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Effect of Silicon Fertilization on Physiological Parameters and Yield of Hybrid Maize under Irrigated and Rainfed Conditions

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A field experiment was conducted to study the effect of silicon fertilization on physiological parameter and yield of hybrid maize under irrigated and rainfed conditions during *Rabi*, 2017-18 at eastern block farm of Tamil Nadu Agricultural University, Coimbatore. The treatments comprised of two factors*viz*., three irrigation strategies and two silicon sources as seed priming and foliar application. The results of the study indicated that adequate irrigation strategy registered significantly higher physiological parameters, grain yield (6679 kg/ha) and stoveryield. Silicon application as seed priming with 1.5 mM of sodium meta silicate and foliar application of silicic acid @ 0.2 % at knee high and tassel initiation stages was recordedhigher physiological parameter like SPAD meter value and Relative Water Content (RWC) and grain (6130 kg/ha) and stoveryield.It was comparable with foliar application of silicic acid @ 0.2 % at knee high and tassel initiation stages alone in registering higher growth and yield of maize.

Key words: Maize, Silicon, Knee, Tassel, Yield

Maize *(Zea mays* L.) ranks third in total world production after wheat and rice and it isprincipal staple food in many countries, particularly in the tropics and sub tropics (FAO, 1999). It is also an important *kharif*food grain crop of India and it plays an important role in Indian agriculture economy both in terms of food for human being and feed for animals. In India, maize is grown in about 9.3 m ha with a production of 24.19 mt and average productivity of 2.60 t/ha (MOA, 2016). In Tamil Nadu, it is grown in an area of 3.8 lakh ha with a production of 2.24 mt and productivity of 5902 kg/ha (Season and Crop Report, 2016).Drought is the second important constraint of maize production in the developing countries. Drought affects the organ growth and leads to reduction in leaf and silk elongation thus decreasing light interception and increasing theAnthesisSilkingInterval (ASI), finally affecting corn production (Boyer, 1970; Saab and Sharp, 1989). The role of various macro and micro nutrients in enhancing the yield has been understood very well. However, the present focus is to examine the beneficial role of any nutrient in alleviating moisture stress in crops besides maximising yield. The potentiality of silicon (Si) towards its drought tolerance mechanism was evaluated in various crops through conducted elsewhere. The role of Si on drought tolerance examined by Hattori *et al.* (2005) in *Sorghumbicolor*, clearly indicated that Si applied on sorghum could extract a large amount ofwater from drier soils and can maintain a higher stomatal conductance. Similar results were obtained by Ma *et al.* (2004) in cucumber; they concluded that Si enhances the net photosynthetic rate of cucumber under drought stress. Si has also been found to reduce the oxidative membrane damage and improves the water use efficiency up to 35 per cent in maize (Gao *et al.,* 2004). Kaya *et al.* (2006) reported an enhancement in relative water content indicating the retention of water in cells increasing the moisture stress tolerance in maize. Pei *et al.* (2010) reported that Si application stimulates antioxidant defense mechanism in wheat, when grown under water stress conditions. The present investigation was undertaken with the objective to study the effect of silicon application on physiological parameters (chlorophyll index, relative water content) and yield of hybrid maizeunder the three irrigation strategies *viz.,* adequate irrigation, limited irrigation and no irrigation conditions.

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Material and Methods

The field experiment was carried out at Eastern Block farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *Rabi,* 2017-18. The farm is geographically situated in Western Agro Climatic Zone of Tamil Nadu with coordinates of 11°N latitude, 77°E longitude and an altitude of 426.7 m above Mean Sea Level (MSL). During the cropping period (October 2017 to February 2018), a total rainfall of 217.7 mm was received in 12 rainy days. The soil of the experimental site was clay loam texture and was slightly alkaline in pH (8.59), non-saline in EC (0.36 dS/m), medium in available N (238.0 kg/ha), medium in available P (14.0 kg/ha), high in available K (452.0 kg/ha). The organic carbon status in the experimental soil was 0.72 per cent with available silicon content of 72.0 kg/ha. TNAU maize hybrid CO 6 was used for the field experiment. The experimentwas laid out in split plot design with three

replications. The treatment details comprised of two factors. Factor one consists of three irrigation strategies *viz.,* M_1 –adequate irrigation (at regular intervals), M_2 – limited irrigation (at critical stages) and M_3 – no irrigation (rain fed) and factor two consists of silicon sources *viz.,* S_1 seed priming with 1.5 mM of sodium meta silicate for 12 hrs, S_2 foliar application of silicic acid @ 0.2 per cent at knee high and tassel initiation stages, S_3– seed priming with 1.5 mM sodium meta silicate and foliar application of silicic acid @ 0.2 per cent twice at knee high and tassel initiation stages, S_4 water spray and S_5 control. The recommended cultural practices were carried out as per the Crop Production Guide (CPG, 2012). The recommended dose of NPK (250:75:75 kg/ha) was applied to the crop in three splits (as basal and two top dressings). Irrigation was given as per the treatments plots. For adequate irrigation M_1(*i.e.,* irrigation at regular intervals), nine irrigations were given throughout the crop growth period at an interval of 8 to 12 days, whereas five irrigations were given to M_2 treatment (limited irrigation at critical stages) at seedling, knee high, tasseling, silking and maturity stages. M_3treatment was maintained completely under rainfed condition. Biometric observations on physiological parameters *viz.,*chlorophyll index and relative water content were recorded at knee high, tasseling, silking and maturity stages. Similarly, the grain yield and stover yield were recorded at the time of harvest. The data collected were subjected to statistical analysis following the standard procedure (Gomez and Gomez, 2010) and presented.

Results and Discussion

Physiological parameters

Chlorophyll is one of the most important chelates for plants, which has the capacity to channelize the energy of sunlight into chemical energy through the process of photosynthesis. In addition to indicatethe plant nitrogen status, chlorophyll content is an important indicator of leaf senescence.

Table 1. Effect of irrigation strategies and silicon sources on chlorophyll index (SPAD value) at different growth stages of hybrid maize

Treatments	Knee high stage	Tasseling stage	Silking stage	Maturity stage
Main plots				
M_1	41.1	54.6	49.2	42.3
M_2	39.9	45.9	44.5	36.2
M_3	37.5	41.2	38.1	31.4
SEd	0.8	0.3	0.4	0.7
CD (0.05 %)	1.7	0.7	1.0	1.5
Subplots				
S_1	37.9	46.5	44.1	36.8
S_2	41.9	48.2	46.8	37.9
S_3	42.8	50.5	44.7	39.2
S_4	31.1	47.3	41.8	37.1
S_5	36.6	43.7	42.2	32.4
SEd	0.7	0.8	0.6	0.8
CD (0.05 %)	1.7	1.6	1.3	1.6

The SPAD value data observed under the three irrigation strategiesexperimented showed that adequate irrigation condition (M_1) recorded higher chlorophyll index of 41.1 at 25 DAS and it was at par with limited irrigation condition (M_2). However, the same treatment showed its significant superiority over the other two treatments in producing higher chlorophyll index of 54.6, 49.2 and 42.3 at 45, 60 and 90 DAS, respectively. Higher SPAD values under adequate irrigation condition recorded at all the stages of observation might be due to higher chlorophyll content because of free from moisture stress as chlorophyll concentration is a measure of functional stay green, as reported by Barker *et al.* (2005),that was not fulfilled under water limited condition.

Table 2. Effect of irrigation strategies and silicon sources on relative water content (%) at different growth stages ofhybrid maize

Treatments	Knee high stage	Tasseling stage	Silking stage	Maturity stage
Main plots				
M_1	77.7	72.1	64.1	52.5
M_2	75.6	67.9	58.4	46.9
M_3	68.4	58.5	45.0	41.5
Mean	1.0	1.1	0.5	0.6
SEd	2.2	2.3	1.1	1.3
CD (0.05 %)				
Subplots				
S_1	76.2	66.6	55.7	47.4
S_2	73.7	72.7	56.3	48.1
S_3	77.6	69.4	60.1	49.7
S_4	72.3	62.3	54.4	46.7
S_5	69.9	59.8	52.7	43.0
Mean				
SEd	1.2	1.2	1.1	0.9
CD (0.05 %)	2.6	2.5	2.3	1.9

On comparing the silicon sources, seed priming with sodium meta silicate and foliar application of silicic acid at knee high and tassel initiation stages (S_3) was comparable with foliar application of silicic acid alone (S_2) in registering higher chlorophyll index at 25 and 90 DAS, while the treatment (S_3) had recorded significantly higher chlorophyll index at 45 and 60 DAS. The lowest chlorophyll index of 31.1 and 41.8 was recorded with water spray treatment (S_4) at 25 and 60 DAS, respectively. This might be due to the fact that silicon application could help in improving the photosynthetic efficiency of the crop through improved water use, reduced transpiration, and improved nutrient influx from the soil solutionthat resulted in maintenance of higher chlorophyll content (SPAD values) in the silicon applied treatments. Similar findings are reported by (Ahmed *et al.*, 2011).

Relative Water Content (RWC) is considered as an alternative measurement of water status which is associated with plant's drought by the ability to maintain high RWC in leaves under stress.The data showed that maize crop raised under adequate irrigation condition (M_1) recorded higher relative water content of 77.7, 72.1, 64.1, and 52.5 per cent at 25, 45 60 and 90 DAS, respectively.The present study

revealed that supply of adequate irrigation to maize at regular intervals resulted in higher RWC in the leaves when compared to limited or no irrigation conditions. The maintenance of adequate soil moisture with better availability to the crop without any stress for moisture might be the reason for higher RWC under such condition.

Table 3. Effect of irrigation strategies and silicon sources on grain yield (kg/ha) and stover yield (kg/ha) of hybrid maize

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Main plots		
M_1	6679	11119
M_2	5851	9483
M_3	4980	8498
SEd	136	266
CD (0.05 %)	298	538
Subplots		
S_1	5847	9631
S_2	6033	10005
S_3	6130	9699
S_4	5668	9666
S_5	5505	9499
SEd	148	213
CD (0.05 %)	306	NS

With regard to silicon sources, significant increase in relative water content (77.6 %, 60.1 % and 49.7%) was observed with seed priming using sodium meta silicate and foliar application of silicic acid at knee high and tassel initiation stages (S_3) at 25, 60 and 90 DAS, respectively. At 45 DAS, foliar application of silicic acid at knee high and tassel initiation stage alone (S_2) did record significantly higher RWC of 72.7 per cent. Application of silicon sources either as seed priming or as foliar spray recorded higher RWC of leaves. Silicon accumulation and deposition in plant parts could make the leaves thick, alter the stomatal openings with reduction in transpiration loss, thus maintain leaf turgidity. This was supported byKaya *et al.,* 2006 whofound that 2 mM sodium meta silicate increased leaf relative water content by 26.5 per cent in water stressed maize.

Grain and stover yield

In the present study, significantly higher grain yield of 6679 kg/ha was recorded under adequate irrigation, supplied at regular intervals, when compared to the other two irrigation strategies adopted. This strategy might have resulted in a favourable soil environment and better solubilization, uptake and assimilation of soil and applied nutrients. Seed priming with sodium meta silicate and foliar application of silicic acid at knee high and tassel initiation stages resulted in higher grain yield of 6130 kg/ha than other treatments. However, the treatment was statistically on par with foliar application of silicic acid at knee high and tassel initiation stages. Exogenous supply of silicon could have improved the photosynthetic activity, enabling the maize plants to accumulate sufficient photosynthates and thereby higher Dry Matter Production (DMP) and these together with efficient translocation resulted in higher grain yield. Similar results were noticed in rice by Narayanan *et al.* (2008). Stover yield also showed the similar trend as that of grain yield. Crop raised under adequate irrigation condition did producesignificantly higher stover yield of 11119 kg/ha than the limited irrigation and no irrigation conditions. The increased stover yield might be due to better vegetative growth and higher dry matter production.

It is concluded that application of silicon sources as seed priming with 1.5 mM of sodium meta silicate and foliar application of silicic acid @ 0.2 per cent at knee high and tasseling stages influenced higher growth and yield of maize even under the strategy of no irrigation as compared with adequate and limited irrigation strategies. Therefore, application of silicon through seed priming or foliar spray could be a suitable management strategy for sustainable production of TNAU maize hybrid CO 6 under irrigated and rainfed conditions.

References

Ahmed, M., Qadeer, U. and Aslam, M.A. 2011. Silicon application and drought tolerance mechanism of sorghum. *African Journal of Agricultural Research,* ***6*****(3)**: 594-607.

Barker, T., Campos, H., Cooper, M., Dolan, D., Edmeades, G.O., Habben, J., Schussler, J., Wright, D. and Zinselmeier, C. 2005. Improving drought tolerance in maize. *Rev., **25**: 173253.*

Boyer, J.S. 1970. Leaf enlargement and metabolic rates in corn, bean and sunflower at various leaf water potential. *Plant Physiol.***, 46:** 233- 235.

CPG. 2012. Crop production guide. Published by Directorate of Agri., Chennai and TNAU, Coimbatore, India. pp. 93-100.

FAO, 1999. Quarterly bulletin of statistics 2 **(3)**: 25-26.

Gao, X., Zou, C.,Wang.L. and Zhang, F. 2004. Silicon improves water use efficiency in maize plants. *J. Plant Nutr.*,**8(27):**1457-1470.

Gomez, K.A. and Gomez, A.A. 2010. Statistical Procedures for Agricultural Research (2nd ed). John Wiley and Sons, New York, U.S.A.

Hattori, T., Inanaga, S., Araki, H., An, P., Morita, S., Luxova, M. and Lux, A. 2005. Application of silicon on enhanced drought tolerance in *Sorghum bicolor*. *Physiol.Plant.***123(4)**: 459- 466.

Kaya, C., Tuna, L. and Higgs, D. 2006. Effect of silicon on plant growth and mineral nutrition of maize grown under water stress conditions.*J. Plant Nutr.***29:**1469-1480.

Ma, C., Li, Q., Gao, Y. and Xin, T. 2004. Effect of silicon application on drought resistance of Cucumber plants. *Soil Sci. and Plant Nutr.,***50:**623-632**.**

MOA. 2016. Ministry of Agriculture. Annual report 2015-2016.http://agricoop.nic.in.

Narayanan, S., Sandy, A., Shu, D., Sprung, M., Preissner, C., and Sullivan, J. 2008. Design and performance of an ultra-high-vacuum-compatible artificial channel-cut monochromator. *J. of sync. radiation, **15*****(1):**12-18.

Pei, Z. F., Ming, D.F., Liu, D., Wan, X.X., Geng, H.J., Gong and Zhou, W.J. 2010. Silicon improves the tolerance of water deficit stress induced by polyethylene glycol in wheat (*Triticumaestivum*L.) seedlings. *J. Plant Growth Regul.,***29:**106-115.

Saab, I.N. and Sharp, R.E. 1989. Non-hydraulic signals from maize roots in drying soil: inhibition of leaf elongation but not stomatal conductance. *Planta,* **179:**466-474. Season and Crop Report. 2016. Department of Economics and Statistics, Chennai.