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BRIEF COMMUNICATION

Use of photosynthesis and transpiration for early selection of salt tolerant triticales

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Abstract

Three cultivars of winter hexaploid triticales M2A/JAIN, DF 99/Yogu "S5", and Asseret were grown on nutrient solution with or without 75 mM NaCl. Stomatal permeability and transpiration rate decreased in all salt-stressed triticale cultivars. Net photosynthetic rate (P_N) of cv. M2A and Asseret was not affected by NaCl. On the contrary, P_N in cv. DF99 was reduced in relation to control plants. A higher water-use efficiency under saline conditions led to better salt tolerance of cv. M2A compared to cvs. Asseret and DF99.

Additional key words: stomata; water use efficiency.

Among physiological criteria used in breeding for salt tolerance, osmotic adjustment, K^+/Na^+ selectivity, Na^+ exclusion from leaves, and cytokinin concentration (Touraine and Ammar 1985, Slama 1986, Bizid *et al.* 1988, Gorham 1990, Kuiper *et al.* 1990, Karim *et al.* 1992) appear to be indicative in cereals. We studied other physiological criteria in an attempt to select, at an early stage, salt tolerant genotypes of triticale. In preliminary work, six triticales preselected by the station of cultivation of cereals of Constantine, Algeria, presented the same level of osmotic adjustment on a moderate saline medium (Houchi and Coudret 1994). In order to detect cultivar differences, stomatal aperture, transpiration rate (E), and P_N were measured, and water-use efficiency (WUE) was calculated for three of them. The WUE had

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previously been used to characterize cereals grown under water stress (Morant-Avice *et al.* 1994).

Seeds of three hexaploid triticales M2A/JAIN, DF99/Yogu"S5", and Asseret were supplied by the Oued Smar station of cultivation of cereals (Algeria). Seeds were germinated in Petri dishes in the presence of distilled water before transfer to hydroponic culture. The plants were grown on aerated Coic and Lesaint (1973) nutrient solution without (M0) or with 75 mM NaCl (M75). The osmotic potential of M0 was -0.077 MPa and that of M75 was -0.48 MPa. The plants were grown at 16 h photoperiod, irradiance of 150 μmol m^{-2} s^{-1} PAR at the collar level (*Li-Cor*, Lincoln, U.S.A.) provided by 400 W *Phytoclaude* lamps, the air temperature and water vapour pressure deficit of 28 °C and 2.62 kPa during the light period and of 23 °C and 1.85 kPa during the dark period, respectively.

The stomatal permeability was measured on a fully expanded leaf of 21-d-old triticales with a hydrogen porometer (Louguet 1969). The coefficient of permeability [cm] in the figures is the foliar permeability [cm^{-3} s^{-1}] divided by the diffusive coefficient for H_2 in air [cm^2 s^{-1}]. This term is proportional to the average opening of stomata. Maximal stomatal permeability was obtained after irradiation of dark adapted plants and sweeping the leaf with dry CO_2-free air. The experimental setting (Lascève and Couchat 1980) had allowed continuous measurement of *E* rate with

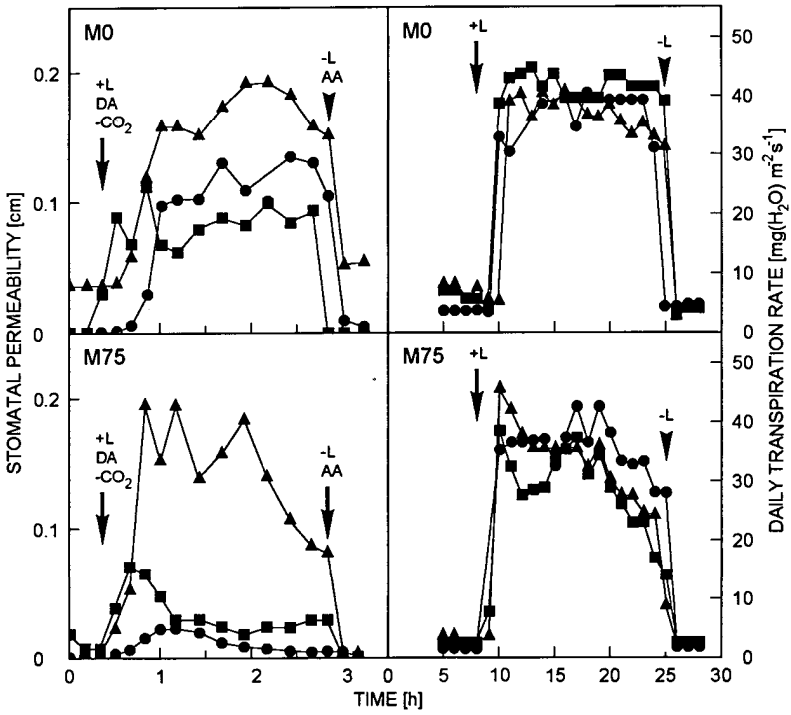

Fig. 1. Stomatal permeability and transpiration rate of M2A (■), DF99 (▲), and Asseret (●) grown on nutrient medium (M0) or on nutrient medium complemented with 75 mM NaCl (M75). +L, light; -L, darkness; DA, dry air; AA, ambient air; $-CO_2$, CO_2-free air.

dewpoint hygrometer (*General Eastern*, Elcowa, Mulhouse, France) and CO_2 exchange with infrared gas analyser (*Beckman*, Gagny, France) of a whole plant with 3-4 leaves (Morant-Avice *et al.* 1994) put in the same conditions as in the growth chamber. WUE was the ratio of P_N and E. Each experiment was repeated two or four times with different plants.

Under control conditions, the maximal opening treatment (Fig. 1) provoked a higher stomatal permeability in DF99 than in Asseret and M2A. Differences in stomatal permeability between cultivars were not correlated with E (Fig. 1) since the E of triticales was close on M0. Salt stress drastically decreased stomatal permeability of M2A and Asseret whereas that of DF99 was little affected. When light was put on, E of salt stressed-plants reached the control level, but it regulary decreased during the photoperiod in presence of NaCl.

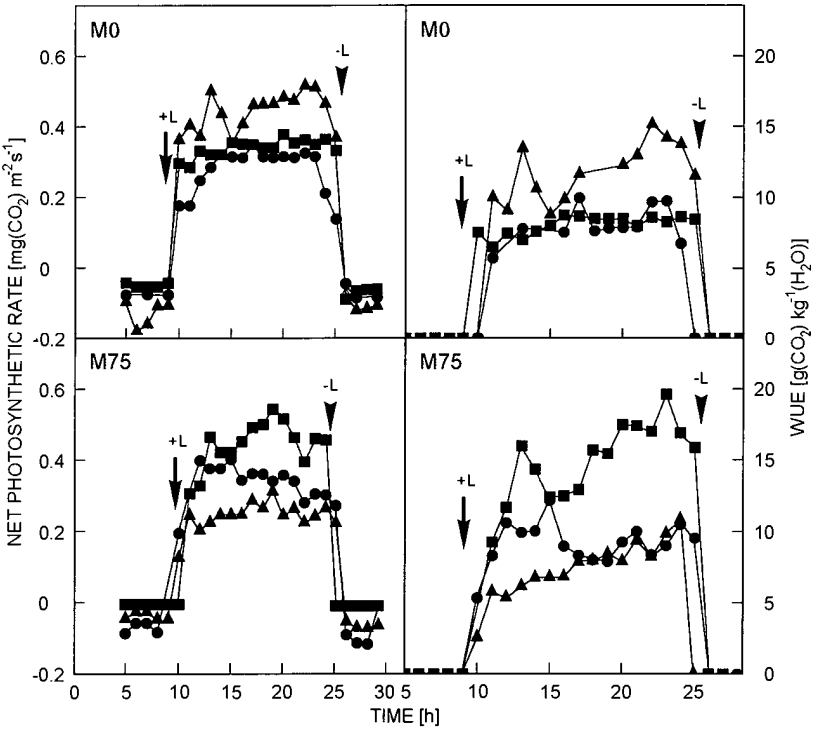

Fig. 2. Net photosynthetic rate and daily water-use efficiency (WUE) of M2A (■), DF99 (▲), and Asseret (●) grown on nutrient medium (M0) or on nutrient medium complemented with 75 mM NaCl (M75). For symbols see Fig. 1.

Presence of NaCl reduced by 50 % the P_N of DF99 in relation to control plants (Fig. 2) whereas P_N of Asseret and M2A was not disturbed by NaCl. The WUE (Fig. 2) of M2A and Asseret was close on M0 whereas that of DF99 was high. On the contrary, in presence of 75 mM NaCl, WUE of DF99 was lower than that of Asseret or M2A (M2A>Asseret>DF99). Presence of salt in root medium twice increased WUE of M2A compared to control plants.

The maximal stomatal opening treatment (*i.e.*, irradiation and dry CO_2-free air) permitted to measure the ability of stomata to open. The coefficient of stomatal permeability was then twice to four times greater than that measured under usual conditions of cultivation (*i.e.*, irradiation and ambient air) (results not shown). On nutrient medium (M0), stomata of the three triticales stayed open as long as the stomatal opening treatment was applied. On the contrary, stomatal opening of salt-stressed M2A and Asseret was inhibited, but that of DF99 was little affected. Similar results have been obtained under water stress: stomatal opening of rye was inhibited whereas stomatal opening of triticale T300 was not affected (Morant-Avice *et al.* 1994). Stomatal closure of salt-grown plants is a protective mechanism against water loss.

Cuticular transpiration measured during darkness was higher in control than in salt-grown triticales. As soon as light was put on, stomata opened and E rapidly increased. During light period, E of control triticales was almost constant. On the contrary, E of salt-stressed triticales decreased during the photoperiod. Presence of 75 mM NaCl in root medium decreased P_N of DF99 whereas it slightly increased that of M2A, and did not affect that of Asseret. Karim and Shigenaga (1992) have also observed that under moderate salinity P_N of the hexaploid triticale Welsh increased and that of cv. Currency was not affected by 50 mM NaCl.

WUE of M2A was greater on M75 than on M0. Similar results were obtained with salt-stressed *Sorghum bicolor* (Richardson and McCree 1985), *Rosa hybrida* (Jimenez *et al.* 1997), and rye and *Triticum dicoccum farrum* (Morant-Avice *et al.* 1994). In conclusion, the better WUE of M2A under salinity led to a better salt tolerance than in DF99 and Asseret.

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