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VARIABILITY AND CHARACTER ASSOCIATION IN CINNAMON GERMPLASM

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Abstract

The experiment was conducted at the Regional Spices Research Center, BARI during May 2014 to April 2015 to study the variability and character association in cinnamon germplasm taking the characters - tree growth, leaf characteristics, bark thickness, specific bark weight and quality of bark of cinnamon plants. Range, variance and coefficient of variation of 30 different characters showed variations in 53 cinnamon accessions. High coefficient of variation was found for base girth, main stem height, number of tertiary branches/plant, tree volume, fresh and dry bark weight of tertiary branches. Bark thickness and specific bark weight gradually declined from main stem to lateral branches. The hierarchical cluster analysis with single scaled dendrogram showed eight clusters due to variation among the germplasm. Cluster III contained maximum 14 genotypes followed by cluster I and cluster VII, each having 12 genotypes. Association analysis revealed that significant correlation of base girth with tree volume, and secondary branches/plant had also significant correlation with leaf thickness and tree volume. It also revealed that significant correlation of fresh bark thickness of main stem with fresh bark thickness of primary, secondary and tertiary stems, also with fresh and dry bark weight of main, primary, secondary and tertiary stems. Specific bark weight had also significant correlation with fresh and dry bark weight of main, primary, secondary and tertiary barks.

Keywords: Variability, correlation, cinnamon, germplasm, cluster, dendrogram.

Introduction

Cinnamon (*Cinnamomum*spp) locally known as 'Darchini' belonging to the family Lauraceae is a common tree spice which is obtained from the inner bark of trees. The genus *Cinnamomum* consists of about 32 genera and 2000-2500 species and they are mainly evergreen trees of tropics and subtropics (Tiwari and Agarwal, 2004). The genus has two main species- *Cinnamomum verum* Presl (syn- *C. zeylenicum* Blume) and *C. cassia*. The former is known as 'true cinnamon' and the later as 'Chinese cinnamon'. Cinnamon is used widely in food industry and medicinally since ancient times (Yao, 2015). The flavor of cinnamon is due to an aromatic essential oil that makes up 0.5 to 1% (Chang *et al*., 2013). It is full of antioxidants, may cut the risk of hurt disease or stoke and has powerful anti-diabetic effect and lower blood sugar level (Anon., 2015). It is

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native to Srilanka and India but also grown commercially in the tropical conditions e.g. Brazil, Java, Madagascar, Vietnam, the West Indies and Zanzebar.

Cinnamon and cassia flourish well in the humid regions with temperature 20^{O}C-30^{O}C, average temperature of 27^{o}C receiving an annual rainfall of 1500-2500 mm. Prolonged spell of dry weather are not conducive for its grown. It can be grown from sea level to 2000 m altitude in Indian conditions. In Srilanka, it is abundant in the regions of 30-220 m and is also grown up to 1200 MSL (Anon., 2015; Tiwari and Agarwal, 2004). Cinnamon is suitable for wide varieties of climatic condition but it specially requires hot and humid climate. It is a hardy plant which can be grown in almost all types of soils. The quality of the bark is highly influenced by the soil and ecological factors. Cinnamon prefers relatively elevated land and a sandy soil is considered best for better quality with lower insect pest incidence but gave lower yield compared to other soils (Anandaraj and Devasabayam, 2004). Bangladesh is an ideal place to grow cinnamon commercially, especially the eastern hilly region of Bangladesh. But so far there is no commercial cultivation of this exotic spice in this country because there is no released variety of this spice and no production technology is available to the farmers.

Germplasm evaluation is a part of selecting high yielding and potential varieties of any crop (Rema *et al*., 2003). More than 50 cinnamon plants of different origin were collected and planted at different times at the Regional Spices Research Center (RSRC), BARI, Gazipur. All plants were in suitable condition for collection of economic product, bark. The present investigation was therefore, undertaken to study the variability and character association in cinnamon germplasm and finally to evaluate the growth of tress, bark characteristics and bark quality of the present 53 cinnamon plants.

Materials and Method

The experiment was conducted at the Regional Spices Research Center (RSRC), BARI during May 2014 to April 2015. The selected 53 cinnamon plants were given accession number for evaluation. All the cinnamon plants were not planted at the same time. The plants were fertilized two times every year in May and September with cowdung 2 kg, nitrogen 60 g, phosphorus 50 g, potassium 50 g and sulphur 20 g per tree and mixed well with soil with the help of khurpi and spade. As there was no severe attack of disease and insect pest, no pesticide was applied. Some unexpected bushy and dead branches of trees were removed by light pruning. Base girth, main stem height, number of main branches, tree height and tree spread were measured with the help of a long bamboo stick, measuring tape and meter scale. Tree volume was calculated using the formula (Blozan, 2004):

$$\text{Tree volume} = \frac{\text{Plant height } (0.3\pi)\,(\text{E - Wspresd} + \text{N - S spread})^2}{4}$$

A little portion (approximately 10 cm ×2.5 cm) of bark from main stem, primary, secondary and tertiary branches were collected detaching with the help of a knife and kota(one type of bended tools) for collecting data. Size (length×width), weight and thickness of fresh collected bark were measured with the help of a digital balances and digital slide callipers. Collected barks were dried under shade followed by sun drying to get a constant dry weight. The area of bark was calculated by direct multiplication of width with length of the bark. The specific bark weight (weight of 100 cm^2 dry barks)was calculated dividing the dry weight (g) by area (actual bark size) then multiplying by 100. All data were calculated using MS-Excel and analyzed through software SPSS Version 16 and interpreted properly.

Results and Discussion

The existing 53 cinnamon plants were used to measure 30 different characters for evaluation of their growth and bark production. Descriptive statistics on 30 different characters of 53 cinnamon plants are presented in Table1. The age of plant varied from 4 to 16 years with a mean of 7.23 years, standard deviation 2.30 and CV% 31.86. The base girth ranged from 14.00 to 142.24 cm with mean 37.24 cm, standard deviation 18.02, variance 325.66 and CV% 57.26. The length of trunk or main stem length ranged from 1.65 cm to 152.00 cm with 53.11 cm mean, 36.36 standard deviation, 1322.05 variance and 60.45 CV%. It was more variable due to varied stem length for early branching and late branching somewhat depending on training of pants done at younger stage. Branching increased gradually from primary to tertiary but variation was higher in tertiary branches. The variation of leaf length was also found higher with high variance (3.05) compared to leaf width and thickness. Leaf thickness varied due to maturity *e.g.* age of leaf. Tree volume ranged from 2.64m^3 to 39.06 $m^3$with a mean of 9.18 m^3, standard deviation 5.43 $m^3$and CV% 59.35. The variation of tree volume was higher due to different aged tree and planting place was not uniform that differed the tree growth.Fresh bark thickness gradually declined from main stem to lateral branching. Thicker barks obtained from main stem medium from primary branch, medium thin from secondary branch and thinner from tertiary branches.

Fresh and dry bark weight also declined from main stem to distal branches as its thickness varied from main stem to tertiary branches.Freshbark size showed higher standard deviation and variance due to non-uniform cutting of bark which is not actually a character of the genotype. The specific bark weight (weight of 100 cm^2 dry bark) was higher in the main stem and gradually it was declined up to tertiary branches. Association analysis revealed significant correlation of fresh weight of bark with dry bark yield (Krishnamoorthy*et al*., 1992).

Table 1. Descriptive Statistics of 53 Cinnamon accessionsfor 30 characters

Parameters		Range		Mean	Std. Dev.	Variance	CV%
		Minimum	Maximum				
Age of plant		4.00	16.00	7.23	2.30	5.31	31.86
Base girth (cm)		14.00	142.24	31.24	18.05	325.66	57.26
Main stem height (cm)		1.65	152.40	53.11	36.36	1322.03	60.45
No. of branch / plant	Primary branch	1.00	5.00	2.21	0.86	0.75	39.10
	Secondary branch	1.00	13.00	4.47	1.90	3.60	42.43
	Tertiary branch	4.00	68.00	11.04	8.64	74.58	78.24
Leaf size	Leaf length (cm)	5.50	16.56	11.22	1.75	3.05	15.57
	Leaf width (cm)	3.50	8.14	6.00	1.03	1.06	17.15
	Leaf thickness (mm)	0.11	0.33	0.23	0.44	0.02	19.00
Tree volume (m^3)		2.64	39.06	9.18	5.43	29.50	59.15
Fresh bark thickness (mm)	Mainstem	2.60	9.80	5.71	1.54	2.36	26.92
	Primary branch	1.80	7.90	4.07	1.30	1.69	31.93
	Secondary branch	1.57	7.10	3.21	1.13	1.27	35.06
	Tertiary branch	1.00	4.50	2.36	0.90	0.82	38.18
Fresh bark weight (g)	Mainstem	3.61	27.90	14.98	5.69	32.40	38.00
	Primary branch	3.00	15.90	9.67	3.23	10.44	33.41
	Secondary branch	2.08	14.76	7.20	2.70	7.27	37.42
	Tertiary branch	1.06	10.66	4.93	2.21	4.89	44.82
Dry bark weight (g)	Mainstem	1.39	12.86	7.01	2.48	6.13	35.33
	Primary branch	1.24	7.88	4.59	1.60	2.56	34.84
	Secondary branch	0.71	7.19	3.41	1.25	1.56	36.72
	Tertiary branch	0.56	4.98	2.28	1.01	1.02	44.48
Fresh bark size (cm^2)	Mainstem	11.10	42.67	31.09	6.19	38.36	19.42
	Primary branch	13.56	42.93	27.81	5.64	31.84	20.24
	Secondary branch	11.70	39.59	26.34	5.91	34.92	22.44
	Tertiary branch	11.57	37.35	22.91	5.81	33.81	25.18
Specific bark wt.(g/ $100cm^2$)	Mainstem	11.74	66.75	22.88	8.81	77.69	38.52
	Primary branch	6.35	41.29	16.76	5.96	35.51	35.55
	Secondary branch	4.16	29.39	13.18	4.77	22.79	36.22
	Tertiary branch	3.99	18.10	9.91	3.53	12.47	35.62

Hierarchical cluster analysis

Fig. 1. showed the Hierarchical cluster analysis using different growth and bark characters of 53 cinnamon germplasm. The dendrogram using single linkage showed eight clusters of germplasm. The members of different clusterswere

given in Table 2.Cluster one and seven consists of12germplasm each which has minimum distances among them. Cluster three represented the maximum 14 germplasm. Cluster two has nine germplasm while only one germplasm represented each by the cluster IV, V and VIII.

Table 2. Cluster Membership on the basis of growth and bark characteristics

Cluster	Accessions	No. of accessions
Cluster I	CZ GAZ 001, CZ GAZ 004, CZ GAZ 005, CZ GAZ 010, CZ GAZ 022, CZ GAZ 025, CZ GAZ 026, CZ GAZ 028, CZ GAZ 042, CZ GAZ 043, CZ GAZ 051, CZ GAZ 052	12
Cluster II	CZ GAZ 002, CZ GAZ 003, CZ GAZ 008, CZ GAZ 015, CZ GAZ 023, CZ GAZ 029, CZ GAZ 041, CZ GAZ 046, CZ GAZ 050	9
Cluster III	CZ GAZ 006, CZ GAZ 007, CZ GAZ 009, CZ GAZ 014, CZ GAZ 017, CZ GAZ 018, CZ GAZ 019, CZ GAZ 020, CZ GAZ 021, CZ GAZ 024, CZ GAZ 027, CZ GAZ 031, CZ GAZ 032, CZ GAZ 033	14
Cluster IV	CZ GAZ 011, CZ GAZ 030, CZ GAZ 053	3
Cluster V	CZ GAZ 012	1
Cluster VI	CZ GAZ 013	1
Cluster VII	CZ GAZ 016, CZ GAZ 034, CZ GAZ 035, CZ GAZ 036, CZ GAZ 037, CZ GAZ 038, CZ GAZ 039, CZ GAZ 040, CZ GAZ 044, CZ GAZ 045, CZ GAZ 047, CZ GAZ 049	12
Cluster VIII	CZ GAZ 048	1

The germplasm differed from one cluster to another due to the morphological features of the plant and bark characters. Some parameters were similar with nearby population in a cluster because all other characteristics were similar within the group members. The cluster V was different from other clusters probably belongs from cassia and not true cinnamon. The existence of different clusters in dendrogram represented the inter cluster similarity or dissimilarity. Dendrogram showed two major group of cluster that cluster III, I, V and VI were closer one other while they differed from other group of cluster IV, VII and II.

Correlation among 26 characters (growth and bark characters) of 53cinnamon germplasm

The 2-tailed Pearson correlation co-efficient values and level of significance among 10 growth parameters and 16 bark characteristics of 53cinnamon germplasm are presented in Table 3a and Table 3b. There was highly significant positive correlation (r= 0.833**) observed in base girth and tree volume. Negative correlation was found in main stem height with all other growth

parameters. Leaf width also showed negative correlation with base girth and branching. Secondary branch was significantly positively correlated with leaf thickness (r= 0.606**) and tree volume (r= 0.487**) denoted that plants having more number of secondary branches have higher tree volume and thicker leaves.

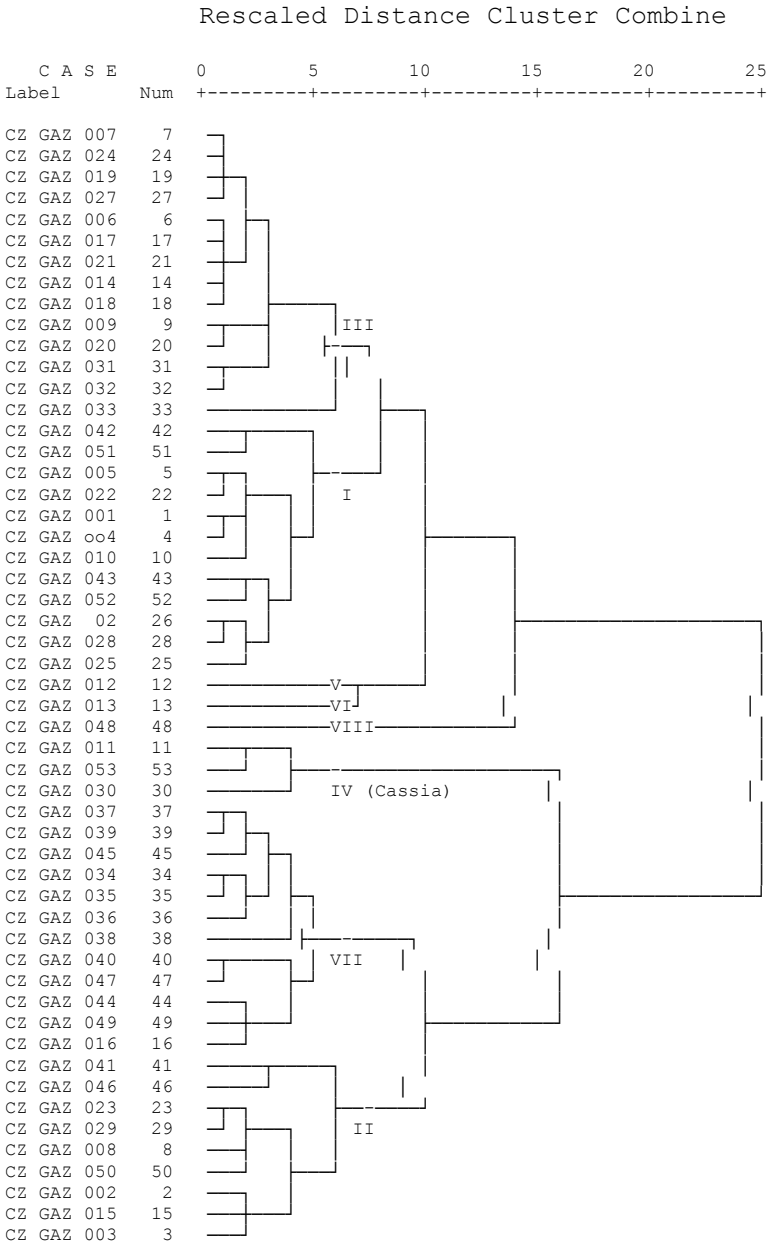

Fig.1. Hierarchical cluster analysis showing Dendrogram using Complete Linkage.

Table 3a. Pearson correlation on the basis of growth parameters

	BG	MSH	PBP	SBP	TBP	LL	LW	LT	Tree volume
Age of plant	0.212	0.226	-0.275*	-0.142	0.396**	0.429**	0.257	-0.065	0.079
Base girth (BG) cm		-0.271*	0.322*	0.369**	0.141	0.317*	-0.016	0.195	0.833**
Main stem height (MSH) cm			-0.417**	-0.327*	-0.056	-0.142	0.048	-0.204	-0.146
Primary branch /plant (PBP)				0.362**	0.053	-0.081	-0.195	-0.053	0.341*
Secondary br./ plant (SBP)					0.127	0.030	-0.333*	0.606**	0.487**
Tertiary branch/ plant (TBP)						0.117	0.090	0.102	0.087
Leaf length (LL) cm							0.478**	0.002	0.198
Leaf width (LW) cm								-0.309*	-0.087
Leaf thickness (LT) mm									0.278*

*, ** represents the level of significance at 5% and 1% level of significance, respectively.

All bark parameters showed significant positive correlation with all other bark characteristics. Fresh bark thickness of main stem (FBTM) showed strong positive correlation with fresh bark thickness of primary stem (r= 0.756**), fresh bark thickness of secondary stem (r= 0.535**), fresh bark thickness of tertiary stem (r= 0.679*), fresh bark weight of main stem(r=0.609**), fresh bark weight of primary stem(r=0.558**), fresh bark weight of secondary stem(r=0.636**), fresh bark weight of tertiary stem(r=0.606**), dry bark weight of main stem(r=0.572**), dry bark weight of primary stem(r=0.543**),dry bark weight of secondary stem(r=0.537**) and dry bark weight of tertiary stem(r=0.572**).

FBTM - Fresh bark thickness of main branch, FBTP - Fresh bark thickness of primary branch, FBTS - Fresh bark thickness of secondary branch, FBTT- Fresh bark thickness of tertiary branch, FBWM- Fresh bark weight of main branch, FBWP- Fresh bark weight of primary branch, FBWS- Fresh bark weight of secondary branch, FBWT- Fresh bark weight of tertiary branch, Fresh bark thickness of main branch, DBWM - Dry bark weight of main branch, DBWP- Dry bark weight of primary branch, DBWS- Dry bark weight of secondary branch . DBWT- Dry bark weight of tertiary branch ,SBWM–Specific bark weight of main branch, SBWP - Specific bark weight of primary branch, SBWS - Specific bark weight of secondary branch, SBWT- Specific bark weight of tertiary branch.

Table 3b. Pearson correlation on the basis of bark characteristics

Parameters	FBTP	FBTS	FBTT	FBWM	FBWP	FBWS	FBWT	DBWM	DBWP	BDWS	DBWT	SBWM	SBWP	SBWS	BWT
FBTM	0.756**	0.535**	0.679**	0.609**	0.558**	0.636**	0.606**	0.572**	0.543**	0.537**	0.468**	0.467**	0.509**	0.390**	0.407**
FBTP		0.693**	0.580**	0.276*	0.513**	0.450**	0.481**	0.301*	0.479**	0.415**	0.286*	0.211	0.400**	0.293*	0.179
FBTS			0.578**	0.226	0.308*	0.457**	0.390**	0.259	0.363**	0.416**	0.214	0.245	0.337*	0.368**	0.199
FBTT				0.308*	0.366**	0.514**	0.692**	0.303*	0.330*	0.432**	0.516**	0.234	0.195	0.222	0.409**
FBWM					0.709**	0.656**	0.557**	0.926**	0.657**	0.633**	0.519**	0.586**	0.506**	0.481**	0.431**
FBWP						0.762**	0.618**	0.741**	0.893**	0.714**	0.603**	0.514**	0.657**	0.550**	0.576**
FBWS							0.704**	0.714**	0.708**	0.763**	0.689**	0.555**	0.551**	0.553**	0.604**
FBWT								0.598**	0.559**	0.634**	0.792**	0.422**	0.330*	0.447**	0.580**
DBWM									0.758**	0.731**	0.618**	0.715**	0.583**	0.568**	0.543**
DBWP										0.779**	0.613**	0.574**	0.756**	0.632**	0.626**
DBWS											0.755**	0.617**	0.612**	0.777**	0.693**
DBWT												0.463**	0.350*	0.491**	0.830**
SBWM													0.504**	0.579**	.517**
SBWP														0.735**	0.459**
SBWS															0.499**

Specific bark weight showed strong positive correlation with fresh and dry bark weight of main, primary, secondary and tertiary barks while weaker but positive correlation showed with the thickness of different stem barks. Raghu*et al*. (2007) observed that leaf area showed the maximum morphological variability;he also found among the six morphometric characters studied, all the charactersexcept inter-nodal length showed significant positive correlation towards each other. This result ensured the assumption of the sources of variation in respect ofbark characteristics which were actually the yield attributes of cinnamon are mostly depends on plant growth. Thus the variation seems to be environmental and genetic variation might not be the major exterminator.

Conclusion

Based on the above results, it might be concluded that variability exists among 53 cinnamon germplasm in respect of growth parameters *e.g*. stem height, base girth, leaf size, leaf shape and leaf thickness, fresh bark thickness, specific bark weight. There depicts a phenotypic correlation among growth parameters and bark characteristics of cinnamon. The genotypes are grouped into eight clusters. The genotypes falling into the same cluster are genetically close. The genotypes of cluster III, I or VIII will be further evaluated with special emphasis giving to bark characteristics and their organoleptic taste for selection of suitable cinnamon genotypes which could be emerged as variety(ies) of cinnamon.

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