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RESEARCH ARTICLE

ARBUSCULAR MYCORRHIZAL STATUS OF UPLAND RICE IN JHUM CULTIVATION OF RI-BHOI DISTRICT, MEGHALAYA

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ABSTRACT

AMF status of two local upland rice varieties, *Kba Soh-pieng (KP*) and *Kba Saw (KS)* was investigated from two sites (Site I-KP1 and KS1; Site II- KP2 and KS2)in the year 2012. Site I exhibited higher AMF colonization in comparison to those in Site II. In site I, the colonization ranged from 24.05% to 70.77% in KP1 and 28.00% to 76.01% in KS1 whereas in Site II, the AMF colonization ranged from 21.90% to 70.36% in KP2 and 24.76% to 71.64% in KS2. In both the varieties of site I and II, the percent AMF colonization was lowest during the initial stage of plant development that increases gradually and it was highest during the booting and maturation period i.e., in the month of September and October2012.ANOVA shows no significant variation in AMF colonization in different varieties of the same sites. While, there was significant variation in the same varieties at different sites.

INTRODUCTION

Arbuscular mycorrhizal fungi (AMF) comprise one of the main components of soil microbiota in most agroecosystems. These obligate mutualistic symbionts colonize the roots of most plants, including agricultural crops (Smith and Read., 1997). The importance of AMF in the improvement of crop plant is well documented. It is known that AMF enhance plant nutrient acquisition, improves soil quality, growth performance and productivity of the plants. The effectiveness of AMF on the growth and nutrient acquisition of rice grown under upland condition has also been reported by many workers (Gao *et al*., 2007; Herdler *et al*., 2008; Purakayastha and Chhonkar 2001; Zhang *et al.*, 2005). Rice plants readily form mycorrhizal associations under upland conditions (Rajeshkannan *et al*., 2009; Ilag *et al*., 1987). There are several reports on AMF association of rice plants under greenhouse and field conditions. However, no such studies have been conducted on AMF association of upland rice under shifting cultivation locally known as *jhum* cultivation which is the main upland rice cropping system in the hilly areas of Ri-Bhoi district Meghalaya. Therefore, the present investigation was conducted to study the mycorrhizal status of two upland rice varieties in Jhum cultivation.

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MATERIALS AND METHODS

Site description and field sampling

The roots and rhizospheric soils of two local upland rice varieties namely K*baSoh-Pieng (KP)* and *Kba Saw (KS)* were collected from two different sites of Nongpoh (25°52′15.1′′N, 91°53′17.9′′ E), Ri-Bhoi, Meghalaya. Site I is a freshly slashed and burnt land prepared for cultivating rice (first year of *jhumming*) and Site II is a *jhum* fallow field which was abandoned for 3 years and then again brought under shifting cultivation where ginger was grown primarily and continued in the second year where rice was grown as a sequential crop to ginger (second year of *jhumming*). Both the varieties were planted in each site (Site I- KP1 and KS1; Site II- KP2 and KS2) and sampling was done at monthly intervals starting in the month of June, thirty days after sowing up to the harvesting stage in November. From each sampling site, rhizospheric soils and roots of ten plants per site were randomly selected with sampling points approximately 5 m apart, mixed, kept in sterile polythene bags and transported to the laboratory for analysis.

Analysis of AMF colonization

Roots were washed thoroughly in tap water and cut into approximately 1 cm segments. The roots were then cleared in 10% (w/v) KOH by heating at 90ºC for 20 min.

It is then washed and stained with trypan blue (Phillips and Hayman, 1970). The stained root samples were mounted with lactoglycerol on microscope slides and examined for AM fungal structure under light microscope. AMF colonization in the form of arbuscules, vesicles and hyphae were quantified by the magnified intersections method of McGonigle *et al*. (1990) and expressed it in percentage.

Statistical analysis

Data were statistically analyzed using one-way ANOVA. Pearson correlation coefficient was employed to determine the relationships between AMF colonization and soil physico-chemical properties. Standard errors of means were calculated.

Soil physico-chemical analysis

Soil temperature was recorded in the field at the time of sampling. Soil moisture content was determined by drying 10 g fresh soil at 105°C for 24 h in a hot-air oven. Soil pH was determined using a digital pH meter. Organic carbon and total nitrogen of the soil were determined using methods outlined in Anderson and Ingram (1993). Soil exchangeable potassium was estimated using flame photometer method of Jackson (1973). Available phosphorus of soil was estimated by molybdenum blue method of Allen *et al*. (1974)

RESULTS

Both the rice varieties KP and KS grown in the two sites harbored AMF association and the extent of AMF colonization varied between the varieties and the sites. Site I exhibited higher AMF colonization in comparison to those in Site II Table 1.

In Site I, the colonization ranged from 24.05% to 70.77% in KP1and 28.00% to 76.01% in KS1whereas in Site II the AMF colonization ranged from 21.90% to 70.36% in KP2and 24.76% to 71.64% in KS2.Initial drop in AMF colonization was observed in the month of June and then gradually increases and reached its maximum at the booting and maturation stage i.e., in the month of September and October.

However, a slight decreased in AMF colonization was observed at the harvesting stage. Root colonization was characterized by the presence of hyphae, arbuscules and vesicles. Both the varieties in the two different sites, the percentage of arbuscular colonization was found to be higher followed by hyphal and vesicular colonization. Initially both vesicles and arbuscules were less in number. The arbuscules increased with age and were maximum at the booting stage; thereafter a slight decreased in arbuscular colonization at maturity was observed. On the other hand, number of vesicles increased slowly with age and reached to maximum at maturity. Whereas, hyphal colonization was maximum at the initial stage of plant development. ANOVA shows no significant variation (P <0.05) in AMF colonization in different varieties of the same sites. While, there was significant variation in the same varieties at different sites. In KP1, AMF colonization showed a positive correlation with moisture content (r = 0.86, p <0.05) and negative correlation with K (r= −0.80, p <0.05) similarly, a positive correlation with moisture content (r = 0.75, p <0.05) and negative correlation with K (r= −0.94, p <0.05) was recorded in KS1. In KP2, AMF colonization showed a negative correlation with K (r = −0.79, p <0.05) and N (r= −0.87, p <0.05), in KS2, AMF colonization showed a negative correlation with K (r = −0.84, p <0.05).

Table 1. Mean AMF colonization (%) in KP and KS rice varieties of Site I and II.Values in parenthesis indicate the minimum and maximum range

Sites	Rice Varieties	Arbuscules	Vesicles	Hyphea	AMF
Site I	KP1	23.15 ± 5.70	8.18 ± 2.08	19.70 ± 1.66	51.03 ± 7.79
		(9.97-44.29)	(1.23-15.21)	(12.85-22.31)	(24.05-71.77)
	KS1	24.38 ± 5.80	9.36 ±2.36	20.13 ±1.96	53.87 ± 8.18
		(10.07-44.59)	(1.50-15.51)	(14.79-24.66)	(28.00-76.01)
Site II	KP2	20.50 ±3.96	8.34±2.34	19.39 ± 1.09	48.22 ± 8.04
		(6.77-35.66)	(0.80-15.04)	(14.33-23.02)	(21.90-70.36)
	KS2	20.80 ± 4.78	8.87 ± 2.54	19.39 ± 1.33	49.06 ± 7.98
		(7.13-34.39)	(0.22-14.91)	(13.52-23.51)	(24.76-71.64)

Table 2. Mean values of soil physico-chemical properties of KP and KS rice varieties in Site I and II. Values in parenthesis indicate the minimum and maximum range

Sites	Rice Varieties	MC (%)	Temp (˚C)	pH	OC (%)	N (%)	P (%)	K (%)
Site I	KP1	20.63± 1.44	27.97±1.84	5.86±0.05	1.89±0.03	0.33±0.02	0.0051±0.0003	0.13±0.008
		(15.13 – 25.53)	(22-35.3)	(5.72-6.10)	(1.77-2)	(0.29-0.40)	(0.0038-0.0059)	(0.10-0.16)
	KS1	20.58 ±1.39	28.17±1.76	5.88±0.05	1.95±0.04	0.33±0.02	0.0050±0.0003	0.12±0.01
		(15.17 -24.90)	(22.3-35.6)	(5.76-6.12)	1.78-2.1	(0.28-0.41)	(0.0038-0.0060)	(0.09-0.17
Site II	KP2	20.44±1.02	28.66±1.42	5.35±0.06	1.48±0.07	0.22±0.01	0.0039±0.003	0.09±0.01
		(16.65 – 23.86	(23-33.6)	(5.14-5.49	(1.27-1.7)	(0.19-0.29)	(0.0030-0.0050)	(0.06-0.12)
	KS2	20.38 ± 1.10	28.70±1.42	5.37±0.05	1.50±0.07	0.23±0.01	0.0039±0.0003	0.08±0.01
		(16.31-24.03)	(23-33.8)	(5.18-5.49)	(1.25-1.72)	(0.19-0.30)	(0.0028-0.0052)	(0.05-0.13)

Note: MC = Moisture content; Temp = Temperature; OC = Organic carbon; N =total Nitrogen; P =Available Phosphorus; K = Exchangeable Potassium.

All the soil physico-chemical properties were higher in Site 1 except soil temperature which was higher in Site II. Moisture content, available P and exchangeable K were higher in KP1 whereas pH and organic carbon was higher in KS1. Total N was higher in KP1 and KS1 Table 2.

DISCUSSION

Although it has been reported that AMF association may be reduced due to disturbance (Brundrett, 1991; Gould *et al*., 1996) a high level of mycorrhizal association was observed in both the rice varieties grown in different sites of *jhum* field indicating the importance of mycorrhizal association in upland rice.

A high percentage of AMF colonization in shifting cultivated soil was also reported by Songachan and Kayang (2011). Forest conversion by means of slash- and –burn followed by cultivation does not affect much on AMF colonization (Aguilar-Fernández *et al*., 2009). Bellgard *et al*. (1994) suggested that moderate fires had no significant impact on the infectivity of AMF. However, the AMF colonization in this study was found to reduce significantly in site II which involved intensive agricultural practice. Continued jhumming and cultivating in the same piece of land may have resulted in the destruction of AMF propagules and unfavourable edaphic conditions for regeneration of AMF (Singh *et al*., 2003).Varieties also differed in AMF colonization and ranked differently depending on the location. Jakobsen and Nielsen (1983) reported that AMF root colonization varies greatly in different plant species grown in different types of soils. Colonization of a root system by AMF is influenced by a variety of potential mechanisms, including biological characteristics of rhizosphere under host species, host cultivar susceptibility to root infection, specific habitat conditions, AMF diversity and species composition, climatic and edaphic factors such as season, soil fertility, pH, temperature, soil moisture, soil organic matter and nutrient demand of the host (Wu *et al*., 2009; Stajerova *et al*., 2009; Gange *et al*., 1990; Muthukumar and Udaiyan, 2002).

AMF colonization in roots changes across phenological stages of plants (Schalamuk *et al*., 2004; Singh *et al*., 2008). In both the varieties of site I and II, the percent AMF colonization was lowest during the initial stage of plant development, which increases gradually and it was highest during the booting and maturation period i.e, in the month of September and October The increase in AMF colonization as the host matures as found in both the varieties of site I and II was also earlier reported by Rajeshkannan *et al*. (2009); Ammani *et al*. (1985); Hayman (1970) and Mason (1964). In both KP and KS varieties of site I and II, number of arbuscles was found to be maximum at booting stage of the plant, a stage of active growth. The arbuscules are considered to be the preferential site for fungus-plant metabolite exchange (Cox *et al.,* 1975). The high percentage of vesicular colonization at maturity may be for their survival, as presence of intra-radical vesicles in the infected roots increase the inoculum potential of the infected root (Biermann and Lindermann, 1983).

Hyphal colonization increases during the initial stage of the rice varieties. deCarvalho-Niebel *et al*. (2002) also reported that AMF colonization in rice at the germination stage starts with the establishment of hyphal structures, which ensures contact with the host root and establishment of symbiosis. In all the study sites, negative correlation between K and AMF colonization was observed which is in agreement with Oliveira and Oliveira (2010). Significant positive correlation was observed between AMF colonization and moisture content in KP1 and KS1. Lingfei *et al*. (2005) and Lugo *et al*. (2003) suggested that moisture content is an important factor influencing AMF colonization. A positive correlation between soil moisture and AMF colonization was also reported by Jha *et al.* (1992).

Conclusion

The study reveals both the rice varieties KP and KS grown in the two sites harboured AMF colonization indicating the importance of AMF association in upland rice. It also reveals that first year *jhumming* followed with rice cultivation does not affect much on the AMF community and its colonization. Whereas, continuous cultivating in the same piece of land coupled with short fallow period causes a decrease in AMF colonization in upland rice.

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REFERENCES

Aguilar-Fernández, M., Víctor, J. J., Varela-Fregoso, L. and Gavito, M. E. 2009. Short-term consequences of slash-and-burn practices on the arbuscular mycorrhizal fungi of a tropical dry forest.Mycorrhiza*,* 19: 179-186.

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. and Quaramby, C. 1974. Chemical analysis of ecological materials.Blackwell Scientific Publications, Oxford.

Ammani, K., Venkateswarlu, K. and Rao, A.S. 1985. Development of vesicular- arbuscularmycorrizal fungi on upland rice variety. *Curr. Sci.,* 54(21): 1120-1122.

Anderson, J.M. and Ingram, J.S.I. 1993. Tropical soil biology and fertility: A handbook of methods. CAB International, Oxford.

Bellgard, S. E., Whelan, R. J. and Muston, R. M. 1994. The impact of wildfire on vesicular-arbuscular mycorrhizal fungi and their potential to influence the re-establishment of post-fire plant communities.Mycorrhiza*,* 4: 139-146.

Biermann, B. and Linderman, R.G. 1983. Use of vesicular–arbuscularmycorrhizal roots, intraradical vesicles and extraradical vesicles as inoculum. *New Phytol.,* 95:97–105.

Brundrett, M. 1991. Mycorrhizas in natural ecosystems. *Adv.Ecol. Res.,* 21: 171–313.

Cox, G., Sanders, F.E., Tinker, P.B. and Wild, J.A. 1975. Ultrastructural evidence relating to host endophyte transfer in a vesicular arbuscular mycorrhiza. In

"Endomycorrhizas', Ed. By Sanders, F.E. Mosse, B. and Tinker, P.B., Academic Press, London, pp. 297-312.

deCarvalho-Niebel, F., Timmers, A.C.J., Chabaud, M., Defaux-Petras, A. and Barker, D.G. 2002. The Nod factor-elicited annexin MtAnn1 is preferentially localized at the nuclear periphery in symbiotically activated root tissues of *Medicagotruncatula*. Plant J., 32: 343–352.

Gange, A.C., Brown, V.K. and Farmer, L.M. 1990. A test of mycorrhizal benefit in an early successional plant community. NewPhytol., 115: 85-91.

Gao, X., Kuyper, T.W., Zou, C., Zhang, F.S. and Hoffland, E. 2007. Mycorrhizal responsiveness of aerobic rice genotypes is negatively correlated with their zinc uptake when nonmycorrhizal. *Plant Soil.,* 290:283–291.

Gould, A.B., Hendrix, J.W. and Richard, S.F. 1996. Relationship of mycorrhizal activity to time following reclamation of surface mine land in western Kentucky. 1. Propagule and spore population densities. Can. J. Bot., 74:247-261.

Hayman, D.S. 1970. Endogone spore numbers in soil and vesicular arbuscular mycorrhiza in wheat as influenced by season and soil- treatment. *Trans. Brit. Mycol. Soc.,* 54: 53-63.

Herdler, S., Kreuzer, K., Scheu, S. and Bonkowski, M. 2008. Interactions between arbuscular mycorrhizal fungi (*Glomus intraradices*, Glomeromycota) and amoebae (*Acanthamoebacastellanii*, Protozoa) in the rhizosphere of rice (*Oryza sativa*). Soil Biol.Biochem., 40:660–668.

Ilag, L.L., Rosales, A.M., Elazegvi, F.V. and Mew, T.W. 1987. Changes in the population of infective endomycorrhizal fungi in a rice based cropping system. *Plant Soil*, 103: 67-73.

Jackson, M.L. 1973. Soil chemical analysis. Prentice Hall of India, Private Limited, New Delhi, pp. 496.

Jakobsen, I. and Nielsen, N.E. 1983. Vesicular arbuscular mycorrhiza in field grown crops. 1. Mycorrhizal infection in cereals and peas at various times and soil depths. New *Phytol.,* 93:401-413

Jha, D.K., Sharma, G.D. and Mishra, R.R. 1992. Ecology of soil microflora and mycorrhizal symbiont in degraded forests at two latitudes. Biol.Fertil. Soils, 12: 272-278

Lingfei, L., Anna, Y. and Zhiwei, Z. 2005. Seasonality of arbuscular mycorrhizal symbiosis and dark septate endophytes in a grassland site in southwest China.FEMS *Microbiol. Ecol.***,** 54: 367–373.

Lugo, M.A., Maza, M.E.G. and Cabello, M.N. 2003. Arbuscular mycorrhizal fungi in a mountain grassland II: Seasonal variation of colonization studied, along with its relation to grazing and metabolic host type. *Mycologia*, 95: 407-415.

Mason, D.T. 1964. A survey of numbers of Endogone spores in soil cropped with barley, raspberry and strawberry. Hortic. Rec., 4: 98-103.

McGonigle, T. P. and Fitter, A.H. 1990. Ecological specificity of vesicular- arbuscular mycorrhizal associations. *Mycol. Res.*, 94: 120–122.

Muthukumar, T. and Udaiyan, K. 2002. Seasonality of vesicular arbuscularmycorrhizae in sedges in a semi-arid tropical grassland. *Acta.Oecol.,* 23:337-347.

Oliveira, A.N. and Oliveira, L. A. 2010. Influence of edaphic-climatic factors on the sporulation and colonization of arbuscular mycorrhizal fungi in two Amazonian native fruit species. *Braz. Arch.Biol. and Tech.,* 53: 653–661.

Phillips, J.M. and Hayman, D.S. 1970. Improved procedures for clearing roots and staining parasitic and vesicular–arbuscular mycorrhizal fungi.*Trans. Br. Mycol. Soc.,* 55: 158–160.

Purakayastha, T. J. and Chhonkar, P. K. 2001. Influence of vesicular– arbuscularmycorrhizal fungi (*Glomus etunicatum* L.) on mobilization of zinc in wetland rice (*Oryza sativa* L.). BiolFertil Soils*,* 33:323–327.

Rajeshkannan, V., Sumathi, C.S. and Manian, S. 2009.Arbuscular Mycorrhizal Fungi Colonization in Upland Rice as Influenced by Agrochemical Application. *Rice Science*, 16(4): 307–313.

Schalamuk, S., Velásquez, H., Chidichimo, H. and Cabello, M. 2004.Effect of no-till and conventional tillage on mycorrhizal colonization in spring wheat.BolSoc Argent Bot., **39**: 13–20.

Singh, S., Pandey, A., Chaurasia, B. andPalni, L.M.S. 2008. Diversity of arbuscular mycorrhizal fungi associated with the rhizosphere of tea growing in natural and cultivated ecosites. *BiolFertil Soils*, 44:491–500.

Singh, S.S., Tiwari, S.C., and Dkhar, M.S. 2003. Species diversity of vesicular-arbuscular mycorrhizal (VAM) fungi in jhum fallow and natural forest soils of Arunachal Pradesh, north eastern India. *Trop. Ecol.,* 44(2): 207-215.

Smith, S. E., and Read, D. J. 1997. Mycorrhizal symbiosis, 2nd ed. Academic Press Ltd., London, England.

Songachan, L.S. and Kayang, H. 2011. Diversity and species composition of arbuscularmycorrhizal fungi in *Flemingiavestita* under shifting and continuous cropping system *NeBio.,* 2(4): 1-8.

Stajerova, K., Smilauerova, M. and Smilauer, P. 2009. Arbuscularmycorrhizal symbiosis of herbaceous invasive neophytes in the Czech Republic. Preslia, 81: 341-355.

Wu, Y., Liu, T. and He, X. 2009. Mycorrhizal and dark septateendophytic fungi under the canopies of desert plants in Mu Us Sandy Land of China. FrontAgric China, 3(2): 164-170.

Zhang, X.H., Zhu, Y.G., Chen, B.D., Lin, A.J., Smith, S.E. and Smith, F.A. 2005. Arbuscularmycorrhizal fungi contribute to resistance of upland rice to combined metal contamination of soil. *J. Plant. Nutr.,* 28:2065–2077.

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