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Evaluation of Best Cinnamon *(Cinnamomum verum)* Cultivars at Nursery Stage for Commercial Cultivation

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Abstract *–A field experiment was laid out in a randomized complete block design (RCBD) with six treatments (cinnamon cultivars) and four replicates of each cultivar to find out the best cultivar/s of cinnamon with reference to their germination percentage and growth performances at nursery stage. A laboratory experiment was carried to find out the chlorophyll content (mg/g), stomatal density (mm^{-2}) and dry matter content (g). Ripped seeds of selected cinnamon cultivars, i.e. CRS 351, CRS 317, CRS 184, CRS 83 and CRS 40 and true cinnamon, were established in the Cinnamon Research Station, Thihagoda, Matara and data collection started from one month after planting. Ten poly bags were selected randomly from 100 bags of each replicate and one seedling was randomly selected from each bag to measure the growth parameters. The selected seedlings were tagged with labels to differentiate from rest of the seedlings. Data were tabulated and analyzed by using Analysis of Variance (ANOVA) Procedure of Statistical Analysis System (SAS). The highest total germination percentage was given by CRS 83 (97.78%). The cultivar CRS 40 recorded the highest chlorophyll content (1.03 mg/g). Stomatal density ranged from 640 to 682 per 1 mm^2 in all treatments tested. Among different cultivars tested CRS 40 was the best performed cultivar. However the highest stomatal density was shown by CRS 351. Linear correlation analysis showed a significant positive relationship between total chlorophyll content and dry matter content of the cultivars tested. The study findings clearly revealed that dry matter production of cinnamon seedlings was associated with chlorophyll content and the stomatal density during the early stage of growth.*

Keywords*: Cinnamon, Cultivars, Germination, Nursery, Growth*

1 INTRODUCTION

Cinnamon (*Cinnamomum verum* Presl L.) which is known as true cinnamon; is the most important spice produced in Sri Lanka. The genus *Cinnamomum* is represented in Sri Lanka by 9 species where 7 of them are endemic to the country (Sritharan, 1984). Sri Lanka still produces the best quality true cinnamon and the only regular supplier of cinnamon bark and leaf oils to the export market (Annon, 2006). Sri Lankan export economy recorded around Rs.8927.6 million in the year 2008 by exporting cinnamon. Currently it covers up to 30865.8 ha of land extent (Annon., 2009). Furthermore, current

national average of cinnamon bark yield is less than 500 kg/ha/year despite of potential yield is over 1000kg/ha/year. Also most of the existing cinnamon plantations are over aged and wide genetic variability among the plants could be observed (Bavappa, 1982). Replanting of the overage cinnamon with better quality ones is a national requirement to bring those lands more productive and economically viable. One of the major problems in cinnamon cultivation is the unavailability of improved varieties for commercial cultivation. On the other hand, there is relatively little work reported on cinnamon breeding in Sri Lanka. However, Sri Lanka dominates the cinnamon industry of the world and no other country has done intensive research on cinnamon (Sawmyasiri et al.,2006). Therefore, it is a permitting step into selection of desirable characters such as yield performances, quality as well as nursery performances. To fulfill the above requirements, screening of the available cinnamon germplasms was done (Wijesinghe *et. al*, 2004). The evaluation was based on scoring system developed at Cinnamon Research Station. Among the 100 cultivars which were subjected for the study, ten were identified as the better cultivars. Those were *CRS* 351, *CRS* 166, *CRS* 156, *CRS* 23, *CRS* 201, *CRS* 83, *CRS* 317, *CRS* 184, *CRS* 318 and *CRS* 40. According to Samaraweera and Wijesinghe (2006), a detailed study of growth characters including plant height (cm), plant diameter (mm) and number of harvestable stems during first five harvests were carried out. Further, dry bark yield (kg/ha/year), oil percentages of bark and leaf, cinnamaldehyde percentage in bark oil and eugenol percentage in leaf oil were recorded. According to the collected results, from the above ten cultivars, five were identified as the better cultivars. Those were *CRS* 40, *CRS* 317, *CRS* 184, *CRS* 83, and *CRS* 351. But systematic nursery evaluation is not done yet. In the light of this situation present study aimed to investigate the best cinnamon cultivar or cultivars with reference to their germination percentage and growth performances at nursery stage which could be recommended as better quality cultivar or cultivars to the growers. It will help to develop cinnamon industry by increasing its efficiency, productivity and quality while increasing foreign exchange to the country.

2.METHADOLOGY

2.1 Experimental Site

A field experiment was carried out in 2010 at the Cinnamon Research Station, Thihagoda, Matara located in the Low Country Wet zone (WL2) of Sri Lanka. The soil type of the area is Red Yellow Podsolic. The mean air temperature ranged from 25°C to 30°C with an annual rainfall of the region is varying from 1250mm-2500mm (Annon, 2005).

2.2 Experimental materials treatments and Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments (cinnamon cultivars) and four replicates. The six treatments were: T_1 – Control (true cinnamon); T_2) – CRS 40; T_3 - CRS 317; T_4– CRS 184; T_5 - CRS 83 and T_6 - CRS 351. Each plot had thousand seedlings (100 bags with 10 seeds in each). The experiment was conducted in two steps, i.e. as a field experiment and a laboratory experiment.

2.2.1 Field Experiment

The field experiment also carried out in two steps, i.e. (i) Assessment of quantitative parameters of seeds and their germination percentage. (ii) Evaluation of growth

performances of seedlings. Ripped seeds were collected from the selected cinnamon cultivars (CRS 351, CRS 317, CRS 184, CRS 83 and CRS 40) and true cinnamon, established in the Cinnamon Research Station. Poly bags were filled up to 7″ and 10 seeds were evenly distributed on it. Seeds were covered with a thin layer (1/2″) of nursery mixture. Then they were covered with a mulch of coir dust. Bags were kept under a shade up to two months of period from seed germination. Same conditions were applied for all treatments, i.e. shade, water, light etc. (Annon., 2005). Data collection started from one month after planting. Ten poly bags were selected randomly from 100 bags of each replicate and one seedling was randomly selected from each bag to measure the growth parameters. The selected seedlings were tagged with labels to differentiate from rest of the seedlings. There was no incidence of pests or diseases during the study period.

2.2.2 Laboratory Experiment

2.2.2.1 Estimation of Chlorophyll content (mg/g)

Leaf chlorophyll content was determined according to the method described by Ekanayake and Adeleke (1996). Fully expanded upper leaves were crushed and the resulting solution was thoroughly mixed and 5ml was pipetted into a 50ml volumetric flask and made up to the volume with 80% acetone. The absorbance of the extract was then measured at 645 and 663nm wave lengths for chlorophyll a and chlorophyll b respectively.

Calculation :

Chlorophyll a- $(20.2*D_{645}) * (50/1000) * (100/5) * (1/2)$

Chlorophyll b- $(8.02*D_{663}) * (50/1000) * (100/5) * (1/2)$

Total Chlorophyll Content = Chlorophyll a content + Chlorophyll b content

The number of stomatal impressions in area of $1mm^2$ was counted under an optical microscope at a magnification of 400. Three measurements of stomatal counts were taken from three places of each strip. Average of these three values was calculated (Ekanayake and Adeleke, 1996).

2.3 Data Analysis

Data of the field experiment were tabulated and analyzed by using Analysis of Variance (ANOVA) Procedure of Statistical Analysis System (SAS). Duncan's New Multiple Range Test (DNMRT) was used to compare the differences among the treatment means at $p = 0.05$.

3. RESULTS AND DISCUSSION

3.1 Quantitative measurements of seeds

Among different treatments tested, CRS 317 showed the highest values in all parameters. Seed length showed a significant difference at $p<0.05$ and it ranged from 11.28-13.05 mm. Seed diameter also showed significant differences at $p<0.05$ and it ranged from 6.92-7.76 mm. The lowest seed diameter was given by CRS 83 (Table 1).

According to the study findings the seed weight with pericarp and without pericarp showed highly significant differences at $p<0.001$.The values for seed weight with pericarp and without pericarp ranged from 0.94-0.74g and 0.41-0.29g respectively.
According to the department recommendations (Annon, 2005), for better results, seeds which are using for germination must be greater than 9.9 mm in length and 6.1 mm in diameter. According to the Table 1, seeds of the all treatments has shown higher values than department recommendations.

Table 1 quantitative measurement of the Cinnamon seeds in different cultivars

Treatments	weight (g) with pericarp	weight (g) without pericarp	Seed length (mm)	Seed diameter (mm)
CRS 351	0.93^{a}	0.33^{c}	12.47^{b}	7.12^{b}
CRS 317	0.94^{a}	0.41^{a}	13.05^{a}	7.76^{a}
CRS 184	0.78^{c}	0.30^{d}	11.28^{d}	7.13^{b}
CRS 83	0.74^{d}	0.29^{e}	11.79^{dc}	6.92^{b}
CRS 40	0.80^{bc}	0.35^{b}	11.43^{d}	7.63^{a}
Control	0.83^{b}	0.35^{b}	12.12^{bc}	7.67^{a}
LSD (0.05%)	0.03	0.01	0.56	0.43
CV (%)	2.80	2.90	3.12	3.93
Sig.level	***	***	***	**

****=Significant at p<0.001; **=significant at p<0.01; Note: Means with same letter/s along the columns are not significantly different at p>0.05.*

3.2 Total germination percentage (%)

To find out the total germination percentages, data collection was started two weeks after planting (WAP) and continued up to 6th WAP. According to the results (Table 2), total germination percentage in 2nd, 3rd, 4th and 5th WAPs showed highly significant differences at $p<0.001$ while in 6th WAP, it was at $p<0.05$. The values for total germination percentage ranged from 12.28 - 34.30% at 2nd WAP, 52.03 - 82.95% 3rd WAP, 69.43 -90.30% 4th WAP, 81.94 - 94.24% at 5th WAP and 90.72 - 97.78% at 6th WAP. Control showed the shortest period of time to achieve 50 (%) germination. It was significantly different with other treatments. All the treatments were able to achieve 50 (%) germination, within three weeks after planting. However, at the 6th WAP, all the treatments showed over 90% germination. On the other hand highest germination was observed by CRS 83 (97.78%) followed by control (97.15%), CRS 40 (96%) and CRS 317 (95.68%) while CRS 83, CRS 40 and CRS 317 were non significantly different with control (Table 2).

Table 2 Total germination percentage (%) of Cinnamon seeds in different cultivars

Treatments	Weeks after planting (WAP)				
	2nd	3rd	4th	5th	6th
CRS 351	25.32^{b}	56.95^{cb}	71.38^{cd}	82.10^{c}	90.72^{c}
CRS 317	12.28^{d}	68.15^{b}	83.36^{b}	91.33^{ab}	95.68^{a}
CRS 184	27.12^{b}	57.58^{bc}	74.50^{c}	84.35^{c}	90.95^{b}
CRS 83	29.06^{b}	62.98^{bc}	81.37^{b}	90.11^{b}	97.78^{a}
CRS 40	19.30^{c}	52.03^{c}	69.43^{d}	81.94^{c}	96.01^{a}
Control	34.30^{a}	82.95^{a}	90.30^{a}	94.24^{a}	97.15^{a}
LSD (0.05%)	3.94	11.97	3.36	2.94	4.55
CV(%)	10.66	12.51	2.84	2.24	3.18
Sig.level	***	***	***	***	*

****=Significant at p<0.001; *=significant at p<0.05; Note: Means with same letter/s along the columns are not significantly different at p>0.05.*

3.3 Growth measurements

To investigate the growth performances of each selected cultivar, measurements were taken on; seedling height, seedling stem diameter, number of leaves and leaf area by using one month old seedlings, in two weeks intervals. Among different cultivars tested, CRS 40 recorded the highest seedling height at nursery stage. Twenty weeks after planting, the lowest stem diameter was given by CRS 83 (0.21cm) while it was significantly different with other treatments tested. Among different cultivars tested, CRS 40 performed better compared to the other treatments (Table 3).

Table 3 Overall mean values of growth measurements of different cinnamon cultivars

Treatments	Seedling Height (cm)	Stem Diameter (cm)	No. of leaves	Leaf Area ($mm^{2)}$	Root Volume (cm^3)	Root Weight (g)
CRS 351	15.6^{b}	0.24^{b}	7.2^{b}	37.7^{b}	**0.49^{a}**	**0.32^{a}**
CRS 317	14.4^{c}	0.23^{b}	7.3^{ab}	41.7^{a}	**0.47^{a}**	**0.32^{a}**
CRS 184	15.5^{b}	0.23^{b}	7.4^{ab}	34.0^{c}	0.42^{b}	0.25^{b}
CRS 83	13.8^{c}	0.21^{d}	7.1b^{c}	30.1^{d}	0.33^{c}	0.22^{bc}
CRS 40	**16.8^{a}**	**0.25^{a}**	**7.7^{a}**	**43.3^{a}**	**0.47^{ab}**	0.30^{a}
Control	14.0^{c}	0.22^{c}	6.75^{c}	33.1^{cd}	0.31^{c}	0.20^{c}

Note : Means with same letter/s along the columns are not significantly different at p>0.05

3.4 Correlation analysis

According to the results of the linear correlation analysis, total chlorophyll content was positively and significantly correlated with dry matter content. In fact, the better the correlation between dry matter content and total chlorophyll content of a cultivar, the higher would be the dry matter content. Stomatal density was positively and significantly correlated with total chlorophyll content and in addition, it was positively and significantly correlated with dry matter content. The results were confirmed by the previous study findings on the physiology of stomata in higher plants which had suggested that stomata influence the rate of CO_2 fixation in leaf mesophyll tissues while stomatal conductance positively correlates with photosynthetic capacity (Wong et.al., 1978). Among different cultivars tested all the growth parameters were positively and significantly correlated with total chlorophyll contents. Total germination percentage was not significantly correlated with growth parameters, total chlorophyll contents, stomatal density or dry matter content. Seedling height was positively and significantly correlated with seedling diameter, number of leaves and leaf area while stem diameter was positively and significantly correlated with number of leaves and leaf area. Further, number of leaves was positively and significantly correlated with leaf area. The study findings indicated that dry matter production of cinnamon seedlings was associated with chlorophyll content and stomatal density during the early stage of growth.

Table 4 Linear Correlation Coefficients between total germination (%), growth parameters, total chlorophyll content, stomatal density and dry matter content for the overall data set

	TG	SH	SD	NL	LA	TC	ST	DM
TG	-	0.179^{NS}	0.161^{NS}	0.198^{NS}	0.174^{NS}	0.415^{NS}	0.206^{NS}	0.202^{NS}
SH	-	-	0.735^{*}	0.848^{*}	0.777^{*}	0.753^{*}	0.562^{*}	0.848^{*}
SD	-	-	-	0.554^{*}	0.655^{*}	0.784^{*}	0.542^{*}	0.845^{*}
NL	-	-	-	-	0.567^{*}	0.639^{*}	0.304^{NS}	0.653^{*}
LA	-	-	-	-	-	0.548^{*}	0.548^{*}	0.783^{*}
TC	-	-	-	-	-	-	0.639^{*}	0.834^{*}
ST	-	-	-	-	-	-	-	0.682^{*}
DM	-	-	-	-	-	-	-	-

*Ns= non significant; *significant at p<0.05*

TG - total germination (%) , SH – seedling height, SD – stem diameter, NL – number of leaves, LA – leaf area, TC – total chlorophyll, ST – stomatal density, DM – dry matter

3.5 Estimation of stomatal density and chlorophyll content

Results revealed that, CRS 40 had the highest level of chlorophyll *a*, *b* and total chlorophyll contents while control showed the lowest values. According to the data of chlorophyll content of all treatments tested, CRS 40 showed the highest value same as in growth performances (Table 3). High chlorophyll content helps to increase photosynthesis rate and it will directly affect the plant growth (Stryer, 1975).

Present study clearly revealed that cultivar CRS 351 had the highest number of stomatal content (682). The highest dry matter content was shown by CRS 40 (1.56g) followed by CRS 317 (1.43g), CRS 184 (1.34g), CRS 83 (1.19g), CRS 351 (1.07g) and control (0.97g) . The cultivar CRS 40 was significantly different with other treatments tested (Table 5).

When the leaf chlorophyll content is increasing, photosynthetic activity is also get increased and it will indirectly increases the dry matter content (Stryer, 1975). By confirming this statement, the study results revealed that, dry matter contents of seedlings increased positively and linearly with total leaf chlorophyll contents (Fig 1).

Table 5 Estimated values of Stomatal density, Chlorophyll content and Dry matter of different Cinnamon cultivars

Cultivars	Chlorophyll *a* (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)	Stomatal Density (mm^{-2})	Dry matter content (g)
CRS 351	0.42^{b}	0.47^{ab}	0.89^{bc}	682.33^{a}	1.07^{e}
CRS 317	0.46^{b}	0.49^{ab}	0.95^{ab}	669.33^{ab}	1.43^{b}
CRS 184	0.45^{b}	0.48^{ab}	0.93^{bc}	652.33^{ab}	1.34^{c}
CRS 83	0.43^{b}	0.43^{b}	0.86^{cd}	640.33^{b}	1.19^{d}
CRS 40	0.50^{a}	0.53^{a}	1.03^{a}	673.67^{ab}	1.56^{a}
Control	0.38^{c}	0.41^{b}	0.79^{d}	648.33^{ab}	0.97^{f}
LSD (0.05%)	0.037	0.089	0.083	36.81	0.038
CV	4.587	10.481	5.012	3.061	1.654
Sig.level	**	*	**	*	***

Note : Means with same letter along the columns are not significantly different at p>0.05.
***=significant at p<0.01; *=Significant at P<0.05*

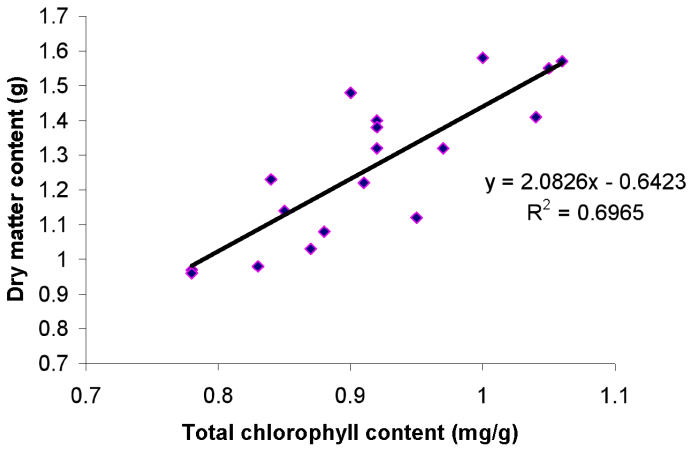

Fig.1 Relationship between total chlorophyll contents (mg/g) and dry matter content (g) of Cinnamon seedlings

4. CONCLUSION

Among different cinnamon cultivars tested CRS 40 was the best performed cultivar. The highest total germination percentage was given by CRS 83 (97.78%). The cultivar CRS 40 recorded the highest chlorophyll content (1.03 mg/g). The study findings clearly revealed that dry matter production of cinnamon seedlings was associated with chlorophyll content and the stomatal density during the early stage of growth.

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