MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 73-2015 (YEAR 1)
2015 Annual Report

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

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BACKGROUND AND OBJECTIVES

Over 50% of Mississippi soybeans are grown on dryland or non-irrigated sites. These soybean plants are more susceptible to yield loss from drought stress. The Intergovernmental Panel on Climate Change predicts that drought will increase in intensity and frequency in the United States, especially in the Southern states. Therefore, there is a great need to develop production systems designed to maintain consistent yields of soybeans grown on dryland or nonirrigated sites across years.

Silicon has recently been recognized as an important element in plant nutrition. Silicon has been shown to increase plant biomass in rice, sorghum, and wheat. Plants with supplies of soluble silicon produce stronger cell walls, making them more heat and drought tolerant. When supplemented with soluble silicon, several crops including corn, wheat and rice showed marked increases in drought tolerance compared to unamended plants. Additionally, under drought conditions, silicon applied to resulted in plants with higher relative water content compared to those plants without the silicon treatment.

Possible physiological mechanisms behind increased drought tolerance from silicon application include reduced water loss through transpiration at leaf stomata and the cuticle, and increased water use efficiency. In the soil, the total silicon content may be large, but the amount of soluble silicon (silicic acid) available for plant uptake is limited. Plants take up soluble silicon into their tissues, but it is not returned to the soil through biodegradation. Thus, continuous cropping of land can cause deficiency of soluble silicon in the soil.

In light of the beneficial effects of silicon on crops described above, silicon application may prove to be a strategy to improve the growth and yield of soybeans grown on dryland or nonirrigated sites. In this project, we propose to test the effects of silicon on the growth and yield of soybeans grown on nonirrigated sites. The specific objectives of the project are:

1) Evaluate the effects of silicon application (potassium silicate) on the vegetative growth of soybeans grown on nonirrigated sites**;**
2) **E**valuate the effects of silicon application (potassium silicate) on the seed yield of soybeans grown on nonirrigated sites.

REPORT OF PROGRESS/ACTIVITY

Objective 1: Effects of silicon application (potassium silicate) on the vegetative growth of soybeans grown on nonirrigated sites

Two Soybean varieties, AG 5332 (Indeterminate) and Progeny 5333 (Determinate), were used in the study. The experiments were conducted in a greenhouse of North Farm, Mississippi State University. The experimental design was a CRD with four replicates of each treatment.

As the source of silicate, potassium silicate (K_2SiO_4) was used from Pfaultz and Bauer, USA. To cancel the effect of potassium, a similar amount of potassium chloride is used in the control treatment.

The drought treatments were imposed by withholding water from plants. All the plants treated with potassium silicate grow well as compared to non-silicate-treated plants under the drought condition.

Compared to the plant growing with only watering, drought treatment adversely affected plant vegetative growth. By measuring different morphological parameters (moisture index [Figure 1], the number of leaves, the number of nodes, and root biomass), it was found that the optimal concentration of potassium silicate application was between 4 and 8 millimolar. The effect of potassium silicate application on plant growth under drought conditions is shown in a representative picture (Figure 2). In sum, application of potassium silicate (4-8 mM) can significantly improve soybean growth and maintain plant vigor under drought (nonirrigated) conditions. These results are preliminary.

Objective 2: Effects of silicon application (potassium silicate) on the seed yield of soybeans grown on nonirrigated sites

The experiments for Objective 2 have not been completed. We will conduct field studies using the optimal concentration of potassium silicate application determined for Objective 1. These studies should be completed by the end of the Year 2 funding period.

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

Soybeans are Mississippi's top row crop in terms of planted acreage and farm gate value. Drought stress reduces soybean yield potential and lowers grain quality. Drought can strike soybean plants at any time during summer in southern states like Mississippi. Therefore, we should develop effective strategies to cope with drought for crop production.

We have found that application of potassium silicate can significantly improve soybean growth and maintain plant vigor under nonirrigated (drought) conditions. The expected outcome of the research includes the development of root application of silicon as an effective means to improve soybean yield under limited water conditions. This research is likely to establish a new drought coping strategy for the Mississippi soybean industry, which should benefit all Mississippi soybean producers who grow soybeans on dryland or nonirrigated sites.

END PRODUCTS–COMPLETED OR FORTHCOMING

Publications:

Sah SK, Reddy KR, and **Li J** (2016). Abscisic acid and abiotic stress tolerance in crop plants. Frontiers in Plant Science 7:571. doi: 10.3389/fpls.2016.00571

It is expected that we will have at least one more peer-reviewed scientific publication.

Presentations:

Sah SK, Reddy KR, and **Li J.** "Effect of silicon on the growth and drought resistance of soybeans" A poster for the annual meeting of Mississippi Academy of Sciences (February 18-19, 2016, Hattiesburg, MS).

My graduate student, Saroj Sah, won the third place for the poster presentation at the annual meeting of Mississippi Academy of Sciences (February 18-19, 2016, Hattiesburg, MS).

Graphics/Tables

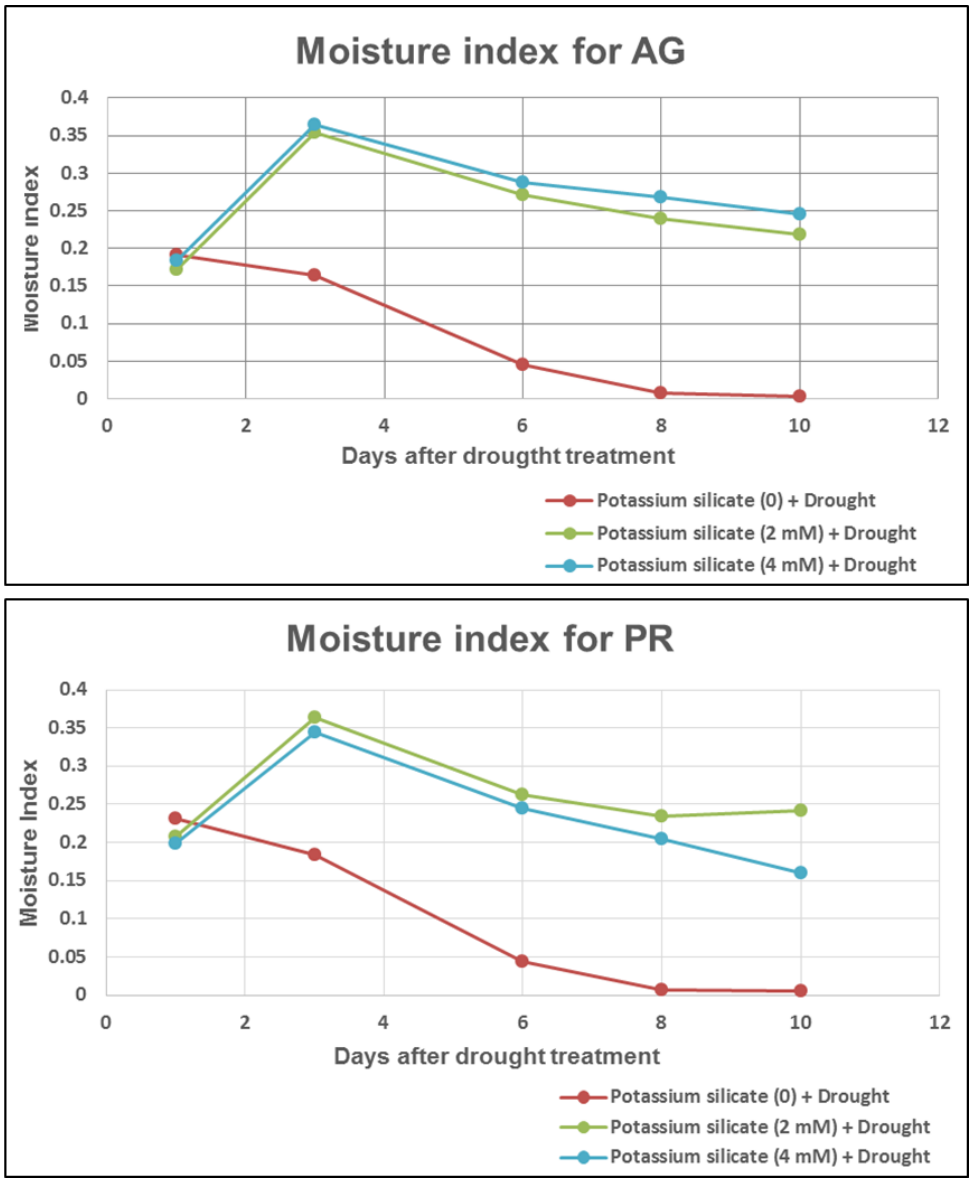

Figure 1. Moisture index in soil with or without potassium silicate supplement.
Two Soybean varieties, AG 5332 (AG) and Progeny 5333 (PR), were grown in plastic pots filled with soil supplemented with or without potassium silicate. Soil moisture index was recorded using an HH2 moisture sensor meter (Delta-T Devices Ltd) during drought treatment.

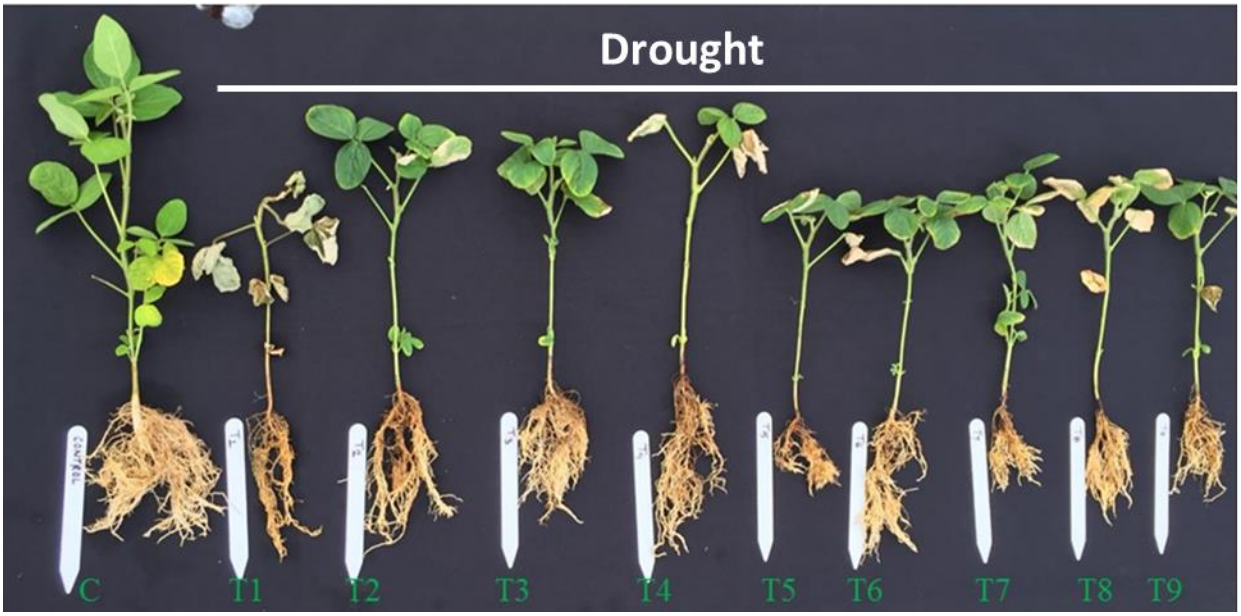

Figure 2. Vegetative growth of soybean plants in soil with or without potassium silicate supplement under drought conditions.
Forty-day-old plants with roots after 25 days of treatment with various concentrations of potassium silicate, i.e. T1 (0 mM), T2 (4 mM), T3 (8 mM), T4 (10 mM), T5 (15 mM), T6 (20 mM), T7 (25 mM), T8 (30 mM), and T9 (40 mM). C = the control plant with watering.