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Analysis of spatial variability of turmeric (*Curcuma longa* L. syn. *C. domestica* Val.) yield in India

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Abstract

This paper examines the yield variability of turmeric in India. The data on maximum, minimum and mean fresh rhizome yield of 200 experiments from secondary sources of published research papers/reports were collected. These data were utilized with an objective to calculate summary statistics and to identify maximum and minimum yields and yield differences obtained in each state. The summary statistics indicated that in India maximum yield ranged between 4.59 and 95.0 t ha^{-1} with a mean of 28.48 ± 14.29 t ha^{-1}. The minimum yield ranged between 1.34 and 56.25 t ha^{-1} with a mean of 13.73 ± 18.60 t ha^{-1} and the mean yield ranged from 3.09 to 72.68 t ha^{-1} with a mean of 22.99 ±11.60 t ha^{-1}. The maximum yield obtained in all the cases was due to adoption of improved production techniques such as variety, manure and better crop management practices compared to minimum yield of control treatment. The yield differences between maximum and minimum ranged from 6.69 to 93.50 t ha^{-1}.

Key words: crop production, crop yield, *Curcuma longa*, spatial variation, turmeric.

Agriculture is a spatial and temporal activity. However, there is a growing interest in placing site-specific information in a spatial and temporal perspective. The analysis of yield variability is an important issue in agricultural research. Geographical Information System (GIS) and Global Positioning System (GPS) are used for Site Specific Management (SSM), Precision Agriculture (PA) and yield monitoring and mapping in many countries. Such a system uses data from multiple sources. India has to go a long way to use such advanced system for crop production. Instead, compilation and analysis of results generated in different centers located in different agro-ecoregions of India will give useful information regarding production potential of crops or attainable yield or information for site-specific management. In India, we have the well developed agricultural research network, but information generated from different research centers is not properly compiled and analyzed to draw meaningful conclusions.

Turmeric is one of the important spices grown and used in India since time immemorial. It is cultivated in 1.61 lakh ha in more than 200 districts spread over 20 states with a production of 6.54 lakh tones and a productivity of 4052 kg ha^{-1}. The export during 1999-2000 was to the tune of Rs. 9106 lakh (34500 tones). Kumar & Sankaran (1998) noted the instability of turmeric yield and production in India.

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They suggested that developing appropriate production techniques suitable to different agro-climatic zones would stabilize the yield and production. The information generated on this crop, particularly on production aspects from different research centers, are available in large numbers. In this paper we have attempted to compile and analyse the turmeric yield reported from different research centers with an objective to calculate summary statistics and to study the yield variability among different states of India.

The secondary data on fresh rhizome yield of turmeric (t ha^{-1}) were collected from 200 research papers, published in different journals and annual reports (all are not listed in the reference list). The data were collected with maximum care and caution and we have covered important journals where turmeric research results are usually being published. The annual reports of the institutes involved in turmeric research were also surveyed. Wherever the yields were not given on hectare basis (eg. yield per plant or per plot), they were converted to hectare. While converting, 25% of the land area was not accounted as it might have been used for forming channel, bunds etc. When the yield was given in dried product (14% moisture content), it was converted to fresh yield by assuming 80% moisture at raw. In some cases yield data were based on one year trial. The yield data were collected from research centers located in Andhra Pradesh (Anantharajupet, Chintapalli, Jagtial, Maruteru, Pedapalam, Rastakuntabai, Rudrur and Tirupati); Assam (Dipbu); Bihar (Dholi and Pusa); Gujarat (Navasari); Himachal Pradesh (Dhaulakuan and Solan); Karnataka (Bangalore, Dharwad, Mudigere and Sirsi); Kerala (Ambalavayal, Kannara, Kasargod, Peruvannamuzhi, Pilicode, Trichur and Vellanikara); Madhya Pradesh (Jagdalpur, Raigarh and Sehore); Maharashtra (Dapoli, Parbhani, Pune, Rahuri and Sangli); Meghalaya (Shillong); Mizoram (Kolasib); Nagaland (Medziphema); Orissa (Pottangi and Udayagiri); Punjab (Ludhiana); Tamil Nadu (Coimbatore and Bhavanisagar); Tripura (Lembucherra); Uttar Pradesh (Almora, Nainital and Pithoragarh) and West Bengal (Kalyani). These data were used to derive summary statistics (mean, median, mode, range and SD) by using Microsoft Excel computer package. The maximum and minimum yields and yield differences in each state were identified.

The summary statistics is presented in Table 1. The maximum yield ranged from 4.59 to 95.0 t ha^{-1} with a mean of 28.48 ± 14.29. The minimum yield ranged between 1.34 and 56.25 t ha^{-1} with a mean of 13.73 ± 18.60 and the mean yield ranged from 3.09 to 72.68 t ha^{-1} with a mean of 22.99 ± 11.60. The crop is distributed and adapted across the fields according to its ecological niche. Turmeric prefers a warm and humid climate. It needs a well distributed annual rainfall of 2500-4000 mm for successful production as a rainfed crop. It can also be grown under irrigation in areas where the rainfall ranges from 1200 to 1500 mm during the growing period. The crop grows up to an altitude of 1200 m MSL. It needs an optimum temperature of 20 – 30°C for normal growth and satisfactory production. Turmeric can be grown on soils ranging from light loam to heavy loam. A well drained, friable, sandy loam soil, rich in organic matter is preferred. Light red, brown or ash colourd sandy loam is also suitable for turmeric. Alkaline soils are not suited for its cultivation. The yield of the crop in a particular field/ location is a result of an integrated effect of genotype, soil, climate and management. It is very difficult to quantify the ultimate yield potential of crop under field conditions.

The maximum and minimum yields recorded in different states are presented in Table 2. The maximum yield of 95 t ha^{-1} (38 kg per 3 m^2 bed) was recorded at Muvattupuzha, Ernakulam District, Kerala during 1992-93 with Acc. No. 364 (Sasikumar *et al.* 1996). This region is one of the well known source for the world famous Alleppey turmeric. The maximum yield of 37.1 t ha^{-1} was observed with a short duration accession JTS 610 at Jagtial, Andhra Pradesh (AICRPS 2000). In Tamil Nadu, the higher yield was noted in Acc. No. 364 (68.75 t ha^{-1})

Table 1. Summary statistics of turmeric fresh rhizome yield in India

Statistics	Maximum yield (t ha^{-1})	Minimum yield (t ha^{-1})	Mean yield (t ha^{-1})
Maximum	95.00	56.25	72.68
Minimum	04.59	01.34	3.09
Mean	28.48	13.73	22.99
Median	28.72	15.25	22.16
Mode	25.20	14.60	05.65
Standard deviation	14.29	18.60	11.60

(27.5 kg per 3 m^2 bed) (Sasikumar *et al.* 1996). In Himachal Pradesh, line ST–55 yielded maximum (22.19 t ha^{-1}) (Rana & Rattan 1994). The higher yield of 15.8 t ha^{-1} was harvested from cultivar Kuchipudi at Tripura (Sasikumar & Saradana 1989). The accession RH 5 out yielded in the comparative yield trial in Bihar (43.29 t ha^{-1}) and Madhya Pradesh (30.35 t ha^{-1}). In Gujarat cultivar 'Kesar' recorded higher yield (10.86 t ha^{-1}) (Mehta & Patel 1982). Using whole mother rhizome as a planting material, higher yield of 49.16 t ha^{-1} was observed in Maharashtra (Patil & Borse 1980). Planting turmeric at 30 cm x 30 cm spacing (closer spacing) gave maximum yield (39.33 tha^{-1}) at Kalyani, West Bengal (Kundu & Chatterjee 1982). Fertilizer application of 180:90:220 kg ha^{-1} NPK for Co-1 turmeric at Mudigere, Karnataka resulted in higher yield (Sheshagiri & Uthaiah 1994). Similarly in North Eastern states too higher yields were obtained with increased levels of N ranging from 60-160 kg ha^{-1} (Govind *et al.* 1990; Pandey 1992; Singh *et al.* 1992; Borah & Longthesa 1994). In Orissa, application of 60 kg N ha^{-1} + *Azatobactor* + *Azospirillum* gave maximum yield (Jena *et al.* 1999). At Ludhiana, Punjab, application of 60 t FYM ha^{-1} produced higher yield (Gill *et al.* 1999). The maximum yield was obtained at Nainital, Uttar Pradesh with 100 kg N ha^{-1} (Singh & Singh 1988). It could be seen from the results, that the maximum yields were recorded with improved technologies such as improved cultivars, appropriate manure appli-

Table 2. Maximum and minimum fresh rhizome yield (t ha^{-1}) of turmeric and yield difference among different states of India

No. State	Max. yield (t ha^{-1})	Reference	Min. yield (t ha^{-1})	Reference	Yield difference (t ha^{-1})
1. Andhra Pradesh	37.10	AICRPS (2000)	3.59	Rao & Swamy (1984)	33.51
2. Assam	20.53	Borah & Langthesa (1994)	11.06	Borah & Langthesa (1994)	9.47
3. Bihar	43.29	AICRPS (2000)	11.82	AICRPS (2000)	31.46
4. Gujarat	10.86	Mehta & Patel (1982)	4.17	Mehta & Patel (1982)	6.69
5. Himachal Pradesh	29.22	Rana & Rattan (1994)	1.78	Jaswal *et al.* (1993)	27.44
6. Karnataka	39.70	Sheshagiri & Uthaiah (1994)	6.78	Shashidhar *et al.* (1997)	32.91
7. Kerala	95.00	Sasikumar *et al.* (1996)	1.50	Pushkaran *et al.* (1985)	93.50
8. Madhya Pradesh	30.35	AICRPS (2000)	6.50	Gupta & Sengar (1998)	23.85
9. Maharashtra	49.16	Patil & Borse (1980)	9.39	Chaugle & Mohite (1962)	39.76
10. Megalaya	22.80	Govind *et al.* (1990)	9.60	Govind *et al.* (1990)	13.20
11. Mizoram	33.00	Pandey (1992)	4.67	Saha (1988)	28.33
12. Nagaland	45.13	Singh *et al.* (1992)	11.15	Singh & Kar (1991)	33.98
13. Orissa	35.09	Jena *et al.* (1999)	2.48	Mishra *et al.* (1997)	32.61
14. Punjab	36.54	Gill *et al.* (1999)	3.45	Randhawa *et al.* (1984)	33.09
15. Tamil Nadu	68.75	Sasikumar *et al.* (1996)	4.57	Subramanian *et al.* (1978)	64.18
16. Tiripura	24.80	Sasikumar & Sardana (1989)	6.88	Sasikumar & Sardana (1989)	17.93
17. Uttar Pradesh	11.63	Singh & Singh (1988)	4.37	Singh *et al.* (1988)	7.25
18. West Bengal	39.33	Kundu & Chatterjee (1982)	8.52	Pal *et al.* (1993)	30.80

cation and better crop management practices. The minimum yields in all the states were recorded under control treatment. The control treatment is probably the farmer's practices or existing technologies of respective locations. The yield under control was considered as the actual yield obtained by farmers. The yield realized with improved production techniques is attainable yield for that location. There is a gap between actual and attainable yield at different locations. In many states maximum and minimum yields were recorded at different periods and difference between them may not reflect the exact yield gap. However, the yield difference ranged from 6.69 to 93.50 t ha^{-1}. The analysis indicated great variations in turmeric yield among different states. More efforts are required to spread and popularize the improved cultivars and production technologies among farmers of different states to stabilize turmeric yield and production in India.

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