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Evaluation of short and tall true turmeric (*Curcuma longa*) varieties for growth, yield and stability

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True turmeric, is an important commercial crop. Plant height (of pseudostem) in turmeric is a single important morphological character for which selection for yield could be made (Nambiar 1979). Correlation analysis of morphological traits indicated that tall plants having longer and broader leaves with higher number of suckers and tillers/plant would be an ideal plant type for higher rhizome yield (Roy *et al*. 2011). In a geneotype×environment study, Anandaraj *et al*. (2014) found that a large proportion (70.8%) of variation on turmeric yield was attributed to environments and genotype effect. There are several methods to study the genotype stability; however, genotype grouping method proposed by Francis and Kannenberg's (1978) is a versatile in its applications due to its simplicity (Funnah and Mak 1980, Ngevel and Bouwkamp 1993). In this study tall and short varieties of true turmeric representing different geographical regions of India are compared for their growth and yield and yield stability.

A field experiment was conducted at Experimental Farm, Indian Institute of Spices Research, Peruvannamuzhi, Kerala, (11°34'N, 75 °48'E and 60 mMSL) for four years 2008-09 to 2011-12. Eleven turmeric varieties selected for the study were BSR 2, Duggriala Red, IISR Alleppey Supreme, IISR Kedaram, IISR Prathibha, Megha Turmeric 1, Narendra Haldi 1, Rajendra Sonia, Rasmi, Roma, Suranjana (Anandaraj *et al*. 2014). They were planted on 3 m × 1 m size raised bed during first week of June with a spacing of 25 cm × 30 cm in a randomized block design with three replications under rainfed. Annual rainfall received during the experimentation, i.e. 2008, 2009, 2010, and 2011 was 3777.8 mm, 5420.4 mm, 4121.0 mm, 4907 mm in 145 days, 158 days, 167 days and 154 days, respectively. The mean annual maximum temperature was 31.7°C, 31.8 °C, 31.5 °C, 31.9 °C and mean annual minimum temperature recorded was 21.9 °C, 22.3 °C, and 22.3 °C and 21.8 °C. Soil of the experimental site was laterite having a mean pH of 4.81, and major nutrient status of N, P, K are 147, 4.3 and 186 mg/kg soil during the study period. Uniform cultivation practices were adopted. Growth observations recorded during October. Main pseudostem (first emerged shoot from seed) height was measured from soil surface to the point where last leaf was attached with main shoot and number of leaves and tillers were counted. Leaf area (LA) was calculated by using formula LA= 5.71 + 0.72 × Length × Breadth of leaf (Panja *et al*. 2005). Leaf area index (LAI) was calculated by dividing total leaf area/plant with land area occupied/plant (750 cm^2). Crop was harvested during first week of February at maturity and fresh yield/plant of sample plants and/plot ($3m^2$) were recorded after cleaning. One kilogram of fresh rhizomes were boiled in water for 45 minutes uniformly and kept in a hot air oven at 58 – 60°C for 4 – 5 days and drying percentage (dry recovery) was calculated, i.e. Drying percentage = (Dry weight/Fresh weight) × 100, with this dry yield was worked out, i.e. Dry yield = (Fresh yield × Drying percentage)/100. Pooled analysis was done as suggested by Gomez and Gomez (1984) and Rangaswamy (1995). Francis and Kannenberg's (1978) mean-CV method were used to evaluate performance and stability.

Turmeric varieties exhibited a variation for growth characters like main pseudostem height, tiller and number of leaves, total leaf area, LAI and yield (Table 1). The varieties which produced the tall plants were having more tillers, leaves, leaf area and LAI, whereas varieties with short plants had few tillers and less leaves, total leaf area and LAI and it was due to the genotypic variations. Genotypic variation also noted for height, the maximum main pseudostem height of 39.2 cm was recorded in Duggriala Red followed by Megha Turmeric (37.7 cm) and Rasmi (37.6 cm) and they are on a par with each other. Short plants were observed in Narendra Haldi 1(24.7 cm), Suranjana (26.2 cm) and Rajendra Sonia (28.8 cm) and these were on a par with each other. The remaining varieties were recorded medium height between 31.9 cm to 34.8 cm. The mean tiller

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Table 1 Growth and yield characters and yield of true turmeric varieties (Pooled over four years)

Varieties	Plant height (cm)	Tillers/ plant	Total leaf numbers/ plant	Total leaf area (cm^2/plant)	Leaf Area Index (LAI)	Fresh yield (g/plant)	Mean fresh yield (kg/plot ($3m^2$)	Dry recovery (%)	Mean dry yield (kg/plot ($3m^2$)
Megha turmeric	37.7	3.1	19.6	7 078.9	9.4	521.8	10.5	18.7	1.92
IISR Alleppy Supreme	31.9	2.9	22.8	6 335.6	8.4	460.6	9.4	18.3	1.68
IISR Kedaram	34.4	3.6	23.1	6 449.0	8.6	426.8	8.2	17.6	1.45
IISR Prathibha	33.9	3.3	24.6	7 738.9	10.3	470.6	9.8	19.3	1.88
BSR 2	34.8	3.8	20.0	6 208.9	8.3	579.5	11.0	12.7	1.38
Suranjana	26.2	2.8	17.1	3 812.4	5.1	574.9	12.3	16.7	2.09
Rajendra Sonia	28.8	2.9	16.1	3 309.1	4.4	778.9	17.0	11.2	1.92
Roma	34.2	3.0	22.4	7 266.7	9.7	423.7	7.7	18.7	1.38
Rasmi	37.6	3.8	23.7	6 304.2	8.4	447.8	7.5	18.5	1.29
Duggriala Red	39.2	3.1	22.3	7 477.3	10.0	525.7	9.6	17.3	1.81

number of turmeric varieties was 3.2. Maximum tiller of 3.8 recorded in Rasmi and BSR 2 followed by IISR Kedaram (3.6), whereas Narendra Haldi 1, Suranjana, Rajendra Sonia and IISR Alleppey Supreme were recorded less than 3.0 tillers/plant. IISR Prathibha has recorded more leaves (24.6), leaf area (7738.9 cm^2) and LAI (10.3). Rajendra Sonia, Narendra Haldi 1 and Suranjana have recorded comparatively lesser leaves, leaf area and LAI of 16.1, 3309.1, 4.4; 16.6, 4028.0, 5.4; 17.1, 3812.4, 5.1, respectively, than other varieties.

Pooled data on fresh yield/plant, fresh and dry yield/ plot ($3m^2$), dry recovery percentage, fresh and dry estimated yield/ha given in Table 1 indicated that fresh rhizome yield per plant varied between 423.7g/plant (Roma) to 792.3g/ plant (Narendra Haldi 1). Narendra Haldi 1 was on a par with Rajendra Sonia (778.9 g/plant), in addition to these two varieties, BSR 2 (579.5 g/plant) and Suranjana (574.9 g/plant) have recorded higher yield above the mean value (545.7g/plant) and remaining seven varieties are below the mean level. Fresh yield per plot ($3m^2$ area) was in the range of 7.5 kg (Rasmi) – 17.0 kg (Rajendra Sonia) with a mean of 10.7 kg/plot. Similar trend as noted in fresh yield/plant has been seen in fresh yield/plot and it is attributed varietal character. Varietal variation was also noted for dry recovery, maximum dry recovery percentage of 19.3% was noted in IISR Prathibha and lower value was with Rajendra Sonia (11.2%), Narendra Haldi 1(11.8%) and BSR 2(12.7%). Remaining eight varieties have seen with higher dry recovery percentage than mean (16.4%). Dry rhizome yield per plot varied between 1.29 kg to 2.09 kg with a maximum yield was observed in Suranjana followed by Rajendra Sonia and Megha Turmeric 1 with 1.92 kg/plot. Four varieties recorded below the mean value of 1.69 kg/plot and remaining seven are above the mean.

The comparison of short and tall varieties of true turmeric has brought out the clear distinction in growth, yield and duration between them. Varieties such as Megha Turmeric, Duggriala Red, Rasmi which produced the tall plants were having more tillers, leaves, leaf area and LAI, whereas, varieties Rajendra Sonia, Narendra Haldi 1 and Suranjana with short plants had few tillers and less leaves, total leaf area and LAI. Several researchers studied the growth of turmeric, Chaturvedi *et al*. (2010) and Naidu and Murthy (2013) have reported that varietal variations in turmeric for plant height, number of tillers and leaves. Chaturvedi *et al*. (2010) has noted from their two years mean data that varieties with shorter plants produced less tillers and it is in agreement with ours, whereas, shorter varieties produced more leaves than taller varieties and it is not in agreement with present study. The results of Naidu and Murthy (2013) was not consistent, for example plant height, number of tillers and leaves of varieties BSR 1 and TCP 2 were 82.2 cm, 2.2, 16.1; 42.5 cm, 2.2, 11.0 for first year, and 100.3 cm, 1.8, 10.1; 86.2 cm, 4.0, 17.7 for second year, respectively. Our result is not in agreement with this. One year result of Pirjade *et al*. (2007) indicated that variety Brahmani recorded shorter plant height (71.96 cm) produced lesser tillers (3.05) and leaves (11.95) compared to Krishna (95.53 cm, 14.15 leaves, 4.55 tillers) and Waigaon (107.22 cm, 3.7 tillers, 13.7 leaves) and it is in agreement with present study. Rao *et al*. (2006) has found that long duration varieties had more LAI than short duration varieties at 180 days after planting.

A simple graphical form by plotting the mean performance of each entry against its coefficient of variation (CV) was used for study of stability. The resultant graph was divided into four quadrants using the mean performance and mean CV across all genotypes (Fig 1). A low CV indicated that a genotype had low variability over environments. Farmers are not paid based on fresh yield, traders buy only processed dry turmeric, hence, dry turmeric yield is important. The varieties IISR Alleppey Supreme and IISR Kedaram are stable yielders but not high yielders. The varieties like BSR 2 and Suranjana were produced better fresh yield and their processed dry yield is low, when rhizome is plump their dry recovery is low and it is attributed to varietal trait. The variety Rajendra Sonia, inspite of its bulky nature and low dry recovery it produced better dry yield. Mother rhizomes of variety with short plants are smaller and contributes around 10% to the total clump weight (data not shown), whereas, tall plants had bold mother rhizomes which contributes around 25% to the clump weight

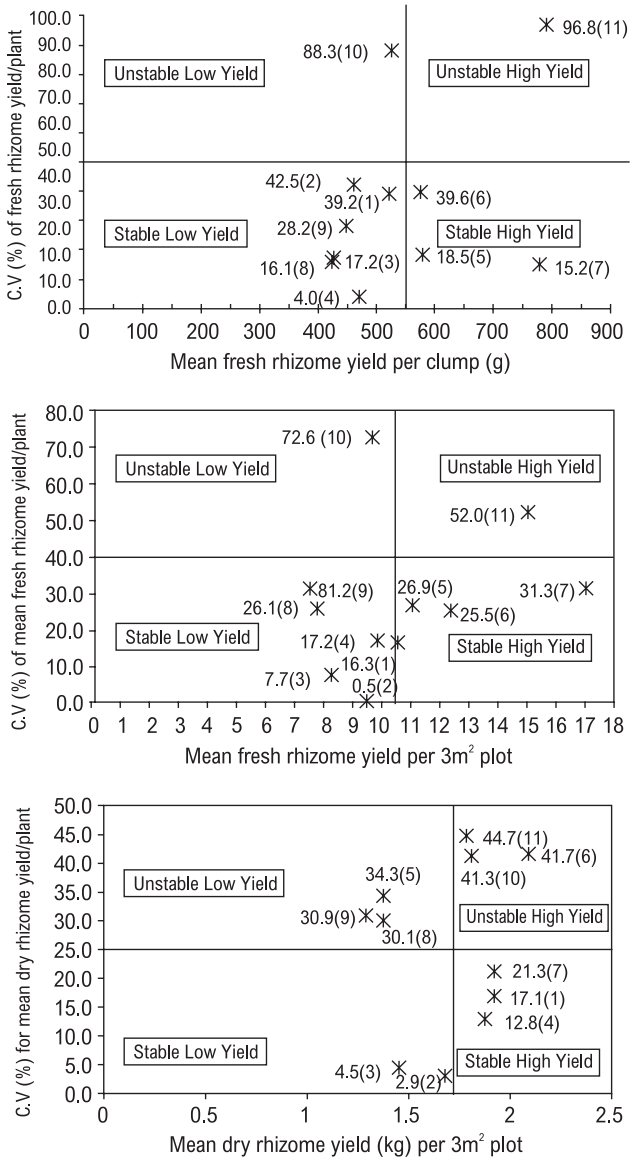

Fig 1 (1) Megha Turmeric, (2) IISR Alleppey Supreme, (3) IISR Kedaram, (4) IISR Prathibha, (5) BSR 2, (6) Suranjana, (7) Rajendra Sonia, (8) Roma, (9) Rasmi, (10) Duggriala Red and (11) Narendra Haldi 1

(data not shown). Varieties with shorter plants matured 30 days ahead of tall varieties. Mother rhizome of the varieties with short plants was smaller than tall varieties owing to their genetics. The varieties Rajendra Sonia, Megha Turmeric 1 and IISR Prathibha are stable and high yielders, whereas, Narendra Haldi 1, Suranjana and Duggriala Red are high yielders but unstable, BSR 2, Roma and Rasmi are low and unstable yielders at Kozhikode, Kerala.

SUMMARY

Field experiments to evaluate eleven true turmeric varieties, viz. BSR 2, Duggirala Red, IISR Alleppey Supreme, IISR Kedharam, IISR Prathibha, Megha Turmeric 1, Narendra Haldi 1, Rajendra Sonia, Rasmi, Roma and Suranjana for its growth and yield were conducted in rainfed for four years (2008-09 to 2011-12). Turmeric varieties such as Rajendra Sonia, Narendra Haldi 1 and Suranjana were relatively short plants had lesser tillers/plant, leaves/plant and total leaf area/plant than the other varieties which had tall plants with more tillers/plant, leaves/plant, total leaf area/plant. Varieties with short plants produced more fresh rhizome yield/plant. Dry recovery percentage was low in varieties with short plants except in Suranjana (16.7%). Dry rhizome yield for 3m^2 plot was varied between 1.29–2.09 kg with a maximum observed in Suranjana followed by Rajendra Sonia and Megha Turmeric 1. Genotype grouping method was employed to study yield stability. The varieties IISR Kedaram and IISR Alleppey Supreme are stable but low yielders, Rajendra Sonia, Megha Turmeric 1 and IISR Prathibha are stable and high yielders, whereas, Narendra Haldi 1, Suranjana and Duggriala Red are high yielders but they are unstable, BSR 2, Roma and Rasmi are low and unstable yielders at Kozhikode, Kerala.

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