Stress responses and ABA root signals in relation to drought stress intensity in three upland rice cultivars

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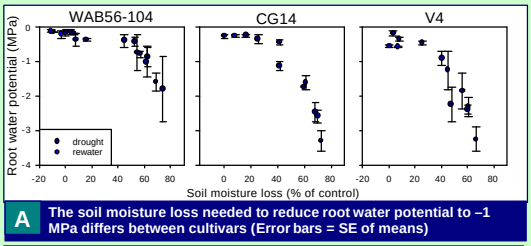
INTRODUCTION

The common view is that soil moisture loss (SML) results in some types of chemical signalling between roots and shoots. Abscisic acid (ABA) is suggested to play a major role in this root to shoot communication, and root-born ABA is generally accepted to regulate stomatal resistance (R_S) and transpiration rates, when plants are exposed to drying soil. ABA is therefore supposed to influence conservation of water and ultimately water use efficiency (WUE). Because of the possible connection between ABA and WUE, analysing xylem-[ABA] has become interesting in regard to screening for drought resistance. The present study focuses on three well described rice cultivars, on cultivar differences in reaction to drought and to two different rates of soil drying. It has been suggested that plants reacts differently when exposed to slow adaptive drought compared to shock-like severe drought. The latter is supposed to induce fast physiological responses in order to stabilize metabolism in periods with limiting water availability, while slow adaptive drought more likely triggers more permanent metabolic changes in order to adapt to sub-optimal conditions.

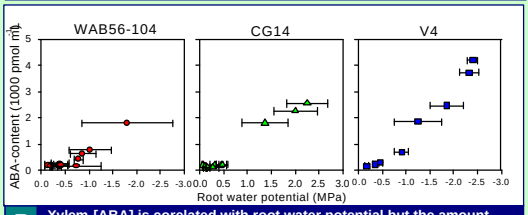
CONCLUSION

- The SML needed to reduce RWP to -1 MPa depends on speed of soil drying, but the cultivars reacts opposit when exposed to either shock-like severe drought or more slow adaptive drought.
- Xylem [ABA] and stomatal resistance correlates when rate of soil drying is high.
- Xylem-[ABA] differs between cultivars when exposed to shock-like severe drought, but not during adaptive drought.
- A cultivar dependent difference in sensitivity to ABA is expresed when speed of soil drying is more slow.
- Xylem-[ABA] seems to increase at the same time as a RWP starts increasing detectably.

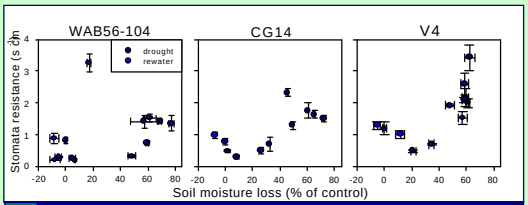
SHOCK-LIKE SEVERE DROUGHT



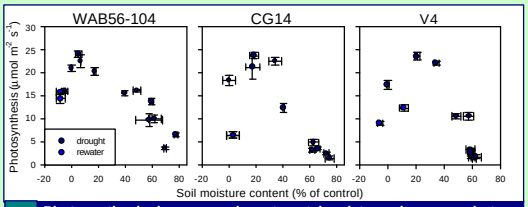
A The soil moisture loss needed to reduce root water potential to –1 MPa differs between cultivars (Error bars = SE of means)



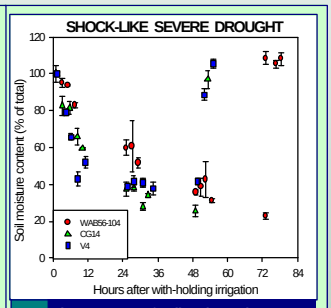
B Xylem-[ABA] is corelated with root water potential but the amount produced differs between cultivars. (Error bars = SE of means)



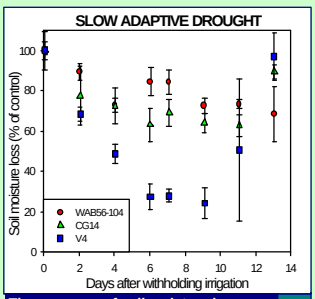
C Stomatal resistance increases with increasing xylem-[ABA] but the cultivars differed in degree of reaction (Error bars = SE of means)



D Photosynthesis decreases when stomatal resistance increases, but most in CG14 and V4. (Error bars = SE of means)

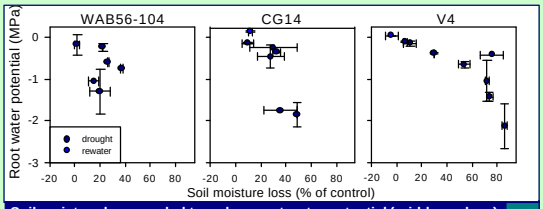


1 Time courses of soil moisture loss during the shock-like soil drying period

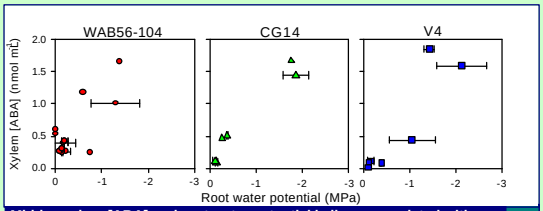


2 Time courses of soil moisture loss during the adaptive soil drying period

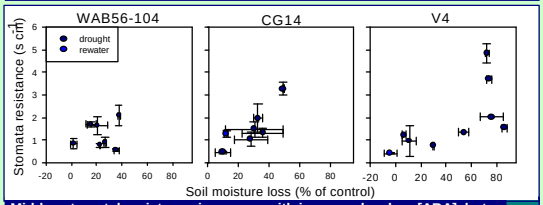
SLOW ADAPTIVE DROUGHT



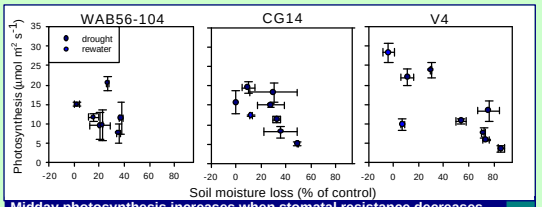
E Soil moisture loss needed to reduce root water potential (midday values) to –1 MPa differs between cultivars (Error bars = SE of means)



F Midday xylem-[ABA] and root water potential is linaer correlated with very small difference between cultivars (Error bars = SE of means



G Midday stomatal resistance increases with increased xylem-[ABA], but the cultivars differed in degree of reaction (Error bars = SE of mean)



H Midday photosynthesis increases when stomatal resistance decreases (Error bars = SE of mean)

DISCUSION

Rate of soil drying when the rice cultivars were exposed to shock-like severe drought situations (Fig.1) is opposite correlated with the SML needed to obtain a decrease in RWP (Fig.A) to -1 MPa. This value has been found to be threshold for stomata closure. In the present study, the cultivar decreasing RWP at the smallest SML also produces the highest [ABA] in xylem sap (Fig.B), indicating a possible relation between gene-expression and SML. The increase in R_S (Fig.C) seems to depend on xylem [ABA], and R_S determines the decrease in CO_2-assimilation rate (Fig.D) and the SML at which photosynthesis reaches negligible levels.

When exposed to a more slow adaptive drought situation (Fig.2) the picture is precisely opposit in regard to rate of soil drying and SML needed to obtain RWP at -1MPa (Fig.E). No significant cultivar dependent differences were detected in regard to xylem [ABA] (Fig.F). In despite of this, both R_S and photosynthesis seems to differ between the cultivars. This can be explained as a cultivar specific change (increase) in sensitivity to [ABA] in the transpiration stream, indicating that some adaptation to the abiotic stress has occured.

MATERIALS & METHODS

Experiments were conducted in both climate chamber (shock-like severe drought) and greenhouse (slow adaptive drought). Experiments durated three days in climate chamber (pots contained about 500 g. of soil) and 14 days in greenhouse (pots contained about 14 kg. of soil). Climate conditions were 26/24 day/night, RH 50-80%, PAR was 600-800 (mol m^{-2} s^{-1}) photoperiod 12½ h. The rice cultivars used were *O. sativa* L. WAB56-104 (tropical *japonica* improved), indignous *O. glaberrima* L. CG14 (drought resistante and weed competetive), and an interspecific hybrid WAB450-24-3-2-P18-HB (V4). Plants were exposed to a shock-like severe drought situation and a more adaptive soil drying during late vegetative stage/early reproductive stage. Soil moisture content, photosynthesis, stomata resistance and root water potential were measured/conducted 4-5 times a day using 2-5 plants. Root water potentials were determined using a Scholander-type pressure chamber. Xylem-[ABA] were collected using a sap-sampling tecnique pressurerising the entire root system. For Xylem-[ABA] analysis were used ELISA.

ACKNOWLEDGEMENTS

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