IN VITRO EVALUATION OF SILICON SOURCES AGAINST LATE BLIGHT (Phytophthora infestans) OF TOMATO

*Kedarnath¹, K. T. Rangaswamy¹, N. B. Prakash², N. Nagaraju¹, C. N. Lakshminarayana Reddy³ and N. C. Narasegowda⁴

¹Department of Plant Pathology, UAS, GKVK, Bengaluru-560 065
²Department of Soil Science and Agricultural Sciences, UAS, GKVK, Bengaluru-560 065
³Department of Plant Pathology, College of Sericulture, UAS, GKVK, Bengaluru-563 125
⁴Department of Horticulture, UAS, GKVK, Bengaluru-560 065

Corresponding author email: kedarnath.govin@gmail.com

ABSTRACT

The antifungal activity of different concentration of silicon sources viz., OSAB, Silixol plus, Greensil plus, Greensil, Silicon power and Pro-sil in inhibiting the mycelial growth of *P. infestans* was investigated by using poison food technique. The results from *in vitro* study revealed that, all the silicon sources tested at different concentrations showed a wide range of inhibitory effect (1.11 to 90.37 %) over untreated control. However, OSAB recorded highest mean mycelial growth inhibition (51.58 %) and it was followed by Greensil plus (49.84 %), Silixol plus (47.75 %), Greensil (29.87 %), Pro-sil (21.39 %) and Silicon power (21.35 %). However, different sources of silicon were inhibited mycelial growth of *P. infestans* with increasing concentration in the medium. The silicon sources used at 4.0 ml or g L⁻¹ of medium were found to be significantly superior over other lower concentrations in inhibiting the mycelia growth of *P. infestans*.

KEYWORDS: Phytophthora infestans, Silicon, OSAB, Silixol plus, Mycelial growth.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to family solanaceae and is one of the most important and widely grown vegetable crop in both tropics and subtropics in the world. In India, it is fully fledged in different states under diverse climatic conditions. It is affected by several fungal, bacterial, viral and virus like diseases, known to contribute consistently to yield loss of the crop. Silicon (Si) is the second richest element found on the surface of the earth’s crust (Liang et al., 2007). While silicon is not regarded as an essential nutrient for most of the plants, many studies have shown that Si treatment progress the growth and yield of various plants, mainly when they are subjected to both biotic and abiotic stresses. The beneficial results of Si have been observed in an ample variety of plant species. The beneficial effects of Si are typically expressed more clearly in Si-accumulating plants under various abiotic and biotic stress conditions. Silicon is effective in managing various pests and diseases caused by both fungi and bacteria in different plant species. Silicon also exerts alleviative effects on various abiotic stresses including salt stress, metal toxicity, drought stress, radiation damage, nutrient imbalance, high temperature, freezing and so on. These beneficial results are chiefly attributed to the high accumulation of silica on the tissue surface although other mechanisms have also been suggested (Ma, 2004). Although direct antifungal activity of silicates against plant pathogens has been studied by Maekawa et al. (2003) who reported that hyphal growth of rice blast fungus was very slow on agar plates containing soluble silicon (liquid potassium silicate). Kaiser et al. (2005) examined the effect of liquid potassium silicate against several types of phytopathogenic fungi and determined *in-vitro* dose-responses towards soluble potassium silicate (20.7 % silicon dioxide) for *Phytophthora cinnamomi, Phytophthora capsici, Sclerotinia sclerotiorum, S. rolfsii, Pythium F-group, Mucor pusillus, Drechslera spp, Fusarium oxysporum, F. solani, A. solani, C. cocodes, Verticillium fungicola, C. lunata and Stemphylium herbarum*. They observed 100 per cent inhibition of mycelial growth at 40 and 80 ml of soluble silicon (20.7 % silicon dioxide) per litre of agar media. Also observed complete inhibition of *C. cocodes, M. pusillus, S. rolfsii, S. sclerotiorum* and *P. cinnamomi* at 5, 10 and 20 ml of soluble silicon per litre of agar. Bi et al. (2006) reported that, 100 mM sodium silicate was completely inhibited mycelial growth of *A. alternata, F. semitectum* and *Trichotheicum roseum* which cause *Alternaria, Fusarium* and pink rots of Hami melon. Bekker et al. (2006) studied the effect of liquid potassium silicate against several phytopathogenic fungi viz., *A. solani, C. gloeosporoides, C. lunata, F. solani, P. capsici, S. rolfsii* and observed 100 per cent inhibition of mycelial growth at 40 ml (pH 11.5) and 80 ml (pH 11.7) soluble potassium silicate per litre of agar. Rachniyom and Jaenaksorn (2008) showed that all tested soluble silicon significantly reduced mycelial growth and sporangial production of *Pythium aphanidermatum*. Li et al. (2009) reported that, *F. sulphureum* spore germination was inhibited by sodium silicate (Aldrich, 27 % SiO₂) at different concentrations (0, 25, 50, 100, 200 mM), with greater inhibitory effects at higher concentrations. Sodium silicate at different concentrations also markedly inhibited *F. sulphureum* mycelial growth, with greater inhibitory effects at higher concentrations. They also observed, morphological changes in sodium silicate-treated hyphae
such as mycelium sparsity and asymmetry, hyphal swelling, curling and cupped shape by scanning electron microscopy. Ultrastructural alterations were also observed under transmission electron microscopy, including thickening of the hyphal cell walls, cell distortion, cavity or electron-dense material in hyphal cells. Shen et al. (2010) investigated the effect of potassium silicate on the growth of five soil borne phytopathogenic fungi \textit{in vitro} and showed that the growth of the fungal isolates (\textit{Rhizoctonia solani}, \textit{Pestalotiopsis clavispora} and \textit{F. oxysporum f. sp. fragariae}) was significantly (P <0.05) inhibited on potassium silicate amended PDA plates. Fayadh and Aledani (2011) reported that silicon elements were completely inhibited the growth of the pathogenic fungus \textit{R. solani}, at 30, 200, 500 ppm respectively. Khan et al. (2013) reported silicon in the form of sodium silicate was found to be effective in reducing mycelial growth of \textit{Macrophomina phaseolina} and also observed gradual reduction of mycelia growth with increase concentration of silicon. With a view to better characterizing the role of silicon in tomato late blight disease control, \textit{in-vitro} experiment was performed to determine the effect of different silicon sources treatment on mycelial growth of \textit{P. infestans} which cause a devastating late blight disease on tomato.

**MATERIALS & METHODS**

**Silicon sources used and their composition**

The details of silicon sources used in the present study were presented below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Product name</th>
<th>Composition</th>
<th>Manufactured and Marketed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid formulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>OSAB</td>
<td>Silicic acid-0.8% KCL-1.2% H$_2$BO$_3$-0.8 % HCl-1.0 % Peg 400- 48 % Demi water- 47% Orthosilicic acid-0.6 % Plant booster-2.0% Stabilizer-40% Solvent-QS</td>
<td>Rexil agro BV Jamal Fazal Chambers, First Floor, &quot;B&quot; Block No. 26, Greams Road, Chennai (TN) – 600 006</td>
</tr>
<tr>
<td>2</td>
<td>Silixol plus</td>
<td>Silica-24 %</td>
<td>Privi life sciences Pvt. Ltd A-71, TTC Thane Belapur Road, Kopar Khairane, Navi Mumbai- 400 709 Vedant Agrotech</td>
</tr>
<tr>
<td>3</td>
<td>Greensil plus</td>
<td>Potassium-10 % QS- 66 %</td>
<td>Sr. No. 32, Savitri Warehousing, Katraj-Kondhwa-Hadapsar bye-pass, village-Pisoli, Tq- Haveli, Dist- Pune</td>
</tr>
<tr>
<td>Powder formulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Greensil</td>
<td>Silicon as SiO$_2$ -50 % Aluminium as Al-20 % QS-30 %</td>
<td>Vedant Agrotech 221, Mahalaxmi market, 2nd floor, Marketyard, Pune-411 037 Modern agro industries</td>
</tr>
<tr>
<td>5</td>
<td>Power silicon</td>
<td>Silicon-80 % Amino acid-15 % QS-5 %</td>
<td>Factory No. 1, Lohiya compound, Survey No. 497, Naigaon Road, At. Post- Shinde MIDC, Tq and Dist- Nashik- 422 101 Poorva Chemtech Pvt. Ltd.</td>
</tr>
<tr>
<td>6</td>
<td>Pro-sil</td>
<td>Silicon Compound-60 %</td>
<td>A-24 to 29 Samarth Co-Op, Industrial estate, Mukhed Road, Pimpalgoan (B) 422 209, Tq- Niphad, Dist- Nashik</td>
</tr>
</tbody>
</table>

The data obtained from this study were subjected to statistical analysis as per the procedure given by Sundaraj \textit{et al}. (1972). Factorial complete randomized design used for to study and compare the treatments effects.

**RESULTS & DISCUSSION**

All the silicon sources tested at different concentrations by poison food technique showed a wide range of inhibitory effect (1.11 to 90.37 %) on \textit{P. infestans} over untreated
control. Further, the per cent mycelial inhibition of *P. infestans* was found increased with increase in the concentration of silicon sources in the medium (Table 1, Fig. 1 and Plate 1).

Among the silicon sources tested at concentration of 4.0 ml or g L$^{-1}$, Silixol plus showed significantly higher inhibition of mycelial growth of *P. infestans* (90.37 %) followed by OSAB (89.81 %) and Greensil plus (89.63 %) and found on par with each other and Power silicon was found to be least effective (44.63 %) among the tested silicon sources. However, OSAB recorded highest mean mycelial growth inhibition (51.58 %) followed by Greensil plus (49.84 %), Silixol plus (47.75 %), Greensil (29.87 %), Pro-sil (21.39 %) and Power silicon (21.35 %). However, different sources of silicon were inhibited mycelial growth of *P. infestans* with increased concentration in the medium. However, silicon sources used at 4.0 ml or 4 g per litre of medium were found to be superior over other lower concentrations in inhibiting the mycelia growth of *P. infestans*.

**TABLE 1:** Antifungal activity of silicon sources against *Phytophthora infestans* under *in vitro* condition

<table>
<thead>
<tr>
<th>Silicon sources</th>
<th>Per cent inhibition</th>
<th>Per cent mean inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration (ml or g L$^{-1}$)</td>
<td>0.1</td>
</tr>
<tr>
<td>OSAB</td>
<td>10.74</td>
<td>16.67</td>
</tr>
<tr>
<td>Silixol plus</td>
<td>7.59</td>
<td>10.74</td>
</tr>
<tr>
<td>Greensil plus</td>
<td>11.67</td>
<td>16.11</td>
</tr>
<tr>
<td>Greensil</td>
<td>3.52</td>
<td>8.70</td>
</tr>
<tr>
<td>Power silicon</td>
<td>1.11</td>
<td>1.85</td>
</tr>
<tr>
<td>Pro-sil</td>
<td>1.48</td>
<td>6.11</td>
</tr>
<tr>
<td>Control</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Silicon Sources (S) Concentrations (C) S x C
SEm ± 0.02 0.02 0.05
CD at 5 % 0.05 0.06 0.15

**FIGURE 1:** Antifungal activity of silicon sources against *Phytophthora infestans* under *in vitro* condition

**PLATE 1:** Inhibitory effect of silicon sources against *Phytophthora infestans* under *in vitro* condition

*SP*: Silixol plus  
*GSP*: Greensil plus  
*PS*: Power silicon
In the present study, silicon sources tested at different concentrations directly inhibited the *in vitro* mycelial growth of *P. infestans*, and these results showed that silicon sources had fungitoxic activity against *P. infestans*. These result are in line with the observations of Bi *et al.* (2006) who found complete inhibition of the mycelial growth of *Alternaria alternata*, *Fusarium semitectum* and *Trichothecium roseum* with 100-mM sodium silicate. Postharvest pathogens *Pencillium expansum*, *Monilinia fructicola* (Qin and Tian, 2005), *Colletotrichum spp.* (Biggs, 1999), *Botryosphaeria dothidea* (Biggs, 2004) mycelia growth was inhibited by different silicon sources tested under *in vitro*. Silicon amended PDA @ 0.6 per cent or more completely inhibited the growth of *P. expansum* (Ebrahimi *et al.*, 2012). Li *et al.* (2009) also observed morphological changes in sodium silicate-treated hyphae such as mycelium sparsity and asymmetry, hyphal swelling, curling and cupped shape by scanning electron microscopy. Ultrastructural alterations viz., thickening of the hyphal cell walls, cell distortion, cavity or electron-dense material in hyphal cells were also observed under transmission electron microscopy. These findings strongly suggest that silicon sources have direct fungitoxic activity against the pathogen.

**ACKNOWLEDGEMENT**

Author is thankful to the DST for financial assistance to conduct research by awarding DST INSPIRE Fellowship.

**REFERENCES**


