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Co-inoculation of mycorrhizal fungi and *Streptomyces* on morphometric indices of grapevine (*Vitis vinifera* L.) under salt stress

Arefeh Noori [1], **Rouhollah Karimi** [1*]

[1*] Department of Horticultural Sciences and Landscape Engineering, Facultyof Agriculture, Malayer University, Malayer, Iran.

R.Karimi@malayeru.ac.ir

Abstract

In present study, the effect of the single and combined (co-inoculation) application of *Glomus mosseae* (*Gm*) AMF and *Streptomyces rimosus* (*Sr*) PGPR on salt tolerance of Sultana grapevine (*Vitis vinifera* L.) was performed. Based on results, the combined inoculation with *Gm* AMF and *Sr* PGPR markedly improved shoot and root morphometric traits compared to those vines inoculated with these symbionts alone or uninoculated vines under salinity stress. The highest main root length was related to inoculated vines with *Sr* PGPR, which was 18.5% higher than uninoculated control plants during exposure to NaCl. Under saline condition, co-inoculation with *Gm* AMF and *Sr* PGPR decreased leaf necrotic index by 31% compared with control uninoculated plant.

Introduction

Salinity is one of the main environmental stresses that destroys the soil structure and reduces its hydraulic conductivity, disrupting the normal water-soil-plant relationship. Morphologically, salinity reduces the fresh and dry weight of roots and shoots, root to shoot ratio, leaf area, root and shoot diameter, number of nodes, internode length, number of lateral branches, length of trunk and canes and finally reduces general vine growth (Karimi et al., 2022). Accumulation of salt in flower structures has also led to reduced fruit set, reduced berry growth and development, changes in the internal composition of berries and cluster rachis drying (Walker et al., 2010). So far, various viticultural operations have been employed to prevent or reduce the negative effects of salinity stress in vineyards (Karimi et al. 2022). However, the application of a combination of biofertilizers on grapevine morphometric indices under salt stress has not been investigated. Therefore, in the present study, the root and stem growth indices of Sultana grape (*Vitis vinifera* L.) cultivar was investigated in response to the application of Streptomyces bacteria and mycorrhizal fungi under different concentrations of sodium chloride.

Materials and methods

This research was conducted factorially based on completely randomized design with three biological replications (two vines in each replicate). Treatments included of two factors: (1) the first factors consist of four biofertilizer treatments namely (i) control uninoculated vines (CK), (ii) vines inoculated with *G. mosseae* (*Gm*) AMF alone, (iii) vines inoculated with *S. rimosus* (*Sr*) PGPR alone, (iiii) vines co-inoculated together with *Gm* AMF and *Sr* PGPR (*Gm* + *Sr*). (2) The second factor included of salinity at two levels of 0 (normal condition) and 75 mM sodium chloride (NaCl; saline condition). At the end of experiment, some main morphometric traits of shoot and root were measured in each vine. Leaf necrosis index was measured in each treatment. Data were analyzed using SAS (9.1) software.

Results and discussion

The maximum increment in main branch length, lateral branches number, canopy fresh weight, and canopy dry weight were observed with vines co-inoculated with *Gm* AMF and *Sr* PGPR, which were recorded 32.2%, 35.1%, 55.8 and 52.3% higher than uninoculated plants under saline condition, respectively (Table 1).

Table 1. The effect of *Glomus mosseae* (*Gm*) mycorrhizal fungusand *Streptomyces rimosus* (*Sr*) rhizobacteria on some canopy morphometric indices of *Vitis vinifera* cv. Sultana under normal (0 mM NaCl) and saline (75 mM NaCl) condition.

Treatments		Main branch length (cm)	Lateral branches number	Canopy fresh weight (g)	Canopy dry weight (g)
NaCl	Bioinoculants				
0 mM (Normal condition)	CK	58.67 ± 2.34c	6.00 ± 0.47e	30.42 ± 1.32c	11.60 ± 0.38d
	Gm	58.00 ± 3.17 c	7.33 ± 0.36bc	41.58 ± 0.78b	15.88 ± 0.82ab
	Sr	83.33 ± 2.18 a	7.67 ± 0.44b	41.97 ± 0.98b	15.12 ± 0.65b
	Gm + Sr	68.33± 3.52b	8.00 ± 0.54ab	46.09 ± 0.96a	16.89 ± 0.67a
75 mM (Saline condition)	CK	47.00 ± 3.34d	4.33 ± 0.55f	20.14 ± 2.13d	7.15 ± 0.76e
	Gm	58.67 ± 2.67c	8.67 ± 0.63a	37.60 ± 1.65b	11.91 ± 0.43d
	Sr	56.67 ± 3.43c	7.00 ± 0.30cd	39.98 ± 2.06b	12.97 ± 0.40c
	Gm + Sr	69.33 ± 2.77b	6.67 ± 0.38de	45.53 ± 1.30a	14.99 ± 0.51b

CK, control, Gm *G. mosseae*,Sr *S. rimosus*, Gm + Sr co-inoculation of *G. mosseae* and *S. rimosus*. The means with same Duncan's multiple range test letters in each column are not statistically significant (P≤ 0.01).

However, the highest root volume, root fresh weight and root dry weigh were observed with those vines co-inoculated with *Gm* AMF and *Sr* PGPR, which were respectively 17.5%, 46.9% and 41.97% higher than control (no bioinoculants) plants under saline condition (Table 2).

Table 2. The effect of *Glomus mosseae* (*Gm*) mycorrhizal fungusand *Streptomyces rimosus* (*Sr*) rhizobacteria on some root morphometric indices of *Vitis vinifera* cv. Sultana under normal (0 mM NaCl) and saline (75 mM NaCl) condition.

Treatments		Main root length (cm)	Root volume (cm_3)	Root fresh weight (g)	Root dry weigh (g)
NaCl	Bioinoculants				
0 mM (Normal condition)	CK	40.00 ± 0.1.4d	31.4 ± 0.8c	46.75 ± 1.7f	11.67 ± 0.6d
	Gm	43.00 ± 1.2cd	37.9 ± 1.3a	66.18 ± 2.3c	16.40 ± 0.9ab
	Sr	48.33 ± 0.9a	34.5 ± 1.1ab	68.67 ± 1.3c	17.62 ± 1.3a
	Gm + Sr	49.67 ± 0.8a	36.4 ± 1.2a	96.12 ± 2.4a	17.17 ± 1.3a
75 mM (Saline condition)	CK	36.67 ± 0.3e	27.4 ± 0.6d	39.47 ± 1.1g	9.21 ± 0.7e
	Gm	42.00 ± 0.8d	33.2 ± 0.9b	55.96 ± 1.4e	13.76 ± 0.7c
	Sr	45.00 ± 0.7bc	31.0 ± 0.9c	61.49 ± 2.5d	14.66 ± 0.9bc
	Gm + Sr	43.33 ± 0.5cd	33.6 ± 0.8bc	74.27 ± 1.5b	15.87 ± 0.8b

In vines co-inoculated with *Gm* AMF and *Sr* PGPR, leaf necrosis index by 31.1% (Fig. 1), compared with uninoculated plant under saline condition, indicating the involvement of these bioinoculants in reducing the incidence and severity of salinity stress in treated vines.

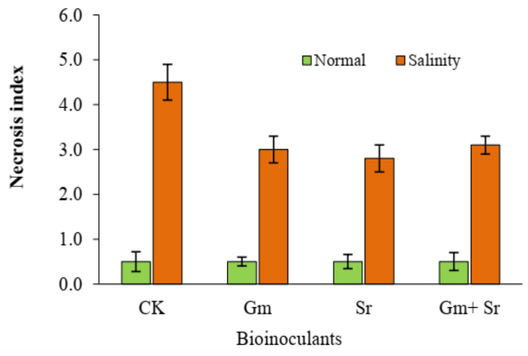

Fig.1. The effect of *Glomus mosseae* (*Gm*) mycorrhizal fungusand *Streptomyces rimosus* (*Sr*) rhizobacteria on leaf necrosis index of *Vitis vinifera* cv. Sultana under normal (0 mM NaCl) and saline (75 mM NaCl) condition.

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