The Bioscan 11(1): 459-462, 2016 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF PLANTING DATES AND VA-MYCORRHIZA ON THE PERFORMANCE OF TURMERIC (*CURCUMA LONGA* L.) CV. SALEM

UTTAM TRIPURA*, N. K. HEGDE AND CHAYA P. PATIL
Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Tq. Gokak, University of Horticultural Sciences, Bagalkot, Arabhavi - 591 310, Karnataka, INDIA
e-mail: uttam_uhs@yahoo.in

KEYWORDS
Planting dates
VA-Mycorrhiza
Rhizome yield
Curing percentage
Turmeric

Received on :
14.09.2015

Accepted on :
11.02.2016

***Corresponding author**

ABSTRACT
A field investigation was carried out to find out the suitable planting dates and with or without inoculation of VA-Mycorrhiza. Planting dates (fortnight intervals) starting from 2nd fortnight of April influenced the growth and yield of turmeric with or without inoculation of VA-Mycorrhiza. Various growth parameters (plant height, number of tillers per clump, number of leaves per clump and leaf area) of mean data were significantly varied at 180 days after planting in turmeric with or without inoculation of VA-Mycorrhiza. Highest plant height, number of tillers per clump, number of leaves per clump and leaf area were recorded by crop planted 2nd fortnight of May (102.79 cm, 9.20, 88.97, and 63.56 dm^2 respectively) followed by 1st fortnight of May (96.04 cm, 8.37, 83.70, and 60.16 dm^2 respectively). Fresh rhizome yield per hectare was also significantly higher by the crop planted in 2nd fortnight of May (47.32 t ha^{-1}) followed by 1st fortnight of May (38.03 t ha^{-1}). Similarly, the curing percentage and estimated cured yield were significantly higher by 2nd fortnight of May (34.00 % and 16.12 t ha^{-1}, respectively) compared to the lowest in 1st fortnight of July (20.68 % and 0.98 t/ha respectively). Hence, planting of turmeric during 2nd fortnight of May with inoculation of VA-mycorrhiza is ideal under northern dry zone of Karnataka.

INTRODUCTION

Turmeric (*Curcuma longa* L.), a herbaceous rhizomatous crop, belonging to zingiberaceae family is one of the most valuable spices all over the world. It is used as spice and condiment, dye stuff and in cosmetic and drug industry. India is the world's largest producer and exporter of turmeric and it produces nearly 50 per cent of global turmeric production. It is grown in an area of 2.33 lakh hectares with an average production of 11.90 lakh MT (Anon., 2015). The date of planting has a great impact on growth of turmeric. Early planting on 25th April and harvesting date of 5th March gave the highest yield, gross return and net return compared to May 10th and May 25th planting (Manhas *et al.,* 2010). Planting rhizome in the second week of March showed highest plant height, maximum number of tillers, maximum number of leaves and highest rhizome yield (Sengupta and Dasgupta, 2010).

Mycorrhizal fungi occur in most of the soils and colonize roots of many plant species. They are the structures resulting from the symbiosis between Mycorrhizal fungi and plant roots, and are directly involved in plant mineral nutrition. The symbiotic root-fungal association increases the uptake of less mobile nutrients (Ortas *et al.*, 2001), essentially phosphorus (P) but also of micronutrients like zinc (Zn) and copper (Cu), the symbiosis has also been reported as influencing water uptake. Mycorrhizal fungi can also benefit plants by stimulating the production of growth regulating substances, increasing photosynthesis, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006). These benefits are mainly attributed to improved phosphorous nutrition (Plenchette *et al.,* 2005). The fresh weight, biomass, chlorophyll, lipid, protein, carbohydrate and nucleic acid contents were significantly increased with application of VAM compared to all other treatments in sweet flag (Vijaya *et al.,*2008). Combined inoculation of *Glomus mosseae, G. fasciculatum* and azotobactor or with *G. mosseae* and *G. fasciculatum* or with *G. mosseae* or *G. fasciculatum* increased chlorophyll content, plant height, number leaves, leave area and tuber weight compared to un-inoculated coleus plants (Aruna *et al.,* 2007).

Although, several researchers published reports on dates of planting in turmeric. However, the information on mycorrhizal fungi in turmeric is limited. Therefore the present study was intended to find out the suitable planting dates and VA-mycorrhiza on performance of turmeric (*Curcuma longa* L.) cv.Salem.

MATERIALS AND METHODS

The experiment was conducted during 2011-2012 (one year) at K.R.C College of Horticulture, Arabhavi, Karnataka. Arabhavi is situated in northern dry zone of Karnataka state with mean rainfall of this area is about 523.10 mm which distributed between April to November. Experiment was laid out in split plot design with three replications. The experiment consisted of six fortnightly planting dates starting from 2nd fortnight of April to 1st fortnight of July as main treatment and two sub plot treatments *viz.*, with or without application of VAM. Healthy, uniform size rhizomes, having an average weight of 20-25 g

were utilized for planting after dipping in the solution of captan (3 g/L) and endosulphon (2 ml/L) for 30 minutes before planting (Manhas *et al.,* 2010). Recommended dose of farmyard manure (25 t/ha) and chemical fertilizers (180, 90 and 90 kg NPK/ ha) were applied. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose. Remaining nitrogen was top dressed at 45 days after planting after weeding. The inoculation of VAM fungus (*Glomus fasiculatum*) to turmeric was done during planting by applying 5 grams (soil form) per rhizome, just before planting (Singh *et al.*, 2012). The uninoculated VAM rhizomes served as a control. The crop was harvested in the month of second week of February. Observations on growth parameters (at 180 days after planting) and seed to yield ratio were recorded on randomly selected thrice replicated plants. Fresh rhizome yield/ plant, yield/plot and estimated yield/ha and curing percentage was also worked out.

Curcumin content was estimated by following the method suggested by (Manjunath *et al*., 1991). The volatile oil content was estimated as per the methods described in ASTA (Anon., 1968).

RESULTS AND DISCUSSION

The rhizome planted with VAM inoculation recorded lowest numbers of days (29.89) for sprouting as compared to uninoculated VAM (38.33) rhizome as indicated in (Table 1). Significantly minimum number of days was taken for germination by the rhizome planted in 2nd fortnight of May (29.17) while the maximum was recorded by April 1st fortnight (39.67). Plant height (90.20 cm), number of leaves per clump (81.96) and leaf area (56.25 dm^2) at 180 days were significantly higher by VAM inoculated plant compared to uninoculated control (84.82 cm, 73.77 and 47.85 dm^2 respectively). However, number of tiller per clump showed non-significant effect among the treatments. Among the different planting dates, planting in 2nd fortnight of May recorded the highest plant height of 102.79 cm, followed by 1st fortnight of May (96.04 cm) compared to the lowest recorded by 1st fortnight of July (67.81cm).

The highest number of tiller per clump (9.20), number of leaves per clump (88.97) and leaf area (63.56 dm^2) was recorded by the turmeric crop planted in 2nd fortnight of May which was on par with 1st fortnight of May (8.37, 83.70 and 60.16 dm^2 respectively) compared to the planting in July 1st fortnight (7.43, 66.25 and 37.93 dm^2 respectively).

This positive influence of growth parameters is attributed early sprouting of turmeric planted during May 1st and 2nd fortnight might have helped the plants to get better establishment and rapid growth thereby producing better vegetative performance compared to early and late planting. The atmosphere was also congenial for better growth as it was comparatively hot and humid during this period. There was decrease in growth attributes of turmeric crop planted beyond 2nd fortnight of May which may be attributed to reduced physiological conditions of rhizome for sprouting and establishment leading to poor field performance. Similar results were also reported by (Bandopadhyay *et al.,* 2005; Kandiannan and Chandaragir 2006; Shadap, 2010; Manhas *et al.,* 2010 and Singh *et al.,* 2013). Vegetative performance was higher in VAM inoculated plant compared to uninoculated control. This might be due to enhanced uptake of nutrients and water by the plant inoculated with VA-mycorrhiza leading to increased vegetative growth. Inoculation with arbuscular-mycorrhizal fungi improved the plant biomass and phosphorous uptake in *Coleus aromaticus* (Earanna *et al.,* 2001) and *Catharanthus roseus* (Karthikeyan *et al.,* 2008).

The data on fresh rhizome yield (g/clump), yield to seed ratio and yield (t/ha) differed significantly among different planting dates and VAM inoculation (Table 2). However, crop duration was non-significant among the treatments. Turmeric crop receiving VAM inoculation recorded significantly higher fresh rhizome yield per plant (378.54 g), yield to seed ratio (18.93) and yield (27.25 t/ha) compared to the uninoculated control (320.02 g, 16.00 and 22.85 t/ha respectively). Planting rhizome in 2nd fortnight of May resulted in the highest fresh rhizome yield per plant (532.23 g), yield to seed ratio (26.61) and yield (47.32 t/ha) compared to the lowest recorded by July 1st fortnight (114.43 g, 5.72 and 4.70 t/ha respectively). The crop duration ranged between 287.17 days (April 2nd

Table 1: Effect of planting dates and VA-Mycorrhiza inoculation on sprouting percentage and growth parameters in turmeric cv. Salem

Treatment	Days to Sprout (%)			Plant height (cm)			No of tillers clump^{-1}			No. of leaves clump^{-1}			Leaf area (dm^2)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
D_1	35.00	44.33	39.67	93.86	86.98	90.42	8.80	8.47	8.63	84.47	78.47	81.47	58.16	49.93	54.05
D_2	30.33	38.67	34.50	98.21	93.87	96.04	8.60	8.13	8.37	88.23	79.17	83.70	64.74	55.59	60.16
D_3	25.33	33.00	29.17	105.79	99.79	102.79	9.40	9.00	9.20	93.30	84.63	88.97	68.83	58.28	63.56
D_4	27.00	37.33	32.17	91.89	86.63	89.26	8.40	7.80	8.10	78.97	70.27	74.62	53.54	46.13	49.83
D_5	29.33	37.33	33.33	80.96	76.50	78.73	8.00	7.40	7.70	76.83	67.53	72.18	50.61	42.94	46.77
D_6	32.33	39.33	35.83	70.47	65.15	67.81	7.60	7.27	7.43	69.93	62.57	66.25	41.62	34.24	37.93
Mean	29.89	38.33		90.20	84.82		8.47	8.01		81.96	73.77		56.25	47.85	
For comparison of mean															
	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)
D	1.28	4.02	9.19	1.76	5.55	4.93	0.359	1.130	10.683	3.63	11.44	11.41	1.23	3.89	5.81
S	0.60	1.86	7.49	0.92	2.85	4.48	0.181	NS	9.345	1.70	5.23	9.24	1.08	3.33	8.81
D x S	1.48	4.55		2.26	6.96		0.444	1.361		4.15	12.80		2.65	8.15	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

NS - Non significant

Table 2: Effect of planting dates and VA-Mycorrhiza inoculation on fresh rhizome yield and crop duration in turmeric cv. Salem

Planting date	Yield per plant (g/clump)		Mean	Yield to seed ratio		Mean	Yield (t/ha)		Mean	Crop duration (days)		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
D_1	401.93	377.40	389.67	20.10	18.87	19.48	31.29	22.72	27.00	291.67	282.67	287.17
D_2	524.27	438.00	481.13	26.21	21.90	24.06	41.56	34.50	38.03	285.33	277.33	281.33
D_3	590.73	473.73	532.23	29.54	23.69	26.61	50.62	44.03	47.32	270.00	261.67	265.83
D_4	367.87	307.53	337.70	18.39	15.38	16.88	18.93	18.11	18.52	251.67	243.33	247.50
D_5	261.13	219.93	240.53	13.06	11.00	12.03	15.77	13.67	14.72	232.67	227.33	230.00
D_6	125.33	103.53	114.43	6.27	5.18	5.72	5.35	4.05	4.70	206.33	199.67	203.00
Mean	378.54	320.02		18.93	16.00		27.25	22.85		256.28	248.67	
For comparison of mean												
	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at 5%	CV (%)	S.Em±	C.D. at5%	CV (%)	S.Em±	C.D. at5%	CV (%)
D	13.64	42.98	9.57	0.68	2.15	9.57	1.85	5.82	18.07	3.48	10.97	3.38
S	6.98	21.52	8.48	0.35	1.08	8.48	1.41	4.36	23.92	2.71	NS	4.57
D x S	17.10	52.71		0.85	2.64		3.46	10.67		6.65	20.49	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

NS: Non-significant

Table 3: Effect of planting dates and VA-Mycorrhiza inoculation on quality parameters in turmeric cv. Salem

Planting date	Curing percentage		Mean	Estimated cured yield (t/ha)		Mean	Curcumin content (%)		Mean	Volatile oil (%)		Mean
	S_1	S_2		S_1	S_2		S_1	S_2		S_1	S_2	
D_1	29.73	25.23	27.48	9.28	5.70	7.49	4.93	4.36	4.64	1.33	1.25	1.29
D_2	34.38	29.28	31.83	14.32	10.09	12.20	5.20	4.72	4.96	1.28	1.15	1.22
D_3	35.27	32.73	34.00	17.85	14.40	16.12	4.60	4.22	4.41	1.12	0.80	0.96
D_4	30.46	27.31	28.88	6.19	4.97	5.58	4.22	3.89	4.06	1.08	0.75	0.91
D_5	27.19	24.00	25.59	4.30	3.28	3.79	4.07	3.67	3.87	0.78	0.70	0.74
D_6	21.57	19.79	20.68	1.16	0.81	0.98	3.73	3.33	3.53	0.78	0.63	0.70
Mean	29.77	26.39		8.85	6.54		4.46	4.03		1.06	0.88	
For comparison of mean												
	S.Em±	C.D. at5%	CV(%)	S.Em±	C.D. at5%	CV(%)	S.Em±	C.D. at5%	CV (%)	S.Em±	C.D. at5%	CV(%)
D	0.532	1.686	4.650	0.499	1.579	15.876	0.122	0.395	7.260	0.022	0.087	6.781
S	0.297	0.919	4.483	0.243	0.748	13.385	0.059	0.181	5.877	0.021	0.061	8.527
D x S	0.727	2.241		0.594	1.838		0.144	0.447		0.052	0.143	

Main plot (D): Dates of planting

D_1 - 2nd fortnight of April, 2011
D_2 - 1st fortnight of May, 2011
D_3 - 2nd fortnight of May, 2011
D_4 - 1st fortnight of June, 2011
D_5 - 2nd fortnight of June, 2011
D_6 - 1st fortnight of July, 2011

Sub plot (S): VAM application

S_1- With VAM
S_2- Without VAM

fortnight) and 203.00 days (July 1st fortnight).

Higher fresh yield and yield attributes in turmeric planted during 2nd and 1st fortnight of May might be attributed to better growth and development during the growth period due to higher growth attributes like ample number of functional leaves, more number of tillers and higher leaf size. Vigorous plant growth must have contributed for higher yield due to higher photosynthesis. Further, it also must have resulted in higher sink capacity and accumulation of more of carbohydrates and its translocation into rhizome thereby increased the fresh rhizome yield. Similar results were also reported by Bandopadhyay *et al*. (2005), Kandiannan and Chandaragir (2006) and Manhas *et al*. (2010).

The increase in fresh rhizome weight in inoculated plants also could be correlated with increased mycorrhizal colonization. The reason may also be due to the formation of external mycelium around the roots by VAM fungi. Inoculation of VAM must have helped to increase the mineral phosphorous uptake in the plant and might have resulted in the higher fresh rhizomes yield. These results are agreement with the findings of earlier Investigators (Aruna *et al.,* 2007; Karthikeyan *et al.,* 2008 and Vijaya *et al.,* 2008).

Crop receiving application of VAM showed the higher curing percentage (29.77), estimated cured yield (8.85 t/ha), content of curcumin (4.46%) and volatile oil (1.06%) than the control (26.39, 6.54 t/ha, 4.03 and 0.88% respectively) (Table 3). Significantly higher curing percentage (34.00) and estimated cured yield (16.12 t/ha) were recorded by 2nd fortnight of May compared to the lowest recorded by 1st fortnight of July (20.68 and 0.98 t/ha respectively). However, early planting i.e., May

1st fortnight and April 2nd fortnight recorded the higher curcumin (4.96%) and volatile oil content (1.29%).

The variation in quality parameters *viz.,* curing percentage, cured yield, curcumin and volatile oil content might be due to the longer crop duration which might have increased the dry matter accumulation in the crop as crop duration of earlier planting was more than later planting dates. The rhizome formation starts early and gets more time for development thus resulting in more accumulation of dry matter and curcumin content in early planted crops than the late planted crops. The results in the present investigation are in conformity with earlier finding of (Kandiannan and Chandaragir, 2006; Shadap, 2010 and Singh *et al.,* 2013). Application of VAM might have helped to increase the quality parameters of turmeric. This may be due to the role of VAM (*Glomus fasciculatum*) in increased mineralization of organic matter. P is one of the main nutrients involved in the synthesis of secondary metabolites as their production demands ATP (Sangwan *et al.,* 2001). The increase in availability of P through mycorrhizal association would probably underlie the increase of curcumin. Similarly, the result was supported with earlier finding (Silva *et al*., 2008 in ginger and Yamawaki *et al.,* 2013 in turmeric) inoculated mycorrhizal fungi found oil concentration was modulated according to VAM.

REFERENCES

Al-Karaki, G. N. 2006. Nursery inoculation of tomato with arbuscular mycorrhizal fungi and subsequent performance under irrigation with saline water. *Scientia Hort.* **109:** 1-7.

Anonymous. 1968. *Official analytical methods of the American Spice Trade Association.* Englewood Cliffs, N.J. pp. 8-11.

Anonymous. 2015. *Indian Horticulture Database, National Horticulture Board.* p. 6

Aruna, S., Charantimath and Lakshman, H. C. 2007. Interaction between arbuscular mycorrhizal fungi and azotobacter on growth of *Coleus amboinicus* L. *The bioscan.* **2(3):** 199-201.

Bandopadhyay, A., Hore, J. K. and Ghosh, D. K. 2005. Effect of time of planting on growth and yield of turmeric grown as intercrop in the coconut plantation of West Bengal. *J. Plantation Crops*. **33(1):** 36-38.

Earanna, N., Mallikarjuniah, R. R., Bagyaraj, D. J. and Suresh, C. K. 2001. Response of *Coleus aromaticum* to *Glomus fasciculatum* and other beneficial soil microflora. *J. Spices and Aromatic Crops*. **10(2):** 141-143.

Kandiannan, K. and Chandaragir, K. K. 2006. Influence of varieties, dates of planting, spacing and nitrogen levels on growth, yield and quality of turmeric (*Curcuma longa*). *Indian J. Agric. Sci.* **76(7):** 432-434.

Karthikeyan, B., Jaleel, C. A., Changxing, Z., Manoharan, M. J., Jothi, S. and Muthukumar, D. 2008. The effect of AM fungi and phosphorous level on the biomass yield and ajmalicine production in *Catharanthus roseus*. *Eur. Asia. J. Bio. Sci.* **2:** 26-33.

Manhas, S. S., Gill, B. S. and Sharma, S. 2010. Effect of different planting material, planting dates and harvesting dates on economy of turmeric crop. *J. Agril. Physics*. **10:** 50-52.

Manjunath, M. N., Stattigeri, V. D. and Nagaraj, K. V. 1991. Curcumin in turmeric. *Spice India.* **12:** 7-9.

Ortas, I., Kaya, Z. and Çakmak, I. 2001. Influence of VA mycorrhiza inoculation on growth of maize and green pepper plants in phosphorus and zinc deficient soils. In: Plant nutrition- Food security and sustainability of agroecosystems (Horst W.J. *et al.,* eds). *Kluwer Acad Publ, Dordrecht.* pp. 632-633.

Plenchette, C., Clermont, D. C., Meynard, J. M. and Fortin, J. A. 2005. Managing arbuscular mycorrhizal fungi in cropping systems. *Can. J. Plant Sci.* **85(1):** 31-40.

Sangwan, N. S., Farooqi, A. H. A., Shabih, F. and Sangwan, R. S. 2001. Regulation of essential oil production in plants. *Plant Growth Regulation.* **34:** 3-21.

Sengupta, D. K. and Dasgupta, B. 2010. Effect of planting time on growth and yield of ginger (*Zingiber officinale* Rose.) in the hilly region of Darjeeling (West Bengal). *Horticultural J.* **23(1):** 35-37.

Shadap, A. 2010. Studies on planting dates and storage of seed rhizome in ginger (*Zingiber officinale* Rosc.). *M.Sc. (Agri.) thesis, University of Agricultural Science, Dharwad.*

Silva, M. F., Pescador, R., Ricardo, A. R. and Sturmer, S. L. 2008. Effect of arbuscular mycorrhizal fungal isolates on the development and oleoresin production of micro-propagated *Zingiber officinale*. *Braz. J. Plant Physiol.* **20(2):** 119-130.

Singh, B. K., Ramakrishna, Y., Deka, B. C., Verma, V. K. and Pathak, K. A. 2013. Varieties and planting dates affect the growth, yield and quality of turmeric (*Curcuma longa* L.) in mild-tropical environment. *Vegetable Science*. **40(1):** 40-44.

Singh, R., Kalra, A., Ravish, B. S., Divya, S., Parameswaran, T. N., Srinivas, K. V. N. S. and Bagyaraj, D. J. 2012. Effect of potential bioinoculants and organic manures on root-rot and wilt, growth, yield and quality of organically grown *Coleus forskohlii* in a semiarid tropical region of Bangalore. *Plant Pathology*. **61:** 700-708.

Vijaya, T., Nagalakshmi Devamma, M. and Nirmala, C. 2008. Response of vesicular arbuscular mycorrhizae (VAM) treated *Acorus calamus* L. to water stress. *The Bioscan.* **3(4):** 437-440.

Yamawaki, K., Matsumura, A., Hattori, R., Tarui, A., Hossain, M. A., Ohashi, Y. and Daimon, H. 2013. Effect of inoculation with arbuscular mycorrhizal fungi on growth, nutrient uptake and curcumin production of turmeric (*Curcuma longa* L.). *Agric. Sci.* **4(2):** 66-71.