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Evaluation of Turmeric (*Curcuma longa* L.) Genotypes for Growth, Yield and Quality under Rainfed Condition of Arunachal Pradesh, India

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A B S T R A C T

Field experiments were conducted in randomized block design with three replications at the Horticulture Experimental Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh for four seasons starting from the year 2013-14 and ending in 2016-17. Total 12genotypes were taken for study including one local and one national check. Observations were recorded for various growth, yield and quality characters such as plant height (cm), number of tillers per plant, number of days to maturity, rhizome yield per plant (kg), rhizome yield (t/ha), dry recovery (%), curcumin content (%), essential oil (%) and oleoresin content (%). The data were analyzed as per statistical procedure. In general during the four years of study the result revealed significant variation for all the characters considered. Taller plant height was recorded in genotype NDH-98, Megha Turmeric-1 and NDH 8. Higher number of tillers per plant was associated with the genotypes NDH-98, NDH-79, PTS-12, TCP-64, Acc.-48 and the local check Megha Turmeric-1. The genotype NDH- 98 recorded the highest rhizome yield per plant and per hectare and it was significantly superior to all the other genotypes including the National Check Prathibha and Local check Megha Turmeric-1 with few exceptions in some years. The significantly higher dry recovery percentage of turmeric was recorded in genotype NDH-8 while the lowest was exhibited in genotype PTS-8 with some exception over the years. Higher curcumin content was recorded in genotype PTS-8, Acc.-48 (IISR Pragati), SLP-389/1, NDH-8, NDH-79, NDH-98, PTS-12 including local check Megha Turmeric 1. The variation in essential oil among the genotypes was found to be not significant. The maximum oleoresin content was recorded in genotype NDH-8 which remained at par to Acc.-79, SLP-389/1, NDH-79 and PTS-8 respectively.

Introduction

Turmeric (*Curcuma longa* L.) is one of the important spice crop grown in India since times immemorial. It is widely used in ceremonies and religious functions. It is an erect, herbaceous perennial belonging to the family *Zingiberaceae* and native to South East Asia (Chickarmane *et al.*, 2003).Turmeric is valued for its deep yellow colour and pungent aromatic flavour due to the presence of colouring matter 'curcumin' and a volatile oil 'termerol'. It is also an important condiment which finds a unique place in culinary arts and

as colouring agent in textile, food, confectionary, cosmetics and drug industries, of late in the preparation of anti-cancer medicines.

Turmeric is a tropical crop and needs a warm and humid climate with an optimum temperature of 20 to 30^{o}C for normal growth and satisfactory production. It thrives best on sandy loam or alluvial, loose, friable and fertile soil rich in organic matter status and having a pH range of 5.0 to 7.5. Alkaline soil is not suitable for its cultivation. The crop cannot withstand water logging. It grows at all places ranging from sea level to an altitude of 1200 m above mean sea level. As a rainfed crop turmeric needs a well distributed annual rainfall of 250 to 400 cm for successful production.

India is the major producer of turmeric and 4th most important spice crop of India. In India it is being cultivated in an area of 1,93,400 ha with an annual production of 10,52,100 MT and productivity of 5.44 MT/ha. In Arunachal Pradesh it is raise in an area of 800 ha with an annual production of 3800 tonnes and productivity of 4.75 t/ha (Anon., 2017).The average productivity of the crop is however low in the state as against the National yield average. Lack of suitable cultivar for a particular agro-climatic condition is one of the reasons for low productivity. Several studies revealed existence of significant variability in turmeric genotypes with regard to growth, yield and quality attributes when grown under different agro climatic conditions.

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. Though wide genetic variability exists in the crop with respect to the growth and yield but not much work seems to have been done on crop improvement through the simple selection of the high yielding genotypes (Singh and Prasad, 2006). Keeping in view the above fact the present investigation was carried out to find a suitable genotype.

Materials and Methods

Twelve genotypes of turmeric including one national check and local check (Acc.-48,Acc.-79, SLP-389/1, NDH-8, NDH 79, NDH-98, TCP-64 , PTS-12 , PTS-8 , PTS-55, Prathibha (NC) and Megha Turmeric-1 (LC)) were grown in randomized block design (RBD) with three replications at Vegetable Research Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh for four seasons starting from the year 2013-14 and ending in 2016-17. The soil of the experimental field was sandy loam in texture with a soil pH of 5.0-5.5, high in organic carbon (1.5%), medium in available nitrogen(327 kg/ha), low in available P_2O_5(35 kg/ha) and high in available K_2O (360 kg/ha).Geographically it is located at latitude of 28^{0}06’N, longitude 93^{0}32’E and altitude of 153 m MSL, hailing to the subtropical hot humid climatic condition and is one of the major production belts of turmeric. Healthy rhizomes having 2-3 buds were planted at 30 cm apart in rows keeping 25 cm plant to plant distance. The entire recommended package of practices was followed to raise a good crop. Five plants were randomly selected from each plot to record observations on quantitative

characters like plant height (cm) and number of tillers per clump. The days to maturity, rhizomes yield (t/ha) and dry recovery were observed and workout. The qualitative characters like curcumin (%), essential oil (%) and oleoresin content were also recorded. The curcumin content was estimated as per the methods of ASTA (Anon., 1968) proposed by Manjunath *et al.,* (1991).

$$\text{Curcumin content (per cent)} = \frac{\text{OD value} \times 125 \times 0.0025}{0.42 \times 0.1 \times 1}$$

The oleoresin content was calculated using the following formula and expressed as per cent (AOAC, 1975).

$$\text{Oleoresin content (per cent) (air dry)} = \frac{W2 - W1}{10} \times 100$$

Where,
W1 = weight of empty beaker
W2 = weight of beaker with air dried oleoresin

The essential oil content was estimated as per the methods suggested by ASTA (Anon, 1968). The volume was measured and the oil content was calculated as

$$\text{Essential oil content (per cent)} = \frac{\text{Volume of oil (ml)}}{\text{Weight of sample (g)}} \times 100$$

The mean values were subjected to statistical analysis of data for each character as per method given by Panse and Shukhatme (1978).

Results and Discussion

Ten turmeric genotypes namely Acc.-48, Acc.-79, SLP-389/1, NDH-8, NDH-79, NDH-98, TCP-64, PTS-12, PTS-8, PTS-55were evaluated in Randomized Block Design with three replications along with National Check, Prathibha and Local Check, Megha Turmeric-1 during four years starting from 2013-14 to 2016-17 at Pasighat, Arunachal Pradesh.

Growth characters

The result revealed that signifcant variation in growth parameters were observed among the different genotypes during the four years of study and in the pooled mean. The tallest plant height was recorded in genotype NDH-98 (103.95 cm) which was statistically at par with Megha Turmeric-1 (94.43 cm) and NDH-8 (93.02 cm) in all the years of investigation and pooled mean with an exception in 2016-17. Though, the shortest stature of plant was observed in PTS-55 (85.70 cm) in 2013-14, Acc.-48 (86.00 cm) in 2014-15, PTS-8 (60.33 cm) in 2015-16 and SLP-389/1 (64.00 cm) in 2016-17 and in (79.88 cm) pooled mean, however, they were at par to each other. The variation in plant height might be attributed to genetic variation among the genotypes. Dhatt *et al.,* (2008), Singh *et al.,* (2013) and Prasath *et al.,* (2016) also reported the differences in plant height with different genotypes. Maximum number of tillers per plant was recorded in NDH-98 in all the years (4.73, 4.07 and 4.30) of study and pooled mean (4.28) except in 2013-14 where NDH-79 (4.13) exhibited the highest number of tillers per plant but remained at par to each other in all the occasions. Again these genotypes (NDH-98, NDH-79) did not differ significantly with PTS-12, TCP-64, Acc.-48 and Megha Turmeric-1 in respect of number of tillers per plant with few exceptions. The minimum number of tillers per plant was associated with the genotype Acc.-79 (2.87, 2.87, 2.73, 2.83 and 2.83) in all the four years of investigation as well as pooled mean. Similar variations in these characters among the genotypes were reported by earlier workers in turmeric and ginger under different agro-climatic conditions (Babu *et al.,* 1993, Dhatt *et al.,* 2008 and Rajyalakshmi and Umajyothi, 2014) (Table 1).

Table.1 Plant height, number of tillers/plant and number of days to maturity as influence by different genotypes of turmeric

Genotype	Plant height (cm)					No. of tillers/plant					No. of days to maturity				
	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years
Acc.-48	100.27	86.00	63.33	78.33	81.98	3.93	3.53	3.33	3.47	3.57	202.07	212.33	208.00	226.00	212.10
Acc.-79	106.20	94.00	70.33	64.67	83.80	2.87	2.87	2.73	2.83	2.83	208.80	216.67	205.00	221.33	212.95
SLP-389/1	98.53	89.67	67.33	64.00	79.88	3.60	3.40	3.07	3.17	3.31	200.93	201.73	198.00	216.00	204.17
NDH-8	110.73	99.00	73.67	88.67	93.02	4.07	3.73	3.27	3.43	3.63	214.60	222.80	208.67	229.00	218.77
NDH-79	103.17	96.23	60.67	83.67	85.94	4.13	4.33	3.60	3.67	3.93	207.93	213.33	206.00	224.33	212.90
NDH-98	115.80	115.00	81.67	103.33	103.95	4.00	4.73	4.07	4.30	4.28	210.00	218.27	208.00	230.00	216.57
TCP-64	90.50	88.33	73.33	86.00	84.54	3.87	3.80	3.40	3.73	3.70	191.17	215.00	200.00	218.00	206.04
PTS-12	98.03	87.00	63.00	79.33	81.84	3.87	3.67	3.33	3.47	3.59	202.93	217.67	203.00	221.33	211.23
PTS-8	107.37	94.67	60.33	72.33	83.68	3.40	3.13	2.87	3.13	3.13	202.53	216.33	188.67	218.00	206.38
PTS-55	85.70	96.00	67.33	72.33	80.34	3.20	3.60	3.07	3.20	3.27	187.27	215.00	196.67	221.33	205.07
Prathibha (NC)	100.17	93.33	70.00	74.33	84.46	3.33	3.20	3.00	3.17	3.18	206.33	215.00	201.33	219.33	210.50
Megha Turmeric-1 (LC)	101.03	109.33	75.67	91.67	94.43	3.93	3.73	3.33	3.50	3.62	209.67	215.00	197.33	221.33	210.83
SEm±	5.29	5.53	3.8	3.59	4.55	0.26	0.31	0.26	0.19	0.25	4.08	3.15	4.57	1.45	3.87
CD at 5%	15.52	16.23	11.36	12.89	14.00	0.76	0.92	0.76	0.72	0.79	14.06	NS	15.6	5.45	11.70
CV %	9.03	10.01	9.74	9.53	9.58	12.13	14.87	13.73	12.34	13.26	4.79	5.85	5.32	1.52	3.98

Table.2 Yield and yield attributes of turmeric as influence by different genotypes

Genotype	Rhizome Yield/plant (kg)					Rhizome yield (t/ha)					Dry recovery (%)				
	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years	2013-14	2014-15	2015-16	2016-17	Pool mean of 4 years
Acc.-48	0.18	0.18	0.09	0.18	0.16	24.15	23.64	12.49	22.00	20.57	21.23	21.13	21.30	23.47	21.78
Acc.-79	0.17	0.18	0.08	0.15	0.15	23.22	23.53	10.66	17.54	18.74	20.95	21.57	21.60	20.13	21.06
SLP-389/1	0.14	0.15	0.05	0.11	0.11	19.04	20.20	7.22	13.55	15.00	21.32	21.17	21.47	22.67	21.66
NDH-8	0.25	0.25	0.06	0.12	0.17	32.76	32.97	8.62	14.65	22.25	32.22	21.80	21.57	22.67	24.57
NDH-79	0.27	0.27	0.07	0.12	0.18	35.50	35.74	8.77	14.71	23.68	20.14	20.63	21.30	21.87	20.99
NDH-98	0.27	0.27	0.17	0.23	0.24	35.63	36.41	22.64	28.3	30.75	21.01	20.60	21.13	19.93	20.67
TCP-64	0.11	0.14	0.05	0.09	0.10	15.25	18.35	6.55	11.43	12.90	21.25	19.73	20.93	22.60	21.13
PTS-12	0.18	0.18	0.06	0.12	0.14	23.61	24.20	7.34	14.99	17.54	19.89	20.03	20.80	23.47	21.05
PTS-8	0.14	0.15	0.05	0.11	0.11	18.90	19.31	6.77	13.88	14.72	18.90	19.83	20.60	22.20	20.38
PTS-55	0.21	0.21	0.08	0.15	0.16	28.45	27.75	10.10	16.65	20.74	20.85	21.57	21.30	18.93	20.66
Prathibha (NC)	0.16	0.16	0.07	0.13	0.13	21.45	21.53	9.32	15.54	16.96	21.17	21.77	21.20	23.53	21.92
Megha Turmeric-1 (LC)	0.17	0.21	0.09	0.2	0.17	22.81	27.75	11.54	23.86	21.49	21.73	21	21.13	21.53	21.35
SEm±	0.01	0.02	0.01	0.01	0.01	1.92	2.52	1.21	1.14	1.69	0.58	0.49	0.36	0.85	0.57
CD at 5%	0.04	0.06	0.03	0.04	0.04	5.62	7.39	3.54	4.11	5.16	1.71	1.42	NS	3.05	1.81
CV %	13.24	16.81	20.57	16.01	16.65	13.24	16.81	20.57	14.05	16.16	4.83	4.02	2.92	8.23	5.00

Table.3 Quality of turmeric as influence by different genotypes

Genotype	Curcumin (%)	Essential oil (%)	Oleoresin (%)
Acc.-48	6.20	7.00	11.12
Acc.-79	5.70	6.50	12.81
SLP-389/1	6.30	6.80	12.50
NDH-8	6.40	7.40	12.91
NDH-79	6.10	7.30	12.36
NDH-98	6.00	6.90	11.52
TCP-64	5.80	6.70	11.25
PTS-12	6.10	6.70	11.97
PTS-8	6.50	7.30	12.75
PTS-55	5.70	6.90	11.36
Prathibha (NC)	5.40	6.50	12.23
Megha Turmeric-1 (LC)	6.20	6.90	11.46
SEm±	0.15	0.34	0.16
CD at 5%	0.52	NS	0.58
CV %	5.09	5.91	4.94

The number of days taken from planting to harvesting differed significantly among turmeric genotypes. The genotype SLP-389/1 took minimum days (204.17) for maturation while NDH-8 recorded maximum days (218.77) for crop maturation followed by NDH-98, Acc.-79 and Acc-48. The differences in crop maturation among the different genotypes of turmeric were also reported by Hrideek *et al.*, (2006), Singh and Prasad (2006) and Singh *et al.*, (2013).

Yield attributes and yield

A perusal of Table 2 showed significant variation in rhizome yield among the genotypes. The genotype NDH-98 recorded the highest rhizome yield per plant (0.27,0.27, 0.17, 0.23 and 0.24 kg) in all the four years of study as well as in pooled mean and it was significantly superior to all the other genotypes in all the years with exception in 2013-14 and 2014-15 where it did not differ significantly with NDH-8 and NDH-79 respectively. The yield per hectare also followed the similar trend as that of rhizome yield per plant with NDH-98 (35.63, 36.41, 22.64, 28.30 and 30.75 t/ha) recording the maximum rhizome yield, which was significantly superior over National Check Pratibha and Local check Megha Turmeric-1. Better growth and higher yield component

contributed positively for the higher rhizome yield in this genotype. The lowest rhizome yield was recorded in genotype TCP-64 (15.25, 18.35, 6.55, 11.43 and 12.90 t/ha) over the years of investigation and pooled mean. Pirjade *et al.,* (2007), Chaturvedi *et al.,* (2010), Negi *et al.,* (2012) and Singh (2013) reported wide variability for rhizome yield among genotypes of turmeric. A significant difference in dry recovery of turmeric was observed among the genotypes in all the years of study with an exception in 2015-16. The significantly higher dry recovery percentage of turmeric was recorded in genotype NDH-8 (24.57 %) in four years pooled mean while the lowest was exhibited in genotype PTS-8 (20.38 %) with some exception over the years.

Quality parameters

The highest curcumin content was recorded in genotype PTS-8 (6.5%) which remained at par to Acc.-48 (IISR Pragati), SLP-389/1, NDH-8, NDH-79, NDH-98, PTS-12 and local check Megha Turmeric-1 but significantly superior to rest of the other genotypes (Table 3). The variation in curcumin content among different cultivars could be related to the genetic character of the cultivars. The differences in curcumin content among the different genotypes was reported earlier by Rao *et al.,* (2006), Deshmukh *et al.,* (2009), Kamble *et al.,* (2011) and Singh *et al.,* (2013). Though variation in essential oil among the genotypes was observed with maximum recording in genotype NDH-8, however, the differences were found to be not significant. The maximum oleoresin content was recorded in genotype NDH-8 (12.91%) which remained at par to Acc.-79, SLP-389/1, NDH-79 and PTS-8 but significantly higher to other genotypes. From the present study, it can be concluded that genotypes NDH-98 and NDH-8 performed better in terms of yield and quality respectively in Arunachal Pradesh.

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