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# EFFECT OF ORTHO SILICIC ACID FORMULATIONS ON PRODUCTIVITY AND PROFITABILITY OF MAIZE

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## Abstract

Field experiments were conducted at two different locations *viz.,* Location-I at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu and Location-II at Farmers Field, Mallamapuram Village, Dharmapuri district, Tamil Nadu during 2015 – 2017 to study the effect of ortho silicic acid formulations on productivity and profitability of maize. The experiment consisted of sixteen treatments *viz.,* each three levels of silixol granules (25, 50 and 100 kg ha$^{-1}$) and Silixol plus spray (1, 2 and 3 ml litre$^{-1}$ on 20, 40 and 60 DAS) and their interactions along with recommended dose of fertilizers (RDF) and as control. The experiments were laid out in Randomized Block Design with three replications. The results of the experiments revealed that, among the different levels of silicon, the combination of soil and foliar application recorded highest values compared to individual application of soil and foliar. Among the treatments tried, combination of soil and foliar application of RDF + silixol granules @ 100 kg ha$^{-1}$ + silixol plus @3 ml l$^{-1}$ recorded maximum plant height, LAI, DMP, cob length, cob diameter, number of grains cob$^{-1}$, test weight and grain and stover yield of 6737, 6842 kg ha$^{-1}$ and 8231, 8304 kg ha$^{-1}$ in Location-I and Location-II respectively. In respect of economics of maize, RDF + silixol granules @25 kg ha$^{-1}$ + silixol plus@ 1 ml l$^{-1}$ recorded highest net return of Rs. 54269.5 and Rs. 55881 and return rupee$^{-1}$ invested of 2.19 and 2.23 in both the locations respectively. Thus it can be concluded that conjoint application of RDF + silixol granules@ 25 kg ha$^{-1}$ + silixol plus @1 ml l$^{-1}$ on 20, 40 and 60 DAS holds immense potentiality to boost the productivity and profitability of maize to the farming community.

***Key words*:** ortho silicic acid formulations, maize, growth, yield, economics

## Introduction

Maize (*Zea mays* L.) is the third important cereal crop next to rice and wheat in the World. Maize has been an important cereal crop because of its high production potential compared to any other cereal crop and adaptability to wide range of environments. Since the crop has very high genetic yield potential, it is called as the "Queen of cereals". Besides being a potential source of food for human being, it is used for feeding cattle and poultry. About 66 per cent of total maize production is used as feed, 25 per cent as food and industrial products while rest is used as seed purposes etc. Maize serves as staple food for millions of people in Asia, Africa and America. Maize is high in carbohydrates, protein and fairly good source of calcium, phosphorus, iron, and vitamin-A, nicotinic acid and riboflavin (Binod Kumar, 2016). Worldwide maize is grown over an area of 181.03 million hectares with a production of 1073.93 million tonnes and with the productivity of 5.73 t ha$^{-1}$. In India, maize occupies an area of 9.50 million hectares with a production of 24.50 million tonnes with the productivity of 2.58 t ha$^{-1}$. In Tamil Nadu, it is cultivated in an area of 0.36 million hectares with production of 2.38 million tonnes with a productivity of 6.5 t ha$^{-1}$ and also it occupies fourth position in Indian maize production. Maize being a $C_4$ plant has higher yield potential which also depends on nutrient supplying capacity of the soil. However, its potential could not be utilized fully due to lack of proper agronomic management practices like Nutrient management weed management, season and variety (Sahrawat *et al.,* 2008). Among them, inadequate supply of macro and micronutrients greatly affect the growth and yield of maize.

Silicon is the second most abundant element in the earth's surface and plays a significant role in imparting biotic, abiotic stress resistance and enhancing crop productivity (Savant *et al.,* 1997). Silicon is the only element known that does not damage plants with excess accumulation. It has been demonstrated to be necessary for healthy growth and stable production. Long term system of intensive crop cultivation depletes the available soil silicon (Si). Depletion of available Si in the soil could be one of the possible limiting factors amongst others contributing to declining yield of maize. The lower values of Si in the soil could be due to severe and frequent soil erosion and sediment transportation. Due to the desilication process, Si in the soil is continuously lost as the result of leaching process. The silicon content in some regions might be limited to sustainable crop production. Hence, improved Si management to increase yield and sustain crop productivity appears to be necessary in tropical as well as in sub-tropical countries (Meena *et al.,* 2014).

The growth and yield of maize was enhanced by silicon fertilization (Pei *et al.,* 2010) and application of silicon increased the growth attributes (leaf area, chlorophyll content, root length, fresh shoot weight, dry shoot weight), yield attributes (cob length, cob diameter, number of grains and test weight) and yield of maize (Jigar Sharma *et al.,* 2013). Although silicon is the second largest element present in the soil but due to its presence in the amorphous form, it is not available for plants. Plants absorb silicon from the soil solution in the form of monosilicic acid, also called orthosilicic acid (Lewin and Reimann, 1969). The beneficial effect of orthosilicic acid was earlier reported by Jawahar *et al.* (2015) in rice. As far as maize is concerned a very few work's have been done with silicon nutrition. Keeping the aforesaid facts in consideration, the present investigation was carried out to study the effect of ortho silicic acid formulations on productivity and profitability of maize in different soils.

## Materials and Methods

Field experiments were conducted at two different locations viz., Location I at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar and Location I at farmer's field at Mallamapuram in Dharmapuri district. The soils of the experimental fields were clay loam and sandy loam respectively. The maize crop was raised during February – June 2016 (Location-I) and December- April 2017 (Location-II). The maize cultivar DKC 9133 (Hybrid) was chosen for the study. Maize crop was fertilized with 250:75:75kg N, $P_2O_5$ and $K_2O$ ha$^{-1}$ and were applied in the form of Urea (46% N), Single Super Phosphate (16% $P_2O_5$) and Muriate of Potash (60% $K_2O$). Fifty percent of the recommended N and full dose of $P_2O_5$ and $K_2O$ were applied basally. Remaining half of N was top dressed in two equal splits at 25 and 45 DAS. The experiment consisted of sixteen treatments *viz.,* each three levels of silixol granules (25, 50 and 100 kg ha$^{-1}$) and Silixol plus spray (1, 2 and 3 ml litre$^{-1}$ on 20, 40 and 60 DAS) and their interactions along with recommended dose of fertilizers and as control. The experiments were laid out in Randomized Block Design with three replications. Silixol granules and Silixol plus were obtained as gift sample from Privi Life Sciences Pvt. Ltd. Navi Mumbai, India-400709 and were applied as per the treatments. Biometric observations were recorded at critical stages of maize crop. The gross return per ha for each treatment was worked out based on the present market rate. The net income was calculated by subtracting the cost of cultivation from the gross income. The BCR was calculated treatment wise by dividing the gross income by cost of cultivation.

## Results and Discussion

### Growth Attributes

The growth attributes were significantly influenced by application of Silicon. Among the different treatments tried, application of RDF + silixol granules @100 kg ha$^{-1}$ + silixol plus @3 ml l$^{-1}$ at 20, 40 and 60 DAS recorded higher values for plant height, leaf area index and dry matter production of maize in Location-I and Location-II respectively (Table 1 and 2). This was on par with $T_{15}$ (RDF + silixol granules @100kg ha$^{-1}$ + silixol plus @2 ml l$^{-1}$ on 20, 40 and 60 DAS) and $T_{14}$ (RDF + silixol granules @100 kg ha$^{-1}$ + silixol plus @1 ml l$^{-1}$ on 20, 40 and 60 DAS). Increase in plant height might due to increased cell division, elongation and expansion caused by silicon. This was in agreement with the findings of Yavarzadeh *et al,* (2008) who reported that increase in plant height could be due to deposition of silica on the plant tissues causing erectness of leaves and stem. The higher values for LAI could be due to increased leaf length, leaf width and more number of leaves per plant caused by silicon fertilization. The higher DMP under $T_{16}$ (RDF + silixol granules @100 kg ha$^{-1}$ + silixol plus@ 3 ml l$^{-1}$on 20, 40 and 60 DAS) could be due to the maintenance of high photosynthetic activity and efficient utilization of light and translocation of assimilated products to sink. Increased plant height, larger leaf area and increased dry matter of shoot might have accumulated more photosynthates and produce higher biological yield (DMP). Similar reports were earlier outlined by Jawahar *et al.* (2009) who reported that application of silicon at 100 kg ha$^{-1}$ through fly ash significantly increased plant height, LAI and DMP of maize.

### Yield Attributes and Yield

The yield attributes *viz.,* cob length, cob diameter, number of grains per cob and test weight and yield viz., grain and stover were significantly enhanced by silicon. Application of RDF + silixol granules@100 kg ha$^{-1}$ + silixol plus @3 ml l$^{-1}$on 20, 40 and 60 DAS registered its superiority over other treatments and recorded higher values for cob length, cob diameter, number of grains cob$^{-1}$, test weight, grain and stover yield in maize (Table 1, 2 and 3). This was on par with $T_{15}$ (RDF + silixol granules @100 kg ha$^{-1}$ + silixol plus@ 2 ml l$^{-1}$ on 20, 40 and 60 DAS) and $T_{14}$ (RDF + silixol granules@ 100 kg ha$^{-1}$ + silixol plus@ 1 ml l$^{-1}$ on 20, 40 and 60 DAS) in Location-I and Location-II respectively. Higher test weight was attributed to better availability and translocation of nutrients as well as photosynthates from source to sink. Increased cob length and cob diameter could due to increased photosynthetic activity caused by silicon. This is in line with findings of Jigar Sharma *et al.* (2013).The adequate silicon supply might have improved the photosynthetic activity, increased enzyme activity; increased concentration of soluble substances in xylem enabled the maize plant to accumulate sufficient photosynthates, which resulted in increased dry matter production. These factors coupled with efficient translocation of photosynthates resulted in more number of grains per cob and increased test weight which ultimately led to higher grain and stover yield. This was in conformity with findings of Moussa *et al.* (2006). Similar reports were earlier outlined by Jawahar *et al.* (2009) who reported that application of silicon at 100 kg ha$^{-1}$ through fly ash significantly increased cob length, cob diameter, number of grains cob$^{-1}$, test weight, grain and stover yield of maize.

### Economics of Maize

Among the different treatments tried T8 (RDF + silixol granules@ 25 kg ha$^{-1}$ + silixol plus@ 1 ml l$^{-1}$ on 20, 40 and 60 DAS) registered higher net return and return rupee$^{-1}$ invested of Rs.54269.5, Rs.55881 and 2.19, 2.23 in Location-I and Location-II respectively (Table 4). This could be due to lesser cost of cultivation over other levels of silicon fertilization. Hence it can be concluded that soil application of silixol granules@ 25 kg ha$^{-1}$ + foliar spray of silixol plus @1 ml l$^{-1}$ on 20, 40 and 60 DAS along with recommended dose of fertilizers holds immense potentiality to boost the productivity and profitability of maize.

**Table 1 :** Effect of ortho silicic acid formulation on growth and yield attributes of maize in Location-I

| Treatments | Growth Attributes | | | Yield Attributes | | | |
|---|---|---|---|---|---|---|---|
| | Plant height at harvest (cm) | LAI at flowering | DMP (kg ha$^{-1}$) at harvest | Cob length (cm) | Cob diameter (cm) | No. of grains per cob | Test weight (g) |
| $T_1$ | 174.08 | 4.12 | 13104 | 13.84 | 4.01 | 272 | 22.82 |
| $T_2$ | 192.82 | 5.34 | 14146 | 18.80 | 4.43 | 291 | 22.98 |
| $T_3$ | 197.67 | 5.75 | 14485 | 20.56 | 4.60 | 298 | 23.01 |
| $T_4$ | 199.12 | 5.78 | 14506 | 20.61 | 4.64 | 299 | 23.07 |
| $T_5$ | 179.42 | 4.53 | 13455 | 15.37 | 4.12 | 278 | 22.87 |
| $T_6$ | 185.61 | 4.93 | 13783 | 16.99 | 4.23 | 284 | 22.89 |
| $T_7$ | 186.85 | 4.96 | 13809 | 17.04 | 4.25 | 285 | 22.93 |
| $T_8$ | 205.11 | 6.19 | 14841 | 22.39 | 4.85 | 305 | 23.11 |
| $T_9$ | 206.08 | 6.21 | 14884 | 22.42 | 4.88 | 306 | 23.15 |
| $T_{10}$ | 207.17 | 6.24 | 14923 | 22.46 | 4.90 | 307 | 23.19 |
| $T_{11}$ | 212.51 | 6.62 | 15247 | 24.26 | 5.13 | 312 | 23.27 |
| $T_{12}$ | 213.98 | 6.65 | 15288 | 24.30 | 5.15 | 311 | 23.30 |
| $T_{13}$ | 214.97 | 6.67 | 15314 | 24.35 | 5.18 | 310 | 23.33 |
| $T_{14}$ | 220.14 | 7.09 | 15624 | 26.15 | 5.44 | 318 | 23.40 |
| $T_{15}$ | 221.08 | 7.11 | 15641 | 26.19 | 5.46 | 319 | 23.43 |
| $T_{16}$ | 223.02 | 7.14 | 15673 | 26.24 | 5.49 | 321 | 23.47 |
| **S.Ed** | **2.03** | **0.06** | **89.88** | **0.22** | **0.05** | **1.79** | **0.39** |
| **CD (p=0.05)** | **4.36** | **0.13** | **192.36** | **0.46** | **0.10** | **3.84** | **NS** |

**Table 2 :** Effect of ortho silicic acid formulation on growth and yield attributes of maize in Location-II

| Treatments | Growth Attributes | | | Yield Attributes | | | |
|---|---|---|---|---|---|---|---|
| | Plant height at harvest (cm) | LAI at flowering | DMP (kg ha$^{-1}$) at harvest | Cob length (cm) | Cob diameter (cm) | No. of grains per cob | Test weight (g) |
| $T_1$ | 204.71 | 5.13 | 14040 | 13.86 | 4.02 | 276 | 22.84 |
| $T_2$ | 218.63 | 6.08 | 14744 | 18.82 | 4.43 | 297 | 22.97 |
| $T_3$ | 222.64 | 6.35 | 14926 | 20.55 | 4.62 | 303 | 23.04 |
| $T_4$ | 223.55 | 6.43 | 14953 | 20.60 | 4.66 | 304 | 23.11 |
| $T_5$ | 209.22 | 5.50 | 14256 | 15.38 | 4.14 | 283 | 22.88 |
| $T_6$ | 213.51 | 5.76 | 14519 | 17.01 | 4.23 | 289 | 22.90 |
| $T_7$ | 214.42 | 5.86 | 14547 | 17.06 | 4.26 | 290 | 22.93 |
| $T_8$ | 227.53 | 6.60 | 15130 | 22.40 | 4.87 | 309 | 23.12 |
| $T_9$ | 228.39 | 6.64 | 15156 | 22.44 | 4.90 | 310 | 23.15 |
| $T_{10}$ | 229.21 | 6.68 | 15173 | 22.47 | 4.92 | 311 | 23.20 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **$T_{11}$** | 232.42 | 6.84 | 15351 | 24.26 | 5.14 | 316 | 23.29 |
| **$T_{12}$** | 233.21 | 6.87 | 15371 | 24.31 | 5.16 | 317 | 23.32 |
| **$T_{13}$** | 233.90 | 6.91 | 15388 | 24.37 | 5.18 | 318 | 23.35 |
| **$T_{14}$** | 237.35 | 7.13 | 15557 | 26.16 | 5.45 | 321 | 23.42 |
| **$T_{15}$** | 238.04 | 7.16 | 15576 | 26.19 | 5.47 | 322 | 23.44 |
| **$T_{16}$** | 238.76 | 7.19 | 15609 | 26.25 | 5.50 | 324 | 23.49 |
| **S.Ed** | **1.01** | **0.06** | **90.41** | **0.20** | **0.05** | **0.99** | **0.32** |
| **CD (p=0.05)** | **2.18** | **0.14** | **193.48** | **0.44** | **0.11** | **2.13** | **NS** |

**Table 3 :** Effect of ortho silicic acid formulation on grain and stover yield (kg $ha^{-1}$) of maize in Location-I and Location-II

| **Treatments** | **Yields (kg $ha^{-1}$) in Location I** | | **Yields (kg $ha^{-1}$) in Location II** | |
|---|---|---|---|---|
| | **Grain** | **Stover** | **Grain** | **Stover** |
| **$T_1$** | 4420 | 7361 | 4495 | 7434 |
| **$T_2$** | 6087 | 8016 | 6192 | 8089 |
| **$T_3$** | 6221 | 8064 | 6326 | 8137 |
| **$T_4$** | 6240 | 8072 | 6345 | 8145 |
| **$T_5$** | 5795 | 7910 | 5900 | 7985 |
| **$T_6$** | 5919 | 7959 | 6024 | 8032 |
| **$T_7$** | 5938 | 7968 | 6043 | 8041 |
| **$T_8$** | 6372 | 8117 | 6477 | 8190 |
| **$T_9$** | 6393 | 8122 | 6498 | 8195 |
| **$T_{10}$** | 6404 | 8128 | 6509 | 8201 |
| **$T_{11}$** | 6542 | 8168 | 6647 | 8241 |
| **$T_{12}$** | 6559 | 8171 | 6664 | 8244 |
| **$T_{13}$** | 6573 | 8174 | 6678 | 8247 |
| **$T_{14}$** | 6701 | 8209 | 6806 | 8288 |
| **$T_{15}$** | 6716 | 8219 | 6821 | 8292 |
| **$T_{16}$** | 6737 | 8231 | 6842 | 8304 |
| **S.Ed** | **60.32** | **17.82** | **56.75** | **18.23** |
| **CD (p=0.05)** | **123.20** | **38.15** | **121.46** | **39.03** |

**Table 4 :** Effect of ortho silicic acid formulation on economics of maize in Location I and Location II

| **Treatments** | **Location I** | | | | **Location II** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Cost of cultivation (Rs.)** | **Gross income (Rs.)** | **Net income (Rs.)** | **Return $rupee^{-1}$ invested** | **Cost of cultivation (Rs.)** | **Gross income (Rs.)** | **Net income (Rs.)** | **Return $rupee^{-1}$ invested** |
| **$T_1$** | 40069 | 69980 | 29911 | 1.74 | 40069 | 71392 | 31323 | 1.78 |
| **$T_2$** | 43569 | 95313 | 51744 | 2.18 | 43569 | 96924.5 | 53355.5 | 2.22 |
| **$T_3$** | 47069 | 97347 | 50278 | 2.06 | 47069 | 98958.5 | 51889.5 | 2.10 |
| **$T_4$** | 54069 | 97636 | 43567 | 1.80 | 54069 | 99247.5 | 45178.5 | 1.83 |
| **$T_5$** | 41869 | 90880 | 49011 | 2.17 | 41869 | 92446.5 | 50577.5 | 2.20 |
| **$T_6$** | 43669 | 92764.5 | 49095.5 | 2.12 | 43669 | 94376 | 50707 | 2.16 |
| **$T_7$** | 45469 | 93054 | 47585 | 2.00 | 45469 | 94665.5 | 49196.5 | 2.08 |
| **$T_8$** | 45369 | 99638.5 | 54269.5 | 2.19 | 45369 | 101250 | 55881 | 2.23 |
| **$T_9$** | 47169 | 99956 | 52787 | 2.11 | 47169 | 101567.5 | 54398.5 | 2.15 |
| **$T_{10}$** | 48969 | 100124 | 51155 | 2.04 | 48969 | 101735.5 | 52766.5 | 2.07 |
| **$T_{11}$** | 48869 | 102214 | 53345 | 2.09 | 48869 | 103825.5 | 54956.5 | 2.12 |
| **$T_{12}$** | 50669 | 102470.5 | 51801.5 | 2.02 | 50669 | 104082 | 53413 | 2.05 |
| **$T_{13}$** | 52469 | 102682 | 50213 | 1.95 | 52469 | 104293.5 | 51824.5 | 1.98 |
| **$T_{14}$** | 55869 | 104619.5 | 48750.5 | 1.87 | 55869 | 106234 | 50365 | 1.90 |
| **$T_{15}$** | 57669 | 104855.5 | 47186.5 | 1.81 | 57669 | 106461 | 48792 | 1.84 |
| **$T_{16}$** | 59469 | 105170.5 | 45701.5 | 1.76 | 59469 | 106782 | 47313 | 1.79 |

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