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ROOT-ZONE SOC AND TN AS AFFECTED BY DW GENOTYPE AND MANAGEMENT, AND SILICON EFFECTS ON DROUGHT TOLERANCE OF BW GENOTYPES.

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Foreword

This research activity titled "ROOT-ZONE SOC AND TN AS AFFECTED BY DW GENOTYPE AND MANAGEMENT, AND SILICON EFFECTS ON DROUGHT TOLERANCE OF BW GENOTYPES" was funded as part of the Project titled "Sustainability and Operationalization of Established Regional Agricultural Research Centers in Five Arab Countries", granted by the Arab Fund for Economic & Social Development (AFESD) and implemented by ICARDA.

The research was started in 2016 as a response to the perceived need to launch interdisciplinary research linking soil and water researchers, crop breeders, and physiologists of ICARDA. The goal of the research is to activate novel research lines to understand if i) soil-improvement traits can become a target in crop breeding, and ii) bio-available Silicon can contribute to increase drought tolerance of cereals. The research was launched on own funds during fall 2016, and recommended for funding by AFESD in 2017.

This is the first progress report of the Silicon-related component of the research, on the effects of bio-available Silicon on the drought tolerance of Bread Wheat genotypes.

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1. Rationale and objective

Silicon is known to improve the growth and development of several monocots and dicots under drought stress. Si-mediated growth improvement includes: dry matter, relative water content and accumulation of osmotic solutes in maize, cucumber, wheat, soybean, sorghum, pistachio and rice. The mechanisms for Si-mediated increase of tolerance to drought include physiological, biochemical and physical aspects (e.g., enhancement of photosynthetic enzymatic activities, maintaining nutrient balance, improving water retention by decreasing water loss from leaves and increasing water uptake by roots, and scavenging reactive oxygen species by improving the capabilities of antioxidant defense). In the case of wheat, the mechanisms are still partially unclear, and limited quantitative evidence exists about the effects of silica inputs on wheat tolerance to drought, and about its water use efficiency.

This experiment was focused on bread wheat, considering the relevance of this cereal in drylands and the potential economic impacts that could derive from the research results. The trial was conducted in laboratory, under controlled conditions. The main objective was to develop laboratory methods under dry-down conditions to quantify the effects of inputs of bio-available Silicon on tolerance to drought of BW lines with different water use behavior.

2. Methods

Pot experiments have been set up at ICARDA controlled-environment facilities (Rabat, Guich station), in collaboration with ICARDA's Plant Physiologist. Bread (Winter) Wheat genotypes with contrasting behavior in terms of response to drought conditions were selected to be subjected to a dry-down experiment under controlled conditions in laboratory. The selected lines are the following:

Genotype ID (Selected and candidate)	**Transpiration behavior**
28, 221 (247)	Water "conserver": starts reducing water use in early water stress stage
83, 88 (9, 63)	Water "spender": keeps water consumption rate until severe water stress conditions

Before the experiment, a survey was conducted in some experimental stations (Guich, Koudia, and Merchoch) of INRA with which ICARDA collaborates to sample soils and to determine the natural levels of bio-available Silicon. Soil samples were sent to Göttingen (Germany) for analyses of both Si and Asi.

The mobile Silicon Si is the Silicon that is readily available for plants (as soon as water solution is present). The ASi is the amount Silicon present in amorphous silica. This is an important source of Si, much more soluble than most other minerals. As shown in the table below, the sample from Guich station was relatively low in ASi (Asi in the topsoil layer usually is >1mg/g, often 2-3 mg/g), on the contrary Asi was rather high compared to the average for the sample from Merchouch. The Si from Guich was very low, whereas Merchouch was in the average. Samples from Koudia stations had intermediate values. The latter was then selected for the experiment, and a stock of soil was collected in the field and brought to the laboratory to be used as substratum for the experiment.

Sample	**Mobile Si [µg/g]**	**ASi content [mg/g]**
1 (R) Guich	5.5	0.83
2 (M) Merchouch	12.5	5.74
3 (K) Koudia	7.1	4.89

The physiological response of crops to soil drying in dry-down (DD) experiments was measured by a slow and controlled imposition of water stress in potted trials for approximately 2-3 weeks and by monitoring the daily transpiration by weighing pots. Plants were grown in PVC pots with soil holding capacity of around 5 kg of soil, filled at bulk density. Dry-down was conducted at vegetative stage, a stage in which leaf area and plant transpiration behavior are developed enough. Soil surface of the pots was covered with plastic sheets, on top of which a uniform 2cm layer of plastic beads was applied, together to check soil evaporation. The well-watered (WW) plants of each genotype were maintained at about 80% field capacity, whereas the latter decreased gradually in water-stressed (WS) pots. The transpiration of all pots on each day was calculated as the difference in pot weight between successive days plus the water added to pot between two successive weighing. When transpiration of WS plants decrease below 10 % of that in WW plants, the experiment was stopped. Silicon was applied to half of both WW and WS pots, since the beginning of the experiment, with irrigation water as Potassium Silicate 2.5 mM. Potassium inputs were compensated in the non Si-treated pots by adding an equal amount of Potassium. The used product was PottaSol® (BIOFA enthält, Germany; 8.5% K_2O and 20% SiO_2). The concentration applied was decided based on literature and on the advice of the German partner who already tested it in other trials and observed that it is enough to trigger observed effects of Silicon on metabolism, although depending on the stages of growth, the application strategy would be different.

The experiment was conducted in randomized design (RBD) with 5 replications (4 G x 2 W-regimes x 2 Si-treatments), for a total of 80 pots. In addition to that, 48 control pots were used to assess possible effects of Si on plants before the beginning of the DD experiment by harvesting 3 plants per G in each of two different dates after germination. In each of the latter dates, as well at final harvest, leaf area, and fresh and dry aerial matter were determined on harvested plants, and dry aerial and root matter was collected for analyses of Si in tissues. Stomatal conductance was also measured before harvesting. Thermal images were taken during DD experiment.

Scientific collaboration was established with a highly qualified laboratory in Germany. An informal agreement was taken with the Institute of Geography (Faculty of Geosciences and Geography) of the Georg-August University of Göttingen for collaboration in research on bio-available Silicon.

Informal scientific collaboration was also established with INRA (Institut National De Recherche Agronomique, Département de l'Environnement et des Ressources Naturelles), which provided information for the evaluation of the baseline properties of the soil used for the trial.

A Moroccan female PhD student was trained on conducting experiment on the effects of bio-available Silicon on wheat drought tolerance.

3. Way forward

The experiment was launched during September 2017 and is proceeding according to the schedule. Preliminary data will be available in November 2017.