Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 301-304
Received: 11-11-2019
Accepted: 15-12-2019

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Yield parameter of tobacco (*Nicotiana tabacum* L.) as influenced by AM fungi under *Orobanche* infested soils

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Abstract
Tobacco is a one of the commercial products prepared from the tobacco leaves by curing them. Among the different species of tobacco, *Nicotiana tabacum* and *Nicotiana rustica* are well known tobacco species grown commercially across the world. Tobacco contains several phyto-chemicals like nicotine a principle alkaloid known for its insecticidal property in the form of nicotine. Recent studies have revealed that the AM fungal colonization is likely to induce growth promotional activities like number of leaves per plant and yield of tobacco per plot compared to uninoculated control under *Orobanche* infested soils. In this regard a field investigation was carried out to evaluate the three different methods of application of AM Fungal culture *viz*., planting of pre colonized tobacco seedling; soil application and the combination of both. The experiment was carried out in *Orobanche* infested soils of tobacco growing areas of Nipani in Belagavi district. The results of the present field investigation has revealed that the yield of tobacco at 150 DAP increased in the treatment received both planting of pre colonized tobacco seedling as well as soil application of STD AMF (2.52 kg/plot) which is significantly higher to the treatment received pre colonized tobacco seedling with UASDAMFT alone (2.44 kg /plot). However the lowest yield performance was recorded in uninoculated control tobacco plants (1.73kg/plot). Furthermore number of tobacco leaves per plant at 120 DAP increased in the treatment received pre colonized plus soil application of STD AMF at the time of planting documented the highest tobacco leaves (25.44 leaves/plant) compared to un inoculated control(17.55 leaves/plant). Thus our findings are of positive indicative of the effectiveness of application of AMF as mycorrhized seedlings followed by soil application will be a promising strategy to develop a growth promotional activity in tobacco under *Orobanche* infested soils.

Keywords: AMF, *Orobanche*, tobacco, yield

Introduction
Tobacco belongs to the family Solanaceae and the genus *Nicotiana*, native to South America. Tobacco also called "Golden Leaf" is one of the important commercial crops of India and being so it is vital to the economy. India stands third in production of tobacco next to China and Brazil. Tobacco contains several phyto-chemicals like nicotine a principle alkaloid known for its insecticidal property in the form of nicotine sulphate (40%), solanesol a co-enzyme Q-9 used as cardiac drug, malic acid (4.5%) and citric acid (0.5%) used in food beverages. Dried leaves of tobacco are mainly used for smoking, pipe tobacco, chewing tobacco, dipping tobacco and snus Anon (2013) [2]. Recent studies have revealed that the AM fungal colonization is likely to induce growth promotional activities like number of leaves per plant and yield of tobacco per plot compared to un inoculated control under *Orobanche* infested soils<<. In this regard a field investigation was carried out to evaluate the three different methods of application of AM Fungal culture *viz*., planting of pre colonized tobacco seedling; soil application and the combination of both. The experiment was carried out in *Orobanche* infested soils of tobacco growing areas of Nipani in Belagavi district.

Material and Methods
A field experiment was conducted during *Kharif* 2018 in order to study the Yield parameter of tobacco (*Nicotiana tabacum* L.) as influenced by AM fungi under *Orobanche* infested soils. These experiments were carried out in *Orobanche* infested soils of tobacco growing areas of Nipani in Belagavi district of northern Karnataka.

Selection of experimental site: Before conducting the experiment, an extensive survey was under taken in the tobacco growing areas of Belgavi district for the *Orobanche* infested fields.

Based on the severity and the tobacco crop damage, the ARS Nipani was selected for conducting the present investigation.

AMF culture

Table: For the present investigation the following AMF culture are used presented below

Code Number	AMF species	Functional character
UASDAMFT (Isolated from *Orobanche* suppressive soils in tobacco)	*Glomus fasciculatum Glomus deserticola Glomus mosseae Glomus radiata*	*Orobanche* suppressive and growth promotional activity in tobacco (Chandrashekharagowda *et al.*, 2018) [4]
UASDAMFS (Isolated from *Striga* suppressive soils in sugarcane)	*Glomus leptotichum Acaulospora maarowe*	*Striga* suppressive cultures in sugarcane (Shubha *et al*. 2018) [9]
STD AMF Consortium	*Glomus macrocarpum, Gigaspora margarita Acaulospora laevis*	Growth promotional and Striga suppressive cultures from the reposity of department of agricultural microbiology, UAS Dharwad

Table: Treatment details

T_1	**UASDAMFT + Pre colonization**
T_2	UASDAMFT + Soil application
T_3	UASDAMFT + Pre colonization + Soil application
T_4	UASDAMFS + Pre colonization
T_5	UASDAMFS + Soil application
T_6	UASDAMFS + Pre colonization + Soil application
T_7	STD AMF + Pre colonization
T_8	STD AMF + Soil application
T_9	STD AMF + Pre colonization + Soil application
T_{10}	UIC outside the experiment run with RCBD

Application of mycorrhizal cultures

Pre colonization of the tobacco seedlings in the nursery beds with AMF @ 2 kg /m^2

Nursery beds were prepared and subjected for solarization (4 to 5 weeks) in order prevents the native AMF infective propagules. AMF culture along with vermicompost @ 2:25 was applied in the furrows prior to the sowing of tobacco seeds (plate 2 and 3).

Soil application

AMF culture @ 8 kg per acre was applied along with 200 k g of vermicompost at the time of transplanting of tobacco seedlings.

Observations

Number of leaves per plant: Number of leaves per plant was documented average of five plants per treatment.

Length and width of tobacco plants: Length and width of tobacco leaves per plant was documented average of five plants per plot in centimeter.

Yield of tobacco: yield of tobacco in kgs was documented gram per plot at the time of harvesting stage.

Statistical analysis and data interpretation

The data collected at different growth stages of crop were subjected to statistical analysis. Based on mean values obtained, analysis and interpretation of data were studied using the Fischer's method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was p = 0.05. Critical difference values were calculated wherever the 'F' test was significant.

Results and Discussion

Yield of tobacco as influenced by AM fungal cultures in *Orobanche* infested soil: The yields of tobacco documented at 150 DAP, yield parameters in tobacco was influenced by the application of STD AMF (2.34 kg/plot), followed by UASDAMFT (2.33 kg/plot) and UASDAMFS (2.12 kg/plot). Application of mycorrhizal cultures enhanced the tobacco yield significantly over the UIC.

With respect to the methods of applications the treatment received pre colonized plus soil application at the time of planting documented the highest tobacco yield (2.41 kg/plot) compared to planting of pre colonized tobacco seedling alone (2.31 kg/plot) and least yield was observed with soil application at the time of planting (2.07 kg/plot). However the lowest yield performance was recorded in uninoculated control tobacco plants (1.73kg/plot).

Among the interactive studies, the yield of tobacco increased in the treatment received both planting of pre colonized tobacco seedling as well as soil application of STD AMF (2.52) which is significantly higher to the treatment received pre colonized tobacco seedling with UASDAMFT alone (2.44 kg /plot). However the lowest yield performance was recorded in uninoculated control tobacco plants (1.73kg/plot). Your results are accordance with the results of Allen *et al*. (1982) [1] examined the performance of *Glomus* to improve growth, shoot dry matter, nutrient uptake and synthesis of plant growth promoting hormones in maize under *Striga* infected rhizosphere soils. The positive interactions between native isolates AMF and host plants indicated an increased growth promotional activity in sugarcane by several workers Madhura *et al*. (2017) [6]; Manjunath *et al*. (2018) [7]; Shubha *et al*. (2018) [9]. Asif *et al*. (2019) [3]. reported that the tomato plants pre colonized with native AM fungal cultures enhanced the plant height and yield compared to non mycorrhizal tomato plants under *Orobanche* infested soils. The *Glomus etunicatum, G. mosseae, G. intraradices, G. albidum* and *G. fasciculatum* were screened against root parasite *Striga* under *in-situ* conditions. The outcome of results indicated an increased in the plant physiological, growth and yields parameters of sorghum compared to uninoculated control (Nuhu *et al*., 2003).

Number of tobacco leaves per plant as influenced by AM fungal cultures in *Orobanche* infested soil

The number of tobacco leaves was documented at 120 DAP, number of tobacco leaves per plant was influenced by the application of STD AMF (23.51/plant), followed by UASDAMFT (21.99/plant) and UASDAMFS (21.14/plant). Application of mycorrhizal cultures enhanced the number of tobacco leaves significantly over the UIC (17.55/plant).

With respect to the methods of applications the treatment received pre colonized plus soil application at the time of planting documented the highest tobacco leaves (23.92/plant) compared to planting of pre colonized tobacco seedling alone (22.47/plant) and least number of leaves was observed with

soil application at the time of planting(20.25/plant). However the less number of leaves was recorded in uninoculated control tobacco plants (17.55/plant).

Among the interactive studies, the leaves of tobacco increased in the treatment received both planting of pre colonized tobacco seedling as well as soil application of STD AMF (25.44/plant) which is significantly higher to the treatment received pre colonized tobacco with UASDAMFT as well as soil application at the time of planting (23.66 /plant). However the less number of leaves was recorded in uninoculated control tobacco plants (17.55/plant) our findings are similar to the findings of Datta and Kulkarni (2014) reported mycorrhizal inoculation of plants improved leaf area and leaf protein content in legumes under the stress condition. Chandrashekharagowda *et al*. (2018) [4] in tobacco; Asif *et al*. (2019) in tomato reported that the plants pre colonized with native AM fungal cultures enhanced the plant height, plant biomass and yield parameters compared to non mycorrhizal tomato plants under *Orobanche* infested soils.

The tobacco leaf length per plot was documented at 120 DAP

The tobacco leaf length per plot was documented at 120 DAP. Length of tobacco leaf per plot was influenced by the application of UASDAMFT (58.52 cm/plot) followed by STD AMF (58.20 cm/plot), and UASDAMFS (46.70 cm/plot). Application of mycorrhizal cultures enhanced the tobacco leaf length significantly over the UIC (45.2 cm/plot).

With respect to the methods of applications the treatment received pre colonized tobacco seedling alone(55.62 cm/plot) documented the highest length of tobacco leaf compared to planting of pre colonized plus soil application at the time of planting (53.92 cm/plot) and less length was observed with soil application at the time of planting(53.87 cm/plot). However the least length of tobacco leaf was recorded in uninoculated control tobacco plants (45.2 cm /plot). Among the interactive studies, the length of tobacco leaf increased in the treatment received both planting of pre colonized tobacco seedling as well as soil application of UASDAMFT (61.42 cm/plot) which is significantly higher to the treatment received pre colonized tobacco with STD AMF as well as soil application at the time of planting (58.96 cm /plot). However the less length of tobacco leaves was recorded in uninoculated control tobacco plants (45.2 cm /plot).

The tobacco leaf width per plot was documented at 120 DAP

Width of tobacco leaf per plot was influenced by the application of UASDAMFT (28.98 cm/plot) followed by STD AMF (28.65cm/plot), and UASDAMFS (26.46 cm/plot). Application of mycorrhizal cultures enhanced the width of tobacco leaf significantly over the UIC (20.66 cm/plot).

With respect to the methods of applications the treatment received pre colonized plus soil application at the time of planting (29.37 cm/plot) documented the highest width of tobacco leaf compared to planting of pre colonized tobacco seedling alone (29.12 cm/plot) and less width was observed with soil application at the time of planting(25.60 cm/plot). However the least width of tobacco leaf was recorded in uninoculated control tobacco plants (20.66cm /plot).

Among the interactive studies, the width of tobacco leaf increased in the treatment received both planting of pre colonized tobacco seedling as well as soil application of UASDAMFT (30.75 cm/plot) which is significantly higher to the treatment received pre colonized tobacco with STD AMF as well as soil application at the time of planting (30.33 cm /plot). However the lest width of tobacco leaf was recorded in uninoculated control tobacco plants (20.66 cm /plot) our findings are similar to the findings of Datta and Kulkarni (2014) reported mycorrhizal inoculation of plants improved leaf area and leaf protein content in legumes under the stress condition. Chandrashekharagowda *et al*. (2018) [4] in tobacco; Asif *et al*. (2019) in tomato reported that the plants pre colonized with native AM fungal cultures enhanced the plant height, plant biomass and yield parameters compared to non mycorrhizal tomato plants under *Orobanche* infested soils.

Conclusion

The methods of application of AMF native isolates *viz.*, the treatment received as a both pre colonization of tobacco seedling as well as soil application of STD AMF followed by pre colonized tobacco seedling UASDAMFT alone improve growth promotional activity like yield parameter of tobacco, number of leaves, leaf length and width in tobacco plants under *Orobanche* infestation soils. Hence our findings are of positive indicative of the effectiveness of application of AMF as mycorrhized seedlings followed by soil application will be a promising strategy to develop a growth promotional activity in tobacco under *Orobanche* infested soils.

Table 1: Yield of tobacco as influenced by AM fungal isolates in *Orobanche* infested soil at 150 DAP (kg/plot)

AM Fungi	Method of application			
	S_1	S_2	S_3	Mean
M_1	2.44	2.16	2.38	2.33
M_2	2.13	1.89	2.33	2.12
M_3	2.36	2.15	2.52	2.34
Mean	2.31	2.07	2.41	
UIC				1.73
	S.Em±		C D at 5 %	
M	0.05		0.19	
S	0.04		0.13	
M at S	0.07		0.26	
UIC	0.07		0.22	

AM Fungi	Method of application
M_1: UASDAMFT (tobacco native)	S_1: pre-colonized
M_2: UASDAMFS (sugarcane native)	S_2: soil application
M_3: STD AMF	S_3: pre-colonized + soil application
UIC: Uninoculated control	

Table 2: Number of tobacco leaves as influenced by AM fungal isolates in *Orobanche* infested soil at 120 DAP (leaves/plant)

AM Fungi	Method of application			
	S_1	S_2	S_3	Mean
M_1	23.55	18.77	23.66	21.99
M_2	19.88	20.88	22.66	21.14
M_3	23.99	21.1	25.44	23.51
Mean	22.47	20.25	23.92	
UIC				17.55
	S.Em±		C D at 5 %	
M	0.51		2.03	
S	0.31		0.98	
M at S	0.68		2.44	
UIC	0.07		0.22	

AM Fungi	Method of application
M_1: UASDAMFT (tobacco native)	S_1: pre-colonized
M_2: UASDAMFS (sugarcane native)	S_2: soil application
M_3: STD AMF	S_3: pre-colonized + soil application
UIC: Uninoculated control	

Table 3: Tobacco leaf length and width as influenced by AMF fungal cultures in *Orobanche* infested soil (120 DAP) in centimeters

Treatment	Leaf length(cm)				Width(cm)			
	Method of application				Method of application			
AM Fungi	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	58.87	55.26	61.42	58.52	30.75	26.4	29.75	28.98
M_2	49.19	49.53	41.39	46.70	26.29	24.49	28.59	26.46
M_3	58.80	56.83	58.96	58.20	30.33	25.87	29.76	28.65
Mean	55.62	53.87	53.92		29.12	25.60	29.37	
UIC				45.2				20.66
	S.Em±		C D at 5 %		S.Em±		C D at 5 %	
M	0.47		1.86		0.70		2.77	
S	0.72		2.23		0.70		2.167	
M at S	1.25		3.87		1.21		3.75	
UIC	1.26		3.76		1.22		3.65	

AM Fungi	Method of application
M_1: UASDAMFT (tobacco native)	S_1: pre-colonized
M_2: UASDAMFS (sugarcane native)	S_2: soil application
M_3: STD AMF	S_3: pre-colonized + soil application
UIC: Uninoculated control	

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