MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 73-2016 (YEAR 2)
2016 ANNUAL REPORT

Title: The effect of silicon on the growth and yield of soybean grown on nonirrigated sites

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BACKGROUND AND OBJECTIVES

Silicon is now designated as a "plant beneficial substance" by the Association of American Plant Food Control Officials. Silicon application has been reported to improve water use efficiency and enhance drought tolerance in several crops (rice, sugarcane, wheat, etc.). However, it is not clear whether silicon application has beneficial effects on soybean growth and seed yield under water deficit conditions.

Our preliminary results in the greenhouse indicate that application of potassium silicate to soil could enhance drought tolerance in soybeans. The objectives of this project are to: 1) evaluate the effects of silicon application on the vegetative growth of soybeans grown under water deficit conditions**;** and **2)** evaluate the effects of silicon application on the seed yield of soybeans grown on nonirrigated sites**.**

REPORT OF PROGRESS/ACTIVITY

Objective 1.

In 2016, the first experiment conducted was to determine the optimal concentration of silicon on soybean growth. Asgrow 5332 soybean plants were grown in 2-liter plastic pots containing different amounts of potassium silicate outside at the Environment and Plant Physiology Laboratory, Mississippi State University. To cancel the effect of potassium, a similar amount of potassium chloride was used as controls. At 45 days after planting, parameters such as plant height, number of nodes, and soil moisture content were measured. From this study, 500 ppm of silicon was found to be the optimal concentration for soybean vegetative growth (Figure 1).

After determining the optimal silicate concentration for soybean growth in 2-liter plastic pots outside, we evaluated the effect of potassium silicate (500 ppm Si) on the growth of soybean plants (Asgrow AG 5332 and Progeny 5333) subjected to different levels of water deficit. In this experiment, water-limiting conditions (66 % and 33%) were imposed on 20-day-old seedlings. After 30 days of treatments, morpho-physiological parameters such as plant height, leaf area, soil moisture, chlorophyll content, photosynthesis, stomatal conductance, leaf water potential, root branch number, and root volume were recorded.

Overall, silicate-treated plants were taller, greener, and stronger than corresponding control plants under water deficit conditions. Stomatal conductance decreased in silicate treated plants compared to control plants growing in the diminished water level. The decrease in stomatal conductance was responsible for maintaining the mid-day leaf water potential under stress conditions.

There was a significant interaction in the ratio of internal to external CO_2 concentrations (Ci/Ca) between the treatments but not in the cultivars. Furthermore, silicate application improved water use efficiency of both soybean varieties grown under water-limiting conditions.

Another key finding was that **silicate application increases** soil moisture content under water limiting conditions (Figure 2)**.** Taken together, the results from these studies indicate that silicon application can improve the vegetative growth of soybeans under reduced water conditions via increasing water use efficiency of plants and **enhancing** the **soil's** ability to retain **moisture**.

Objective 2.

Two soybean varieties (determinate versus in**determinate growth habit)** were grown in the field on Mississippi State University's North Farm in the respective plots (three replicates) with applied potassium silicate (Si + treatment) or potassium chloride (Muriate of Potash) as controls to balance the same total potassium in the Si treatment so as to identify only the effect of silicon. Growth parameters such as number of main stem nodes and plant height were measured. Plants grown in potassium silicate-applied plots (100 kilogram Si/ hectare) had slightly increased height and increased node numbers compared to plants grown in the soil with applied potassium chloride.

Seed yield of Asgrow 5332 plants grown in the soil with applied potassium silicate (100 kilogram Si/ hectare) was about 5% higher than that from soybean grown in soils with applied potassium chloride (control). However, the same application rate of potassium silicate did not increase seed yield of Progeny 5333 (a determinate variety). These data/results are preliminary, and we are going to carry out field studies using two more silicon application rates to determine the effect of silicon application on seed yield of soybean grown in the filed in the 2017 planting and growing season.

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

Water deficit stress constrains plant growth and **reduces crop yield**. Drought can affect soybean plants at any time during summer in southern states such as Mississippi. Thus, there is the need to develop effective strategies to cope with drought for soybean production. We have found that potassium silicate application to the soil can significantly improve vegetative growth and maintain vigor of soybeans under **water-limiting condition**s**.** The anticipated outcome of this project is the determination of the optimum soil application of silicate as an operative technique to improve soybean growth and **yield under** water-**limiting condition**s. This research is likely to establish an effective drought-coping strategy for the Mississippi soybean industry, which should benefit all Mississippi soybean farmers who grow soybeans on nonirrigated sites.

END PRODUCTS–COMPLETED OR FORTHCOMING

Presentations:

Saroj Kumar Sah, Meng Li, Muteb Alrifdi, K. Raja Reddy, and **Jiaxu Li** (2017). **Silicon improves soybean growth** under water limiting conditions. The Mississippi Academy of Sciences 81st Annual Meeting, Hattiesburg, MS, February 23-24, 2017.

Our graduate student, Saroj Sah, won the third place for oral presentation at the Mississippi Academy of Sciences 81st Annual Meeting (February 23-24, 2017, Hattiesburg, MS).

Saroj Kumar Sah, K. Raja Reddy, and **Jiaxu Li** (2016). The effect of silicon on the growth and drought resistance of soybeans. Educational exhibit (poster), North Mississippi Row Crops Field Day, Verona, MS., August 11, 2016.

Publications:
Saroj Sah et al. (2017). Silicon improves soybean growth under water limiting conditions. **Shortly to be submitted to** Journal of Plant Physiology.

Submission of a manuscript on the effects of silicon application on seed yield of soybeans grown on nonirrigated sites is **anticipated** by the end of 2017.

Graphics/Tables

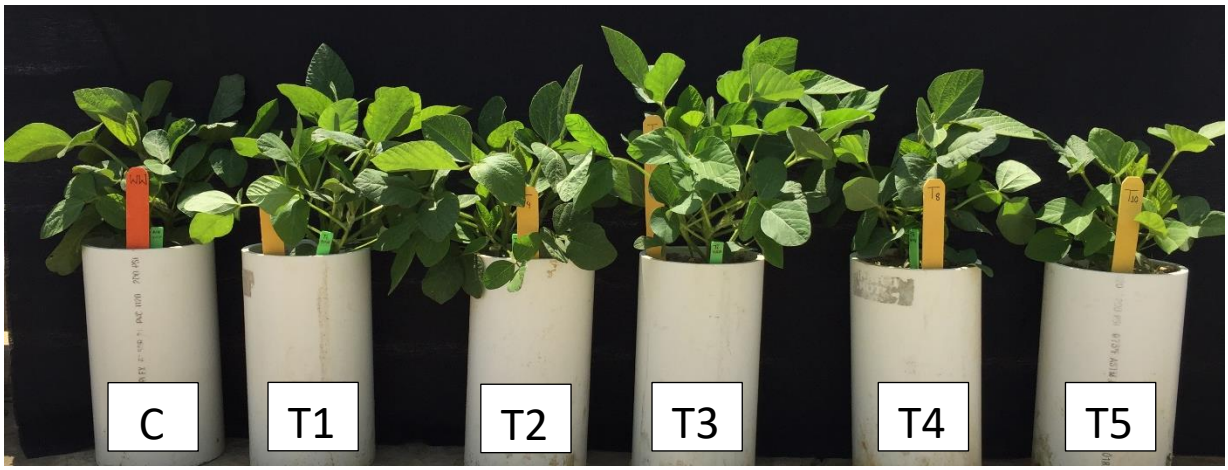

Figure 1. The effect of silicon on vegetative growth of soybean plants.
Potassium silicate was incorporated into soils to give different silicon concentrations: T1 (50 ppm), T2 (150 ppm), T3 (500 ppm), T4 (1500 ppm), and T5 (2000 ppm). The control pots (C) contained soils with no added potassium silicate. Asgrow 5332 soybean plants were grown in pots with soil and nutrient supply **at natural light and temperature conditions for 45 days.**

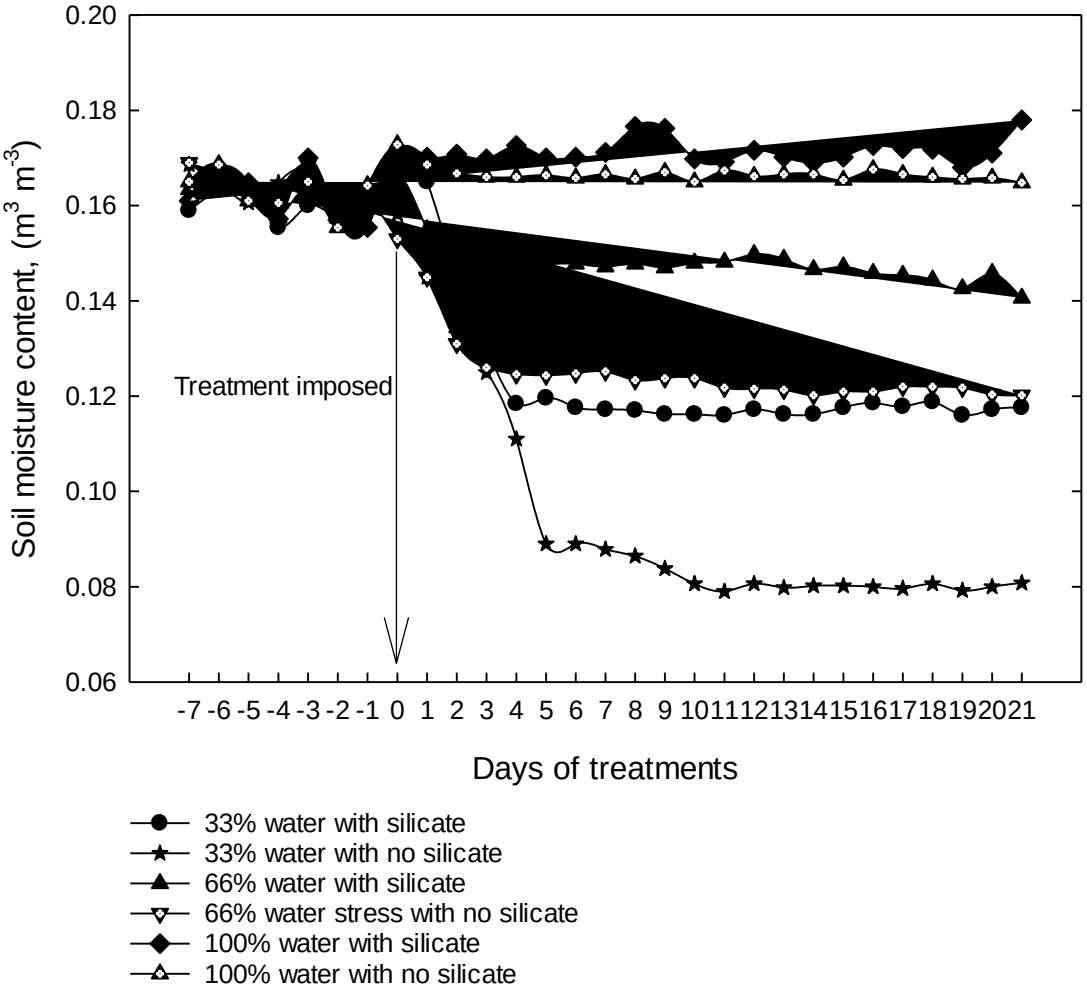

Figure 2. Silicate application increases soil moisture content under water limiting conditions. Two soybean varieties (Asgrow 5332 and Progeny 5333) were grown at natural environment in polyvinyl chloride pots containing soil supplemented **with or without potassium silicate (500 ppm Si).** Soil moisture content was measured every day for 29 days using an HH2 moisture sensor meter (Delta-T Devices Ltd). During the first 7 days (-7 to -1) of measurements, all pots were supplied with normal amount of water (100%). On day 0 and afterwards, plants were supplied with normal (100%) or reduced (66% or 33%) amount of water.