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Propagule size affects yield and quality of *Curcuma mangga* Val. et Zijp.: An important medicinal spice

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ABSTRACT

Curcuma mangga is a medicinally important species grown in tropical Asian nations and is known to yield rhizomes that are source of curcumin and essential oil. This species has been valued in both traditional as well as modern medicines and has wide applications in cosmetic and pharmaceutical industries. However, the species has largely remained underutilized and its systematic cultivation could help in assuring continuous supply of uniform quality raw material to meet the industrial demands. During present investigation, effect of different size groups of seed rhizome was studied on yield and quality parameters, which revealed size dependent differences. Considering higher dry matter recovery (24.44%), oil yield (17.57 ml/m^2) and curcumin content (0.46%), use of seed rhizomes of 20–25 g size could be recommended for producing raw material meant for aroma and pharmaceutical industries. On the other hand, if the final produce is meant for processing and value addition, use of seed rhizomes of 15–20 g size would be optimum as it would save the seed rhizome requirement without compromising with the yield. GC–MS analysis revealed β- Myrcene and Cyclofenchene as dominant constituents in essential oil of mother, primary and secondary rhizomes. Findings of present study would be helpful for large scale production of raw material required by flavor, food and pharmaceutical industries.

1. Introduction

The genus *Curcuma* with *ca.* 80 species is widely known for its culinary, medicinal, dyeing and other properties across the world (Chaveerach et al., 2008). *Curcuma mangga* is a species with lateral flowering habit and bold aromatic rhizomes (Ravindran et al., 2007). The cut rhizome emits raw mango odour and hence, the species is known as mango ginger. It was originally described from Java (Leong-Škorničková et al., 2010) and is distributed in Andaman & Nicobar Islands of India, Thailand, Indonesia and Malaysia (Pandey and Diwakar, 2008; Singh et al., 2016; Singh, 2017; Sirirugsa et al., 2007). *C. amada* (a centrally flowering species native to Eastern India) is also known as mango ginger due to similar aroma and is grown in different parts of India (Ravindran et al., 2007; Singh, 2017).

Traditionally, rhizomes of *C. mangga* are used in the preparation of pickles, sauce, candy etc. apart from their use as a spice, vegetable and salad (Sirirugsa et al., 2007; Singh, 2017). Curcumin obtained from *Curcuma* species, commonly known as Indian Solid Gold, has multifaceted applications in drug industry as anticancer, cardio-protectant, antiviral, anti-fungal, anti-allergic, antioxidant and wound healing agent besides its use as a natural colourant and preservative in food industry (Aggarwal et al., 2007). Mango ginger rhizomes with 0.18–0.47% curcumin are also an alternative source of this industrially important compound (Bos et al., 2007). Crude and fractionated extracts of rhizomes have been reported to possess anti-cancer activity against six human cancer cell lines (Malek et al., 2011). In vivo toxicity studies suggested safety of ethanolic extracts of rhizomes in tested animals and hence the species could be used as an alternative to modern medicines (Yuandani and Suwarso, 2017). Leaf extracts also possessed functional food properties such as antioxidant, anti-inflammatory and anti-cancer activities (Liu and Nair, 2012). A patent (WO2015063751 A1) has recently been granted for use of its extract in the treatment of prostate cancer. Essential oil from rhizomes contains industrially valuable β-Myrcene as major component, which has been regarded as infrageneric chemotaxonomical marker for the species (Wahab et al., 2011).

Despite multifaceted applications, no systematic efforts have been made to cultivate the species on large scale. Most of the raw material is contributed by the non-discrete supplies from wild, which reduces uniformity of the final product. Cultivation could provide homogeneous quality raw material and hence, standardization of suitable agro-techniques is a pre-requisite (Waman and Bohra, 2016). Optimization of propagule size could help in saving the seed rhizome requirement

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Table 1
Weather parameters of the experimental site during cropping seasons (2015–16 and 2016–17).

Month	Min. temperature (°C)		Max. temperature (°C)		Rainfall (mm)	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
May	25.4	26.5	31.8	33.3	368.8	271.0
June	25.1	25.0	30.5	30.0	409.5	495.9
July	25.3	25.2	30.6	30.6	305.6	425.3
August	24.5	25.2	29.1	31.0	567.5	325.3
September	24.3	24.0	30.0	29.5	434.6	956.1
October	24.8	24.3	30.9	31.0	233.8	358.8
November	25.3	25.1	30.9	31.0	210.4	167.0
December	24.8	24.1	32.0	29.3	151.0	444.7
January	24.5	21.3	31.6	27.2	62.3	94.7
February	24.2	24.2	30.9	30.7	0.0	0.6

without compromising the economic yield (Hailemichael and Tesfaye, 2008; Padmadevi et al., 2012). Though rhizomatous species are well studied in this regard, no attention has been paid so far in this species. Hence, the present study is the first report concerning standardization of size of seed rhizome for commercial cultivation of *C. mangga*. Further, profiling of essential oil from different rhizome tissues was attempted for the first time.

2. Material and methods

2.1. Experimental site

Present investigation was conducted for two years (2015–16 and 2016–17) in the Division of Horticulture and Forestry, ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India (11°36′42.7″ N, 92°43′3.9″E). Mean minimum and maximum temperature and rainfall of the experimental site during cropping period is presented in Table 1.

2.2. Treatment details

Local collection of *Curcuma mangga* Val. et Zijp., maintained in the germplasm block of the institute, was used for the study. Earlier report on *C. longa* suggested that planting of extra-large rhizomes resulted in poor yields due to presence of secondary and tertiary rhizomes in the propagules (Hossain et al., 2005). Further, extra-large rhizomes are easily broken during planting which also renders them unsuitable for mechanical planting. Considering this, rhizome size was limited to 25 g in the present study. Healthy rhizomes were allowed to cure in the field and then graded into different size groups viz. 5–10 g, 10–15 g, 15–20 g and 20–25 g before planting on raised beds.

2.3. Crop management

Fields were ploughed using a tractor mounted plough to bring the soil to fine tilth followed by leveling. Raised beds of 2 m × 1 m × 0.15 m were prepared and well decomposed farmyard manure was applied at the rate of 15 kg/m^2. Graded rhizomes were planted in these beds at 0.3 m × 0.3 m spacing. Crop was grown under rainfed conditions. During each cropping cycle, two hand weedings were carried out followed by earthing up. After first hand weeding, second dose of farmyard manure was applied at the rate of 15 kg/m^2 to all the treatments. No pests or diseases were noticed in both the cropping seasons.

2.4. Record of morphometric observations

Crop was harvested when the leaves showed drying symptoms. Rhizomes were carefully uprooted from soil without damaging the clump. From each treatment, ten representative clumps were selected for recording clump weight (g), number of primary rhizomes and number of secondary rhizomes per clump. Fifteen rhizomes from each treatment were used for recording weight (g) and length (cm) of primary and secondary rhizomes. Known amount of rhizome pieces were sliced (five replications), oven dried at 60 °C and dry recovery percentage was calculated.

2.5. Curcumin and total phenol content

Curcumin content and total phenols were determined in primary, secondary and mother rhizomes obtained from each treatment. Cured rhizomes were sliced, oven dried at 45 °C for 72 h, grinded in electric grinder and used for determination of curcumin content (%) following method described elsewhere (Shamina et al., 2012). Six gram dried powder was cold percolated with 30 ml methanol followed by vacuum filtration and evaporation to obtain the crude extracts, which were used for determining total phenol content. Both the analyses were performed with four replications.

2.6. Essential oil determination and GCMS analysis

For determining essential oil content, 200 g fresh rhizomes were sliced into small pieces and hydro-distillation was carried out using Clevenger apparatus for oils lighter than water. Essential oil yield (ml) was pooled from mother rhizomes, primary rhizomes and secondary rhizomes to represent the mean oil yield per plot in each treatment. Essential oils of primary, secondary and mother rhizomes were subjected for gas chromatography–mass spectroscopy (GC-MS) analysis.

The GC-MS analysis was carried out in Varian-3800 Gas Chromatograph coupled with Varian-4000 Ion-Trap Mass Spectrometer. For analysis, extracted samples of mother rhizome, primary rhizome and secondary rhizome were injected into the injector port. MS column viz. VF-5MS (Factor four) (Varian, USA) fused-silica capillary column of 30 m × 0.25 mm id, 0.25 mm film thickness was used for the analysis. Temperature of the injector was set at 250 °C and all injections were made initially in split (1:20) mode for 0.5 min followed by split-less. Temperature of the detector was 270 °C and temperature programme for column was as followed: 40 °C for 3 min at an increment of 3 °C/min to 190 °C, hold for 1 min, then 5 °C/min to 220 °C and maintaining the constant temperature for 5 min.

Mass spectrometer was operated in external electron ionization mode with Helium as carrier gas (1 ml/min), 250 °C as injector temperature, 180 °C as trap temperature, 190 °C for ion source-heating, 260 °C as transfer line temperature, 70 eV as EI-mode and full scan-range (50–350 amu) was used. Total volatile production was estimated by summing all the GC peak areas in the chromatogram and individual compounds were quantified as relative percent area. The compounds were identified by comparing the retention index which was determined by using homologous series of *n*-alkanes (C5–C32) as standard (Kovatz, 1965) and comparing the spectra using two spectral libraries available as Wiley and NIST-2007.