THE EFFECT OF EXOGENOUS SILICONE TREATMENTS ON MAIZE PRODUCTIVITY UNDER THE SPECIFIC CONDITIONS OF GATAIA, TIMIS COUNTY

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Abstract. *Silicon (Si) is the second most abundant element in soil. Previous researches have shown its importance in increasing tolerance to biotic and abiotic stress of crop plants. This paper presents the assessment of the silicon translocation in maize plants grown under specific field conditions, near Gataia town, on uniform background fertilization with macroelements (N, P, and K) and the application of three different doses of exogenous silicon as an aqueous solution: 3, 4, 5 si 6 l/ha by spraying the leaves at two developmental stages: 4-6 leaves and 8-10 leaves respectively, corresponding to14-16 and 19 BBCH code. The silicon content of plants (roots, stem and leaves samples - 10 plants from each variant) was performed at 10 and 20 days after exogenous treatment. The determination of Si in plants was achieved by the classic gravimetric method, of the insoluble and thermally stable form of* SiO_2*. The highest accumulation of* SiO_2 *was determined in roots with 6 l/ha exogenous silicon treatment (ESi), in plant stems treated with 4l/ha ESi and in leaves treated with 3l/ha ESi. This demonstrates that high doses of ESi applied will stimulate accumulation in maize root, and the medium and small doses are accumulated in above ground vegetative part of maize plant.*

Key words: *exogenous silicone, maize productivity,* SiO_2

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as "queen of cereals" because it has the highest genetic yield potential among the *Gramineae* family. Maize can be grown successfully in a variety of soils ranging from loamy sand to clay loam. However, soils with good organic matter content having high water holding capacity with a neutral pH are considered good for higher productivity.

Silicon (Si) is the second most abundant element in soil. In soil solution, Si occurs mainly as monosilicic acid (H_4SiO_4) at concentrations ranging from 0.1 to 0.6 mM and is taken up by plants in this form (EPSTEIN, 1994). All terrestrial plants contain Si in their tissues although the content of Si varies considerably with the species, ranging from 0.1 to 10% Si on a dry weight basis (MA, 2002).

Several beneficial effects of Si have been reported, including increased photosynthetic activity, insect and disease tolerance, reduced mineral toxicity, improvement of nutrient imbalance, and enhanced drought and frost tolerance (MOUSSA, 2015; CHEN, 2016; KHAN, 2018). Si has been recognized as an "agronomically essential element" in Japan and silicate fertilizers have been applied to paddy soils (LIANG, 2003). The other characteristic is that the beneficial effects of Si are usually expressed more clearly when plants are subjected to various abiotic and biotic stresses. Si stimulates absorption and metabolism of phosphorus influencing the crop productivity. It is involved in the processes of growth and defenses against different stress factors (SUMALAN, 2009). Silicon is probably the only element which is able to enhance the resistance to multiple stresses (DELAVAR, 2018; ABDEL LATEF, 2016; MA, 2004, MITANI, 2014).

The objectives of the study were: (1) the monitoring of the effects of exogenous silicon (ESi) treatments on silicon accumulation in maize organs (2) assessing the influence of the ESi dose on maize productivity.

MATERIAL AND METHODS

The experiment was established in the agricultural year 2015, located near the town Gataia town (lat 45.43, long 21.43), Timis county using a commercial cultivar of maize (Phileaxx, FAO 400). The experimental design, with four experimental variants, had a total area of 1848 m^2, being arranged in randomized blocks, each block having 462 m^2, Figure 1.

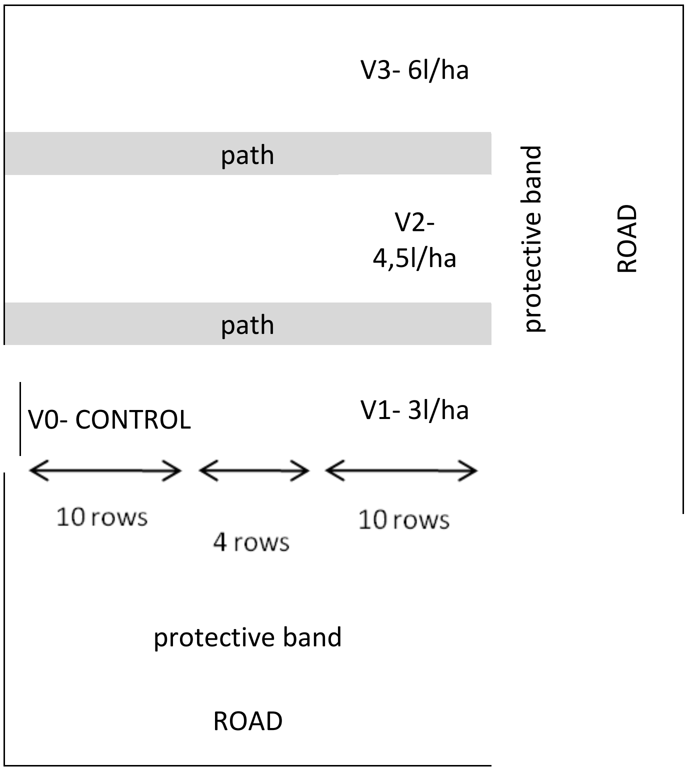

Figure 1. Experimental design

At the time of seeding a NPK fertilizer was applied in following quantity of active compound: 91,6 N kg/ha, 33,6 P kg/ha and 33,6 K kg/ha

The four experimental variants were:

- V_0 – control –tap water was applied
- V_1 – a ESi dose 3l/ha
- V_2 - a ESi dose 4,5l/ha
- V_3 - a ESi dose 6l/ha

The ESi treatments were applied in two developmental stages, BBCH 14-16 (4-6 leaves) and BBCH 19 (8-10 leaves), by spraying on corn plant foliage.

The silicon content of plants was performed at 10 and 20 days after ESi has been applied - an average sample was taken from the root, stem, and leaves of 10 plants from each experimental variant. Si determination in plants was achieved by the classic gravimetric method, of the insoluble and thermally stable form SiO_2.

Vegetable tissue (approx. 25g) were calcinated at 550ºC and the resulting ash (approx. 1g) was treated two times with hot HCl 30% until complete removal of soluble salts and converting alkali silicates in soluble chlorides and insoluble SiO_2. Formed SiO_2 was quantitatively filtered using a quantitative paper filter, dried at 110ºC, calcinated to 550ºC, and weighed at analytical balance with five decimals. The content of SiO_2 is presented as the percentage from dry matter (%/dw) of a mean sample of roots, stem, and leaves.

The influence of exogenous silicon treatments on the maize productivity was done of the physiological maturity of the maize, and reported at the standard humidity of 15% in the seed.

RESULTS AND DISCUSSIONS

The experimental results concerning the quantitative determination of SiO_2 in different organs of maize treated with ESi has demonstrated the capacity to accumulate this element, especially in roots.

In the variants with 4.5 and 6 l /ha, ESi the amounts of SiO_2 reported (%) to the dry matter from the roots were 16.49 and 17.7%, compared to 5.51% in the variant without ESi, figure 2. The accumulation of silicon in the stems was lower compared to roots and dependent of the ESi dose: 0.85% in V0, 1.33% in V1, 1.76% in V2, whereas in V3 was 1.23 %, figure 3.

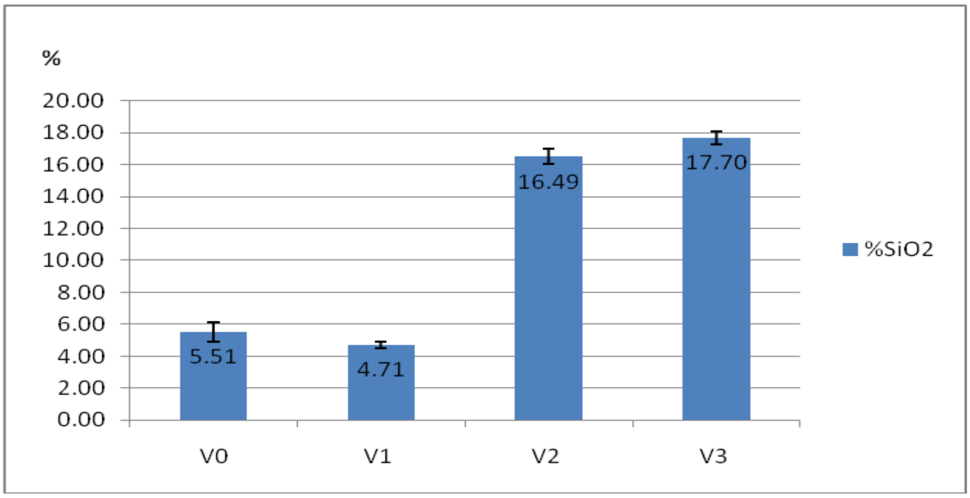

Figure 2. The quantity of SiO_2 (%/dw) in maize roots.
V0- control; V1 - 3l/ha ESi; V2- 4,5 l/ha ESi; V3 -6l/ha ESi

The highest rate of SiO_2 from the leaves was recorded in V1, 3l/ha ESi and it was 5.32%, and the lowest in V3, 1.97%, under the highest dose of ESi, see figure 4.

MA and YAMAJI, 2008, and MITANI, 2009, showed that two genes *Lsi1* and *Lsi2* localized at equal distances between exoderm and endoderm in roots are implicated in rice plants in the translocation of silicon, but their roles are different. Thus, *Lsi1* plays a role in the transport of silicon influx from the external solution to the root cells while *Lsi2* is involved in the efflux transport, namely facilitates the transport of Si from root cells to the plant by apoplast, YAMAJI, 2011. Considering these observations, we can deduce that the high amount of silicon accumulated in the roots is due to the genetic mechanism that determines Si influx transport. This ensures good protection of maize root against pests (microorganisms, worms, etc.), and also supports the growth and development of the entire vegetative apparatus. MA et al., 2011, noted with *ZmLsi1* the gene responsive to silicon transport in corn but the silicon transporting are from different roots cells including epidermal, hypodermal and cortical cells comparative with Si transporter in rice. For silicon efflux translocation in maize, the genetic determination is due to the *ZmLsi2* gene located strictly at the endoderm.

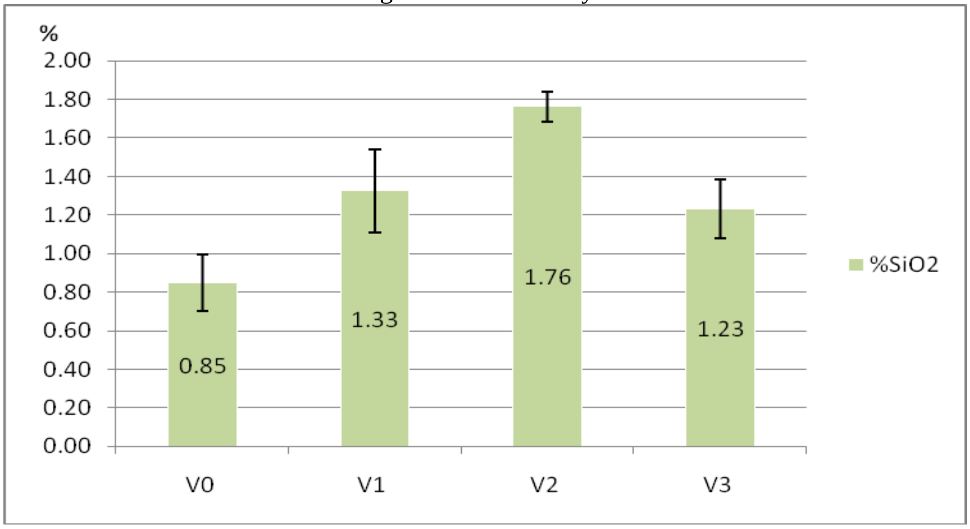

Figure 3. The quantity of SiO_2 (%/dw) in maize stems
V0- control; V1 - 3l/ha ESi; V2- 4,5 l/ha ESi; V3 -6l/ha ESi

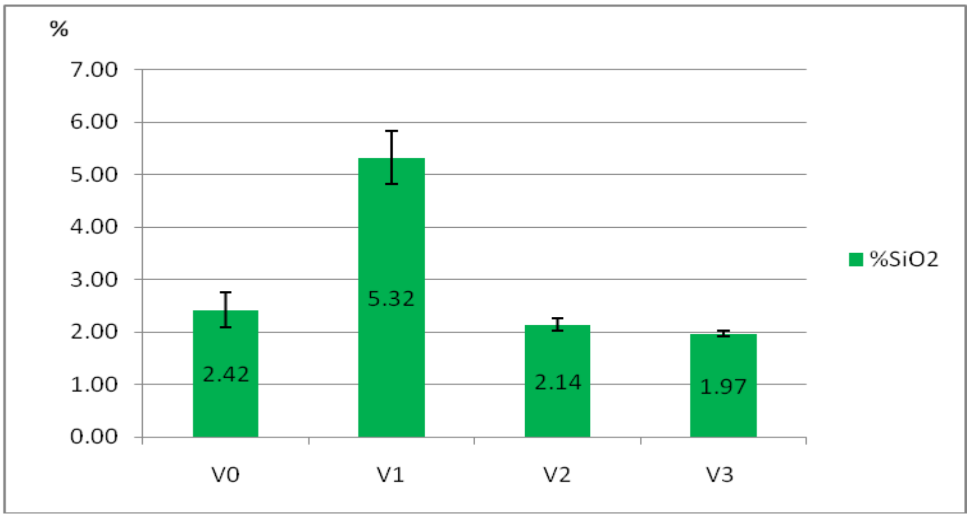

Figure 4. The quantity of SiO_2 (%/dw) in maize leaves.
V0- control; V1 - 3l/ha ESi; V2- 4,5 l/ha ESi; V3 -6l/ha ESi

As it can see from figure 5, application of ESi stimulated the maize productivity, especially at the doses of 4, 5 and 6 litres/ha. The highest productivity was recorded in V3 with 6l / ha ESi treatment of 7814 kg corn/ha with 15% humidity. The smallest production was recorded for the control variant of 7517 kg/ha. The differences are statistically assured for P<0.5

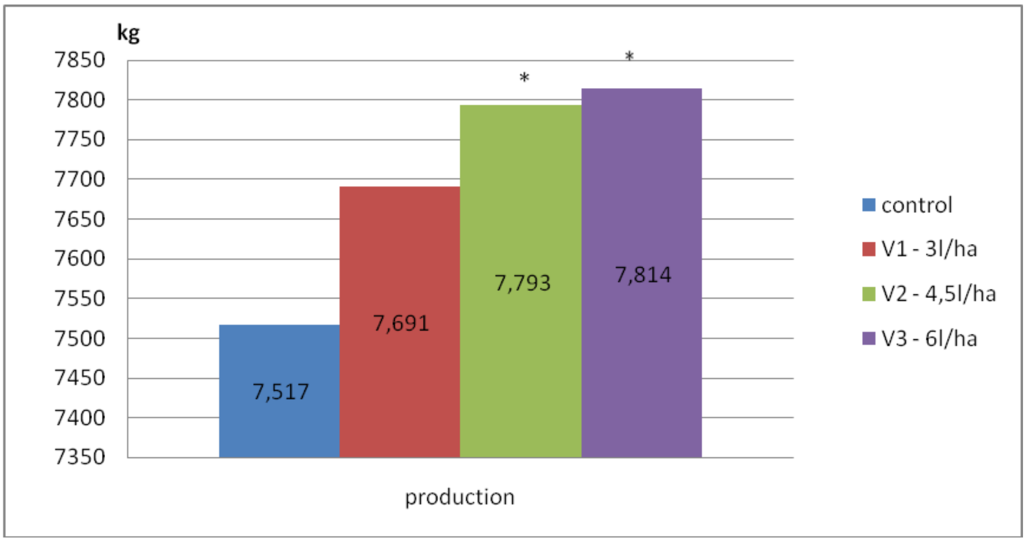

Figure 5. Averages of production recorded for the maize treated with different ESi doses

The yield increases are actually due to indirect effects, the exogenous silicon treatments penetrate into the plant cells, tissues, and organs and "build" stronger plants, thus are protected to factors that generate stresses. The increases are directly related to increasing the ESi dose.

CONCLUSIONS

- The spraying the maize leaves with an aqueous solution of exogenous silicone solution have beneficial effects on the general development of the maize plants, the effects are visible even after 10 days of application.
- The highest accumulation of $SiO2$ was determined in root with 6 l/ha ESi, in plant stems treated with 4l/ha ESi and in leaves treated with 3l/ha ESi. This demonstrates that high doses of ESi applied will stimulate in root accumulation, and the medium and small doses are accumulated in above ground vegetative part of the plant.
- Application of exogenous silicone treatment stimulated the plant productivity, especially the doses of 4.5 and 6 litres/ ha.
- From an economic point of view, the exogenous silicone recommended dose is 4.5l / ha in 250 litres of water, applied by spraying on maize leaves in phenophases 4-10 (1.4-1.8 BBCH)

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