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Association of growth and yield parameters with bioactive phytoconstituents in selection of promising turmeric genotypes

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ABSTRACT

Turmeric is an economically important plant for production of curcumin, oleoresin and essential oil. The correlation of yield parameters with phytoconstituent content (curcumin, oleoresin, and essential oil) of 10 selected turmeric genotypes was analyzed to find out a promising turmeric genotype. Leaf area exerted high positive significant correlation with yield and phytoconstituent content followed by tiller number. Among the selected genotypes, P40 and P44 recorded for highest leaf biomass of 450 ± 90.05 g and P32 recorded for highest rhizome biomass of 850 ± 95.05 g followed by P44 having 800 ± 95.05 g yield/plant. Leaf blotch disease was reported only in P36 and P37. Accession P36 yielded high curcumin content (8.8%), P44 yielded high oleoresin content (15%), high leaf oil content (1.9%) and high rhizome oil content (2%). In GC–MS analysis alpha-phellandrene content was highest (63.91%) in P40 and Ar-tumerone was highest (63.69%) in P44. Altogether, P36, P40, and P44 were found to be better in terms of agronomical, yield attributing traits and high bioactive phytoconstituents. This study provides insight on the relative influence of growth and yield parameters on the phytoconstituents. The identified promising genotypes could be useful as parental materials in cultivar and variety development for the various natural health product industries.

1. Introduction

Turmeric (*Curcuma longa* L.) is a commercially important medicinal plant and plays an important role in the Indian economy. India is the largest manufacturer of turmeric and its value added products which cost more than 50% of the world trade (Muthusamy, 2013). The rhizome of turmeric consists of curcumin, various curcuminoids, essential oil, and oleoresin which exhibit a wide range of activities, e.g., food colour in cheese, spices, cereal products, pickles potato flakes, soups, ice-creams, yoghourt, as hypolipidemic, hepatoprotective antibacterial, antifungal, anticancer, antioxidant, insect repellent, and anti snake venom agent (Prasad and Aggarwal, 2011). Turmeric oil is used in aromatherapy, perfume industry and in the preparation of mosquito repellents. The oleoresin in turmeric is used in flavouring industries as a replacement of powdered rhizome (Prasad and Aggarwal, 2011). India produces 11 lakh tonnes of turmeric per year which contributes 78% of the total production in world, while China contributed 8%, Myanmar 4%, Nigeria and Bangladesh together produces 6% of them globally. Also India is the largest exporter of value added products of turmeric and United Arab Emirates is the main importer of turmeric from India accounting for 18% of the total exports after United States of America (USA) with 8%. The other countries which imported turmeric from India are Bangladesh, Japan, Sri Lanka, United Kingdom, Malaysia, South Africa, The Netherlands, and Saudi Arabia which accounts for 75% of the world imports. United States of America imports 97% of turmeric and its value added products from India (Muthusamy, 2013; Angles et al., 2011). The export demand of turmeric is rising higher in the last few years on account of increased non-food as well as food use in some countries. Now the use of turmeric and its value added products are spreading globally so the production of turmeric has to be increased to meet up the national and international requirements. This can be achieved by increasing both the area of cultivation and the yield per unit area. Hence the essential priority is to develop varieties of turmeric with high contents of bioactive phytoconstituents, i.e., plants with higher content of curcumin/oleoresin/essential oil. These value added products of turmeric have major industrial applications including the production of drugs, cosmetics, flavouring agents, etc. Because of constantly increasing worldwide demand, there is a pressing need to increase productivity of turmeric yield as well as its phytoconstituents. Therefore, the production of rhizome and leaf biomass

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with high yielding variety and suitable agronomical suggestion is a promising job for both the farmers and industries. Although, a large number of different turmeric genotypes exist in different agroclimatic zones of India, a promising turmeric genotype with respect to high curcumin, oleoresin, and essential oil content as well as with higher biomass yield has to be identified for commercial cultivation. Molecular diversity study of turmeric genotypes from different agroclimatic zones already showed high polymorphism ranging from 42.5% to 67.5%, with an average of 76.8% through both RAPD and ISSR primers (Singh et al., 2012). So, selection of high yielding turmeric genotypes is needed to boost the production at farmers' level. The presence of wide variability in the existing cultivars and genotypes of turmeric in respect of yield components, yield, and quality was reported by several workers (Philip, 1983; Philip and Nair, 1986; Philip et al., 1982; Mohanty, 1979; Rama Rao et al., 1975; Pujari et al., 1986). However, limited information is available regarding the correlation between the yield parameters with high yield and phytoconstituent content of the turmeric genotypes that are being commonly used in health related applications, raising concern over the ability of the plant to produce desired results. Key bioactive phytoconstituents found in turmeric plant need to be quantified in order to ensure that the plants being used possess the bioactive compounds essential to produce the desired effects in consumers. Once plants with these attributes have been identified, they can be used for selection of suitable promising genotypes that can be further developed into cultivars and varieties specific for the natural health product processing industries. Therefore, the present study was undertaken to assess the correlation of growth and yield parameters with the content and productivity of different bioactive phytoconstituents of turmeric to identify the promising genotypes from different agroclimatic regions of India.

2. Materials and methods

2.1. The study region

The experiments were carried out in the field gene banks of Centre of Biotechnology of Siksha 'O' Anusandhan University Odisha (India) during 2009–2011. The state Odisha is one of the native places for turmeric cultivation. Many regions of this state consist of foothills to marshy lands, dry lands, urban and flood affected areas which are geographically different.

2.2. Selection of genotypes

Ten elite genotypes viz., P36, P37, P38, P39, P40, P44, P41, P28, P31, and P32 (Table 1) were selected based on initial screening (Singh et al., 2013) from 60 turmeric germplasm collected from different agroclimatic zones. Rhizomes of each genotype were planted in experimental field with same climatic conditions. For assessment of promising genotypes, growth and yield attributing parameters were recorded.

2.3. Growth and yield characteristics

The plants grown in the experimental field were studied in terms of growth and yield parameter like plant height (cm), number of tiller, area of leaf (cm^2), number of leaf, leaf biomass (g), rhizome length (cm), rhizome biomass/yield (g). These parameters were later correlated with the content of curcumin, oleoresin, and essential oil to identify the promising genotypes among them.

2.4. Disease occurrence

Disease infestation was recorded throughout the year for evaluation of less susceptible genotype among the selected one. The occurrence of leaf blotch disease was recorded in selected genotypes of turmeric. The percent disease index was calculated by the following method (Sarmah et al., 2011):

$$\text{PDI} = \frac{\text{Total number of infected leaves} \times \text{Grade value given}}{\text{Total number of leaves} \times \text{Maximum grade value}} \times 100$$

whereas stage 1 = no disease; stage 2 = 0–5% disease; stage 3 = 6–25% disease; stage 4 = 26–50%; stage 5 = 51–100% disease.

2.5. Phytochemical analysis

Phytochemical analysis of selected turmeric genotypes from different agroclimatic regions has been done by extracting curcumin, oleoresin, and essential oil from turmeric leaves and rhizomes. The quality evaluation of essential oil was carried out through GC–MS analysis.

2.5.1. Extraction and estimation of curcumin

For extraction of curcumin turmeric rhizomes were washed thoroughly with water and then cut into pieces and air dried. The properly dried rhizome was powdered in a mortar pestle and 0.1 g of crushed rhizome was taken in a flat bottom flask, mixed with 75 ml of acetone and refluxed for 4 h. The refluxed filtrate was cooled and washed with 100 ml of acetone on filter paper. Then 10 ml of the filtrate was diluted with 250 ml of acetone. The percentage of the curcumin was estimated spectrophotometrically by comparing the absorbance of the diluted sample with the reference curcumin (95% HPLC Purified, purchased from Charak International) at 420 nm according to the ASTA method (Method no. 1.09, 1997).

Table 1
Phytochemical analysis of 10 elite turmeric genotypes selected from different agroclimatic zones of India.

Genotype no (place of collection)	Agroclimatic zone	Climate	Curcumin (%)	Oleoresin (%)	Leaf oil (%)	Rhizome oil (%)
P36 (Potangii) cv. Surama	Eastern ghat highland	Hot and moist sub humid	8.8 ± 0.64	14 ± 1.33	0.5 ± 0.20	1 ± 0.26
P37 (Potangii) cv. Roma	Eastern ghat highland	Hot and moist sub humid	6.2 ± 0.28	12 ± 1.33	0.7 ± 0.09	0.9 ± 0.26
P38 (Potangii) cv. Ranga	Eastern ghat highland	Hot and moist sub humid	5.8 ± 0.55	10 ± 0.95	0.58 ± 0.20	1 ± 0.26
P39 (Potangii) cv. Rasmi	Eastern ghat highland	Hot and moist sub humid	5.2 ± 0.51	13 ± 1.33	0.65 ± 0.20	1 ± 0.26
P40 (Potangii) cv. Lakadong	Eastern ghat highland	Hot and moist sub humid	8.2 ± 0.64	15 ± 1.33	0.5 ± 0.20	1.2 ± 0.26
(P44) acc. Malkangiri	South eastern ghat	Hot and moist sub humid	8.2 ± 0.64	15 ± 1.33	1.9 ± 0.26	2 ± 0.26
(P41) acc. Nabarangpur	Eastern ghat highland	Hot and moist sub humid	6.2 ± 0.28	12 ± 1.33	1 ± 0.26	1.4 ± 0.26
(P28) acc. Draingabadi	North eastern ghat	Warm and humid	7.2 ± 0.64	9.5 ± 0.953	0.7 ± 0.09	1 ± 0.57
(P31) acc. Phulabani	North eastern ghat	Warm and humid	7 ± 0.64	11 ± 0.953	0.7 ± 0.09	1.2 ± 0.26
(P32) acc. Koraput	North eastern ghat	Warm and humid	6.3 ± 0.28	14 ± 1.33	0.7 ± 0.09	2.5 ± 0.577
Mean			6.91	12.55	0.79	1.32
SD			1.17	1.97	0.41	0.52

Desired character chosen for elite status: (for curcumin > 5%, oleoresin > 9%, leaf oil > 0.5% on fresh weight basis, rhizome oil > 0.8% on fresh weight basis) (Singh et al., 2013).