International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Evaluation of arbuscular mycorrhizal fungi in cultivated crops

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International Journal of Science and Research Archive, 2023, 10(02), 497–501

Publication history: Received on 16 October 2023; revised on 25 November 2023; accepted on 28 November 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.10.2.0972

Abstract

Arbuscular mycorrhizal fungi are ubiquitous and form a symbiotic association with many higher plants. They improve mineral nutrient uptake and enhance abiotic stress tolerance. Common cultivated crops (green pea, chick pea, red lentil, green gram, tomato, black gram and pigeon pea) at Aligarh District were evaluated to ascertain the presence and dominance of AM fungi. Glomus was the predominant genus and showed high frequency of occurrence at all the sites investigated. Five species belongs to genera Glomus (*G. fasciculatum, G. mosseae, G. etunicatum, G. macrocarpum* and G. *constrictum*) were found to be associated with these crops. Distribution of AM fungi on studied crops was tomato > green pea > chickpeas > black gram > red lentil > pigeon pea. *G. fasciculatum* register the dominancy in terms of spore count in this study whereas *G. constrictum* trail the spore count.

Keywords: Microbial bio-stimulant; AM fungi; *Glomus*, Rhizosphere; Plant health

1. Introduction

In Wester Uttar Pradesh, Aligarh is one of the important districts which spreads from 27°29' to 28°10' north latitudes. Topographically the district represents a shallow soil formed by river Ganga in north-east and Yamuna in north-west. The city experiences tropical monsoon type climate. Temperature as well as rainfall ranges between 44 °C to 14 °C and 65 to 75 cms, respectively throughout the year. The soil of the district is mainly sandy loam (Khan 2023). The pH ranges between 6.7 to 8.3 and good irrigational facilities with a significant soil moisture between 4.05 to 8.90%. The relative humidity oscillates between 64.1 to 79.2% throughout the year.

Arbuscular mycorrhizal (AM) fungi belong to the phylum Glomeromycota and are ubiquitous in natural as well as agricultural ecosystems (Brundrett and Tedersoo 2018). They are key components of soil microbiota. AM fungi are known to develop the association with 80% of host plants (Bueno et al. 2019). Lehmann and Rillig (2015) reported the symbiosis confer the benefit directly to the host plant growth and development through the acquisition of P and other mineral nutrient like, N, K, Ca, Mg, Fe, Zn, Cu and Mn from the soil by the fungus. In addition to that they may enhance the plant resistance to biotic and abiotic stress. They can be used as biocontrol agent individually or in combination with other microbes and thus help to reduce the severity of several plant diseases (Barea et al. 2002; Akkopru and Demir 2005). Therefore, we conducted a survey to enumerate the status of AM fungi in some economic crops under Aligarh district.

2. Materials and Methods

A survey of economically important crops was conducted with the aim to obtain different spores of AM fungi associated with different crops. Under present study four different locations, marked as A, B, C and D were selected having a particular distance from each other. All selected sites were found to grow some common cultivated crops like, green pea (*Pisum sativum*), chick pea (*Cicer arietinum*), red lentil (*Lens culinaris*), green gram (*Vigna radiata*), tomato

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(*Lycopersicon esculentum*), black gram (*Vigna mungo*) and pigeon pea (*Cajanus cajan*) etc. Sampling at selected sites was done at a regular interval for each crop throughout the year. The soil around each plant was examined for the presence of AM spore propagules during the investigation. Soil samples (soil cones of 5 cm drain) were collected randomly from each crop with the help of soil auger upto a depth of 15 cm. The rhizosphere soil along with roots were collected carefully without causing damage to the roots. Ten samples were collected from each crop. The collected soils were thoroughly mixed to make a composite sample. Seven samples of 100 g soils were used to study the AM spores.

2.1. Quantitative estimation of AM spores from soil

Spores of different species of AM fungi were isolated by wet sieving and decanting method (Gerdemann and Nicolson 1963). The stepwise isolation was carried out as follows.

- Thorough mixing of each sample of 100 g dry soil added in the beaker containing 2000 ml distilled water was followed by homogeneous stirring
- The soil solution was left for few minutes to allow the heavier particles to settle down
- The supernatant muddy suspension was poured through coarse sieve (610 μ)for the removal of large sized particles and organic debris
- The suspension was then passed through a series of sieves of varied pore size, i.e. 80, 100, 150, 250 and 400 mesh, these mesh sizes were used to retain even smaller spores of AM fungi
- The spores obtained on sieves were collected along with water in separate beakers
- The spore suspensions were repeatedly washed with Ringers' solution (NaCl $6g1^{-1}$, KCl $0.1g1^{-1}$ and $CaCl_2$ $0.1g1^{-1}$ in distilled water of pH 7.4) in order to remove the adherent soil particles from the spores.

The suspension obtained was gently stirred to make the homogeneous distribution of spores. From this suspension, one ml was taken by pipette into a counting disk (Hawksley, UK) for counting the AM spores under stereoscopic microscope. Ten counts were made from each suspension and average count was calculated to determine the density of spores per unit volume. Finally, the number of spores per 100 g dry soil was estimated for each crop.

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

3. Results and Discussion

Table 1 Spore population of different AM fungal species at Site A

Crops	***G. fasciculatum***	***G. macrocarpum***	***G. etunicatum***	***G. mosseae***	***G. constrictum***	**Total spores (100g soil)**
Green Peas	119.00	90.00	20.00	52.00	5.00	286.00
Chick pea	54.00	73.00	18.00	36.00	11.00	192.00
Red lentil	27.00	9.00	1.00	7.00	2.00	46.00
Green gram	2.00	4.00	0.00	1.00	0.00	7.00
Tomato	165.00	141.00	16.00	60.00	7.00	389.00
Black gram	20.00	8.00	2.00	12.00	10.00	52.00
Pigeon pea	9.00	5.00	3.00	0.00	1.00	18.00
C.D.(P=0.05)	5.74	5.07	0.89	2.46	0.50	14.45
C.D.(P=0.01)	8.05	7.11	1.24	3.45	0.70	20.26

Plant microbial bio-stimulants, such as AM fungi promote the concentration of nutrients in plants. The present investigation was carried out with the aim to find the different species of genus *Glomus* in various crops at study sites. The data presented in Tables 1-4 represents that all four sites (A, B, C and D) revealed the presence of genus *Glomus* species. All the study sites clearly showed the dominance of AM fungi on tomato crop followed by green pea > chickpeas

> black gram > red lentil > pigeon pea. In tomato crops the highest number of spores (389.00 / 100g soil) have been obtained from site A, whereas the lowest number of spores (53.00 / 100g soil) were recovered from site D. However, site B and C registered 319.00 / 100g soil, and 131.00/ 100g soil, number of spores, respectively.

The statistical analysis showed significant variations in the spore numbers among different crops. After tomato crop maximum no of spores (100gm soil) were recorded on green peas followed by chick pea, black gram, red lentil and pigeon pea (286.00, 192.00, 52.00, 46.00 and 18.00 respectively). (Table 1)

Table 2 Spore population of different AM fungal species at Site B

Crops	***G. fasciculatum***	***G. macrocarpum***	***G. etunicatum***	***G. mosseae***	***G. constrictum***	**Total spores (100g soil)**
Green Peas	109.00	69.00	25.00	36.00	1.00	239.00
Chick pea	97.00	44.00	0.00	4.00	2.00	147.00
Red lentil	7.00	11.00	1.00	2.00	0.00	21.00
Green gram	1.00	3.00	1.00	0.00	0.00	5.00
Tomato	143.00	104.00	17.00	42.00	13.00	319.00
Black gram	26.00	19.00	0.00	9.00	6.00	60.00
Pigeon pea	5.00	1.00	0.00	0.00	0.00	7.00
C.D.(*P*=0.05)	5.79	3.68	0.78	1.47	0.39	11.81
C.D.(*P*=0.01)	8.12	5.16	1.09	2.06	0.54	16.56

Table 3 Spore population of different AM fungal species at Site C.

Crops	***G. fasciculatum***	***G. macrocarpum***	***G. etunicatum***	***G. mosseae***	***G. constrictum***	**Total spores (100g soil)**
Green Peas	18.00	7.00	6.00	10.00	8.00	49.00
Chick pea	7.00	11.00	1.00	3.00	0.00	22.00
Red lentil	8.00	6.00	0.00	1.00	0.00	15.00
Green gram	2.00	4.00	2.00	1.00	4.00	13.00
Tomato	56.00	32.00	29.00	19.00	14.00	131.00
Black gram	12.00	5.00	1.00	0.00	0.00	18.00
Pigeon pea	1.00	0.00	1.00	5.00	1.00	8.00
C.D.(*P*=0.05)	1.60	0.97	0.78	0.57	0.41	3.79
C.D.(*P*=0.01)	2.24	1.37	1.09	0.80	0.57	5.31

Among the various species of the *Glomus,* the most common species recovered are *Glomus fasciculatum*, *G. mosseae, G. etunicatum, G. macrocarpum* and *G. constrictum* in this study. *G. fasciculatum* registered the dominance (165.00, 143.00, 56.00 and 16.00 respectively, in tomato) among all species as well as study sites. However, *G. constrictum* recorded the lowest spore count (2.00, 7.00, 13.00 and 14.00, respectively). In the present study association of *Glomus* species were found dominant with all crops. Similar results are supported by Zhang et al. (2004). AM fungus spore formation, distribution, and mycorrhiza development, may be dependent on plant diversity in natural ecosystems (McGonigle and Fitter 1990; Gange et al. 1993).

Table 4 Spore population of different AM fungal species at Site D

Crops	*G. fasciculatum*	*G. macrocarpum*	*G. etunicatum*	*G. mosseae*	*G. constrictum*	Total spores (100g soil)
Green Peas	2.00	14.00	0.00	1.00	0.00	17.00
Chick pea	10.00	6.00	7.00	16.00	4.00	39.00
Red lentil	13.00	2.00	0.00	1.00	0.00	6.00
Green gram	0.00	0.00	2.00	0.00	3.00	5.00
Tomato	16.00	15.00	8.00	12.00	2.00	53.00
Black gram	7.00	0.00	0.00	3.00	1.00	11.00
Pigeon pea	0.00	1.00	1.00	2.00	0.00	4.00
C.D.(P=0.05)	0.65	0.58	0.31	0.59	0.16	1.98
C.D.(P=0.01)	0.91	0.81	0.44	0.83	0.22	2.77

Host plant relationship and favorable environmental conditions might be responsible for highest no of spores in tomato plants. Under these conditions spores flourish and deposited in soil. Similar observations were reported by Al-Karaki et al. (2001) and Hart et al (2015). Our results are in fully agreement with Coccina et al. (2019) and Pellegrino et al. (2020) in which they reported that arbuscular mycorrhizal fungi could be used as an important tool for enhancing tomato yield and mineral nutrient concentration. Findings from Arcidiacono et al. (2023) pointed the inclusion of AM fungal within the selection criteria for the development of biofertilizers under organic farming systems. Present findings also suggest to use *G. fasciculatum* to be used in tomato crop to improve plant health.

4. Conclusion

Green peas, chick pea, red lentil, green gram, tomato, black gram and pigeon pea are commonly cultivated crops at Aligarh district. Plant microbial bio-stimulants promote the concentration of nutrients in plants. Therefore, an investigation was carried out at selected sites with the aim to find the different species of genus *Glomus* in various crops. We recorded the presence of genus *Glomus* species at all study sites. Present findings clearly showed the dominance of AM fungi on tomato crop > green pea > chickpeas > black gram > red lentil > pigeon pea. Among the various species of the *Glomus,* the most common species recovered are *Glomus fasciculatum*, *G. mosseae, G. etunicatum, G. macrocarpum* and *G. constrictum* in this study. Therefore, it was found suitable to suggest the use of *G. fasciculatum* in tomato crop to improve plant health.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Akkopru A. and Demir S. (2005). Biological control of Fusarium wilt in tomato caused by Fusarium oxysporum f. sp. lycopersici by AMF Glomus intraradices and some rhizobacteria. J. Phytopathol, 153: 544–550.

[2] Al-Karaki G.N., Hammad R. and Rusan M. (2001). Response of two tomato cultivars differing in salt tolerance to inoculation with mycorrhizal fungi under salt stress. Mycorr, 1:43–47. doi.org/10.1007/s005720100098.

[3] Arcidiacono M., Pellegrino E., Nuti M. and Ercoli L. (2023). Field inoculation by arbuscular mycorrhizal fungi with contrasting life-history strategies differently affects tomato nutrient uptake and residue decomposition dynamics. Plant Soil, doi.org/10.1007/s11104-023-05995-8

[4] Barea J.M., Azcon R. and Azcon-Aguilar C. (2002). Mycorrhizosphere interactions to improve plant fitness and soil quality. Antonie van Leeuwenhoek, 81: 343–351.

[5] Brundrett M.C. and Tedersoo L. (2018). Evolutionary history of mycorrhizal symbioses and global host plant diversity. New Phytol, 220: 1108–1115. doi.org/10.1111/nph.14976

[6] Bueno C.G., Gerz M., Zobel M. and Moora M. (2019) Conceptual differences lead to divergent trait estimates in empirical and taxonomic approaches to plant mycorrhizal trait assignment. Mycorr, 29: 1–11. doi.org/10.1007/s00572-018-0869-1

[7] Coccina A., Cavagnaro T.R., Pellegrino E., Ercoli L., McLaughlin M.J. and Watts-Williams S.J. (2019). The mycorrhizal pathway of zinc uptake contributes to zinc accumulation in barley and wheat grain. BMC Plant Biol, 19: 1–14. doi.org/10.1186/s12870-019-1741-y

[8] Gange A.C., Brown V.K. and Sinclair G.S. (1993). Vesicular-arbuscular mycorrhizal fungi: A determinant of plant community structure in early succession. Funct. Ecol, 7: 616–622.

[9] Gerdemann J.W. and Nicolson T.H. (1963). Spores of mycorrhizal endogone sp. extracted from soil by wet sieving and decanting. Trans. Brit. Mycol. Soc, 46: 235–246.

[10] Hall I.R. and Fish B.J. (1979). A key to endogonaceae. Trans. Brit. Mycol. Soc, 73: 262–270.

[11] Hart M., Ehret DL., Krumbein A., Leung C., Murch S., Turi C. and Franken P. (2015). Inoculation with arbuscular mycorrhizal fungi improves the nutritional value of tomatoes. Mycorr, 25: 359–376. doi.org/10.1007/s00572-014-0617-0.

[12] Khan Z. (2023). Root colonization and spore population of AM fungi in cultivated crops. Int. J. Sci. Res. Arch, 10: 984–989. doi.org/10.30574/ijsra.2023.10.1.0853

[13] Lehmann A. and Rillig M.C. (2015). Arbuscular mycorrhizal contribution to copper, manganese and iron nutrient concentrations in crops - a meta-analysis. Soil Biol Biochem, 81: 147–158. doi.org/10.1016/j.soilbio.2014.11.013.

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

[15] Pansey V.G. and Sukhatme P.V. (1985). Statistical methods for agricultural works. Publication and Information Division, ICAR, New Delhi, pp. 355.

[16] Pellegrino E., Piazza G., Arduini I. and Ercoli L. (2020). Field inoculation of bread wheat with Rhizophagus irregularis under organic farming: variability in growth response and nutritional uptake of eleven old genotypes and a modern variety. Agron. 10:333. doi.org/ 10.3390/agronomy10030333

[17] Trappe J.M. (1982). Synoptic key to the genera and species of Zygomycetous mycorrhizal fungi. Phytopathol, 72: 1102–1128.

[18] Zhang Y., Guo L.D. and Liu R.J. (2004). Survey of arbuscular mycorrhizal fungi in deforested and natural forest land in the subtropical region of Dujiangyan, southwest China. Plant and Soil, 261: 257–263.