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(Research Article)

Root colonization and spore population of AM fungi in cultivated crops

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Abstract

Microorganisms have been extensively used in supplementing the nutrient demand of the crop, thereby reducing dependence on chemical fertilizers. Rhizospheric microorganisms maintain a close relationship with plants and help stimulate plant growth. Arbuscular mycorrhizal fungi are ubiquitous and improve mineral nutrient uptake and enhance abiotic stress tolerance. *Glomus fasciculatum, G. macrocarpum, G. etunicatum, G. mosseae, G. constrictum* were recovered from the roots of almost all the plants in present study. *G. fasciculatum* was the dominant one. The percent colonization occurred to the maximum extent with tomato crop at all the sites. Spore population of AM fungi was found highest in case of tomato and lowest for okra plants.

Keywords: AM fungi; Microorganisms; Rhizosphere; Plant health

1. Introduction

Deficiency of micro nutrients in soil has become major constraint to plant productivity. Chemical fertilizers have been used extensively to enhance crop productivity, resulting in deleterious effects on animal health and environment. In rhizosphere, beneficial bacteria and fungi tend to improve plant health and performance under different micro-environments. They play key role in natural ecosystems and influence plant productivity, plant nutrition along with inhibition of fungal plant pathogens (Wehner et al. 2010; Abohatem et al. 2011; Leventis et al. 2021) and damages caused by root-parasitic nematodes (Khan et al. 2017; Gough et al. 2020). Synergistic interaction of beneficial microorganism with other bioinoculants have been reported.

Arbuscular mycorrhizal fungi are ubiquitous among a wide array of soil microorganisms inhabiting the rhizosphere. Reaching out of the nutrient depletion zone, AM fungi develop symbiotic associations with plant roots by exchanging, inorganic nutrients, especially phosphate and nitrate (Smith et al. 2011) but these fungi also transfer other nutrients such as N, Zn, Mg, and Ca (Bucher 2007; Sikes et al. 2010; Lehmann et al. 2014). Increasing spore density and root colonization with increase in age of the crop plant offers the possibility of using AM fungi as a potential biofertilizer for enhancement of crop growth as well as productivity (Hindumathi and Reddy 2011). Thus, there is an emerging need to decrease the reliance on chemical fertilizers through the sustainable agriculture approaches (Kantar et al. 2007; Mason et al. 2023). Therefore, the researchers emphasized the need to opt for alternative yield raising techniques without affecting the soil health and environment.

2. Material and methods

An extensive survey of economically important cultivated crops at Aligarh district was conducted for quantitative assessment of AM fungal spore populations and percent root colonization. Six different locations (A,B,C,D,E & F) at about two Km distance from each other were chosen carefully for the assessment of per cent root colonization. Common cultivated vegetables at each site was *Lycopersicon esculentum* (tomato), *Solanum melongena* (brinjal), *Capsicum*

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annuum (chilli), *Abelmoschus esculentus* (okra), *Vicia faba* (broad bean), *Lagenaria siceraria* (bottle gourd) and *Brassica oleracea* (cauliflower). At a regular interval samples of plant roots and rhizosphere soil were collected separately for each vegetable at two locations (A & B) throughout the crop session to examine the presence of AM spore propagules.

Ten soil samples from each plant species, marked and packed in polythene bags were brought to laboratory to estimate various soil characteristics. The collected soils were thoroughly mixed to make a composite sample. Five samples of 100 g soils were used for study of AM spores. Similar sampling was carried out for each vegetable in order to assess the root colonization of different AM fungi species. A representative sample of the entire root was obtained from different parts of the root system after washing by tap water. These root samples fixed in formaline-acetic acid- alcohol (FAA) or processed fresh for investigation.

The electric conductivity (EC) and pH of soil were measured with the help of EC meter and pH meter, respectively in the extracts collected from the ratio of 1:1 soil/water suspension. The texture of soil as well as particle size were determined by hydrometer method (Allen et al. 1974). Total organic carbon was estimated by the method of Walkley and Black (1934), total nitrogen by Micro kjeldahl method (Nelson and Sommers 1972), total phosphorus by molybdenum blue method (Allen et al. 1974) and potassium by using flame photometer (Jackson 1973). Spores of different species of AM fungi were isolated by wet sieving and decanting method (Gerdemann and Nicolson 1963). Assessment of colonization of roots by AM fungi and clearing and staining of different root samples were determined according to the method described by Phillips and Hayman (1970). Percentage of root colonization as well as arbuscules were separately determined by slide method (Giovanetti and Mosse 1980). The presence or absence of colonization in each root segment was recorded separately and percent root colonization was calculated as follows:

$$\%\text{ AM colonization } = \frac{\text{No. of mycorrhizal segments}}{\text{Total no. of segments screened}} \times 100$$

Isolated spores of different species of AM fungi were identified with the help of keys provided by different research (Hall and Fish 1979; Trappe 1982). The data collected during this study in the form of critical difference C.D ($\underline{P}$=0.05) and C.D ($\underline{P}$= 0.01) were statistically analyzed in simple randomized design by the method of Pansey and Sukhatme (1985).

3. Results

3.1. Physical and chemical characteristics of rhizosphere soil

Results presented in table 1 clearly shows alkaline to acidic soil having high pH (8.3) and low (6.7) at site A & F, respectively. Soil texture was sandy loam at all sites. Per cent organic carbon was highest (0.31) at site A and lowest (0.17) at F site. Among available nutrients N, P, K were highest 153, 0.256 and 93.1, respectively at site A followed by site C, D, B, E and F.

Table 1 Physical and chemical characteristics of rhizosphere soil at various locations

Sites of sampling	pH	Soil texture	Particle size			E.C. (m mohs cm^{-1})	Organic carbon (%)	Available nutrients (kg/ha)		
			Sand (%)	Silt (%)	Clay (%)			N	P	K
Site –A	8.3	Sandy loam	78.1	18.8	4.5	3.9	0.31	153	0.256	93.1
Site –B	7.7	„	73.0	16.8	7.0	5.1	0.22	111	0.205	86.4
Site –C	8.1	„	76.6	17.1	6.3	4.2	0.29	147	0.248	91.7
Site –D	7.9	„	74.4	16.6	8.1	4.0	0.26	129	0.221	89.6
Site –E	7.0	„	71.0	15.7	5.5	6.3	0.21	93	0.172	84.0
Site –F	6.7	„	67.5	14.7	9.2	6.7	0.17	84	0.132	77.3

3.2. Percent colonization

Percent colonization of AM fungi at different sites associated with different crops is shown at table 2. The percentage colonization occurred to the maximum extent with tomato crop at all the sites, with an average of 80.50%. In Bottle gourd the percent colonization recorded as second highest level with an average of 59.30% and was found to be lowest in okra with an average of 35.17%. Hence the data indicated that the percent colonization differ widely at different sites under all the crop served in this study.

Table 2 Per cent root colonization at various locations of different crops

Crops	**Study sites**					
	A	**B**	**C**	**D**	**E**	**F**
Cauliflower	77.00	64.00	71.00	67.00	61.00	60.00
Bottle gourd	69.00	58.00	66.00	62.00	53.00	48.00
Brinjal	66.00	43.00	57.00	48.00	39.00	35.00
Okra	46.00	31.00	41.00	37.00	30.00	29.00
Tomato	89.00	79.00	87.00	83.00	74.00	71.00
Broad bean	59.00	50.00	57.00	55.00	48.00	49.00
Chilli	49.00	40.00	47.00	44.00	38.00	33.00
C.D.(P=0.05)	4.74	3.88	4.46	4.17	3.63	3.45
C.D.(P=0.01)	6.65	5.44	6.26	5.84	5.09	4.83

3.3. AM population in soil

The data presented in tables 3 & 4 represents that all sites revealed the presence of AM fungi species however at varying degree with the crops. Dominance of AM fungi on tomato crop was noticed as total spores 410 and 209 per100 g soil were recorder at site A and B, respectively. Followed by cauliflower, bottle gourd, chilli, brinjal, cowpea and okra. The lowest number of spores (19 and 4 per100 g soil) have been obtained from okra crops at site A and B, respectively. The statistical analysis showed significant variations in the spore numbers among different crops.

Different species of AM fungi recovered from these sites such as *Glomus fasciculatum, G. macrocarpum, G. etunicatum, G. mosseae, G. constrictum* from the roots of almost all the plants. The distribution pattern of spores of AM fungi at various sites associated with different cultivated vegetable is given in table 3 and 4. *G. fasciculatum* (C.D at 0.05; 6.66) made their presence felt as dominant among five species of *Glomus*. The total spore count of *G. constrictum* was quite less (C.D at 0.05; 1.23) at both the sites as compared to other species.

Table 3 Spore population of different AM fungal species at site (A)

Crops	**Gf**	**Gmac**	**Get**	**Gm**	**Gc**	**Total spores (100 g soil)**
Cauliflower	148.00	110.00	9.00	42.00	15.00	324.00
Bottle gourd	71.00	86.00	30.00	64.00	14.00	265.00
Brinjal	49.00	16.00	6.00	13.00	4.00	88.00
Okra	9.00	3.00	0.00	5.00	2.00	19.00
Tomato	173.00	134.00	18.00	81.00	4.00	410.00
Broad bean	37.00	64.00	30.00	21.00	38.00	191.00
Chilli	15.00	5.00	12.00	9.00	1.00	42.00
C.D.(P=0.05)	6.66	5.71	1.40	3.25	1.23	17.33
C.D.(P=0.01)	9.34	8.00	1.96	4.56	1.72	24.30

Table 4 Spore population of different AM fungal species at site (B)

Crops	Gf	Gmac	Get	Gm	Gc	Total spores (100g soil)
Cauliflower	40.00	47.00	14.00	12.00	10.00	123.00
Bottle gourd	11.00	19.00	9.00	13.00	1.00	53.00
Brinjal	2.00	8.00	6.00	6.00	2.00	24.00
Okra	0.00	1.00	0.00	2.00	1.00	4.00
Tomato	105.00	71.00	28.00	63.00	12.00	209.00
Broad bean	16.00	10.00	5.00	9.00	0.00	40.00
Chilli	1.00	7.00	3.00	1.00	1.00	10.00
C.D.(P=0.05)	3.02	2.35	0.91	1.79	0.40	6.75
C.D.(P=0.01)	4.23	3.30	1.27	2.51	0.57	9.46

Gf = *G. fasciculatum*; Gmac = *G. macrocarpum*; Get = *G. etunicatum*; Gm = *G. mosseae*; Gc = *G. constrictum*

4. Discussion

The present investigation was carried out with an aim to find the different species of genus *Glomus* in various crops in different locations of Aligarh district. Results have shown wide distribution of AM fungi occurred in all the areas investigated. *Glomus* species were found dominant and well distributed in such soils. Padmavathi et al. (1991) found that spores of different AM fungi occurring in agricultural soils in India and only the species of *Glomus* to be predominant in all the samples collected. Different species of *Glomus* were recovered such as *Glomus fasciculatum*, *G. macrocarpum, G. etunicatum, G. mosseae* and *G. constrictum* in this study. Ho (1987) reported that the predominance of *Glomus* species under varying edaphic conditions, may be due to the fact that they are very adaptable to varied soil, temperature, conditions and can survive in acidic as well as alkaline soil. The data revealed that AM fungi prefers tomato crop followed by cauliflower, this may be due to favourable host-plant relationship, environmental condition, soil texture, etc. due to which spores kept multiplied in association with plants and remain in soil. Arcidiacono et al. (2023) also reported preference of AM fungi upon tomato. Growth-promoting effect of AM fungi on cherry tomato were made by Tang (2022). It has been found further that colonization varies to different levels in all sites. Szada-Borzyszkowska et al. (2022) also reported the differences in AM fungi root colonization between different crops. Peng and Shen (1990) reported that the complex environmental factors, seasonal fluctuations, various agricultural practices and their soil microflora may influence the development of mycorrhizal fungi.

AM fungi spread widely in these crops seems to be due to their potential for crop improvement which has been studied extensively by research workers (Mukerji 1995; Leventis et al. 2021). Dominance of *Glomus* species in cultivated soils clearly indicated that there is a need of maintaining them in cultivated soil through proper management practices for crop improvement. Secondly by determining the requirements of various AM fungi, one will be able to select species for physiological experimentation on the basis of particular characteristics. They have great importance due to their higher capacity to increase growth and yield through efficient nutrient uptake in infertile soil, water uptake, drought resistance, and infected plants. Similar observation were obtained by Constantino et al. (2008); Ahmed et al. (2009); Patale and Shinde (2010); Arumugam et al. (2010).

5. Conclusion

A study was conducted to assess the arbuscular mycorrhizal fungal spore population and per cent root colonization in commonly cultivated crops of Aligarh district. Crops commonly cultivated in Aligarh district includes cauliflower, bottle gourd, brinjal, okra, tomato, broad bean and chilli. These crops were examined for their AM fungi status. Five species of AM fungi belonging to genera *Glomus* were found to be associated with these crops. *Glomus* was the predominant genus and showed high frequency of occurrence at all the sites investigated. High values of per cent colonization were observed in tomato crop. There was no definite relationship between cultivated crops and AM fungi, as the spore number in soil obtained from rhizosphere of plants during different crops varied at different sites but AM fungi preferred tomato, cauliflower and bottle gourd crops. The result of this study emphasized the need to assess the status of arbuscular mycorrhizal association of crop plants from different micro-ecosystem to understand their mycorrhizal status.

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