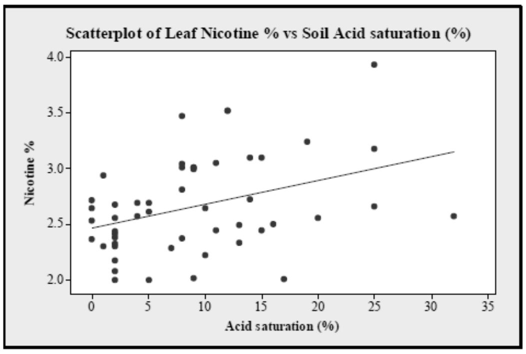

Fig. 5. Scatterplot of Nicotine and Acid Saturation

Figure 6, 7, 8, and 9 show scatterplots of leaf chloride with soil pH, soil potassium, soil acid saturation, and soil magnesium, respectively. Low soil pH, low soil potassium, high soil acid saturation, and low soil magnesium levels result in lower chloride level in tobacco leaves. Having too much of potassium in soil can lead to salt damage and acid fixation of the root system. It may result in increasing the leaf chloride level.

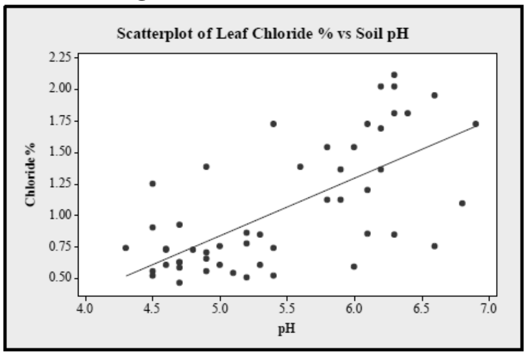

Fig. 6. Scatterplot of Chloride and pH

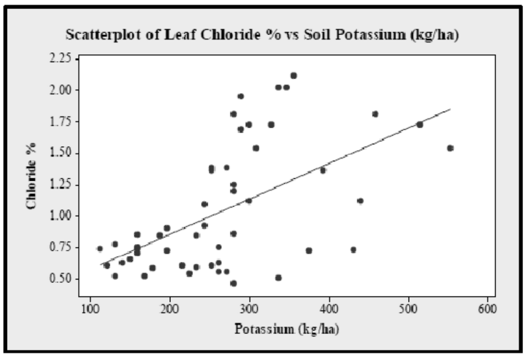

Fig. 7. Scatterplot of Chloride and Potassium

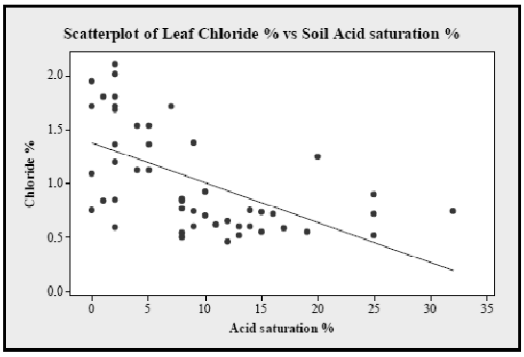

Fig. 8. Scatterplot of Chloride and Acid Saturation

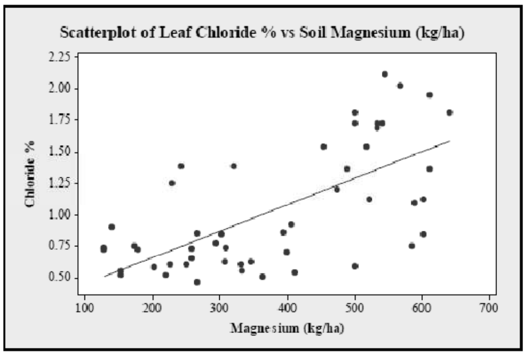

Fig. 9. Scatterplot of Chloride and Magnesium

Figure 10, 11, 12 show scatterplots of leaf sugar with soil pH, soil nitrogen, and soil magnesium, respectively. Low soil pH, low soil nitrogen, and low soil magnesium levels result in lower chloride level in tobacco leaves. 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 Figure 9, leaf sugar levels can be affected directly by soil nitrogen.

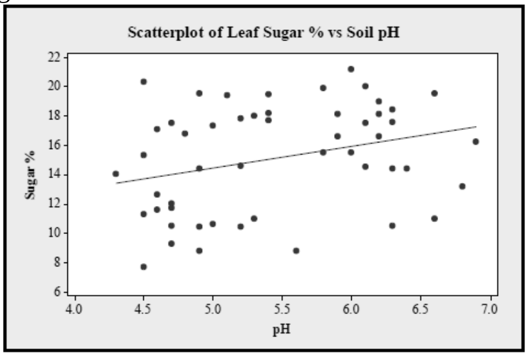

Fig. 10. Scatterplot of Sugar and pH

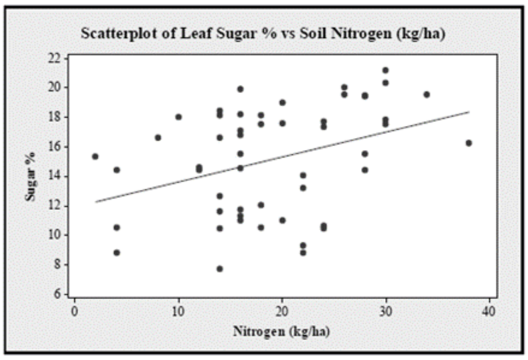

Fig. 11. Scatterplot of Sugar and Nitrogen

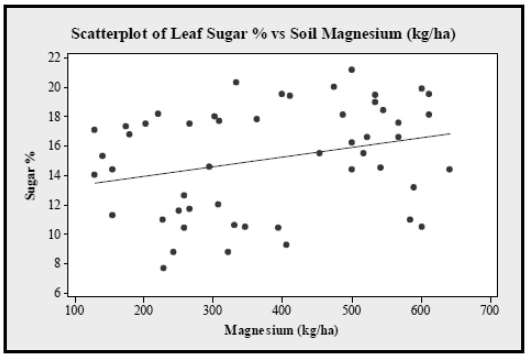

Fig. 12. Scatterplot of Sugar and Magnesium

According to correlation analysis soil pH and magnesium have an effect on nicotine, chloride and sugar levels in tobacco leaves. Low soil pH and low soil magnesium levels resulted in lower chloride and sugar levels but higher nicotine level in the tobacco leaves. Acid saturation of the soil basically affected on the nicotine level of tobacco leaves. High acid saturation in soil resulted in high nicotine level in tobacco leaves. Soil potassium level effect on the chloride level of tobacco leaves. When the potassium level of soil is low chloride level of tobacco leaves is also low. 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. Therefore, soil with low pH, low nitrogen, low magnesium, low potassium and high acid saturation are favorable for quality tobacco production.

To find the potential areas for quality tobacco production (Figure 15), tobacco leaf quality data were used because accuracy of finding potential areas is higher in tobacco leaf quality maps (Figure 13 and Figure 14). There is a future potential to process potential maps using soil properties, which are analyzed with agro ecological conditions.

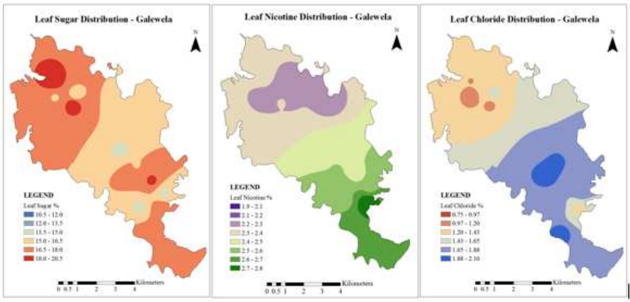

Fig. 13. Galewela selected area leaf quality distribution maps

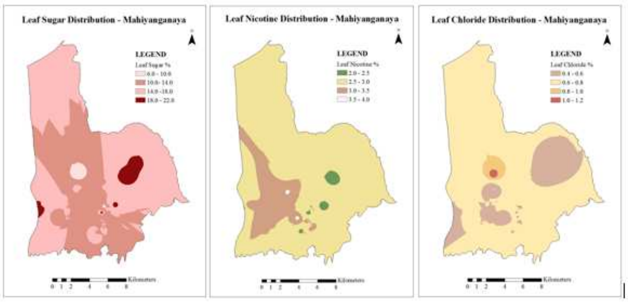

Fig. 14. Mahiyanganaya selected area leaf quality distribution maps

Analysis in leaf quality data reveals that Mahiyanganaya; Rideela, Dehiaththakandiya, Sandunpura, Nawa Madagama and Diyawiddagama are identified as the most suitable areas for tobacco cultivation. Polonnaruwa; Sirpura, Pallegama and Selasumgama are identified as the most suitable areas. In Galewela; Tholombagolla and Kalawewa are the most suitable areas for quality tobacco production.

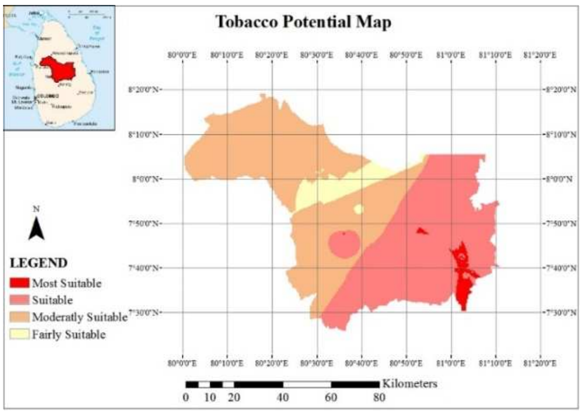

Fig. 15. Tobacco Potential Map

III. Conclusion

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

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Mr. Marasinghe won the medal for best research presenter award at 5th research Symposium of Uva Wellassa University, January 29-30, 2015