



Evaluation of elite cardamom (*Elettaria cardamomum*) genotypes for yield, quality and resistance to *Cardamom mosaic virus*

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Abstract

Nine genotypes of cardamom (*Elettaria cardamomum* Maton) along with two commercial cultivars, Green Gold and Appangala 1 were evaluated for their yield and selected horticultural traits. There were significant differences amongst different genotypes with respect to yield and other traits. The genotype IC 349651 was found to be highest in yield (1048.2 kg ha⁻¹) followed by IC 547167 (987.1 kg ha⁻¹). The genotype IC 547167 (Appangala 2) was found to be moderately resistant to *Cardamom mosaic virus* under artificial conditions and rich in α terpinyl acetate content which was comparable to Appangala 1. In 2014, the genotype IC 547167 was recommended for high yield and resistance to *Cardamom mosaic virus* under field conditions and released as Appangala 2 for Karnataka and adjoining areas of Kerala. The variety, Appangala 2 (IC 547167) was developed through hybridization between Appangala 1 x NKE 19.

Keywords: Cardamom, evaluation, hybrid, *Katte*, quality, yield

Introduction

Cardamom (*Elettaria cardamomum* Maton), is the most valuable and export oriented spice crop. Until late seventies, India was a pioneer in the world trade of cardamom, thereafter Guatemala came to the scene as a major producer. At present, Guatemala leads with 66 per cent of world's cardamom production pushing India to be the second largest producer (Ankegowda *et al.*, 2017). One of the major production constraint in cardamom cultivation is *Katte* disease incited by *Cardamom mosaic virus* (CdMV) representing the *Potyvirus* genus, vectored by *Pentalonia caladii* and cosmopolitan to all cardamom cultivating agro-ecological zones of India with a meager (0.01%) to higher (99%) proportions of incidence (Venugopal, 2002; Foottit *et al.*, 2010). The loss in yield due to the disease depends on growth stage at the time of infection and yield loss will be almost total in early

infected plants, whereas, the productivity progressively declines when infection occurs in the later stages of crop growth. Since India is the centre of origin of cardamom, the natural populations exhibit great degree of variability for quantitative and qualitative characters due to genetic and environmental causes (Prasath and Venugopal, 2004). The improvement programmes are aimed at utilizing this genetic diversity to develop elite genotypes suited to different agro-ecological regions and hybrids having higher yield, superior quality and resistance to stresses (biotic and abiotic).

In order to enhance crop yield and to impart resistance to diseases, the exploitation of hybrid vigour is of paramount importance. Cardamom, blessed with both sexual and vegetative reproduction paves way for heterosis breeding and the genetic purity of the resultant progenies can be maintained *via* vegetative means (Prasath *et al.*,

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2009; Padmini *et al.*, 2000). This article reports evaluation of promising genotypes from different cardamom research centres and identification of a high yielding cardamom hybrid with improved quality and disease resistance. The hybrid, Appangala 2 (IC 547167) was developed from the cross between Appangala 1 (moderate yielder) and NKE 19 (mosaic resistant) at ICAR-Indian Institute of Spices Research Regional Station, Appangala, Karnataka.

Materials and methods

Eleven cardamom genotypes, coded as IC 349545, IC 547167, IC 547185, IC 349651, PL No 14, CL 691, CL 726, Green Gold and Appangala 1 were evaluated at ICAR-IISR Regional Station, Appangala, Kodagu District, Karnataka during 2011 to 2014 (12°26'N Latitude, 75°45'E Longitude and located at 920 meters above mean sea level). The information about the genotypes and corresponding research centre is given in Table 1. The genotypes like Green Gold and Appangala 1 were used as check clones which represent the standard varieties of the testing area. Randomized complete block design (RCBD) was the design adopted and replicated thrice. Twelve plants were maintained in each plot with a spacing of 2x2 m and recommended package of practices (Ankegowda *et al.*, 2015) were adopted. The

morphological, yield and quality characters were recorded and the pooled data was used for analysis.

In order to analyze the essential oil content in respective test entries, 20 g of dried capsules representing each genotype were crushed to remove the seeds. The oil content was estimated by hydro distillation of the capsules performed for three hours in a Clevenger-type apparatus (ASTA, 1997).

For screening the genotypes of *Katte* mosaic virus under artificial conditions, the clones of the genotypes (with ten replications) were planted in earthen pots and maintained in insect proof glass house during 2014 to 2016. The Appangala strain of CdMV maintained in cardamom variety Appangala 1 was used as the source of virus inoculum and fourth or fifth instar apterous viruliferous aphids were used for transmission. In each plant, two young leaves were rolled into funnel shape and inoculated with the aphids (@ 5 per tiller). The aphids were allowed for inoculation feeding on the test entries overnight (14-16 hours) after which, the vectors were killed by spraying recommended insecticide. The inoculated test entries were observed at different periods for the development of symptoms (if any) and at an interval of 50 days, the process of challenge inoculation was repeated (Venugopal, 1999).

Table 1. List of genotypes and their contributing centres

Genotype	Important characteristics	Contributing centre
IC 349545	High yield	ICAR-Indian Institute of Spices Research, Appangala, Karnataka
IC 349651	High yield	ICAR-Indian Institute of Spices Research, Appangala, Karnataka
IC 547167	Hybrid, high yield, mosaic resistant	ICAR-Indian Institute of Spices Research, Appangala, Karnataka
IC 547185	High yield	ICAR-Indian Institute of Spices Research, Appangala, Karnataka
CL 691	High yield	Zonal Agriculture and Horticulture Research Station, UAHS, Mudigere, Karnataka
CL 726	High yield	Zonal Agriculture and Horticulture Research Station, UAHS, Mudigere, Karnataka
PL No. 14	High yield	Cardamom Research Station, Kerala Agricultural University, Pampadumpara, Kerala
CR 6	High yield	
MCC 346	High yield	Indian Cardamom Research Institute, Spices Board, Myladumpara, Kerala
SKP 104	High yield	Indian Cardamom Research Institute, Spices Board, Sakleshpur, Karnataka
SKP 164	High yield	Indian Cardamom Research Institute, Spices Board, Sakleshpur, Karnataka

Results and discussion

All the existing improved varieties of cardamom have been evolved by selection of superior plants for desirable characters like high yield and superior capsule characters. Since cardamom is highly heterozygous, seedlings will not be true to type to its parent. But clonally propagated plants will be genetically identical to its parents. Cardamom selections developed were highly location specific in their agro-ecological requirements (Madhusoodanan *et al.*, 1990). Heterosis breeding has been considered as the most powerful tool to generate diverse traits and its subsequent commercialization in several crops of economic importance had a great impact in plant breeding. Since, cardamom is amenable to both sexual and vegetative propagation, heterosis breeding assumes a vital role in breeding programs. The genetic variability of the parents and breeding values plays an important role in the superior performance of the F1 hybrids (Jordaan, 1999). Research at various institutes resulted in the identification of heterotic hybrids and recombinants with superior agronomic traits. Madhusoodanan *et al.* (1999) reported high yielding heterotic recombinants in cardamom. The hybrids MHC 18,

MHC 10 and MHC 12 showed vigour with regard to yield and yield attributing characters (Pradipkumar *et al.*, 2002). Prasath *et al.* (2010) and Nirmal Babu *et al.* (2012) reported that hybridization rather than selection should be the preferred method of improvement to expand the genetic resources of cultivated cardamom as the varieties developed by hybridization have higher divergence.

The superior performance of the hybrids over the existing local cultivars or varieties determines its commercial acceptance and popularity. Yield performance of cardamom genotypes over a period of three years under Appangala conditions (Table 3) revealed that the mean yield per hectare ranged from a lowest of 325.9 kg ha⁻¹ to a highest of 1048.2 kg ha⁻¹. Out of the eleven genotypes tested, four genotypes from Appangala *viz.*, IC 349651 (1048.2 kg ha⁻¹), IC 547167 (987.1 kg ha⁻¹), IC 547185 (933.4 kg ha⁻¹) and IC 349545 (877.2 kg ha⁻¹) were found to out yield the check varieties, Appangala1 and Green Gold with a mean yield of 678.0 and 844.7kg ha⁻¹, respectively.

In the year 2011-12, the genotypes exhibited significant variation with respect to yield. The genotype IC 349651 registered maximum yield

Table 2. Variation in morphological and quality characters of cardamom genotypes

Genotype	Plant height (cm)	Total no. of tillers	No. of bearing tillers	No. of panicles	oil content (%)
IC 349545	186.6	19.6	6.0	6.0	4.5
IC 349651	171.1	17.3	5.8	6.2	5.0
IC 547167	211.7	19.2	7.4	8.4	6.3
IC 547185	211.9	20.9	6.5	9.4	5.0
CL 691	197.1	21.5	5.9	6.3	5.0
CL 726	189.5	17.2	5.7	12.2	5.0
PL NO. 14	203.4	18.6	6.6	8.4	4.0
CR 6	192.6	17.4	6.3	8.8	4.0
MCC 346	202.5	19.0	6.5	7.5	4.0
SKP 104	214.1	19.6	6.4	8.9	4.0
SKP 164	199.2	21.5	5.5	6.2	4.0
Appangala 1	186.5	18.2	5.6	5.8	5.0
Green Gold	200.4	20.1	6.8	7.7	5.5
Mean	197.6	19.1	6.2	7.7	4.7
CV (%)	11.6	18.9	24.9	39.5	15.1
CD (p=0.005)	38.5	6.1	2.6	5.2	3.1

Table 3. Yield performance of cardamom genotypes over a period of three years

Accession	Yield (kg ha ⁻¹)			Mean
	2011-12	2012-13	2013-14	
IC 349545	1059.9	947.0	624.7	877.2
IC 349651	1757.9	853.0	533.8	1048.2
IC 547167	1392.9	798.6	769.8	987.1
IC 547185	1439.9	861.3	499.0	933.4
CL 691	661.4	378.2	354.7	464.8
CL 726	587.3	321.0	302.5	403.6
PL No. 14	954.5	657.7	541.9	718.0
CR 6	418.9	297.8	260.9	325.9
MCC 346	533.9	459.4	328.2	440.5
SKP 104	724.6	397.6	328.9	483.7
SKP 164	873.9	423.9	357.5	551.8
Appangala 1	1066.4	621.3	346.4	678.0
Green Gold	1033.2	826.2	674.6	844.7
Mean	961.9	603.3	455.6	
CV	11.8	19.9	2.0	
CD (p=0.005)	189.3	194.8	15.4	

(1757.9 kg ha⁻¹), followed by the genotype IC 547185 (1439.9 kg ha⁻¹) which was on par with the genotype IC 547167 (1392.9 kg ha⁻¹). Whereas in the year 2012-13, maximum yield was observed in the genotype IC 349545 (947.0 kg ha⁻¹) and was on par with the genotypes IC 349651 (853.0 kg ha⁻¹), IC 547185 (861.3 kg ha⁻¹) and Green Gold (826.2 kg ha⁻¹). In the next year (2013-14), highest yield was observed in the genotype IC 547167 (769.8 kg ha⁻¹) and lowest in the genotype CR 6 (260.9 kg ha⁻¹). Similar type of variation in yield over the years was also observed by Prasath and Venugopal (2009) in the evaluation of cardamom selections.

With regard to morphological characters (Table 2), the analysis of variance revealed significant variation among the genotypes taken for the study. The genotype SKP 104 registered maximum plant height (214.1 cm) and was on par with the genotypes IC 547167 (211.7 cm) and IC 547185 (211.9 cm). Among the genotypes, total number of tillers ranged from 17.2 (CL 726) to 21.5 (SKP 164) while maximum number of bearing tillers (7.4) were observed in the genotype IC 547167. Number of panicles was significantly more (12.2) in the genotype CL 726, followed by the genotype IC 547185 with 9.4 panicles.

Table 4. *Katte* disease incidence among the genotypes of cardamom

Genotype	Reaction to <i>Katte</i> disease under			
	field condition		artificial condition	
	Total number of plants	PDI	Total number of plants	PDI
Appangala 1	30	6	10	8
IC 349545	30	0	10	2
IC 349651	30	2	10	4
IC 547167	30	0	10	1
IC 547185	30	0	10	2
CL 691	30	0	10	2
CL 726	30	2	10	2
PL No. 14	30	3	10	4
CR 6	30	3	10	3
MCC 346	30	4	10	6
SKP 104	30	0	10	2
SKP 164	30	0	10	2
GG	30	4	10	5

PDI- per cent disease incidence

Upon screening cardamom genotypes for CdMV / *Katte* incidence under natural condition for a period of two years from 2014-2016, it was observed that there was no incidence of *Katte* disease in IC 547167, IC 349545, IC 547185, CL 691, SKP 104 and SKP 164 (Table 4). Under artificial conditions, it was observed that except IC 547167, all the plants of the genotypes under study had taken up infection whereas in IC 547167, only one plant was infected. Prasath *et al.* (2009) has

Table 5. Characteristic features of Appangala 2

Characters	
Plant height (cm)	215.9
Tillers per plant	22.9
Panicles per plant	8.4
Dry recovery (%)	21.1
Capsules per plant	2053.3
Wet yield/plant (g)	1765.5
Dry yield/ha (kg)	927.3
Oil (%)	5.8
αterpinyl acetate	40.3
1,8-cineole	29.5
Reaction to <i>Katte</i> (field)	Resistant
Reaction to <i>Katte</i> (artificial)	Moderately resistant



Fig 1. (a) Panicle and (b) capsule characters of Appangala 2

already reported the hybrid, Appangala 1 x NKE 19 (IC 547167) has shown resistance to *Katte* disease under field and as well as artificial conditions. In the present study, the other genotypes that yielded more than IC 547167 were not tolerant to mosaic disease, hence the genotype IC 547167 was found to be promising in terms of resistance to CdMV. The resistance to CdMV is quantitative and governed by dosage dependent completely dominant gene action (Prasath *et al.*, 2009).

The genotype, IC 547167 with a height of 211.7 cm, had an average of 11.5 bearing tillers with 15.5 panicles per plant and has recorded the potential yield of 1392.9 kg ha⁻¹ at Appangala conditions (Table 5). The average number of capsules per plant was recorded as 3123.3 with a wet weight of 2641.5 g per plant, dry recovery of 21.1 per cent, high oil content (6.3%) (Table 2), high α terpinyl acetate (40.3%) with 1,8 - cineole (29.5%) content and 37.9 per cent of the capsules were categorized as bold (>8 mm) (data not shown). High yield and quality traits combined with *Katte* resistance is the peculiarity of this hybrid, IC 547167 which also has 67.5, 28.0 and 28.0 mid parent, better parent and standard heterosis values respectively (Prasath *et al.*, 2010).

Evaluation of cardamom genotypes revealed superiority of the hybrid (IC 547167) for yield, quality and resistance to *Katte* disease. Since all these superior candidates are promising selections developed from different research centres, the identified promising genotype in this study, IC 547167 was recommended for release in the name of Appangala 2 by AICRPS, Kozhikode.

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