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The Role of *Glomus fasciculatum* and Soil Water Conditions on Growth of Soybean and Maize

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The effects of *Glomus fasciculatum* and soil water condition were studied in soybean and maize. Two harvests were carried out to measure the growth response and mycorrhizal colonization. *G. fasciculatum* increased plant and grain dry weights at both harvests of the two plants but the response was not always statistically significant. There was no interaction observed between inoculation and soil water condition. Reduction in soil water condition reduced the percentage of mycorrhizal colonization and consequently reduced plant and grain dry weights in inoculated treatment. Similarly in uninoculated controls, soil water condition decreased both plant and grain dry weights.

Key words: *Glomus fasciculatum*, soil water conditions, soybean, maize

Most studies on beneficial effects of arbuscular mycorrhizal fungi (AMF) on plant growth are mainly concentrated on the ability of the fungi to improve P uptake in P deficient soils. Other aspects such as improving water used, however, have not been extensively explored. Allen *et al.* (1981) and Allen & Boosalis (1983) reported that AMF influenced the efficiency of water use in both grasses and wheat. Furthermore Ellis *et al.* (1985) reperted that AMF inoculation incresed biomass production of both shoot and root whiat.

In an effort to increase the productivity of crop plants on irrigated arable land in Indonesia, a study was carried out on the beneficial effect of *Glomus fasciculatum* on maize and soybean under different soil water conditions.

MATERIALS AND METHODS

Materials. Top soil (0 to 20 cm) of latosol soil was collected from Cimanggu Garden. Soil was sieved through 5 mm wire mesh and autoclaved at 121°C for one hour. After sterilization, soil was limed with 500 kg $CaCO_3$ per ha soil. Eight kg soil was placed in a plastic pot for soybean and 10 kg soil was for maize. The day before sowing, the soil was given basic fertilizer contained urea (25 kg/ha), TSP (100 kg/ha), and KCl (100 kg/ha). An addition of 25 kg/ha urea was also applied after 30 days of sowing.

Methods. Ten percent by weight of inoculum of *Glomus fasciculatum* was used. The inoculum consisted of soil, spores and dried roots applied under the seeds. After the seeds germinated, plants were thinned to one plant per pot. Two inoculation treatments were used i.e.: inoculated by *G. fasciculatum* and uninoculated treatment. Four water condition treatments were conducted, they were 20%, 40%, 60%, and 80% of field capacity. A split-plot design with three replicates per treatment was used.

The experiment was carried out in a glass house with temperature ranging between 28-35°C and a day length of 10 – 14 hours. To keep the soil water conditions steadily the pots with plant were weighed and watered daily. Two harvests were conducted, they were 6 and 9 weeks for soybean and 9 and 12 weeks for maize.

At harvest, shoots and roots were detached. one to two gram samples of roots were staned by trypan blue for measurement of mycorrhizal colonization. The rest of the roots and shoot were oven dried at 70°C until the plant dry weight was constant. Clearing and staining of roots followed the method of Koske & Gemma (1989) and total and infested root lengths were determined by the method of Giovannetti & Mosse (1980).

RESULTS

Soybean. In general, there was no significant interaction between *G. fasciculatum* inoculation and soil water conditions for both soybean and maize. In soybean, *G. fasciculatum* inoculation did not significantly affect the production of shoot (leaves and stem) and root dry weights at early harvest (6 weeks after sowing). At later harvest, however, plant dry weight and total dry grain of soybean increased significantly after inoculation by *G. fasciculatum*. Root dry weight of inoculated plants at later harvest was in general, higher than that of uninoculated plants but the difference was not statistically significant (Table 1).

Maize. *G. fasciculatum* inoculation had no effect. Plant and root dry weight and yield production of inoculated plants were higher than those of uninoculated controls but the difference was not statistically significant at both early and later harvests (Table 2).

Soil Water Conditions. Soil water conditions had significant effects on plant growth in both soybean and

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Table 1. Biomass of soybean plants at 6 and 9 weeks after sowing

Treatments	Plant age (weeks)				
	6 weeks		9 weeks		
	Root dry weight (g)	Stem & leaves dry weight (g)	Root dry weight (g)	Stem & leaves dry weight (g)	Total dry grain (g)
Glomus fasciculatum	0.68	3.05	1.26	7.75a	5.69a
Uninoculated	0.61	0.27	0.84	6.39bc	4.74b
Water conditions					
80%	0.72a	3.85a	1.48	8.80a	7.47a
60%	0.69ab	3.12ab	1.39	8.77a	5.22a
40%	0.64ab	2.50b	0.71	6.58b	4.52b
20%	0.52b	2.18b	0.62	4.13c	3.67b

Figures in the same column followed by the same letter or by no letter are not significantly different ($p < 0.05$).

Table 2. Biomass of maize plants at 9 and 13 weeks after sowing

Treatments	Plant age (weeks)				
	9		13		
	Root dry weight (g)	Stem & leaves dry weight (g)	Root dry weight (g)	Stem & leaves dry weight (g)	Total dry grain (g)
Glomus fasciculatum	4.02	36.79	5.33	35.73	18.78
Uninoculated	3.93	30.00	4.51	33.80	17.8
Water conditions					
80%	5.48a	39.88a	6.08	40.78a	23.26a
60%	4.57a	35.25ab	5.33	35.57ab	19.56b
40%	5.50ab	31.27	4.38	33.47ab	16.84b
20%	2.35b	27.18b	3.87	29.23b	13.51c

Figures in the same column followed by the same letter or by no letter are not significantly different ($p < 0.05$).

maize. The decrease in soil water availability from 80% to 20% of field capacity reduced plant dry weight up to 50% in soybean (Table 1) and 35% in maize (Table 2).

Mycorrhizal Colonization. There was a reduction on mycorrhizal colonization under low soil water conditions for both plants, but the effect was not statistically different. At the lowest level of soil water condition (20%) the percentage of mycorrhizal colonization was almost half of that of at 80% of field capacity treatment (Table 3). The reduction in mycorrhizal colonization in the lowest water condition was closely related to the reduction in plant and grain dry weighs at the two harvests of both soybean and maize (Table 1,2, and 3).

DISCUSSION

It has been reported that inoculation by AMF increased growth of water-stressed plants. It was also showed that inoculation with either of the two species of AMF, *G. fasciculatum* and *G. deserticola*, was equally effective in

Table 3. Percentage of mycorrhizal colonization of soybean and maize inoculated with *Glomus fasciculatum* at several weeks after sowing

Soil water conditions (%)	Mycorrhizal colonization (%)			
	Soybean		Maize	
	6 weeks	9 weeks	9 weeks	13 weeks
80	59	64	68	68
60	43	56	67	60
40	41	55	50	46
20	31	43	34	38

Figures in the same column followed by no letter are not significantly different ($P<0.05$).

promoting growth of wheat during and after water-stress (Ellis *et al.* 1985). In this experiment plants did not experience water stress even at the lowest level of soil water condition (20% of field capacity). In fact, in both soybean and maize inoculation by *G. fasciculatum* relatively increased plant growth in all levels of soil condition, but the difference was so small therefure there was no significant interaction between *G. fasciculatum* inoculation and soil water treatments.

The effect of *G. fasciculatum* was only significant in soybean at later harvest. This may be due to the increase in its root colonization. The percentage of root colonization at later harvest, in general, was higher in all levels of soil water condition compared to that of in early harvest.

The percentage of root colonization decreased by reducing soil water condition at the two harvests of both soybean and maize. Nelson & Safir (1982) found that sporulation in stressed plant was reduced by the same proportion as was in plant weight. However, Simpson & Daft (1990) reported that arbuscular mycorrhizal colonization level was not affected by water-stress and host effect varied amongst the inoculum. *G. fasciculatum* is the only arbuscular mycorrhizal fungus used in this experiment. Therefore, comparison amongst isolates cannot be made. Looking at the root colonization, both soybean and maize were colonized by the fungus at almost the same level. This indicates that this fungus is an effective inoculum in terms of root colonization.

Small responses in promoting plant growth of the *G. fasciculatum* in this experiment may have been due to the adequate nutrition in the growth medium particularly P fertilizer since basic fertilizer applied at the beginning of this experiment may be too much. Therefore the plant was not deficient in nutrients particularly P. It is known that mycorrhizas are more effective in promoting growth of a host plant in low P content than in higher ones. High level of root colonization have often been related with low soil P content (Daniels *et al.* 1984).

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