Proc. Indian Acad. Sci. (Plant Sci.), Vol. 97, No. 4, August 1987, pp. 289–294.

Genotype dependent variation in vesicular-arbuscular mycorrhizal colonisation of coconut seedlings*

GEORGE V THOMAS and S K GHAI
Division of Microbiology, Central Plantation Crops Research Institute, Kasaragod 670 124, India

MS received 27 October 1986; revised 27 February 1987

Abstract. Vesicular-arbuscular mycorrhizal colonisation was assessed on one year old coconut seedlings of 17 cultivars and 4 hybrids, growing in a sandy loam soil. The proportion of root segments with vesicular-arbuscular mycorrhizae ranged from 56·8–95·2%. In general, more root segments of tall cultivars were infected (68·8–95·2%) than those of dwarf cultivars (62·4–75·2) and hybrids (56·8–86·4%). Similar trends were detected in the infection grading and when the spores in soil near to seedlings was examined. The extent of vesicular-arbuscular mycorrhizal colonisation within infected root segments of same cultivars also varied. The vesicular-arbuscular mycorrhizal fungi associated with coconut seedlings included *Gigaspora decipens*, *Gigaspora aurigloba*, *Gigaspora rosea*, *Glomus multicaule* and *Glomus fasciculatum*.

Keywords. Coconut; VA mycorrhizae; genotype; cultivars; hybrids.

1. Introduction

Plants infected with vesicular-arbuscular (VA) mycorrhizal fungi are known to have enhanced nutrient uptake and hence exhibited better growth compared with plants without VA mycorrhizal infection (Gerdemann 1975; Mosse 1977). VA mycorrhizae have also been reported to suppress many types of plant pathogens including fungi (Schonbeck and Dehne 1977) and nematodes (Hussey and Roncardi 1978). Since it was reported that rapid and high levels of VA mycorrhizal colonisation may be the prime determinant of symbiotic efficiency (Menge 1983) there is a need to survey the occurrence and identification of VA mycorrhizae found in the roots of different plant species so that controlled inoculation can be done if deemed desirable.

In the present investigation a survey of major coconut (*Cocos nucifera* L.) cultivars from the exotic and indigenous collections and hybrids, has been done so as to gauge the extent of root infection and numbers of spores of VA mycorrhizal fungi in soil.

2. Materials and methods

One year old coconut seedlings from the germplasm collection of the Institute were used. They were grown in an acidic (pH 5·1–5·5) sandy loam (arenic paleustults) field soil having organic carbon 0·5%, available phosphorus 11·8 ppm and potash 57·6 ppm. The soil contained an indigenous mycorrhizal population of 65 spores/50 g soil.

Seventeen coconut cultivars, obtained *inter se* from the indigenous and exotic

*Contribution No. 499 of C.P.C.R.I., Kasaragod.

accessions from the South East Asian and Pacific Islands, and 4 hybrids were used. Five seedlings were randomly selected from each cultivar/hybrid raised in 3–4 replicate rows and undamaged feeder rootlets collected. The soil samples (0–15 cm) were drawn with the help of a 25 mm soil auger from the base of seedlings.

To determine the extent of colonisation by VAM fungi, 25 root samples were collected from each replicate seedling and a total of 125 samples were obtained for each cultivar/hybrid. Root samples were cut into 1 cm segments, fixed in FAA (1 : 1 : 14), cleared in 10% KOH and stained in 0·5% solution of trypan blue in lactophenol (Phillips and Hayman 1970). The proportion of root samples infected was determined microscopically by the root slide technique (Nicolson 1959). Mycorrhizal colonisation was expressed using the following formula:

$$\text{Colonisation}(\%) = \frac{\text{Number of root segments with VAM}}{\text{Total number of root segments examined}} \times 100.$$

Roots with VA mycorrhizae were arranged in 4 categories of infection intensity viz 1–25, 26–50, 51–75 and 76–100%. To obtain the mean infection grading of infected roots the number of roots in each category were multiplied by their respective infection intensity index (1, 2, 3 or 4) and summed.

Numbers of spores of VAM fungi in air dried soil samples were determined by the wet sieving and decantation technique (Gerdemann and Nicolson 1963).

The VAM fungi infecting coconut roots were identified with the help of the slide collection prepared by Hall and Abbott (1981).

3. Results and discussion

The coconut cultivars studied can be classified agronomically into 3 categories viz tall cultivars, dwarf cultivars and hybrids (of tall × dwarf or dwarf × tall). Root mycorrhizal colonisation varied significantly in different cultivars and hybrids (table 1). In general, a greater proportion of root segments of tall cultivars had VA mycorrhiza colonisation than those of dwarf cultivars and hybrids indicating that talls derive more benefits from the mycorrhizal symbiosis than the other two groups. Laccadive Ordinary and British Solomon Islands cultivars, which were introduced from geographically divergent regions, had the largest percentage of root colonisation while the hybrid MDY × WCT and the dwarf cultivar Malayan dwarf yellow had the least. Among the hybrids roots of CDO × WCT and WCT × CDO were colonised more than those of other hybrids, the amounts of colonisation being comparable to that of some of the tall cultivars. Seventeen of the coconut cultivars studied had more than 70% roots infected with VAM. The high degree of colonisation of coconut roots by mycorrhizae indicated an efficient symbiotic system in coconut for the absorption of nutrients especially in the absence of root hairs in the root system. A number of exotic cultivars were superior while some others were at par with the indigenous cultivars which had evolved and originated in these local soils.

The spore population in soil samples from the root region ranged from 133–287 per 50 g soil. In general, the spore count was more (163–287 per 50 g soil) in soil samples from tall cultivars. The spore count from dwarfs was minimal (133–153 per 50 g soil) whereas spore count from soils of hybrid was intermediate (143–203 per 50 g soil).

Table 1. Occurrence of VA mycorrhizae on roots of coconut seedlings (cultivars and hybrids) grown for one year in a sandy loam soil.

Cultivar/hybrid	Colonisation in roots (%)	Mean infection grading (IG) of infected roots	Spores per 50 g of soil
Tall			
San Ramon	81·6 (67·4)	45·2	210
Philippine Ordinary	84·0 (69·6)	46·4	183
Borneo	82·4 (66·2)	38·0	287
British Solomon Islands	94·4 (81·4)	59·6	207
Fiji Tall	82·4 (65·6)	41·0	233
Java	74·4 (59·9)	32·6	187
Zanzibar	84·8 (67·7)	40·0	177
Strait Settlement Green	77·6 (62·1)	32·6	173
Andaman Ordinary	83·2 (67·0)	43·8	223
Kappadam	68·8 (56·5)	34·8	187
Laccadive Ordinary	95·2 (78·8)	55·6	223
Laccadive Micro	88·8 (70·9)	44·4	163
West Coast Tall (WCT)	74·4 (59·7)	34·6	227
Mean	82·5 (67·1)	42·2	206
LSD	(11·4)	12·5	51
Dwarf			
Gangabondam	75·2 (60·4)	36·4	147
Chowghat Dwarf Orange (CDO)	68·0 (55·9)	29·4	153
Malayan Dwarf Orange (MDO)	72·0 (61·9)	35·2	133
Malayan Dwarf Yellow (MDY)	62·4 (52·4)	24·4	137
Mean	69·6 (57·7)	31·3	143
LSD	NS	NS	NS
Hybrid			
CDO × WCT	84·0 (69·1)	51·8	203
WCT × CDO	86·4 (69·3)	43·6	197
MDO × WCT	75·2 (60·9)	32·4	157
MDY × WCT	56·8 (48·9)	21·2	143
Mean	75·6 (61·6)	37·2	175
LSD	(11·1)	10·8	36
LSD for comparison of cultivars irrespective of grouping	11·7	12·6	44
LSD for comparisons of means of talls with dwarfs and talls with hybrids	4·8	5·1	18
LSD for comparisons of means of dwarfs with hybrids	NS	NS	22

Numbers in parentheses are transformed values obtained by the formula $\sin^{-1}\sqrt{P}$, where P is the proportion of colonisation.
All LSD values for $P = 0{\cdot}05$.

The extent of VAM colonisation within infected root segments of same cultivar varied (table 2). Thus in the cultivar Laccadive Ordinary, 16·0, 38·4, 35·2 and 5·6% root segments were 1–25, 26–50, 51–75 and 76–100% colonised. When integrated these gradings suggested that, as with per cent infections, tall cultivars were more copiously colonised by VA mycorrhizae (IG 32·6–59·6) than dwarf cultivars (IG 24·4–

Table 2. The intensity of VAM infection in root segments of coconut cultivars and hybrids grown in sandy loam soil.

Cultivar/hybrid	Root segments (%)			
	1–25% infection	26–50% infection	51–75% infection	76–100% infection
Tall				
San Ramon	19·2	29·6	28·8	4·0
Philippine Ordinary	20·0	32·8	24·8	6·4
Borneo	28·8	38·4	14·4	0·8
British Solomon Islands	12·8	32·8	35·2	13·6
Fiji Tall	27·2	32·8	16·8	5·6
Java	32·0	28·8	12·8	0·8
Zanzibar	32·0	35·2	12·8	4·8
Strait Settlement Green	35·2	32·0	9·6	0·8
Andaman Ordinary	23·2	31·2	24·0	4·8
Kappadam	20·0	30·4	15·2	3·2
Laccadive Ordinary	16·0	38·4	35·2	5·6
Laccadive Micro	26·4	39·2	20·0	3·2
West Coast Tall (WCT)	32·0	25·6	12·0	4·8
Dwarf				
Gangabondam	28·8	27·2	14·4	4·8
Chowghat Dwarf Orange (CDO)	36·0	21·6	7·2	4·0
Malayan Dwarf Orange (MDO)	27·2	28·8	11·2	5·6
Malayan Dwarf Yellow (MDY)	35·2	20·8	4·8	1·6
Hybrid				
CDO × WCT	18·4	22·4	28·8	14·4
WCT × CDO	30·4	30·4	20·0	5·6
MDO × WCT	35·2	27·2	11·2	1·6
MDY × WCT	35·2	15·2	6·4	0·0

36·4) and hybrids (IG 21·2–51·8). It is interesting to see that the high yielding hybrid, CDO × WCT also had more intense VAM infection in root system compared to other hybrids, dwarfs and most of the tall cultivars.

Statistical comparison of the data for talls, dwarfs and hybrids show that differences in root colonisation, infection grading and spore counts were significant between talls and dwarfs and talls and hybrids (table 1). However, dwarfs and hybrids did not differ significantly with respect to root colonisation and infection grading.

The observation that Laccadive Ordinary had higher mycorrhizal colonisation (95·2%) and higher intensity of infection (IG 55·6) could be one of the reasons for the better performance of this cultivar under drought conditions as observed in another study from this institute (Anonymous 1985). Because the experimental material was grown in the same field and because there was significant differences in the extent of root colonisation by VA mycorrhizae it is suggested that the differences observed are probably attributable, at least in part, to genetic factors controlling host/fungus compatibility. The differences in colonisation could arise from the differences in the physiological and biochemical characteristics of the root system, which are con-

trolled by genetic constitution of a particular cultivar/hybrid. Similar genotype dependent preference for VA mycorrhizal colonisation have been reported in pearl millets (Krishna *et al* 1985), sorghum (Clark 1983), wheat (Azcon and Ocampo 1980) etc.

Attempts were made to identify the VA mycorrhizal fungi infecting coconut seedlings from the morphology of vesicles and spores. Infections attributable to *Gigaspora decipens*, *Gigaspora coralloidea*, *Gigaspora aurigloba*, *Gigaspora rosea*, *Glomus multicaule* and *Glomus fasciculatum* could be identified. An earlier study (Ramesh 1982) based on spore morphology, and using the same soil as reported in this paper, identified the occurrence of *Gigaspora gigantea*, *Gigaspora gilmorei*, *Glomus macrocarpa*, *Glomus microcarpa* and *Glomus fasciculatum*. All of these observations except that of *G. fasciculatum* are first VAM records in association with coconut. Importantly it was observed that more than one type of VA mycorrhizal fungi could be infecting the root segments from the same coconut seedling and even the same root segment.

Acknowledgements

The authors are thankful to Dr K V A Bavappa for providing research facilities and encouragement, and to Dr E V V B Rao and Mr R V Pillai for the coconut germplasm. We also thank Mr Jacob Mathew and Mr M V George for the help in statistical analysis.

References

Anonymous 1985 Performance of coconut hybrids and Lakshadweep Ordinary; *Proc. VIIth Workshop All India Coordinated Coconut and Arecanut, Spices and Cashew Improvement Project* Trivandrum, Nov 6–9, 1985, pp 156–162

Azcon R and Ocampo N A 1980 Factors affecting the vesicular-arbuscular infection and mycorrhizal dependency of thirteen wheat cultivars; *New Phytol.* **87** 677–685

Clark R B 1983 Plant genotype differences in the uptake, translocation, accumulation and use of mineral elements required for plant growth; *Plant Soil* **72** 175–196

Gerdemann J W 1975 Vesicular-arbuscular mycorrhizae; in *The Development and Function of roots* (eds) J G Torrey and D T Clarkson (New York, London: Academic Press) pp 575–591

Gerdemann J W and Nicolson T H 1963 Spores of mycorrhizal Endogone species extracted by wet sieving and decanting; *Trans. Br. Mycol. Soc.* **46** 235–244

Hall I R and Abbott L K 1981 *Photographic slide collection illustrating features of the Endogonaceae* 3rd edition (New Zealand: Southern South Island Region Agricultural Research Division, Ministry of Agric. and Fisheries) p 23

Hussey R S and Roncardi R W 1978 Interaction of *Pratylenchus brachyureus* and an endomycorrhizal fungus on cotton; *J. Nematol.* **10** 16–20

Krishna K R, Shetty K G, Dart P J and Andrews D J 1985 Genotype dependent variation in mycorrhizal colonisation and response to inoculation in pearl millet; *Plant Soil* **86** 113–125

Menge J A 1983 Utilisation of vesicular-arbuscular mycorrhizal fungi in agriculture; *Can. J. Bot.* **61** 1015–1024

Mosse B 1977 The role of mycorrhizae in legume nutrition on marginal soils In *Exploiting the legume Rhizobium symbiosis in tropical agriculture* (eds) J M Vincent, A S Whitney and J Bose (University of Hawaii, College of Tropical Agriculture) pp 275–292

Nicolson T H 1959 Mycorrhizae in the Graminae 1 Vesicular-arbuscular endophytes with special reference to the external phase; *Trans. Br. Mycol. Soc.* **42** 421–438

Phillips J M and Hayman D S 1970 Improved procedure for clearing and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection; *Trans. Br. Mycol. Soc.* **55** 158–161

Ramesh C R 1982 Root infection and population density of VA mycorrhizal fungi in a coconut based multistoreyed cropping system; *Proc. 5th Annu. Symp. Plantation Crops*, Kasaragod Indian Soc. Plantation Crops pp 548–554

Schonbeck F and Dehne H W 1977 Damage to mycorrhizal and nonmycorrhizal cotton seedlings by *Thielaviopsis basicola*; *Plant Dis. Rep.* **61** 266–267