Arbuscular mycorrhizal fungi may alleviate virus influence on photosynthesis related parameters in grapevine

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~~~~~~~~~~~~ INTRODUCTION ~~~~~~~~~~~~

Interactions of grapevine, viral pathogens and arbuscular mycorrhizal fungi (AMF) are yet to be clarified, despite their predominant presence in vineyards worldwide. Therefore, the aim of this study is to give insight into influence of AMF on photosynthetic physiology processes of virus infected grapevine. For that purpose, the ubiquitous GRSPaV is used as a less pathogenic, and GRSPaV coinfection with GLRaV-3 and GPGV as more pathogenic grapevine stress inducer.

~~~~~~~ MATERIALS AND METHODS ~~~~~~~

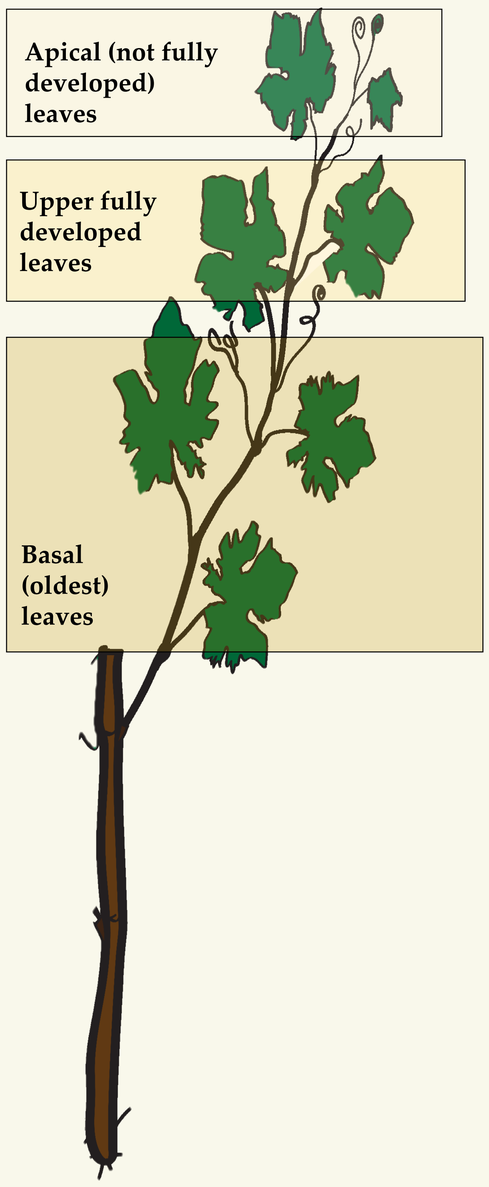
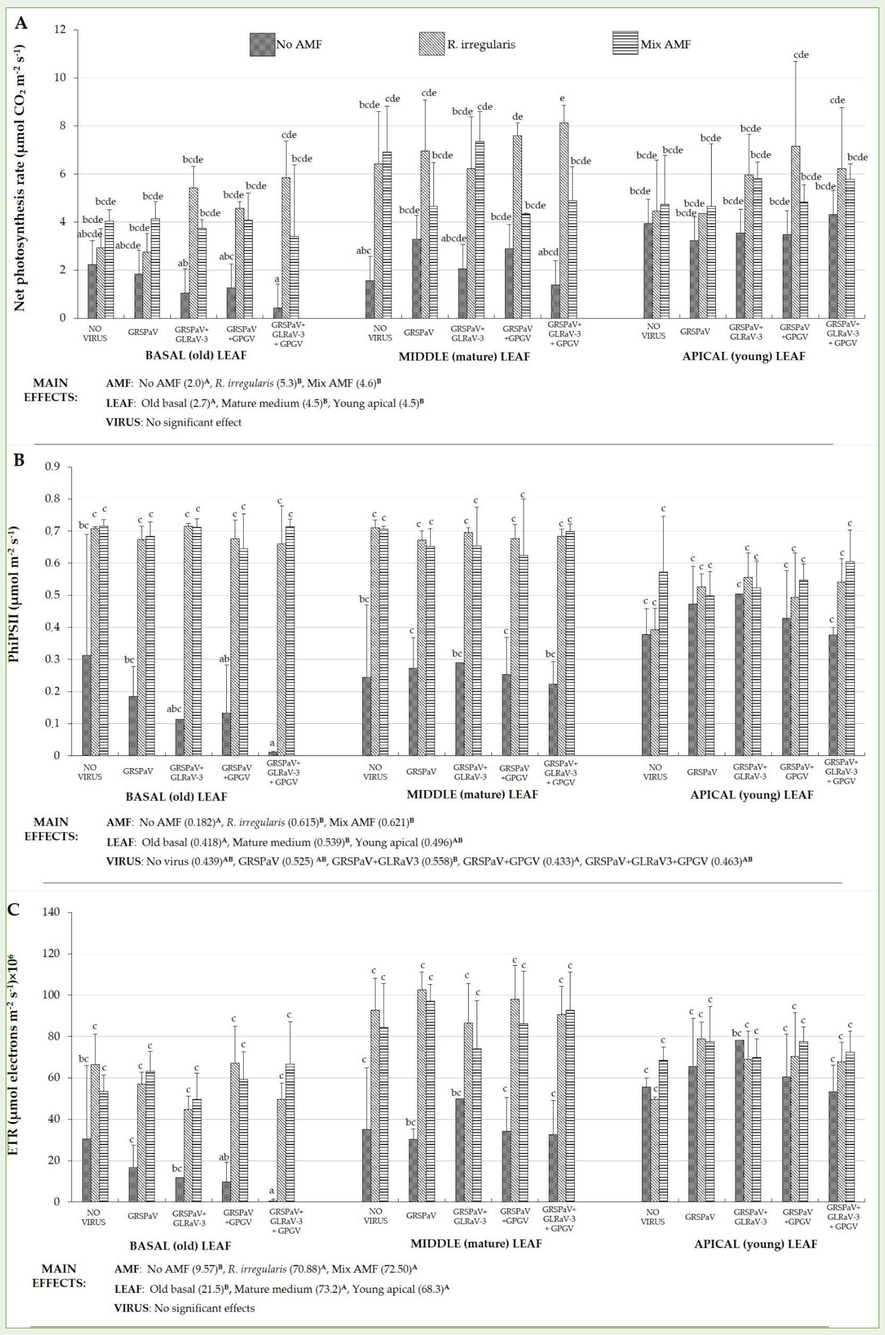


Figure 1. Overview of leaf developmental phases used in the analysis

The Kober 5BB rootstock was grafted with Merlot scions. The presence of ten viruses was checked: GLRaV-1, -2, -3, GVA, GVB, GFkV, GFLV, ArMV, GRSPaV (Gambino 2015), and GPGV (Morelli et al. 2014). The uninfected grapevines and those which harboured only GRSPaV were further used for "chip budding" grafting with buds containing GLRaV-3, GPGV or had no viruses. Virus transmission was confirmed by qPCR and plants were further treated with mycorrhizal inoculums (only *Rhizophagus irregularis* or mixture of *R. irregularis, Funneliformis mosseae* and *F. caledonium)*. Three months post inoculation, photosynthesis related parameters were measured for three leaves per plant differing in age and developmental phase (figure 1). Parameters were: net photosynthesis rate (A_N), quantum efficiency in light (ΦPSII), electron transport rate (ETR) and concentrations of pigments.

~~~~~~~~~~~~~~~~~~RESULTS AND DISCUSSION~~~~~~~~~~~~~~~~~~



Three-way ANOVA revealed significant interaction virus × AMF × leaf type for the quantum efficiency in light (ΦPSII) and electron transport rate (ETR). The lowest values of all the parameters were measured in old basal leaf, since in grapevine challenged with virus induced stress photosynthetic perturbances could occur more easily in older leaves where the accumulation of viral titer is expectedly highest. Compared to No AMF controls, AMF alleviation influence was the strongest in basal and upper fully developed leaf. No significant differences were found between two types of AMF inoculums.

Figure 2. A_N, ΦPSII and ETR of grapevine treatments used in this study

Addition of AMF significantly increased pigment concentration in respect to their non-AMF control for treatments T8/9 and T14/15 (Figure 3). Pigments concentrations revealed higher values with 'Mix AMF' rather than R. irregularis alone. Two-way ANOVA revealed significant interactions between AMF and virus compositions influencing chlorophyll a and total chlorophyll. The treatments containing GLRaV-3 had the most severe depletion of chlorophyll a and total carotenoid concentrations.

Treat-ment	Virus StaTUS	AMF Status	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Total Carotenoids	Chlorophyll a/ Chlorophyll b	Chlorophyll/ Carotenoids
T1	NO VIRUS	NO AMF	1.43 ± 0.10 ab	0.85 ± 0.10	2.28 ± 0.19 ab	0.52 ± 0.07 abc	1.68 ± 0.08	4.39 ± 0.19
T2		*R. irregularis*	1.76 ± 0.40 ab	0.56 ± 0.32	2.32 ± 0.72 ab	0.76 ± 0.10 abc	4.09 ± 1.62	2.97 ± 0.55
T3		MIX AMF	1.96 ± 0.43 b	1.04 ± 0.16	3.00 ± 0.59 ab	0.73 ± 0.24 abc	1.87 ± 0.12	4.29 ± 0.59
T4	GRSPaV	NO AMF	1.65 ± 0.38 ab	1.22 ± 0.45	2.87 ± 0.83 ab	0.54 ± 0.01 abc	1.44 ± 0.22	5.32 ± 1.44
T5		*R. irregularis*	1.59 ± 0.31 b	1.28 ± 0.64	2.87 ± 0.91 b	0.43 ± 0.14 abc	1.59 ± 0.77	8.34 ± 5.29
T6		MIX AMF	2.15 ± 0.47 b	1.21 ± 0.47	3.35 ± 0.89 b	0.79 ± 0.15 bc	1.94 ± 0.50	4.28 ± 1.10
T7	GRSPaV + GLRaV-3	NO AMF	0.71 ± 0.09 a	0.36 ± 0.05	1.07 ± 0.14 a	0.37 ± 0.08 abc	1.96 ± 0.04	2.93 ± 0.24
T8		*R. irregularis*	1.88 ± 0.27 b	1.34 ± 0.61	3.22 ± 0.84 b	0.54 ± 0.14 abc	1.69 ± 0.73	6.49 ± 2.63
T9		MIX AMF	2.65 ± 0.37 b	2.06 ± 0.16	4.71 ± 0.21 b	0.70 ± 0.29 abc	1.31 ± 0.29	8.01 ± 3.01
T10	GRSPaV + GPGV	NO AMF	1.40 ± 0.11 ab	1.00 ± 0.31	2.40 ± 0.42 ab	0.45 ± 0.09 abc	1.50 ± 0.36	5.67 ± 2.02
T11		*R. irregularis*	1.88 ± 0.35 b	1.04 ± 0.34	2.92 ± 0.60 b	0.65 ± 0.19 abc	1.91 ± 0.43	4.85 ± 1.83
T12		MIX AMF	2.24 ± 0.45 b	1.11 ± 0.29	3.35 ± 0.65 b	0.82 ± 0.21 bc	2.11 ± 0.49	4.29 ± 1.08
T13	GRSPaV + GLRaV-3 + GPGV	NO AMF	1.37 ± 0.10 ab	1.23 ± 0.27	2.61 ± 0.37 ab	0.28 ± 0.08 a	1.15 ± 0.16	9.52 ± 1.28
T14		*R. irregularis*	1.58 ± 0.11 ab	0.96 ± 0.13	2.53 ± 0.23 ab	0.57 ± 0.06 abc	1.67 ± 0.17	4.52 ± 0.60
T15		MIX AMF	2.32 ± 0.61 b	1.29 ± 0.59	3.61 ± 1.18 b	0.82 ± 0.15 c	1.92 ± 0.31	4.39 ± 1.17

Figure 3. Table of pigment concentrations

TAKEAWAY MESSAGE

Viral influence on grapevine photosynthesis and photosynthesis related parameters is shown to be alleviated by AMF colonization, but in dependence to tissue type, since primarily effect was observed in basal and fully developed upper leaves.

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