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Evaluation of Arbuscular Mycorrhizal (AM) fungi on availability of soil nutrient and yield under Direct Seeded Rice (DSR)

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ABSTRACT
The application of treatment T_3 (Glomusmosseae+ 100% RDF NK) gavemaximum available nitrogen (92.00 mg kg^{-1}) content in soil. It might be due to the production of more shoot biomass and root biomass by the application of given treatments and might be due to the structural changes in the microbial community.The application with the treatment T_3 (G. mosseae + 100% RDF NK) given significantly more availability of phosphorus by 10.42%, 4.37%, 2.43%, 1.06% and 8.52% than treatment T_1 (control) condition, T_2 (100%RDF), T_4 (G. intraradices + 100% RDF NK), T_5 (G. coronatum + 100%RDF NK) and T_7 (BAU AM-1(Glomus sp.) + 100% RDF NK) respectively. The similar trend was observed for availability of potassium, T_3 (Glomusmosseae + 100% RDF NK), which was significantly higher when compared with other treatments, while soil organic carbon showed that the application of all treatments were non-significant when compared with recommended dose of T_2 (100% RDF) and T_1 (control) treatment. The application of treatment T_3 (Glomusmosseae + 100% RDF NK) showed that highest grain yield (14.08g pot^{-1}) among all AM fungi species and it was at par with the treatment T_2 (100% RDF).
Key words: *DSR, microbial population, NPK, mycorrhiza, rice yield*

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INTRODUCTION
Rice (*Oryza sativa* L.) is a predominant staple food and a major source of dietary carbohydrate for more than half of the world's population (Zimmermann and Hurrell, 2002).Mycorrhiza is a mutualistic symbiosis between certain groups of soil fungi and most plant root systems (Hata*etal*., 2010).Colonization of roots with arbuscularmycorrhizal fungi (AMF) often improves the phosphorus nutrition of host plants growing on soils with sparingly soluble P forms (Shenoy and Kalagudi, 2005). Increased absorption surface and lower threshold concentration for P uptake in mycorrhizal root systems are contributing factors (Peterson and Massicotte, 2004). Recent evidences suggest that AMF can provide the dominant route for plant P supply, even when overall growth or P uptake remains unaffected (Smith *et al.,* 2003). Improved uptake of other mineral elements by mycorrhizal roots has also been demonstrated for nitrogen, potassium (George *et al.,*1995) and for micronutrients such as Zn, Cu, Fe and Mn(Azcon*et al.,* 2003, Ortas and Akpinar, 2006).Arbuscular mycorrhizae are probably the most abundant fungi in agricultural soil accounting for somewhere between 5 and 50% of biomass of soil microbes live on carbohydrates obtained from the root cells. They alter root exudation considerably (Marschner*et al.,*1997) and are therefore expected to influence rhizosphere populations as well (Hayman, 1983). Numerous studies have shown conclusively that AM is having synergistic interaction with other beneficial soil microorganism such as N fixers and P solublizers. The present investigation was undertaken with an objective to determine the effect of AM inoculation on soil nutrient status and yield of Direct seeded rice (DSR).

MATERIALS AND METHODS
The present study was undertaken to screen the AM fungi for direct seeded rice crop during the *kharif* season of 2015-16 with a promising variety Shushk Samrat, at Bihar Agricultural University, Sabour, Bhagalpur, India. Inoculums of the five AM species viz., *Glomusmosseae*, *Glomus coronatum,Glomus*

intraradices, Gigaspora decipien and were commercial products of The Energy Resource Institute (TERI), New Delhi, India and Local strain (BAU AM-1 i.e.,*Glomus sp*).from Department of Soil Science & Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur (Bihar).

The experimental soil used for the pot experiment was loamy sand in texture, having a pH of 7.8 and EC of 0.20 dS m^{-1}. The organic carbon content of the substrate was 0.47%, and the available nitrogen, phosphorus and potassium content was found 125.44, 12.55 and 240.92 kg ha^{-1},respectively. Among micronutrient zinc content was 0.48 ppm.

Seeds were surface-sterilized by treatment with a 1:1 mixture of H_2O_2 and absolute ethanol for 2 minutes followed by a treatment with 0.05% $HgCl_2$ for 1 minute. The sterilizing agents were drained aseptically, and the seeds were washed for 10-12 times in sterile distilled water to remove all traces of the chemicals. Earthen pots of 15 cm height and 30 cm diameter were filled with 15 kg of sterilized substrate. The following treatment structure was formulated for the study: T_1- control, T_2- RDF (100%), T_{23}*G. mosseae*+ 100%RDFNK, T_4- *G. coronatum*+ 100%RDFNK, T_5- *G. intraradices*+ 100%RDFNK, T_6- *G. decipien*+ 100%RDFNKand T_7- Local (BAU AM-1(*Glomus sp.*) + 100%RDFNK. About 5 g of the AM inoculum source (containing and 8-10 spores g^{-1}) was mixed with the upper 4 cm of the substrate in each pot. In each pot, 5 sterile seeds of rice were planted. The one third dose of nitrogen and full dose of phosphorous and potassium were applied at the time of sowing and remaining two third dose of nitrogen were applied at the tillering and panicle initiation stage. Irrigation was applied as per crop requirement. Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). A given weigh of soil was treated with excess of alkaline $KMnO_4$. The organic matter present in the soil was oxidized by nascent oxygen liberated by $KMnO_4$ in present of sodium hydroxide. Ammonium thus released was absorbed in known volume of standard acid, excess of which was titrated with standard alkali using methyl red as indicator. Available phosphorous was determined by Olsen *et al.,* 1954. Method and available potassium by 1N neutral ammonium acetate (Hanway and Heidel, 1952).Analysis of variance (ANOVA) was performed as described by Gomez and Gomez, 1984 to determine the effects of various treatments. Critical difference (CD) at 5% level of probability and P values was used to examine differences among treatment means.

RESULTS AND DISCUSSION

Available Nitrogen (mg kg^{-1})

The presented data reflected that the numerical increment was found in the available nitrogen content in soil when compared with the control and treatment T_7 (BAU AM-1(*Glomussp*). The maximum available nitrogen (92.00 mg kg^{-1}) content in soil was obtained by the application of treatment T_3 (*G. decipien* + 100%RDF NK). It might be due to the production of more shoot biomass and root biomass by the application of given treatments and might be due to the structural changes in the microbial community. These changes in the microbial community may alter the nutrients dynamics in the rhizosphere. The similar results were observed by the Beura*et al*., 2016.

Available phosphorous (mg kg^{-1})

The presented data showed that addition of AM inoculation increased soil P concentration which was significantly higher over control. The application with the treatment T_3 (*G. mosseae* + 100% RDF NK) given significantly more availability of phosphorus by 10.42%, 4.37%, 2.43%, 1.06% and 8.52% than treatment T_1 (control) condition, T_2 (100%RDF), T_4 (*G. intraradices* + 100% RDF NK), T_5 (*G. coronatum* + 100%RDF NK) and T_7 (BAU AM -1(*Glomus sp.*)+ 100% RDF NK) respectively. It may be due to the *Glomus*mosseae had pronounced effect for phosphorus acquisition in soil. A parallel trend was also seen in case of available N, K and organic carbon status of soil (Hodge and Fitter, 2010 and Olsson *et al*., 2010).

Available potassium (mg kg^{-1})

The application of treatment T_3 (*Glomus mosseae*+100% RDF NK) gives significantly higher amount of available potassium by 24.92%, 14.60%, 7.45%, 5.47%, 3.92%, 14.11% when compared with the application of treatment T_1 (control) condition, T_2 (100%RDF), T_4 (*Glomusintraradices*+ 100% RDF NK), T_5 (*Glomuscoronatum*+ 100%RDF NK), T_6 (*G. decipein* 100%RDF NK) and T_7 (BAU AM -1(*Glomus sp.*) + 100% RDF NK) respectively. The obtained results are in the agreement of Beura*et al.,* 2016.

Soil organic carbon (%)

The data revealed with percent organic carbon in soil showed that the application of all treatments were non-significant when compared with recommended dose of T_2 (100% RDF) and T_1 (control) treatment. However, all the applied treatments were numerically better than T_2 (100% RDF) and T_1 (control). The maximum (0.54%) was recorded by the application of T_3 (*G. mosseae*+100% RDF NK),T_5 (*G. coronatum* + 100%RDF NK) and T_6 (*G. decipein* 100%RDF NK). It might be due to the AM colonization produced more root biomass and plant biomass (Beura*et al.,*2016).

Yield and yield parameter

The inoculation with T_3 (*Glomusmosseae* + 100% RDF NK) given grain yield significantly higher by 44.81%, 14.77%, 8.59%, 8.23% and 21.94% than T_1 (control), T_4 (*Glomusintraradices* + 100%RDF NK), T_5 (*Glomuscoronatum*+ 100% RDF NK), T_6 (*G. decipein*+ 100%RDF NK) and T_7 (BAU AM -1(*Glomus sp.*) + 100% RDF NK) respectively. It might be due to the AM hyphae attached to the roots extend beyond this depletion zone and promote nutrient translocation from the soil to the plants through the root cortex. Studies conducted by Sabia*et al.,*2015 also revealed a significant effect of AM inoculation on dry matter yield and quality of forage maize cultivated within a low input system.

Table 1: Effect of *Glomusmosseae, Glomuscoronatum, Glomusintraradices, Gigasporadecipien* on soil chemical properties

Treatment	N (mg kg^{-1} soil)	P (mg kg^{-1} soil)	K (mg kg^{-1} soil)	O.C (%)
T_1 - Control	90.33	5.24	75.97	0.53
T_2 - 100% RDF	91.88	6.27	86.41	0.54
T_3 - *Glomusmosseae*+ 100% NK	91.33	7.40	101.19	0.54
T_4 – *Glomusintraradices*+ 100% NK	91.00	6.77	93.65	0.54
T_5 – *Glomuscoronatum*+ 100% NK	90.89	6.91	95.95	0.54
T_6 – *Gigasporadecipein*+ 100% NK	92.00	7.07	97.22	0.54
T_7 – BAU AM-1(*Glomus sp.*) + 100% NK	89.33	5.59	86.91	0.54
CD (0.05)	NS	0.22	0.64	NS
SE(m)	-	0.10	0.30	
C.V.	-	0.16	0.40	-

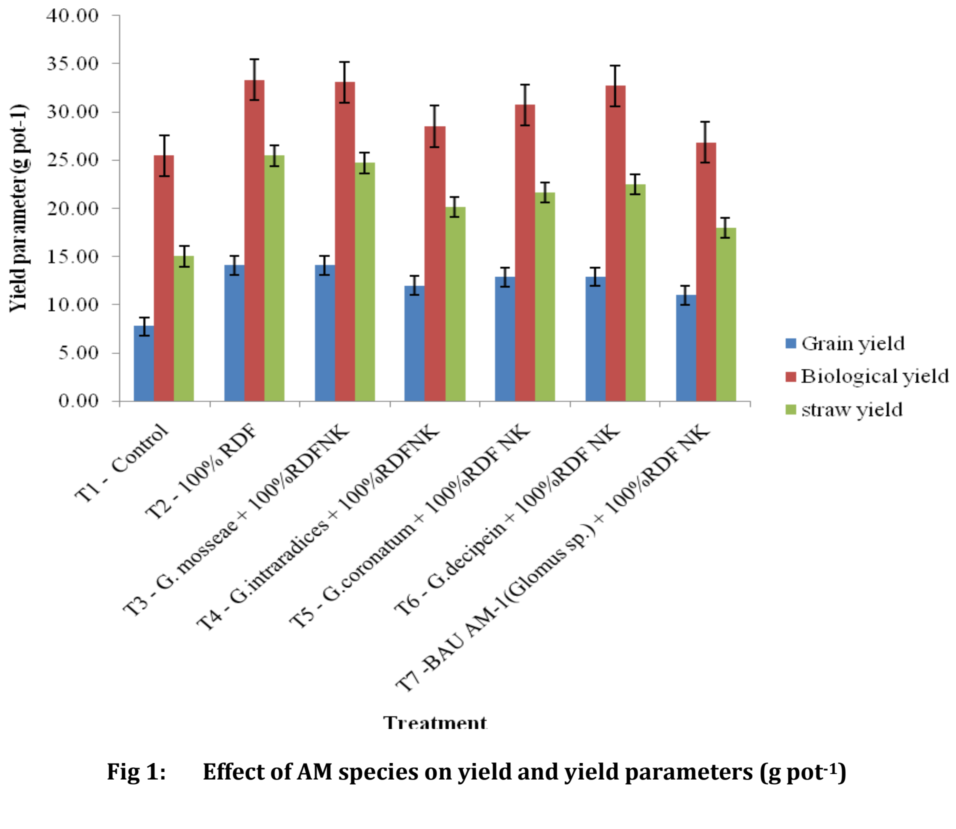

Fig 1: Effect of AM species on yield and yield parameters (g pot^{-1})

CONCLUSION

It is evident from the data that AM fungi inoculation contributed to relative better plant growth and improves phosphorous availability in the soil.

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