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# IMPACT OF THE ADOPTION OF GOOD AGRICULTURAL PRACTICES ON TEA BUSH DEBILITATION IN TWO SMALLHOLDING RANGES IN GALLE DISTRICT SRI LANKA

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**ABSTRACT**

**It was reported that tea bushes of smallholdings in some areas were debilitated and are expressing certain stress symptoms. This study attempted to understand the technology adoption level among the tea smallholders in Neluwa and Udugama ranges and to examine their tea bush debilitation status and identify possible attributes. Data were collected from randomly selected smallholdings. Cultivation history, technology adoption, and field problems were identified by using a structured questionnaire and were statistically analyzed. Results show that stress symptoms appeared in 75% of the holdings from a low to a moderate acuteness level and mostly distributed less than 30% of the lands investigated. However, in certain cases, there has been an impact on the yield. Results revealed that the adoption level of some of the GAPs is not at a satisfactory level and was identified as one of the attributes of debilitation. It was found that certain pests such as Lowcountry live wood termite, Canker, Wood-rot, and Horsehair blight are significantly contributing to the problem. About 28% of parasitic nematode incidents were detected, which could make a serious consequence under the poor crop management strategies.**

Keywords: Debilitation, GAPs, Neluwa, Smallholdings, Tea, Udugama

## INTRODUCTION

Tea, being the main foreign exchange earning crop in Sri Lanka, provides a substantial contribution to the national economy and livelihood of people in the industry while generating an array of benefits to society. The agriculture sector generates about 25% of the country's total export earnings of which, tea alone contributes to 58% (Central Bank of Sri Lanka 2015--2016). Based on the elevation, the tea growing area of Sri Lanka is divided into three categories, namely, low country, mid -country, and upcountry. Among them, the low country is the largest tea growing area and situated below 600 m MSL. The contribution of low-grown tea to the tea industry of Sri Lanka is very significant in terms of tea production, as about 60 % of the total tea production of Sri Lanka comes from Low-country tea lands (Tea Small Holding Development Authority 2015). In terms of the size of holdings, three main segments could be identified in low-grown tea areas. They are smallholdings of less than 4 ha of land, proprietary estates, of a land size between 4-20 ha, and corporate sector estates having over 20 ha of land. Although the productivity of the tea smallholding sector is relatively high over the other two sectors, the global statistics revealed that it is still lower than that of the productivity of Kenya and North India (Sri Lanka Tea Board 2015). Many studies revealed that adoption of some of the good agricultural practices (GAP) recommended by the Tea Research Institute of Sri Lanka (TRI) is not satisfactory among the small tea growers (Jayamanne *et al*. 2002; Jayarathna 2012) and which possibly can affect

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**Table 1: Tea productivity in the smallholding sector in the period from 2012 – 2017**

| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| **Tea productivity (Made Tea kg/ha/year)** | 2,001 | 2,107 | 2,123 | 2,059 | 1,872 | 1,995 |

Source: Annual Reports Tea Smallholding Development Authority (2012-2017).

productivity (The current average yield of the sector is 1958 kg made tea/ha/year, which is below the potential yield).

It was reported that tea bushes in some areas of the low-country tea growing region, in the smallholding sector, were debilitated due to certain factors including nematode infestation and poor adoption of agricultural practices (Rajasinghe *et al*. 2015). The considerable number of casualties and a significant drop in yield are the main consequences of this debilitation. This bush debilitation was expressed as stress symptoms such as flowering & fruiting, wilting, bangi formation, and die-back (Rajasinghe *et al*. 2015). Sivapalan (1972) and Gnapragasam, (1988) have observed that such kinds of symptoms could occur in both young and mature tea, as a result of plant-parasitic nematodes. Nevertheless, these types of stress symptoms can occur, not only due to nematodes but also due to various entomological, pathological, cultural, and environmental factors. Hence, tea growers have a prominent role in managing this situation, primarily through a proactive approach -like the adoption of GAPs. In a study conducted in the corporate sector tea estates of low-country, it was revealed that senility of tea, improper adoption of some cultural practices, and loss of bush vigor due to some pest attributes for the declining of yield in the particular sector (Mahindapala *et al*. 2018).

The tea productivity of the smallholding sector during the period from 2012 – 2017 has given in table 1, which shows a stagnant state. This could be due to various reasons, perhaps including the issues discussed above.

Many cases of tea bush debilitation have been reported across the low-grown areas. Outcomes of some case studies revealed that possible causes for the debilitation of tea have regional diversity. (Rathnayake *et al*. 2011; Rajasinghe *et al*. 2015). Therefore, a need has arisen to conduct a systematic study in different regions to understand these various attributes.

This study attempted to understand the technology adoption level among the tea smallholders in the study areas and to examine the impact of the level of technology adoption on tea bush debilitation, existed in the region.

## MATERIALS AND METHODS

The Galle District is the second-largest tea smallholding district in Sri Lanka, where 21% of tea smallholdings are located in four sub-regions namely, Elpitiya, Wanduramba, Akmeemana, and Hiniduma (Department of Census and Statistics and Tea Small Holding Development Authority 2005). Similar tea bush debilitation cases have been reported to TRI from smallholdings in Neluwa and Udugama Tea Inspector Ranges (TIR) of Hiniduma and Wanduramba sub-regions respectively. Therefore, the research team purposively selected those two TIRs for the investigation. These TIRs, have mostly a fairly similar ecological condition and belong to the WL1a Agro-ecological region based on the map developed by Punyawardana *et al*. (2003), and the soil series of Weddagla is associated with the Pallegoda series (Senarath and Dissanayake 1999). As per the last island-wide census published in 2005, the smallholder population was 7739 and 12,912

in Neluwa and Nagoda divisional secretariat areas (DSA), in which the studied locations (TIRs) were situated, and accordingly, approximately 4,000 and 2,500 operators were reported from Neluwa and UdugamaTIRs respectively. However, according to the recent statistics approximately 7,500 holdings from these two TIRs were registered in the Tea Small Holding Development Authority (TSHDA) to obtain the government fertilizer subsidy, and that list was used as a sampling frame for the study. Out of 18 and 15 tea-growing Grama Niladhari Divisions (GND) available in Neluwa and Udugama TIRs, 9 and 8 GN divisions were randomly selected for the study respectively. Hundred and twenty smallholders were randomly selected from each TIR (altogether 240), initially, and they were interviewed through telephone to collect the basic data to see whether they fit into the pre-determined prerequisite in the study design (i.e. age group of 3-25 years of tea cultivation, accessibility, single owner-operated land, not abandoned). Finally, 105 smallholders were selected proportionately for the study from these two TIRs. Further, stratification was done during the sampling procedure to represent a fair amount of tea growers in both 3-10 years and 10-25 years of cultivations in the sample, as per the population proportion. The questionnaire was prepared based on the objectives of the study by the authors and perfected with the inputs given by the research and extension staff of TRI. The questionnaire mainly consisted of the following three parts

(i) The necessary information from tea growers on their tea cultivation and past practices that have been adopted – data were collected through the interview

(ii) How growers have responded to the GAPs that were recommended by TRI.

(iii) The various pest and disease problems encountered.

Data concerning the above (ii) and (iii) were collected through the visual examinations by individually visiting the sampled growers by the authors and it was done in the period of September-December, 2017. The questionnaire was pretested (by administration few smallholders) before it was used to collect the data. The field examinations were also used as a triangulation technique to verify the data collected through the interviews.

TRI recommendations, published in the form of Advisory circulars (www.tri.lk) were used as guidelines to determine the standard practices in evaluating the grower's practices. The adoption level of cultural practices and severity of pest and disease infestation levels were measured by using a 0 - 5 (0 for No;1 for Very low; 5 for very high) scale. Different pest and disease incidents and severity levels were measured separately from randomly selected healthy and unhealthy tea bushes that were present in the affected tea holdings (tea holdings with stress symptoms). Further, soil and plant samples were collected for laboratory estimations. Out of the 105 growers, only data from 98 smallholders were tabulated (balance was non-reliable) and analyzed using descriptive statistics, Chi-Square Test, correlation and Mann-Whitney u test (non-parametric pool t-test) using SPSS and Minitab statistical software.

## RESULTS AND DISCUSSION

### General soil and environmental condition

Tea growers of the sample were distributed in the latitude and longitude ranges of 6.09324N-6.40519N and 80.22512E-80.42150E, while elevation ranged from 50 -200m MSL. The physical properties of the tea lands (soil depth, slope, gravel content, rockiness) were estimated, and accordingly all these lands were having deep soil (soil depth>1m) and less amount of rocks (rockiness<10%). About 44% of the holdings were having a slope of less than 25%, 44% of the holdings were in the range of 25-50% of slope, and the rest were having a slope of more than 50%. Moreover, 67% of the land had a low gravel percentage (<25%) and 22% of the land had

**Table 2: Severity of the appearance of the symptoms**

| Severity category | No. of holdings and % (N= 74) |
|---|---|
| Very Low | 9 (12%) |
| Low | 23 (31%) |
| Moderate | 31 (42%) |
| High | 8 (11%) |
| Very High | 3 (4%) |

moderate gravel content. The Chi-square test revealed that the variability in the gravel and slope in the soil/land condition has no significant impact on the debilitation symptoms (The Chi-square values 7.9876, 10.894 p values 0.786, 0.816, respectively).

**Presence of the stress symptoms**

The stress symptoms appeared in 75% of the holdings, and it varied with the TIR and maturity level of the tea cultivation. Eighty-three per-cent of the tea holdings in Neluwa TIR showed stress symptoms while it was 67% in Udugama. There was a significant association between age level and presence of symptoms (p=0.01). and accordingly, 83% of tea holdings who had mature cultivations showed stress symptoms while it was 54% for young tea cultivations.

The major symptoms observed in the tea bushes were flowering and fruit set, die-back and dwindling of new shoot development, yellowing, and banji formation, of which flowering and fruiting were the most prominent symptoms noticed. These symptoms did not occur in a solitary manner but in clusters with an association of several symptoms. The spreading of the stress symptoms within the holdings showed a diverse pattern and out of the 'affected' holdings, 23% showed less than 10% and 50% showed 10-30% level of spread throughout of the land, while 15% showed the coverage of 30-40% of the land and balance 12% showed over 40% distribution. The severity of the symptoms is also an essential

**Table 3: Mean yield of tea under different stress scenarios**

| Severity category | Mean yield Green leaves kg/ac/month | Standard Deviation |
|---|---|---|
| Very Low | 406.0 | 150.3 |
| Low | 385.4 | 186.0 |
| Moderate | 340.0 | 131.1 |
| High | 269.7 | 127.8 |

measurement to describe the debilitation level, and it was summarized in Table 2. The table shows that the majority (85%) of the tea holdings have a moderate to low level of severity of the stress symptoms.

Considering both criteria (coverage and intensity), it can be concluded that, bush debilitation in this region varies from Low to moderate level, even though the number of incidents was high. This debilitation level is comparatively lower than the previously recorded observations in Balangoda the region, where categories of moderate and high levels of debilitation were recorded as 78% (chi-square value= 6.742, p=0.009) (Rajasinghe *et al*. 2015).

**Impact on yield**

The impact of debilitation on the yield of tea was assessed, and Table 3 gives the mean yield level under different severity levels of stress symptoms.

Spearman correlation test was performed, and the correlation is significant at 0.05 level (Correlation coefficient -.275, p=0.016) suggesting that there is a negative correlation between the severity of debilitation on the tea yield.

**Technology Adoption**

The adoption of Good Agriculture Practices (GAPs) by these farmers was also evaluated, as this could trigger the debilitation in tea. Table 4 illustrates the adoption level of some of the important practices.

**Table 4: Adoption of different agriculture practices**

| Good Agriculture Practice (GAP) | Adoption level % (n= 98) |
|---|---|
| Basic practices | |
| Deep forking during land preparation | 24.5 |
| Rehabilitation of soil before planting | 13.3 |
| Use of average or good quality nursery plants | 40.8 |
| Use only recommended cultivar (TRI2026, TRI 2025, TRI 2027, TRI 4042) | 31.5 |
| Use of correct fertilizer mixtures | 49.0 |
| Use of correct dosage of fertilizer | 44.9 |
| Testing of soil for pH | 32.7 |
| Applying a satisfactory dose of Dolomite | 43.9 |
| Mossing and removing of Ferns | 69.4 |
| Presence of any soil conservation structures | 74.5 |
| Presence of medium shade | 86.7 |
| Presence of high shade | 14.3 |
| Proper harvesting interval | 74.4 (N=91)[1] |
| Advance practices | |
| Application of foliar fertilizer | 4.3 (N=91)[1] |
| Correct period of resting | 13.1 (N=84)[2] |
| Burying of prunings | 4.8 (N=84)[2] |
| Applying wound dressing on pruning cuts | 0.0 (N=84)[2] |
| Satisfactory maintenance of soil conservation structures | 14.2 |
| Adoption of sanitary type pruning | 11.3 (N=84)[2] |

(Different count numbers are due to differences in the bearing stage and differences in the pruning stage)

Table 4 shows that the adoption levels were satisfactory with concerning few basic GAPs such as the fertilizer mixture, presence of medium shade, mossing and ferning, proper harvesting interval, and presence of soil conservation structures, while it was at a moderate level for use of correct fertilizer doze, use of quality nursery plants, application of foliar fertilizer, and intervention on amelioration of soil. Although the use of recommended cultivars appeared at a poor adoption rate, it is noteworthy that 53% of smallholders had planted recommended cultivars together with TRI 2023 (not recommended for the region). Moreover, most of the practices listed under advanced practices and some basic practices such as soil rehabilitation, forking, and presence of high shade, which contribute to the sustainability of the cultivation have received poor adoption. Associations between the above-mentioned GAPs were tested and stress symptoms and the results are given in Table 5.

The test statistics show that the above GAPs have a significant association with stress symptoms at 10% and 5% probability levels. These results revealed that the cultural practices have an impact on the debilitation of tea and would suggest that the chance of occurring of stress symptoms could be reduced by the adoption of such agricultural practices.

**Pest and Disease Status**

Key pest and disease incidents such as Shot-hole-borer (SHB), Low country live wood

**Table 5: Association between GAPs and stress symptoms**

| Type of Association | p-values |
|---|---|
| Deep forking and % bushes with stress symptoms | 0.068* |
| Soil rehabilitation and % of bushes with stress symptoms | 0.061* |
| Correct dosage of dolomite and % bushes with stress symptoms | 0.088* |
| Quality of nursery plant and Intensity of stress symptoms | 0.02** |
| Degree of sanitary measures at pruning and Intensity of stress symptoms | 0.049** |
| The correct resting period before pruning and Intensity of stress symptoms | 0.064* |

*significant at 10% level ** significant at 5 % level

termite (LCLWT), Stem and branch canker (SBC) Wood-rot (WR), and Horsehair blight (HHB) which have been observed in healthy-looking tea bushes and unhealthy bushes in the sample is shown in the Fig.1.

LCLWT, SBC, WR, and HHB are the major pest and diseases in the particular smallholdings and the incident levels reported in unhealthy tea bushes (debilitated) relatively higher than that of healthy tea bushes (Fig.1).

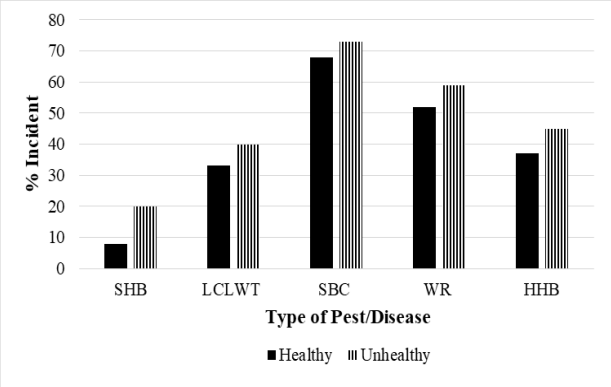


**Figure 1: Pest and disease incidence levels in the sample. SHB: Shot-hole-borer, LCLWT: Low country live wood termite, SBC: Stem and branch canker, WR: Wood -rot, and HHB: Horsehair blight.**

**Table 6: Analysis of severity of pests and diseases of healthy and unhealthy tea**

| Pest/ Disease | Median value of Likert scale | | Significance level |
|---|---|---|---|
| | Healthy | Unhealthy | |
| LCLWT | 0 | 1 | 0.0015 |
| Collar Canker | 1 | 3 | 0.0003 |
| SBC | 2 | 3 | <0.00001 |
| WR primary branches | 1 | 3 | <0.00001 |
| HHB | 0 | 2 | <0.00001 |

The elevation of the studied area was less than 300m MSL and thus SHB did not become a major pest agrees with the findings of Walgama and Pallemulla (2005). High canker incidents would have been attributed to certain predisposing factors such as poor adoption of cultural practices that prevailed in the region. (Amarathunga 2001; Tea Small Holding Development Authority 2008). The high wood-rot incident also an inevitable consequence of LCLWT and canker, as described by Balasuriya (2003).

However, rather than the number of incidents, severity could have more impact on the debilitation of tea. Therefore, the comparison of healthy and unhealthy tea concerning Likert scale values on the severity of pest and disease was made using Man- Whitney test and the results are given in Table 6.

This analysis revealed that severity levels of LCLWT, canker (both Collar and Branch), WR, and HHB are significantly high in unhealthy tea and thus, those pests and diseases have an impact on bush debilitation in these holding.

Moreover, soils and root samples obtained in the field have been tested in the laboratory, and plant-parasitic nematodes were detected in 28% of the samples, of which 96.3% was a very light level of infestation, and 4.7% at

light infestation. However, the Chi-square test confirmed that there is no association between nematode incidents and the presence of symptoms. (Chi-square value 4.375, p=0.224) Even those holdings which have high debilitation levels did not show a direct association with nematode incidence. (Chi-square value 2.599, p=0.107). This situation is different from the scenario observed in the Balangoda region (Rajasingh *et al*. 2015) and the Mathugama region (Mahindapala *et al*. 2018) and would have been due to very light nematode counts. Nevertheless, it was able to establish a relationship among the tea holdings, that are less than ten years old and showing severe symptoms of debilitation with nematode incidents (Chi-square value 4.913, p= 0.041). On the other hand, it should be noted that those very light nematode counts can be developed into a higher level, if the conditions are conducive (Mohotti 2008; Mohotti *et al*. 2017) - especially when considering the poor adoption level of related GAPs in the region.

## CONCLUSION

The stress symptoms that appeared on the tea bushes indicated that tea bushes of the smallholdings in this region are being debilitated and if it continues, can cause a detrimental impact on overall tea production. The adoption level of some of the critical GAPs is not at a satisfactory level and which were identified as some of the attributes of this debilitation. The primary pests like low country live wood termite, stem and branch canker and collar canker, wood-rot and horsehair blight too have a bearing on the debilitation. It seems that such primary pests have paved the way for some of the secondary pests such as wood rot and horsehair blight and, which have also contributed to the problem. Although fairly high parasitic nematode incidents were detected, their impact was not visible. However, such, higher incident would be possible to make a serious consequence under a poor crop management strategy of the smallholders.

## RECOMMENDATION

The line extension agency indeed provides appreciable assistance to the tea smallholders. However, the findings of this study suggest that relevant extension agents need to pay extra attention to some areas where smallholders have failed to show a reasonable level of adoption such as sanitary pruning, planting of improved cultivars, and following a proper planting technique through the extension and development programs. Effective extension strategies need to be implemented in collaboration with other supportive services to achieve success. Those who have old tea lands should be encouraged to replant with quality planting materials with improved tolerant cultivars. It is necessary to take the present nematode incidence level as an alarming situation and need to pay special attention to contain the nematode incidences through the planting material. They should explore the possibility of integrating the government assistance programs that are underway.

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***Author Contribution***

*KGJPM conceptualized and designed the study. KGJPM, TGNM and SPAPKJ performed the experiments. KGJPM and SPAPKJ analyzed the data. SPAPKJ and PDAA tabulated the data. KGJPM wrote the manuscript. All authors discussed the results and commented on the manuscript.*