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Effect of arbuscular mycorrhizae on nutrient content and seedling quality of important fodder tree species of central India

Ashok Shukla, Anuradha Jha, Anil Kumar, V. D. Tripathi
ICAR-Central Agroforestry Research Institute, Jhansi, India
corresponding author e-mail : ashok_shukla1@yahoo.com

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Introduction

Acacia nilotica, *Albizia procera*, *Dalbergia sissoo* and *Leucaena leucocephala* are important multipurpose tree species (MPTs). These are being utilized in agroforestry systems at ICAR-Central Agroforestry Research Institute (ICAR-CAFRI), Jhansi and are also being utilized in reforestation programme in Central India. The success of any agroforestry model and/or reforestation programme depends upon the quality seedling materials. Nursery-produced seedlings can be an effective means of ensuring successful establishment of agroforestry models and/or reforestation programme. However, such seedlings sometimes fail to establish themselves in the fields. The poor performance of planted seedlings is often associated with transplant shocks and low seedling quality. The preconditioning of young seedlings with efficient arbuscular mycorrhizal fungi (AMF), an important soil microorganism improves plant health and helps in their establishment in fields (Jha *et al*., 2014). However, before utilizing these fungi for inoculation purpose, the suitable AMF species must be identified. Therefore, to find out the efficient AMF species for inoculations of above mentioned plant species, present study was carried out.

Materials and Methods

Separate experiments on the response of above mentioned MPTs to AMF inoculations were carried out at ICAR-CAFRI, Jhansi (78°17′E, 24°11′N), India, under net-house conditions. Study consisted of 12 mycorrhizal treatments (Table 1) and a control (un-inoculated). Mycorrhizal treatments were imposed in plastic pots, filled with red soil (alfisol; pH- 6.5 (1:2.5 H_2O), EC- 134 μScm^{-1}, OC- 0.27%, Olsen P- 2.5 ppm). For AMF inoculations, 50 g mycorrhizal inoculum consisted of sand with chopped root bits, spores and extramatrical mycelium were placed 4-5 cm below the seeds, and for control, equal amount of autoclaved inoculum was applied which provides general microbial population free from AMF propagules. All pots were kept under green-house in a completely randomized design, and were watered as and when required. After four months growth, observations on morphological parameters *viz*., shoot height (cm), collar diameter (mm), fresh and dry weights (g) of shoot and root were recorded. Phosphorus (P) content in host tissues was estimated (Jackson, 1973). Mycorrhizal dependency (MD) was calculated in terms of plant growth as $[(M - NM)/M] \times 100$, using dry weights of individual mycorrhizal plants (M) and mean dry weight of corresponding non-mycorrhizal (NM) plants (Plenchette *et al*., 1983). The seedling quality index (Dickson *et al*.,1960) was calculated by using following formula:

Seedling Quality Index (SQI) = Total dry weight (g) / (Plant height (cm)/Collar diameter (mm)) + (Shoot dry weight (g)/Root dry weight (g))

All the generated data were analyzed statistically using a general linear model for analysis of variance. Least significant difference ($LSD_{0.05}$) was used to compare treatment differences (SYSTAT version 12).

Results and Discussion

Phosphorus content was significantly (P<0.05) increased by all AMF inoculants in *A. nilotica*, *A. procera* and *D. sissoo*, whereas only five inoculants increased it in *L. leucocephala* (Table 1). The dependency of plants for dry matter production on AMF inoculants was recorded maximum in *A. nilotica* (mean: 55.3, range: 42.3–64.6%), followed by *A. procera* (mean: 50.0, range: 34.0–67.0%) and *D. sissoo* (mean: 31.1, range: 15.5–39.2%). This increase in plant growth upon AMF inoculations could be due to more volume of soil exploration for available nutrients and water by inoculated fungi as compared to un-inoculated plants. Better P content in mycorrhizal plants, which is evident from the study, improves plant biomass. Results also suggested that in *L. leucocephala*, the MD values for most of inoculants were in the negative range. The inoculated fungi reduced its biomass as compared to control. Such growth reduction resulting from the inoculations can be attributed to carbohydrate loss to fungal symbiont (Jha *et al*., 2014). Reduced growth of *L.*

leucocephala seedling even after AMF inoculation can be reversed later and may be followed by a positive growth response. Hence, long-term studies involving field inoculations are needed to test transient effect in *L. leucocephala*.

Table 1 Effect of arbuscular mycorrhizae on phosphorus (P) uptake (mg) plant^{-1} and mycorrhizal dependency (%) in *A. nilotica*, *A. procera*, *D. sissoo* and *L. leucocephala*.

AM inoculants	***A. nilotica***		***A. procera***		***D. sissoo***		***L. leucocephala***	
	P uptake	**MD[1]**	**P uptake**	**MD**	**P uptake**	**MS**	**P uptake**	**MD**
Acaulospora mellea	26.46	60.2	48.25	46.5	29.74	27.6	53.31	-0.9
Acaulospora scrobiculata	27.19	54.5	43.07	40.8	35.46	39.2	44.63	-4.1
Claroideglomus etunicatum	26.17	63.9	33.54	50.8	34.31	36.8	37.02	-21.1
Glomus aggregatum	19.91	42.3	53.24	56.1	31.30	37.6	35.96	-11.8
Glomus arborense	26.42	59.8	37.25	54.5	20.07	24.3	45.35	-18.5
Glomus cerebriforme	22.25	54.5	55.77	58.2	40.25	44.1	57.44	-1.63
Paraglomus occultum	25.83	50.7	27.55	45.2	26.54	15.5	30.17	-27.1
Rhizophagus diaphanus	25.28	53.6	28.87	34.0	34.33	39.6	62.24	0.85
Rhizophagus fasciculatus	24.62	64.3	53.29	67.0	27.37	21.6	38.08	-11.7
Rhizophagus intraradices	19.49	51.6	27.68	42.2	30.05	18.0	39.70	-16.82
Simiglomus hoi	25.45	52.9	42.88	54.5	31.20	37.5	36.95	-7.15
Un-inoculated (control)	8.38	-	3.57	-	12.69	-	26.81	
F-ratio	3.573	0.909	4.341	1.536	4.486	2.051	3.599	2.297
P value	0.002	0.536	0.000	0.171	0.000	0.059	0.002	0.036
$LSD_{0.05}$	8.10	NS	20.57	NS	9.97	NS	16.47	17.5

[1]Mycorrhizal dependency

SQI, computed on the basis of growth parameters suggested that most of AMF inoculants significantly improved the quality of *A. nilotica*, *A. procera* and *D. sissoo* as compared to control, whereas none of the inoculants were found effective to improve quality of *L. leucocephala* seedling (Table 2). According to Tsakaldimi *et al*. (2013), SQI can predict out-planting survival of seedlings of certain species.

Table 2. Effect of arbuscular mycorrhizae on seedling quality index of *A. nilotica*, *A. procera*, *D. sissoo* and *L. leucocephala*

AM inoculants	***A. nilotica***	***A. procera***	***D. sissoo***	***L. leucocephala***
Acaulospora mellea	0.91	3.96	1.11	2.71
Acaulospora scrobiculata	0.76	4.89	1.26	2.67
Claroideglomus etunicatum	0.96	4.54	1.30	2.10
Glomus aggregatum	0.67	5.03	1.40	2.32
Glomus arborense	0.92	5.31	1.04	2.11
Glomus cerebriforme	0.68	5.20	1.49	2.46
Paraglomus occultum	0.68	4.33	0.95	2.02
Rhizophagus diaphanus	0.79	2.97	1.26	2.49
Rhizophagus fasciculatus	0.88	7.53	0.97	2.12
Rhizophagus intraradices	0.75	3.99	0.99	2.48
Simiglomus hoi	0.82	5.53	1.30	2.39
Un-inoculated (control)	0.32	2.41	0.74	2.57
F-ratio	2.594	4.614	3.786	1.577
P value	0.015	0.000	0.001	0.148
$LSD_{0.05}$	0.30	1.74	0.32	NS

Conclusion

Thus, the results suggested that among studied MPTs, utilization of AMF inoculants will be more effective for increasing growth of *A. nilotica*, *A. procera* and *D. sissoo*, and these had non-significant influence on growth of *L. leucocephala*, at seedling stage. The preconditioned seedlings of *A. nilotica*, *A. procera* and *D. sissoo* with AMF inoculants could be utilized for transplantation in the fields.

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