















New Candidate Tea (*Camellia sinensis*), Cultivars of TRI 5000 Series for Low-Country Tea Growing Regions of Sri Lanka

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Abstract.

Among tea growing regions in Sri Lanka, lower elevations, popularly known as “Low Country” contributes about two third of the total tea production of the country. Through a series of experimentation, five new tea *Camellia sinensis* (L.) accessions (84, 174, 278, 12/11, 23/5) have been identified as candidate cultivars of TRI 5000 series, suitable for the region. All these accessions possess compatible yield potential with standard cultivars. Moreover, all of them possess high tolerance level to drought and 2-3 other desirable attributes, in terms of tolerance to major pests (shot hole borer, nematodes and low country live wood termites) and disease (stem and branch canker), prevailing in the tea cultivations of the region. In addition 02 of these accessions have exhibited moderate amenability to mechanical harvesting. These desirable attributes in terms of productivity and resilience of the new accessions will provide better opportunity to growers in the region to face emerging challenges including climate change effects, mainly prolonged dry weather and scarcity of skilled workers.

Keywords: TRI 5000 Series, Candidate cultivars, Low country, Sri Lanka, Tea accessions

1 Introduction

Tea (*Camellia sinensis* L.) is a predominantly out-breeding woody perennial with a long generative cycle. Tea is unique among perennials, because its vegetative parts (2-3 tender leaves and a bud) are harvested to produce one of the most popular non-alcoholic beverages in the world. The sustainability and profitability of the tea cultivation primarily depends on the availability of desired planting materials (1). Hence, the development of improved planting materials has been recognized as one of the main goals of the Tea Research Institute of Sri Lanka (TRISL) from the beginning.

Tea crop improvement program, in general, is a multi-stage procedure including multi-location testing with a span of over 20-25 years (Gunasekare, 2008). Continued efforts towards the development of improved planting materials have yielded several batches of cultivars viz. TRI 2000 series in 1960's, TRI 3000 series in 1970's and TRI 4000 series in 1994 (Singh, et.al., 2003). At the beginning yield

was the main target with tolerance to one or two major pest/s or disease/s. However, in subsequent releases priority was given to incorporate multiple resistances to pests and diseases. Recently, emphasis was given to develop tea cultivars with tolerance to major biotic and abiotic stress factors while increasing yield and made tea quality. Moreover novel challenges faced by the tea cultivation and industry due to the impact of global climate change, specially the rising temperatures and extreme weather events ; prolonged droughts, sudden downpours (Wijeratne, 2018) and the increase of the incidence of pests, diseases and weeds. In addition, need of tea cultivars amenable to mechanization particularly to mechanical harvesting due to the scarcity of skilled work force (Wijeratne, 2018) also taken into consideration. .

Low country tea cultivation produces about two third of the total tea production in Sri Lanka (Anon, 2023) and dominated by the tea small holding sector (about 75%). Further, the low country tea growing region has been recognized as one of the most vulnerable regions for abiotic stresses particularly caused by climate change effects (Wijeratne, 2018) and biotic stresses viz. stem canker, shot hole borer (SHB) and low country live-wood termites (Mahindapala, et al., 2017, Mahindapala, et al., 2019, Mahindapala, et. al., 2020). Recently, the change in nematode population densities and their distribution have also been reported in tea growing regions particularly in lower elevations exhibiting varying magnitudes of damage symptoms (Amarasena, et. al., 2019).

Considering all the above issues, the main objective of the research programme was to develop new tea cultivars having a combination of desirable attributes with enhanced environmental adaptability and grower acceptability than the existing cultivars to ensure increased productivity, profitability and long term sustainability of tea plantations in the Low Country tea growing region.

2 Materials and Methods

2.1 Progeny trials and initial evaluation

Evaluation to develop TRI 5000 Series in the Low Country dated back to 1979/ 1980, when five progeny trials consisting total of 7692 accessions /seedlings of 12 parental sources were established. Progeny trials were established using single plant randomization method. In the progeny trials all individual plants were subjected to evaluation using morphological and agronomic characteristics.

2.2 Preliminary yield trials (Phase I) and medium scale trials (Phase II)

All together 481 Promising seedlings selected from five progeny trials were vegetatively propagated and subsequently included in five preliminary yield trials (Phase I) for further evaluation. Phase I trials were established in a randomized complete block design (RCBD) having 5-7 plants per plot. Selected 85 accessions based on morphological and agronomic characteristics from Phase I trial were subsequently included in two medium scale field trials (Phase II) which were established in RCBD having 24 plants per plot. Both Phase I and II trials were established at TRI regional stations in the Low Country Wet Zone. During the evaluation in Phase I and II, the selected accessions were subjected to rigorous evaluation and screening by making comparative evaluations with existing proven cultivars using as standards to identify accessions which were superior to the existing cultivars.

2.3 Yield evaluation in Phase I and Phase II trials

In the yield evaluation, crop yield data were recorded for 1-2 pruning cycles by seven days plucking intervals. The green leaf yield was converted into made tea yield measured by kg per hectare (Kottawa-Arachchi, et. al., 2019).

In addition to the yield evaluation, other agronomic characteristics / parameters viz. pruning weights, tipping weights, recovery after pruning, visual growth performances and periodical visual observations throughout the evaluation period had been recorded and reported accordingly to supplement the evaluation. The initial screening for pest and disease occurrence / tolerance was also conducted in these stages.

2.4 Establishment of adaptive trials (Phase III) in Estates and small holdings

From the evaluation in Phase II, 35 (Table 1) promising accessions were selected based on yield, other agronomic characteristics and initial screening for pest and disease occurrence/tolerance for further evaluation in adaptive trials in tea growers fields (Phase III).

Table 1. Details of the 35 accessions selected for Phase III adaptive trials based on Phase II evaluation.

Parentage	No. of accessions selected for Phase III (Adaptive trials)	
	From LVP 74 ¹ (Phase II)	From LVP 75 ² (Phase II)
Ais. 2025 x 2024 OP	12	
Hug. 2025 x 2024 OP	01	
Ais. 2025 x 2023 OP		05
Vy. 2026 X DN OP		03
TRI 777 OP		02
DT 1 OP		01
TRI 2025 OP		02
K 2016 OP		04
K S106 OP		02
K 2023 OP		01
U 2016 OP		02
Total	13	22

AER = Agro Ecological Region

LVP74¹: Phase II trial at old TRI station Deniyaya - AER:WM1a

LVP75²: Phase II trial at St. Joachim Estate, Ratnapura - AER:WL1a

Ais., Hug., K, U, Vy. ; Seeds from Aislaby, Hugoland, Karadupona, Urumeevela,

Vykumbura Tea seed gardens, respectively / OP = Open Pollinated

When selecting the locations for phase III trials, adequate representation of the agro-ecology based on (Punayawardena, et. al., 2003) and main tea growing areas/districts (Ratnapura, Kalutara, Galle and Matara) of the region was made sure. Moreover, dissimilar to other regions (Up country, Uva and Mid country) small holdings contribute about 75% of the total tea extent in the Low Country. Therefore, it

is necessary to test the accessions not only under the conditions of co-operate sector estates but also in the small holdings, adequately. Considering these factors, all together 21 phase III trials; eight trials at estates/TRI Stations and 13 trials in small holding sector were established. Commercial yield evaluation and in-depth screening of tested accessions for tolerance to biotic and abiotic stresses were made in the Phase III stage.

2.5 Yield evaluation in adaptive trials of adaptive trials

Low country being a comparatively large area, it was not possible to carry out long term yield evaluation of all the tested accessions in all the adaptive trials, therefore in addition to the commercial yield recording yield component assessments were made based on methods described by (Wijeratne, 2001) in a representative sample of eight adaptive trials established between 2012 and 2015 covering all four districts in the region to explain yield differences and the supplement the yield evaluation. In the yield component assessment, shoot density and average shoot fresh and dry weights in grams of the harvested shoots were measured using 1 x 1 feet quadrat. Assessment was made two times (covering wet and dry seasons) during 2023 to 2024, on six bushes in each tested accession. There are 35 recommended cultivars for low country, however according perception studies as well as authors long field experience, representative sample of 03 most popular / recommended cultivars ; TRI 2026, TRI 4042 and TRI 4049) were also assessed in each location for comparison.

2.6 Screening of accessions for Abiotic (Drought) and Biotic (Pest and Diseases) stresses

A recently established protocol (Damayanthi, et. al., 2017) was used in screening for drought tolerance. In the method, responses of tea plants to drought were evaluated in relation to soil moisture content and physiological parameters viz. photosynthetic rate, transpiration, stomata conductance, relative water content and total soluble sugar content. In addition, long term observations on the performances under dry weather were also conducted to supplement the drought screening.

Screening of accession for the tolerance to major disease in the Low Country; screening for the stem and branch canker, caused by fungal pathogen *Macrophoma theiocola* Siemaszko, was carried out by adopting field screening as practiced traditionally and as well as by artificial inoculation studies at the glass house.

Screening of the new accessions for the tolerance/susceptibility to Low Country live wood termite (LCLWT); screening for *Glyptotermis dilatatus* was carried out along with standard cultivars (Standard susceptible: TRI 2026 and standard tolerant: TRI 2027) at the time of pruning (Phase II and III stages). Determination of the severity of damage was assessed by observing the colony development of LCLWT in each cultivar/accession.

Tolerance / susceptibility to shot-hole borer (SHB) (*Xyleborus fornicates*) was assessed by a method described by (Walgama et al., 2008). Number of stems infested and total number of galleries in stem were included for final analysis. Field observations were validated with the results of a bioassays in the laboratory.

Screening of TRI 5000 series accessions against the both nematode species (*Pratylenchus loosi* and *Radopholus similis*) was carried out under controlled conditions in infested tanks by destructive sampling technique as per the standard protocols (Kottawa-Arachchi, et. al., 2019)

2.7 Determination of comparative resilience levels of accessions / standard cultivars for abiotic and biotic stresses

To determine the comparative resilience levels accessions / standard cultivars were characterized by assigning simultaneous susceptibility status /scores based on Descriptors for Tea (*Camellia sinensis* L.) by International Plant Genetic Resources Institute (IPGRI, 1997) as follows (Table 2) and cumulative and average susceptibility scores were calculated subsequently.

Table 2. Criteria for determination of comparative resilience levels of accessions / standard cultivars for abiotic and biotic stresses

Tolerance status	Simultaneous susceptibility status	Susceptibility score
High	Low	3
Moderate	Intermediate	5
Poor	High	7

2.8 Biochemical analysis of fresh tea leaves and made tea

Biochemical analysis of fresh and made tea have not been an essential component of the cultivar evaluation in the Low Country in the past. Therefore, considering present market trends and future predictions, biochemical analysis of green leaf and made tea has been initiated with few selected accessions in comparison to popular cultivars recommended for the Low Country. Analyses were carried out by following standard protocols (ISO-14502-1 and 2, 2005) and as per the methods adopted previously (Kottawa-Arachchi, et. al., 2019).

2.9 Screening cultivars for amenability for mechanical harvesting

Amenability of tea cultivars for mechanical harvesting has becoming an important factor due to the scarcity of skilled workers at present. Therefore, the amenability for motorized mechanical harvesting (non-selective) of selected accessions as an alternative to manual harvesting in terms of tea yield and growth of the tea shoots was assessed in comparison to a popular / recommended cultivar (TRI 4042) as a standard as per methods adopted previously (Pathirana, 2019).

2.10 Data analysis

Statistical analyses by the analysis of variance (ANOVA), mean separation tests by the Duncan Multiple Range Test (DMRT) and summary statistics were performed using SAS (version 9.1) software.

3 Materials and Methods

3.1 Yield evaluation

Out of the 35 accessions evaluated in the Phase III, 05 accessions (3 from LVP 74 + 2 from LVP 75) exhibited better cycle yields than at least one of the standards in at least one adaptive trial and exhibited comparatively better performances in terms of bush survival and growth (based on the long term field observations/ assessments). Therefore selected as potential TRI 5000 series accessions. The summary of the yield data of those five accessions are presented in Table 3 (LVP 74 selections) and in Table 4 (LVP 75 selections), acronyms based on their respective phase II trial identity).

Table 3. Summary of results of the yield evaluation at different stages of 05 selected accessions of LVP 74 Selections.

Accession/ Standard	Cycle yield in Made Tea kg per hectare per year in different stages								
	Phase I#	Phase II#		Phase III ^s					
	Hanford Deniyaya	TRI Deniyaya	TRI, Kottawa	Indola Mawarala	Delmella SH	Morawa ka SH	Unanavitiya SH	Neluwa SH	Palawella SH
	AER WM1a	AER WL2a	AER WL1a	AER WL1a	AER WL1a	AER WL1a	AER WL1a	AER WM1a	AER WL1a
84	5349 ^a	2901 ^d		<u>3634</u>	<u>4592</u>	<u>2688</u>			
174	4404 ^a	2757 ^d				<u>3947</u>			
278	4445 ^a	3094 ^{cd}	<u>3479</u>		<u>5201</u>	1564	<u>3957</u>	<u>6276</u>	<u>1392</u>
TRI 2026		4576 ^{abc}	5680	4052	3712	3928	3735	3928	2394
TRI 2027	4344 ^a			3994					
TRI 4042			2697	2686	6156	3201	3257	4447	1109
TRI 4049					5137	2312			1120

SH = Small holdings, AER = Agro ecological region

#Means followed by the same superscript letter are not significantly different in Phase I and Phase II

^sAccessions which are higher than at least one of the standards are double underlined in Phase III

Out of the three accessions, no. 84 has exhibited better yields than at least one standard in all the adaptive trial locations (100%), whereas No. 278 has exhibited similar phenomenon in five out of six locations (83 %) and was better than all standards in two locations. Accession no. 174 was included to Phase III some times after based on its long term performances / bush survival, and was included in only one adaptive trial location. However exhibited best yield performances (better than all standards) in the particular trial.

Table 4. Summary of results of the yield evaluation in different stages of 02 selected accessions of LVP 75 Selections.

Accession/ Standard	Cycle yield in Made Tea kg per hectare per year in different stages						
	Phase I [#]		Phase II [#]		Phase III [§]		
	St. Joachim Estate	St. Joachim Estate	Deniyaya Estat	Cecilton Estate	Delmella SH	Morawaka SH	Palawella SH
	AER-WL1a	AER-WL1a	AER-WM1a	AER-WM1b	AER-WL1a	AER-WL1a	AER-WL1a
12/11	4103*	4916 ^{cdefg}		<u>2726</u>	<u>6097</u>		<u>1307</u>
23/5	4438*	4050 ^{efghi}	<u>1274</u>		<u>5992</u>	2258	<u>3162</u>
TRI 2026	4298 ^{abcd}	5213 ^{bcde}		2803	3712	3928	2394
TRI 4042				2899	6156	3201	1109
TRI 4049			749		5137	2312	1120
TRI 2023	4645 ^{abcd}	6368 ^{ab}					
TRI 2025	4270 ^{abcd}	3491 ^{hij}					
TRI 2027		4078 ^{defgh}					
S 106	3782 ^{bcd}	i	831				
DG 39	2777 ^d			2658			

SH = Small holdings, AER = Agro ecological region

#Means followed by the same superscript letter are not significantly different in Phase I and Phase II §Accessions which are higher than at least one of the standards are double underlined in Phase III

* Not replicated and therefore not considered for statistical analysis

Out of the two (02) accessions 12/11 has exhibited better yields than at least one standard in all four adaptive trial locations (100 %) and 23/5 has exhibited similar phenomenon in 03 out of 04 locations (75%) and yielded better than all standards in two locations.

3.2 Evaluation of yield components

When consider the overall results of the yield component assessment (Table A1 - Annexure I), all the five (05) accessions exhibited comparable or significantly higher performances compared to at least one of the 3 standards (TRI 2026, TRI 4042 and TRI 4049), with respect to both yield components, across the districts/AERs, except for following isolated incident

- Mean shoot dry weight (SDW) of No. 84 significantly lower than all 3 standards at Morawaka in Matara district

The results provides supplementary evidences for the comparable yield performances of the five (05) accessions in comparison to the popular recommended cultivars of the region.

3.3 Screening for drought, Canker, LCLWT, nematodes and SHB

The results of cultivar screening for abiotic (drought) and biotic (Canker, LCLWT, nematodes and SHB) stresses have been summarized in Table 5.

Table 5. Summary of the available results of screening for abiotic and biotic stresses of five (05) potential TRI 5000 Series accessions.

Accession No.	Tolerance Rating					
	Drought	Stem and branch canker	SHB	Nematodes		LCLWT
				<i>P. loosi</i>	<i>R. similis</i>	
12/11	High	Moderate	Poor	Poor	Moderate	Poor
23/5	High	Poor	Moderate	Moderate	Moderate	Poor
84	High*	High	Moderate	Poor	Poor	High
174	High	Moderate	Poor	Moderate	N/A	Poor
278	High	High	Moderate	Poor	N/A	Poor
TRI 2026 (standard)	Moderate	Poor	Poor	Poor	Poor	Poor

* Long term visual observations

SHB = Shot Hole Borer, LCLWT = Low Country Live Wood Termites, N/A = Results not available

To determine the resilience level accessions / standard cultivars were characterized by assigning susceptibility scores based on tea descriptor list (IGRI, 1997) as follows (Table 6).

Abiotic / Biotic susceptibility scores were assigned to Tolerance status based on) and cumulative and average susceptibility scores were calculated subsequently.

Table 6. Summary of the susceptibility scores of abiotic and biotic stresses of five potential TRI 5000 Series accessions.

Accession No. / Standard	Susceptibility scores					
	Drought	Stem and branch canker	SHB	Nematodes		LCLWT
				<i>P. loosi</i>	<i>R. similis</i>	

12/11				7	5	7
23/5	3	7	5	5	5	7
84	3	3	5	7	7	3
174	3	5	7	5	N/A	7
278	3	3	5	7	N/A	7
TRI 2026	2	7	7	7	7	7
(standard)						

SHB = Shot Hole Borer, LCLWT = Low Country Live Wood Termites, N/A = Results not available

All five (05) accessions possess lower susceptibility scores than the standard by a clear margin, reflecting considerable higher resilience to biotic / biotic stresses of the accessions against the standard. Based on characterization no. 84 being the most resilient overall among the 5 accessions followed by 278, 23/5, 174 and 12/11 respectively.

Major biochemical parameters of green leaves

Major biochemical parameters of green leaves of five potential TRI 5000 series accessions were assessed in comparison with three popular cultivars recommended for the Low Country (Table 7).

Table 7: Major biochemical parameters in green leaves of potential TRI 5000series accessions.

Accession / Standard	Biochemical parameters*							
	TPP %	Caffeine %	Catechin %	EGC %	EC %	EGCG %	ECG %	Total Catechin %
84	25.42 ^{bac} ± 0.2	2.74 ^f ± 0.13	0.175 ^d ± 0.01	1.54 ^f ± 0.09	1.61 ^d ± 0.05	4.13 ^h ± 0.23	2.24 ^g ± 0.07	9.69 ^g ± 0.43
174	25.09 ^{bac} ± 0.62	4.2 ^b ± 0.07	0.314 ^a ± 0.01	3.12 ^c ± 0.06	1.96 ^c ± 0.11	7.04 ^c ± 0.23	2.99 ^{cd} ± 0.07	15.41 ^d ± 0.47
278	18.76 ^e ± 0.88	3.53 ^d ± 0.09	0.236 ^{cb} ± 0.002	3.68 ^{ba} ± 0.07	3.31 ^a ± 0.02	6.07 ^e ± 0.2	3.25 ^a ± 0.06	16.74 ^e ± 0.34
12/11	21.33 ^{cd} ± 1.81	3.59 ^d ± 0.002	0.168 ^d ± 0.001	2.363 ^d ± 0.29	1.45 ^e ± 0.004	6.46 ^f ± 0.003	1.76 ^b ± 0.001	12.19 ^f ± 0.002
23/5	27.64 ^a ± 0.28	4.13 ^b ± 0.01	0.15 ^e ± 0.003	3.08 ^b ± 0.11	1.66 ^d ± 0.03	10.04 ^a ± 0.05	3.14 ^b ± 0.01	18.07 ^b ± 0.20
TRI 2026	23.68 ^{dc} ± 0.63	3.77 ^c ± 0.08	0.225 ^c ± 0.01	3.58 ^b ± 0.03	1.90 ^c ± 0.04	9.45 ^b ± 0.19	3.07 ^{cb} ± 0.06	18.22 ^b ± 0.39
TRI 4042	26.57 ^{ba} ± 0.97	4.09 ^b ± 0.06	0.241 ^{cb} ± 0.002	2.85 ^c ± 0.17	2.19 ^b ± 0.06	6.98 ^e ± 0.12	2.67 ^e ± 0.04	15.87 ^d ± 0.39
TRI 4049	24.27 ^{bc} ± 0.09	5.60 ^a ± 0.003	0.124 ^f ± 0.004	3.61 ^b ± 0.01	1.95 ^c ± 0.13	10.22 ^a ± 0.03	2.91 ^d ± 0.01	18.81 ^a ± 0.12

*TPP= Total Polyphenols, CAEGC= Epigallocatechin, EC= Epicatechin, EGCG= Epigallocatechin gallate, ECG= Epicatechin gallate, Means (± standard error) in each column followed by different superscripts letters are significantly different at p<0.05)

The results indicated significant variation in the levels of key biochemical compounds among the accessions. The percentage of total polyphenols was comparable to at least one of the standards in five out of six accessions, whereas accession 278 being the only exception. No new accession is better than the standard cultivars with respect to all the parameters. However, Ac. 174 is higher in catechin but lower in EGCG and total cathene, Ac. 93 is higher in EGC but lower in caffeine, EC, EGCG, ECG and total catechin and Ac. 278 is higher in EC and ECG but lower in TPP, caffeine, EGCG and total catechin than that of standard checks. When examining the variation across all parameters, accessions 174 and 23/5 were found to be similar to the standards, indicating that they could contribute similarly to popular cultivars in the low country. In contrast, the remaining three accessions (84, 278, and 12/11) deviated from the standards, but they could hold potential for producing specialty teas.

Variation of the Total polyphenol content (TPP) in tested black tea samples.

The total polyphenol content (TPP) of made tea samples produced from four selected accessions was compared with that of three standard cultivars (Table 8).

Table 8: Total polyphenol content (TPP) of made tea samples.

Accession/Standard	TPP (%) *
12/11	12.91 ± 1.53 ^b
174	18.88 ± 0.75 ^a
23/5	16.46 ± 0.24 ^{ab}
278	13.01 ± 0.79 ^b
84	18.22 ± 0.33 ^a
TRI 2026	16.68 ± 1.04 ^{ab}
TRI 4042	18.28 ± 0.64 ^a
TRI 4049	18.50 ± 0.49 ^a

*TPP= Total polyphenol; Means (± standard error) in a column followed by different superscripts letters are significantly different at $p < 0.05$

According to ISO standards, the total polyphenol content of black tea should be higher than 9% (ISO-14502-1, 2005). All tested samples had a polyphenol content ranging from 12.91% to 18.50%, which exceeds the minimum standard. The highest value was recorded in accession 174, while the lowest value was found in accession 12/11 (Table 8). Notably, a consistent trend was observed between the TPP (%) of green leaf samples (Table 7) and the corresponding made tea in tested four accessions, further supporting the reliability of the obtained results.

3.4 Amenability for mechanical harvesting

In the screening it was evident that none of the accessions including the standard were highly amenable for mechanical harvesting. However 2 accessions; 174, 12/11 and the standard TRI 4042 found to be moderately amenable for mechanical harvesting.

Summary of results of the overall experimentation has been presented in Table 9.

Table 9: Summary of results of the overall experimentation

Accession No.	Parentage	Average Yield* in Adaptive trials (Phase III)	Tolerance status					
			Drought	Canker	LCLWT	Nematodes		SHB
						<i>P. loosi</i>	<i>R. similis</i>	
12/11	TRI 2026 X DN	3377	H	M	P	P	M	P
23/5	TRI 2026 X DN	3804	H	P	P	M	M	M
84	Ais. TRI 2025 x TRI 2024 OP	3638	H	H	H	P	P	M
174	Ais. TRI 2025 x TRI 2024 OP	3947	H	M	P	M	NA	P
278	Hug. TRI 2025 x TRI 2024 OP	3645	H	H	P	P	NA	M
TRI 2026	ASM 4/10 OP	3661	M	P	P	P	P	P

* considered only, the Trials included TRI 2026 as a standard

SHB = Shot Hole Borer, LCLWT = Low Country Live Wood Termites, N/A = Results not available
Ais., Hug., : Seeds from Aislaby, Hugoland, Tea seed gardens respectively / H= High / M= Moderate / P = Poor / Long term field observations / OP = Open pollinated / MH = Mechanical harvesting

Being a perennial crop with long generative cycle finding a single tea cultivar with all the desirable attributes is almost impossible specially to a which expands over different agro-ecological regions with versatile grower composition yet producing two third of total production of the country. Therefore it is always necessary to identify and recommend basket of varieties each one with several desirable attributes. As reflected by the summary of results the average yield levels of cultivars have not exhibited considerable difference with the highest yielding standard (TRI 2026) present in the adaptive trials. However as described previously all the accessions have produced better yields than at least one of standards in more than 75% adaptive trials proved the compatible yield performances of the accessions. On the other hand all the accessions have exhibited far better resilience levels to abiotic and biotic stresses compared to the standard. Whereas as all 05 accessions exhibiting higher tolerance levels to

drought in a situation that the country has been identified as the most vulnerable region for anticipated consequences of global climate change mainly prolong dry periods (Wijeratne, 2018). Moreover based on the authors long field experience as well as learning from recent reports on yield decline and bush debilitation of tea in the Low Country (Mahindapala, *et. al.*, 2017, Mahindapala, *et. al.*, 2019, Mahindapala, *et. al.*, 2020), it has been evident that stem and branch canker is the major disease causing the debilitation and 04 out of 05 accessions have exhibited tolerance to canker (84 & 278 with high tolerance / 12/11 & 174 with moderate tolerance). With respect to LCLWT only No. 84 has been found with high tolerance. Moreover 03 out of 05 accessions (23/5, 84, 278). In addition with the recent reports on higher densities of nematode population particularly in low elevations exhibiting varying magnitudes of damage symptoms (Amarasena *et. al.*, 2019), out of 05 accessions, 03 (12/11, 23/5, 174) have exhibited nematode tolerance, whereas 23/5 showing moderate tolerance to both nematode species. Out of the 35 cultivars recommended to low country only 2 (TRI 4006, DG 7) found tolerant to both nematode species (Anon, 2002). Furthermore 02 of these accessions (12/11 and 174) have exhibited moderate amenability to mechanical harvesting, providing a better opportunity in management due to the scarcity of skilled labour at present day.

Due to the agro-ecological variation offered by the low country it is very difficult to introduce a single cultivar for all the areas in low country. The basket of 5 cultivars identified here consists of all the desirable traits necessary for low country will provide a better solution to the growers. However to achieve maximum results, the most suitable the most suitable cultivar / or set of cultivars to different agro-ecology should be selected judiciously by matching their desirable features with the requirement offered by the respective agro-ecology.

4 Conclusions

Based on the overall performances with respect to desirable attributes, the study identified a basket of five new tea accessions viz. 84, 174, 278, 12/11 and 23/5 as candidate cultivars of TRI 5000 series, suitable for the Low Country, Sri Lanka. All these accessions possess compatible yield potential with standards and highly tolerance to drought. They also possess 2-3 other desirable attributes with them, in terms of tolerance to major pests (shot hole borer, nematodes and low country live wood termites) and disease (canker) that are prevailing in the tea cultivations of the region. In addition two of these accessions viz. 174 and 12/11 having moderate amenability to mechanical harvesting also. Therefore inclusion of these new accessions will contribute towards enhancement of productivity and long term sustainability of the tea cultivation.

Declaration of conflict of interest

No conflict of interest

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Annexure I

Table A1: Summary of the results of the yield component assessment

Accession / Standard	Mean values of the yield components															
	Kaluthara District				Ratnapura District				Matara District				Galle District			
	Delmella		Halindola		Palawella,		St. Joachim		Deniyaya		Morawaka		Kottawa		Nelawa	
	AER - WL1a	AER - WL1a	AER - WL1a	AER - WL1a	AER - WL1a	AER - WL1a	AER - WL1a	AER - WL1a	AER - WM1a	AER - WL1a	AER - WL1a	AER - WL2a	AER - WL2a	AER - WM1a	AER - WM1a	
SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	SDE (f2)	SDW (g)	
12/11	21.4 ^{bc}	0.17 ^a	20 ^{bc}	0.2 ^{bc}	16.5 ^{bc}	0.20 ^{bc}	19.8 ^{bc}	0.17 ^a	19.4 ^a	0.18 ^a			21.8 ^{bc}	0.21 ^b		
	±1.5	±0.02	±1.6	±0.02	±1.1	±0.03	±1.1	±0.04	±1.4	±0.01			± 0.81	±0.01		
23/5	20.6 ^{bc}	0.17 ^a			19.3 ^{bc±}	0.2 ^{ba}	20.3 ^{bc±}	0.19 ^a	20.1 ^a	0.17 ^a	23.8 ^{ba}	0.2 ^{ba}	21 ^{ba}	0.19 ^b		
	±1.2	±0.01			1.2	±0.02	2.4	±0.02	± 3.4	±0.03	±0.8	±0.02	± 0.95	±0.01		
278	21.2 ^{bc}	0.14 ^a	18.4 ^{bc}	0.18 ^{bc±}	17.3 ^{bc±}	0.17 ^{bc±}	18.7 ^a	0.22 ^a			21.6 ^{bc}	0.2 ^{ba}			19.2 ^b	0.2 ^{ba}
	±1.2	±0.02	±1.3	0.02	1.2	0.02	±1.3	±0.04			±1.2	±0.02			± 1.8	±0.02
93			26.1 ^a	0.17 ^{bc}	22.3 ^{a±}	0.17 ^{ba}					22.9 ^{ba}	0.2 ^{ba}			23.8 ^a	0.14 ^c
			±2.4	±0.01	0.8	±0.02					±2.8	±0.01			± 1.7	±0.01
174							25.3 ^a	0.15 ^a			24.1 ^a	0.21 ^a				
							±1.95	±0.02			±2.1	±0.04				
84	18.8 ^b	0.18 ^a									18.5 ^a	0.14 ^{b±}				
	±1.6	±0.02									±1.3	0.01				
195			19.7 ^{bc}	0.27 ^a	23 ^{a±}	0.15 ^{b±}										
			±2.3	±0.04	0.99	0.01										
TRI	21.9 ^{bc}	0.17 ^a	22.3 ^{bc}	0.2 ^{bc}	22.1 ^{ba}	0.2 ^{ba}	21.1 ^{bc}	0.18 ^a	20.3 ^a	0.19 ^a	23.7 ^{ba}	0.22 ^{b±}	22.2 ^{ba}	0.21 ^{ba}	22.6 ^{ba}	0.18 ^b
2026	±2.6	±0.02	±1.4	±0.02	±1.2	±0.03	±0.4	±0.02	±1.5	±0.02	±1.6	0.01	± 1.0	±0.02	± 0.9	±0.01
TRI	23.6 ^a	0.16 ^a	21 ^{bc}	0.17 ^c	17.3 ^{bc±}	0.18 ^{ba}	18.8 ^a	0.16 ^a	20.7 ^a	0.18 ^a	22.2 ^{bc}	0.22 ^a	23.3 ^a	0.22 ^{ba}	19.3 ^b	0.2 ^{ba}
4042	±1.8	±0.02	±0.7	±0.01	1.2	±0.02	±2.5	±0.02	±1.3	±0.02	±1.0	±0.02	± 1.7	±0.02	± 0.75	±0.01
TRI	17.8 ^b	0.19 ^a	17.3 ^c	0.23 ^{bc±}	14.3 ^{d±}	0.23 ^{bc±}	16.2 ^c	0.23 ^a	17.5 ^a	0.21 ^a	19.7 ^{bc}	0.21 ^{bc±}	18.9 ^b	0.27 ^a	21.8 ^{bc}	0.23 ^a
4049	±0.8	±0.02	±1.3	0.01	0.6	0.03	±1.2	±0.04	±0.8	±0.02	±0.7	0.02	± 2.2	±0.04	± 1.7	±0.02
CV	17.7	25.0	20.2	24.9	14.0	31.8	20.8	38.7	23.7	28.2	17.3	27.1	16.7	24.0	15.2	15.7

Means in a column followed by different superscripts letters are significantly different at $p < 0.05$ /

SDE = Mean Shoot Density /

SDW = Mean shoot dry weight in g / SH = Small holding / AER = Agro ecological region / ± =

standard error/ CV = Coefficient of variance

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