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Response of cardamom (*Elettaria cardamomum* Maton) seedlings to vesicular arbuscular mycorrhizal fungi

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Abstract

The growth response of cardamom (*Elettaria cardamomum*) seedlings (cv. Malabar) to 13 different vesicular arbuscular mycorrhizal fungi was tested under mat house conditions at Bangalore, India. In general, seedlings inoulated with the fungi grew taller, had more number of leaves and tillers, increased seedling biomass and uptake of nutrients compared to control seedlings. Among the various mycorrhizal fungi tested, seedlings inoculated with *Gigaspora margarita* and *Glomus monosporum* exhibited significantly higher growth with increased uptake of nutrients.

Key words : cardamom, *Gigaspora margarita, Glomus monosporum,* vesicular arbuscular mycorrhiza.

Introduction

Vesicular arbuscular mycorrhizal (VAM) fungi are known to form a mutualistic symbiotic association with many crop plants and help in better crop growth through increased uptake of nutrients and alleviating various plant stressess, including diseases (Sharma *et al.* 1992; Vaast & Zasoski 1992; Zhi 1993). The response of a particular host varies with its associated VAM fungi (Plenchette *et al.* 1982; Nalini *et al.* 1986), emphasizing the need for selecting efficient VAM fungi for inoculating mycotrophic crop plants (Bagyaraj & Verma 1996). No study has been made earlier to know the symbiotic response of cardamom (*Elettaria cardamomum* Maton) to these beneficial fungi. Hence it was contemplated to screen and select efficient VAM fungi for inoculating cardamom in the nursery.

Materials and methods

Thirteen VAM fungi maintained at the Department of Microbiology, University of Agricultural Sciences, Bangalore were screened in the experiment (Table 1). These fungi were multiplied separately on Rhodes grass (*Chloris gayana*) as the

Table 1. Influence of VAM fungi on vegetative characters and colonization of cardamom seedlings *

VAM fungi	Source	Seedling height (cm)	No.of leaves per seedling	Leaf area (cm^2)	No.of tillers per seedling	Mycorrhizal root colonization (%)
Acaulospora laevis	Invermay, New Zealand	80.2	11.9	133.3	1.6	43.3
Gigaspora calospora	Hyderabad, India	76.9	11.2	124.4	1.4	25.0
Gi. margarita	Hyderabad, India	86.3	12.6	144.4	2.0	58.3
Glomus caledonicum	Nedlands, Australia	71.9	11.1	120.6	1.3	21.7
Gl. deserticola	Salt lake city, USA	79.9	11.8	132.2	1.5	41.7
Gl. etunicatum	Salt lake city, USA	77.1	11.4	126.4	1.4	28.3
Gl. fasciculatum	Riverside, USA	82.8	12.2	138.4	1.7	50.0
Gl. intraradices	Salt lake city, USA	80.4	12.0	134.2	1.6	45.0
Gl. leptotichum	Bangalore, India	78.7	11.7	130.3	1.5	36.7
Gl. macrocarpum	Bangalore, India	79.5	11.8	130.8	1.5	40.0
G. monosporum	Nedlands, Australia	84.5	12.5	141.4	1.8	55.0
G. mosseae	Hyderabad, India	81.0	12.0	137.0	1.7	46.7
G. versiformae	Bangalore, India	77.8	11.6	128.9	1.4	30.0
Uninoculated		63.2	10.8	108.5	1.2	13.3
CD (P=0.05)		3.96	0.72	13.13	0.18	9.38
CV %		8.12	9.93	16.20	18.42	14.62

*At 9 months after transplanting

host and sand : soil (1:1) mix as the substrate. The experiment including control had 14 treatments with 20 replications laid out in a Completely Randomized Block Design. The experiment was conducted in polybags (size 20 cm x 28 cm of 100 gauge thickness) filled with 2 kg potting mixture comprising of forest top soil (sandy clay loam) : sand : FYM (2:1:1). The soil used in the substrate had a P content of 13.5 kg/ha and a native VA mycorrhizal spore load of 18 spores/25 ml soil. The potting mixture was mixed with full recommended dose of N and K and half the recommended dose of P. The recommended fertilizer dose for optimum yield is 37.5-37.5-75.0 kg NPK/ ha (Package of Practices 1985, University of Agricultural Sciences, Banglore). The quantity of fertilizer required for 2 kg potting mixture was calculated and added.

Cardamom seedlings (cv. Malabar) raised in sterilized soil were used in the study. Healthy and three leaf staged uniform seedlings were selected and used for planting @ one seedling per polybag. After 20 days of seedling establishment in polybags, mycorrhizal inoculum comprising of fungal hyphae, root bits and spores were added @ 12,500 infective propagules (IP) per seedling close to the root. The quantity of VAM inoculum of different fungi added per seedling ranged from 0.69 g to 20.16 g in order to give 12500 IP/ seedling. The seedlings were watered whenever necessary and maintained in regulated shade under mat house conditions.

Seedling height and number of leaves were recorded at 3, 6 and 9 months after transplanting (MAT). At 9 MAT the seedlings were harvested and the leaf area of the seedling (George *et al.* 1984) and the number of tillers per seedling were determined. Shoot and root dry weights were estimated after drying to a constant weight at 60°C. Phosphorus content in shoot and root were estimated separately by vanadomolybdate phosphoric yellow colour method (Jackson 1973). The iron, copper and zinc contents in the seedlings were determined using atomic absorption spectrophotometer at wave lengths 248, 325 and 215 nm, respectively (Issac & Kerber 1971). The per cent mycorrhizal root colonization was determined after staining the roots with trypan blue (Phillips & Hayman 1970).

Results and discussion

Seedling height and number of leaves per seedling at 3, 6 and 9 MAT were influenced by different VAM fungi (Table 1). Seedlings inoculated with VAM fungi grew taller and had more number of leaves per seedling than uninoculated seedlings. Among the 13 diferent VAM fungi tested, seedlings inoculated with *Gigaspora margarita* and *Glomus monosporum* had maximum seedling height (86.3 and 84.5 cm) and number of leaves (12.6 and 12.5) at 9 MAT and were on par with each other. Control seedlings had the lowest seedling height and number of leaves (Table 1).

Leaf area was highest in seedlings inoculated with *Gi. margarita.* The number of tillers was also maximum in the same species which differed significantly from all other treatmets. In general, seedlings inoculated with VAM fungi had higher shoot and root biomass compared to uninoculated seedlings. Maximum seedling dry biomass was observed in seedlings inoculated with *Gi. margarita* followed by those inocu-

lated with *Gi. monosporum*, *Gl. fasciculatum* and *Gl. mosseae* (19.2 to 23.0 g/plant). The lowest seedling dry biomass was seen in uninoculated seedlings (Table 2). Mycorrhizal inoculation resulted in significant increase in shoot and root P contents of the seedlings. P content, both in shoot and root, was maximum in seedlings inoculated with *Gi. margarita* and *Gl. monosporum* both being statistically on par with each other (Table 2). Inoculation with VAM fungi greatly influenced uptake of micronutrients like iron, copper and zinc (Table 3). Seedlings inoculated with *Gi. margarita*, *Gl. monosporum*, *Gl. fasciculatum* and *Gl. mosseae* had higher uptake of iron, copper and zinc.

Maximum root colonization was observed in seedlings inoculated with *Gi. margarita* followed by *Gl. monosporum* and *Gl. fasciculatum* and were on par with each other (Table 1).

The results of the present study indicates that VAM fungi influenced the growth of cardamom seedlings to a large extent compared to uninoculated seedlings. Among the 13 different VAM fungi tested, *Gi. margarita* and *Gl. monosporum* were more efficient in improving the growth of seedlings. Seedlings inoculated with *Gi. margarita*, *Gl. monosporum* and *Gl. fasciculatum* had nearly twice the seedling dry weight compared to uninoculated seedlings. The main effect of VAM fungi in improving seedling growth is through increased uptake of diffusion limited nutrients especially phosphorus. Such increased P uptake has been attributed to increased surface area of absorption and enhanced translocation (Sanders &

Table 2. Influence of VAM fungi on seedling biomass and P content in cardamom seedlings

Treatment	Biomass (g/seedling)			P content (mg/seedling)	
	Shoot	Root	Total	Shoot	Root
Acaulospora laevis	12.9	5.6	18.5	89.0	24.6
Gigaspora calospora	10.9	4.5	15.4	54.5	16.7
Gi. margarita	14.5	8.5	23.0	123.3	45.9
Glomus caledonicum	10.5	4.5	15.0	47.3	16.2
Gl. deserticola	12.2	5.3	17.5	83.0	22.3
Gl. etunicatum	11.4	4.7	16.1	61.6	18.3
Gl. fasciculatum	13.5	6.8	20.3	105.3	34.7
Gl. intraradices	13.0	5.7	18.7	91.0	25.7
Gl. leptotichum	11.9	5.1	17.0	76.2	20.9
Gl. macrocarpum	12.0	5.2	17.2	79.2	21.3
Gl. monosporum	13.8	7.4	21.2	113.2	39.2
Gl. mosseae	13.2	6.0	19.2	99.0	28.2
Gl. versiformae	11.7	4.8	16.5	67.9	19.2
Uninoculated	8.6	3.1	11.7	37.8	10.5
CD (P=0.05)	1.34	1.13	2.10	12.23	7.03
CV %	6.56	12.18	7.08	9.04	17.07

Table 3. Influence of VAM fungi on iron, copper and zinc contents in cardamom seedlings

Treatment	Iron (mg/seedling)		Copper (mg/seedling)		Zinc (mg/seedling)	
	Shoot	Root	Shoot	Root	Shoot	Root
Acaulospora laevis	2.40	0.38	0.16	0.02	0.48	0.07
Gigasopra calospora	1.92	0.27	0.11	0.02	0.35	0.05
Gi. margarita	2.84	0.61	0.20	0.04	0.58	0.14
Glomus caledonicum	1.83	0.26	0.10	0.01	0.33	0.05
Gl. deserticola	2.26	0.35	0.15	0.02	0.45	0.06
Gl. etunicatum	2.02	0.28	0.12	0.02	0.38	0.05
Gl. fasciculatum	2.61	0.48	0.19	0.03	0.53	0.10
Gl. intraradices	2.47	0.39	0.16	0.03	0.49	0.08
Gl. leptotichum	2.18	0.32	0.13	0.02	0.42	0.06
Gl. macrocarpum	2.21	0.34	0.14	0.02	0.43	0.06
Gl. monosporum	2.69	0.53	0.19	0.03	0.55	0.11
Gl. mosseae	2.53	0.41	0.18	0.03	0.50	0.08
Gl. versiformae	2.11	0.30	0.13	0.02	0.40	0.05
Uninoculated	1.48	0.17	0.08	0.01	0.25	0.03
CD (P=0.05)	0.33	0.08	0.02	0.01	0.08	0.02
CV %	8.60	12.54	8.23	13.38	10.62	14.82

Tinker 1971; Hatting *et al.* 1973). Seedlings inoculated with VAM fungi thus had higher P content in both shoot and root compared to uninoculated seedlings. In general, seedlings inoculated with VAM fungi had significantly more iron, copper and zinc in the shoot and root compared to uninoculated seedlings. Higher iron, copper and zinc contents were observed in seedlings inoculated with *Gi. margarita, Gl. monosporum, Gl. fasciculatum* and *Gl. mosseae*. Seedlings inoculated with *Gl. margarita* and *Gl. monosporum* had maximum per cent mycorrhizal root colonization indicating that a direct relationship exists between seedling dry weight, uptake of nutrients especially P, and the endophyte association in terms of per cent root colonization which clearly showed that a preferential association occurs with certain VAM fungi.

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