ICARDA
Science for Better Livelihoods in Dry Areas

ARAB FUND FOR ECONOMIC
& SOCIAL DEVELOPMENT

PROJECT
Sustainability and Operationalization of Established Regional Agricultural Research Centers in Five Arab Countries

SUB-PROJECT
ROOT-ZONE SOC AND TN AS AFFECTED BY DW GENOTYPE AND MANAGEMENT, AND SILICON EFFECTS ON DROUGHT TOLERANCE OF BW GENOTYPES.
BUS 200280, 2017.

An activity led by CLAUDIO ZUCCA, PhD

Progress report 2017

Deliverable N. 2-2017.
“Silicon pot-experiment at Guich station, year 1”

This activity contributed to

CGIAR
RESEARCH PROGRAM ON
Climate Change,
Agriculture and
Food Security
CCAFS

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SUGGESTED CITATION:
Zucca C. (2017). Silicon pot-experiment at Guich station, year 1. Progress Report. International Center for Agricultural Research in Dry Areas (ICARDA). Rabat, Morocco.

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[1] International Center for Agricultural Research in Dry Areas (ICARDA). Rabat, Morocco.

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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 annual 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. Summary

We studied the effects of inputs of bio-available Silicon on plant transpiration behavior of selected wheat varieties by means of dry-down experiments in laboratory.

Preliminary results showed that additions of Si sharply changed the transpiration behavior of water-conservative genotypes, which became less conservative, and increased water consumptions and biomass production under both well-watered and water stressed conditions. Strongly contrasted effects of Si across genotypes were observed, indicating that there is scope for establishing larger experiments to screen more Gs and investigate the potentially important implications of the observed effects.

2. 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. 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.

3. Methods

Pot experiments have been set up at the ICARDA Physiology lab (Rabat, Guich station), in collaboration with ICARDA’s Plant Physiologist. Winter Wheat (WW) genotypes with contrasting transpiration behavior in response to drought conditions were selected to be subjected to a dry-down experiment under controlled conditions (Table 1). An informal agreement was established with the Institute of Geography (Faculty of Geosciences and

Geography) of the Georg-August University of Göttingen (Germany) for collaboration in research on bio-available Silicon.

Genotype ID	Transpiration behavior
9, 83,	Water "conserver": starts reducing water use in early water stress stage
28, 221	Water "spender": keeps water consumption rate until severe water stress conditions

Table 1. Selected WW genotypes.

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 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 of Silicon present as 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 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 Guich	5.5	0.83
2 Merchouch	12.5	5.74
3 Koudia	7.1	4.89

Table 2. Bio-available Si in the soils of three experimental stations.

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 2-3 weeks and by monitoring the daily transpiration by weighing pots. Plants were grown in PVC pots with soil holding capacity of around 3 kg of soil, filled with soil. Dry-down was conducted at vegetative stage, a stage in which leaf area and plant transpiration behavior are developed enough. During dry-down the soil surface of the pots was covered with a uniform 2cm layer of plastic beads and with a plastic sheet, to control evaporation.

The well-watered (WW) plants of each genotype were maintained at about 80% field capacity, whereas the latter percent value 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 decreased 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, by means of irrigation with a water solution of Potassium Silicate 2.5 mM. The used product was PottaSol® (BIOFA enthält, Germany;

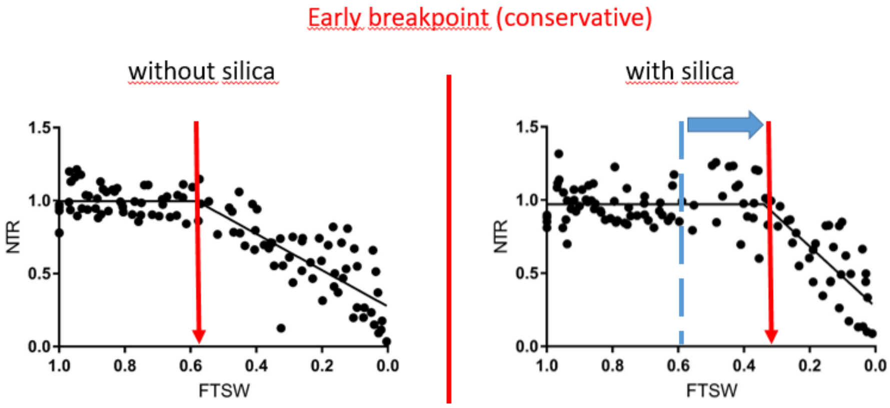
8.5% K_2O and 20% SiO_2). The concentration applied was decided based on literature as a sufficient amount to trigger the expected effects of silicon on wheat metabolism, although, depending on the stages of growth, the application strategy would be different. Potassium inputs were compensated in the non Si-treated pots by adding an equal amount of potassium as sulfate.

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. Dry aerial matter was collected and shipped to Germany for analysis of Si accumulation in plant tissues.

4. Results

The first experiment was successfully completed in November 2017 by student Fatima Ezzahra Rachdad, under the supervision of Dr. Michel Ghanem and Dr. Claudio Zucca. Data produced in Rabat were analyzed. The plant samples sent to Germany for analyses were still in laboratory by the end of the reporting period, data will be available during the second year.

The (preliminary) results showed that addition of Si changed the transpiration behavior of conservative genotypes; after Si addition conservative genotypes became less conservative (figure 1). This did not happen with non-conservative Gs, which behavior was not affected by Si inputs. In the case of conservative Gs, Si addition increased water consumption and biomass production under both well-watered and water stressed conditions. Yield variables were less affected by Si inputs in the case of non-conservative Gs.


Early breakpoint (conservative)

without silica

with silica

Figure 1. After Si addition conservative genotypes become less conservative (ex.; genotype 9).

5. Way forward

The preliminary results highlighted contrasted effects of Si across genotypes, suggesting that there is scope for launching more in-depth experiments and for screening more Gs. This could have interesting scientific and practical implications. On one side, it would contribute to the understanding of the mechanisms, still partially unexplained, driving the observed genotypic response to Si additions. On the other side it would enable predicting the productivity of groups of genotypes having similar water management behavior ("ideotypes") under given conditions of Si-availability in soils, and of water-availability.

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