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Characterization of genotypes of small cardamom (*Elettaria cardamomum* Maton) for yield parameters and disease resistance

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Small cardamom (*Elettaria cardamomum* Maton), also known as 'Queen of Spices', is the dried capsule of perennial herbaceous plant belonging to the family Zingiberaceae. Being a cross pollinated crop and propagated mostly through seeds, a lot of diversity exists in the natural population of wild and cultivated traits of cardamom in Western Ghats. Generally, when compared to Malabar morphotypes, Vazhukka and Mysore types are more robust. Various types of panicles, branched raceme, female sterility and cleistogamy are some of the exceptional variants observed in cardamom (Madhusoodanan *et al.*, 1994). Padmini *et al.* (2001) reported the occurrence of variability within and between cultivars of small cardamom for economically important characters. About 600 cardamom genotypes have been maintained at National Active Germplasm Site at ICAR-IISR Regional Station, Appangala. The ultimate utilization of germplasm material depends on the appropriate and adequate characterization of available variability; besides its collection and conservation. Genetically resistant cultivars/varieties have been the major component in the integrated disease management (IDM).

A study was carried out to characterize 70 genotypes of small cardamom at ICAR-IISR Regional Station, Appangala (Kodagu District, Karnataka, India) in terms of morphological and yield parameters and also to identify resistance sources for diseases like rhizome rot and leaf blight. The experimental materials comprised of 70 genotypes of small cardamom which was planted during 2010 at a spacing of 2 x 2 m with five replications wherein each clump represented a replication. Standard package of practices were adopted to raise the crop. Observations with respect to vegetative and yield characters were recorded for three consecutive years (from third to fifth year of planting) and the pooled data was used for analysis. Correlation coefficients were computed as per the method described by Singh and Chaudhary (1985). The natural incidences of rhizome rot and leaf blight diseases were recorded during the months of August and September, respectively for three consecutive years (from third to fifth year of planting). Five clumps of each genotypes were scored for leaf blight incidence by employing 1 - 6 disease rating scale as 1 = no symptoms, 2 = isolated spots on young leaves, 3 = sparse elongated spots on young and mature leaves, 4 = coalescing elongated spots on young and mature leaves; 25 per cent of leaf area is affected, 5 = extensive elongated spots on all leaves and upto 50 per cent of leaf area is affected; plant appears green from a distance and 6 = total infection of all leaves; plant appears blighted from a distance and the per cent

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disease index (PDI) was calculated. The genotypes were further classified into highly resistant (< 10%), resistant (11 - 20%), moderately resistant (21 - 30%), moderately susceptible (31 - 40%), susceptible (41 - 50%) and highly susceptible (> 51%) based on PDI. Similarly, the disease rating scale for rhizome rot was designed based on the number of infected tillers in a clump. For each genotype, disease incidence in five clumps was recorded as 1 = no infection, 2 = positive infection with advancing margins less than 1 cm; one tiller infected, 3 = advancing margins and water soaked patches prominent; infection on 2 to 5 tillers or 25 per cent tillers of the plant, 4 = spreading of infection to 50 per cent of the total tillers and 5 = all the tillers infected; plant decaying or dead and PDI was calculated. The genotypes were subsequently categorized into five groups *viz*., highly resistant (0.0 - 5.0 PDI), resistant (5.1 - 10.0 PDI), moderately susceptible (10.1 - 25.0 PDI), susceptible (25.1 - 50.0 PDI) and highly susceptible (> 50.0 PDI) (Venugopal *et al*., 2006).

Per cent Disease Index (PDI) for leaf blight =

$$\frac{Y_1(1\text{-}1) + Y_2(2\text{-}1) + Y_3(3\text{-}1) + Y_4(4\text{-}1) + Y_5(5\text{-}1) + Y_6(6\text{-}1) \times 100}{N \times 6}$$

Per cent Disease Index (PDI) for rhizome rot =

$$\frac{Y_1(1\text{-}1) + Y_2(2\text{-}1) + Y_3(3\text{-}1) + Y_4(4\text{-}1) + Y_5(5\text{-}1) \times 100}{N \times 5}$$

Where, Y_1 to $Y_{5/6}$ = number of infected plants in each category, N = total plants in the plot.

Significant variations were observed for morphological characters *viz*., plant height, number of bearing tillers, capsules per plant and fresh weight of capsules. Among the 70 small cardamom genotypes evaluated (data not shown), the plant height was found to range from 110 (IC 547208) to 310 cm (IC 547186). The maximum number of bearing tillers (18) was observed in IC 547214 which was on par with IC 547196 with 17.66 tillers. The genotype, IC 547205 recorded the longest panicle (119.4 cm) with more number of nodes per panicle (36.4). The maximum number of capsules (3516) and fresh weight of capsules per plant (3456.2 g) was observed in the genotype IC 547205 followed by IC 584093 with 2276.6 capsules per plant with fresh weight of 2182 g. With regard to capsule characters, the genotype IC 584096 registered long (2.18 cm) and broader (1.48 cm) capsule with more number of seeds (27.4) whereas, short (1.16 cm) and small (0.73 cm) capsule was recorded in the genotypes IC 547281 and IC 584072, respectively.

In correlation studies, all the traits showed significant positive correlation with respect to yield (Table 1). Fresh weight of capsules (yield) per plant exhibited highly significant and positive correlation with number of capsules per

Table 1. Estimates of correlation coefficients between characters in cardamom

Character	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
x1	1.000	0.504*	0.494	0.625*	0.529*	0.532	0.188	0.094	0.157	0.091	0.166	0.172	0.195	0.092
x2		1.000	0.575*	0.300	0.216	0.531	0.313	0.315	0.165	0.292	0.070	0.110	0.225	0.284
x3			1.000	0.256	0.280	0.934**	0.262	0.293	0.146	0.279	0.093	0.129	0.137	0.271
x4				1.000	0.572*	0.323	0.135	-0.001	0.168	0.139	0.128	0.121	0.178	0.137
x5					1.000	0.274	0.005	-0.038	-0.034	0.010	0.092	0.140	0.099	0.010
x6						1.000	0.329	0.286	0.226	0.305	0.136	0.105	0.173	0.297
x7							1.000	0.686*	0.700**	0.764**	0.382	0.257	0.317	0.762**
x8								1.000	0.528	0.492	0.358	0.408	0.276	0.488
x9									1.000	0.498	0.321	0.192	0.207	0.498
x10										1.000	0.358	0.266	0.331	0.999**
x11											1.000	0.587*	0.625*	0.358
x12												1.000	0.605*	0.260
x13													1.000	0.328
x14														1.000

x1 – plant height (cm) x2- no. of tillers x3- no.of bearing tillers x 4- leaf length (cm)
x5- leaf breadth (cm) x6- no. of panicles x7- panicle length (cm) x8 – inter nodal length (cm)
x9 – no. of nodes x10- no. of capsules x11- capsule length (cm) x12- capsule breadth (cm)
x13- no.of seeds x14- fresh wt. of capsules * significant at 5% level ** significant at 1% level

plant (0.999) and panicle length (0.762) which indicated that, these traits can be utilized for yield improvement. Backiyarani *et al.* (2002) established a highly significant and positive correlation between yield and number of panicles, panicle length, plant height, number of tillers as well as seed number. In the present study, number of capsules per plant exhibited highly significant and positive correlation only with panicle length (0.764) whereas, Korikanthimath *et al.* (2000) reported that the number of capsules per plant had significant positive correlation with total number of tillers, bearing tillers and panicles per plant. Since, yield has highly significant and positive correlation with number of capsules per plant and panicle length, selection based on these traits can be utilized for the improvement of cardamom.

Leaf blight and rhizome rot diseases are the most devastating and widely spread diseases of cardamom even though several strategies encompassing phytosanitation, organic amendments and biocontrol agents have been evolved and recommended to manage both the diseases (Thomas and Suseela, 2000). In an attempt to identify resistant sources, the genotypes were categorized based on the incidence of leaf blight (Table 2) under natural conditions and found that, 22 genotypes were resistant with PDI ranging from 11 to 20 per cent while, only 2 genotypes IC 584075 and IC 547196 were grouped under susceptible category with the PDI ranging between 41 to 50. Among the genotypes evaluated for resistance to rhizome rot, 29 genotypes were categorized under highly resistant to rhizome rot disease (0.0 to 5.0 %) (Table 3). On the other hand, five genotypes

Table 2. Categorization of cardamom genotypes based on reaction towards leaf blight

Per cent Disease Index (%)	Classification	Genotypes
< 10 %	Highly resistant (HR)	Nil
11 - 20 %	Resistant (R)	IC 547189, IC 584073, IC 584083, IC 584086, IC 584087, IC 584088, IC 547224, IC 584081, IC 547185, IC 547225, IC 547226, IC 547207, IC 547208, IC 547188, IC 547187, IC 584084, IC 547183, IC 547202, IC 547203, IC 547204, IC 547210, IC 547213
21 - 30 %	Moderately resistant (MR)	IC 547190, IC 547199, IC 547200, IC 547201, IC 547214,IC 547215, IC 547162, IC 547169, IC 584096, IC 584095,IC 584094, IC 584091, IC 584090, IC 584089, IC 584079, IC 584072, IC 584069, IC 584068, IC 547184, IC 584085, IC 584080, IC 584082, IC 547182, IC 547206, IC 547212, IC 547207
31 - 40 %	Moderately susceptible (MS)	IC 547198, IC 584093, IC 584092, IC 584078, IC 584077, IC 584076, IC 584074, IC 584071, IC 584070, IC 584067,IC 547186, IC 547195, IC 547197, IC 547205, IC 547208,IC 547172
41 - 50 %	Susceptible (S)	IC 584075, IC 547196
> 51 %	Highly susceptible (HS)	Nil

Table 3. Categorization of cardamom genotypes based on reaction towards rhizome rot

Per cent Disease Index (%)	Classification	Genotypes
0.0 - 5.0	Highly resistant (HR)	IC 547190, IC 547198, IC 547199, IC 547200, IC 547201, IC 547215, IC 584093, IC 584075, IC 584072, IC 584069, IC 584068, IC 584067, IC 584087, IC 547224, IC 584081, IC 547226, IC 547186, IC 584084, IC 547183, IC 547210, IC 547182, IC 547195, IC 547196, IC 547197, IC 547202, IC 547203, IC 547204, IC 547207, IC 547208
5.1 - 10.0	Resistant (R)	IC 584070, IC 584083, IC 547208, IC 547188 , IC 547185
10.1 - 25.0	Moderately susceptible (MS)	IC 547214, IC 547169, IC 584096, IC 584095, IC 584091, IC 584089, IC 584078, IC 584077, IC 584076, IC 584073, IC 584085, IC 584086, IC 584080, IC 547225, IC 547172
25.1 - 50.0	Susceptible (S)	IC 547189, IC 547162, IC 584094, IC 584092, IC 547187, IC 547172, IC 584090, IC 584079, IC 584074, IC 58407I, IC 547205, IC 547184, IC 584088, IC 584082, IC 547207, IC 547206, IC 547212
> 50.0	Highly susceptible (HS)	Nil

viz., IC 584070, IC 584083, IC 547208, IC 547188 and IC 547185 were found to fall under resistant category with PDI ranging from 5.1 to 10.0 per cent. Extensive exploration for natural resistance is imperative in any crop to delineate resistant sources which is the most economical, feasible and sustainable strategy to manage diseases which was successfully adopted in the identification of the rhizome rot resistant variety of cardamom, IISR Avinash (Venugopal *et al*., 2006). Once such resistant sources are identified, they can be incorporated in the resistant breeding programmes for developing varieties with other superior qualities.

Developing multiple disease resistant varieties and its large scale deployment at field level lessens the cost of production due to a substantial reduction in the use of plant protection chemicals and ensures food safe spices. In an attempt to identify small cardamom genotypes that possess dual resistance against leaf blight and rhizome rot diseases, it was found that genotypes *viz*., IC 584083, IC 584087, IC 547224, IC 547188, IC 584081, IC 584084, IC 547185, IC 547183, IC 547226, IC 547202, IC 547203, IC 547204 and IC 547210 exhibited dual resistance against leaf blight and rhizome rot diseases. This may be attributed to the distribution of resistant genes among elite cultivars, adopted non-elite germplasm, improved elite germplasm, land races, primitive varieties or wild related species as depicted in genetic diversity pyramid (Carson, 1997). The present study revealed that, characterization of disease resistant genotypes is vital in harnessing genetic potential of the genotypes for further improvement of these traits which is highly imperative for evolving varieties suitable to various biotic stress conditions.

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