International Journal of Advanced Multidisciplinary Research
ISSN: 2393-8870
www.ijarm.com
DOI: 10.22192/ijamr Volume 4, Issue 7 -2017

Research Article

DOI: http://dx.doi.org/10.22192/ijamr.2017.04.07.005

Effect of the role of mycorrhizal combating soil salinity under field conditions in *Trigonellafoenum- graecum* L.

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Keywords

Arbuscularmycorrhizal fungi;
Saline soil;
Trigonellafoenum-graecum L.

Abstract

In the present study was carried out to demonstrate and examine the impact of arbuscularmycorrhizal fungi (AMF) on the growth in *Trigonellafoenum- graecum L.* exposed to salt stress. Salt stress reduced plant growth and AMF colonisation. However, AMF ameliorated the negative effect of salinity on these growth parameters. Salt stress increased the activities . Plants subjected to salt stress showed considerable variations in the field experiments of *Trigonellafoenum- graecum* L. seeds were germinated in a glass house. The overall study was divided into two different experiments Commercial mycorrhizas experiment and Individual species of mycorrhizas experiment. The two types of mycorrhizal species used in this experiment were *Glomus pubescenes* and *Glomus facciculatum*, which were inoculated singly and in combination with an untreated control species. Both experiments were grown for four months, after which plants were harvested and different plant parameters were recorded, including height, leaf number, inflorescence number, and length.The results obtained from both field experiments showed that mycorrhizas did not actually help the plant overcome salinity at higher stress. Also, different levels of salinity and different salt types influenced mycorrhizal species interaction with plants in different ways.

Introduction

Arbuscularmycorrhizal fungi can increase plant growth, photosynthesis, nutrients storage, metabolites and beneficial chemical compounds and decrease soil borne plant diseases by inhibition of fungal pathogen (Ratti*et al*., 2010; Oliveira *et al*., 2013).Thus, many researchers have studied the structure and function of AMF communities, and the relationship between AMF and its ecological factors (Gai and Liu, 2003; Wu *et al*., 2007; Moreira *et al*., 2007; Wolfe *et al.,*2007). AMF occurred in a wide variety of ecosystems, such as farmland, forestland, grassland, desert, saline and alkaline soil (Wang *et al.,* 2003).

Salinity induced alteration in phosynthetic attributes results in perturbed carbon assimilation and hencerestricts supply of photoassimilates for plant development (Hameed *et al*., 2014; Iqbal *et al*., 2015). Arbuscularmycorrhizal fungi (AMF) form symbiotic associations with several plant species. AMF contributes to growth improvement of the host plant by enhancing the characteristics of rhizospheric soil as well as modifying and protecting the root architecture of the host plant (Abd_Allah *et al.*, 2015a,b).

Soil salinity is one of the serious environmental problems that adversely affects plant metabolism and growth of crop (Rueda-Puente *et al*., 2007). Salinity affects plant physiology through changes in the water and ionic status of the cells (Sultana *et al*., 1999).
Salinity problem mostly seen in arid and semiarid regions may also be a problem in irrigated land. It wasestimated that approximately one third of irrigated land has been affected by salinity problem (Shannon, 1984).The plants exposed to salt stress adapt their metabolism in order to cope with the changed environment. Survival under these stressful conditions depends on the plant's ability to perceive the stimulus, generate and transmit signals and instigate biochemical changes that adjust the metabolism accordingly (Hasegawa *et al.*, 2000).In present study for important the crop plant was used for AMF and salinity tolerant study.

Materials and Methods

Fenugreek (*Trigonellafoenum-graecum* L.) belonging to the Leguminosae (Fabacecae family) is an important leguminous seed spice and well known aromatic and medicinal crop. *Trigonellafoenum- graecum* L. (Fenugreek) seed were collected from Arya Farm products Pvt, Ltd. Bangalore seeds were germinated in a glass house when the department of botany Govt. Arts. College Ariyalur. When the germinated seedlings reached the four-leaf stage, they were transplanted into pots filled with commercial sterilised compost (organic potting mix from nutria-gro). During the process of potting the plants, half of the seedlings were treated with mycorrhizas (Mycotonemycorrhiza from amazon.in), and the other half were kept without treatment as controls. The potted plants were transferred and kept in the glasshouse at a temperature range of 20±28°C in daylight. The plants were maintained in the glasshouse for approximately two weeks to establish the mycorrhizal-plant association and watered daily as required before transfer to the open-field conditions. The field study and plant transfer took place the summer season of May and the end of August. Inside the field plot, the plants were arranged in a complete randomized block design, with a space of 50 cm between each plant. The overall study was divided into two different experiments

Commercial mycorrhizas experiment (First experiment)

In the first treatment a commercial mix of mycorrhizas (Mycotonemycorrhiza) was used in this experiment.

Treatment conditions were with or without mycorrhizas, four levels of salinity, and two types of salts (NaCl and mixed) with six replicate plants.

Individual species of mycorrhizas experiment (Second experiment)

The two types of mycorrhizal species used in this experiment were *Glomus pubescenes* and *Glomus facciculatum*, which were inoculated singly and in combination with an untreated control species. Only mixed salts were used (with and without), with three levels of salinity. The experiment used six replicates of plants.

In both field experiments (first and second experiments), mixed salts were used as the experimental treatment. The first field experiment (using commercial mycorrhizas) used different salt types (NaCl and mixed) and four salinity levels of electrical conductivity (2.2, 5, and 10 dS/m at 25°C and a control). The second experiment used only mixed salts without NaCl to mimic the real field situation with three salinity levels of electrical conductivity (1.5 and 3.5 dS/m at 25°C and a control). Every week, 200 mL of salt solution was added to each desired plant treatment to prevent the salinity level in the soil from flushing away.

Both experiments were grown for four months, after which plants were harvested and different plant parameters were recorded, including height, leaf number, inflorescence number, and length. The weight of inflorescences was taken to indicate the weight of the seeds contained. The harvested shoots of plant weight were taken and considered as initial shoot biomass as well as final dry shoot weight. Roots for each plant were cleaned and stained for mycorrhizal visualisation. The stained roots were prepared on glass slides for AM fungal quantification and identification of different parts of mycorrhizas such as vesicles, hyphae, and arbuscules.
The seeds produced from F1 plants treated under the salinity conditions explained above were used for the germination of F2 generation plants. From each plant, 15 healthy seeds were selected for the germination test. Petri dishes of 90-mm diameter with filter paper inside were used for the germination test under constant room temperature (26°C). The seeds of each plant were

divided into three Petri dishes, and five seeds were placed in each Petri dish for a total of 15 seeds for each plant. The seeds were watered daily with distilled water, and daily seedling germination was recorded for seven days of the experiment. Final total shoot and root lengths for each successfully germinated seedling were recorded.

Statistical analysis

The data obtained were tested for normality and then analyzed by one factors analysis of variance (ANOVA).

Results

First generation

There was a significant difference in the effect of salt type on mean leaf number (Table -1), with NaCl tending to produce plants with higher number of leaves than those treated with mixed salts (Figure -1). Overall, the mycorrhizal-association factor alone did not have any effect on mean leaf number (Table -1). However, the addition of mycorrhizas enhanced mean leaf number at the 2.2 dS/m salinity level only, leading to a significant interaction term between salinity and AM (Table -1; Figure -1). With respect to mean final plant height, no effect of salt or mycorrhizal inoculation was found (Table -1; Figure -2). The mean dry shoot biomass showed a significant effect of salt type only (Table -1), as the addition of mixed salts reduced shoot biomass more than the addition of NaCl alone (Figure -3).

Table : 1: Summary of the results of Analysis of Variance of different parameters in different types of treatments. Salt types (NaCl and mixed salts), salinity levels (EC) (0,2.2, 5, and 10dS/m), and mycorrhizal treatment (AM). Degrees of freedom for salt types=1, 40; salinity levels =2,40; AM = 1.40.

Parameters	Leaf number		Plant height (cm)		Shoot dry biomass	
	F- value	P- value	F- value	P- value	F- value	P- value
Salt type	3.7	<0.05	1.6	0.2	4.5	0.04
Salinity (EC)	0.2	0.81	1.1	0.3	1.2	0.3
AM	0.3	0.5	1.1	0.3	0.03	0.8
Salt type x salinity (EC)	1.6	0.2	0.6	0.5	2.4	0.12
Salt type x AM	1.0	0.3	0.2	0.8	0.6	0.4
Salinity (EC)x AM	3.4	<0.05	1.0	0.3	0.2	0.65
Salt type x salinity (EC)x AM	0.90	0.3	1.0	0.3	0.3	0.58

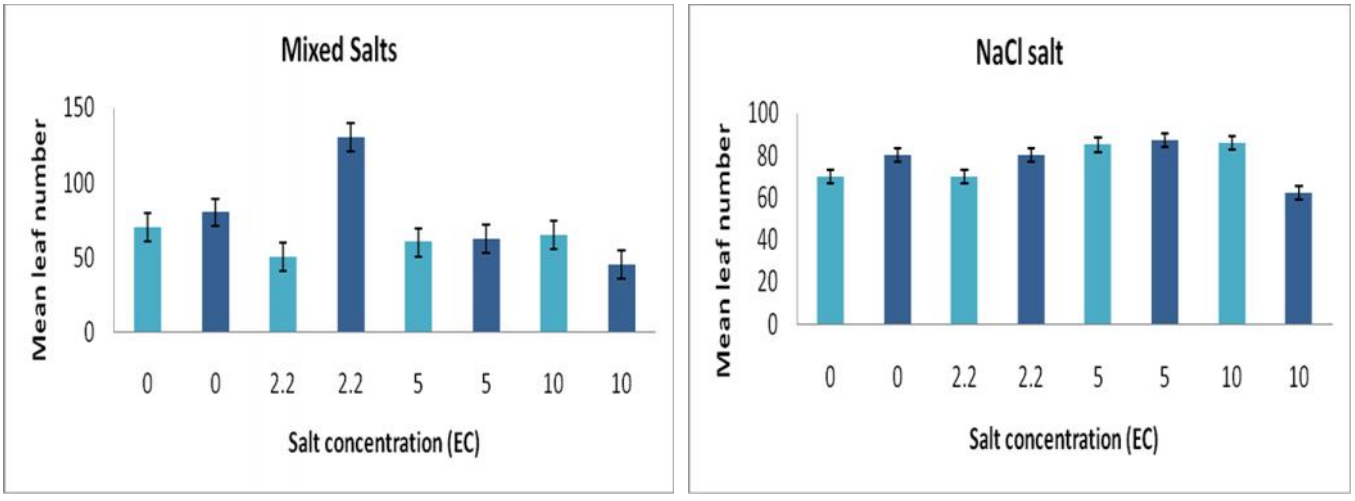

Figure 1: The final leaf plant count for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars commercial mycorrhizal inoculation.

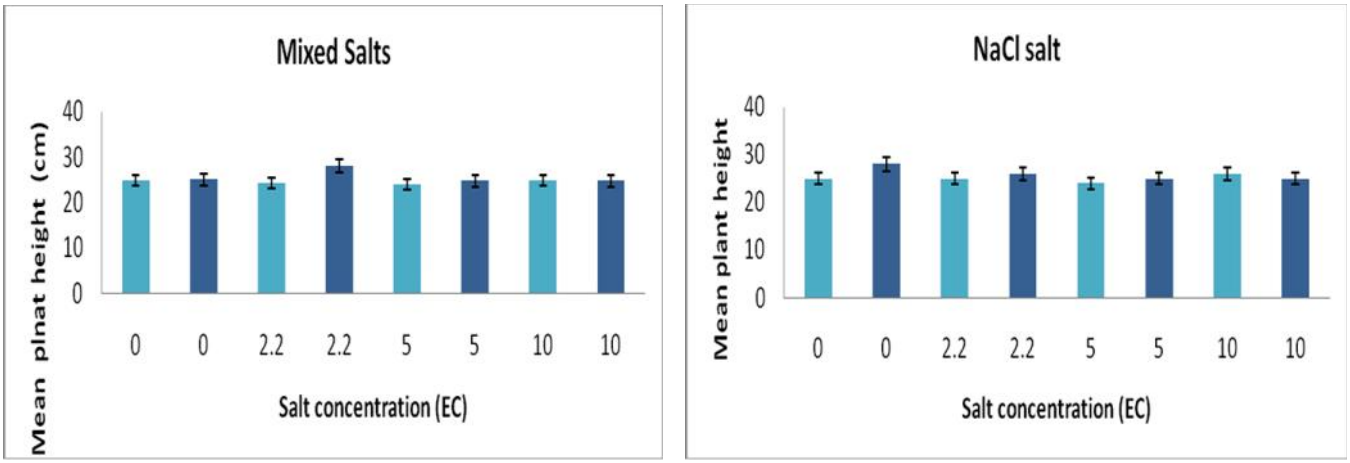

Figure 2: The final plant height in cm for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars commercial mycorrhizal inoculation.

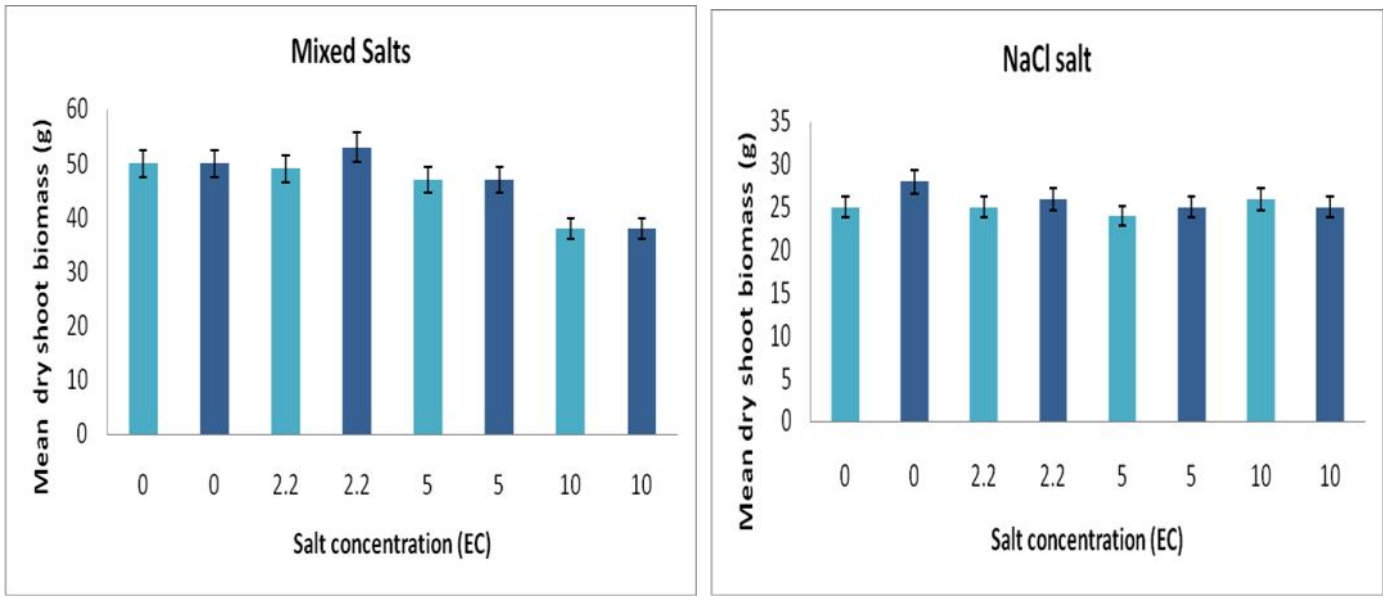

Figure 3: The final plant shoot biomass after oven-drying for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars) commercial mycorrhizal inoculation.

Production of inflorescences was affected by the type of salt addition (Table -2). Addition of NaCl salt enhanced the mean inflorescence number more than the non-salt situation or the addition of mixed salts (Figure - 4). Mycorrhizal addition had no overall effect on mean inflorescence number, but a significant interaction was found between fungal addition and salinity levels (Table -2). This was because at low salinity stress (2.2 dS/m) mycorrhizas enhanced inflorescence number, but with increasing salinity stress levels this positive effect disappeared (Figure - 4). On the other hand, the mean inflorescence length (cm) was not affected by any of the treatments added to the experiment (Table -2). The mean seed weight was reduced by the addition of different salt types (Table -2). Using mixed salts decreased the weight of seeds produced by the plant far more than the addition of NaCl salt (Figure -5). Regarding the effect of different salinity levels (Table -2), medium saline addition produced larger seeds of greater weight

(Figure -5). The medium salinity level produced higher seed weight in comparison with lower salinity addition and no salt treatment (Figure -5). The addition of mycorrhizas did not show any positive effect on mean seed weight produced by the plants under different salinity effect factors (Table -2).

Table 2: Summary of the results of Analysis of Variance of different parameters for different types of treatments. Salt types (NaCl and mixed salts), salinity levels (EC) (0, 2.2, 5, and 10 ds/m), and mycorrhizal treatment (AM), Degrees of freedom for salt types=1,35; salinity levels= 2,35; AM= 1,35.

Parameters	Inflorescence number		Inflorescence head length (cm)		Seed weight (g)	
	F- value	P- value	F- value	P- value	F- value	P- value
Salt type	6.0	<0.01	0.3	0.5	5.8	<0.01
Salinity (EC)	0.5	0.5	0.2	0.5	2.5	<0.05
AM	1.6	0.2	0.1	0.7	0.01	0.9
Salt type x salinity (EC)	1.0	0.3	0.06	0.8	0.05	0.8
Salt type x AM	1.5	0.2	2.0	0.1	1.2	0.2
Salinity (EC)x AM	6.0	<0.01	0.4	0.5	1.0	0.3
Salt type x salinity (EC)x AM	0.50	0.48	1.2	0.2	0.6	0.4

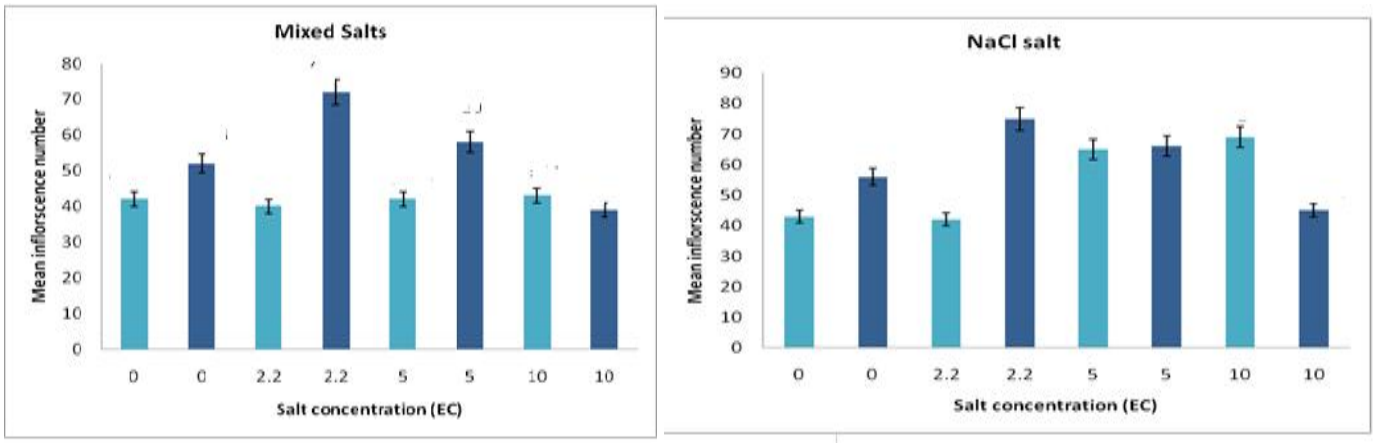

Figure 4: The inflorescence number for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars commercial mycorrhizal inoculation.

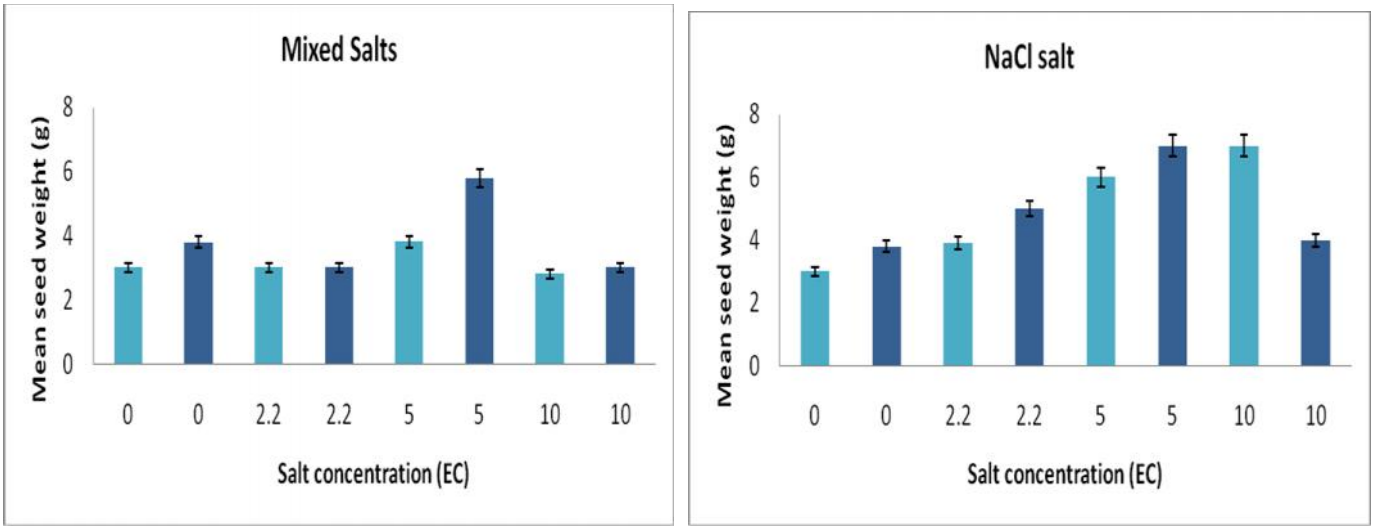

Figure 5: Seed weight production in grams for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars commercial mycorrhizal inoculation.

Mycorrhizal root colonization

Mycorrhizal colonisation was successfully detected in the roots with the average percentage values summarized in (Table -4). Hyphal root colonisation was significantly influenced by the interaction between salt type and salinity, showing different patterns of colonisation across different salinity types and different levels of salinity stress (Table -3). The medium salinity stress (5 dS/m) with mixed salts reduced the incidence of hyphal colonisation, but with NaCl salt, the hyphal colonisation increased across the other treatments (Table -4). The other mycorrhizal parts (vesicles and arbuscules) did not show any significant differences across treatments (Table -3). On the other hand, there was a significant interaction between the spore incidence and salinity levels (Table -5), as spores appeared at higher salinity levels only (Figure -6). With increasing salinity levels, the number of spores produced by mycorrhizas increased, especially at 5 and 10 dS/m (Figure -6). At lower salinity levels (0 and 2.2 dS/m), however, mycorrhizas did not produce spores during their association with plant roots (Figure -6). There was also a significant interaction term between salt type and salinity level (Table -5). This was because the addition of mixed salts produced spores at both medium and high salinity levels, but with NaCl salt spores were only seen at the high level of salinity(10dS/m)(Figure-6).

Table 3 : Summary of the results of Analysis of Variance of different root colonization by mycorrhizas for different types of treatments. Salt types (NaCl and mixed salts), salinity levels (EC) (0,2.2, 5, and 10dS/m), and mycorrhizal treatment (AM), Degrees of freedom for salt types= 1,48; salinity levels = 2,48; AM= 1,48.

Parameters	Hyphae		Vesicles		Arbuscules	
	F- value	P- value	F- value	P- value	F- value	P- value
Salt type	0.7	0.4	0.3	0.5	0.10	0.7
Salinity (EC)	0.1	0.9	0.2	0.8	0.2	0.8
AM	0.2	0.6	0.02	0.8	0.01	0.9
Salt type x salinity (EC)	2.5	0.01	1.4	0.2	1.0	0.3
Salt type x AM	1.8	0.1	1.8	0.1	0.1	0.7
Salinity (EC)x AM	0.1	0.07	1.6	0.2	1.2	0.2
Salt type x salinity (EC)x AM	1.0	0.3	1.0	0.3	0.4	0.5

Tables 4: Mean mycorrhizal colonization percentages (%) for different treatments after root- staining method. H- hyphae ; V- vesicles; A- arbuscules.

Salt type	Mycorrhizas	Salinity level	H%	V%	A%
Mixed	AM	2	37±5	5±3.2	5.4±2.2
		4	35±2.2	6±5.4	1.0±0.6
		8	34±6.5	14±6.6	3.2±2.6
	NO	2	48±4	21±5.2	3±1.2
		4	31±4.2	5±2.4	3±1.4
		8	46±5.6	12±3.6	3±2.2
NaCl	AM	2	37±4.9	8.6±3.8	1±0.2
		4	42±2.8	10.2±3.8	1.0±0.5
		8	38±6	13±6.6	3±2.6
	NO	2	27±7	7±5.4	1±0.2
		4	41±5.2	10±2	5±3.4
		8	32±7.1	2±0.8	2.2±0.6

No Salt	AM	0	39±6	12±3.4	1.2±0.4
	NO	0	45±5	10±2.6	6.2±5.0

Table 5: Summary of the results of Analysis of Variance of Mycorrhizal spore production obtained under different field experience conditions. Degrees of freedom for salt types = 1,50; salinity levels (EC)= 2,50; AM= 1,50.

	Spores Produced	
	F-value	P- value
Salt type	0.1	0.7
Salinity (EC)	3.6	<0.01
AM	0.10	0.7
Salt type x salinity (EC)	4.0	<0.01
Salt type x AM	1.2	0.2
Salinity (EC) x AM	0.1	0.7
Salt typex salinity (EC)x AM	0.3	0.5

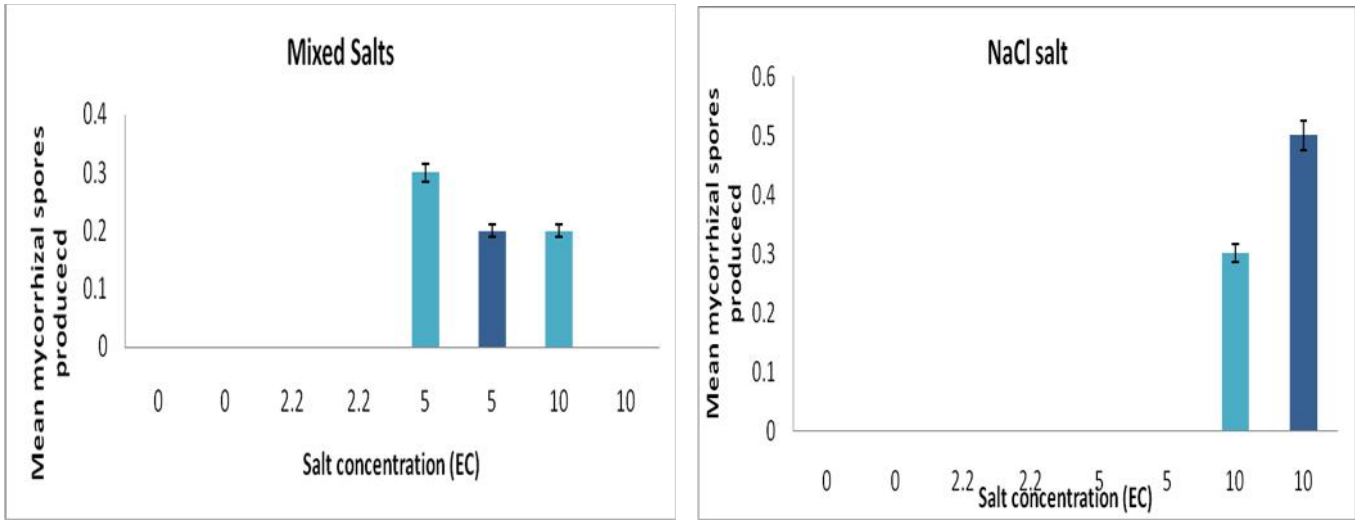

Figure 6: Number of mycorrhizal spores observed for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m), with and without different color bars commercial mycorrhizal inoculation.

Second generation

Neither salt types nor different levels of salinity gradients had any effect on second-generation mean-seedling length (Table -6). Only the addition of mycorrhizas in the field to parental plants produced a significant result and increased seed germination (Table -6; Figure -7). The addition of mycorrhizas enhanced the mean seed germination of the offspring more than non-inoculated parental plants with mycorrhizas with no salt addition, but with salinity addition, the mycorrhizal addition did not show any enhancement (Figure -7).

Table 6: Summary of the results of Analysis of Variance for second- generation seed germination and seedling length. Salt types (NaCl and mixed salts), Salinity levels (EC) (0, 2.2, 5,and 10 dS/m), and mycorrhizal treatment (AM). Degrees of freedom for salt types= 1, 50; salinity levels = 2,50; AM= 1,50.

	Seed germination		Seedling length (cm)	
	F-value	P- value	F-value	P- value
Salt type	0.1	0.7	2.5	0.1
Salinity (EC)	0.5	0.5	0.6	0.3
AM	5.0	<0.05	1.4	0.1
Salt type x salinity (EC)	0.5	0.4	0.1	0.7

Salt type x AM	0.1	0.7	0.1	0.7
Salinity (EC) x AM	0.6	0.4	1.1	0.3
Salt typex salinity (EC)x AM	1.4	0.2	2.4	0.1

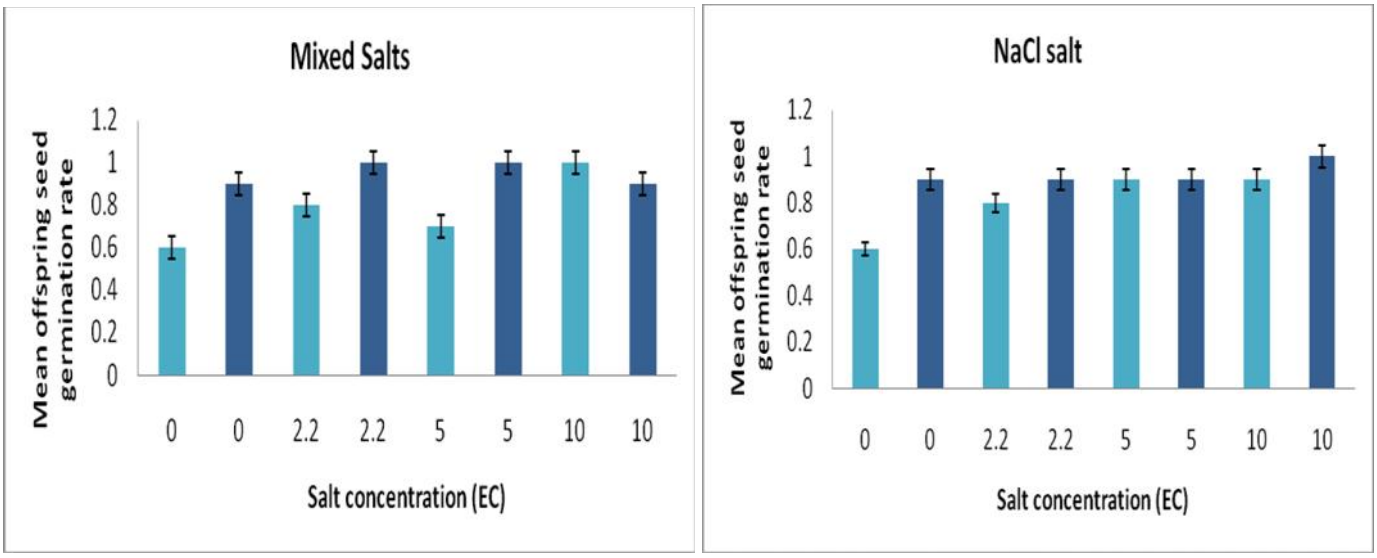

Figure 7: Seed gerrmination rate of second- generation plants under lab conditions and their parental mycorrhizal association effect in field conditions for different salinity types (mixed and NaCl) and different salinity levels (EC) (0, 2.2, 5, and 10 dS/m). Groups shown are with and without different color bars commercial mycorrhizal inoculation.

Results of the second field experiment

First generation

In this experiment, there were very few significant effects of different salinity levels or mycorrhizal species on different plant vegetative or reproductive parameters (Table -7; Table -8). Even in flowering stages and seed production, mycorrhizal addition had no effect in the field (Table -8). The one exception was seen with mean plant height (Table -7). Plants inoculated with *Glomus facciculatum* were taller than those treated with *Glomus puescenes* mycorrhizal fungi (Figure-8).

Table : 7 Summary of the results of Analysis of Variance for different salinity levels (EC) (0, 1.5, and 3.5 dS/m) and AM treatment (Gp= *Glomus pubescenes*, Gf= *Glomus facciculatum*, and the two combined). Degrees of freedom of salinity levels = 2, 46; Gp=1, 46; Gf=1,46.

	Leaf number		Plant height (cm)		Shoot dry biomass (g)	
	F- value	P- value	F- value	P- value	F- value	P- value
Salinity (EC)	0.68	0.45	0.86	0.42	0.76	0.47
Gp	0.75	0.39	2.4	0.12	1.7	0.19
Gf	0.1	0.7	5.0	<0.03	2.2	0.14
Salinity (EC)x Gp	0.40	0.67	0.16	0.8	0.36	0.6
Salinity (EC)xGf	0.50	0.6	1.0	0.30	3.0	0.05
GpxGf	0.22	0.64	0.84	0.30	0.06	0.8
Salinity (EC)x GpxGf	0.16	0.69	0.1	0.7	0.50	0.48

Table : 8 Summary of the results of Analysis of Variance for different plant pararameters at different salinity levels (EC) (0,1.5, and 3.5dS/m) and AM treatments (Gp= *Glomus pubescenes*, Gf= *Glomus facciculatum*, and the two combined). Degrees of freedom of salinity levels = 2.46; Gp=1,46; Gf=1.46.

	Inflorescence number		Seed weight (g)	
	F- value	P- value	F- value	P- value
Salinity (EC)	0.22	0.80	1.0	0.37
Gp	0.62	0.43	0.41	0.52
Gf	1.0	0.3	0.90	0.34
Salinity (EC)x Gp	0.60	0.44	1.1	0.2
Salinity (EC)xGf	1.2	0.27	1.2	0.27
GpxGf	0.65	0.42	0.10	0.75
Salinity (EC)x GpxGf	1.5	0.22	0.02	0.88

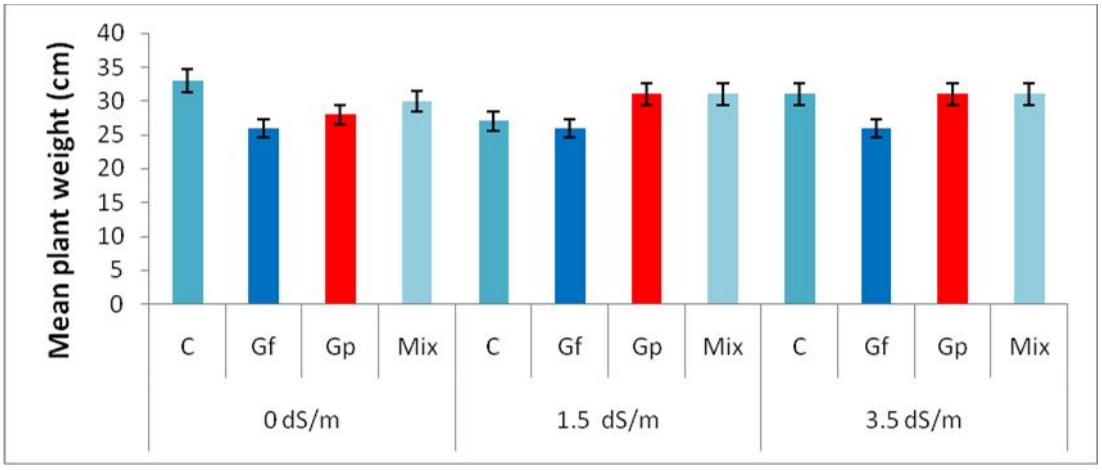

Figure 8: Plant height (cm) for salinity treatments with different species of mycorrhizas. Gf, *G. facciculatum*; Gp, *G. pubescenes*; Mix, adding *G. facciculatum*+ *G. pubescenes*; C, control. Salt salinity levels (0, 1.5, and 3.5 dS/m).

Mycorrhizal root colonization

The addition of mycorrhizal species was associated with different colonisation rates of hyphae under salt stress (Table -9). Addition of species of mycorrhizas had no effect on hyphal root colonisation at the low salinity level (1.5 dS/m), but at no salt addition (0 dS/m) and high salinity (3.5 dS/m) stress, the different species of mycorrhizas produced a remarkable increase in hyphal colonisation, more than non-inoculated plants (Figure -9). Overall, the addition of salt had no effect on vesicle colonisation rate (Table -9). However, a significant interaction term was found between salinity and the AM species (Table -9; Figure -10). At no salt stress, *G. pubescenes*and *G. facciculatum* increased the production of vesicles, but this effect was lost with salinity addition in comparison with non-inoculated plants (Figure -10)

Table : 9 : Summary of the results of Analysis of Variance of mycorrhizal physiological organ root association at different salinity levels (EC) (0, 1.5, and 3.5 dS/m) and AM treatment (Gp= *Glomus pubescenes*, *Gf= Glomus facciculatum*, and two combined). Degree of freedom of salinity levels = 2, 48; Gp=48;,Gf=1,48.

	Hyphae		Vesicles		Arbuscules	
	F- value	P- value	F- value	P- value	F- value	P- value
Salinity (EC)	0.92	0.40	1.2	0.3	0.89	0.41
Gp	3.0	0.08	0.14	0.7	1.4	0.24
Gf	1.2	0.27	0.01	0.92	0.01	0.92

Salinity (EC)x Gp	0.6	0.4	1.5	0.22	0.6	0.4
Salinity (EC)xGf	2.0	0.16	3.6	<0.05	0.2	0.7
GpxGf	0.1	0.7	5.4	<0.05	0.6	0.4
Salinity (EC)x Gp x Gf	3.3	<0.05	3.6	<0.05	3.2	<0.05

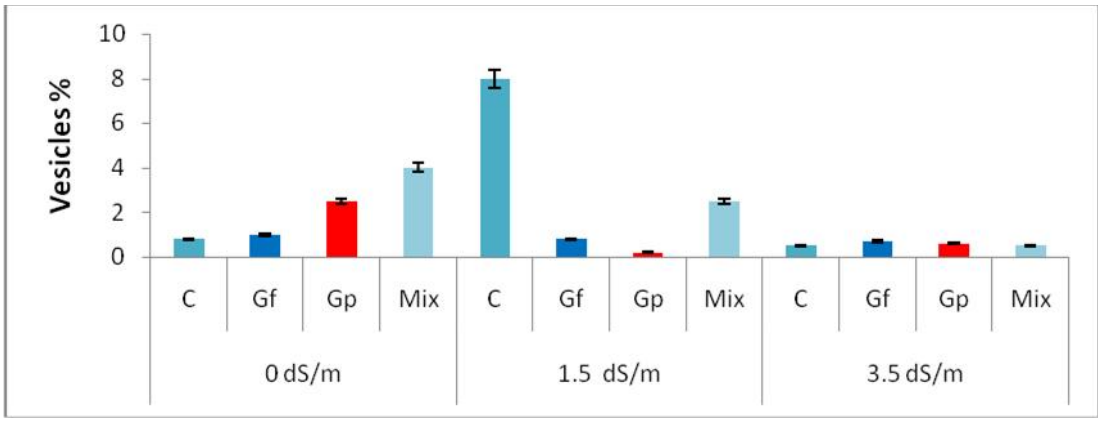

Figure 10 Percentage of vesicles colonisation of plant root at different salinity levels (0, 1.5 and 3.5 dS/m). The mycorrhizal treatments were C, without mycorrhizal addition; Gp, *Glomus pubescenes;*Gf, *Glomus facciculatum* and Mix, a mix of the two species.

Arbuscules were not affected by salinity stress nor the addition of different mycorrhizas species; yet, the interaction of these factors resulted in a significant influence on arbuscule production (Table -9). Inoculation with *G. pubescences* and *G. facciculatum* had no effect on arbuscule formation at low (1.5 dS/m) salinity level (Figure -11). Otherwise, the addition of mycorrhizas tended to increase arbuscule formation under no salt condition (0 dS/m) and at the high (3.5 dS/m) salinity level (Figure -11).

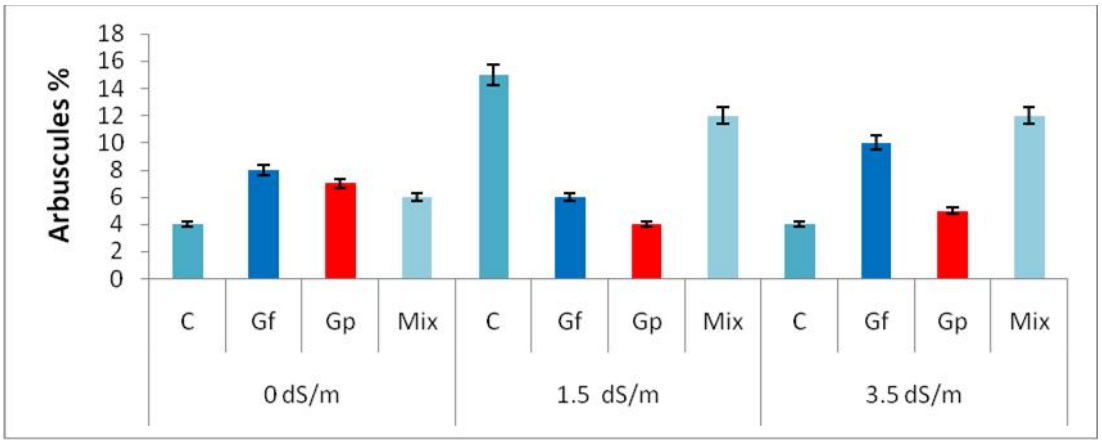

Figure -11: Percentage of arbusculescolonisation of plant root at different salinity levels (0, 1.5 and 3.5 dS/m). The mycorrhizal treatments were C, without mycorrhizal addition; Gp, *Glomus pubescenes*; Gf, *Glomus facciculatum* and Mix, a mix of the two species.

Second generation

Salinity did not show any effect on second generation seed germination; however, there were different rates of seed germination with mycorrhizal inoculation and a significant interaction between the fungi (Table -10). The combined addition of both species of mycorrhizas was associated with a little increase in seed germination compared to individual AM fungi, which tended to reduce it slightly (Figure 12). On the other hand, the different mycorrhizal inoculation and salinity effect did not show any remarkable effects on seedling growth (Table-10).

Table : 10. Summary of the results of Analysis of Variance for offspring seed germination and seedling length at different salinity levels (EC) (0,1.5, and 3.5dS/m) and AM treatments (Gp= *Glomus pubescenes*, Gf= *Glomus facciculatum*, and a Mix of the two). Degrees of freedom of salinity levels = 2.49; Gp=1,49; Gf=1.49.

	Seed germination		Seedling length (cm)	
	F- value	P- value	F- value	P- value
Salinity (EC)	2.6	0.08	0.8	0.4
Gp	0.08	0.77	0.01	0.92
Gf	0.02	0.88	0.2	0.65
Salinity (EC)x Gp	0.64	0.42	0.5	0.48
Salinity (EC)xGf	1.1	0.29	0.3	0.58
GpxGf	4.0	<0.05	0.03	0.86
Salinity (EC)x GpxGf	0.21	0.6	0.84	0.36

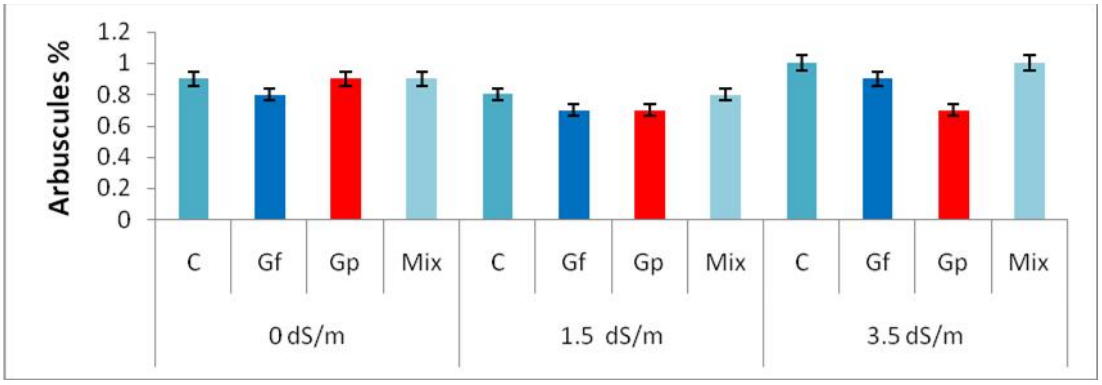

Figure 12 : Seed germination rate for offspring whose parental plants were treated with salinity and different species of mycorrhizas. Gf, *G. facciculatum*; Gp, *G. pubescenes*; Mix, adding G. *facciculatum*+ *G. pubescenes*; and C, control. Salt salinity levels (0, 1.5, and 3.5 dS/m).

Discussion

It has been well documented that inoculation of plants with AM fungi can stimulate nodulation and nitrogen fixation by legumes (Xie *et al*., 1995).AM fungi have been reported to increase growth of plants by enhancing nutrient uptake (Mathur and Vyas, 1995) through a reduction of the distance that nutrients must diffuse to plant roots by accelerating the rate of nutrient absorption and nutrient concentration at the absorbing surface and finally chemically modifying the availability of nutrients for uptake by plants through mycorrhizal hyphae. The present study on fenugreek inoculation with AM fungi has also provided similar results as those obtained by several other researchers (Xavier and Germida, 2003, Hameed, *et al*., 2014, Iqbal, *et al*., 2015).AM fungi have been shown to promote plant growth and salinity tolerance by many researchers. They promote salinity tolerance by utilizing various mechanisms, such as (a) enhancing nutrient uptake (Evelin *et al*.2012). Liu *et al*. (1999) reported that an increase in organic matter concentration was related to an increase in AMF species richness when organic matter concentration was below 1.5%, whereas, and a decrease when organic matter concentration was over 1.5%. The data in this study also pointed out that changes in organic

matter, available P and available N were correlated with AMF community structure, especially *Glomus* distribution, which may be mainly attributed to the effect of these ingredients on AMF sporulation and colonization (Liu *et al*., 1999).

Conclusion

The results obtained from both field experiments showed that mycorrhizas did not actually help the plant overcome salinity at higher stress. Also, different levels of salinity and different salt types influenced mycorrhizal species interaction with plants in different ways. In the first field experiment with higher salinity levels and mixed commercial mycorrhizas, the results were impressive regarding the plant offspring quality. In the second experiment with reduced levels of salinity and the addition of individual mycorrhizal species, the results were not conclusive. Thus, it is recommended that the second field experiment be repeated under controlled conditions for comparison of results.

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DOI:10.22192/ijamr.2017.04.07.005

How to cite this article:
M. P. Johnson and R. Stephan. (2017). Effect of the role of mycorrhizal combating soil salinity under field conditions in *Trigonellafoenum- graecum* L. Int. J. Adv. Multidiscip. Res. 4(7): 22-34.
DOI: http://dx.doi.org/10.22192/ijamr.2017.04.07.005