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SHORT COMMUNICATION

Compound inflorescence cardamom (*Elettaria cardamomum* (L.) Maton) in India

D. Prasath · M. N. Venugopal

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Abstract Cardamom (*Elettaria cardamomum* (L.) Maton) is an important spice crop of India and valued for its dried capsules. Regular surveys are being undertaken by Indian Institute of Spices Research (IISR), Appangala, Karnataka, India for collecting the variable germplasm of cardamom. At present 436 cardamom accessions collected from cardamom growing tracts of South India are conserved in field gene bank. Among the collections, 23 accessions with varied branching pattern were assembled during explorations and characterized for 16 plant, panicle and capsule characters during 2003–2005. The coefficient of variation was greatest for yield per plant (77.94%) followed by branches per panicle (49.40%) and minimum for dry recovery per cent (7.73%). Two accessions, IC 547214 and IC 349544 were identified as promising with desirable yield contributing characters. The accessions, IC 349553 with extensive branching at the proximal end of the panicle and IC 547180 with dark green capsules even after drying were found to be unique. All the characterized accessions are maintained under *ex situ* cardamom gene bank of IISR.

Keywords Cardamom · Characterization · Compound panicle · *Elettaria cardamomum* · Panicle branching

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Introduction

Cardamom, popularly known as 'Queen of spices' is the tall perennial herbaceous plant, *Elettaria cardamomum* (L.) Maton, belonging to the family Zingiberaceae. The genus *Elettaria* is one of the few compact and small natural groups, whose origin is evergreen rainforests of South India and Sri Lanka from where it spread to other tropical countries (Purseglove et al. 1981). Cardamom cultivation in India is mostly concentrated in the Western Ghats of South India. It is also cultivated in Guatemala, Tanzania, Sri Lanka, El Salvador, Vietnam, Laos, Cambodia and Papua New Guinea. India is reported to have rich genetic diversity in cardamom (Mayne 1951; Abraham and Tulasidas 1958). Cardamom being a cross-pollinated crop, large number of phenotypic variants exists in nature and some of the pronounced variants have panicles of various types, compound panicle, branched cincinnus, female sterility and cleistogamy (Prasath and Venugopal 2004; Sudharshan et al. 1998; Madhusoodanan et al. 1994).

The normal inflorescence (panicle) possesses a long cane-like peduncle having nodes and internodes (Fig. 1A). Each node has a scale leaf, in the axile of which flowers are borne on modified helicoids cyme (cincinnus). Thus panicle is branched (Madhusoodanan et al. 2003). The Multiple branching of panicles (Fig. 1B) occurs in seedling progenies of certain cultivars. In such cases the central peduncle undergoes further branching (secondary and tertiary branches) producing multiple branching panicles (compound panicles). The compound panicle types directly contribute to yield. Hence, the natural segregants needs attention in crop genetic resources and crop improvement programmes. In the framework of a national research programme on cardamom, the Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Karnataka, India is engaged in collection of the aforementioned species in target areas of South India, to assemble a diversified gene pool. Given the very limited information available on compound panicle types the objective of this study was to characterize and conserve the compound panicles accessions of cardamom from hill ranges of Karnataka, India.

Materials and methods

The *ex situ* cardamom gene bank of IISR consisted of 436 accessions collected from cardamom-growing regions of South India. The 23 compound panicle accessions were collected from six collection sites covering two districts of Karnataka (Kodagu and Chickmagalur), across Western Ghats, where commercial cultivation of cardamom is mostly through seedlings. The physiography of the area surveyed was undulating slopes and hills with an altitude ranging from 800–1,500 m. The sampling strategy followed was selective from seedling progenies.

The 23 compound panicle accessions collected from Karnataka were used for characterization (Table 1). Suckers of the 23 accessions (five suckers

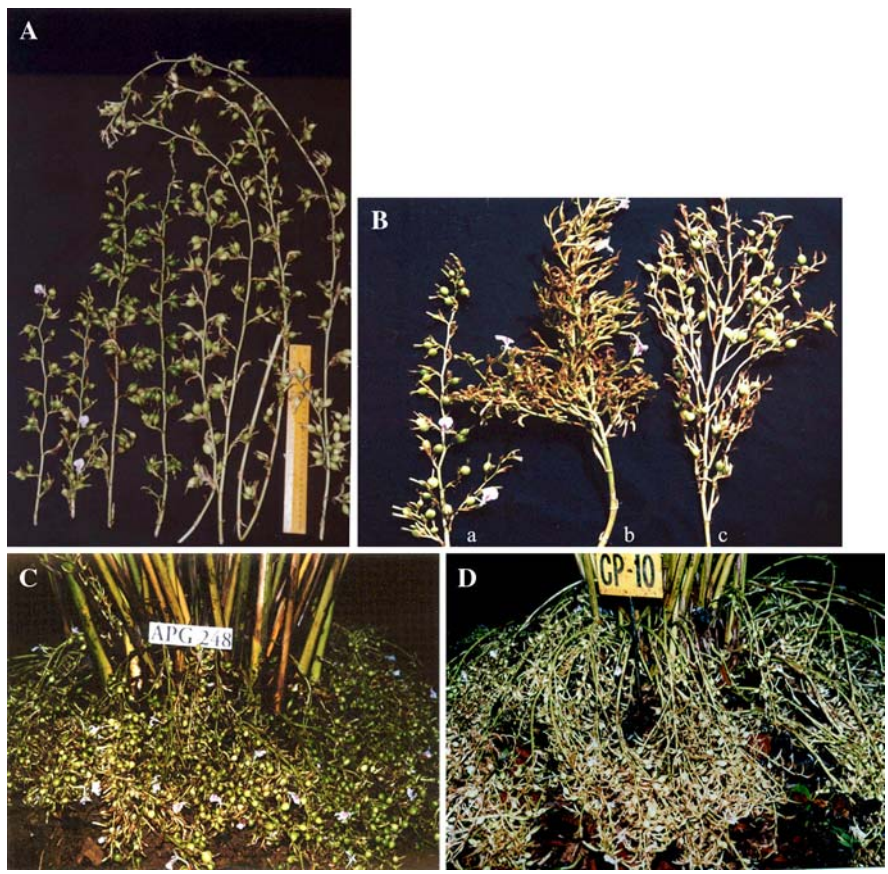

Fig. 1 **A** Normal panicle. **B** Multiple branched panicle (**a** basal, **b** terminal, **c** uniform). **C** Accession with maximum panicle number per plant. **D** Accession with maximum number of branches per panicle

per accession) were planted at a spacing of 2.0 m × 2.0 m in Cardamom Research Centre, Appangala (1,100 m), Karnataka during 2003. Seventeen plant, panicle and capsule characters were recorded during 2005–2006 based on IPGRI descriptor (IPGRI 1994).

Dry recovery: 100 g of matured capsules (per accession) were harvested on the third harvest. The capsules were dried in electrical drier to the moisture content of 11–12% by maintaining the temperature of 45–50°C. The difference in fresh and dry weight was converted in to per cent dry recovery.

Essential oil: Dried cardamom capsules (20 g per genotype) were crushed and the seeds were separated and weighed. The decorticated seeds were subjected to hydro distillation in a Clevenger-type apparatus for 3 h and the volatile oil yield was recorded. The oil was dried over anhydrous sodium sulphate and kept in refrigerator until the analysis was carried out (ASTA 1997).

The observed data were statistically analysed for mean, range, standard deviation, standard error and co-efficient of variation. All statistical analyses were performed using Statistica 5.1 (Statsoft 1997).

Results and discussion

In general, three types of panicle branching pattern were observed among the 23 accessions. In four accessions, the branching was only at base and of primary branching type (Fig. 1A). In the second type, branching was at the terminal portion of the panicle (Fig. 1B) and the pattern of branching was secondary and tertiary (four accessions). Third type of branching, uniform throughout the panicle (Fig. 1C) was observed in remaining 15 accessions.

Plant height is an important component character by which the growth and vigour of the plants are measured. The mean plant height ranged from 208.60 to 305.81 cm with a general mean of 280.33 cm (Table 2). Tillers per plant influence the yield to a significant extent through facilitating the production of more number of panicles per plant and it ranged

Table 1 Passport data of compound panicle cardamom germplasm collections from Karnataka, India

S. no.	IC no.	Collection no.	Locality	District
1	IC 349381	APG 51	Mudigere	Chickamagalur
2	IC 349541	APG 248	Halery	Kodagu
3	IC 349542	APG 249	Appangala	Kodagu
4	IC 349543	APG 250	Boikeri	Kodagu
5	IC 349544	APG 251	Appangala	Kodagu
6	IC 349545	APG 252	Appangala	Kodagu
7	IC 349546	APG 253	Appangala	Kodagu
8	IC 349547	APG 254	Appangala	Kodagu
9	IC 349548	APG 255	Appangala	Kodagu
10	IC 349553	APG 260	Kandanakolli	Kodagu
11	IC 349554	APG 261	Kandanakolli	Kodagu
12	IC 547180	APG 411	Appangala	Kodagu
13	IC 547205	APG 436	Appangala	Kodagu
14	IC 547206	APG 437	Appangala	Kodagu
15	IC 547207	APG 438	Appangala	Kodagu
16	IC 547208	APG 439	Hervanad	Kodagu
17	IC 547209	APG 440	Appangala	Kodagu
18	IC 547210	APG 441	Appangala	Kodagu
19	IC 547211	APG 442	Appangala	Kodagu
20	IC 547212	APG 443	Hervanad	Kodagu
21	IC 547213	APG 444	Appangala	Kodagu
22	IC 547214	APG 445	Appangala	Kodagu
23	IC 547215	APG 446	Hervanad	Kodagu

Table 2 Variability in compound panicle collections of cardamom

Characters	Mean	Range	SD	SE	CV (%)
Plant characters					
Plant height (cm)	280.33	208.60–305.81	31.24	8.35	11.15
Tillers per plant	38.62	25.33–52.00	8.53	2.28	22.08
Panicle characters					
Panicles per plant	48.10	30.00–64.10	9.43	2.52	19.61
Panicle length (cm)	87.00	57.50–107.50	14.83	3.96	17.04
Branches per panicle	15.64	3.5–29.5	7.73	2.07	49.40
Internodal length (cm)	3.79	2.80–4.70	0.62	0.16	16.23
Cincinni per panicle	51.64	15.00–77.50	22.09	5.91	42.76
Flowers per panicle	272.25	109.50–527.00	130.79	34.97	47.52
Capsules per panicle	82.36	29.00–141.00	29.19	7.80	35.44
Fruit set (%)	31.62	17.55–44.10	6.28	1.68	19.85
Yield per plant-dry weight (g)	108.34	35.21–708.30	84.42	3.01	77.94
Capsule characters					
Capsules per cincinnus	3.09	1.33–4.25	0.59	0.16	19.21
Capsule length (cm)	1.77	1.54–2.12	0.18	0.05	9.92
Capsule breadth (cm)	1.18	1.05–1.49	0.11	0.03	9.39
Seeds per capsule	19.59	13.70–23.20	2.69	0.72	13.73
Dry recovery (%)	20.16	18.0–23.5	1.56	0.42	7.73
Essential oil (%)	5.39	5.0–6.5	0.49	0.13	9.04

SD standard deviation, *SE* standard error, *CV* co-efficient of variation

from 25.33 to 52.00. The range for panicles per plant was found to be between 30.00 and 64.10, wherein IC 547214 recorded the maximum (Fig. 1D). Variation observed in panicle length (57.50–107.50 cm), internodal length (2.80–4.70 cm) and cincinni per panicle (15.00–77.50) were moderate to high. The number of branches per panicle was the primary important character in compound panicle type of cardamom. Among the accessions, the branches per panicle varied from 3.5 to 29.5 with a mean of 15.64 (Fig. 1C). Flowers per panicle ranged from 109.50 to 527.00 with a general mean of 272.25.

The compound panicle types, in general produce more number of flowers per panicle compared to normal panicles where as, per cent fruit set is comparatively low (Padmini et al. 2000). In the present study, fruit set ranged from 17.55 to 44.10 per cent and eleven genotypes exceeded the general mean for this component character. Yield per plant (dry weight) varied from 35.21 to 708.30 g. Maximum capsules per cincinnus (4.25) were recorded in IC 349543 and the minimum of 1.33 in IC 349553. Capsule length and girth decides the individual dry fruit weight and thereby the yield potential, besides boldness of the capsule which fetches premium price in the market. Capsule length and width exhibited moderate variability. The seeds per fruit is an important trait that influences the individual fruit weight and ranged from 13.70 to 23.20. Dry recovery is an equally important character in deciding the yield potential and showed variation between 18.0 and 23.5%. Compared to the plant and panicle characters, variations observed in capsule characters were limited. Colour of capsules at physiological maturity varied from light green to dark green. Dark green colour of capsules, which fetches premium price in the market, was recorded in IC 547180, which retained green colour even after processing. With respect to essential oil, four accessions were found to be superior in mean performance with more than six per cent of oil. Variability was found to be maximum for yield per plant (77.94%) followed by branches per panicle (49.40%) and minimum for dry recovery (4.72%). Earlier studies on the variability in the seedling populations of commercial plantations reported the existence of wide variability for panicle

and capsule characters (Korikanthimath et al. 1998; Padmini et al. 2000).

Two promising accessions with desirable yield contributing characters were identified from this study. Highest yield per plant (708.30 g/plant), number of panicles per plant (62.32), branches per panicle (24.5) and capsules per panicle (84.33) were recorded in IC 547214, which was followed by IC 349543 with panicles per plant (57.00), capsules per panicle (78.94), bold capsules (2.12/1.49 cm, length/breadth) and dry recovery (23.20%). The accession, IC 349553 was unique with extensive branching at the terminal portion of the panicle and in another accession (IC 547180) the capsules retained dark green colour even after drying, which fetches premium market price.

Conclusions

In general, the compound panicle accessions showed a surprisingly high diversity which could be a result of evolutionary processes allowing for three cultivar mixtures, cross pollination, preferential selection pressure and distant exchange of germplasm by the planters. Compared to normal panicle types, the compound panicle types have high yield potential per unit area besides synchronized flowering and fruit set. The promising accessions thus identified are conserved under *ex situ* cardamom gene bank and are the important source in cardamom crop improvement programmes with the aim to increase the yield and sustainable production.

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