Indian Journal of Agricultural Sciences **86** (9): 1189–92, September 2016/Article

Performance of turmeric (*Curcuma longa*) genotypes for yield and root-knot nematode resistance

D PRASATH[1], S J EAPEN[2] and B SASIKUMAR[3]

ICAR–Indian Institute of Spices Research, Marikunnu PO, Kozhikode, Kerala 673 012

Received: 3 October 2015; Accepted: 21 April 2016

ABSTRACT

Two hundred and fifty three turmeric (*Curcuma longa* L.) accessions were screened against root-knot nematode (*Meloidogyne incognita*) and identified seven nematode resistant accessions (Accs. 35, 48, 79, 130, 142, 146 and 200). These genotypes along with a susceptible accession (Acc. 376) and a released variety, IISR Prathibha were evaluated during 2008-2012 to assess the yield performance under Kerala conditions. The results indicated that in terms of yield, one resistant accession (Acc. 79) and moderately resistant accession (Acc. 48), performed significantly higher compared to the released variety IISR Prathibha. The pooled yield over three consecutive years varied from 10.56 kg/3m^2 (Acc. 130) to 14.52 kg/3m^2 (Acc. 48). Among the genotypes, Acc. 48 and Acc. 79 performed consistently with higher yield in all the three years. Maximum yield over three years pooled data was recorded in Acc. 48 (31.94 tonnes/ha) followed by Acc. 79 (31.79 tonnes/ha) over three years pooled data. The stability parameters of Acc. 48 and Acc. 79 showed good stability for yield and it indicates general adaptability of these two genotypes over years.

Key words: *Curcuma longa*, Genotypes, *Meloidogyne incognita*, Resistance, Root-knot nematode, Turmeric, Yield

Yield losses due to nematode infestation are reported in turmeric (*Curcuma longa* L.)-growing areas (Udo and Ugwuoke 2010). Root-knot nematode [*Meloidogyne incognita* (Kofoid and White 1919) Chitwood 1949] is the most predominant nematode, causing considerable crop loss in the states of Kerala, Tamil Nadu, and Andhra Pradesh (Eapen *et al.* 1999). Turmeric plants infected with *M. incognita* are reported to have large root galls, stunted growth, yellowing, marginal and tip drying of leaves and reduced tillering with galling and rotting of roots (Ray *et al.* 1995, Koshy *et al.* 2005). Mani *et al.* (1987) observed that infested rhizomes tended to loss their bright yellow colour. Levels of protein, carbohydrate, chlorophyll a and b and curcumin were lower in plants infested with *M. incognita* (Poornima and Sivagami 1998). One hundred juveniles of *M. incognita* caused significant reduction in growth characters of turmeric (Haidar *et al.* 1998). Similarly, Poornima and Sivagami (1998) reported that an initial inoculum level of more than 5 000 *M. incognita* larvae/plant was highly pathogenic to turmeric.

Rich genetic diversity present in the cultivators' fields on account of wild sources and their recombinations and segregants can result in distinct genotypes possessing high yield and resistance to biotic stress. Existence of wide variability among the turmeric cultivars with respect to growth parameters, yield attributes and resistance to biotic and abiotic stresses reported by various workers (Jalgaonkar and Jamdagni 1989, Yadav and Singh 1989, Indiresh *et al.* 1992, Chandra *et al.* 1997, Kumar and Jain 1996, Lynrah and Chakraborty 2000, Mohanty 1979, Nirmal Babu *et al.* 1993, Pathania *et al.* 1988, Sharma 2005, Velayudhan *et al.* 1999, Sasikumar 2005). Due to pesticide residue problem and developing resistance to nematicides, resistant breeding considered as safe and effective strategy to evolve resistant varieties in many crops (Hussey and Janssen 2002). A few cultivars and breeding lines of turmeric have been reported to be resistant to *M. incognita* in some earlier screening studies (Gunasekharan *et al.* 1987, Mani *et al.* 1987, Eapen *et al.* 1999). The present paper reports the preliminary screening for nematode resistance and yield evaluation of turmeric genotypes.

MATERIALS AND METHODS

Seed rhizomes (25 g) of 253 turmeric germplasm accessions were planted in polythene bags (15 cm × 30 cm) containing sterilized potting mixture (2:1:1 of soil: sand: farm yard manure). One month after germination, they were inoculated with root knot nematodes @ 1 000 J2/plant. After two months, the plants were uprooted, roots were carefully washed free of soil and stained in Phloxine B (Holbrook *et al.* 1983). The egg masses were counted using a 0-5 scale. Accessions with an egg mass index (EMI) of less than two or equal were short-listed for subsequent

[1]e mail: prasath@spices.res.in

Table 1 Screening of turmeric germplasm accessions to root knot nematode, *Meloidogyne incognita* (mean of five replications)

No. of accessions screened	Egg mass index (EMI)	Promising accession
253	≤ 2	Accs. 03, 21, 31, 35, 43, 48, 62, 64, 67, 72, 78, 79, 82, 84, 130, 142, 146, 150, 165, 178, 182, 193, 198, 199, 200, 203, 210, 223, 224, 228, 235, 237, 239, 243, 245, 246, 250, 252, 253, 255, 260, 262, 263

testing. In the second round, the final nematode population was also estimated by staining in acid fuchsin – acetic acid solution followed by maceration in a blender (Byrd *et al.* 1983). Finally host status of each accession was rated based on nematode reproduction and EMI (Sasser *et al.* 1984).

The experiment was conducted during 2008-12 at ICAR-Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala. The experimental materials consisted of seven short listed nematode resistant germplasm accessions (Eapen *et al.* 1999), a susceptible germplasm accession (Acc. 376) and a released variety IISR Prathibha, as a check. The trials were laid out in randomized block design (RBD) with three replications. The net plot size was 3 m × 1 m and rhizomes were planted in second week of June each year with a spacing of 25 cm × 30 cm. Recommended package of practices were followed and observations were recorded on various yield and yield contributing characters. The data were subjected to statistical analysis (Panse and Sukhatme 1978).

Table 2 Reaction of short-listed accessions on inoculation with root knot nematodes, *Meloidogyne incognita*

Entry	Gall index (GI)	Egg mass index (EMI)	Reproduction factor (R)	Host reaction
Acc. 35	2.0	0.2	0.67	Resistant
Acc. 48	2.7	3.0	1.07	Moderately Resistant
Acc. 79	2.0	2.0	0.03	Resistant
Acc. 130	2.0	1.8	0.24	Resistant
Acc. 142	3.0	2.0	0.00	Resistant
Acc. 146	1.0	1.2	0.56	Resistant
Acc. 200	1.3	0	0.12	Resistant
Acc. 376	3.3	4.3	2.07	Susceptible
IISR Prathibha	3.0	2.8	2.12	Susceptible

RESULTS AND DISCUSSION

Of the 253 turmeric accessions screened against root knot nematode, the EMI (egg mass index) varied from 0 to 5.0 and the accessions with ≤2.0 EMI and <1.0 reproduction factor (R) were shortlisted for further evaluation. Among 253 germplasm accessions, 43 accessions were found resistant to *M. incognita* in the preliminary evaluations (Table 1). These lines were clonally multiplied during 2007-08 (data not shown) and shortlisted seven promising lines (Table 2) which yielded above 10 kg/3m^2. The shortlisted 7 promising lines along with Acc. 376 (a susceptible line) and IISR Prathibha (check) were evaluated for yield during 2008–12.

The data on plant height showed significant variation among different cultivars (Table 3). Maximum plant height (164.75 cm) was recorded in IISR Prathibha which was at par with Acc. 35 (149.50 cm). The variation in plant height is probably due to genetic variation among the cultivars. Number of tillers/plant varied significantly and was highest in Acc. 142 (5.75). Moderate number of tillers is a desirable character in turmeric as it can produce more number of leaves. Acc. 142 recorded significantly more number of leaves/plant (28.50). The genotypes showed significant variation with respect to leaf length and the longest leaf

Table 3 Evaluation of turmeric accessions for morphological characters

Entries	Plant height (cm)	No of tillers	No.of leaves	Leaf length (cm)	Leaf breadth (cm)	Fresh yield 2010-11 (kg/3 m^2)	2011-12 (kg/3 m^2)	2012-13 (kg/3 m^2)	Mean (kg/3 m^2)	Projected yield (kg/ha)
Acc. 35	149.50	3.75	15.50	64.75	17.15	12.00	9.92	15.25	12.39	27.26
Acc. 48	94.75	2.50	13.75	45.75	15.00	14.00	13.44	16.13	14.52	31.94
Acc. 79	92.50	2.00	11.50	46.75	13.00	14.00	13.34	16.00	14.45	31.79
Acc. 130	133.50	1.00	9.00	56.50	19.00	9.75	9.05	12.88	10.56	23.23
Acc. 142	116.63	5.75	28.50	54.00	16.75	9.75	11.42	14.56	11.91	26.20
Acc. 146	122.75	2.00	11.75	59.00	14.00	10.25	12.32	14.88	12.48	27.46
Acc. 200	119.00	2.50	13.50	55.63	20.15	10.50	9.67	10.38	10.81	23.78
Acc. 376	142.50	2.25	11.00	68.25	14.25	10.25	10.42	12.75	11.14	24.51
Prathibha	164.75	2.25	14.25	76.00	18.25	15.23	10.62	12.25	12.70	27.94
Mean	126.21	2.67	14.31	58.69	16.39	11.75	11.13	13.90	12.26	
CD (P=0.05)	21.01	1.25	4.81	10.34	3.67	1.82	1.69	2.53	1.12	
CV (%)	11.41	22.17	23.04	12.07	15.35	10.62	8.80	12.48	10.57	

Table 4 Analysis of variance for yield of nine turmeric cultivars

Source of variation	df	Mean square	
		Fresh yield ($kg/3m^2$)	% of total SS
Cultivars (G)	8	7.03**	12.50
Environment (E)	2	18.96**	50.01
G x E interaction	16	1.91**	6.24
Environment +(G × E)	18	3.81**	
Environment (linear)	1	37.91**	
(G × E) linear	8	1.38**	
Pooled deviation	9	2.17**	
Pooled error	81	0.43	

Table 5 Stability analysis of nine turmeric genotypes for fresh yield

Cultivar	Yield ($kg/3m^2$)		
	Mean	b	Sd^2
Acc. 35	12.39	1.820	0.339
Acc. 48	14.52	0.977	0.015
Acc. 79	14.45	0.955	0.026
Acc. 130	10.56	1.402	0.058
Acc. 142	11.91	1.425	0.897
Acc. 146	12.48	1.245	0.999
Acc. 200	10.81	0.174	0.256
Acc. 376	11.14	0.927	0.260
Prathibha	12.70	0.975	0.607
Mean	12.26		

(76.00 cm) was recorded in IISR Prathibha which was statistically at par with Acc. 376 (68.25 cm). Significant variation in leaf breadth was observed among the genotypes. The widest leaf (20.15 cm) was recorded in Acc. 200 which was on par with Acc. 130 (19.00 cm), IISR Prathibha (18.25 cm), Acc. 35 (17.15 cm) and Acc. 142 (16.75 cm). Nirmal Babu *et al.* (1993) reported high variability for all the traits in 108 germplasm collections of turmeric.

The yield level was recorded over three consecutive years and analysis of variance showed that the nine genotypes differed significantly for yield (per 3 m^2) in all the three years (Table 3). The pooled mean yield over three years varied from 10.56 $kg/3m^2$ (Acc. 130) to 14.52 $kg/3m^2$ (Acc. 48). Singh *et al.* (2003) reported wide variability for rhizome yield while studying variability among 65 exotic and indigenous genotypes of turmeric. The yield of Acc. 48 and Acc. 79 were significantly higher compared to other genotypes and check, IISR Prathibha.

The results of combined analysis of variance for yield are presented in Table 4. There were significant differences among cultivars, environments, and for cultivar by environment interactions. Significant G × E effects indicated that cultivar responded differently to changes in environments. The stability parameters for yield are shown in Table 5. Acc. 48 and Acc. 79 showed good stability for yield and it indicates general adaptability of these two genotypes over years. Similar results were reported by Shah *et al.* (1994), Sharma (2005) and Anandaraj *et al.* (2014). Considering our results on yield and nematode resistance, two promising turmeric accessions (Acc. 48 – high yield and moderately resistant to nematodes; Acc. 79 – high yield and resistant to nematodes) were identified from this study. These two cultivars could be a good genetic source for yield and nematode resistance and need to be evaluated under different agro-climatic conditions.

REFERENCES

Anandaraj M, Prasath D, Kandiannan K, John Zachariah T, Srinivasan V, Jha A K, Singh B K, Singh A K, Pandey V P, Singh S P, Shoba N, Jana C, Ravindra Kumar K and Uma Maheswari K. 2014. Genotype by environment interaction effects on yield and curcumin in turmeric (*Curcuma longa* L.). *Ind Crop Prod* **53**: 358–64.

Byrd D W Jr, Kirkpatrick T and Barker K R. 1983. An improved technique for clearing and staining plant tissue for detection of nematodes. *Journal of Nematology* **14**: 142–3.

Chandra R, Desai, A R, Govind S and Gupta P N. 1997. Metroglyph analysis in turmeric (*Curcuma longa* L.) germplasm in India. *Scientia Hort* **70**: 211–22.

Eapen S J. 2006. Screening of spice Ggermplasm for reaction to nematodes - final report. ICA-Indian Institute of Spices Research, Kozhikode, Kerala, 69 p.

Eapen S J, Ramana K V, Sasikumar B and Johnson K G. 1999. Screening ginger and turmeric germplasm for resistance against root-knot nematodes. (*In*): Proceedings of National Symposium on 'Rational Aapproaches in Nematode Management for Sustainable Agriculture', 23-25 Novermber, Nematological Society of India, New Delhi, pp 142–4.

Gunasekharan, C R, Vadivelu S and Jayaraj S. 1987. Experiments on nematodes of turmeric: A review. (*In*): Proceedings of 3rd Group discussions on 'Nematological Problems of Plantation Crops, 29-30 October, Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, pp 45–6.

Haidar M G, Jha R N and Nath R P. 1998. Studies on the nematodes of spices. Pathogenicity effect of root knot (*Meloidogyne incognita*) and reinform nematodes (*Rotylenchulus reinforms*) alone and in combination on turmeric (*Curcuma longa* L.). *Indian Journal of Nematology* **28**: 52–5.

Holbrook C C, Knauft D A and Dickson D W. 1983. A technique for screening peanut for resistance to *Meloidogyne arenaria. Plant Disease* **57**: 957–8.

Hussey R S and Janssen G J W. 2002. Root-knot nematodes. (*In*): Plant Resistance to Parasitic Nematodes, pp 43–70. Starr J L, Cook R and Bridge J (Eds). CABI, Oxford, UK.

Indiresh K M, Uthaiah B C, Reddy M J and Rao K B. 1992. Genetic variability and heritability studies in turmeric. *Indian Cocoa, Arevanut and Spices Journal* **16**: 52–54.

Jalgaonkar R and Jamdagni B M. 1989. Evaluation of turmeric genotypes for yield and yield determining characters. *Annals of Plant Physiology* **3**: 222–8.

Koshy P K, Eapen S J and Pandey R. 2005. Nematode parasites of spices, condiments and medicinal plants. (*In*) Plant parasitic nematodes in sub-tropical and tropical agriculture, 2nd Edn, pp 751–91. Luc M, Sikora RA and Bridge J (Eds). CABI Publishing, USA.

Kumar R and Jain B P. 1996 Growth and rhizome characters of some turmeric (*Curcuma longa* L.) cultivars. *Journal of Research Birsa Agricultural University* **8**: 131–3.

Lynrah P G and Chakraborty B K. 2000. Performance of some turmeric and its close relatives/ genotypes. *Journal of Agricultural Science Society of North East India* **13**: 32–7.

Mani A, Naidu P H and Madhavachari S. 1987. Occurrence and control of *Meloidogyne incognita* on turmeric in Andhra Pradesh, India. *Inter Nematol Network Newslett* **2**: 11–12.

Mohanty D C. 1979. Genetic variability and inter relationship among rhizome yield and yield components in turmeric. *Andhra Agri J.* **26**: 77–80.

National Horticulture Board. 2016. Area production statistics, Final area and production estimates for horticulture crops for 2014-2015, http://www.nhb.gov.in.

Nirmal Babu K, Sasikumar B, Ratnambal M J, George J K and Ravindran P N. 1993. Genetic variability in turmeric (*Curcuma longa* L.). *Indian J Genet Plant Breed* **53**: 91–93.

Panse V G and Sukhatme P V. 1978. Statistical methods for agricultural workers.3 rd edn., ICAR, New Delhi, p 347.

Pathania N K, Arya P S and Singh M. 1988. Variability studies in turmeric (*Curcuma longa* L.). *Indian J Agri Res* **22**: 176–8.

Poornima K and Sivagami V. 1998. Pathogenicity of *Meloidogyne incognita* of turmeric (*Curcuma longa* L.). (*In*) Proc. 3rd Int. Symp. 'Afro-Asia Society of Nematologists' (TISAASN), April 16-19, Sugarcane Breeding Institute (ICAR), Coimbatore, India, UK., pp 29–31.

Ray S, Mohanty K C, Mohapatra S N, Patrick P R and Ray P. 1995. Yield losses in ginger (*Zingiber officinale* Rosc) and turmeric (*Curcuma longa* L.) due to root-knot nematode (*Meloidogyne incognita*). *J Spices Arom Crops* **4**: 67–69.

Sasikumar B and Jayarajan K. 2004. Phenotypic stability for fresh rhizome yield in turmeric. *J Spices Arom Med Plants Sci* **26**: 277–278.

Sasikumar B. 2005. Genetic resources of *Curcuma*: diversity, characterization and utilization. *Plant Genetic Resources: Characterization and Utilization* **3**: 230–251.

Sasser J N, Carter C C and Hartman K M. 1984. Standardization of host suitability studies and reporting of resistance to root-knot nematodes. Raleigh, North Carolina, USA, p 7.

Shahi R P, Yadava H S and Sahi B G. 1994. Stability analysis for rhizome yield and its determining characters in turmeric. *Crop Res* **7**: 72–78.

Sharma V K. 2005. Stability analysis for yield and quality characters in turmeric (*Curcuma longa* L.). M.Sc. thesis. Narendra Deva University of Agriculture and Technology, Faizabad.

Singh Y, Mittal P and Katoch V. 2003. Genetic variability and heritability in turmeric (*Curcuma longa* L.) *Himachal J Agri Res* **29**: 31–34.

Udo I A and Ugwuoke K I. 2010. Pathogenicity of *Meloidogyne incognita* Race 1 on turmeric (*Curcuma longa* L.) as iInfluenced by inoculum density and poultry manure amendment. *Plant Pathol J* **9**: 162–168.

Velayudhan K C, Muralidharan V K, Amalraj V A, Gautam P L, Mandal S and Dinesh Kumar. 1999. *Curcuma* genetic resources. Scientific monograph No. 4. National Bureau of Plant Genetic Resources, New Delhi. p 149.

Yadav D S and Singh S P. 1989. Phenotypic stability and genotype x environment interaction in turmeric (*Curcuma longa* L.). *Indian J Hill Farm* **2**: 35–37.