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Growth analysis and curcumin content of long, medium and short duration turmeric (*Curcuma longa* L.) genotypes

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Abstract

Six turmeric (*Curcuma longa*) genotypes, two genotypes each from long (Armoor and Duggirala), medium (CLI-317 and CLI-330) and short (PCT-13 and PCT-14) duration were evaluated at Jagtial (Andhra Pradesh). Long duration genotypes accumulated more dry matter and maintained leaf area index, chlorophyll content and cumulative growth rate for longer period up to 210 days, resulting in higher yield and curing percentage over medium and short duration genotypes. The long duration genotype Duggirala produced highest fresh rhizome yield (168 g plant^{-1}) and Armoor had highest curing percentage (20.26). Curcumin content was higher in short duration genotypes over medium and long duration genotypes. Maximum curcumin content was recorded in short duration genotype PCT-14 (4.06 %).

Keywords: *Curcuma longa*, curcumin, genotypes, growth, turmeric.

Introduction

Wide variability among cultivars for growth, yield parameters and quality characters is observed in turmeric (*Curcuma longa* L.) (Nirmal & Yamgar 1998). Turmeric varieties are generally classified into three groups and the varieties maturing in 7, 8 and 9 months are classified as short, medium and long duration varieties, respectively. Growth analysis studies would facilitate a better understanding of their growth and physiology for designing future lines of crop improvement work. With this objective two cultivars each from long, medium and short duration groups were selected and studied for growth, yield and quality, at different stages of growth.

Materials and methods

The field experiments were laid out at Regional Agricultural Research Station, Jagtial (Andhra Pradesh) during 1995–96 and 1996–97 in a randomized block design with four replications with six genotypes, two each of long duration (Armoor and Duggirala) , medium duration (CLI-317 and CLI-330) and short duration (PCT-13 and PCT-14), respectively. A plot size of 3 m x 3 m was adopted. The crop was planted during the second week of June during both the years and harvested,

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whenever the variety showed symptoms of maturity (drying of aerial parts). The recommended spacing (30 cm x 15 cm) and package of practices were followed uniformly for all the genotypes. Observations were recorded by taking samples of two plants randomly from each plot at 30 days interval from 60th day after planting to final harvest. For recording observations on dry matter accumulation, the samples were dried in the sun for 2 days and later in a hot air oven at 80^{0}C till no loss of weight was observed. Chlorophyll content was determined in fresh leaves by extracting the leaf tissue using dimethyl sulphoxide (DMSO) following the non-maceration technique of Hiscox & Israelstom (1978). Leaf area was calculated by the formula, Leaf area=leaf length x leaf width x 0.6464, as suggested by Rao *et al*. (2004). Leaf area index (LAI) was calculated by using the following formula:

LAI=leaf area/unit ground area

For growth analysis of the plant, the mean total accumulated plant weight (biological yield), the mean leaf area and mean dry weight of different plant parts were collected at different growth stages of the crop. These data were used to calculate crop growth rate (CGR), relative growth rate (RGR) and net assimilation ratio (NAR) as described by Watson (1952) and Redford (1967).

The curcumin content of genotypes was estimated by following the ASTA method (ASTA 1968) and modified by Manjunath *et al*. (1991). The pooled data of two years (1995–96 and 1996–97) was statistically analyzed.

Results and discussion

Growth rate

Growth and dry matter production of turmeric genotypes were interrelated and higher in long duration genotypes over medium and short duration genotypes, at harvest (Table 1). However, short duration genotypes had the highest dry matter production at all stages of crop growth till their harvest. Dry matter accumulation increased as the age

Table 1. Dry matter production, leaf area index and chlorophyll content in turmeric genotypes in relation to age of the plant

Genotype / Duration	60 DAP			90 DAP			120 DAP			150 DAP			180 DAP			210 DAP			240 DAP			Harvest
	DMP	LAI	CC	DMP	LAI	CC	DMP	LAI	CC	DMP	LAI	CC	DMP	LAI	CC	DMP	LAI	CC	DMP	LAI	CC	DMP
Armoor (Long)	5.16	1.96	4.08	10.77	2.93	4.93	17.19	3.01	5.47	26.08	3.45	6.24	33.36	3.60	6.54	39.41	3.11	6.45	41.58	1.30	3.13	43.73
Duggirala (Long)	6.02	2.11	4.19	11.49	3.01	4.93	20.59	3.22	5.81	28.55	3.52	6.60	35.72	3.60	6.71	40.93	3.84	6.67	43.76	1.39	2.95	46.91
CLI-317 (Medium)	6.02	1.86	4.37	11.86	2.80	5.06	16.69	3.41	5.89	22.77	3.59	6.61	31.95	3.69	6.59	38.10	1.35	3.16	-	-	-	42.04
CLI-330 (Medium)	5.56	1.86	4.28	10.11	2.75	4.90	15.27	3.06	5.80	22.74	3.52	6.51	30.49	3.51	6.42	36.51	1.21	3.09	-	-	-	38.20
PCT-13 (Short)	9.60	3.02	5.23	18.30	3.23	6.02	31.68	3.46	6.82	37.79	3.30	6.75	39.33	1.22	3.57	-	-	-	-	-	-	40.10
PCT-14 (Short)	8.43	2.70	4.63	16.34	3.26	6.01	28.76	3.36	6.67	34.50	3.35	6.60	36.32	1.48	3.31	-	-	-	-	-	-	37.45
SE	0.15	0.09	0.07	0.19	0.08	0.04	0.77	0.02	0.04	0.32	0.09	0.02	0.21	0.04	0.09	0.12	0.04	0.02	-	-	-	0.27
CD (P=0.05)	0.32	0.20	0.14	0.40	0.18	0.08	1.65	0.05	0.10	0.69	0.19	0.05	0.48	0.10	0.19	0.27	0.08	0.05	-	-	-	0.57

DAP=Days after planting; DMP=Dry matter production (g plant^{-1}); LAI = Leaf area index; CC=Chlorophyll content (mg fresh weight) of the crop advanced in all the genotypes. The peak rate of dry matter production was recorded between 90–120 days in short and 120–180 days in long and medium duration genotypes, respectively. The LAI as well as chlorophyll content were maintained at a significantly higher level for longer period up to 210 days in long duration genotypes, while it was maintained up to 180 days in medium and 150 days in short duration genotypes (Table 1). The increased duration of LAI and chlorophyll content in long duration genotypes might have produced more photosynthates resulting in higher growth rates as higher dry matter production is a prerequisite for higher rhizome yield.

The short duration genotypes PCT-13 and PCT-14 recorded higher crop growth rates (CGR, RGR, NAR and LAI) during early stages of crop growth (60–120 days). In long duration genotypes, the LAI showed gradual increase which was maintained up to 210 days in Armoor and 240 days in Duggirala. The short duration genotypes had higher LAI between 60–90 days and maintained up to 150 days which decreased later due to maturity of the crop. The LAI in medium duration genotypes had increased up to 180 days and decreased at 210 days. Maintenance of LAI at higher level for longer period (210 days) resulted in higher yield in long duration genotypes which was reflected through higher dry matter production in long duration genotypes. Duggirala maintained LAI for long period (240 days) over Armoor (210 days) and also resulted in higher yield over Armoor. Leaf area is one of the most important physiological trait which determines rhizome yield in turmeric.

CGR is the expression of crop productivity per unit land area per unit time. The maintenance of CGR at significantly higher level for extended period in long duration genotypes seems to be the reason for higher yields (Table 2). This is also indicated by the higher levels of LAI and NAR for extended period in longer duration genotypes as the CGR is the product of LAI and NAR (Watson 1958).

Table 2. Crop growth rate, net assimilation rate and relative growth rate in turmeric genotypes in relation to age of the plant

Genotype /	61-90 DAP			91-120 DAP			121-150 DAP			151-180 DAP			181-210 DAP			211-240 DAP		
Duration	CGR	NAR	RGR	CGR	NAR	RGR	CGR	NAR	RGR	CGR	NAR	RGR	CGR	NAR	RGR	CGR	NAR	RGR
Armoor (Long)	4.11	0.0172	0.0245	4.71	0.0160	0.0160	6.52	0.0204	0.0138	5.35	0.0153	0.0082	4.43	0.0133	0.0055	1.59	0.0077	0.0017
Duggirala (Long)	4.02	0.0159	0.0215	6.68	0.0216	0.0194	5.83	0.0146	0.0108	5.27	0.0149	0.0074	3.81	0.0103	0.0045	2.10	0.0087	0.0022
CLI-317 (Medium)	4.29	0.0188	0.0226	3.54	0.0148	0.0113	4.46	0.0127	0.0103	6.83	0.0187	0.0114	4.40	0.0025	0.0057	-	-	-
CLI-330 (Medium)	3.35	0.0147	0.0199	3.77	0.0130	0.0137	5.49	0.0168	0.0133	5.69	0.0163	0.0097	4.41	0.0027	0.0059	-	-	-
PCT-13 (Short)	6.38	0.0203	0.0215	9.77	0.0294	0.0182	4.44	0.0132	0.0058	1.23	0.0060	0.0015	-	-	-	-	-	-
PCT-14 (Short)	5.83	0.0198	0.0221	8.18	0.0249	0.0173	4.95	0.0148	0.0073	1.52	0.0066	0.0019	-	-	-	-	-	-

DAP = Days after planting; CGR = Crop growth rate ($g\ m^{-2}\ day^{-1}$); NAR = Net assimilation rate ($g\ dm^{-1}\ day^{-1}$); RGR = Relative growth rate ($g\ dm^{-1}\ day^{-1}$)

NAR is the net increase of dry matter per unit leaf area per unit time. Higher NAR values were recorded up to 180 days in long and medium genotypes and 120 days in short duration genotypes. The short duration genotypes recorded lower NAR values at 150 to 180 days, which could be due to lower dry matter production during that period (Table 2). The relative growth rate (RGR) values were more in early crop growth stage and decreased as the growth advanced (Table 2). A similar trend was noticed irrespective of duration and genotype.

Yield

The fresh weight of rhizome plant^{-1} during various stages significantly differed among different genotypes (Table 3). During crop growing period, the fresh weight of rhizome plant^{-1} increased with crop ontogeny in all the genotypes. At 60, 90 and 120 DAP, the short duration genotypes (PCT-13 & PCT-14) recorded significantly higher rhizome yield plant^{-1} over medium and long duration genotypes. Among short duration genotypes, PCT-13 recorded higher yield over PCT-14 during this period. It might be due to early crop growth, which was reflected in more dry matter accumulation, LAI and crop growth rates in the early period of crop growth in these short duration genotypes. But at harvest, the long duration genotypes Duggirala and Armoor produced more fresh rhizome weight than medium and short duration genotypes. It can be ascribed to accumulation of dry matter, maintenance of LAI and chlorophyll content for longer period, which was reflected in the final yield of long duration genotypes. This might be the reason for the higher rhizome yield in long duration genotypes over medium and short duration genotypes. The variation in rhizome yield was mostly due to duration of crop and genetic potential of a genotype and similar variation among the genotypes were reported by Cholke (1993).

The curing percentage increased with increase in age and attained its peak at maturity in all the genotype groups (Table 3). It

Table 3. Yield of fresh rhizomes and curing percentage in turmeric genotypes in relation to age of the plant

Genotype / Duration	60 DAP	90 DAP	120 DAP		150 DAP		180 DAP		210 DAP		240 DAP		At harvest	
	Wt. of fresh rhizome (g plant^{-1})	Wt. of fresh rhizome (g plant^{-1})	Wt. of fresh rhizome (g plant^{-1})	Curing percentage	Wt. of fresh rhizome (g plant^{-1})	Curing percentage	Wt. of fresh rhizome (g plant^{-1})	Curing percentage	Wt. of fresh rhizome (g plant^{-1})	Curing percentage	Wt. of fresh rhizome (g plant^{-1})	Curing percentage	Wt. of fresh rhizome (g plant^{-1})	Curing percentage
Armoor (Long)	12.86	31.38	59.10	9.48	77.78	10.55	99.65	13.65	109.03	16.52	124.40	19.12	130.31	20.20
Duggirala (Long)	22.85	47.52	70.38	9.15	98.35	10.21	126.02	13.15	149.27	16.11	163.78	18.67	168.85	19.94
CLI-317 (Medium)	18.96	35.31	56.98	11.71	69.82	13.84	91.17	16.01	112.63	18.38	-	-	116.85	19.91
CLI-330 (Medium)	15.95	30.13	48.65	11.39	63.53	13.52	83.45	15.50	103.00	17.96	-	-	106.93	19.70
PCT-13 (Short)	37.35	59.23	78.70	14.15	90.47	15.79	106.30	17.20	-	-	-	-	112.12	17.48
PCT-14 (Short)	33.92	55.32	73.72	14.48	91.05	16.05	102.25	17.43	-	-	-	-	108.56	17.60
SE	0.46	0.94	0.97	0.07	1.42	0.06	1.52	0.05	1.95	0.06	-	-	0.83	0.17
CD (P=0.05)	0.98	2.00	2.07	0.16	3.03	0.13	3.23	0.12	4.42	0.14	-	-	1.77	0.36

DAP=Days after planting

Table 4. Curcumin content in rhizomes of turmeric genotypes, in relation to age of the plant

Genotype /	Curcumin content in rhizome (%) during growth (DAP)							
Duration	60	90	120	150	180	210	240	At harvest
Armoor (Long)	0.82	1.10	1.48	2.11	2.86	3.30	3.16	3.12
Duggirala (Long)	0.79	1.02	1.40	1.64	1.92	2.35	2.28	2.25
CLI-317 (Medium)	0.90	1.39	1.89	2.76	3.68	3.52	-	3.52
CLI-330 (Medium)	0.88	1.36	1.83	2.36	3.21	3.13	-	3.10
PCT-13 (Short)	1.38	2.09	3.18	4.06	3.97	-	-	3.90
PCT-14 (Short)	1.38	1.44	3.28	4.15	4.09	-	-	4.06
SE	0.01	0.01	0.01	0.02	0.03	0.03	-	0.02
CD (P=0.05)	0.02	0.03	0.03	0.05	0.06	0.06	-	0.03

DAP=Days after planting

can be attributed to high moisture content in rhizomes during early stage of crop. On the other hand, as the plant ages the dry matter accumulation increased with a gradual decrease in the moisture content of rhizomes leading to a higher curing percentage (Tables 1 and 3). Similarly, curing percentage increased with the duration of genotypes and was maximum in long duration genotypes followed by medium and short duration genotypes. The increase in dry matter production in long duration genotypes might have increased curing percentage. However, higher curing percentage was reported in short duration genotypes by Subbarayudu *et al*. (1976). The curing percentage depends on the genotype, duration, soil, nutrient management and agro-climatic conditions. Varied curing percentages in different genotypes in different agro climatic conditions have been reported (Subbarayudu *et al*. 1976; Reddy *et al*. 1989).

Curcumin content

The curcumin content varied in different genotypes and such variations were reported by Ratnambal *et al*. (1992) and Kurian & Nair (1996). In the present study highest curcumin content (4.05%) was recorded in the short duration genotype PCT-14 whereas it was low in long duration genotype Duggirala (2.25%) (Table 4). The short duration genotypes PCT-13 and PCT-14 recorded significantly higher curcumin content than medium and long duration genotypes. Curcumin content appears to be more dependent on ontogeny of the crop and genotypes. Several reports on curcumin content showed contradictory results. This quality trait is highly sensitive to environmental micro and macro changes and variations in curcumin content in different agro-climatic conditions have been reported (Ratnambal *et al*. 1992; Kurian & Valsala 1996).

The study indicated that the long duration genotypes Duggirala and Armoor produced higher fresh rhizome yield with high curing percentage over medium and short duration genotypes due to more dry matter accumulation, maintenance of LAI, chlorophyll content and CGR for longer period. Extended period of growth parameters up to 240 days in long duration genotypes and low LAI during early crop growth period up to 120 days indicated the scope to plant other short duration intercrops in long duration turmeric genotypes. Whereas, early crop growth rates (60 to 120 days) recorded in short duration genotypes indicated the scope to increase cropping intensity by planting another crop immediately after harvesting of turmeric crop. The short duration genotypes PCT-14 (4.06%) and PCT-13 (3.90%) recorded higher curcumin content over medium and long duration genotypes.

References

American Spices Trade Association (ASTA) 1968 Official Analytical Methods. 2nd Edn. American Spices Trade Association, New York.

Cholke S M 1993 Performance of turmeric (*Curcuma longa* L.) cultivars. MSc (Ag) Thesis, University of Agricultural Sciences, Dharwad.

Hiscox J P & Israelstom G F 1978 A method for extraction of chlorophyll from leaf tissue without maceration. Canadian J. Bot. 57: 1332–1334.

Kurian A & Nair G S 1996 Evaluation of turmeric germplasm for yield and quality. Indian J. Gen. Res. 9: 327–329.

Kurian A & Valsala P A 1996 Evaluation of turmeric types for yield and quality. J. Trop. Agric. 33: 75–76.

Manjunath M M, Sattigeri V V & Mangraj K V 1991 Curcumin in turmeric. Spice India 4 (3): 7–9.

Nirmal S V & Yamgar V T 1998 Variability in morphological and yield characters of turmeric (*Curcuma longa* L.) cultivars. Adv. Plant Sci. 11: 161–164.

Rao V P, Rao A M, Ramakrishna M and Rao P S 2004 Leaf area measurement by linear measurement in turmeric. Ann. Agric. Res. 15 (2) : 231–233.

Ratnambal M J, Babu K N, Nair M K & Edison S 1992 PCT-13 and PCT-14-Two high yielding varieties of turmeric. J. Plantn. Crops 20: 79–84.

Redford P J 1967 Growth analysis formulae, their use and abuse. Crop Sci. 7: 171–175.

Watson D J 1952 The physiological basis of variation in yield. Adv. Agron. IV: 101–105.

Watson D J 1958 The dependence of net assimilation rate on leaf area index. Ann. Bot. 22: 37–45.