Investigation of debilitation of tea and technology adoption in smallholders in Mathugama division in Kalutara district of Sri Lanka.

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Abstract - *Tea is the main foreign exchange earning crop in Sri Lanka, which provides greater strength to the national economy. Smallholders are the major producers of the tea industry. It was reported that tea bushes in some smallholdings in low-country tea growing region were debilitated. This study attempted to examine whether such debilitation exists in tea in Mathugama division and identify the attributes. Fifty smallholdings were selected for the study. Data were collected through the interviews and field observation and analysed using descriptive statistics, pool t-test and chi-square test.*

About 50% of the sample has shown light to moderate level of stress symptoms mainly dieback and dwindling of new shoot development, dispersed up to 30% of the land area. However, T-test revealed that stress symptoms have no impact on tea yield. Only canker and wood-rot diseases were found in a relatively high percentage of the sample but at low or moderate intensity. The parasitic nematode infestation was detected in a considerable percentage of smallholdings. Statistical analysis revealed that except nematode infestation, no any other pest or diseases condition associated with the stress condition. Further, it was revealed that growers' technology adoption levels were poor for many important good agricultural practices. A negative association between soil rehabilitation and stress condition have also been detected.

Although it was viewed that tea smallholdings in the region are in a safe position with respect to the debilitation, certain important indication revealed in the study should also be considered in implementing the extension program in the future.

Keywords- Tea, Smallholding, Mathugama, Bush-debilitation, Adoption

I. INTRODUCTION

Tea, being the main foreign exchange earning crop in Sri Lanka, provides greater strength to the national economy and livelihood of people in the tea industry while generating numerous benefits to the society. The agriculture sector generates about 25% of the country's total export earnings and of which, tea alone contributes 58%. (Anon, 2015a-2017). In terms of the size of the holding, three main segments can be identified in Sri Lankan tea industry. They are smallholders (less than 10 acres), proprietary estates (10 – 50 acre) and corporate sector tea estates (Over 50 acres). Smallholders in the tea industry are becoming a crucial factor, day by day, as their production and the land share have been increased to 73% and 62% respectively (Anon 2017, Anon 2005). The contribution of the Low grown tea (Tea growing areas below 600m of elevation from the mean sea level) is highly significant to Sri Lankan tea industry as about 60% of the total tea production of Sri Lanka comes from Low-country tea lands (Anon, 2015b). The favourable environmental factors (Watson *et al.*, 2008; Wijerathna, 1996) and a large percentage of smallholders are the two factors responsible for its greater contribution of low-country to the national tea production. Yet, when considering the tea productivity in Kenya and North India, the productivity in the smallholding sector in Sri Lanka is low. (Anon, 2015c), and soil fertility is one of the main factors believed to be responsible for low productivity.

It was reported that tea bushes are in some part of the low-country tea growing region, in smallholding sector were debilitated due to certain factors including nematodes infestation and poor adoption of agricultural practices (Rajasinghe, 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 and fruiting, wilting, *bangi* formation and die-back (Rajasinghe *et al.* 2015). Some previous authors (Sivapalan, 1967, 1972, Gnapragasam 1988) have noted that such kind of symptoms could be occurred in both young and mature tea, as a result of plant-parasitic nematodes. Nevertheless, as per the literature, it has been shown that these types of stress symptoms, leading to debilitation and poor performance can occur not only due to nematodes but also due to various entomological, pathological, cultural and environmental factors (Balasuriya,2003; Wijerathne *et al*., 2007; Arulpragasam and Balasuriya, 2008; Senawirathna and Mohotti, 2008; Kulasegaram and Wijeratne,2008). Hence, tea grower has a vital role to play in managing this situation.

In a study conducted in corporate sector tea estates of low-country, revealed that senility of tea, improper adoption of some cultural practices, loss of vigour as a result of some pest are the attributes of declining of yield in the particular sector (Mahindapala, *et al.* 2017). Further, the poor adoption of agriculture practices has been

revealed as one of the main problems in the smallholding sector in several other studies (Jayamanna*, et al.*, 2002; Anon, 2008).

The number of cases of tea bush debilitation has increasingly been reporting since 2015, in different parts of low grown area (Unpublished data, TRI) and which resulted an uncertainty condition among the tea growing communities. Thus, a need was arisen to conduct a systematic study in different regions representing the different districts to understand the specific causative factors. Therefore, the objective of this study was to

1. Examine whether the debilitation, that was experienced in some tea smallholdings in low-country, is existed in Mathugama region
2. Find out the possible causes that contribute to the tea bush debilitation in the study area.
3. Evaluate the level of technology adoption among the tea smallholders

Mathugama Divisional secretariat area (DSA) comes under Kalutara district. Kalutara district was predominantly Rubber growing area. When reviewing the records, it appears that majority of the smallholdings in Kalutara doesn't have a long history and were immerged in relatively recent times. The number of holdings reported as per the sense of smallholding conducted in 1984 was 1,843 (Anon, 1990), while it was increased to 38,263 at 2004 (Anon, 2005), indicating the large scale new planting (planting of tea in a land which was previously under any other crop or vegetation) that had been undertaken. As previously pointed out, studies proved that land which has less exposed to degradation has greater potential to generate higher yield (Jayanath *et al.*, 2001). Out of fourteen administrative districts, where tea have been planted, Kalutara district has given the highest average tea yield (2544kgMT/ha/year) as per the census conducted in 2004 (Anon, 2005) which indicates the higher productivity potential of the tea lands in Kalutara district.

Out of thirteen tea-growing DSA in Kalutara, cases of debilitation of tea have been reported from smallholdings in Mathugama DSA (Unpublished data, TRI Mathugama Extension Centre) and therefore, this study was conducted in Mathugama DSA.

II. METHODOLOGY

Mathugama DSA belongs to WL1a Agro-Ecological region (Punyawardhana *et al.,* 2003), where 2767 smallholdings were reported as per the 2004 census (Anon, 2005). However, according to the recent statistics approximately 3000 holdings were registered in the Tea Small Holding Development Authority (TSHDA) to obtain the government fertiliser subsidy, and that list was used as a sampling frame for the study. Out of 57 *Grama Niladhari* Divisions (GND) available in Mathugama DSA, about 20 GNDs were identified as tea growing GNDs (As shown in fig 1) and of which, 9 GN divisions were randomly selected for the study. Considering the total population of the GND, a sample consist of 5-6 tea growers were again randomly selected from each GNDs. When drawing the sample from GNDs, a stratification has also been done. They were proportionally selected from two age groups such as tea cultivations belong to 3 – 8 years old (A) and 8- 20 years (B). Finally, 50 sampling units were selected for the study.

The sampling procedure is sketched out in the fig.1

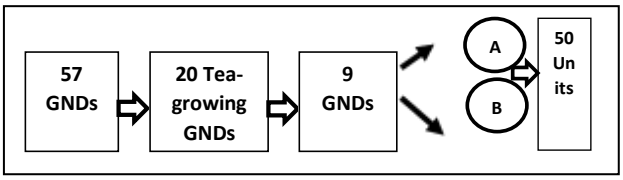

Fig.1: Rough sketch of the sampling procedure.

A structured questionnaire was deployed to collect the data, which consist of two parts-

i. To collect the basic information from tea growers on their tea cultivation and pass practices being adopted – data were collected through the interview
ii. To record the quality of the good agriculture practices (GAP) that grower has adopted, and type and magnitude of the various problems (pest and diseases) encountered – data were collected through the field observation. These field examinations also used as a triangulation technique to verify the data collected through the interviews.

TRI recommendations published in the form of Advisory circulars (www.http.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 level were measured by using 0 - 5 (0 for No; 1 for Very low; and 5 for very high) Likert Scale. Different pest and disease incidents and severity levels were measured separately from randomly selected healthy and unhealthy tea bushes from affected tea holdings (tea holdings with stress symptoms). Further, Soil and plant samples were collected for the laboratory estimations. The collected data were tabulated and analysed using descriptive statistics, chi-square and mean comparison technique using SPSS.

III. RESULTS AND DISCUSSION

A. General soil and environmental condition

Tea growers of the sample were distributed in the elevation ranges from 10-55msl. The physical properties of the tea lands (Soil depth, Slope, gravel content, rockiness) were estimated and accordingly all these lands are having deep soil (Soil depth>1m) and less amount of rocks (rockiness<10%). About 80% of the holdings are having less than 25% of slope, 10% of the holdings are less than 25-50% of slope, and the rest are less than 70% of the slope. These lands are located in the soil series of Agalawatta associated with Dodangoda series (Mapa *et al.*, 1999) which is predominantly considered as gravel-rich soil, but 90 % of the holdings were estimated as less than 25% of the gravel content.

B. Presence of the stress symptoms

About 50% of the sample has shown at least some degree of stress symptoms. Major symptoms observed in the tea bushes were flowering, and fruit setting, Die-back and dwindling of new shoot development, yellowing, *banji* formation and lack of feeder roots and of which die-back and dwindling of new shoot development was the most prominent symptom noticed. However, these symptoms were not only occurred in a solitary manner but also cluster manner with the association of several symptoms. The spreading of the stress symptoms within the holdings shows a diverse pattern, and out of the 'affected' holdings 36% showed less than 10% and 48% showed 10-30% level of spread within the land while 16% has shown the coverage of 30-40% of the land. The severity of the symptoms is also an important measurement and, which measured using a Likert scale and values are given in table 1. The table shows that majority of the tea holdings express the symptoms with less severity.

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Table1: Severity of the symptoms appeared

Severity category	No. of observation and % (N= 25)
Very Low	2 (8%)
Low	11 (44%)
Moderate	12 (48%)

This condition is different from the previous observations recorded in Balangoda region (Rajasinghe *et al.* 2015, Mahindapala *et al.* 2018) where symptoms are much severe than that have been observed here. Therefore, tea holdings in this region are appeared to be in a relatively safer state.

C. Impact on yield

Pool T-test was carried out to see the impact of stress symptoms on the yield of tea bushes which are in between 8-18 years old. Test statistics (t-.308, P-value 0.854) did not show yield difference between teas without stress symptoms (mean yield 321.2kg green leaves/acre/month) and with stress symptoms (mean yield 301.4kg green leaves/ acre/month) and revealed that stress condition has no impact on tea yield. This result is entirely different from the result obtained from the previous authors as the same type of stress condition, occurred due to nematode infestation has shown 4-40% yield drop depending on the various factors (Gnanapragasam, 1988). However, as discussed in the previous chapter, majority of the cases, symptoms occurred at less severity, and that would be the reason for such a situation.

D. Pest and disease status

Key pest and main diseases on tea which have been observed in the study area is summarized in table 2. Accordingly, Shot – hole –borer (SHB) and Low country live wood Termite (LCLWT) infestation levels were very low. This result on SHB is in agreement with the finding of Walgama (2005) as he found that highest outbreak of SHB occurred in the mid-elevation (400-600msl). On the other hand, canker disease (both collar and branch canker) and wood-rot were found in a relatively high proportion of the tea bushes, yet the severity of these disease infestations were mostly at a low or moderate level, as illustrated in table 3. The chi-square test statistics reveal that these two diseases have no meaningful relationship with those stress condition.

Table 02: Incident level of different pest and diseases

Type of the pest and part of the damage	No. of incident and % (N= 48)
SHB in secondary branches	1 (2.1%)
SHB in primary branches	1 (2.1%)
SHB in the main stem	1 (2.1%)
LCLWT in primary branches/main stem	6 (12.5%)
Collar Canker	23 (47.9%)
Branch Canker	28 (58.3%)
Wood-rot in primary branches	22 (45.8%)
Wood-rot in the main stem	22 (45.8%)

Table 03: Severity of Canker and Wood-rot diseases

	Severity level %			
	High	Moderate	Low	V. Low
Collar Canker (N=23)	8.7	39.1	39.1	13.1
Branch Canker (N=28)	7.1	46.5	35.7	10.7
Wood-rot in primary branches (N=22)	0.0	54.5	36.4	9.1
Wood-rot in main stem (N=22)	13.6	54.5	27.3	4.6

Moreover, through the soil and root sample analysis, it was found that 21% of the samples have been infected with parasitic nematodes and which is an alarming situation. Although the infested levels are very light, at any time, it can be developed into a higher level if the conditions are conducive (Mohotti *et al*., 2008). The chi-square test was performed to see the association of nematode infestation and stress symptoms, and it was revealed that the association is significant at $\alpha = 0.15$ (85% CI)

E. Technology adoption

The adoption of Good Agriculture Practices (GAP) of these farmers was also evaluated, as poor adoption of GAPs can be attributed to debilitation of tea and poor yield. Table 4 illustrate that adoption level for some of the important practices.

Table 4: Adoption of different agriculture practices

Good Agriculture Practice (GAP)	Adoption level % (N= 48)
Deep Forking During land preparation	29.2
Rehabilitation of soil before planting	10.4
Use of nursery plant raised in 5"X 7" polybag	8.3
Use of resistance cultivar	8.3
Use of correct fertiliser mixture	77
Use of correct fertiliser dosage	14.6
Applying of Wound dressing on pruning cuts	33.3
Mossing and removing of Ferns	3.1
Presence of Leader drains and lateral drains	12.5 & 25
Presence of Medium shade	89.6
Presence of High shade	2.1
Resting before prune	17.1
Applying of Dolomite	79.2
Applying correct Dolomite dosage	47.9

Table 4 shows that the adoption levels were satisfactory with respect to only a few GAPs such as use of correct fertiliser mixture, presence of medium shade and 'weather applying Dolomite', while it is at moderate level for applying of correct amount of Dolomite. The adoption levels were estimated as inferior for rest of all the essential Agricultural practices.

A mix cropping system with minor export crop (Pepper/Cinnamon), other plantation crops (Coconut/Rubber), fruit crops and timber etc. were practiced by 85% of the tea growers and of which 80% (68% of the sample) planted these crops in an irregular manner owing to excessive shady condition within the system. Wijerathna *et al.* 2016 emphasised that 60% sunlight require to be received by tea canopy to maximise the yield. Based on the visual observation, the level of sunlight fallen to the tea canopy was poor and that would be the reason for relatively lower average yield of the holdings under study (300kg green leaves/acre/month or approximately 2000kgMT/ha/year) than the average yield of Kalutara district obtained in 2004 (2544kgMT/ha/year).

A chi-square test was performed to see any association between the above mention GAPs and stress condition and results are given in table no.5.

Table 5: Chi-square test statistics of different association

Type of Association	Chi-square value (p-value given within the parenthesis)
Deep Forking X Stress symptoms	0.101 (0.921)
Soil Rehabilitation X Stress symptoms	3.197 (0.074)
Polybag nursery plant X Stress symptoms	0.233(0.972)
The correct dose of fertiliser X Stress symptoms	1.167 (0.558)
Wound dressing X Stress symptoms	0.127 (0.721)
Mossing and furning X Stress symptoms	2.330 (0.675)
Resting before prune X Stress symptoms	1.373 (0.503)
Applying of Dolomite X Stress symptoms	0.206 (0.650)
Sanitary measures at pruning X Stress symptoms	2.868 (0.720)

Among these interactions, only the association between soil rehabilitation and stress condition become significant at $p<0.1$. This suggests that chance of occurring of stress symptoms would be less if the land would be rehabilitated by planting of grass before planting of tea. Although early findings have shown that lands which have been rehabilitated have less likely to occur the nematode infestation (Gnapragasam 1982), this study was unable to establish a correlation between effect of soil rehabilitation and nematode incidence, due to lack of infested cases (only N= 10). However, it was observed that 9 out of 10 Nematode infested fields had not been rehabilitated and hence it cannot undermine such strong evidence.

IV. CONCLUSIONS

Although certain stress symptoms appeared on the tea bushes of the smallholdings in this region, they are not in a severe state to cause a significant yield loss. Thus, it can be concluded that tea bush debilitation is not severe in the smallholding sector in Mathugama division. However, 20% of the smallholdings have been detected as lightly infested with nematodes, and it should be considered as an alarming situation as which has some relationship with debilitation. Moreover, the adoption of most of the essential GAPs are at an unsatisfactory level.

Eventually, all these scenarios may increase the vulnerability of smallholdings in this region for the debilitation.

V. RECOMMENDATIONS

The findings of this study strongly suggest that Extension workers should intervene to improve the adoption of GAPs with special reference to the soil rehabilitation, proper land preparation, use of good and non-contaminated nursery plants with nematode and adoption of sanitary measures at the pruning.

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