EFFECT OF FERTILIZER AND IRRIGATION ON VESICULAR-ARBUSCULAR MYCORRHIZAL ASSOCIATION IN COCONUT*

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The effect of NPK fertilizers and irrigation on vesicular-arbuscular mycorrhizal (VAM) association in coconut cultivars, West Coast Tall (WCT) and hybrids WCT x Chowghat Orange Dwarf (WCTxCOD) and COD x WCT, was studied in an acidic sandy loam soil. There was 32.7% reduction in VAM colonization at the recommended level of fertilizers and 55.5% reduction at the higher level of application. Fertilizers also adversely affected the intensity of mycorrhizal infection in roots and spore counts in root region soils. WCT was superior to the two hybrids in harboring VAM in its roots followed by WCT x COD and COD x WCT. Root colonization by VAM and infection grading were more during the pre-monsoon period when compared to the post-monsoon period. Coconut palms which received irrigation in summer months exhibited higher level of association with VAM when compared to unirrigated palms.

INTRODUCTION

The role of vesicular-arbuscular mycorrhizae (VAM) in increasing the uptake of phosphorus and other nutrient elements such as sulphur, calcium, zinc, and copper particularly from soils of low fertility has been well established (Mosse 1981). There are also reports to indicate the role of VAM in alleviating drought effects in crop plants under stress conditions (Bethlenfalway et al. 1988). A number of factors are known to influence the incidence and intensity of VAM association in various crops (Hayman 1975). A better understanding of the fluctuation of their population under different management practices is essential for their effective utilization in crop production.

Coconut (*Cocos nucifera* Linn.) is an important plantation crop grown in many tropical countries. The incidence of VAM in coconut (Johnson 1949; Lilly 1975) and variation in mycorrhizal association due to genotypic differences (Thomas and Ghai 1987) and mixed cropping with tree spices (Ramesh and Rohini Iyer 1979) have already been reported. The present study reports the effect of different levels of fertilizers and irrigation on VA mycorrhizal association in the popular cultivar, WCT and the two released hybrids, COD x WCT and WCT x COD.

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MATERIALS AND METHODS

The coconut palms in the genotype-nutrient interaction experiment started in 1965 at Central Plantation Crops Research Institute, Kasaragod, India were selected for the study. The soil of the plot is acidic sandy loam of medium phosphorus status. Palms were divided into 18 treatments comprising of three genotypes under three nutrient levels in irrigated and rainfed conditions. The coconut cultivar, West Coast Tall (WCT), and hybrids, Chowghat Orange Dwarf x WCT (COD x WCT) and WCT x COD were planted in 1965 at a spacing of 7.5 x 7.5 m. The fertilizer treatments in the experiment included graded levels of NPK *viz.* M_o (No fertilizer), M_1 (500g N + 500g P_2O_5 + 1000g K_2O/ palm/ year) and M_2 (1000g N + 1000g P_2O_5 + 2000g K_2O/ palm/year). The N is being applied in the form of urea, P as single super phosphate, and K as muriate of potash, in two split doses *viz.* one-third in May and two-thirds in September every year. A set of palms under each treatment was maintained under irrigation I_1 (irrigated with 20 mm water per week) and another set under rainfed condition (I_1). Three replicate palms were sampled from each treatment both in the pre-monsoon (March 1990) and post-monsoon (September 1990) period, and the undamaged feeder rootlets were collected. Soil samples were obtained from basins as a lateral distance of 1 m from the bole of the palm at a depth of 0-25 cm with the help of a soil auger. One composite sample was obtained by pooling samples from three locations in the basin.

To determine the extent of colonization by VAM fungi, 35 root segments were taken from each replication. The samples were processed as per the method described by Koske and Gemma (1989). The proportion of root infected by VAM was determined microscopically by the root slide technique (Nicolson 1959). Percent mycorrhizal colonization was determined as per the following formula:

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

Intensity of infection (infection grading) was calculated based on the length of the root traversed by the VAM fungus (Giovanetti and Mosse 1980).

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

RESULTS

Table 1 presents the data on the changes in the percentage mycorrhizal colonization due to fertilizer application and irrigation for coconuts grown under field condition. The colonization percentage was significantly lower in palms which received the recommended level of fertilizers (M) when compared to that in unfertilized palms (M_0). The colonization observed under the higher dose of fertilizers (M_2) was significantly lower than that in M_1 treatment. The extent of reduction was 32.7% at M_1 level and 55.5% at M_2 level when compared to that in M_0. It was evident from the data that fertilizer application adversely affected VAM symbiosis in the cultivar WCT and the hybrids, COD x WCT and WCT x COD.

There was significant variation in the VAM colonization in the roots of three genotypes of coconut. The percentage colonization was more in roots of WCT (43.6) as compared to that in WCT x COD (40.46) and COD x WCT (33.7). Comparative study of irrigated and unirrigated palms revealed the positive influence of irrigation on VAM colonization in roots of coconut. Irrigation caused a greater increase in mycorrhizal colonization particularly at M_1 and M_2 fertilizer treatments. It was also evident from the data that the palms, in general, maintained a higher level of colonization during the pre-monsoon period when compared to the post-monsoon period. The percentage VAM colonization was significantly higher at M_0 level in all the three genotypes during the pre-monsoon period as compared to the post-monsoon period.

The data on the intensity of root infection measured in terms of infection grading are presented in Table 2. The adverse effect of fertilizers was also reflected in the intensity of infection. In all the three genotypes, infection grading in M_1 and M_2 fertilizer treatments was significantly lower than that in M_0 treatment. However, the difference in the grading in the two fertilizer treatments was not significant. Comparison of infection grading in the three genotypes revealed significantly higher grading in WCT (11.5) followed by that in WCT x COD (9.9) and COD x WCT (6.7). The intensity of infection was also higher in irrigated palms as compared to that in rainfed palms.

The occurrence of VAM fungal spores in the root region soils of three genotypes of coconut under different fertilizer and irrigation treatments are presented in Table 3. The spore counts in M_0 and M_1

TABLE 1. Percentage VAM colonization in three genotypes of coconut as influenced by fertilizer application and irrigation

		PRE-MONSOON			POST-MONSOON					
	Treatments	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean
WCT	M_0	72.38	66.66	69.52	54.29	48.57	51.43	63.33	57.62	60.48
	M_1	35.24	60.00	47.62	34.29	40.00	37.14	34.76	50.00	42.38
	M_2	20.95	40.00	30.48	18.10	33.34	25.72	19.52	36.67	28.10
	Mean	42.86	55.55	49.21	35.56	40.63	38.10	39.21	48.09	43.65
COD X WCT	M_0	51.43	61.91	56.67	41.90	36.19	39.05	46.67	49.05	47.86
	M_1	34.28	30.48	32.38	31.43	35.24	33.33	32.86	32.86	32.86
	M_2	16.19	21.91	19.05	11.43	32.38	21.90	13.81	27.14	20.48
	Mean	33.97	38.10	36.03	28.25	34.60	31.43	31.11	36.35	33.73
	M_0	56.19	80.00	68.10	53.33	44.76	49.04	54.76	62.38	58.57
	M_1	22.86	52.38	37.62	33.33	40.00	36.66	28.09	46.19	37.14
	M_2	19.04	33.34	26.19	14.28	36.19	25.24	16.66	34.76	25.72
	Mean	32.70	55.24	43.97	33.65	40.32	36.98	33.17	47.78	40.48
	Mean									
	M_0	60.00	69.52	64.76	49.84	43.17	46.51	54.92	56.35	55.63
	M_1	30.79	47.62	39.21	33.02	38.41	35.71	31.90	43.01	37.46
	M_2	18.73	31.75	25.24	14.60	33.97	24.29	16.67	32.86	24.76
	Mean	36.51	49.63	43.07	32.49	38.52	35.50	34.50	44.07	39.29

C.D. (P = 0.05) for Pre-monsoon vs. Post-monsoon, Rainfed vs. Irrigated = 6.11
C.D. (P = 0.05) for Genotypes, Fertilizer level = 7.48

TABLE 2. Effect of fertilizers and irrigation on the intensity of infection (infection grading) in the three genotypes of coconut

		PRE-MONSOON			POST-MONSOON					
	Treatments	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean
WCT	M_0	26.00	29.24	27.62	12.00	12.00	12.00	19.00	20.62	19.81
	M_1	5.62	14.57	10.09	5.81	11.33	8.57	5.71	12.95	9.33
	M_2	4.57	8.28	6.43	2.47	6.09	4.28	3.52	7.19	5.36
	Mean	12.06	17.36	14.71	6.76	9.81	8.28	9.41	13.59	11.50
COD X WCT	M_0	14.76	15.91	15.33	8.86	6.48	7.67	11.81	11.19	11.50
	M_1	6.67	4.19	5.43	4.57	6.29	5.43	5.62	5.24	5.43
	M_2	1.90	3.81	2.85	1.62	5.81	3.71	1.76	4.81	3.28
	Mean	7.78	7.79	7.87	5.02	6.19	5.60	6.40	7.08	6.74
WCT X COD	M_0	12.10	26.10	19.10	9.81	15.81	12.81	10.95	20.95	15.96
	M_1	4.19	15.05	9.62	5.90	8.86	7.38	5.05	11.95	8.50
	M_2	3.71	8.57	6.14	2.38	6.47	4.43	3.05	7.52	5.29
	Mean	6.67	16.57	11.62	6.03	10.38	8.20	6.35	13.48	9.91
Mean	M_0	17.62	23.75	20.68	10.22	11.43	10.82	13.92	17.59	15.74
	M_1	5.49	11.27	8.38	5.43	8.83	7.13	5.46	10.05	7.76
	M_2	3.40	6.89	5.14	2.16	6.13	4.14	2.78	6.51	4.64
	Mean	8.84	13.97	11.4	5.94	8.79	7.36	7.39	11.38	9.38

C.D. (P = 0.05) for Pre-monsoon vs. Post-monsoon, Rainfed vs. Irrigated = 2.59
C.D. (P = 0.05) for Genotype, Fertilizer level = 4.49

TABLE 3. Effect of fertilizers and irrigation on the spore counts of VAM fungi in the root region soils of three coconut genotypes

		PRE-MONSOON			POST-MOON					
	Treatments	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean
WCT	M_0	87.00	84.67	85.84	128.33	110.33	119.33	107.67	97.50	102.59
	M_1	83.67	84.00	83.84	101.00	108.33	104.67	92.33	96.17	94.26
	M_2	76.00	53.33	64.67	95.33	99.33	97.33	85.67	76.33	81.00
	Mean	82.22	74.00	78.11	108.22	106.00	107.11	95.22	90.00	92.61
COD X WCT	M_0	82.33	80.67	81.5	105.33	91.33	98.33	93.83	85.83	89.92
	M_1	82.67	79.67	81.17	96.00	98.00	97.00	89.33	88.33	89.09
	M_2	53.67	77.00	65.00	68.67	71.00	69.84	61.17	74.00	67.42
	Mean	72.89	79.11	76.00	90.00	86.78	88.39	81.44	82.89	82.20
WCT X COD	M_0	83.33	82.67	83.00	118.33	101.33	109.83	100.83	92.00	96.42
	M_1	80.67	81.67	81.17	104.67	106.67	105.67	92.67	94.17	93.43
	M_2	79.67	77.33	78.5	89.33	96.00	92.67	84.50	86.67	85.59
	Mean	81.22	80.56	80.89	104.11	101.33	102.72	92.67	90.94	91.81
Mean	M_0	84.22	82.67	83.44	117.33	100.89	109.11	100.78	91.78	96.28
	M_1	82.33	81.78	82.06	100.56	104.33	102.44	91.44	93.06	92.25
	M_2	69.78	69.22	69.50	84.44	88.78	86.61	77.11	79.00	78.06
	Mean	78.78	77.89	78.33	100.78	98.00	99.38	89.78	87.95	88.86

C.D. (P = 0.05) for Pre-monsoon vs. Post-monsoon = P9.36
C.D. (P = 0.05) for Fertilizer level = 11.46
C.D. (P = 0.05) for Irrigated vs. Rainfed, genotypes = NS

treatments did not vary significantly, whereas there was significant reduction in counts in M_2 treatments as compared to that in M_0 and M_1 treatments. Comparison of the spore counts obtained from the root region of the three genotypes did not reveal any significant difference among them in harboring the spores. The difference in the spore counts in the root region of rainfed and irrigated palms was also not found to be significant. The data also revealed a higher level of spore population in post-monsoon period when compared to that in pre-monsoon period.

DISCUSSION

Studies on the mycorrhizal association in the coconut cultivar WCT, and hybrids (COD x WCT and WCT x COD) in relation to fertilizer application revealed the adverse effect of fertilizer application on VAM symbiosis in coconut. Presumably, with the addition of mineral fertilizers, the nutrients become readily available to plants and the natural system of absorbing mycorrhizal structure is retarded. High soil P level is known to be detrimental for the symbiotic establishment of VAM. Mosse and Philips (1971) observed reduction in VAM colonization due to the application of phosphatic fertilizers. Rhodes and Gerdemann (1980) showed that mycorrhizal infection intensity was inversely correlated to soil P level and at very high P fertility, the root system of normally mycorrhizal plants was sparsely infected. Similarly, the application of nitrogenous fertilizers was also found to decrease the colonization by VAM in *Araucaria cunninghammi* (Bevege 1971).

The nutrient status of the soil of the present experiment was reported by Khan et al. (1986). The levels of major nutrients were reported as: mineralization nitrogen - 75.0, 80.3 and 86.3 ppm; phosphorus - 15.3, 63.63, and 96.7 ppm; and potassium - 18.7, 55.3 and 70.7 ppm, at M_0, M_1, and M_2 levels, respectively. The continuous application of fertilizers in the experimental plot has resulted in the buildup of a high concentration of P and K in coconut basin soil, but there was no buildup of N. A recent study from the same plot also corroborated these observations (Sajeev 1990). This suggests that the low level of colonization observed in the present study could be due to the higher level of the P in the soil. The adverse effect of fertilizers on the VAM association in white clover (Lim and Cole 1984), chickpea (Jalali and Thareja 1985), and bell pepper (Waterer and Coltmann 1989) has been reported. The yield data reported earlier from the same experiment revealed an average yield of 35 nuts per palm per year in the M_0 treatment without any fertilizer application, compared to 79.4 and 86.5 nuts in M_1 and M_2 levels (Khan et al. 1986). The present study revealed maximum mycorrhizal colonization in M_0 treatment indicating a higher level of dependence by the crop on VAM in the absence of fertilizer additions. The VAM colonization gradually decreased with the increase in the dose of fertilizers.

Mycorrhizal colonization and infection grading were significantly different in the three genotypes of coconut viz. WCT, COD x WCT, and WCT x COD (Table 1-3). WCT was superior to the two hybrids in harboring VAM in its roots. The present results are in agreement with an earlier report on higher proportion of roots with VAM in seedlings of tall cultivars as compared to the dwarfs and hybrids (Thomas and Ghai 1987). The fact that the three genotypes differed in the colonization of VAM, although they were grown under identical conditions, reflects on the probable influence of genetic factors controlling the host/fungus compatibility. The variation in VAM colonization could arise from the differences in the physiological and biochemical characteristics of the root system, which are controlled by the genetic constitution of a particular cultivar/hybrid. Similar genotype dependent variation in mycorrhizal colonization has been reported in wheat (Clark 1983), pearl millet (Krishna et al. 1985), and pea (Estaun et al. 1987).

The present study also revealed the favorable influence of irrigation in summer months on VAM symbiosis in coconut. Allen et al. (1989) reported increased root length and mycorrhizal colonization in two tussock grasses, *Agropyron desertorum* and *Elymus spicatus* up to certain levels of moisture. The mycorrhizal colonization in the irrigated palms in the present study was particularly high under fertilizer treatments when compared to that in unirrigated palms. The increase in colonization under irrigated conditions may be due to the lowering of the effect of high doses of fertilizers by dilution and also due to the movement of fertilizers from the surface to the lower layers of soil under irrigated conditions. However, the interaction effects of fertilizer treatments, irrigation, and genotypes on percentage colonization, intensity of infection, and spore counts were found to be insignificant. The present study has showed that mycorrhizal association in coconut was greatly influenced by management practices and genotypic variation of the host, and pointed to the need to take into consideration these factors in order to enhance the benefits from the natural mycorrhizal system for the nutrition of the palm.

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