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Research Article
Evaluation of Growth Performances of Some Locally Farmed Maize (*Zea mays* L.) in Cross River State, Nigeria under Different Concentrations of Silicon

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Abstract
Objective: Growth performances of four maize varieties (91 SUWANI, TZL COMP 4, DT STR Y SYN 2 and IWO SYN C2) were investigated at four levels of silicon concentration (0, 2500, 5000 and 7500 mg, with 0 mg as control). **Methodology:** Viable seeds were planted in polythene bags (64 bags) containing soil in a randomized complete block design (a 4×4 factorial experiment) with four replications. Plant height, stem girth, leaf area and leaf number were evaluated at 4, 6, 8 and 10 weeks after planting. **Results:** There was significant difference ($p \leq 0.05$) for all growth parameters and across varieties. Highest mean plant height (144.58 cm) and mean number of leaves (12.23) were recorded at 5000 mg silicon concentration in all varieties, while stem girth and stem biomass were highest in TZL COMP4 (3.42 cm, 38.44 dry weight g^{-1}). **Conclusion:** Based on these results, 5000 mg silicon concentration is recommended as nutrient supplement to enhance maize production.

Key words: Silicon, growth performance, biomass, maize, concentration, leaf area, plant height, leaf number, stem girth

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Owing to the increasing concern expressed over food crisis in the world today, the need to ensure food security has become a priority with attention being paid mostly to cereal crops. Maize is one of such cereal crops and is considered as the most important cereal crops in the economy of Africa and the world[1]. In Nigeria, maize is mostly grown in the areas with forest but large scale production has moved to the savanna zone where yield potential is much higher. Irrespective of its great importance, yields are low due to some factors as soil infertility, pests, disease and drought. Maize is commonly used as roughage feed for livestock and in poultry feed[2].

Silicon serves as a bioactive and advantageous element. Silicon is highly abundant in soil and its occurrence is ubiquitous in all organisms. Recently, the nutritional significance of silicon for plant health and in the agricultural sector has gotten increased attention[3,4]. Silicon holds a crucial position in the growth and developmental processes of plants which includes amelioration or complete protection of these plants from biological and a biological stresses[5]. In light of the aforementioned and due to deficiencies in information regarding the role of silicon in crop production in this region, the present study sought to investigate the effect of different silicon concentrations on the growth parameters, yield and vigour of four varieties of *Z. mays* L.

MATERIALS AND METHODS

Field studies were conducted from June-August, 2014 in the Botanical Garden, University of Calabar, Calabar. The location lies in the rainforest zone of South-South Nigeria. Four varieties of *Zea mays* L. were procured from the International Institute for Tropical Agriculture, Ibadan, Nigeria, while the soil used for planting was sourced from the botanical garden. The soil was filtered using a mesh with pore size of 0.5×0.5 cm and 64 polythene bags were filled with 20 kg of the filtered soil. Composite soil sample was collected from the plot in the study location and the physicochemical properties determined using standard methods.

The experiment was a 4×4 factorial experiment. The factors are 4 varieties of *Z. mays* L., 91 SUWANI, TZL COMP 4, DT STR Y SYN 2 and IWO SYN C2 and 4 treatments of powdered silicon (0, 2500, 5000 and 7500 mg). The design adopted for this study was a Randomized Complete Block Design (RCBD), replication was done 4 times for each treatment, making a total of 64 experimental units. About five seeds each of the four varieties of *Z. mays* L. were sown in polythene bags and replicated 4 times. After germination, thinning was done to one plant per bag. Plants were treated with powdered silicon 2 weeks after germination by broadcasting away and around the plant and on the soil, thereafter watered into soil.

Growth parameters was measured beginning 4 Weeks After Planting (4 WAP), then 6, 8 and 10 WAP, respectively. Plant height was measured with a tailor's tape to the nearest centimeter from the stand to the top of the plant and stem girth (cm) was measured to the nearest centimeter with a vernier caliper at the base of the plant. Leaf area (cm^2) was determined using the equation for the estimation of individual leaf area by Chen *et al.*[6]:

$$LA = Li \times Wi \times A$$

where, L represents the length of the leaf, W represents the maximum width of the leaf and A is a constant which numerically equals 0.75. Leaf number was counted on each plant.

Plants in each plot was harvested 10 WAP, the roots of the plants were discarded while the leaves and stems was weighed using a weighing balance to obtain fresh weights. Subsequently dry weights was obtained after oven drying (Model 0432-B, UK) for about 2 days at a constant temperature of 80°C. Data was analyzed using ANOVA and means separated using LSD at $p = 0.05$.

RESULTS

The results showed that the application of different levels of silicon improved the growth and yield of the maize varieties studied. There was a significant difference between the interaction of plant height at the different levels of silicon concentration ($p \leq 0.05$) and the control with the highest mean plant height recorded at 5000 mg silicon concentration, this was followed by 2500 mg silicon concentration. The least mean plant height was observed at 7500 mg silicon concentration (Fig. 1). Plant height varies significantly ($p \leq 0.05$) compared with the control and across the four varieties, 91 SUWANI had the highest mean plant height at the various levels of concentration, also 91 SUWANI had the same mean plant height at 2500 mg and 5000 mg silicon concentrations. The DT STR Y SYN 2 had the least mean plant height at all concentrations of silicon (Fig. 1). Stem girth of the four varieties showed significant differences ($p \leq 0.05$). The TZL COMP 4 had the highest mean stem girth followed by DT STR Y SYN 2. 91 SUWANI recorded the least mean stem girth (Fig. 2). The stem girth showed no significant difference at the various concentrations of silicon applied.

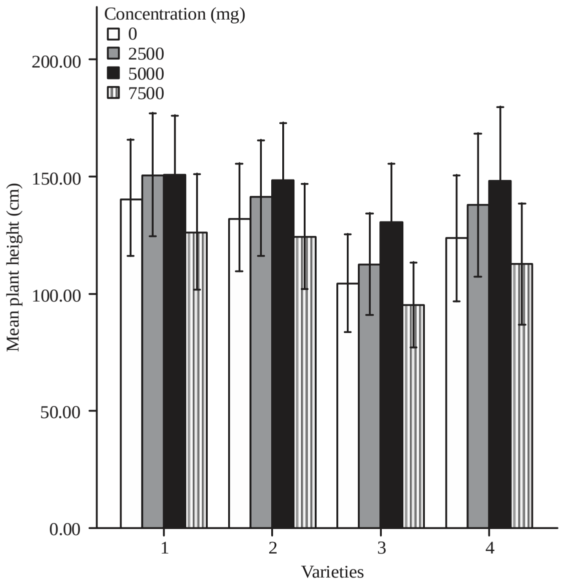

Fig. 1: Mean plant height (cm) of four varieties of *Z. mays* L., at different levels of silicon concentration

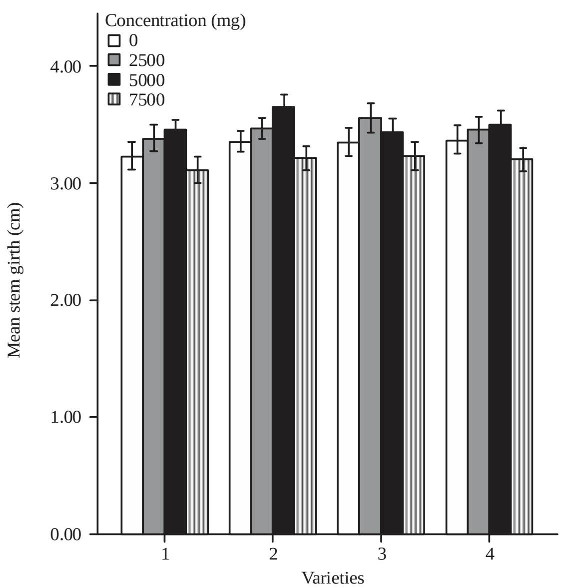

Fig. 2: Mean stem girth (cm) of four varieties of *Z. mays* L., at different levels of silicon concentration

91 SUWANI, TZL COMP 4 and IWO SYN C2 had the highest mean stem girth at 5000 mg silicon concentration, while DT STR Y SYN 2 had the highest mean stem girth at 2500 mg silicon concentration (Fig. 2). Mean stem girth at 7500 mg silicon concentration was lowest in all four varieties (Fig. 2). The mean leaf area was observed to be highest in TZL COMP 4, followed by 91 SUWANI. Leaf area varied significantly ($p \leq 0.05$) in four varieties (Fig. 3). The IWO SYN C2

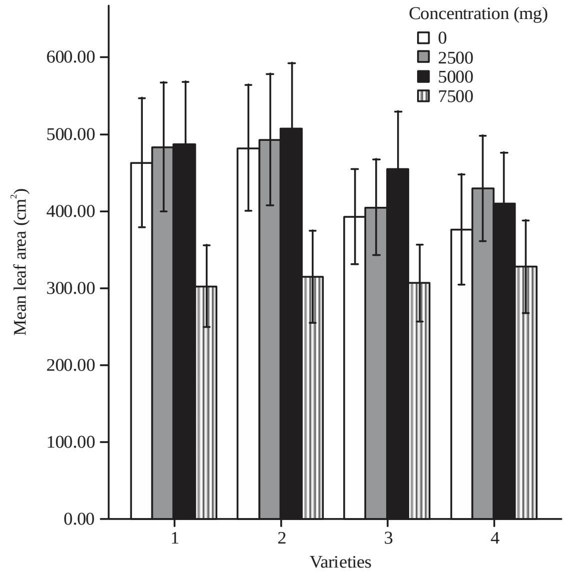

Fig. 3: Mean leaf area (cm^2) of four varieties of *Z. mays* L., at different levels of silicon concentration

had the least mean leaf area. There was no significant effect on the leaf area however, plants treated with 5000 mg had the highest mean leaf area in 91 SUWANI, TZL COMP 4 and DT STR Y SYN 2. The highest mean leaf area in IWO SYN C2 was recorded at 2500 mg concentration (Fig. 3). The four varieties showed significant difference ($p \leq 0.05$) in mean leaf number produced. The highest mean leaf number was however recorded in DT STR Y SYN 2, IWO SYN C2 had the second highest mean leaf number, while 91 SUWANI recorded the least in mean leaf number produced (Fig. 4). There was no significant difference in the mean leaf number produced at the various concentrations of silicon applied. In 91 SUWANI and IWO SYN C2, the highest leaf number was recorded at 2500 mg silicon concentration, while at 5000 mg silicon concentration, TZL COMP 4 and DT STR Y SYN 2 had the highest mean leaf number produced. The least mean leaf number was observed in plants treated with 7500 mg silicon concentration in all varieties (Fig. 4). The results showed that there was no significant difference in biomass at the variety level. However, TZL COMP 4 had the highest mean biomass, followed by 91 SUWANI, the least mean biomass was recorded in IWO SYN C2 (Fig. 5). Interactive effects of silicon concentration and biomass was found to be statistically significant ($p \leq 0.05$). The highest mean biomass was produced at 2500 and 5000 mg silicon concentrations in all varieties except DT STR Y SYN 2 (Fig. 5).

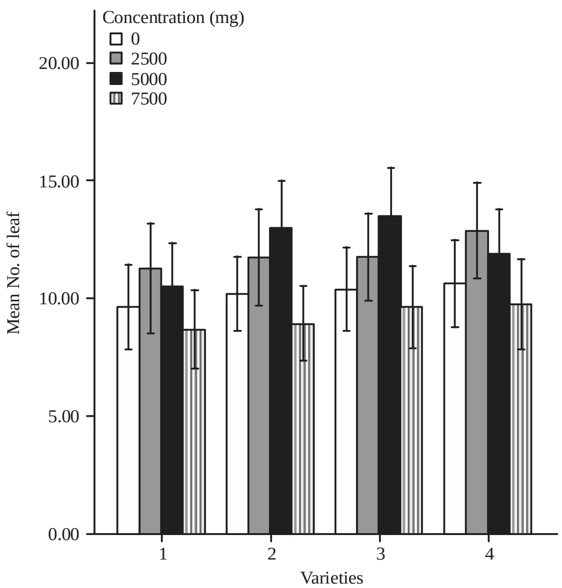

Fig. 4: Mean leaf number of four varieties of *Z. mays* L., at different levels of silicon concentration

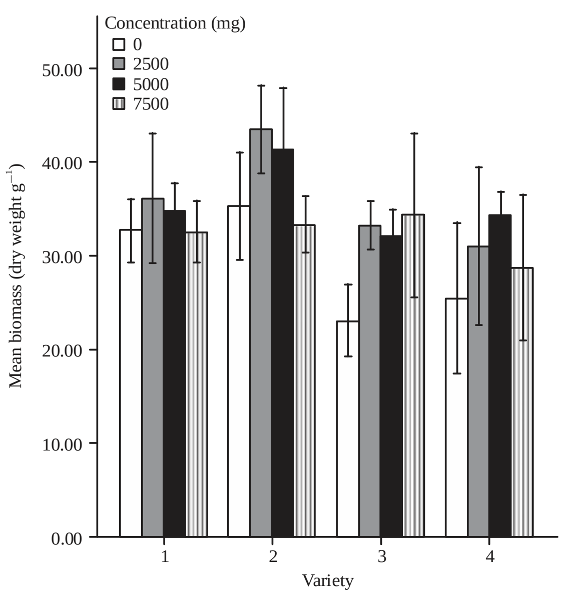

Fig. 5: Mean shoot biomass of four varieties of *Z. mays* L., at different levels of silicon concentration

DISCUSSION

Numerous studies have shown that silicon has an affirmative consequence on the growth performance and development of plants[7]. Benefits of silicon have been reported in terms of enhanced plant height, mechanical strength and straw biomass production[8-10]. From this study, silicon application promoted plant growth. Nonetheless, the peak increase in growth performance was observed at 5000 mg silicon concentration. There was a decrease in the growth parameters in all the varieties of *Z. mays* L., studied at 7500 mg silicon concentration. Plants grown on soils treated with silicon performed better. This would have been due to the enhanced availability of some of the nutrients like phosphorus, nitrogen and potassium in the soil. Malhotra *et al.*[11] asserted that silicon addition to soil boosted the uptake of mineral elements like phosphorus, potassium, calcium and nitrogen. Increase in the plant height of *Z. mays* L., observed in the four varieties (Fig. 1) probably resulted from the increased photosynthetic rate, leaf water status and osmotic adjustment[12]. Amin *et al.*[13] reported that silicon addition boosted all the growth parameters of maize in stressed surroundings. Contrary to these results was the report by Sarto *et al.*[14] who reported that application of silicon did not increase the plant height of wheat. This might have been as a result of dehydration of protoplasm and slow or decreased rate of cell extension. Stem girth showed no significant difference at the various levels of silicon concentration, although, there were slight differences observed in stem girth of the different varieties (Fig. 2). Monocotyledons lack secondary meristem and therefore do not expand in girth like dicotyledons, however, the slight differences in girth could have been the result of the deposition of silicon along the stem. Rather than expand, these deposits of silicon confer strength and firmness on the stem[15,16]. The four varieties of *Z. mays* L., showed increase in leaf area (Fig. 3). This may have been due to deposition of silicon on the epidermal layer causing a change in the morphology of the leaves as well as maintaining turgor through reduction of excessive transpiration and increasing water use efficiency[17,18]. There are also reports that application of silicon increased leaf area in maize which support this result[19,20].

Leaf number in all four varieties of *Z. mays* L., varied in the following trend (3>4>2>1, Fig. 4). Amin[21] recorded similar increase upon application of silicon on maize. Generally, the increased yield (Fig. 5) may be attributed to the mutually stimulatory effect of silicon on photosynthesis and chlorophyll content as well as increased leaf area thus improving the synthesis of starch and supply of cell wall constituents which eventually enhanced growth and yield.

CONCLUSION

From the results of the study, it could be concluded that performance and yield of maize was improved by its cultivation with exogenously applied silicon. Based on this, silicon should be added at 5000-250 mg kg^{-1} of soil as base fertilizer to maize as this would help farmers maximize yield and performance.

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