Enzymatic and non-enzymatic reactions of grapevine (*Vitis vinifera* L.) antioxidant system in response to *Streptomyces* and mycorrhizal application under salinity

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Abstract

This experiment was conducted to elucidate the effect of the single and combined (co-inoculation) application of Glomus mosseae (Gm) AMF and *Streptomyces rimosus* (Sr) PGPR on enzymatic and non-enzymatic antioxidant system of Sultana grapevine (*Vitis vinifera* L.) under salt tolerance. Based on results, among salt stressed plants, the single inoculated vines with Gm AMF showed the highest total phenol and flavonoid content compared to control plants. Under saline condition, co-inoculation with Gm AMF and Sr PGPR increased catalase and guaiacol peroxidase activity by 45%, 26%, 30% and 53% compared with control uninoculated plant. Therefore, combined application of Gm AMF and Sr PGPR assisted host plants to uptake higher nutrients during salt stress; confer salt tolerance to vines by increase in morphometric traits.

Introduction

Grape similar to other plants have an array of mechanisms to reduce the negative effects of salinity stress during various growth and developmental processes, including setting up enzymatic (activity of antioxidant enzymes) and non-enzymatic (accumulation of flavonoid and non-flavonoid phenolic compounds, vitamins) antioxidant systems and toxic ion detoxification (Karimi et al., 2022; Zhou-Tsang et al., 2021).

According to studies, *Streptomyces* (as gram-positive bacteria) are tolerant to salinity and their application in the rootzone of some herbaceous plants such as wheat (Sadeghi et al., 2012) and beans (Nassar et al., 2003) have increased the plant height and dry weight of shoots under salinity stress. So far, various viticultural operations have been employed to prevent or reduce the negative effects of salinity stress in vineyards (Walker et al., 2010; Karimi et al., 2022). However, the effects of inoculation of grapevine plants with *G. mosseae* (*Gm*) AMF were not reported under salinity stress until now. On the other hand, the application of *Streptomyces* in adaptation to salinity alone or in combination with mycorrhiza in grapevine has not been studied.

Materials and methods

Experimental treatments were applied factorially based on completely randomized design with three biological replications (two vines per 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). Twenty weeks from planting time; 10 weeks after symbionts inoculation), the vines were divided into two main groups. The first group was irrigated with distilled water containing Hoagland's solution (normal non-saline condition) and the second group irrigated twice a week with 75 mM NaCl through Hoagland's nutrient solution (saline condition) for 6 weeks. After this time, total phenol and total flavonoid contents and some antioxidant enzymes activities were measured in all tratments and data analyzed with SAS software.

Results and discussion

Subjecting to salinity (75 Mm NaCl) significantly increased the leaf $H_2O_2$and MDA content in all vines compared to first group of plants (Fig. 1B, 1A and B). However, these biomembrane stability indices were found to be lower in inoculated vines with *Gm* AMF, *Sr* PGPR or their combination compared to uninoculated vines under saline condition (Fig. 1B, 1A and B). The lowest H_2O_2 was observed in vines inoculated with *Sr* PGPA alone, which was 34.7% lower than uninoculated vines under saline condition (Fig. 1B).

The highest CAT and GPX activities were related to those vines co-inoculated with *Gm* AMF and *Sr* PGPR (without significant difference with plant inoculated with *Sr* PGPA alone), which were respectively 30.4% and 52.8% higher than uninoculated vines under saline condition (Figs. 1C and D).

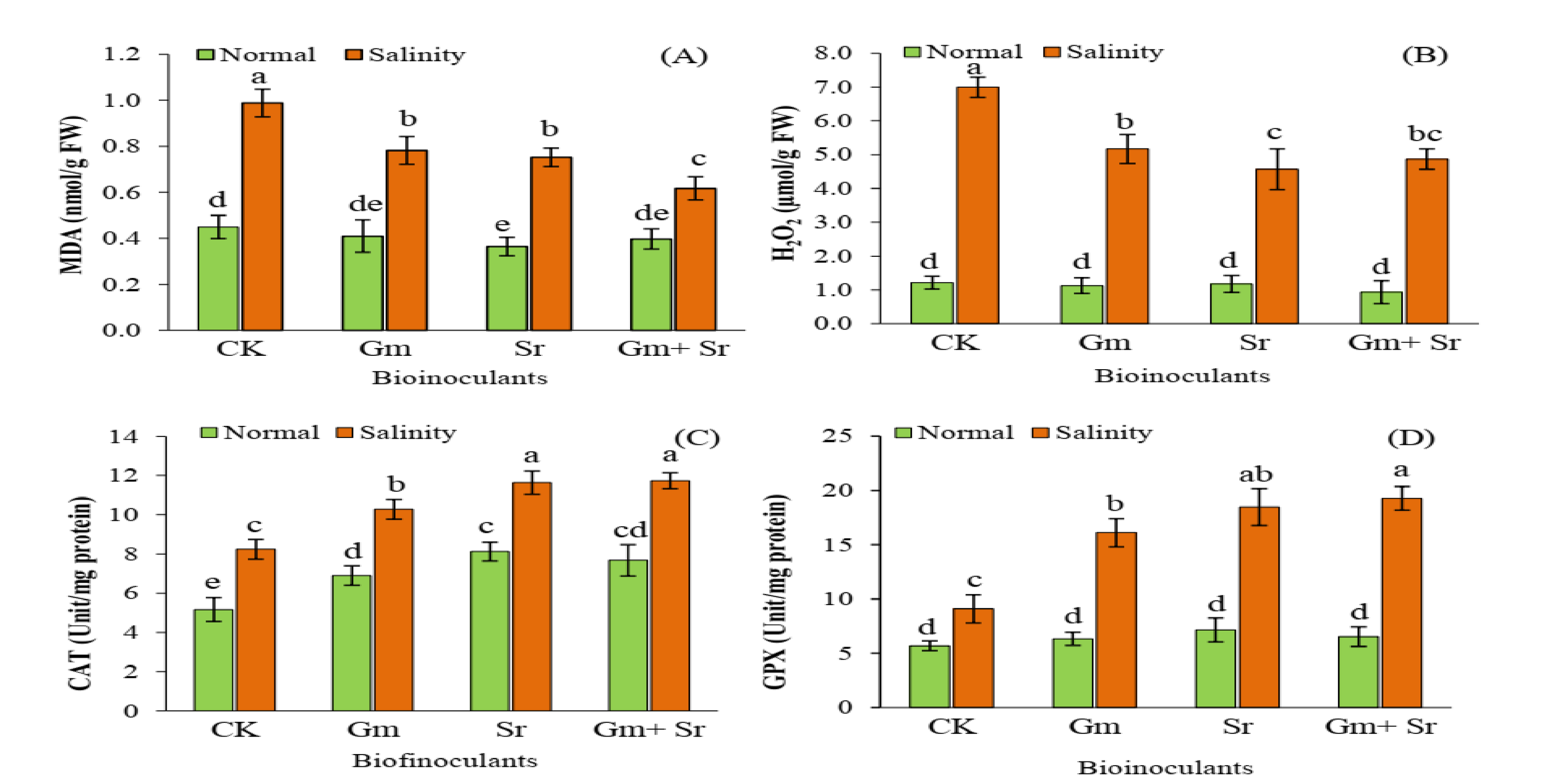

Fig. 1. The effect of *Glomus mosseae* (*Gm*) mycorrhizal fungus and *Streptomyces rimosus* (*Sr*) rhizobacteria on leaf malondialdehyde content (MDA; panel A), hydrogen peroxide content (H_2O_2; panel B), catalase activity (CAT; panel C) and guaiacol peroxidase (GPX; panel D) content of *Vitis vinifera* cv. Sultana under normal (0 mM NaCl) and saline (75 mM NaCl) condition.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). Data are average of three replications ± SE.

Among inoculated salt-stressed plants, the *Gm* AMF –inoculated vines alone showed the highest total phenol and total flavonoid contents. Interestingly, co-inoculation with *Gm* AMF clearly increased the leaf total phenol content by 22.3% and total flavonoid content by 16.1% compared to uninoculated vines under saline condition.

Table 1. The effect of *Glomus mosseae* (*Gm*) mycorrhizal fungus and *Streptomyces rimosus* (*Sr*) rhizobacteria on leaf secondary metabolites of *Vitis vinifera* cv. Sultana under normal (0 mM NaCl) and saline (75 mM NaCl) condition.

Treatments		Total phenol (mg /g FW)	Total flavonoid (mg /g FW)
NaCl	Bioinoculants		
0 mM (Normal condition)	CK	11.76 ± 1.45d	0.93 ±0.06 e
	Gm	11.97 ± 0.98d	0.97 ± 0.05e
	Sr	13.51 ± 1.19cd	1.04 ± 0.07e
	Gm + Sr	12.02 ± 0.90d	1.0 ± 0.07e
75 mM (Saline condition)	CK	14.30 ± 0.73c	1.20 ± 0.05c
	Gm	18.39 ± 0.52a	1.43 ± 0.03a
	Sr	17.55 ±0.40 b	1.32 ± 0.04b
	Gm + Sr	17.21 ±0.51 b	1.37 ± 0.04b

References

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