Assessment of Soil Fertility and Nutrient Management in Betel (*Piper betle*) Cultivations in the Kurunagala District

D.M.P.V.Dissanayakar[1] and R.A.D.R.A.Ranasinghe[2]

[1,2]*Deparment of Export Agriculture, Sri Lanka*

[1]praveena283@yahoo.com, [2]zzrase@yahoo.com

Abstract

Betel plant (Piper betle) leaves, harvested at frequent intervals, result in the permanent depletion of soil nutrients. Farmers often complain that the amount of fertilizer recommended by the Department of Export Agriculture (DEA) is insufficient and there is a tendency to overuse fertilizers. The study aimed to assess the variability of soil fertility in betel cultivations in the Kurunagala district. It investigated the relationship between fertilizer amounts and betel yield, along with relationship of farm scale on soil fertility characteristics. Thirty farmer fields were surveyed, measuring soil fertility traits such as Nitrogen, Phosphorus, Potassium, and soil pH. Of the selected fields, 84% betel poles were cultivated between 2 to 3 years, while 16% were less than 2 years old. The survey found that 61% of farmers used cow dung and 39% used green manure as organic fertilizer. Harvesting was done every three weeks by 68% of farmers and every two weeks by 32%. Chemical fertilizers applied, biweekly by 72%, while the remaining 28% did so every three weeks. All farmers surveyed the used bed method and the same chemical fertilizers mixture. The soil analysis revealed that Wariyapola had the higher nitrogen (2.48±0.8 mg/g), Phosphorus (0.13±0.01 mg/g), Potassium (0.06±0.01 mg/g) and soil pH (5.63) values than Panduwasnuwara and Bingiriya areas. There is a negative relationship between amount of fertilizer applied and yield, but the ratio of leaf length to leaf width had a positive relationship. However, none of these differences or relationship between farm scale and soil fertility traits were statistically significant. The results indicate that over-dosing with fertilizer has no significant impact on betel yield improvement, besides excessive use of chemical fertilizers may increase cost and leads to nutrient loss by leaching, runoff, and evaporation.

Keywords: Betel, Fertilizer, Inorganic, Organic, Soil Fertility

I. INTRODUCTION

Betel (*Piper betel* L.), a member of the Piperaceae family, holds significant economic, social, medicinal, religious, and cultural value in Sri Lanka. This crop is one of the country's important Export Agriculture Crop (EAC) with Sri Lanka being a major producer, consumer, and exporter of betel. The primary utilization of betel is for chewing, although it also finds extensive applications in traditional medicine. Safrole is the predominant chemical compound found in Sri Lankan betel (Anon, 2016).

In Sri Lanka, approximately 8,000 to 10,000 farmers are engaged in the commercial cultivation of betel. The total cultivated land spans an estimated 2,860 hectares, with the majority of cultivation concentrated in the districts of Kurunagala, Gampaha, Kegalle, and Kalutara. In 2022, the annual production reached 13 466 metric tons, with an export volume of 3908.1 metric tons valued at Rs 5034.5 million. (DEA, 2022).

The economic value of betel lies in its leaves, which are harvested at regular intervals of two to three weeks. However, this harvesting process results in the permanent removal of a substantial quantity of nutrients from the fields. Consequently, an abundant supply of both micro and macronutrients is essential for optimal betel growth. For instance, from a one-hectare betel field, approximately 7,200 kilograms of organic materials, along with 288 kilograms of nitrogen, 33 kilograms of phosphorus, and 302 kilograms of potassium are removed annually. Thus, farmers employ a combination of organic and inorganic fertilizers in betel cultivation (Anon, 2016). Given these nutrient demands, the application of chemical fertilizers becomes indispensable for achieving higher yields and promoting better growth. The Department of Export Agriculture recommends a fertilizer mixture, including Urea (195 grams), Triple Super Phosphate (TSP) (65 grams), Muriate of Potash (MOP) (100 grams), and Kieserite (60 grams), totalling 420 grams, for every 100 betel vines, applied every three weeks. Initially, organic manure should be applied to the beds, which can be repeated at intervals of several months. Alternatives such as cow dung, compost, well-composed poultry manure, or goat manure can also be applied in betel cultivation. Additionally, the application of Gliricidia leaves has been shown to be highly beneficial for betel growth, yield, and overall quality. However, a common concern among farmers is that the recommended fertilizer rates are insufficient for betel cultivation. Consequently, some farmers resort to applying higher doses of fertilizer than what is advised by the Department of Export Agriculture (DEA). This practice may incur higher fertilizer costs and results in wastage through leaching, washing, and evaporation, among other issues.To address these challenges and assess the variation in soil fertility within betel fields in the Kurunagala district, as well as to investigate the relationship between soil fertility characteristics and betel yield, the Intercropping and Betel Research Station of the Department of Export Agriculture conducted this investigation.

II. METHODOLOGY

Survey questionnaires and Soil samples were collected from Low country Intermediate Zone of Kurunegala district. Soil samples were analysed under room temperature at soil science lab of the Cinnamon Research Institute, Thihagoda, Matara. Thirty farmer fields were randomly selected from three extension officer's regions (EO Regions) namely, Bingiriya, Wariyapola and Panduwasnuwara (Table 02) of Low Country Intermediate Zone of Kurunegala district. Betel leaf and soil samples were collected from betel farmer's fields. Number of leaf and soil samples were collected depend on extent of betel cultivation in each location. All soil and leaf samples consisted of 3 replicates.

Soil samples were collected from randomly selected locations within the betel field using auger. Collected soil samples were air dried, ground and passed through a 2 mm sieved to get a homogeneous sample prior to soil chemical analysis. Soil pH was measured using a pH meter (ORION 550A model USA) in 1: 2.5 Soil: water solution. Total Nitrogen recorded by Kjeldahl method (Bremner, 1982). Soil available Phosphorous was extracted by Borax solution and Phosphorous was determined by Vanadomolybdate blue method. Available potassium was measured using flame photometer method. Further, ten fresh betel leaf samples of harvesting stage were collected from randomly selected vines. Leaf length and leaf width were measured by a ruler and average length and width in cm were recorded. In addition, a survey was carried out through individual discussion with selected farmers to investigate about fertilizer usage for betel cultivation. Data were analysed using Mini tab 18 software, Microsoft Excel 2016 and SAS 9.0 version software package.

III. RESULTS AND DISCUSSION

A. *Overview of the Betel Farming in the Selected Regions*

Betel cultivation in Sri Lanka primarily employs two methods, namely the bed method and the single support method. Both methods require some form of vertical support for the betel vines to climb. In the surveyed area, it was evident that all farmers (100%) exclusively used the bed method, which involved preparing beds of approximately 1.2 m by 7.5 m in size. Betel cultivations in the region were of varying ages, spanning from 1 to 3 years. These were categorized into two groups, with the majority (84%) falling into the 2–3 year old group, while remaining 16% were less than 2 years old.
Different types of fertilizers were observed in the surveyed areas, and it became apparent that farmers consistently applied excessive doses compared to the recommended fertilizer quantity. The Department of Export Agriculture recommends a three-week interval for fertilizer applications. However, farmers were observed using chemical fertilizers at both two-week and three-week intervals, with a majority (72%) favouring the two weeks.

Apart from inorganic fertilizers, 86% of farmers used cow dung. While there was a growing trend towards the use of goat and poultry manure in the Kurunegala district, 46.6% of farmers applied leaf manure, such as Keppetiya and Giricidia. Notably, these betel farmers refrained from using cow dung sourced from stockyards in the Kurunegala area due to concerns about the presence of coconut oil coming with poonac feed, which they believe transmits the bacterial blight to betel vines. Instead, they procure cow dung from dry zone areas like Anuradhapua, Polonnaruwa, and

Proceedings of Papers, 3rd International Conference on Science and Technology
Faculty of Technology, South Eastern University of Sri Lanka
e-ISBN: 978-955-627-022-8

Vavniya, despite its higher cost (Herath and Rathnasoma, 2010).

The survey revealed that almost all farmers opted for organic fertilizer in betel cultivation, with cow dung (61%) and green manure (39%) being the most prevalent organic choices.

In terms of irrigation, all farmers' ensured betel was irrigated during the dry season, with a frequency of every other day at minimum. Harvesting mature betel leaves followed a consistent pattern, with a 2-week interval for the local market and a 3-week interval for export. According to the survey results, a majority of farmers (68%) adopted a 2-week harvesting interval, while the remaining 32% favoured a 3-week cycle. Regarding market supply, the majority (76%) primarily catered to the local market, while a smaller proportion (24%) mainly engaged in export market supply. Though commercial cultivation lasted up to 6 years, the most favourable yields were obtained from 2-year-old betel plants. A typical yield per 100 poles ranged from 6,000 to 8,000 leaves in a single harvest (Anon, 2016).

B. Soil Fertility Status in Different Betel Growing Regions

Table 01. Soil Fertility Status in Three EO Regions

	Bingiriya	Wariyapola	Paduwasnuwara
N (mg/g)	1.59 ± 0.30	2.48 ± 0.80	1.55 ± 0.90
P (mg/g)	0.10 ± 0.07	0.13 ± 0.01	0.12 ± 0.01
K (mg/g)	0.04 ± 0.01	0.06 ± 0.01	0.05 ± 0.01
pH	5.63 ± 0.90	5.65 ± 080	5.47 ± 0.10

Soil analysis results revealed that the Wariyapola region had the highest values for nitrogen (2.48 ± 0.8 mg/g), Phosphorus (0.13 ± 0.01mg/g), Potassium (0.06 ± 0.01 mg/g), and soil pH (5.63) among selected areas.

C. Correlation Between Chemical Fertilizer Application with Yield of Betel

There was a weak negative relationship between applied fertilzer amounts and yield. However, the total yield of betel do not significantly differ ($p \geq 0.05$) with the application of chemical fertilizer amounts. The recommended fertilizer mixture had the highest number of large Peedunu Kola (betel leaf) productions compared to the application of double the quantity of the recommendation, indicating a waste of fertilizer at higher doses.

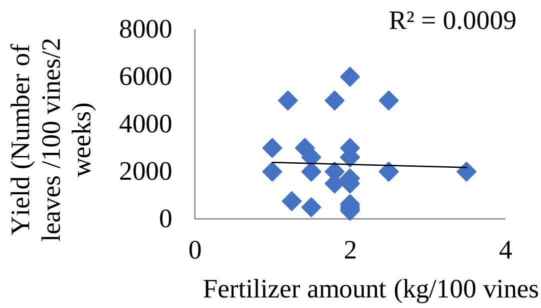

Figure 01. Relationship of Application of Chemical Fertilizer Amount with Yield of Betel

D. Relationship Between Chemical Fertilizer Application and the Average Leaf Length/Width Ratio of Betel Plants

There was a weak positive relationship between applied fertilizer amounts with average leaf length/width ratio.

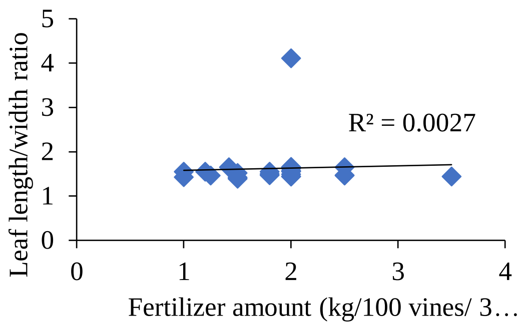

Figure 02. Relationship of Application of Chemical Fertilizer Amount with Average Leaf Length/Width Ratio of Betel

Also, the average leaf length/width ratio was not significantly different ($p > 0.05$) with the application of chemical fertilizer amounts. Farmers commonly believe that increasing fertiliser amounts can boost yields. Nevertheless, experimental results consistently demonstrate that such practises are wasteful. Moreover, achieving optimal betel leaf yields and quality relies on environmental factors such as rainfall, temperature, shading, and sound agronomic practises.

E. Analysis of Soil pH Values Across Various Farm Size Group

The mean soil pH value was not significantly different ($p \geq 0.05$) among different farmer

e-ISBN: 978-955-627-022-8

groups. While the 200–400 pole farm size group showed the lowest soil pH value (5.3 ± 0.47), the highest pH value (5.82 ± 0.28) was shown by the 800-1000 pole farm size group. Small farm size groups have low pH values, probably due to the higher dosage of urea, the most commonly used nitrogen fertilizer in Sri Lanka.

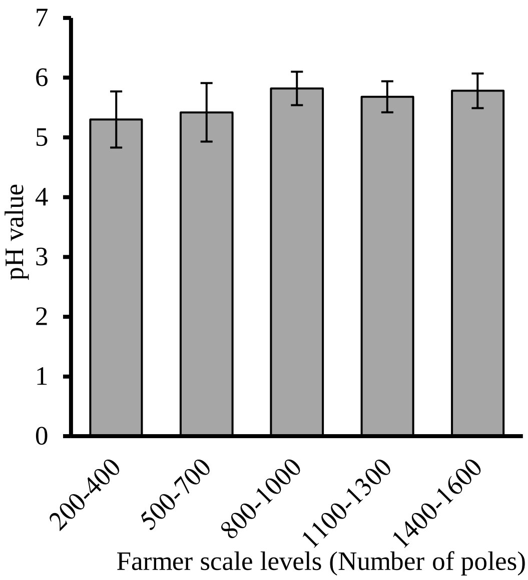

Figure 03. Mean pH Value in Different Farmer Scale Levels

According to the results of the study, Small farmer scale level had lowest pH value due to small farmer scale level were applied higher dosage of Nitrogen fertilizer (N).

F. Assessment of Chemical Fertilizer Application and Soil Fertility Across Diverse Farmer Scale Levels

The mean application of chemical fertilizer was not significantly different ($p > 0.05$) among different farm size groups, according to the current study. The lowest mean application of chemical fertilizer amount (1.48 ± 0.21) was observed in the 1400–1600 pole group, and the highest mean application of chemical fertilizer amount (2.1 ± 0.18) was observed in the 200–400 pole group.

G. Assessing the Influence of Fertilizer Application Levels on Various Farmer Scales

According to the results of the study, a high amount of fertilizer is applied by small-scale farmers, and large-scale farmers apply low amounts of fertilizer.

H. Assessment of Soil Phosphorus (P) Content across Various Farmer Scale Levels

The mean soil Nitrogen (N) content was not significantly different ($p > 0.05$) between different farmer scale levels in the current study. The lowest Nitrogen (N) content in the soil (1.48 mg/g ± 0.13) was recorded from the 800–1000 pole group, and the highest soil N content (2.34 mg/g ± 0.41) was reported from the 200–400 pole group.

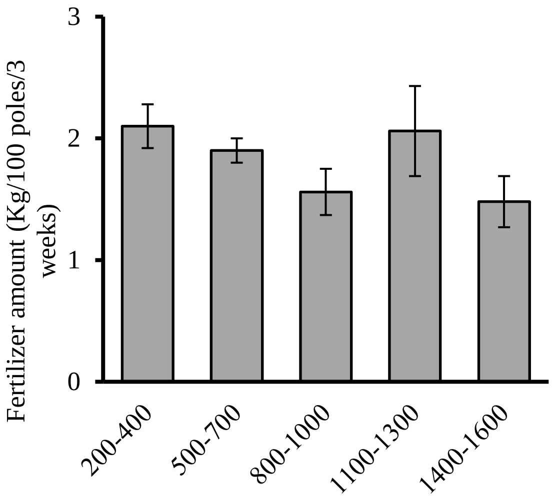

Figure 04. Mean Chemical Fertilizer Application Across Various Farmer Scale Levels

The mean soil Nitrogen (N) content was not significantly different ($p > 0.05$) between different farmer scale levels in the current study. The lowest Nitrogen (N) content in the soil (1.48 mg/g ± 0.13) was recorded from the 800–1000 pole group, and the highest soil N content (2.34 mg/g ± 0.41) was reported from the 200–400 pole group.

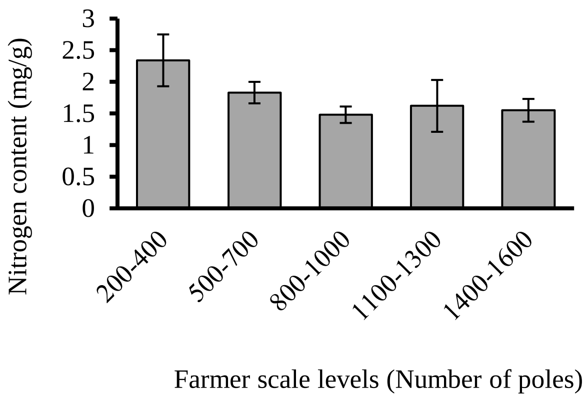

Figure 05. Mean Soil Nitrogen Content in Different Farmer Scale Levels

Proceedings of Papers, 3rd International Conference on Science and Technology
Faculty of Technology, South Eastern University of Sri Lanka
e-ISBN: 978-955-627-022-8

I. Assessment of the soil Phosphorus (P) content across Various Farmer Scale Levels

The mean phosphorus (P) content in the soil was not significantly different ($p \geq 0.05$) between different farm size groups. The lowest soil P content (0.09 mg/g ± 0.02) was recorded from 500–700 pole groups, and the highest P content (0.15 mg/g ± 0.03) was found in 1100–1300 pole groups.

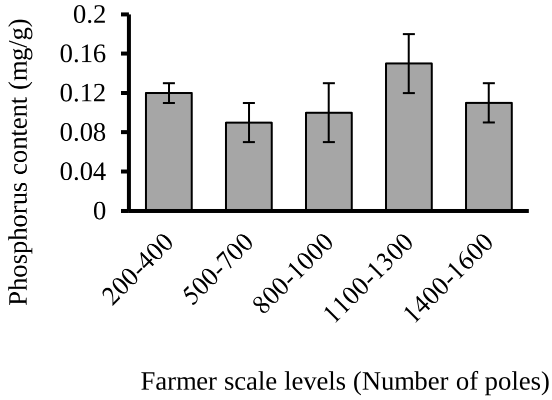

Figure 06. Soil Phosphorus Content in Different Farmer Scale Levels, The Bars Indicate The Mean P Content

J. Assessment of the soil potassium (K) content across Various Farmer Scale Levels

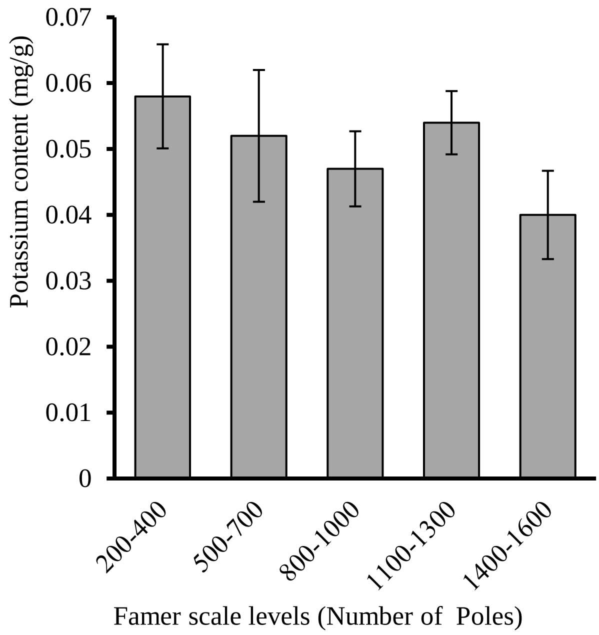

Figure 07. Soil Potassium Content in Different Farmer Scale Levels

The mean soil Potassium (K) content was not significantly different ($p \geq 0.05$) among different farm size groups. The lowest soil K content (0.04 mg/g ± 0.0067) had been recorded in the 1400–1600 group, and the highest soil K content (0.058 mg/g ± 0.0079) was observed in the 200–400 pole group.

IV. CONCLUSION

This study highlights the challenges in betel cultivation, particularly the loss of nutrients due to overuse of chemical fertilizer. The need for balanced nutrient application, with organic, and inorganic fertilizers, is emphasized. Despite farmer concerns about DEA-recommended fertilizer quantities, the study identifies no statistically significant relationships between yield, fertilizer amounts, and soil fertility traits. Moreover, negative correlation between fertilizer application and betel yield indicates the detrimental effects of over-dosing on betel productivity. Although regional soil analysis did not reveal statistically significant findings, Wariyapola exhibited higher nutrient levels. In summary, the study advises against undue reliance on chemical fertilizers, as it may incur additional costs with the risk of environmental issues related to nutrient loss through leaching, runoff, and evaporation. Promoting awareness among farmers about sustainable nutrient management practices is essential for optimizing betel cultivation outcomes.

REFERENCES

Anon, (2016) "Technical Bulleting of betel cultivation number 11", *Department of Export Agriculture, 1095, Peradeniya, Sri Lanka,* 2(1), pp. 02-48.

DEA, (2022) Export Agriculture Crops, Statistical Pocket Book 2021/2022. *Department of Export Agriculture, 1095, Peradeniya, Sri Lanka,* 1(1), pp. 49-50.

Herath, H.M.I.U.K. and Rathnasoma, H.A., (2010). "Evaluation of Alternative Types of Supporting Materials for Betel (*Piper betel* L.) Cultivation". *Journal of Food and Agriculture,* 1(1), pp. 1-10.

e-ISBN: 978-955-627-022-8