Journal of Plantation Crops 21 (Supplement) : 98-103 (1993)

VA-MYCORRHIZAL ASSOCIATION IN RELATION TO DROUGHT TOLERANCE IN COCONUT

GEORGE V. THOMAS, V. RAJAGOPAL and B.M. BOPAIAH

Central Plantation Crops Research Institute, Kasaragod 671 124, Kerala

ABSTRACT

Colonization by vesicular - arbuscular mycorrhizae (VAM) was studied during stress period from five cultivars/hybrids of coconut each, characterised as drought tolerant and drought sensitive on the basis of physiological parameters. The drought tolerant ones had a greater proportion of roots with VAM colonization than the sensitive ones. Data on infection grading revealed that palms in the tolerant group also had more number of roots with higher intensities of infection. Comparison of colonization pattern of VAM in three coconut hybrids during and after the stress revealed the superiority of MYD x WCT over COD x WCT and MOD x WCT in harbouring higher level of VAM colonization in roots during stress period. There was positive relationship between VAM colonization and water relation aspects namely stomatal resistance and leaf water potential.

INTRODUCTION

The symbiotic relationship between plant roots and vesicular-arbuscular mycorrhizal (VAM) fungi has been mainly studied with respect to their role in increasing plant growth by enhancing the uptake of nutrients particularly phosphorus (Mosse, 1981). Crops such as wheat, soybean, groundnut and clovers showed better tolerance to water stress when roots were colonized by VAM fungi (Safir and Nelsen, 1984; Krishna and Bagyaraj, 1984; Bethlenfalvay, 1988). However, there are no reports concerning mycorrhizal association in relation to drought tolerance in perennial crops.

A prolonged dry spell lasting five to seven months in a year and the occurrence of severe drought once in three to four years are affecting the coconut cultivation in the coastal sandy loam soils in northern Kerala. Rajagopal *et al.* (1990) identified certain coconut genotypes with drought tolerant traits on the basis of physiological and biochemical characteristics. The present investigation was undertaken with a view to comparing the mycorrhizal status of drought tolerant and drought sensitive genotypes during stress period and to finding out the relationship, if any, between root mycorrhizal colonization and the physiological parameters like stomatal regulation and leaf water potential associated with drought tolerance in coconut.

MATERIALS AND METHODS

Ten genotypes of coconut (listed in Fig. 1) were selected for the study, of which five were characterized as drought tolerant and the remaining five as drought sensitive on the basis of physiological and biochemical characteristics.

The selected coconut cultivars and hybrids are maintained in the germplasm collection by the Crop Improvement Division of CPCRI. The 24 year old palms were planted with 7.5 x 7.5 m spacing in acidic red sandy loam soil in randomised block design and maintained under rainfed conditions with the recommended agronomic practices including the application of 500 g N, 320 g P_2O_5 and 1200 g K_2O palm^{-1} year $^{-1}$. Undamaged feeder rootlets were collected during drought period in April on two successive years, 1989 and 1990 at a lateral distance of one meter from the bole of the palm. Samples were collected from six randomly selected palms of each genotype. A total of 20 root segments were obtained from a replicate palm each year.

Three coconut hybrids which showed differences in tolerance to drought were also studied for their mycorrhizal association during stress (January to April) and post stress (July) periods. These six year old hybrids viz. Malayan Yellow Dwarf x West Coast Tall (MYD x WCT), Malayan Orange Dwarf x WCT (MOD x WCT) and Chowghat Orange Dwarf x WCT (COD x

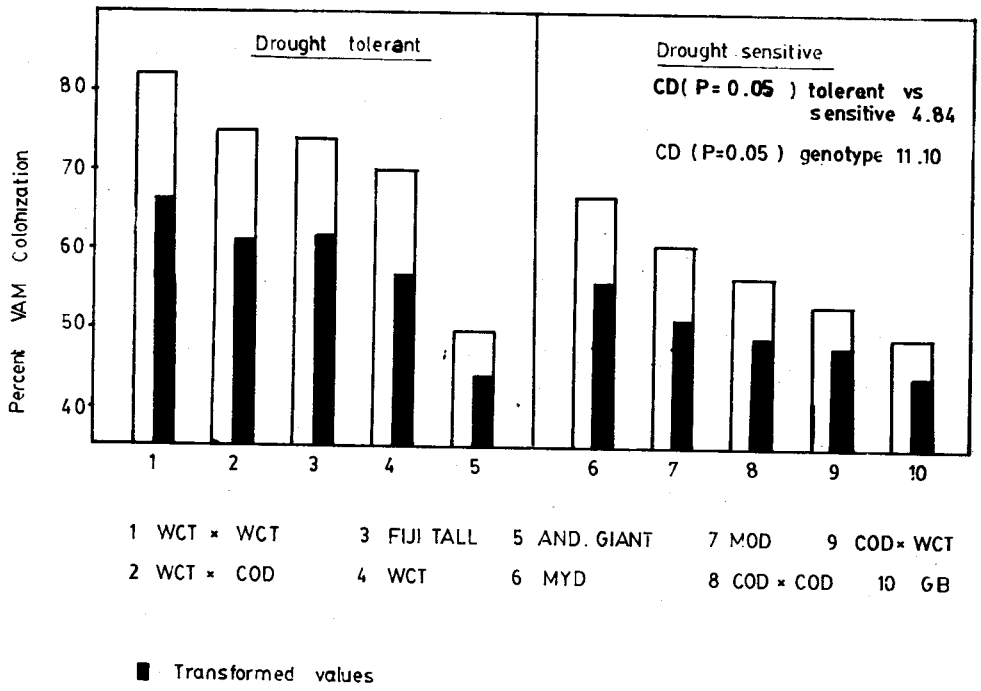

Fig. 1 VAM colonization in relation to drought tolerance in coconut cultivars and hybrids.

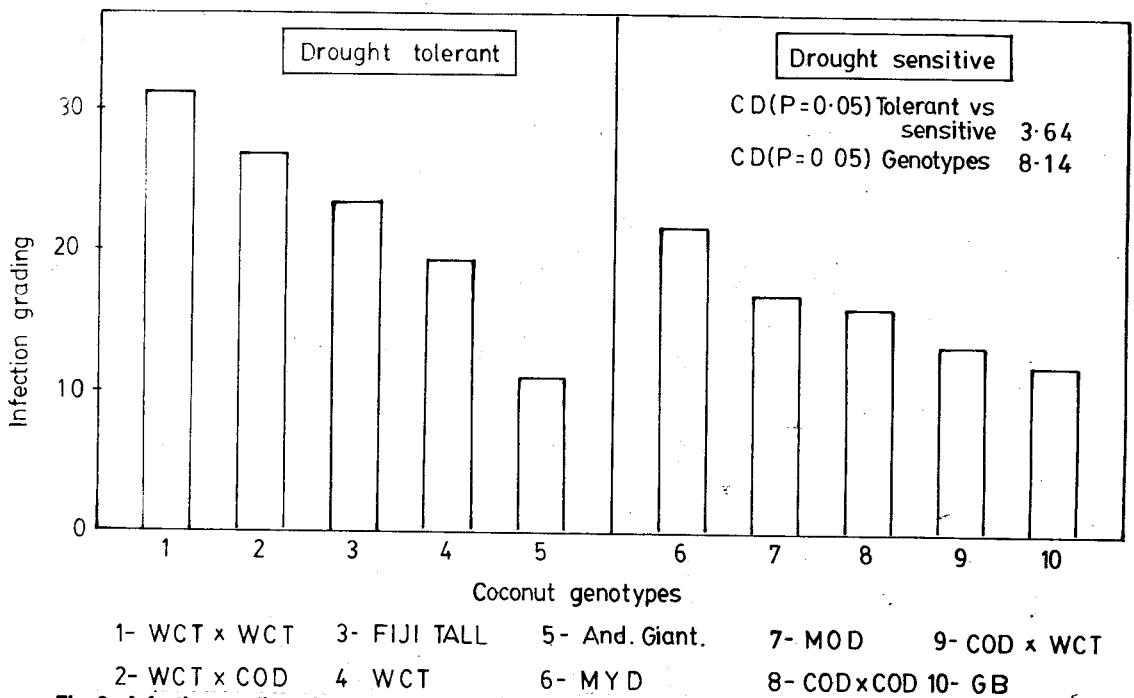

Fig. 2 Infection grading of VAM in relation to drought tolerance in coconut cultivars and hybrids

WCT) are maintained by the Physiology Division with the recommended agronomic practices as mentioned above. Root and soil samples were collected from five replicate palms of each hybrid. Soil samples were obtained from 0-25 cm depth at a distance of one meter using soil auger.

Root samples were cut into one cm long segments, fixed in FAA (1:1:14), cleared in 10% KOH, neutralised with 1% HCL and stained in 0.5% solution of trypan blue in lactoglycerol (Phillips and Hayman, 1970). The proportion of root samples infected was determined microscopically by root slide technique (Nicolson, 1959). Intensity of infection was determined in terms of infection grading on the basis of the length of root traversed by the VAM fungus (Giovanetti and Mosse, 1980). Number of spores of VAM fungi in air dried soil samples were determined by wet-sieving and decantation technique (Gerdeman and Nicolson, 1963). Soil moisture content was determined gravimetrically.

RESULTS AND DISCUSSION

Certain cultivars/hybrids of coconut were reported to be tolerant to drought as characterised by high stomatal resistance with low transpiration rate and high water potential (Rajagopal *et al.*, 1990). The number of roots having VA-mycorrhizal colonization was significantly more in drought tolerant genotypes when compared to that in the sensitive genotypes (Fig. 1). The hybrids, WCT x WCT and WCT x COD and the tall cultivars, Fiji Tall and WCT from the tolerant group showed a higher level of colonization in the range of 70-80%. Maximum colonization of 80.2% was recorded in WCT xWCT. In drought susceptible group, the dwarfs MOD and GB and the hybrids COD x WCT and COD x COD had significantly lower percentage of roots (48-60%) with VAM colonization than the tolerant genotypes. The intensity of VAM infection, as measured by infection grading was also high in drought tolerant group with a mean grading of 22.4 compared to 16.5 in the sensitive group (Fig. 2).

Studies on the distribution of roots with different intensities of infection revealed higher percentage of roots in all the four categories viz., 1-25, 26-50, 51-75 and 76-100% in the tolerant group when compared to that in the sensitive group (Table I). The cultivars/hybrids in the tolerant group had more than 15% roots with more than 50% colonization compared to 8% in the sensitive group.

Table I. Distribution of roots with different intensities of infection in drought tolerant and drought sensitive genotypes of coconut

Cultivar/hybrid	Root segments (%)			
	1-25% infection	26-50% infection	51-75% infection	76-100% infection
Drought tolerant				
WCT x WCT	31.2	26.1	17.9	5.4
WCT x COD	33.1	18.8	16.0	6.8
Fiji Tall	36.3	23.6	12.3	3.2
Andaman Giant	28.9	17.6	2.5	0.0
WCT	35.8	19.8	11.2	1.3
Mean	33.1	21.2	12.0	3.3
Drought sensitive				
COD x WCT	33.2	16.2	5.2	0.4
COD x COD	31.8	15.5	3.8	2.5
MOD	32.2	20.5	9.4	2.0
MYD	27.9	25.3	10.3	3.6
GB	31.0	14.7	4.2	0.4
Mean	31.2	18.4	6.6	1.8

It is evident from the study that the cultivars/hybrids which were characterized as drought tolerant had a greater proportion of roots with VAM colonization, marked by a higher intensity of infection, than the drought sensitive ones. Pai *et al.* (1990) reported maximum mycorrhizal colonization in cowpea roots under severe moisture stress. Studies on a number of annual crops using VAM inoculated and uninoculated plants at different moisture levels revealed that colonization by VAM fungi conferred growth advantage on host plants under drought donditions (Safir and Nelsen, 1984; Bethlenfalvay *et al.*, 1988). The VAM effect on growth during drought is attributed to the ability of VAM roots to take up water that is unavailable to the root alone and to the improved P nutrition due to the limited diffusion of P in dry soils (Nelsen and Safir, 1982). However, there are no reports concerning mycorrhizal root colonization and drought tolerance in perennial crops.

Comparison of the VA-mycorrhizal colonization in different cultivars and hybrids irrespective of the grouping also revealed significant difference in percentage root colonization and intensity of infection. The tall cultivars and hybrids having tall cultivars as female parents had significantly higher level of VAM colonization than dwarfs and hybrids having dwarfs as female parents, indicating varietal dependent preference for VAM colonization in coconut. In an earlier study, on the basis of observations on coconut seedlings, Thomas and Ghai (1987) reported varietal dependent variation in VA-mycorrhizal association of coconut.

The percentage VAM colonization and intensity of infection also varied significantly in the three hybrids, COD x WCT, MYD x WCT and MOD x WCT (Fig. 3) when examined during stress and poststress periods. The proportion of VAM colonized roots as well as infection intensity were significantly more in MYD x WCT when compared to the other two hybrids while MOD x WCT was superior to COD x WCT in VAM colonization. MYD x WCT and MOD x WCT also maintained higher population of spores in their root region than COD x WCT at all the three periods of analysis. The relatively low moisture content in the basins of MYD x WCT indicated higher uptake of water by this hybrid in comparison to the other hybrids during stress period. This is in agreement with the report of Sieverding (1981) that mycorrhizal root colonization will be more beneficial under limited water supply conditions. Apparently, the high degree of VAM colonization in the roots of drought tolerant cultivars/hybrids indicated the occurrence of a more extensive mycorrhizal system in these genotypes to explore more area in soil for the absorption of nutrients and water unavailable to the root system with a low level of root colonization. From a pot culture trail, Bethlenfalvay *et al.*(1988) reported a greater level of water depletion by *Glomus mossae* inoculated soybean plants when compared to uninoculated ones.

The cultivars/hybrids with higher level of mycorrhizal colonization also had higher stomatal resistance and leaf water potential, the two characters directly associated with drought tolerance in plants. The correlation between the parameters were significant (Table II.). Similar comparative studies between mycorrhizal colonization and water relations of plants are reported in *Bouteloua gracilis* (Allen *et al.* 1981), citrus (Levy and Krikun, 1980), red clover (Harche and Leyton, 1981) and onion (Nelsen and Safir, 1982). According to the authors the uptake and transport of water are influenced by presence of mycorrhizae in roots, while most of the above studies were carried out with inoculation of VAM, the present investigation has attempted to relate the natural occurrence of VAM in coconut roots with drought tolerance under field conditions.

Table II. Correlation between physiological parameters and VAM colonization in coconut

Parameter	Stomatal resistance	Water potential
Percent VAM colonization	0.4717**	0.3366*
Infection grading of VAM	0.4288**	0.3414*

* Significant at 5%; ** Significant at 1%

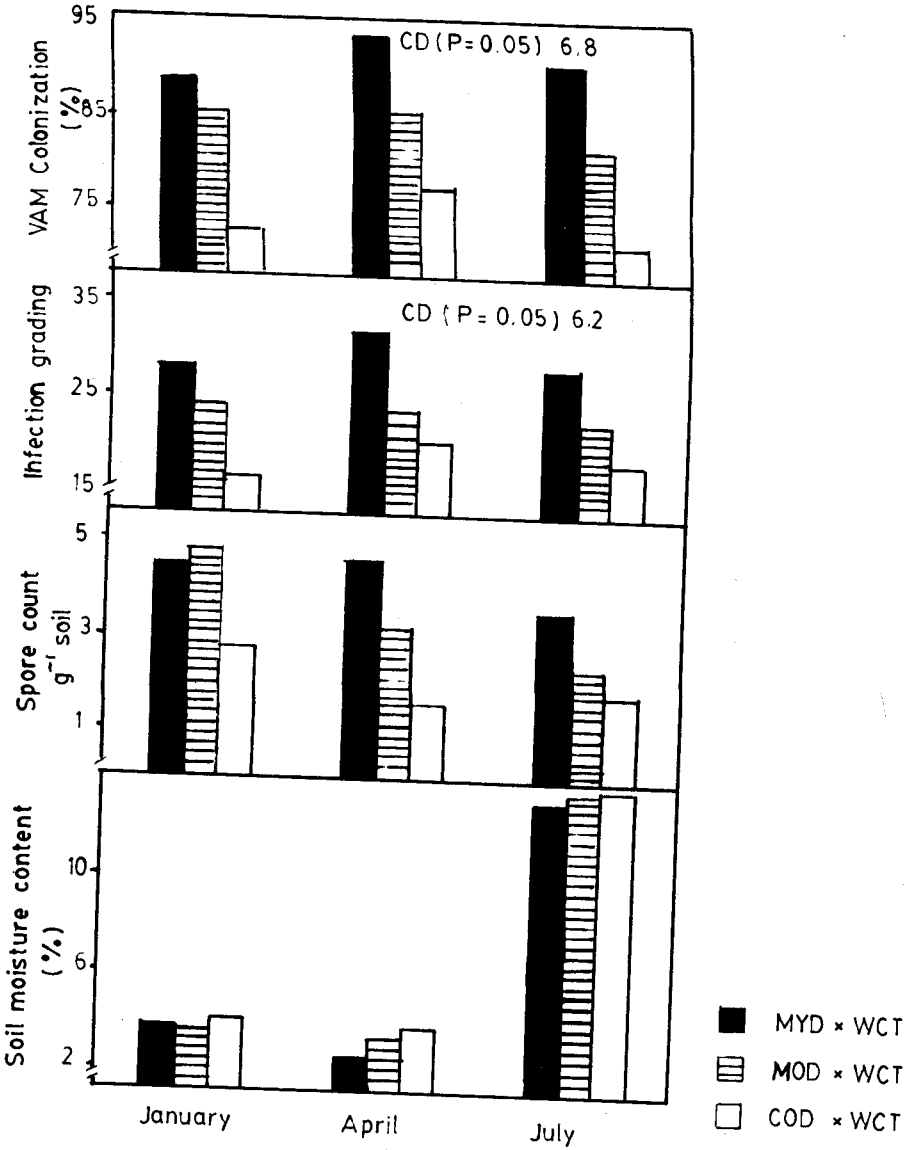

Fig. 3 VAM association in relation to soil (0-25 cm) moisture content in three coconut hybrids during stress and non-stress periods

REFERENCES

ALLEN, M.F., SMITH, W.K., MOORE, T. S. Jr. and CHRISTENSEN, M, 1981. Comparative water relations and photosynthesis of mycorrhizal and non-mycorrhizal *Bouteloua gracilis*. *New Phytol.* **88** : 683-693.

BETHLENFALVAY, G. J., BROWN, M.S., AMES, R.N. and THOMAS, R.S. 1988. Effects of drought on host and endophyte development in mycorrhizal soybeans in relation to water use and phosphate uptake. *Physiol. Planta.* **72** : 565-571.

GERDEMAN, 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.

GIOVANETTI, M. and MOSSE, B. 1980. An evaluation of techniques for measuring vesicular-arbuscular mycorrhizal infection in roots. *New Phytol.* **84** : 489-500.

HARDIE, K. and LEYTON, L. 1981. The influence of vesicular arbuscular mycorrhiza on growth and water relations of red clover. *New Phytol.* **89** : 599-608.

KRISHNA, K. R. and BAGYARAJ, D. J. 1984. Mycorrhiza and plant water relations in *Arachis hypogaea*. Proc. 6th North American Conference on Mycorrhizae. 25-29 June, 1984. Oregon, p. 371.

LEVY, Y. and KRIKUN, J. 1980. Effects of vesicular-arbuscular mycorrhiza on *Citrus jambhiri* water relations. *New Phytol.* **85** : 25-31.

MOSSE, B, 1981. Vesicular-arbuscular mycorrhiza research for tropical agriculture. Research Bull. 194. Hawaii Inst. Trop. Agric. and Human Resources. Univ. of Hawaii, 82 pp.

NELSEN, C. E. and SAFIR, G.R. 1982. Increased drought tolerance of onion plants caused by improved phosphorus nutrition. *Planta* **154** : 407-413.

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.

PAI, G., BAGYARAJ, D.J. and PRASAD, T. G. 1990. Mycorrhizal reproduction as influenced by moisture stress. In Current Trends in Mycorrhizal Research. eds. Jalali, B.L. and Chand, H., HAU, Hissar pp. 25-26.

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.

RAJAGOPAL, V., KASTURI BAI, K. V. and VOLETI, S.R. 1990. Screening of coconut genotypes for drought tolerance. *Oleagineux.* **45** : 215-223.

SAFIR, G. R. and NELSEN, C. E. 1984. VA mycorrhizas, plant and fungal water relations. Proc. 6th North Am. Conf. Mycorrhizae, Bend, Oregon, USA (ed. Molina) pp. 161-164.

SIEVERDING, E. 1981. Influence of soil water regimes on VA mycorrhizae. *Z. Acker-und Pftanzenban* **150** : 400-408.

THOMAS, G. V. and GHAI, S. K. 1987. Genotype dependent variation in vesicular-arbuscular mycorrhizal colonization of coconut seedlings. *Proc. Indian Acad. Sci. (Pl. Sci.)* **97** : 289-294.