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Phenological variation in two species of *Curcuma*

P.K. Sajitha, D. Prasath and B. Sasikumar*

Division of Crop Improvement and Biotechnology, Indian Institute of Spices Research,Marikunnu P.O, Kozhikode-673012, Kerala, India

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The genus *Curcuma* is credited with many species of economic importance besides *Curcuma longa* L., the culinary turmeric (Sasikumar *et al*., 2005). Some *Curcuma* species are important source of starch too besides its use as a spice and in medicine (Jyothi *et al*., 2003, Policegoudra and Aradhya, 2008). Industrially important species of *Curcuma* include *C. amada, C. aromatica, C. zedoaria, C. purpurascens, C. mangga, C. heyneana, C. xanthorrhiza, C. aeruginosa, C. phaeocaulis* and *C. petiolata* (Velayudhan *et al*., 1999). *C. amada* Roxb., 'Manga manjal' (Malayalam-vernacular) is having characteristic odour similar to raw mangoes and used as major ingredient in culinary preparations, medicines and as a source of starch. *C. aromatica* Salisb. or 'Kasturi manjal'(Malayalam-vernacular.) is also used as source of starch besides its known application in many toiletry preparations and medicine (Policegoudra *et al*., 2011).

The present investigation is aimed to study the pattern of variation for growth, yield and quality parameters in two *Curcuma* species *viz.*, *C. amada* and *C. aromatica* at three different stages of growth.

A field experiment was laid out at the Indian Institute of Spices Research, Peruvannamuzhi farm, Kozhikode, Kerala, India during 2012-2013. Plant height, leaf number, tiller number, yield and dry recovery were recorded from 90, 140 and 180 days after planting (DAP) of the two *Curcuma* species *viz.*, *C. amada* and *C. aromatica*. The biochemical parameters such as oil, fiber, protein, starch and curcumin were estimated at these growth stages, using the standard protocols (AOAC., 1975, ASTA., 1968; Hodge and Hofreite, 1962; Kumar and Gill., 2009). Data was analysed statistically as per the standard procedure.

Maximum plant height was recorded at 180 DAP in both the species, 83.25 cm for *C. aromatica* and 78.75 cm for *C. amada* (Table 1). Leaf number registered a decreasing trend (Table 1) and as the age of the plants increased, a decrease in the number of green leaves plant^{-1} was observed. Similar observation was reported in *Curcuma longa* (Asghari *et al*., 2009). Tiller number did not vary with the different growth stages of the plant (Table 1).

Yield and dry recovery of the two species increased with increase in the age of the plants, reaching maximum at 180 DAP. Though there was a wide variation for fresh yield across the different growth stages, dry recovery at 140 and 180 DAP did not vary much (Table 1).

Maximum essential oil yield was recovered at 90 DAP in both the species of *Curcuma* under study, as the age of the plant increased, the oil yield decreased gradually from 4.42 to 2.10 per cent in *C. amada*, and from 6.98 to 5.20 per cent in case of *C. aromatica* (Table 2). Percentage of curcumin in *C. aromatica* slightly increased from 0.036 per cent (90 DAP) to 0.047 per cent (180 DAP), though there was not much difference between 140 DAP and 180 DAP. In *C. amada* the curcumin content decreased slightly from 0.06 per cent (90 DAP) to 0.055 per cent (140 DAP) and then it registered an increase (0.09% at 180 DAP) (Table 2).

*Corresponding Author: bhaskaransasikumar@yahoo.com

Table 1. Mean aerial morphological characters, yield and dry recovery of two *Curcuma* species at three growth stages

Species	Plant height (cm) Days after planting				Leaf number Days after planting				Tiller number Days after planting				Yield (g) Days after planting				Dry recovery (%) Days after planting			
	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean
C. amada	64.72 ^{bc}	76.00 ^{ab}	78.75 ^{ab}	73.16	9.000 ^{a}	8.50 ^{ab}	8.000 ^{ab}	8.50	2.25 ^{a}	2.25 ^{a}	2.000 ^{a}	2.2	99.00 ^{c}	184.0 ^{bc}	398.50 ^{a}	227.17	10.51 ^{d}	13.30 ^{cd}	14.93 ^{bc}	12.91
C. aromatica	54.33 ^{c}	73.25 ^{ab}	83.25 ^{a}	70.28	9.250 ^{a}	8.25 ^{ab}	7.250 ^{b}	8.25	1.75 ^{a}	1.75 ^{a}	1.750 ^{a}	1.75	62.50 ^{c}	133.0 ^{bc}	274.00 ^{a}	156.5	13.73 ^{c}	17.49 ^{ab}	18.81 ^{a}	16.68
Mean	59.53	74.63	81.00		9.125	8.40	7.625		2.00	2.00	1.875		80.75	158.5	336.25		12.12	15.4	16.87	
LSD (P= 0.05)																				
Species x growth stage		15.85				1.174				NS				15.76				2.948		
CV (%)		14.87				9.44								19.28				13.41		

Table 2. Mean oil, curcumin, starch, protein and crude fiber of two *Curcuma* species at three growth stages

Species	Oil (%) Days after planting				Curcumin (%) Days after planting				Starch (%) Days after planting				Protein (%) Days after planting				Crude fiber (%) Days after planting			
	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean	90	140	180	Mean
C. amada	4.425 ^{c}	2.900 ^{d}	2.100 ^{e}	3.142	0.060 ^{ab}	0.055 ^{ab}	0.090 ^{a}	0.068	18.010 ^{c}	35.100 ^{b}	48.750 ^{a}	33.95	10.560 ^{a}	9.355 ^{a}	9.075 ^{a}	9.66	2.800 ^{b}	2.825 ^{b}	3.025 ^{b}	2.88
C. aromatica	6.975 ^{a}	5.900 ^{b}	5.200 ^{bc}	6.025	0.036 ^{b}	0.048 ^{ab}	0.047 ^{ab}	0.043	37.800 ^{b}	37.210 ^{b}	46.850 ^{ab}	40.62	8.528 ^{a}	8.250 ^{a}	9.975 ^{a}	8.92	5.900 ^{a}	3.275 ^{b}	3.250 ^{b}	4.142
Mean	5.7	4.4	3.65		0.048	0.052	0.069		27.905	36.16	47.8		9.544	8.803	9.525		4.35	3.05	3.14	
LSD (P= 0.05)																				
Species x growth stage		0.781				0.068				10.23				NS				0.636		
CV (%)		11.47				6.7				18.55								12.18		

Similar study reported an increase in curcumin content of *C. longa* with maturation of the plant (Hanashiro *et al*., 2003). Starch content of both the species under study increased with the maturity. In *C. aromatica* starch content increased from 37.80 (90 DAP) to 45.85 per cent (180 DAP), whereas in *C. amada*, starch content ranged from 18.02 (90 DAP) to 48.75 per cent (180 DAP) (Table 2). Starch content in *Curcuma* species is known to vary with the location, maturity, accession *etc*. Various authors reported wide ranging values (9.2 to 45%) for starch content in *C. aromatica* and *C. amada* (Srivastava *et al*., 2007; Angel *et al*., 2008; Policegoudra *et al*., 2008; Bhende *et al*., 2013). The relatively high starch content in the present study may be due to the genotype and the stage of maturity. Total protein content in *C. aromatica* ranged from 8.25 to 9.98 per cent; maximum at 180 DAP and least at 140 DAP. But in *C. amada*, the protein content decreased with the increase of age (Table 2). However, there was no significant variation between the two species for protein content across the three stages of growth. Fiber content too showed a similar trend in the two species albeit statistically significant (Table 2).

The two *Curcuma* species studied for variations in yield and quality profile over three growth stages revealed significant variations for the parameters such as plant height, yield plant^{-1}, dry recovery and for the biochemical characters such as starch, curcumin, crude fiber and oil content. However, protein and tiller number did not show any significant variation over three growth stages and remained almost same.

The two species differed significantly for plant height, dry recovery, yield, oil, curcumin and starch between the species as well as among the growth stages. Species x growth stage interaction was also significant in these cases. Significant variation between the species was observed for leaf numbers only at 180 DAP. Tiller number and protein content did not vary with the growth stages in both the species.

Though the two species exhibited uniformity for all the aerial growth attributes, yield and starch, they exhibited varied expression for curcumin, crude fiber and protein content. The study indicated possibility of significant accumulation of photosynthates even after 140 days in both the species as evidenced through the increase in fresh yield. The dry recovery increased slightly after 140 days. This information would be useful in devising or rescheduling the fertilizer requirement for these species.

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