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Original Article

Influence of Flooding on the Survival of Arbuscular Mycorrhiza

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A study was conducted for two consecutive years (2004-2005 and 2005-2006) at Ullapara, Shirajgonj particularly in onion growing flooded area to know the status of arbuscular mycorrhizal fungi (AM) in flooded soil. Twenty farmers were selected for two years who cultivated onion in their fields after flood. Soil samples were collected just after removing of flood water. Again rhizosphere soils with roots of onion were collected from the same plots. After assessment of these samples, two years' results indicate that there is a plenty of AM spores in flooded soil. It proves their ability to survive in flooded condition and after flooding heavy colonization in onion roots was observed. Higher spore population was also recorded from the rhizosphere soils of onion.

Keywords: Arbuscular mycorrhiza, flooding, survivability

Introduction

Arbuscular mycorrhizae (AM) are most important type of fungi and have worldwide recognition for their role in plant survival and nutrient cycling in the ecosystem. Arbuscular mycorrhizal fungi have received considerable attention in the literature due to their potential benefits to host plants by enhancing plant nutrient uptake and increasing tolerance to adverse conditions[1]. The potentiality of AM fungi in sustainable agriculture and natural systems has been underlined recently[1]. The fungi absorb inorganic soil nutrients, most notably phosphorus (P), which is translocated to the plant host in exchange for photosynthetically fixed carbon. Arbuscular mycorrhizal hyphae also absorb, utilize and translocate NH_4^+ to the host plant[2]. Plant roots are interconnected by mycorrhizal hyphae through which the nutrients move from one plant to another[3] and AM can mediate interplant transfer of phosphorus[4] and nitrogen[5]. For some mycorrhizae, the extramatrical hyphae produce hydrolytic enzymes, such as proteases and phosphatases that can have an important impact on organic matter mineralization and nutrient availability.

Arbuscular mycorrhiza can improve plant-water relations in water stress situations[6]. The role of AM fungi in the functioning and biodiversity of terrestrial ecosystems has received little attention[7]. Mycorrhizal associations are potential factors determining diversity in ecosystems: they can probably modify the structure and functioning of a plant community, in a complex and unpredictable way[8]. Little is known of the population structure, ecology, crop dependencies, compatibility and many other properties of AM fungi in flooded areas in Bangladesh[9]. The population of AM fungi was generally low after the wet season when the field was inundated for a long period[10]. It was proved that AM fungi could survive under flooded conditions but could not infect the rice root to be beneficial to the rice crop[11]. It is well known that AM fungi are not only useful under seedbed condition but they may be useful under field conditions as because their infections are not completely prevented by continuous flooding[12].

Bangladesh occupies a vast seasonal flooded area. Now, it is essential to determine the mycorrhizal status in flooded soil. Hence, the present work was undertaken to study the effect of flooding on survival and spore population structure of AM fungi and their capability of colonization in onion root.

Materials and Methods

Twenty farmers at Ullapara, Shirajgonj were selected who cultivated onion in their fields after flood. Soil samples were collected during October 2004 and November 2005 from these 20 selected lands just after flooding. The rhizosphere soil samples were assessed to count AM spore population. For this purpose three sub-samples (each measuring 100 g) were assessed from each sample and considered as three replications. The spore population was assessed by wet sieving and decanting method[13]. All the AM spores were isolated from the extract with the help of fine forceps into a watch glass with small quantity of water. The extract, with AM spores, was observed under stereomicroscope and the number of spores was counted. Spore numbers from three replicates were averaged and the result was expressed as the number per 100 g of dry soil.

Again rhizosphere soils with roots of onion were collected from the same plots during 2005 and 2006. Spore population of arbuscular mycorrhizal fungi collected after onion cultivation were assessed. The root samples were processed and stained after

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Koske and Gemma[14]. Percentage of AM colonization was estimated by root slide technique[15]. One hundred root segments were examined for each sample. The stained roots were observed under a compound microscope. A root segment was considered as AM positive if it showed any fungal bodies like mycelium, vesicles and arbuscules. Per cent of root colonization was calculated as follows:

$$\text{Percent root colonization} = \frac{\text{Number of AM positive segments}}{\text{Total number of segments observed}} \times 100$$

Physical and chemical properties were determined of a composite soil sample following ASI method[16].

Results and Discussion

The present study was carried out at Ullapara, Shirajgonj especially in onion growing flooded area to evaluate the status of arbuscular mycorrhizal fungi in flooded soil. Table 1 shows the physicochemical properties of the soil of the region.

In 2004, among 20 soil samples the highest number of spore (180.7) per 100 g of dry soil was recorded from the sample number 17 collected just after flood, which was followed by sample No. 14, 9, 8, 10, 20 and 2 (Table 2). Poor numbers of spores were found in sample No. 12, 3, 19, 1 and 16. In 2005, the highest spore population (150 spore per 100 g soil) was also recorded in the rhizosphere soil sample 17 (Table 3) which was followed by sample numbers 14, 12 and 16. The lowest spore number (5.7 per 100 g soil) was noted in sample number 4.

Table 1. *Physical and chemical properties of soil at Ullapara, Shirajgonj*

Soil variable	Content	Critical level
pH	5.6	
Organic matter (%)	1.34	
Total N (%)	0.07	
Available P (ppm)	45	14
Available S (ppm)	19	14
Exchangeable K (meq/100 ml)	0.09	0.2
Exchangeable Ca (meq/100 ml)	3.4	2
Exchangeable Mg (meq/100 ml)	1.2	0.8
Available Zn (ppm)	1.1	2
Available Cu (ppm)	2.1	1
Available Fe (ppm)	168	10
Available Mn (ppm)	29	5

In 2004, an increasing tendency of spore numbers was observed after cultivation of onion. The highest spore number (281.3 per 100 g soil) was counted in the rhizosphere soil of onion sample No. 17, (Table 2). More than 200 spores per 100 g soil were observed in sample No. 19, 18, 14, 13, 9, 8, 7, 6, 5 and 3 and more than 100 spores were recorded in rest of the soil samples. In 2005, AM spore density was also high in the rhizosphere soils collected after onion cultivation (Table 3), ranging from 62.7 (sample no. 8) to a maximum of 283.3 (sample No. 2) spores per 100 g soil. Most of the soil samples recorded more than 100 spores. Similar observations were reported by Khanam *et al*.[17-18].

Table 2. *Number of arbuscular mycorrhiza (AM) spore in the rhizosphere soil and root colonization (%) of onion collected from Ullapara, Shirajgonj after flooding during 2004-2005*

Farmer	Sample No.	No. of spore/100g soil[a]		Root colonization (%)[b]	AM Structure[c]			
		After flood	After onion cultivation		H	A	V	VS
Noor Mohammed	1	87.3 ± 5.0	110.0 ± 20.8	76.7 ± 8.8	+	+	-	-
Ahazuddin Fakir	2	147.7 ± 9.6	161.7 ± 6.0	70.0 ± 5.8	+	+	-	-
Shamsuddin	3	81.7 ± 9.0	225.0 ± 14.4	90.0 ± 5.8	+	+	-	-
Abdur Rashid	4	113.3 ± 7.3	127.3 ± 13.0	50.0 ± 5.8	+	+	-	-
Chand Mia	5	115.0 ± 7.3	210.0 ± 5.8	60.0 ± 5.8	+	+	-	-
Alam Mia	6	102.0 ± 7.9	216.7 ± 8.8	46.7 ± 8.8	+	+	-	-
Dulu Sarker	7	120.0 ± 2.9	201.7 ± 4.4	86.7 ± 8.8	+	+	-	-
Alam Sarker	8	161.7 ± 15.9	214.3 ± 7.8	86.7 ± 8.8	+	-	-	-
Mukter Hossain	9	164.0 ± 7.4	235.3 ± 7.9	66.7 ± 3.3	+	+	-	-
Kalu Sarker	10	153.3 ± 8.8	188.3 ± 9.3	90.0 ± 5.8	+	-	-	-
Hossain Uddin	11	140.7 ± 5.8	161.7 ± 7.3	60.0 ± 5.8	+	+	-	-
Mozam Sarker	12	69.0 ± 11.6	163.0 ± 7.8	50.0 ± 5.8	+	+	-	-
Hossain Ali	13	127.3 ± 4.3	202.3 ± 11.8	60.0 ± 5.8	+	+	-	-
Shahid Sarker	14	180.0 ± 15.3	252.3 ± 6.7	50.0 ± 5.8	+	+	-	-
Rashid Sarker	15	121.7 ± 13.0	176.3 ± 9.5	80.0 ± 5.8	+	+	+	O
Akab Ali	16	93.0 ± 5.1	134.7 ± 8.7	90.0 ± 5.8	+	+	+	O
Mohabbat Ali	17	180.7 ± 10.6	281.3 ± 7.3	93.3 ± 3.3	+	+	-	-
Rahmat ali	18	114.7 ± 5.5	254.0 ± 7.4	90.0 ± 5.8	+	+	+	O
Maznu Mia	19	84.0 ± 3.8	262.0 ± 7.3	80.0 ± 5.8	+	+	-	-
Kalu Mia	20	148.7 ± 10.9	192.0 ± 6.1	73.3 ± 8.8	+	+	-	-

[a]Spore number are the means ± SE of three independent counts
[b]Percent root colonization, the means ± SE of three independent counts
[c]H = Hyphae; A = Arbuscule; V = Vesicle; VS = Vesicle shaped; O = Oval shaped; S = Spherical shaped

Table 3. *Number of arbuscular mycorrhiza (AM) spore in the rhiozosphere soil and root colonization collected from Ullapara, Shirajgonj after flooding during 2005-2006*

Farmer	Sample No.	No. of spore/100g soil[a]		Root colonization (%)[b]	AM Structure[c]			
		After flood	After onion cultivation		H	A	V	VS
Noor Mohammed	1	44.0 ± 5.9	189.3 ± 7.5	46.7 ± 8.8	-	+	-	-
Ahazuddin Fakir	2	28.0 ± 3.5	283.3 ± 6.0	43.3 ± 3.3	+	+	-	-
Shamsuddin	3	40.0 ± 5.8	151.7 ± 7.3	33.3 ± 8.8	+	-	-	-
Abdur Rashid	4	5.7 ± 1.3	151.7 ± 6.0	80.0 ± 5.8	+	-	-	-
Chand Mia	5	31.7 ± 4.4	182.3 ± 10.4	80.0 ± 5.8	-	+	+	0
Alam Mia	6	79.0 ± 7.1	176.7 ± 14.5	83.3 ± 3.3	+	+	+	0
Dulu Sarker	7	20.0 ± 2.9	143.3 ± 7.3	83.3 ± 3.3	-	+	+	S
Alam Sarker	8	14.0 ± 3.1	62.7 ± 9.3	50.0 ± 5.8	+	-	-	-
Mukter Hossain	9	26.7 ± 4.4	126.7 ± 16.4	83.3 ± 3.3	+	-	+	O
Kalu Sarker	10	20.3 ±3.8	185.7 ± 18.2	80.0 ± 5.8	+	-	+	O
Hossain Uddin	11	46.7 ± 3.3	83.3 ± 7.8	83.3 ± 3.3	+	+	-	-
Mozam Sarker	12	103.3 ± 8.8	175.0 ± 13.2	56.7 ± 3.3	-	+	+	S
Hossain Ali	13	24.0 ± 3.8	166.3 ± 9.5	80.0 ± 5.8	+	-	+	O
Shahid Sarker	14	107.0 ± 9.8	175.7 ± 15.5	80.0 ± 5.8	-	+	+	O
Rashid Sarker	15	78.3 ± 4.4	185.0 ± 18.0	83.3 ± 3.3	+	+	+	S
Akab Ali	16	88.3 ± 6.0	184.0 ± 10.2	43.3 ± 3.3	+	+	-	-
Mohabbat Ali	17	150.0 ± 5.8	196.7 ± 6.0	53.3 ± 3.3	+	+	-	-
Rahmat ali	18	84.0 ± 6.7	165.3 ± 2.9	33.3 ± 8.8	+	-	-	-
Maznu Mia	19	45.0 ± 2.9	99.0 ± 7.8	85.7 ± 3.3	+	+	+	O
Kalu Mia	20	70.7 ± 7.9	97.0 ± 10.1	60.0 ± 5.8	+	+	+	S

[a]Spore number are the means ± SE of three independent counts
[b]Percent root colonization, the means ± SE of three independent counts
[c]H = Hyphae; A = Arbuscule; V = Vesicle; VS = Vesicle shaped; O = Oval shaped; S = Spherical shaped

Data in Tables 2 and 3 represent the percent root colonization of onion collected from different farmers' fields at Ullapara. In 2005, percent root colonization in onion grown under different fields varied from 46.7-93.3% (Table 2). A total of 20 samples were examined with respect to the degree of AM colonization. Most of the onion roots were heavily colonized by indigenous AM fungi under natural conditions in the field. The high root colonization in the present study might be due to structure root system[19] and edapho-climatic conditions[20]. In 2006, the highest colonization was 85.7% (sample No. 19) and the lowest colonization was 33.3% (Table 3). Gaur and Adholeya[21] recorded 85.0% root colonization in onion. Khanam *et al*.[17-18] also reported 83.3 % and 84.4 % natural colonization in onion by indigenous AM fungi.

The mycorrhizal colonization was characterized by the presence of hyphae, vesicles and arbuscules, varied from sample to sample. In 2005, hyphae were found in all samples. Arbuscular were absent in only sample No. 8 and 10. But vesicles were present in only three samples out of the 20 samples. Hyphae, arbuscules and vesicles were found in most of the samples collected in 2006. Both oval and spherical vesicles found in these studies are supported by Muthukumar *et al*.[22-23].

Figure 1 represents the variation in spore numbers. A considerable variation was observed in average spore number recorded after flood and after onion cultivation and also in 1st year (2004-2005) and 2nd year (2005-2006). Maximum spores were counted from the samples collected after onion cultivation compared to samples after flood in both the years. Again, higher number of spores was recorded in 1st year compared to 2nd year at two times (after flood and after onion cultivation).

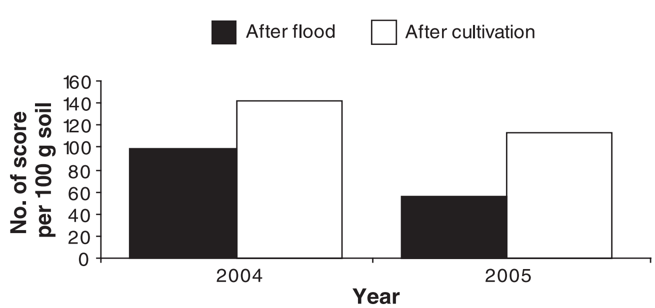

Figure 1. *Variation of arbuscular mycorrhiza (AM) spore number after flood and after onion cultivation during 2004 and 2005.*

Percent root colonization of mycorrhizal fungi differed with year to year (Figure 2). Higher percent root colonization was recorded at 1st year compared to 2nd year.

Figure 3 represents the individual distribution of root colonization of onion during 1st year and 2nd year. Variation in colonization was observed among 20 samples and also in two years.

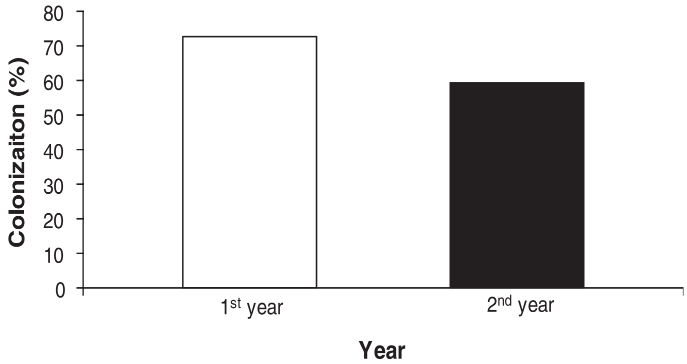

Figure 2. *Variation in root colonization of mycorrhizal fungi between 2005 and 2006.*

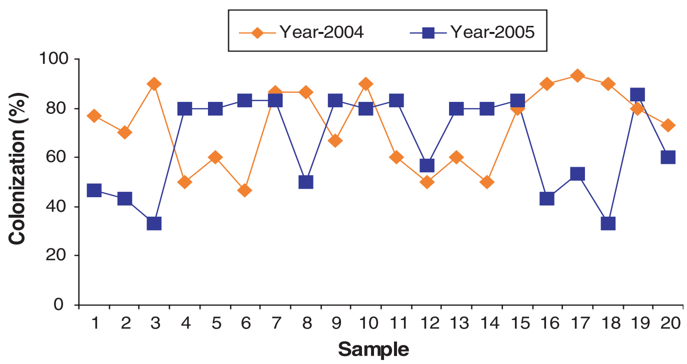

Figure 3. *Distribution of mycorrhizal colonization in individual onion samples during two years.*

It can be concluded that there is a plenty of arbuscular mycorrhiza (AM) spores in every soil sample collected just after flooding. But comparatively more number of spores was found in the rhizosphere soil of onion than that of previous count. Moreover, after flooding AM spores were increasing in the rhizosphere soil of highly mycotropic onion. Roots of onion were colonized heavily by arbuscular mycorrhizal fungi. So, it is clear from the study that arbuscular mycorrhizal fungi can survive in flooded soil and they are able to multiply in favourable condition.

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