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Performance of turmeric (*Curcuma longa* L.) genotypes for yield and yield attributing traits under high altitude conditions of Andhra Pradesh

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Abstract
The present experiment was conducted in randomized block design with three replications during *Kharif* 2014-15, 2015-16 and 2016-17 at Horticultural research Station, Chintapalli. Total 12 genotypes were taken for study including one local check and one national check. Observations were recorded on various growth and yield characters. Analysis of variance revealed that a wide range of variation was observed for all the characters under the study except for leaf width. Among the genotypes, PTS-12 recorded the highest plant height (130.78 cm) followed by PTS-55 (125.16 cm) whereas SLP 389/1 recorded the lowest plant height (84.91 cm) followed by ACC-48 (85.07). The genotype NDH-98 recorded highest yield (53.76 t/ha) followed by NDH-8 (41.36 t/ha). NDH-98 also recorded highest dry recovery percentage (23.13) followed by PTS-8 (22.35). Thus, these genotypes may be recommended for commercial cultivation under high altitude and tribal area of Andhra Pradesh. They can be further evaluated to identify best genotypes suitable for cultivation at other locations and further used in breeding programmes.

Keywords: Turmeric, high altitude area, yield, growth

Introduction
Turmeric (*Curcuma longa* L.) is one of the most widely cultivated spice and also condiment crops are grown in India since times immemorial because of agro-climatic suitability and rich genetic diversity. Turmeric is also known as the “golden spice” as well as the “spice of life” (Ravindran *et al.*, 2007) [13]. It is regarded as a symbol of well-being and widely used in ceremonies and religious functions. It is an erect, herbaceous perennial plant belonging to the family Zingiberaceae and native to South East Asia. India is the largest producer, consumer and exporter of turmeric in the world. In India, it is being cultivated in more than 20 states in an area of 1.93 lakh ha with an annual production of 10.52 MT. It occupies 5.46 per cent of spice area and shares 14.87 per cent of spice production. In India, turmeric is extensively cultivated in the states of Telangana, Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, Assam, Maharashtra, Karnataka, Bihar and Kerala. (Anonymous, 2017) [2]. In Andhra Pradesh, it is being cultivated in an area of 16600 hectares with an annual production of 134100 MT of turmeric.

It has been used in India as a medicinal plant and held sacred from time immemorial. Turmeric has strong associations with the socio-cultural life of the people of the Indian subcontinent. This “earthy herb of the Sun” with the orange-yellow rhizome was regarded as the “herb of the Sun” by the people of the Vedic period (Ravindran *et al.*, 2007) [13]. It has attracted much attention worldwide due to its significant medicinal potential (Cousins *et al.*, 2007) [3]. The typical yellow-orange curcuminoids (curcumin, demethoxy curcumin and bisdemethoxy curcumin) are important bioactive compounds that occur in the rhizomes. Among curcuminoids, curcumin is a major colour pigment. Turmeric possesses anti-inflammatory, hepatoprotective, antitumor, antiviral, wound healing and anti-cancerous properties, and is also beneficial in treating gastrointestinal and respiratory disorders (Polasa *et al.*, 1994; Joe *et al.*, 2004) [10, 6]. Recent data also suggest that curcumin and other antioxidant products from the dried rhizome may be useful in the treatment of some age-related degenerative processes (Miquel *et al.*, 2002) [8].

Turmeric is either grown as a pure crop or as intercrop in maize crop under High Altitude and Tribal (HAT) zone of Visakhapatnam. The average productivity of the crop in this region is very low as against the state average productivity (8.0 t/ha). The low productivity in this region is mainly due to the lack of suitable cultivar and the package of practices for particular

Agro-climatic conditions. Very limited attempts have been made on the evaluation of turmeric genotypes under HAT zone conditions. There is a large number of cultivars available in turmeric and considerable variability exists with regard to morphological, yield and quality characters and several attempts have been made to assess this variability (Chaudhary *et al*., 2006; Rajyalakshmi *et al*., 2013; Vamshikrishna *et al*., 2019) [4, 11, 16].

The performance of any crop or variety largely depends upon its genetic makeup. Further, the performance of the crop depends upon climatic conditions of the region under which they are grown. As a result, genotypes which perform well in one region may not perform well in other regions of varying climatic conditions. Hence, it is very much necessary to collect and evaluate all the available genotypes in order to select suitable and high yielding genotypes for a given agro-climatic condition. Considering the importance of turmeric, research on this crop is very much necessary to find out the suitability of different genotypes for a particular region. Keeping this in view, the present study is taken up to evaluate promising genotypes and released varieties under high altitude and tribal zone of Visakhapatnam, Andhra Pradesh.

Material and Methods

The experiment was carried out at Horticulture Research Station, Chinthapalli, Visakhapatnam, and Andhra Pradesh in the year 2014-15, 2015-16 and 2016-17. The location falls under Agro-climatic zone of High Altitude and Tribal Zone with the average annual rainfall of more than 1300 mm, maximum temperature range 17 to 35ºC, and the minimum temperature range from 3 to 24ºC and is located at an altitude of 933 m MSL. The geographical situation of the experimental site is 170.13' N latitude and 840.33' E longitudes. The soil of the experimental field was alluvial and it was endowed with good drainage. The genotypes studied in this experiment were listed along with the source of origin in Table 1. The experiment was laid out in Randomised Block Design with 12 treatments and 3 replications. The planting was done on raised beds spaced row to row 30 cm with the plant to plant distance of 25 cm and the net plot size was 3 x 1 m^2. Recommended package of practices and plant protection measures were followed as per the package of practices given by Dr. YSR Horticultural University to raise a healthy crop. Five plants in each replication of each genotype were selected and tagged to record observations on quantitative characters *i.e*., plant height (cm)**,** number of tillers, leaf length (cm), leaf width (cm), fresh rhizomes yield per plant (g), Fresh rhizome yield/ha (t/ha) and dry recovery (%). The mean values were subjected to statistical analysis of data for each character as per the method is given by Panse and Shukhatme (1985) [9].

Table 1: Source of the genotypes studied in the Experiment

Sl. No.	Genotype	Place of Origin	District	State
1.	ACC-48	ICAR-IISR	Kozhikode	Kerala
2.	ACC-79	ICAR-IISR	Kozhikode	Kerala
3.	SLP 389/1	Solan	Solan	Himachal Pradesh
4.	NDH-8	Kumarganj	Faizabad	Uttar Pradesh
5.	NDH-79	Kumarganj	Faizabad	Uttar Pradesh
6.	NDH-98	Kumarganj	Faizabad	Uttar Pradesh
7.	PTS-12	Pottangi	Koraput	Odisha
8.	PTS-8	Pottangi	Koraput	Odisha
9.	PTS-55	Pottangi	Koraput	Odisha
10.	TCP-64	Pundibari	Cochlear	West Bengal
11.	Prathiba	ICAR-IISR	Kozhikode	Kerala
12.	Chintapalli local	Chintapalli	Visakhapatnam	Andhra Pradesh

Results and discussion

The analysis of variance showed significant differences among the genotypes for all traits *viz*., plant height, leaf length, leaf area, fresh rhizome yield per plant, fresh rhizome yield per hectare and dry recovery (%) except for the number of tillers per plant and leaf width (Table 2).

Analysis of mean data pooled over 3 years (2014-15, 2015-16 and 2016-17) for the different growth and yield parameters are presented in Table 3. The plant height ranged from 84.91 to 130.78 cm with the general mean of 108.06 cm. Among the genotypes, PTS-12 recorded the highest plant height (130.78 cm) followed PTS-55 (125.16 cm) and NDH-98 (122.40 cm) and these were on par with each other, whereas SLP 389/1 recorded the lowest plant height (84.91 cm) followed by ACC-48 (85.07) and ACC-79 (92.24 cm). The highest number of tiller per clump was produced by NDH-8 (3.19) followed by PTS-12 (2.99) while the lowest tillers resulted from TCP-64 (1.95) followed by ACC-79 (2.20). The leaf length varied from 10.94 to 13.71 cm. The genotype PTS-8 had longest leaf (55.43 cm) followed by PTS-12 (50.51 cm), while the shortest leaf length was recorded in ACC-48 (33.60 cm) followed by ACC-79 (34.26). The maximum leaf width was recorded in genotype NDH-98 (13.71 cm) followed by PTS- 8 (13.54 cm) whereas the minimum was recorded in genotype NDH-79 (10.94 cm) followed by ACC-49 (11.43). The leaf area per plant ranged between 358.14 cm^2 to 679.49 cm^2. The maximum leaf area was recorded in genotype PTS-8 (679.49 cm^2), while the minimum was recorded in genotype ACC-48 (358.14 cm^2). The variation among genotypes for growth traits are in close conformity with the findings of Shashidhar, 2015 [15] and Rohit *et al*., 2018 [14].

Table 2: Analysis of variance of turmeric genotypes for growth and yield traits

DF		Plant height	No. of tillers	Leaf length	Leaf width	Leaf area	Fresh rhizome yield/ plant	Fresh rhizome yield/ha	Dry recovery (%)
Treatments	11	683.32**	0.376	125.50**	2.01	18,331.30**	24,565.90**	258.424**	21.766**
Error	22	140.06	0.185	8.23	2.32	2,152.67	4,109.26	52.341	0.132

There was a significant difference among 12 turmeric genotypes for fresh rhizome yield per plant (Table 3). The maximum fresh rhizome yield per plant was recorded in genotype NDH-98 (505.31 g) followed by NDH-8 (367.71 g). The minimum was recorded in genotype SLP 389/1 (185.6 g) followed by Chintapalli Local (194.78 g). The estimated fresh yield per hectare ranged between 18.99 to 53.76 tons per hectare. The maximum estimated fresh yield per hectare was recorded in NDH-98 (53.76 t/ha) followed by NDH-8 (41.36 t/ha). NDH-98 was significantly superior over all other genotypes including check varieties. The minimum estimated yield per hectare was recorded in genotype Chintapalli Local (18.99 t/ha) followed by SLP 389/1 (24.73 t/ha) and these two were on par with each other.

Table 3: Mean performance of turmeric genotypes for growth and yield traits

Treatments	Plant height (cm)	No. of tillers/plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Fresh rhizome yield/plant (g)	Estimated Fresh rhizome yield/ha (t)	Dry recovery (%)
ACC-48	85.07	2.84	33.60	11.43	358.14	307.88	26.51	14.78 (22.60)
ACC-79	92.24	2.20	34.26	12.93	446.42	298.50	28.85	15.18 (22.92)
SLP 389/1	84.91	2.30	39.77	12.48	534.57	185.60	24.73	21.08 (27.32)
NDH-8	105.46	3.19	42.60	13.14	489.18	367.71	41.36	12.94 (21.07)
NDH-79	111.75	2.37	37.96	10.94	447.98	330.21	39.50	13.84 (21.83)
NDH-98	122.40	2.22	42.81	13.71	543.34	505.31	53.76	23.13 (28.73)
PTS-12	130.78	2.99	50.51	12.84	563.18	242.56	27.74	20.99 (27.25)
PTS-8	119.06	2.67	55.43	13.54	679.49	254.22	31.32	22.35 (28.20)
PTS-55	125.16	2.63	48.01	13.32	508.07	248.10	31.81	18.69 (25.60)
TCP-64	108.86	1.95	46.45	12.14	462.91	213.72	25.10	20.48 (26.89)
Prathiba (National check)	102.24	2.97	43.29	12.43	532.28	214.22	30.18	21.60 (27.68)
Chintapalli local (Local check)	108.73	2.50	46.74	12.81	510.99	194.78	18.99	19.80 (26.41)
SE(m)±	6.83	0.248	1.67	0.88	26.79	37.01	4.18	0.29
CD (5%)	20.17	NS	4.89	NS	79.07	109.25	12.33	0.86

The growth and yield are governed by the genetic composition of the genotype coupled with the environmental conditions under which the crop is grown. When different genotypes are grown under identical conditions, it is the genetic makeup that expresses the morphological differences. Similar variations were observed in turmeric under different agro-climatic conditions by Veena, 2012 [17] and Shashidhar *et al*., 2017 [7].

The dry recovery percentage ranged from 12.94 to 23.13 with general mean 16.14. Genotype NDH-98 (23.13%) recorded the highest dry recovery percentage followed by PTS-8 (22.80%) and these two genotypes were on par with one another and also significantly superior to the superior check, Prathiba (21.60%). The lowest dry recovery percentage was recorded in NDH-8 (12.94%) followed by NDH-79 (13.84%). Even though NDH-8 and NDH-79 recorded high yield, these two genotypes had low dry recovery percentage. It may result in low dry yield in these two genotypes. Rao, 1965 [12] and Aiyadurai 1966 [1] reported that variation in curing percentage was largely related to the genetic factors and environmental conditions under which they were grown and the similar variation in curing percentage was also reported by Jadhao *et al*., 2005 [5] and Lakshmi *et al*., 2017 [11]. The present investigation is also in conformity of these findings.

Among the twelve genotypes studied, NDH-98 recorded the highest yield and highest dry recovery percentage under the conditions of high altitude and tribal area of Andhra Pradesh. Even though ACC 48 recorded relatively lower yields, it is more suitable for rainfed cultivation of turmeric in this region to replace with presently cultivating Chintapalli Local variety, since the genotype ACC 48 is a short duration (180 days) type and most of the farmers cultivate turmeric as a rainfed crop in this area. Under this rainfed situation, short duration varieties may perform well when compared to long duration varieties. Thus, NDH-98 and ACC 48 genotypes may be recommended for commercial cultivation under high altitude and tribal area of Andhra Pradesh. They can be further evaluated to identify the best genotypes suitable for cultivation at other locations and further used in breeding programmes.

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