Malays. Appl. Biol. (2019) 48(1): 43–49

POTENTIAL OF SILICON NUTRIENT IN REDUCING FUNGAL DISEASE IN RED-FLESHED DRAGON FRUIT

NURUL FAZIHA, I.*, MUHAMMAD ARIFF, M.R., FAHIM, N.A., MOHAMAD NAZIEM EZZRY, P. and SUHAIZAN, L.

School of Food Science and Technology, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu
**E-mail: nurulfaziha@umt.edu.my*

Accepted 20 January 2019, Published online 20 March 2019

ABSTRACT

Dragon fruit has a high market value and widely cultivated in Malaysia. Nowadays, the dragon fruit plants are severely infected by fungal diseases causing economic loss to many farmers. This study was carried out to evaluate the potential of silicon treatments in reducing disease incidence and disease severity in dragon fruit plants. For this purpose, three silicon concentrations namely 1.5, 2.5 and 5.0 ml/L were applied as root treatment. Control plant was only irrigated with tap water. Occurrence of disease incidence and disease severity were recorded starting from planting until harvesting period and was later calculated. After harvest, silicon accumulation in both stems and fruits was determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Based on the results, plants treated with T3 showed lower disease incidence and disease severity as compared to the other treatments and control. Average silicon accumulations in stems ranged between 28.10 ppm to 42.22 ppm, and between 110.59 ppm to 198.28 ppm in the fruits. A substantial response has been observed on uptake of silicon in reducing disease severity in dragon fruit plants. Thus, application of silicon nutrient could help to improve plant defence mechanism in many agricultural crops, which could become a good strategy in controlling the diseases.

Key words: Disease incidence, disease severity, dragon fruit, silicon nutrients

INTRODUCTION

Dragon fruit or scientifically known as *Hylocereus* species, has been cultivated on a large-scale in many countries including Malaysia. The plant can tolerate drought and has a long life cycle specially suited for tropical climates (Wybraniec & Mizrahi, 2002; Masyahit *et al*., 2009). It has high commercial value and most common three varieties are namely *Hylocereus undatus, H. polyrhizus* and *H. costaricensis*. Among these, only two varieties are suitable to be grown in Malaysia which are *H. undatus* and *H. polyrhizus*. *H. polyrhizus* is most preferred to be planted by many farmers but its high susceptibility towards fungal diseases has led to major economic loss. Although there is still a great demand for this fruit, the production has greatly decreased due to diseases infection.

Fungal diseases are a major problem in most plantation crops in Malaysia (Masratul Hawa *et al*., 2017; Ibrahim *et al*., 2016, 2017). Some recorded fungal diseases observed on dragon fruit plants are stem end rot, brown spot, anthracnose and fruit brown rot (Masyahit *et al*., 2008; 2009). Among these, stem rot is one of the most destructive disease in dragon fruit plantation. The symptoms can be observed as circular, brown sunken lesions with white mycelium formation on the lesion surface. According to Masratul Hawa *et al*. (2013), the disease is caused by *Fusarium proliferatum*. Similar symptoms might be associated with other pathogens such as *Xanthomonas campestris*, *F. oxysporum* or *Erwina caratovora*. Besides that, anthracnose is also a common disease found in dragon fruit plantations. The symptoms can be observed as red brown concentric lesions with a chlorotic halo. Occurrence of this disease has been reported due to *Colletotrichum gloeosporioides* and *C. truncatum* (Masratul Hawa *et al*., 2008; Masyahit *et al*., 2009; Iskandar Vijaya *et al*., 2014). Fungicidal sprays such as Mancozeb and Maneb are commonly used to control these diseases.

Generally, severity of fungal diseases can be increased due to unfavourable climatic conditions

* To whom correspondence should be addressed.

and poor management practices. Higher amount of precipitation or over watering of the plant could spread the fungal inoculum, which exposes the plants to disease infection. Occurrence of disease will disturb many physiological processes that reduce the plant's defence mechanism. As a result, the infected plant can become stunted, bearing small fruits and very susceptible to disease infection. According to Azlan (2010), disease problem not only affects the postharvest quality of the fruits but also reduces the life span of the plant. Many farmers use high input of pesticides to reduce the occurrence of fungal diseases in dragon fruit plant. Although application of pesticides will give immediate results, the frequent use will increase the resistance of fungal pathogen (Hahn, 2014). Eventually, the pesticide will no longer be effective thus leading to the collapse of the control system in plant. Also increasing concern to the public health due to chemical residue has led to the reduction of chemical pesticides towards more natural compound with fewer residues.

The benefit of silicon in plant growth has been proved to increase the plant defence mechanism (Savant *et al.*, 1997; Ma & Takahashi, 2002; Rodgers-Gray & Shaw, 2004). Previous study shows that silica plays an important role in plant cell wall, which provides rigidity to monocot leaves (Epstein 1999; Tripathi *et al.*, 2014, 2016, 2017). In addition, it takes part in many physiological processes which increases plants resistance to abiotic and biotic stresses. Although silicon has many benefits to the plant, the ability of dragon fruit to uptake silicon is still unknown. Therefore, this study was conducted to observe the effect of silicon treatments on disease incidence and disease severity on red-flesh dragon fruit. The results of this study would perhaps be helpful to many farmers obtaining high quality of fruits while conducting proper disease management practices in dragon fruit plantations.

MATERIALS AND METHODS

Planting of stem cuttings

A total of 160 healthy dragon fruit stem cuttings were planted directly into the soil in November 2016 at Bukit Kor, Marang, Terengganu. There were two stem cuttings per trellis with 1m x 1m distance between the trellises. All the plants were irrigated every day and the soil pH was maintained between 5.5 to 6.5. After a month, soluble silicon was applied at one week interval on each stem, at a volume of 40 ml through root treatment. Application of fertilizer was also applied following the standard agriculture procedure. All the stems were labelled as treatment 1 (T1): 1.5 ml/L Si nutrient, treatment 2 (T2): 2.5 ml/L Si nutrient, treatment 3 (T3): 5.0 ml/L Si nutrient and control (C2): tap water. There were five replicates for each treatment with eight plants per replicate. All the plants were arranged in randomized complete block design (RCBD).

Disease evaluation at field

Occurrence of diseases was studied by recording disease incidence (DI) and disease severity (DS). It was evaluated starting from planting until harvesting period every month. A total of 40 samples were recorded to evaluate both DI and DS, and converted into percentage using the following formula:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of infected plants unit x 100\%}}{\text{Total number of plant units assessed}}$$

$$\text{Disease severity (\%)} = \frac{\Sigma(\text{n x nd}) \text{ x } 100\%}{(\text{N x D})}$$

n = number of infected plant,
N = total number of sampled plant,
d = scoring value,
D = highest scoring value

Silicon quantification

Representative stems and fruits produced from dragon fruit plots were collected to quantify silicon accumulation. Dry-digestion method was used for sample preparation before analyzing using ICP-OES. A total of 1 g sample was dried using a furnace at 500°C for 8 hours. Then, the plant samples were treated with 2 mL of HCl (37% v/v) until evaporated. Ten mL of HNO_3 (20% v/v) was added into the samples and heated slowly in the water bath for 1 hour at 70°C to dissolve the residue. The mixtures were then transferred into 100 mL volumetric flask and made up to the volume, before filtered through Whatman No. 2 filter paper. The samples were ready to be analyzed using ICP-OES. Blanks were prepared in the same way as the sample but omitting the sample.

Statistical analysis

The results were analysed for statistical significance (p = 0.05) using two-way ANOVA by SPSS statistical software (SPSS 20.0 for Windows). Tukey's test was used for pairwise comparison of the mean values.

RESULTS AND DISCUSSION

In this study, assessment of D.I in dragon fruit field plot has been conducted starting from planting until harvesting of the fruits (November 2016-October 2017). Throughout the planting, occurrence of

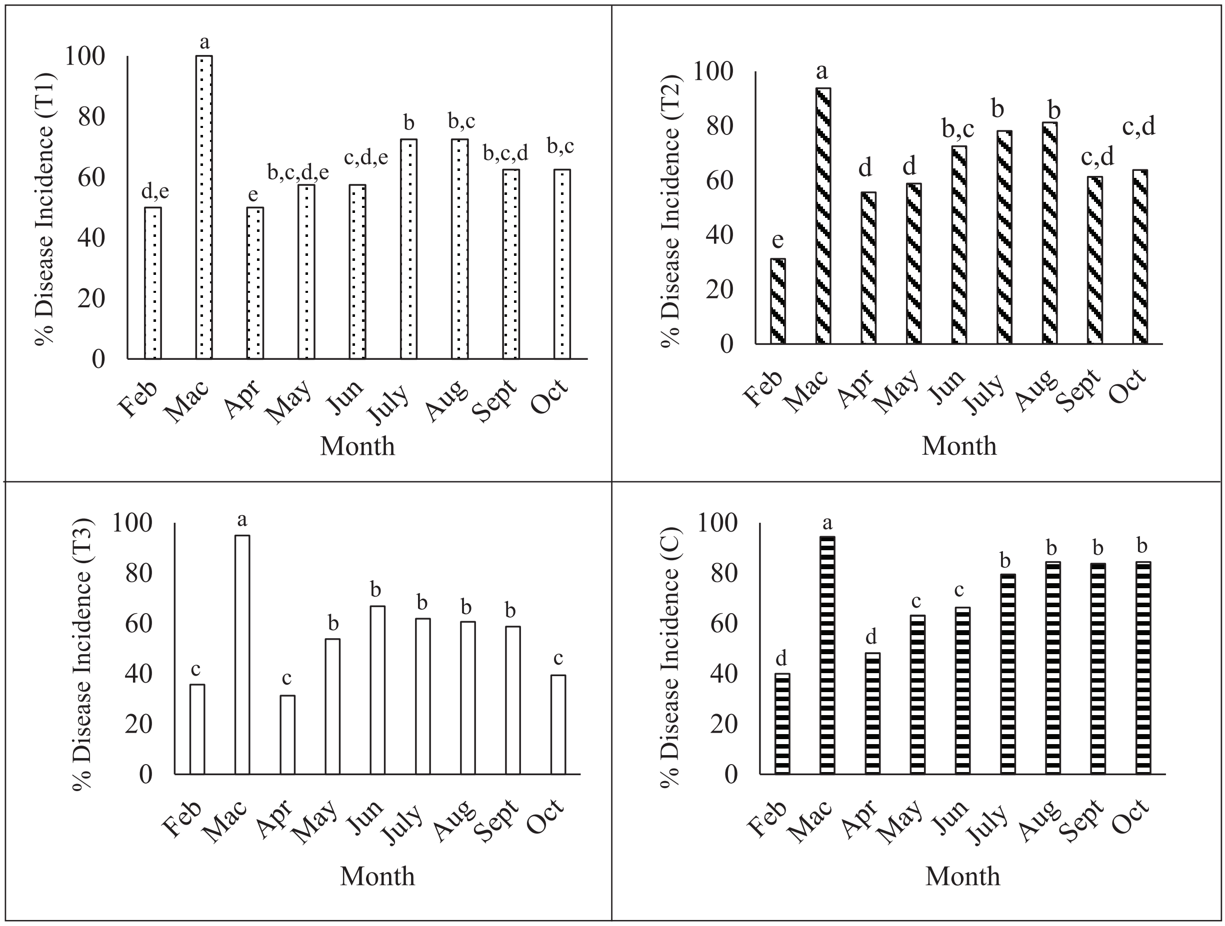

Fig. 1. Percentage of disease incidence in dragon fruit field plot treated with silicon nutrient. Means followed by the same letter within each month are not significantly different ($P < 0.05$) using Tukey's test.

diseases in the field plot initially started in February 2017 and continuously occurred until October 2017 (Figure 1). Percentage of D.I fluctuated among all the treatments. In plants treated with 1.5ml/L silicon (T1), lowest D.I was recorded in April (39.38%) while the highest D.I was recorded in March (93.75%). In plants treated with 2.5 ml/L silicon (T2), 5.0 ml/L silicon (T3) and tap water (control), lowest D.I were recorded in February while the highest D.I were recorded in March. Highest D.I in March was significantly different with the other months for all the treatments including control. Among these treatments, T3 showed lowest D.I (42.93%) as compared to T1 (43.34%), T2 (49.69%) and control (53.65%) (Figure 2).

In all the plants, occurrence of disease initially started in February, which showed lowest D.I in T2, T3 and control. Throughout the observation, production of new shoots also started in February for most of the plants in the field plot. Occurrence of D.I was due to production of new shoots, which attracted many insects to these plants as a food source. According to Terra (2001), many insects facilitate the entry of pathogen into the host through wounds that are made by insects on the plant surface. The injury will facilitate the entry of fungal pathogen (Korth & Dixon, 1997). Once the fungal inoculum penetrates into the plant tissues, it will interfere with the normal function of plant physiological processes, which can be observed such

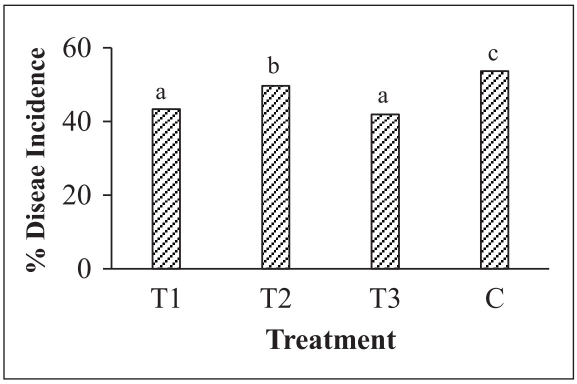

Fig. 2. Percentage of disease incidence in dragon fruit plant treated with different silicon concentrations. Means followed by the same letter within each treatment are not significantly different ($P < 0.05$) using Tukey's test.

as wilting, brown rot, chlorotic and yellowing. In several conditions, specific or non-specific insect vector helps in survival of plant pathogen inside the plant body by obtaining, carrying and delivering fungal inoculum onto new plants which increase the percentage of plant damage and losses (Agriotos, 1997). In addition, fluctuating weather conditions can enhance fungal spore germination that leads to severe infection. As a result, the disease can be spread easily and rapidly to other plant parts or into neighbouring plants causing severe losses.

Throughout the months, plants treated with T2 and T3 showed lower DS ranging from 8.17% to 27.83% as compared to T1 (DS= 12.50% to 36.33%) and control (DS=24.17% to 57.33%) (Figure 3). Among the treatments, lowest DS was recorded in T3 (13.89%) followed by T2 (15.44%), T1 (19.43%) and control (33.58%) (Figure 4). Lowest D.S in T3 was significantly different with T1 and control. Lower DS in treated plants especially in T2 and T3 suggested that it was due to application of silicon nutrient. Silicon is a type of mineral that is available in the soil. However, in a field plot in which intensive agricultural practices have been conducted, silicon might be limiting for plant growth and yield.

Lower range of silicon concentrations in this study, 1.5 ml/L to 5.0 ml/L might influence less significant differences of DS in treated plants and control. According to Keiser *et al*. (2005), silicon concentration at 5 to 20ml/L can inhibit several pathogenic fungi such as *Fusarium*, *Alternaria*, *Curvularia*, *Phythopthora*, *Phythium* and *Verticillium* through in-vitro study. However, Gillman *et al*. (2003) reported that addition of 150ml/L silicon to the irrigation water could suppress black spot infection in *Rosa hybrida*. Although application of silicon can benefit the plant in terms of defence mechanism, lower concentration of silicon nutrient might influence its insufficient uptake to develop physical barrier in the plant tissue. In addition, application of silicon has been proved to successfully reduce disease severity in many plant hosts such as avocado, coffee, cucumber, grape, rice, strawberry, several ornamental plants and sugarcane (Bekker *et al*., 2005; Bowen *et al*., 1992; Cherif *et al*., 1992; Gillman *et al*., 2003; Kanto *et al*., 2006; McAvoy

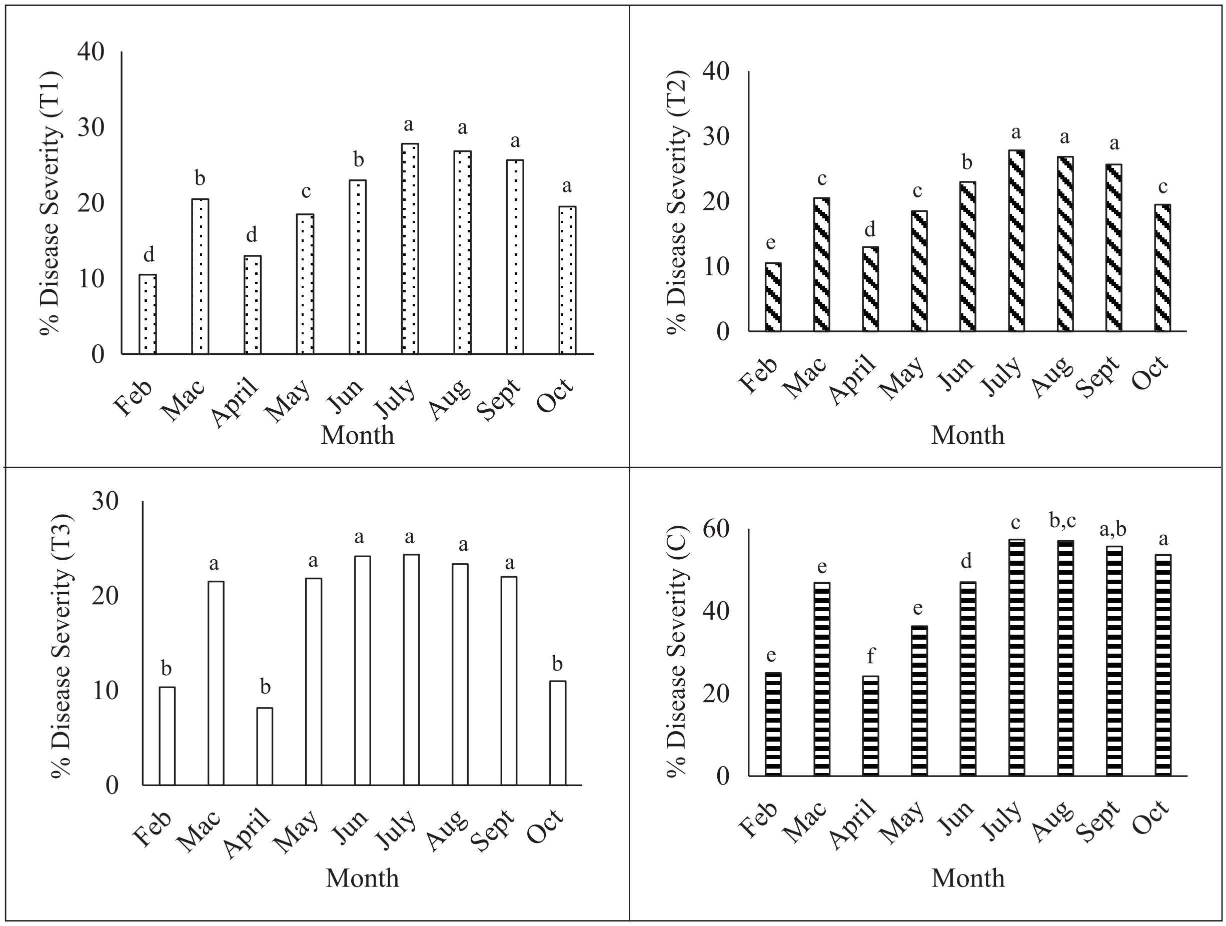

Fig. 3. Percentage of disease severity in dragon fruit field plot treated with silicon nutrient. Means followed by the same letter within each month are not significantly different ($P < 0.05$) using Tukey's test.

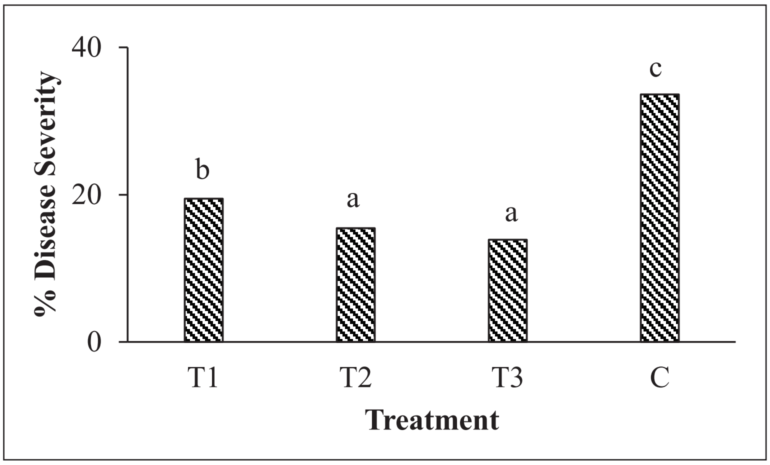

Fig. 4. Percentage of disease severity in dragon fruit plant treated with different silicon concentrations. Means followed by the same letter within each treatment are not significantly different ($P < 0.05$) using Tukey's test.

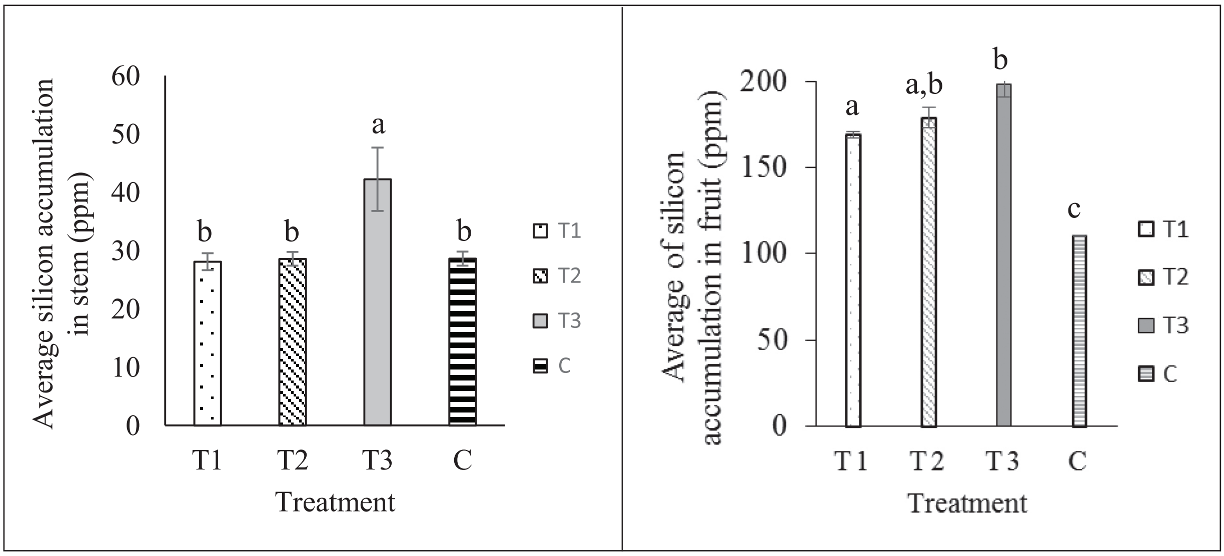

Fig. 5. Average silicon accumulation in the stem (left) and fruit (right) of dragon fruit plant.

& Bible, 1996; Menzies *et al*., 1992; Remus-Borel, 2005; Seebold *et al*., 2001). Laing *et al*. (2006) also reported that silicon fertilization in plant significantly increases the crop yield.

In this study, silicon accumulation was determined in representative stems and fruits of dragon fruit plant. In stem, the highest silicon accumulation was 42.22 ppm in plants treated with T3 followed by 28.64 ppm, 28.58 ppm and 28.10 ppm in control, T2 and T1 plants, respectively (Figure 5). Among these, T3 was significantly different with the plants treated with T1, T2 and control. However, no significant difference was observed among T1, T2, and control plants. In fruit, silicon accumulation was highest in T3 (198.28 ppm), followed by T2 (178.89 ppm), T1 (168.98 ppm) and control (110.59 ppm). Silicon accumulation in fruits produced from treated plants were significantly different with the control. The results of this study showed that dragon fruit plants can uptake the silicon nutrient at different concentrations ranging from 1.5 ml/L to 5.0 ml/L. Higher silicon accumulation in fruits were expected since it helps to develop the sweetness of the fruits. Accumulation of silicon in the plant tissues will help the rigidity and abrasiveness of the plant, which acts as a mechanical barrier (Massey & Hartley, 2009; Reynold *et al*., 2016). Importance of silicon in many crops have been extensively reviewed and proved to enhance the growth and yield, improve mechanical properties, reduction of transpiration, resistance to drought stress, resistance to salinity and increasing plant resistance toward pathogens (Epstein, 1994; 1999; 2001). In addition, application of silicon through root treatment can also benefit the soil by improving soil texture, increase water holding capacity, improve absorption capacity and soil erosion stability (Camberato, 2001; Matichenkov & Bocharnikova, 2001).

CONCLUSION

Uptake of silicon by dragon fruits plants can help in reducing the severity of fungal diseases. In this study, treated plants with 5.0 ml/L silicon showed lowest D.I and D.S as compared to other treatments and control. Therefore, application of silicon in disease management of dragon fruit plant can become an alternative to improve the quality of fruits production. This practice will produce low chemical residue in fruits while reducing the environmental pollution due to intensive application of pesticides.

ACKNOWLEDGEMENTS

The authors would like to thank Universiti Malaysia Terengganu for financing the project under Universiti Malaysia Terengganu Research Grant (TPM Vot 68006/2016/86). Our gratitude also extends to LAPDiM staff for their technical support.

REFERENCES

Agriotos, G.N. 1997. Plant pathology. 4th edition. Academic Press. San Diego, CA.

Azlan M. 2010. Calcium treatment against anthracnose and brown rot in red dragon fruit [*Hylocereus polyrhizus* (F.A.C. Weber) Britton & Rose]. 1-15.

Bekker, T.F., Labuschagne, N. & Kaiser, C. 2005. Effects of soluble silicon against *Phytophthora cinnamomi* root rot of avocado (*Persea americana* Mill.) nursery plants. South African Avocado Growers Association Yearbook, **25**: 60-64.

Bowen, P., Menzies, J., Ehret, D., Samuels, L. & Glass, A.D.M. 1992. Soluble silicon sprays inhibit powdery mildew development on grape leaves. *Journal of the American Society for Horticultural Science*, **117(6)**: 906-912.

Camberato, J.J. 2001. Nitrogen in soil and fertilizers. *SC Turfgrass Foundation News*, **8(1)**: 6-10.

Cherif, M. & Belanger, R.R. 1992. Use of potassium silicate amendments in recirculating nutrient solutions to suppress *Pythium ultimum* on long English cucumber. *Plant Disease (USA)*. **79**: 1008-1011.

Epstein, E. 1994. The anomaly of silicon in plant biology. *Proceedings of the National Academy of Sciences*, **91(1)**: 11-17.

Epstein, E. 1999. Silicon. *Annual Review of Plant Biology*, **50(1)**: 641-664.

Epstein, E. 2001. Silicon in plants: facts vs. concepts. In *Studies in Plant Science*. Elsevier. **8**: 115.

Gillman, J.H., Zlesak, D.C. & Smith, J.A. 2003. Applications of potassium silicate decrease black spot infection in rosa hybrida 'Meipelta' (*Fuschia Meidiland*). *Horticulture Science*, **8**: 1144-1147.

Hahn, M. 2014. The rising threat of fungicide resistance in plant pathogenic fungi: *Botrytis* as a case study. *Journal of Chemical Biology*, **7(4)**:133-141.

Ibrahim, N.F., Mohd, M.H., Nor, N.M.I.M. & Zakaria, L. 2016. Pathogenicity of *Fusarium semitectum* and *Fusarium chlamydosporum* associated with pineapple fusariosis. *Malaysian Journal of Microbiology*, **12(2)**: 164-170.

Ibrahim, N.F., Mohd, M.H., Nor, M., Izham, N.M. & Zakaria, L. 2017. Characterization of *Fusarium* spp. associated with pineapple fruit rot and leaf spot in Peninsular Malaysia. *Journal of Phytopathology*, **165**: 718-726.

Iskandar Vijaya, S., Mohd Anuar, I.S. & Zakaria, L. 2014. Characterization and Pathogenicity of *Colletotrichum truncatum* causing stem anthracnose of red-fleshed dragon fruit (*Hylocereus polyrhizus*) in Malaysia. *Journal of Phytopathology*, **163(1)**: 67-71.

Kaiser, C., van der Merwe, R., Bekker, T.F. & Labuschagne, N. 2005. *In-vitro* inhibition of mycelial growth of several phytopathogenic fungi, including *Phytophthora cinnamomi* by soluble silicon. South African Avocado Growers Association Yearbook. **28**: 70-74.

Kanto, T., Miyoshi, A., Ogawa, T., Maekawa, K. & Aino, M. 2006. Suppressive effect of liquid potassium silicate on powdery mildew of strawberry in soil. *Journal of General Plant Pathology*, **72**: 137-142.

Korth, K.L. & Dixon, R.A. 1997. Evidence for chewing insect-specific molecular events distinct from a general wound response in leaves. *Plant Physiology*, **115**: 1299-305.

Laing, M.D., Gatarayiha, M.C. & Adandonon, A. 2006. Silicon use for pest control in agriculture: A Review. 278-286.

Ma, J.F. & Takahashi, E. 2002. Soil, fertiliser, and plant silicon research in Japan. Elsevier, Amsterdam Masratul Hawa, M., Hew, P.Y., Maziah, Z., Nagao, H. & Salleh, B. 2008. Aethiology and Symptomatology of Anthracnose caused by *Colletotrichum gloeosporioides* on Dragonfruit (*Hylocereus polyrhizus*) in Malaysia. In: The Sixth Regional IMT-GT Uninet Conference, August 28-30, Penang, Malaysia.

Masratul Hawa, M., Salleh, B. & Latiffah, Z. 2013. Characterization and pathogenicity of *Fusarium proliferatum* causing stem rot of *Hylocereus polyrhizus* in Malaysia. *Annals of Applied Biology*, **163(2)**: 269-280.

Masratul Hawa, M., Nurul Faziha, I., Nik Mohamad Izham, M.N. & Latiffah, Z. 2017. *Fusarium fujikuroi* associated with stem rot of redfleshed dragon fruit (*Hylocereus polyrhizus*) in Malaysia. *Annals of Applied Biology*, **170(3)**: 434-446.

Massey,F.P. & Hartley, S.E. 2009. Physical defences wear you down: progressive and irreversible impacts of silica on insect herbivores. *Journal of Animal Ecology*, **78(1)**: 281291.

Masyahit, M., Sijam, K., Awang, Y. & Satar, M.G.M. 2008. Fungi associated with diseases on dragon fruit (*Hylocereus* spp.) in Peninsular Malaysia. Pekan Pahang Publishers, Malaysia, pp: 234-237.

Masyahit, M., Sijam, K., Awang, Y. & Mohd Satar, M.G. 2009. The first report of the occurrence of anthracnose disease caused by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. on dragon fruit (*Hylocereus* spp.) in Peninsular Malaysia. *American Journal of Applied Sciences*, **6(5)**: 902-912.

Matichenkov, V.V. & Bocharnikova, E.A. 2001. The relationship between silicon and soil physical and chemical properties. In *Studies in Plant Science*. Elsevier. **8**: 209-219.

McAvoy, R.J. & Bible, B.B. 1996. Silica sprays reduce the incidence and severity of bract necrosis in poinsettia. *Horticulture Science*, **31(7)**: 1146-1149.

Menzies, J., Bowen, P., Ehret, D. & Glass, A.D. 1992. Foliar applications of potassium silicate reduce severity of powdery mildew on cucumber, muskmelon and zucchini squash. *Journal of the American Society for Horticultural Science*, **117(6)**: 902-905.

Remus-Borel, W., Menzies, J.G. & Belanger, R.R. 2005. Silicon induced antifungal compounds in powdery mildew-infected wheat. *Physiological and Molecular Plant Pathology*, **66(3)**: 108-115.

Reynolds, O.L., Padula, M.P., Zeng, R. & Gurr, G.M. 2016. Silicon: Potential to promote direct and indirect effects on plant defense against Arthropod pests in agriculture. *Frontiers in Plant Science*, **7**.

Rodgers-Gray, B.S. & Shaw, M.W. 2004. Effects of straw and silicon soil amendments on some foliar and stem-base diseases in pot-grown winter wheat. *Plant Pathology*, **53**: 733-740.

Savant, N.K., Snyder, G.H. & Datnoff, L.E. 1997. Silicon management and sustainable rice production. *Advances in Agronomy*, **58**: 151-199.

Terra, W.R. 2001. Special topics issue – biological, biochemical and molecular properties of the insect peritrophic membrane. *Preface. Arch. Insect Biochemistry*, **47**: 46.

Then, K.H. 2011. The effect of compost application to improve the red pitaya yield under various mixture fertilizer rates. In *International Symposium on Tropical and Subtropical Fruits*, **1024**: 189-192.

Tripathi, D.K., Singh, V.P., Gangwar, S., Prasad, S.M., Maurya, J.N. & Chauhan, D.K. 2014. Role of silicon in enrichment of plant nutrients and protection from biotic and abiotic stresses. In *Improvement of Crops in the Era of Climatic Changes* (pp. 39-56). Springer, New York, NY.

Tripathi, D.K., Shweta, S.S., Yadav, V., Arif, N., Singh, S., Dubey, N.K. & Chauhan, D.K. 2017. Silicon: a potential element to combat adverse impact of UV-B in plants. *UVB Radiation: From Environmental Stressor to Regulator of Plant Growth*, **1**: 175-195.

Tripathi, D.K., Singh, V.P., Prasad, S.M., Dubey, N.K., Chauhan, D.K. & Rai, A.K. 2016. LIB spectroscopic and biochemical analysis to characterize lead toxicity alleviative nature of silicon in wheat (*Triticum aestivum* L.) seedlings. *Journal of Photochemistry and Photobiology B: Biology*, **154**: 89-98.

Wybraniec, S. & Mizrahi, Y. 2002. Fruit flesh betacyanin pigments in *Hylocereus cacti Journal of Agricultural and Food Chemistry*, **50**: 6086-6089.

Zainuddin, M. & Hafiz, A. 2015. Status of dragon fruit production in Malaysia. *Improving Pitaya Production and Marketing*. 31-38.