THE NEW SEED-APPLIED FUNGICIDE SEDAXANE IMPROVES DROUGHT TOLERANCE IN EARLY GROWTH STAGES OF MAIZE
IL NUOVO FUNGICIDA CONCIANTE DEL SEME SEDAXANE MIGLIORA LA TOLLERANZA ALLA SICCITÀ NEGLI STADI INIZIALI DEL MAIS

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Abstract
This work investigates the effect of a new seed-applied fungicide (Sedaxane; Syngenta) in maize subjected to progressive water stress. The dynamic of relative transpiration was measured in relation to the fraction of transpirable soil water (FTSW) in a pot experiment. Compared with conventional fungicides (Fludioxonil + Metalaxil), the addition of Sedaxane allowed young plants to transpire at maximum rate down to a similar FTSW – much lower than untreated controls - and to increase significantly root growth and branching.

Keywords: drought, seed-coating, fungicides, maize.
Parole chiave: stress idrico, concia del seme, fungicidi, mais.

Introduction
Water availability is increasingly becoming a limiting factor worldwide, and drought can drastically reduce the final crop yield in maize. Young plants are currently protected against seed-born and soil-born fungal pathogens by using a combination of seed-applied fungicides, a practice also suitable for reducing the amount of pesticides spread into the environment. Research pay now great attention in discovering new fungicide molecules having both protecting and bio-stimulating effects (Gomes Bezerra *et al*., 2015). The purpose of this work was to evaluate the effect of the seed-coating treatment Maxim XL (Syngenta), widely used in maize, in combination or not with Sedaxane, a new SDHI fungicide, on plant growth and transpiration under progressive water stress.

Materials and Methods
The trial was set at the experimental farm of the University of Padova at Legnaro (Padova), using SY-HYDRO (Syngenta) as hybrid (FAO class 600) during year 2016. Using a completely randomized experimental scheme, we have compared 6 treatments: 3 different seed-coatings (untreated control; Maxim XL; Maxim XL + Vibrance 2.5 mL/50 Kseeds at 50% w/w of Sedaxane) and 2 different water regimes: optimal water supply (daily water transpiration restored by irrigation) and progressive water stress down to the wilting point (water lost by transpiration not restored by irrigation). Compared with Fludioxonil and Metalaxil contained in Maxim XL, Sedaxane is known to increase the protection against *Rhizoctonia solani* and *Sphacelotheca reiliana*. Maize was grown in 6-L PVC pots filled with a mixture of sand and silty-loam soil (1:1 w/w), placed in a controlled environment within a greenhouse. Three seeds of maize per pot were sown at 3 cm of depth, leaving only one plant after emergence. The relative transpiration (RT) was detected following the procedure of Vamerali et al. (2003) by daily weighting the pots after sealing at the 3-leaf-stage. RT was plotted against the fraction of transpirable soil water (FTSW), and regressed with a linear plateau model. In the harvested plants, free phenolic acids (caffeic, syringic, vanillic, p-coumaric and t-ferulic) were detected in shoot tissues by HPLC.

Results and Discussion
Based on the results of the overall leaf transpiration over the whole experiment, under optimal water supply, treated plants increased the amount of transpired water by 26% and 24% for Maxim XL and Maxim XL + Vibrance, respectively, compared with untreated controls. This effect was due to higher shoot and root growth of treated plants (data not shown).
Under progressive water stress, no differences were found among treatments in terms of total transpiration, as the experiment lasted at wilting point. However, the dynamics of leaf transpiration over FTSW differed among treatments: with Maxim XL transpiration started to decrease at a FTSW value of 28%, and for Maxim XL + Vibrance at 30% (Fig. 1). Instead, untreated controls showed an early stomatal closure (FTSW = 38%), which can lead in the long-term to yield losses (Schimdt *et al*., 2011). It seems that seed treatments with fungicides retard transpiration decline, probably through a delay in stomatal closure, an effect that in open field can increase productivity in environments with fluctuating rainfall.

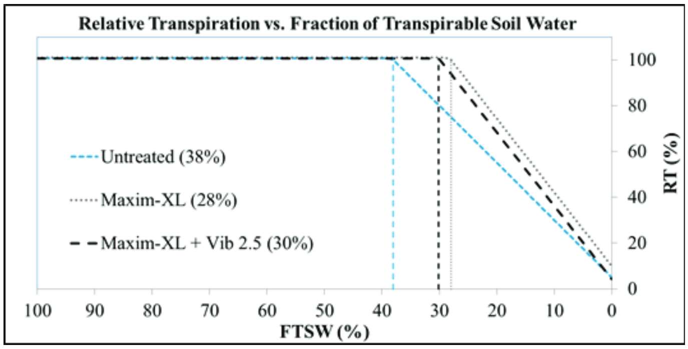

Fig. 1: Linear plateau regressions of relative transpiration (RT) plotted vs. fraction of transpirable soil water (FTSW) of pot-cultivated maize under progressive water stress. Transpiration measured over 27 days after pot closure. In brackets: FTSW values at which RT starts to decline.
Fig. 1: Regressione (linear plateau) della traspirazione relativa (RT) in funzione della frazione di acqua disponibile nel terreno (FTSW) di mais coltivato in vaso con stress idrico progressivo. Traspirazione misurata per 27 giorni dalla chiusura dei vasi. In parentesi: valore di FTSW al quale RT inizia a diminuire.

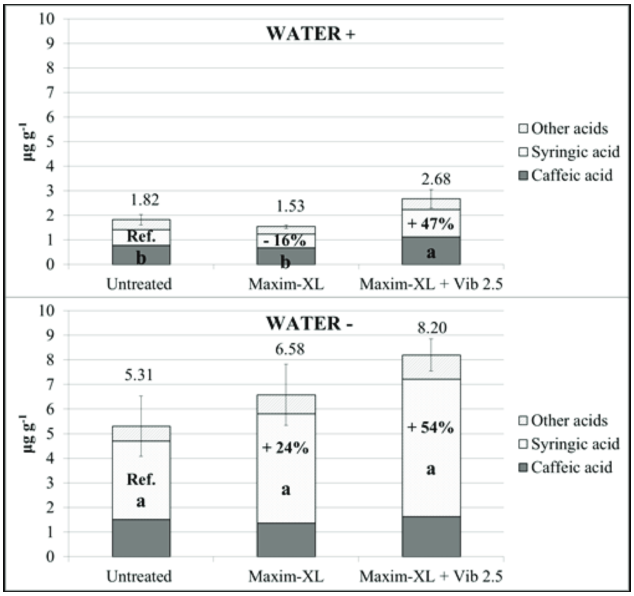

Fig. 2: Antioxidant activity (phenolic acids) (mean ± S.E., n = 4) in shoot tissues of pot-cultivated maize under optimal water supply (water +) and in progressive water stress (water -) (Newman-Keuls test, P≤0.05). Letters for statistical comparisons.
Fig. 2: Attività antiossidante (acidi fenolici) (media ± E.S., n=4) nei tessuti epigei di mais in condizioni di apporto idrico ottimale (acqua +) e con stress idrico progressivo (acqua -). (Test Newman-Keuls, P≤0.05). Lettere per comparazione statistica.

Regarding the abundance of phenolic acids in shoot tissues, the biosynthesis of these antioxidants was stimulated by water stress, with a high increase with Vibrance mainly due syringic acid, and secondly by vanillic, p-coumaric and t-ferulic acids, although there were no statistical differences from controls. Under optimal water supply, Vibrance significantly increased phenolic acid content (+47% vs. control; $P \leq 0.05$), particularly syringic and caffeic acids (Fig. 2). Sedaxane, as a systemic active ingredient, may interfere with some physiological mechanisms of the plant, probably involving abscisic acid, which induces stomata closure. We hypothesized that a higher concentration of phenolic compounds can decrease the abscisic acid content in plant tissues, particularly by vanillic and p-coumaric acid. Such an effect is interesting because these phenolic acids perform many positive functions on the plant, by making cell wall more rigid and resistant and defending the plant against pathogens. Sedaxane probably works by altering the expression of key genes in plant physiology, that code for specific proteins and helping the plant to overcome stressful conditions (Ajigboye *et al.*, 2017).

Conclusions

Under progressive water stress, plants treated with seed-applied fungicides can delay the stomata closure in early stages, thus increasing resilience to fluctuating soil water availability and possibly protecting yield potential of maize.

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