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MYCORRHIZAL STATUS OF SOME BANGLADESH SOILS AND THE EFFECT OF INDIGENOUS VA-MYCORRHIZAL FUNGI ON THE GROWTH OF RICE PLANTS

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Abstract

Number of mycorrhizal endogone spores ranged between 13.4 and 220 per 100 g air dried soil in ten representative Bangladesh soils. The presence of greater number of spores was always associated with the incidence of abundant mycelia. The formation of spores and mycelia was restricted by low soil pH. Soil sterilization by heating at 105C for 24 hrs completely inhibited the infection of rice roots by indigenous mycorrhizal fungi. Mycorrhizal infection greatly improved the growth and nutrient (nitrogen, phosphorus and zinc) contents of rice plants.

Introduction

Very few soils are entirely free from VA-endophytes. Exceptions are those that have been inundated or remained water logged for long periods (Mosse 1981). Various environmental factors, however, modify the number of spores and fungal mycelia in soil. It is a fact that VA-mycorrhizal fungi are able to increase growth in a number of agricultural crops (Mosse 1973, Gerdemann 1975 and Tinker 1975). Sanni (1976) demonstrated the increase in growth of rice plants, inoculated with *Gigaspora gigantea.*

The present work was conducted to monitor the status of indigenous endogone spores and mycelia in ten representative Bangladesh soils under diverse cropping pattern and to evaluate the effect of the indigenous mycorrhiza on the growth and nutrition of rice plants.

Materials and Methods

Soil samples were collected at a depth of 0 to 15 cm from ten different locations during the dry season 15 to 20 days after the harvest of the standing crops. The number of spores and mycelial fragments was estimated using wet

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seiving technique devised by Gerdemann and Nicolson (1963) and Mosse and Bowen (1968). The results have been expressed on air dry soil basis.

Four of the ten soils were used for the culture of rice plants in pots. BR-3 variety of rice, collected from Bangladesh Rice Research Institute, was used as the test crop. Two sets of experiments were conducted –in one set, pots contained sterilized soils and in the other non-sterilized soils. Sterilization was done by heating the soils at 105C for 24 hrs. The experimental soils were prepared by mixing two parts of soil with one part of sand. The sand was pretreated with acid and washed with distilled water subsequently. Pots of 4 kg capacity were used and 3 kg soil-sand samples (2 kg soil with 1 kg sand) were taken in each pot. Each of the experiments was repeated thrice.

Required amount of calcium hydroxide was added to the soil (except Ghatail soil) to bring the pH up to 6.0 as pH value below this is considered to be low for efficient establishment of VA-mycorrhiza. The soils were fertilized with nitrogen and potassium at the rate of 100 kg N and 40 kg K/ha, the sources being urea and muriate of potash, respectively. Ten seeds were sown per pot and thinned to five after germination. The plants were sampled at 28, 56 and 70 days after the emergence of seedlings. The dry weights of the aerial parts of the rice plants (dried at 65 C for 24 hrs) were taken and the shoots were analysed for N, P and Zn following the methods described by Piper (1966).

The roots of the sampled plants were dug very carefully to get most of the finer roots. Root samples were cleaned, cut into 1 cm segments (Hayman *et al.* 1976) and stained according to the method described by Phillips and Hayman (1970). The root segments were then observed under a binocular microscope at a low magnification. The infected and uninfected root segments were counted and per cent infection was calculated.

For mycorrhizal plants (grown in non-sterilized soils), mycorrhizal dependency values were calculated according to the method devised by Plenchette *et al.* (1983). It has been designated relative field mycorrhizal dependency (RFMD) index and was determined by expressing the difference between dry weights of mycorrhizal and that of non-mycorrhizal plants. The results have been expressed as a percentage of dry weight of mycorrhizal plant.

Results and Discussion

Names of the selected soil series, the existing vegetation, soil pH and the mycelial status with the number of spores are presented in Table 1. The results show that the incidence of spores and mycelia varied considerably among the soils. The minimum, 13.4 spores per 100 g air dried soil, was obtained under grassland vegetation in Gerua soil and the maximum, 220 spores per 100 g air dried soil, was obtained under 'Khesari' in Ghatail soil. It was observed that legumes (except lentil) generally stimulate the formation of mycorrhizal spores and mycelia than grass and cereal crops.

Table 1. Vegetation, pH, mycelial status and number of spores in different soils.

Soil series	Existing vegetation	Soil pH (water ext)	*Mycelial status	Number of spores (per 100 g air dried soil)
Savar Bazar	Blackgram	5.3	++	39.2
Sonatala	Lentil	5.3	++	26.0
Pahartali	Blackgram	6.0	+++	158.0
Naraibag	Lentil	5.5	++	30.5
Ghatail	Khesari	6.3	+++	220.0
Gerua	Grass land	4.5	+	13.4
Salna	,,	5.0	++	24.0
Tejgaon	,,	5.4	++	35.1
Noadda	T. Aman	5.1	++	28.2
Chandra	,,	4.8	+	16.2

*Mycelial status : + = scanty, ++ = moderate, +++ = abundant.

All the spores counted in the present study were white or honey coloured and were either smooth or reticulate. It was also observed that the formation of mycorrhizal spores and mycelia is significantly affected by low soil pH. The minimum number of spores was obtained in Gerua soil having an acid reaction (pH 4.5) while the maximum number was in Ghatail soil with a pH of 6.3. A highly significant positive correlation (significant at 0.1% level) was found between soil pH and number of mycorrhizal spores. That pH influences the number of VAM spores and mycelia has been reported by Mosse (1981). She observed that *Glomus mosseae*, an endophyte species, would not generally colonize in soils of pH less than 5.6. It is also apparent that the presence of a greater number of spores is always associated with the presence of abundant mycelia and vice-versa.

Mycorrhizal infection : The incidence of mycorrhizal infection in the rice roots was counted and per cent infection was calculated. It was found that roots of rice plants grown in sterilized soils were not infected at all. Hence, it was concluded that soil sterilization by heating at 105C is sufficient to inhibit the root infection by indigenous mycorrhizal fungi. However, considerable mycorrhizal infection was observed in the roots of rice plants grown in non-sterilized soils. The per cent infection increased gradually with increasing plant age, the rate reaching more than 50 per cent by 70 days.

VAM formation was more in soils having low available phosphate than in soils having comparatively higher amounts of available phosphate (Table 2). The correlation coefficients, calculated between per cent root infection and availabe phosphate contents of the soils, were negative in nature and significant at 1 per cent level. Similar relationships were noticed by a number of investigators.

Table 2. Available phosphate content of soils and per cent VAM infection in rice roots.

Soil series	Available phosphate (ppm)	Per cent root infection		
		28	56	70
Naraibag	19.2	24	35	54
Sonatala	20.5	18	34	52
Ghatail	23.0	15	32	52
Chandra	13.0	26	42	58

Daft and Nicolson (1966) applied different amounts of phosphate to soil and sand cultures, respectively and found that the mycorrhizal infection and the beneficial effects of VA-mycorrhiza on the host plant were inversely related to the amount of available phosphate. Murdoch *et al.* (1967) and Jensen and Jakobsen (1980) reached a similar conclusion by adding phosphates of varying availability to soils.

Effect of VAM on the growth and nutrient status of rice plants : Shoot dry weight was considered as the index of growth parameter. Besides, phosphorus, nitrogen and zinc uptake by rice plants were also estimated to evaluate the effect of indigenous VA-mycorrhiza. For mycorrhizal plants, mycorrhizal dependency values were calculated and has been designated as relative field mycorrhizal dependency (RFMD) index. The shoot dry weights of rice plants grown both in sterilized and non-sterilized soils and the per cent RFMD for mycorrhizal rice plants are presented in Table 3.

Table 3. Shoot dry weight and per cent RFMD for rice plants.

Soil series	* Sterili-zation	Shoot dry wt (g/plant)			** Per cent RFMD		
		Days after emergence of seedlings					
		28	56	70	28	56	70
Naraibag	—	0.89	0.89	2.20	18.75	30.34	34.09
	+	0.26	0.62	1.45			
Sonatala	—	0.29	0.82	2.16	13.79	28.05	29.17
	+	0.25	0.59	1.53			
Ghatail	—	0.29	0.88	2.31	20.69	29.55	31.60
	+	0.24	0.62	1.58			
Chandra	—	0.34	0.84	2.04	23.53	34.52	34.63
	+	0.26	0.55	1.34			

*Sterilization : — = non-sterilized soil (mycorrhizal condition), + = sterilized soil (non-mycorrhizal condition).

$$** \ \% \ RFMD = \frac{\text{(Dry wt of mycorrhizal plant)—(Dry wt of non-mycorrhizal plant)}}{\text{Dry wt of mycorrhizal plant}} \times 100$$

Marked differences were observed between the shoot dry weights of mycorrhizal and that of the non-mocorrhizal plants. At 70 days after emergence of seedlings, shoot dry weight of mycorrhizal plants were 2.2, 2.16, 2.31 and 2.05 g/plant, respectively for Naraibag, Sonatala, Ghatail and Chandra soils and that of non-mycorrhizal plants were, 1.45, 1.53, 1.58 and 1.34 g/plant respectively. At the same period of growth, per cent RFMD for rice plants were 34.09, 29.17, 31.60 and 34.63 in the above soils, respectively. The difference in growth is quite marked (Fig. 1.)

Values for phosphorus, nitrogen and zinc contents in rice shoots are presented in Table 4. It was found that root infection by VAM fungi greatly improved P, N and Zn uptake by rice plants at all the three stages of growth. The effect of mycorrhizal infection on P uptake was most pronounced. However, differences in the uptake of nitrogen and zinc between mycorrhizal and non-mycorrhizal rice plants were also marked.

In fact, the nutritionally significant function of VA-mycorrhiza depends on soil exploration by fungal hyphae. Because of a very large surface to volume ratio, hyphae produce an extra and well distributed absorbing surface. This extra surface is particularly important for phosphate uptake by the plant because this ion is readily sorbed on clay complexes and diffuses very slowly in soils which helps in developing a depletion zone around the actively absorbing rootlet. Hyphae of the VA-mycorrhizal fungi explore the soil beyond the depletion zone and transport the phosphate into the roots. It has already been reported that VA-mycorrhizal infection can also induce a better uptake of nutrients other than phosphate. However, direct mycorrhizal effects on mineral nutrition may well be limited to those elements which have a poor mobility.

Fig. 1. Effect of sterilization on the growth of rice plants.

Improvement of phosphorus uptake by mycorrhizal plants was reported by Islam and Ayanaba (1981), Bagyaraj and Sreeramulu (1982), Jensen (1983), Nielsen and Jensen (1983) and Jensen (1984). Except for legumes, the improvement of N uptake by plants due to VAM infection has yet not been reported. However, the better uptake of nitrogen by rice plant due to indigenous VAM infection might be justified as the exudates from mycorrhizal roots stimulate the fixation of atmospheric N by free-living rhizosphere microorganisms (Mosse 1981). The improvemet of zinc uptake due to VAM infection has been reported by Daft and Hacskaylo (1977), Swaminathan and Verma (1979) and Bagyaraj and Sreeramulu (1982).

Table 4. Phosphprus, nitrogen and zinc contents of rice shoots.

Soil series	Sterili-zation	mg P/plant			mg N/plant			mg Zn/plant		
		Days after emergence of seedlings								
		28	56	70	28	56	70	28	56	70
Naraibag	−	0.54	1.87	7.70	6.27	25.81	35.64	17	19	23
	+	0.24	0.66	2.62	4.29	12.71	17.11	12	13	14
Sonatala	−	0.52	1.80	7.78	5.22	23.45	34.34	16	18	21
	+	0.25	0.68	2.65	4.00	11.51	17.44	11	13	16
Ghatail	−	0.46	1.76	7.59	5.22	24.86	36.96	16	18	20
	+	0.29	0.73	2.81	3.94	12.28	18.49	11	12	16
Chandra	−	0.48	1.60	5.95	6.29	24.19	33.83	16	19	22
	+	0.21	0.63	2.40	4.03	9.96	14.47	10	12	14

It is thus, concluded that the indigenous VA-mycorrhizal spores and mycelia present in many Bangladesh soils are capable of infecting rice roots and VAM infection improves the growth and nutrition of rice plants.

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