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Effect of Integration between Vascular Arbuscular Mycorrhizal Fungi and Potassium Silicate Supplementation on Controlling Onion White Rot

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The inhibitory effect of potassium, calcium and sodium silicate was assessed, in *in vitro* at different concentrations (0.1, 0.5 , 1, 2, 4 and 8ml /l) against *Sclerotium cepivorum* the causal of onion white rot . The results indicated that potassium and calcium silicate at 0.5 ,1,2,4 and 8ml/l inhibited the mycelial growth and sclerotia formation of *S. cepivorum*, but at 0.1ml/l concentration, the mycelial growth decreased to (2.4cm and 5.0 cm) respectively compared with control treatment . On the contrary sodium silicate resulted in low effect on the mycelial growth and sclerotial formation. Our results also showed that, potassium and calcium silicate increased the pH of the PDA medium from 8.8 to 11.4 by increasing K_2SiO_3 and from 8.7 -11.5 by increasing $CaSio_3$ concentration from 0.1to 8 ml/l. Under greenhouse conditions, the incidence of white rot disease was significantly decreased when onion plants were treated with potassium silicate(2,4 and 8ml/l) only or with VAM fungi, as soil drench in potted soil infested with *S. cepivorum* compared with the control. Adding 4ml/l potassium silicate as soil drench showed high reduction to the disease incidence by 71.43%. On the other hand, onion plants treated with different concentrations of potassium silicate as soil drench and VAM fungi or Folicur 25%, increased apparently healthy survived plants at harvest under field conditions of Kalubiya Governorate during 2015/2016 and 2016/ 2017 seasons, since they decreased disease infection percentages. The highest reductions of onion white rot were observed when onion plants were treated with Folicur 25% followed by potassium silicate at (2 ml/l +VAM fungi). Regarding the yield of onion bulbs, our results indicated that all treatments showed significant increase to bulb yield in contrast to the non-treated plants. Spores count and percentage of root colonization with VAM fungi were increased by increasing potassium silicate concentration, in contrast to the percentage of hypha which was increased by decreasing potassium silicate concentration. In addition, VAM fungi and VAM+ 2ml/l potassium silicate treatments were considered the best treatments to give the best hyphal percentage 93% and 80 % respectively.

Keywords: *Mycorrhiza, Onion, Silicon supplement, White rot.*

White rot disease, caused by *Sclerotium cepivorum* (Berk.) is one of the most serious diseases of *Allium* spp., and is widely distributed in Egypt. The causal pathogen, is considered a poor competitor with soil saprophytes and has not the ability to survive in soil as active mycelium. However it can produce small black sclerotia which grow in large numbers on bulbs of infected plants and able to survive in soil for many years (Coley–Smith 1959 and 1987). Different reports devised many chemical, biological, physical and cultural methods, as well as integrative control systems that combine methods for maximum effectiveness in controlling the disease (Garcia-Cazorla & Xiran-Vayred, 2005, Melero-Vara *et al*.,2000, Arasa and Thangavel, 2013). For example cultural and physical control methods of white rot, such as soil solarization (Katan, 1987, Satour *et al*., 1989, and Melero- vara *et al*.,2000) the use of germination stimulants and soil amendments (Stewart and McLean 2007, Brewstar, 2008). Also, chemical control depended on the use of dicarboximide fungicide (Duff *et al*., 2001, Clarkson *et al*., 2002 and (Garcia - Cazorla & Xiran - Vayred, 2005).

Vascular Arbuscular mycorrhizal fungi (AMF) are wide spread in nature, and fundamental component of agro-ecosystems. AM symbioses may also improve plant health through a more specific increase in protection (improve resistance, and or tolerance against biotic and a biotic stresses (Hooker *et al*. , 1994, Linderman, 1994 and (Arasa and Thangavel, 2013). Silicon (Si) is the second most abundant elements in the earth's crust and is also abundant in most soil (Marschner, 1995, Epstein, 1994 and Datnoff *et al*., 1997). It is relatively recorded with high concentration in most plant tissues (Epstein, 1994).

Interestingly, in 1994, Epstein indicated that the concentration of silicon in plant tissues exceed the concentration of nitrogen and potassium. Therefore, Si is often a major constituent of plant tissue, although it is most considered to be essential nutrient for terrestrial plants in general (Epstein, 1991). The beneficial effects of adequate (Si) include decreased susceptibility infection to fungal pathogens and insects, amelioration of a biotic stresses, and increased growth in some plants (Marschner, 1995 and Epstein, 1994). One of the most thoroughly studied beneficial effects of Si on plant health is its role in reducing susceptibility of some plants to fungal disease. This effect of (Si) has been well documented particularly in rice (Datnoff *et al*., 1997) and greenhouse cucumbers (Menzies and Belanger, 1996).

The objectives of the present study are to investigate the effect of integration between (VAM) fungi, and potassium silicate as soil treatment for suppression of onion white rot disease compared to a single treatment. Also the effect of potassium silicate on growth of VAM fungi.

Materials and Methods

1-Laboratory experiments:

Effect of silicate compounds on the linear growth and sclerotia number of *S. cepivorum* and the PH of the PDA medium:

Potassium silicate (K_2SiO_3), calcium silicate ($CaSiO_3$) and sodium silicate (Na_2SiO_3) procured from Sigma –Aldrich for chemicals (USA) in analytical grade. Calcium, sodium and potassium silicate, at 0.1,0.5, 1, 2, 4 and 8 ml/l, concentrations were prepared and added to sterilized warmed (50 to 60^{o}C) potato dextrose agar (PDA) medium. The prepared concentrations were then wisely poured into 9 cm sterilized Petri dishes, and discs (5 mm in diameter from actively growing culture of *S. cepivorum* were placed in the center of the plates. Four plates were used for each treatment, and the inoculated plates were then incubated at 20 ± 1 ^{o}C . PDA plates without silicon compounds were served as control. Mycelial growth was measured daily and sclerotial number was counted 21 days after incubation. The pH of the prepared concentrations from potassium, calcium and sodium silicate tested was measured using pH pen (Jenco) 610. MSA instrument.

Count of (VAM) fungi spores and root colonization:

- Vascular Arbuscular Mycorrhizal (VAM) fungi *Funneliformis coronatum*,(*Glomus coronatum*)*, Claroideoglomus etunicatum* (*G. etunicatum*), and *Funneliformis mosseae* (*G. mosseae*) were used in this experiment. VAM fungi were added to the soil in greenhouse and field experiments, were previously grown on Sudan grass roots, renewed every 3-4 months. They used at the rate of 50g /pot and 1kg / row. Inoculum consisted of (soil, spores, hyphal fragments and colonized Sudan grass root fragments).

During harvesting stage, (100g/ sample) of rhizosphere soil were individually collected from roots of every treatment. Extraction of VAM fungi (propagates) from soil was done under laboratory conditions as soon as possible using wet sieving and decanting technique as described by (Gerdman and Nicolson, 1963). In order to facilities rapid spore counts, one ml of spore suspension was wisely moved onto Petri-dish (9cm diam.) containing a filter paper marked with small squares (1X1cm) in order to count the number of spores using a dissecting binocular.

- *Root colonization:*

To study the percentage of root colonization of onion plants with VAM fungi under greenhouse artificial infection, roots were cleared and stained. Onion hairy root samples were removed from soil washed by tap water and cut into pieces 1cm long. Small pieces of the collected roots were prepared for microscopic observation to determine the percentage of mycorrhizal colonization in the different treatments according to (Philips and Hayman, 1970) at the end of eavery season. Whereas, mycorrhizal fungal species were examined by Olympus microscope at magnification 200 x.

2- Nursery treatment:

Onion seeds cv.Giza 20 were sown on 5th October, during, 2015/2016 and 2016/ 2017 seasons in Kalubiya governorate. Soil drench with potassium silicate at three different concentrations *i.e.* 2, 4 and 8ml/l first at seed sowing and after 30 days.

Also, application of Vesicular Arbuscular Mycorrhizal (VAM) fungi was done at sowing seed beds at rate (1Kg/ row).

3-Greenhouse experiments:

Potassium silicate (Ps)fertilizer used in the experiments, consisted of 10% K_2O and 25% SiO_3 common name C. Ghanim from El Ghanim company. Pots (25cm-diameter) were sterilized by immerging in 5.0% formalin solution for 15 minutes. 3Kg clay loam soil previously sterilized by formalin solution (5.0%) for 2 weeks were added to each pot. Soil infestation with *S. cepivorium* was carried out by growing the fungus on barley sand medium for 15 days at 20 ^{o}C. The fungal growth was then added to each pot at the rate of 10.0g /Kg soil (w/w). Five apparently healthy onion transplants of (Giza 20) cultivar were transplanted in each infested pots. Three different treatments from Ps and VAM fungi were used in this experiment as follows:

- Soil drench only with potassium silicate at three different concentrations *i.e.* 2 or 4 and 8 ml/l 30, 60 and 90 days after transplanting.
- VAM fungi only were added to the soil at transplanting at the rate 50g/pot.
- Soil drench with Ps and VAM fungi together to the soil by the same rates and times previously recorded.
- Folicur fungicide treatment.

Onion transplants were dipped in Folicur (Tebuconazole 25 %EC) at the rate of 25cm /l for 5 min. After six and twelve weeks of transplanting, onion plants were sprayed with Folicur at rate of 1.87cm/l. Non treated transplants were served as control. Five transplants were planted per pot and four pots were used for each treatment. Infected plants that having a symptoms of white rot disease were counted two and four month after transplanting and their percentages were calculated according to Hovius *et al*. (2004) as well as white rot reduction was recorded as follows:

Infection (%) = No. of plants infected with white rot / Total No. of transplants X100

White rot redaction (%) = White rot % in control – White rot % in each treatment / White rot % in control X100

Also, onion plants and soil samples were taken at harvest to determine the count of VAM fungi counts and root colonization.

4-Felid experiments:

Field experiments were carried out during two growing seasons of the year 2015/2016 and 2016/2017 on 5th December in a naturally infested soil with *S. cepivorum* at Kalubiya governorate. Three replicates were used and the plot area was 3.0 X 3.5 m (10.5m^2= 1/400 feddan). Each plot included 6 rows (3.0 m length and 50cm width). Sixty day-old transplanting of onion cv. (Giza 20) were planted per each plot at spacing 10 cm X10 cm, onions were grown to maturity under regular irrigation, fertilizer and pest management practice standards with commercial production in the area. The same treatments that have been used under greenhouse conditions were used under field conditions. White rot incidence and weight of bulbs for each plot were assessed. Also, onion white rot reduction was estimated as previously mentioned.

5 - Statistical analysis:

All experiments were designed in complete randomized blocks. Data were statistically analyzed using "F" test and treatments were compared by L.S.D. at $P < 0.05$ level according to Gomez and Gomez (1984).

Results

Effect of potassium, calcium and sodium silicate on mycelial growth, sclerotial number of S. cepivorum and pH of PDA medium:

Results in Table 1 show that the mycelial growth of *S. cepivorum* was significantly reduced in the presence of potassium and calcium silicate on the PDA medium compared with control. Potassium and calcium silicate at 0.5,1,2,4 and 8 ml/l completely inhibited mycelial growth. At 0.1 ml/l concentration, in both silicon compounds mycelial growth reached 2.5cm in K_2SiO_3 and 5.0 cm in $CaSiO_3$ compared with control treatment (9.0 cm). On the other hand, sodium silicate showed lower effect on mycelial growth of *S. cepivorium*. Also potassium and calcium silicate completely inhibited the forme sclerotia of *S. cepivorium* at 0.5,1,2,4 and 8ml/l concentrations compared with the control. Whereas, potassium silicate at 0.1ml/l concentration significantly reduced sclerotial numbers, sodium silicate treatments at 0.5, 1, 2, 4 and 8ml /l concentration increased sclerotia numbers compared to the control. Also, media amended with potassium and calcium silicate increased the pH of the PDA medium by increasing their concentrations. At 0.1 ml /l of K_2SiO_3 and CaSiO3 treatment, the pH of PDA medium increased from 8.0 in the control treatment to 8.8 in the 0.1ml/l but completely inhibited the mycelial growth of *S. cepivorium* occurs at pH 9.4 to 11.4 by K_2SiO_3 and $CaSiO_3$ at 0.5, 1, 2,4and8 ml/l concentration. On the other side, amendment with sodium silicate decreased the pH of the PDA medium from 8 in the control treatment to the 7.5 in the 1 and 8 ml/l, so no significant ($p \leq 0.05$) difference in colony diameter between the sodium silicate amended plates and the control.

Table 1. Effect of potassium, calcium and sodium silicate on linear growth of mycelium, number of sclerotia of *Sclerotium cepivorum* and pH changes of the medium used under lab. Conditions

Treat. g/L	Potassium Silicate			Calcium Silicate			Sodium Silicate		
	pH	Linear growth (cm)	*N.S/ plate	pH	Linear growth (cm)	*N.S/ plate	pH	Linear growth (cm)	*N.S/ plate
0.1	8.8	2.5	349.7	8.7	5.0	5733	8.0	9.0	4966
0.5	9.4	0.0	0	9.6	0.0	0	8.0	9.0	7669
1	9.8	0.0	0	10.1	0.0	0	7.5	8.8	10394
2	10.5	0.0	0	10.6	0.0	0	8.0	6.8	7588
4	10.9	0.0	0	11.1	0.0	0	8.0	8.2	9699
8	11.4	0.0	0	11.5	0.0	0	7.5	8.3	10746
Check	8.0	9.0	6156	8.0	9.0	6156	8.0	9.0	6156
L.S.D.	--	1.7	533.3	--	3.2	596	--	N.S	616

*N.S/ plate = Number of sclerotia/ plate

Effect of potassium silicate and VAM fungi on white rot disease of onion under greenhouse conditions:

Data presented in Table 2 showed that most of potassium silicate treatments caused significant reduction on onion white rot disease incidence compared with control treatment. In contrast, the combined treatments of VAM fungi and potassium silicate at high concentrations, showed a less significant reduction effect followed by VAM fungi. The most superior treatments for decreasing onion white rot was potassium silicate at 4 ml /l which recorded 24.0 % of white rot disease incidence and 71.43% reduction compared to untreated control, as well as the combined treatment at 2 ml/l potassium silicate and VAM fungi, show best reduction in disease incidence in combined treatments which recorded 36 and 57.14% reduction. Folicur resulted in the highest reduction to white rot incidence (12%) Table (2). Regarding the yield of onion bulbs, all treatments with VAM fungi gave a higher yield than the non-treated control. The highest yield(11.42 gm/one bulb)of onion bulbs was obtained from plants treated with VAM fungi + potassium silicate at the rate 8ml/L, while the lowest yield was obtained from plants treated with potassium silicate at rate 8ml/l.

Table 2. Effect of potassium silicate and VAM fungi on the white rot incidence and plant characters under greenhouse conditions in season 2015/2016

Treatment	% Disease incidence	% Efficacy	Bulb vegetative characters	
			Weight of one bulb. gm	Perimeter of one bulb(cm)
VAM fungi	56.0	33.33	10.27	8.35
VAM fungi+2 Ml Si*	36.0	57.14	9.10	7.48
VAM fungi+4 Ml Si*	44.0	47.62	10.28	8.03
VAM fungi+8 Ml Si*	76.0	9.52	11.42	8.18
2Ml Si*	28.0	66.67	6.52	6.30
4 Ml Si*	24.0	71.43	5.96	6.55
8 Ml Si*	32.0	61.90	5.45	6.18
Folicur	12.0	85.71	8.81	7.31
Check	84.0	-	7.50	6.90
L.S.D.	23.79		1.31	1.00

*Ml Si= Milliter of silicat

Effect of potassium silicate treatments and VAM fungi on incidence of white rot and bulb yield under field conditions:

Data presented in Table 3 reveal that, in general, soil drenched with potassium silicate only caused significant decrease in incidence of onion white rot and increase bulb yield compared to control treatment under natural infection with white rot pathogen. Concentration 4ml/l was the best treatment in this regard, followed by concentration of 2 ml/l with insignificant differences. Also, the obtained indicate that all treatments including potassium silicate and VAM fungi were effective in reducing the incidence of white rot disease. During 2015/2016 season, the lowest percentage (14.31 %) of infected plants by white rot and highest efficacy (66.70%) was observed with plants treated with (VAM+2ml Si/l) compared to (42.07%) infected plants in the non-treated control. Meanwhile, VAM+8mlSi/L treatment had a lower effect in suppressing white rot compared to the other treatments. Folicur fungicide showed the best reduction in disease incidence by (7.95%) and highest efficacy (81.94%). The same trend was observed during 2016/2017 season where the highest reduction percentage of infected plants by white rot ,being 16.52 % in treatment with VAM+2ml Si/l followed by 2 and 4 Ml Si, respectively with out-significant differences.

Regarding to the yield of onion bulbs, all treatments gave higher yield than the non-treated control. The highest yield of onion bulbs/ plot in the two seasons, was being (20.67 and 21.33kg/plot) obtained from plants treated with potassium silicate at the rate 4ml/l respectively, while the lowest yield was being 16.80 and 15.68 kg/plot respectively obtained from plants treated with potassium silicate at the rate 8ml/l in both two seasons. Generally, the percentages of infection in all treatments were higher in season 2015/2016 than 2016/2017.

Table 3. Effect of potassium silicate and mycorrhizal fungi on incidence of white rot and the production bulb yield under field conditions at Kalubia governorate during 2015/2016 and 2016/2017

Treatment	2015/2016			2016/2017		
	Disease incidence	% Efficacy	Weight of bulb kg/plot	% Disease incidence	% Efficacy	Weight of bulbskg/ plot
VAM fungi	23.85	44.50	16.14	30.13	45.46	19.58
VAM fungi+2 Ml Si*	14.31	66.70	16.80	16.52	70.10	19.33
VAM fungi +4 Ml Si*	23.40	45.54	19.71	32.94	40.38	19.63
VAM fungi+8 Ml Si*	35.24	17.99	16.87	34.06	38.35	17.94
2Ml Si*	20.24	52.89	19.63	18.47	66.57	19.24
4 Ml Si*	16.93	60.60	20.67	19.40	64.88	21.33
8 Ml Si*	24.52	42.94	16.80	26.82	51.45	15.68
Folicur	7.95	81.94	17.00	10.67	80.68	16.84
Check	42.97	-	12.72	55.25	-	11.75
L.S.D.	6.16	-	3.31	5.48	-	2.34

*Ml Si= Milliter of silicat

Effect of potassium silicate on spore count and root colonization with (VAM) fungi under greenhouse conditions:

Data presented in Table 4 show that spore count and percentage of root colonization (vesicles and arbuscules) increased by increasing potassium silicate concentration, in contrast to the percentage of hypha which noticeably decreased by increasing potassium silicate concentration. The highest spore count and colonization (% vesicles, hypha and % arbuscular) at 8 ml/l potassium silicate by 1260,46%, 54.0% and 46.0% respectively. On the other hand the treatment of (VAM) + *S. cepevorium* was the only one that shows less spore count and vesicles percentage but higher hypha and arbuscular percentage than potassium silicate treatments. Our findings also revealed that the treatment with (VAM) fungi only show the highest hypha percentage 93% followed by VAM fungi +2 ml/l and 80% hypha by potassium silicate treatment. The different effects of silicate and VA mycorrhizae amendments observed in Fig.1 showed vesicles and hyphae, shape of root colonization. Vesicles, the second characteristic structure of VA mycorrhizae are thick-walled structures ,with oval shape in roots untreated with silicate, Fig.1(G –H).Vesicles were irregular in treatments with high level of potassium silicate (A,B and C,E).

Table 4. Effect of VA Minoculation with fungi and mix of VAM fungi and potassium silicate on root occupation and spore count under greenhouse conditions after 120 days

Treatment	Sporulation / 100g soil	Root occupation		
		% Vesicles	%Hypha	% Arbscules
VAM fungi	759	33	93	14
VAM fungi+2 Ml Si*	702	20	80	8
VAM fungi+4 Ml Si*	849	41	77	41
VAM fungi+8 Ml Si*	1260	46	54	46

*Ml Si= Milliter of silicat

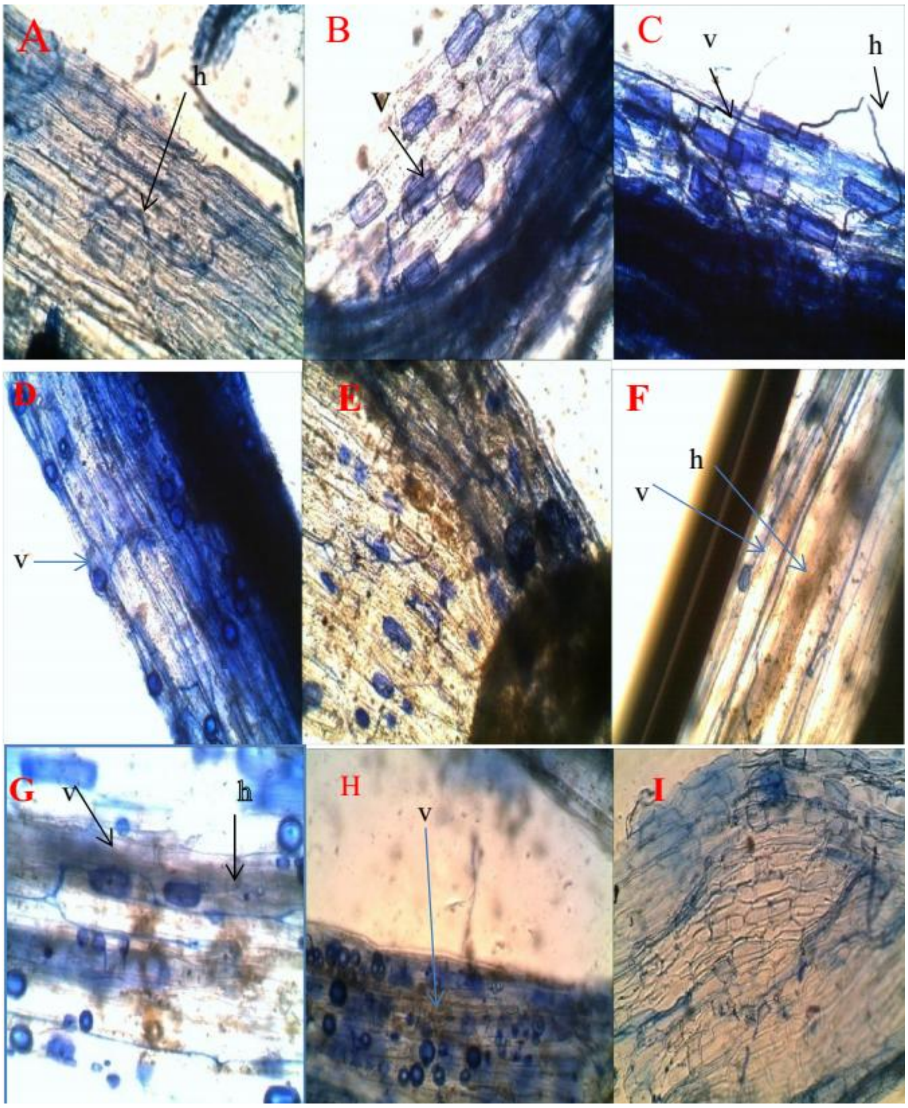

Fig. 1. **(A-I) Effect of potassium silicates at concentration 8g/l(A-B), 4g/l(C-D) and 2g/l (E-F) on hyphal growth and the formation of mycorrhizal vesicles within onion roots compared to the roots colonized with the mycorrhiza only(G-H) and untreated plants (I).(Photo by Olympus microscope at magnification 200 x). V= vesicles and h = hyphae**

Discussion

Previous work has shown that using silicon could prevent pathogen penetration into the host tissues (Kanto *et al.* 2004, Liang *et al.* 2005, Kanto *et al.* 2006 and Kanto *et al.* 2007) and suppress the growth of phyto-pathogens *in vitro* (Maekawa *et al.* 2003 and Bekker *et al*. 2009). In this study, the growth of *S. cepivorum* was inhibited when PDA medium was amended with potassium and calcium silicate. These results were in agreement with the findings obtained by Bekker *et al*. 2009, were they reported that *in vitro* growth of eleven phyto-pathogenic fungi was inhibited on potassium silicate amended PDA medium. Also other studies reported that media amended with potassium and calcium silicate significantly increase the pH of the (PDA) medium by increasing their concentrations. This show decreasing in the linear growth and sclerotia numbers of *S. cepiviorum*. This results were in agreement with (Shen *et al*.2010),who reported that the inhibition of *Rhizoctonia solani, Pestalotiopsis clavispora, Fusarium oxysporum, F. Oxysporum* f.sp. *fragariae* colony growth on potassium silicate amended PDA plates was due to pH effect. In contrast, (Bekker *et al*., 2009) reported that the inhibitory effect of potassium silicate on fungal growth *in vitro* was mostly due to a fungicidal effect. In our investigation potassium silicate fertilization has also been shown to decrease the incidence of white rot under greenhouse and field conditions. On the other hand, the most treatments of potassium silicate improved onion bulb yield. These results were in harmony with thus reported by Nada *et al*. (2014) who stated that (Ps) was the most effective treatment than the other silicon sources tested *i.e.* calcium silicate and sodium silicate in reducing damping-off disease incidence of coriander (*Coriandrum sativum*) and in improving plant growth parameters as well as seed yield and seed oil yield. Also, Khalifa *et al*. (2017) reported that the combined treatments of dipping followed by soil drench of potassium silicate were more efficient for suppressing onion white rot and increasing the plant fresh weight (FW) as well as onion bulb yield under greenhouse and field conditions, respectively . Furthermore, potassium silicate fertilization has, also been shown to decrease greenhouse cucumber susceptibility to Pythium crown and root rots. Also, Menzies and Belanger 1996 reported significant decrease in Fusarium wilt of cucumber grown in soil treated with potassium silicate (Belanger, *et al*., 1995). Possible mechanisms through which Si affects disease susceptibility were discussed by many investigations. Soluble (Si) taken up by plants tends to accumulate in the apoplast, particularly in epidermal cell walls (Epstein, 1994; Marschner, 1995, Tisdale *et al*., 1993; and Samuels *et al*., 1993). This observation has led many investigators to hypothesize that (Si) inhibits fungal disease by physically inhibiting fungal germ tube penetration of the epidermis and most reports indicated that Si accumulated around fungal hyphae and infection pegs in infected host plant cells (Datnoff *et al*.1997 and Belanger *et al*., 1995).

In our study, treated with VAM fungi have also been shown to decrease white rot onion disease incidence under greenhouse and field conditions. Also, the same treatments improved onion bulb yield. These results agreement with Perrin (1990), which refer that a limited protection of onion against *S. cepivorum* by VAM fungi however, as also indicated by the relationship was beneficial for the crop only when the mycorrhizal fungi colonized the roots before the pathogen, since simultaneous infection by both microorganisms showed no effect. (meanwhile, when the infection by both microorganisms at simultaneous there was no effect). Furthermore, as reported also by Zengjia and Xiangdong (1991), inoculation with mycorrhizal fungi before planting conferred more complete protection against plant pathogens. Torres-Barragán *et al.* 1996 found that under filed condition a significant protection against white rot for 11 weeks after onion transplanting, as compared with non mycorrhizal controls. Mycorrhizal plants showed an increase of 22% in yield, regardless the presence of the white rot pathogen.

Interestingly, some scientists reported that phenolic materials and chitinases, also, rapidly accumulate in these infected host cells (Menzies *et al*., 1991, Cherif *et al*., 1991and Belanger *et al*., 1995). These phenolics were also conclusively shown to be fungi toxic (Cherif *et al*., 1994). Consequently, different scientists suggested that Si fertilization may reduces disease susceptibility primarily by stimulating host-plant defenses (Belanger *et al*., 1995 and Datonff *et al*., 1997). Furthermore, the higher production of glycosylated phenolics antimicrobial products such as di-terpenoid ,phyto-alexins and proline –rich protein in the Si-treated plants indicated that these products can have a role in the protection effects of Si against plant diseases (Rodrigues *et al*., 2003).Moreover, role of Si in amelioration of diseases caused by a biotic stresses. Is well known several studies have found that Si can reduce or prevent manganese (Mn) and iron (Fe) toxicity and many also have beneficial effects on aluminum (Al) toxicity (Marschner,1995 and Tisdale *et al*., 1993). Furthermore, Si, has been shown to alleviate on otherwise detrimental nutrient imbalance between zinc and phosphorus (Marschner,1995 and Tisdale *et al*.,1993). Also, in our experiments, data show that potassium silicate supplementation has effect on spore count, and percentage of root mycorrhizal colonization (vesicles and arbuscular) ,which increase by increasing potassium silicate concentrations but percentage of hypha decrease by increasing potassium silicate concentrations. There was a negative correlation between disease incidence and (VAM) fungi root colonization, spore count and hypha percentage. This suggesting that VAM fungi hypha was an important factor in the reduction of white rot disease. This can be observed in (VAM) fungi +2ml /l Ps treatment which showed the highest hypha percentage by 80% than other Ps. The obtained results are in agreement with Frew, *et al.*(2017), which reported that, in the low Si soil (1392 mg /Kg) , AM fungi increased root Si concentrations and increased growth in sugarcane plants by rate 107 and 81 % in both commercial and native AM treatments respectively, but AM colonization positively correlated with root Si concentrations. In the high silicon soil (2221mg/kg) AM fungi had no impact on root Si or root Herbal plants growth as indicated byBabikova *et al*. (2013) and Cameron *et al*. (2013). These highlights were in need for more comprehensive identification and quantification of changes in plant metabolites in response to AM fungi in order to gain a more complete understanding of mechanisms underpinning these relationships. Our study also indicated that AM fungi facilitated the uptake of Si where soil Si concentrations were relatively low.

Lūsīte and Ievinsh (2010) mentioned that in spite of, sometimes, low intensity of mycorrhization, roots of all coastal plants studies possess functional structures of

AM symbiosis. It can be suggested that fluctuating and low intensity of mycorrhizal symbiosis is caused by unfavorable environmental conditions within the vegetation season. The effect can alter according to the AM fungus-host plant combination. As was shown in studies with *Aster tripolium*, AM colonization and vesicles shape is more affected by salinity than by flooding (Carvalho *et al*., 2003). Consequently, for salt marsh plants, increased soil salinity can be suggested as one of the main environmental factors leading to decrease intensity of AM symbiosis.

Conclusion

Based on the obtained results in the present study, it was concluded that the tested potassium and calcium silicate compounds have a significant potential in reducing the mycelial growth and sclerotial number of *S. cepivorium* particularly at high concentrations. Furthermore, the *in vitro* experiment showed that amendment PDA medium with potassium and calcium silicate increased the pH of medium . Under greenhouse and field conduction, the efficacy of VAM fungi and potassium silicate, clearly indicates that (VAM) fungi and potassium silicate at low concentration reduced the incidence and severity of white rot, and increased the plant growth of onion.Also potassium silicate at 2ml/l concentration show highest hypha percentage and lowest root colonization. The outcome of VAM fungi and potassium silicate at 2 ml /l , show good management of onion white rot disease under field conditions.

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تأثير التكامل بين فطريات الميكوريزا الوعائيه الشجريه واضافة سليكات البوتاسيوم في مقاومة العفن الابيض في البصل

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استخدم كل من أملاح سيليكات البوتاسيوم والكالسيوم والصوديوم مع بيئة أجار البطاطس والدكستروز(PDA) بتركيزات ٠,١ ، ٠,٥ ، ١ ، ٢ ، ٤ جم / لتر لتقييم تأثيرها على النمو الميسليومي وكذلك معدل إنتاج الأجسام الحجرية للفطر سكليروشيم سيبيفورم المسبب للعفن الأبيض على البصل وقد وجد أن ملح سيليكات البوتاسيوم والكالسيوم قد ثبطت النمو الميسليومى للفطر وكذلك خفضت بدرجة معنوية عدد الأجسام الحجرية الناتجة وذلك عند كل التركيزات المستخدمه عدا التركيز ٠,١ جم /لتر أما سليكات الصوديوم فلم يكن لها تأثير معنوي. من جهة أخرى أدت إضافة التركيزات المختلفة من الأملاح إلى حدوث تغيير في رقم الحموضة (pH) للبيئة فقد ارتفع في ملحي سليكات البوتاسيوم والكالسيوم عند التركيزات من ٠,١ - ٨ جم /لتر بيئة بمعدل من ٨,٨ – ١١,٤ مع سليكات البوتاسيوم ومن ٨,٧ - ١١,٥ مع سليكات الكالسيوم. حدث انخفاض معنوي لنسبة الاصابة بالعفن الأبيض تحت ظروف العدوى الصناعية بالصوبة عند استخدام سليكات البوتاسيوم منفرده أو بالاشتراك مع الميكورهيزا وكان التركيز ٤ مللي/ لتر ماء من سليكات البوتاسيوم هو الأفضل في خفض الاصابة بنسبة ٧١,٤٣ % بينما حدث تفاوت في نسب خفض الاصابه في باقي المعاملات. أيضا ألمعاملة بالميكورهيزا بمعدل ٥٠ جم / للاصيص منفردة أو بالاضافة مع سليكات البوتاسيوم ٢ ، ٤ ، ٨ مل / لتر وكذلك مبيد الفوليكور ٢٥ % كان لها تأثير معنوي في تحسين الصفات ألمحصوليه للأبصال الناتجة مقارنة بالكنترول. خلال موسمي الزراعه ٢٠١٦ و ٢٠١٧ بالقليوبية كان مبيد الفوليكور هو أفضل المعاملات في خفض الاصابه بالعفن الأبيض ٨١,٩٨ و ٨٠,٦٨ علي الترتيب تلاه ألمعامله ٢ مل سليكات البوتاسيوم مع الميكوريزا. كذلك أثرت المعاملات بصفة عامة علي زيادة وزن الأبصال الناتج معنويا مقارنه بالكنترول. حدث زيادة في أعداد جراثيم فطر الميكوريزا و كذلك نسبه احتلال الجذور بزيادة نسبة إضافة سليكات البوتاسيوم بينما حدث تناسب عكسى بين هيفات الفطر وزيادة التركيز من السليكات حيث كانت ٩٣ في حالة الميكوريزا منفردة بينما كانت ٨٠ و ٧٧ و ٥٤ عند التركيزات ٢ ، ٤ ، ٨ مل على التوالي.