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Effect of basalt powder « Farina di Basalto® » on the development of pests and diseases on pepper crop under greenhouse and during storage

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Abstract
Background: Basalte is a natural mineral fertilizer rich in nutrients (Si, Al, K, Fe, Ca, Mg), is employed to improve crops growth and fruits production under greenhouses, fields and orchards. The purpose of this study is to assess the impact of "Farina di Basalto®" a volcanic rock extracted and produced by "Basalti Orvieto" in Italy, on the appearance and development of diseases and pests on pepper crop under greenhouse and during storage. Three treatments were applied: T0: without "Farina di Basalto®" (Control), T1: 3% of "Farina di Basalto®", T2: 1.5% of "Farina di Basalto®".Obtained results showed that the fertilizer exerted a repulsive effect against pests; mainly Thrips(Frankliniella occidentalis) and mites. A gradual decrease of thrips number was observed just after the spraying with basalte powder to reach low values. Four days after the treatment, a total disappearance of the thrips females was noted in the T1 and T2 treatments, while the control treatment (T0) recorded an average value of about 5 females per flower. On the otherhand, it improved the resistance of the pepper against the bacterial soft rots caused by Pectobacterium sp. By reducing number of attacked plants. The root rot disease caused essentially by the genus Phytophtoracapsici was also studied. Results showed that average values of attacked plants ranked between 1 and 1.33 in treated plot units while in control it was about 6 attacked plants. and the bacterial soft rots caused by Pectobacterium sp.. During storage, treated fruits by "Farina di Basalto" showed mean values lower than those observed in control, which proves that it protected fruits against diseases. Analysis of the results showed that the use of "Farina di Basalto®" at a dose of 3% allowed optimal performance to be obtained. However, the application of the 1.5% half-dose had the same effect as the 3% dose on all of the qualitative and phytosanitary parameters.
Keywords: *pepper crop, protection, thrips, mites, diseases, basalt*

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I. Introduction

Protected crops under greenhouses in Tunisia occupy an area of around 537.2 ha. Among the most developed greenhouse crops in Tunisia are tomatoes (*Lycopercium esculentum*) and pepper (*Capsicum annuum*) [4]. Pepper crop is one of the most important vegetable species. Indeed, it is cultivated almost in all regions and throughout the year. Thus, in Tunisia, four seasons of pepper cultivation have been distinguished. In Africa, Tunisia is the third producer of pepper after Nigeria and Egypt, the third exporter after Morocco and South Africa [31].However, like any other crop, the pepper is threatened by several abiotic constraints such as temperature and salinity [31], and biotic such as fungal, bacterial and viral diseases [5]. In addition, nematodes are classified as enemies that can interfere with the development of pepper plant and reduce the growth of the root system. Arthropods are also among the most formidable pests of pepper crop [7]. The control of these problems is possible by various means even though they are usually controlled by pesticides. However, other ways of control that may preserve and protect environment and human health may be employed such as parasitoids, predators or traps [14].

Basalt is a tuff that comes from volcanic projections. These are small fragments, sometimes with blocks and ashes. Basalt tuffs are often found in active volcanic areas, or also on lands where eruptions have ended since years. Their color is generally black, red or even dark green [35]. Basalt is employed as a crushed rock in different areas such as in construction, in industrial and highway engineering, mineral fiber and cast stone material production, as well as in agronomy [8, 18, 34]. Basalt powder is intended for soil mineralization as a source of natural fertilizer due to its rich nutrient contents. This is explained by the fact that the composition of magmas and volcanic ashes from where it came, is rich in Silicon (Si) and other nutrients. These components are freshly ground and mixed into fine particles and they contain feldspar, micas and zeolites[3]. Basalt mass contents are; SIO_2 (37.76 to 59.64%), Al_2O_3 (11.77 to 14.32%), CaO (5.57 to 14.75%), MgO (5.37 to 9.15%), Fe_2O_3 (10.1 to 20.93%), K_2O (1.7 to 6.69%), Na_2O (1.4 to 3.34%) and TiO_2 (1.81 to 3.73%)[27].Basalt powder is used to restore fertility of poor soils and to restore the nutritional balance of crops. Natural mineral fertilization increases plant growth, total yield, fruits quality and certain chemical constituents and chlorophyll rate of pepper fruits and cucumber [27, 17]. Some other works on acacia in Panama showed that growth rate of trees has increased twice than in normal soils [22]. On the other hand, Barak et *al.* (1983) found that crushed basalt and tuff improved significantly iron nutrition of peanuts plants and their growth in very calcacerous soils and that chlorophyll content was doubled then that in plants grown in untreated soils.

Furthermore, Silicon, which is one of the most important components of basalt powder, plays an active and important role in strengthening resistance to plants against diseases by stimulating their natural defenses reactions[16, 3, 26]. Silicon significantly reduces powdery mildewin wheat cultivation. Indeed foliar and root applications by different productsbased on Si decreased the severity of the disease to 80%. This suggests a prophylactic effectoptimal and direct of Si on the powdery mildew[23]. In the same context, inert powders or dusts in general, such as basalt, have been used as a means of physical control of pests associated with stored commodities [20], even more, the use of inert natural mineral dust is considered as one of the methods of protecting stored grains [1].On the other hand, flours or inert powders not only repel insects but also kill them while causing their desiccation by absorption of the waxy layer surrounding the exoskeleton [9] and are very effective in reducing the dynamics of pest populations[22].

This work aims to study the impact of a fertilizer from a volcanic rock which is basalt on the cultivation of early chilli variety "Chergui". It is a natural mineral fertilizer under the trade name "Farina di Basalto®" rich in nutrients (Si, Al, K, Fe, Ca, Mg) which have an influence on the growth and production of the pepper as well as its resistance to pests ans diseases.

II. Material And Methods

Study location

The experiment took place in a greenhouse shelter at a High School Engineering, situated In Medjez El Beb ,wich belongs to theBeja governorate, Tunisia. The area belongs to the semi-arid bioclimatic floor with a mild winter variant.Its soiltexture is a Clay loam, in which the clay content varies between 42 and 43%. It is also characterized by a low salinity level (1.09; 1.11) a basic pH (8.22, 8.58) and by an important organic matter content (2.90%). This soil is suitable for arboriculture, arable and vegetable crops.

Study design

The pepper variety « *Chergui* » was planted on January 15^{th}2019 at the 5-leaf stage, on simple lines with a density of 6 plants / m².The greenhouse area is 239 m² which is established according to a complete random arrangement with 3 blocks.Each block has a dimension of 12 meters in length and 5 meters in width divided into 3 plot units, each of which represents a treatment.Each plot unit covers 14.4 m² and consists of 3 crop lines, each line contains 30 plants. The planting spacing are 0.6 m between the lines and 0.4m between the plants. This corresponds to a planting density of 6 plants / m². At each block, 6 lines are treated with basalt powder such as T0 corresponds to 0% of basalt powder (control), T1: 3% of the basalt powder, T2: 1.5% of the basalt powder (fig. 1).

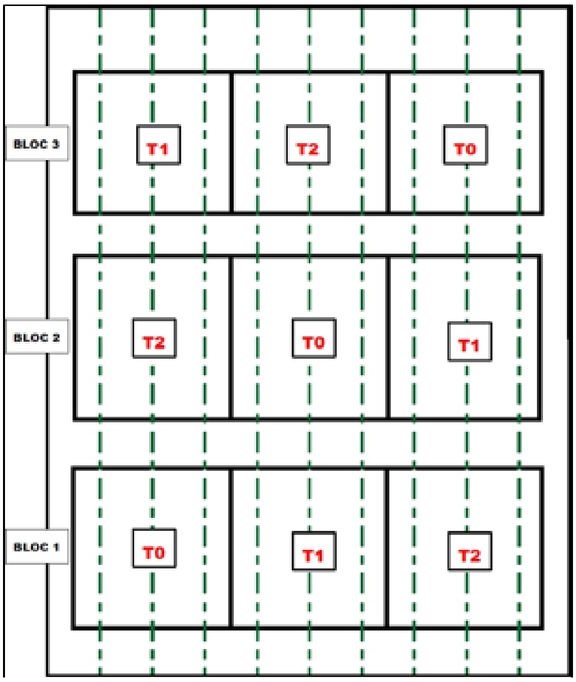


Figure 1. The study design (T0: control plot unit, T1: plot units that received 3% of basalt powder, T2: plot units that received 1.5% of basalt powder).

Pests and diseases monitoring

In each plot unit, number of plants was determined. Each infected plant by diseases was marked. Pests and diseases monitoring is determined from the number of plants, fruits, leaves or flowers at which symptoms of diseases or attacks by pests have been observed.

From each plot unit, three pepper plant were randomly selected from each one three fully opened flowers were collected from each strata. Every single pepper plant that was used for sampling was marked to avoid its sampling in the next time. Each sampled flower was placed into a plastic bag on which the number of sampling units and strata had been marked. The pest counting was carried out at the laboratory under a binocular.

Monitoring started in February, one month after planting and continued until May.

Treatment

Characteristics of the basalt powder

Basalt is a basic volcanic effusive rock containing natural mineral elements, such as Silicium, alumina, potassium and calcium. Micronized basalt powder was obtained by mechanical grinding of Basalt from Orvieto, using ceramic elements, without adding other minerals or chemical products. It does not contain any harmful substances that can damage the environment. The particle diameter is less than 30 mµ, its use therefore requires an application in aqueous dispersion, sprayed with a manual or mechanical nebulizer.

Chemical proprieties of basaltic mineral fines

Different components of basaltic powder are shown in table 1.

Table 1. Chemical proprieties of basaltic mineral fines[3].

Component	Pourcentage
(SiO_2)	49%
(Al_2O_3)	20,5%
(K_2O)	8%
(Fe_2O_3)	7,5%
(CaO)	7,2%
(MgO)	2,8%

(Na2O)	2,5%

Basalt application

Basalt powder was mixed with water and then applied as a foliar spray using a backpack sprayer.The application was carried out every 20 days (three weeks). Three blocks received a dose of 3% of basalt (T2), and other three blocks received a dose of 1.5% (T3). T0 considered as control plots did not receive any treatment.

Diseases monitoring during storage

Thirteen pepper fruits were coated by Farina di Basalto and placed into plastic boxes disinfected by formalin. Three treatment were employed ; T0 as control, T1 where pepper fruits were coated by 3% of basalt and T2 with 1.5%. Each treatment was carried out in three repetitions. Boxes were placed into a fridge at 3°C during 25 days. Daily, each fruit in each box was checked to monitor rotten fruit, with mold or with black spots.

Statistical analysis

Statistical analysis was performed with the aid of statistical software SAS. This program was used for the analysis of variance (ANOVA) and the LSD test for the comparison of means with $p \leq 0.05$.

III. Results and Discussion

Obtained results during the study period showed that pepper crop under greenhouse was attacked by some pests and diseases. Among those pathogens; the western flower thrips*Frankliniellaoccidentalis*Pergande (1895) (Thysanoptera ; Thripidae), the broad mite *Polyphagotarsonemuslatus* syn. *Hemitarsonemuslatus* Banks (1904) (Acari ; Tarsonemidae), the bacterial soft rots caused by *Pectobacteriumcarotovorum*subsp.*carotovorum*Waldee (1945) (syn. *Erwiniacarotovora*subsp. *carotovora*) (Enterobacteriales ; Enterobacteriaceae), and the rot disease caused essentially by the genus *Phytophtoracapsici*Leonian (1922) (Peronosporales ; Peronosporaceae).

Effect of Basalt on Thrips pest *F. occidentalis*

Most important thrips species that may attack pepper crop in Tunisia and causes several damages is *F. occidentalis*[12]. It is a polyphagous species that attacks plants belonging to several botanical families [30]. *F. occidentalis* may cause important damage to its host plants. On roses in Tunisia, damage to the flowers is particularly important, involving yellow spots and distortions that may be observed on petals [10]. On pepper crop, damages are results of feeding of adults and larvae leaving scars on leaves and fruits [12]. Scarring on flower buds may prevent these from fully opening, and sepals become crimped and slightly discoloured[2,6].

During this study, all thrips instars were monitored in pepper flowers; males, females and larvae. Number of females in all studied plots increased progressively until reaching mean values of about 6.33, 6.18 and 6.07 females per flower respectively in T0, T1 and T2 on April 30th 2019. However, a decrease of females' average values was observedtwo days after basalt application with mean values of about 4.59 and 4.44 females per flower respectively in T1 and T2. Four days after spraying basalt on pepper crop, females number dropped to values surrounding 0 and 0.14 female per flower respectively in T1 and T2 while in control average values was about 4.70 female per flower on May 04th 2019 (fig. 2).

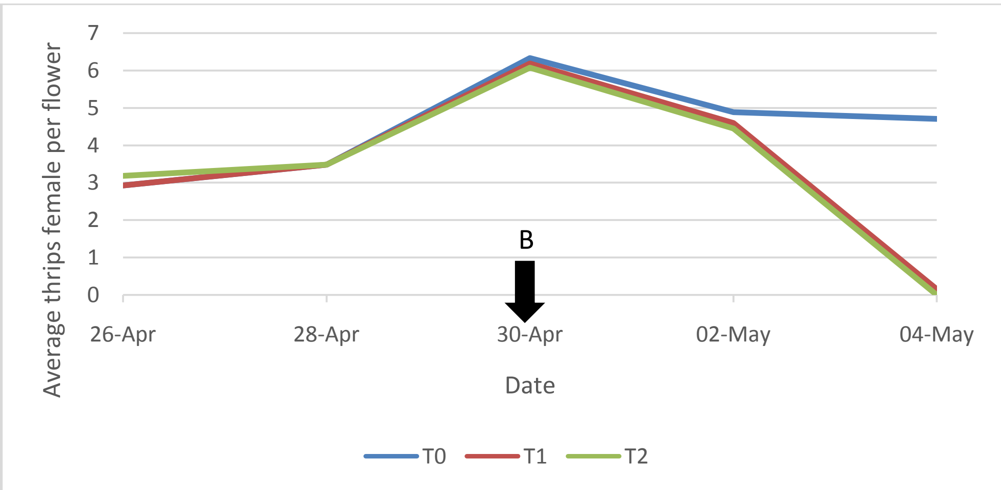


Figure 2. *F. occidentalis*females average values in pepper crop flowers (Legend: B; Basalt application, T0; Control, T1; 3% of Basalt, T2; 1.5% of Basalt).

Regarding males' numbers, they increased progressively in all plots and decreased then slightly before treatment reaching mean values between 3.29 and 4.33 males per flower respectively in T2 and T0 on April 30th 2019. It must be noted that two days after basalt application, a decrease in males mean values was observed in T1 and T2 till dropping to 0 and 0.18 males per flower in T1 and T2 respectively on May 04th 2019 while an average of about 5.37 males was observed in control plots (fig. 3).

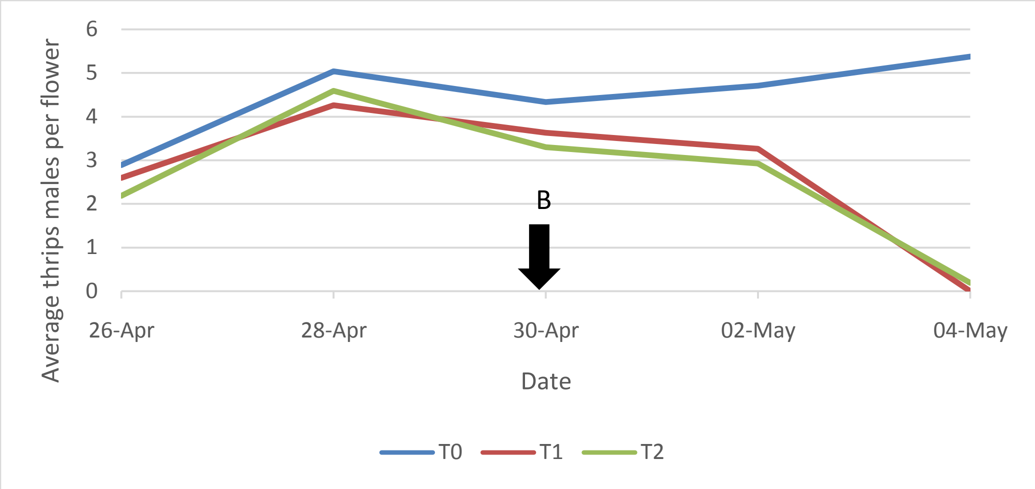


Figure 3.*F. occidentalis*males average values in peppercropflowers (Legend: B; Basalt application, T0; Control, T1; 3% of Basalt, T2; 1.5% of Basalt).

Before treatment by "Farina di Basalto", larvae showed an increase in all plots including control until reaching mean values of about 3.88 in T0 and T2 and 3.74 larvae per flower in T1 on April 30th 2019. Same effect was observed on larvae, where in both treated plots by basalt powder, larvae mean values decreased considerably till dropping to 0.18 and 0.33 larvae per flower respectively in T1 and T2 on May 04th 2019. In control unit plots, larvae number continue to increase to reach 04 larvae per flower during last day of observations (fig. 4).

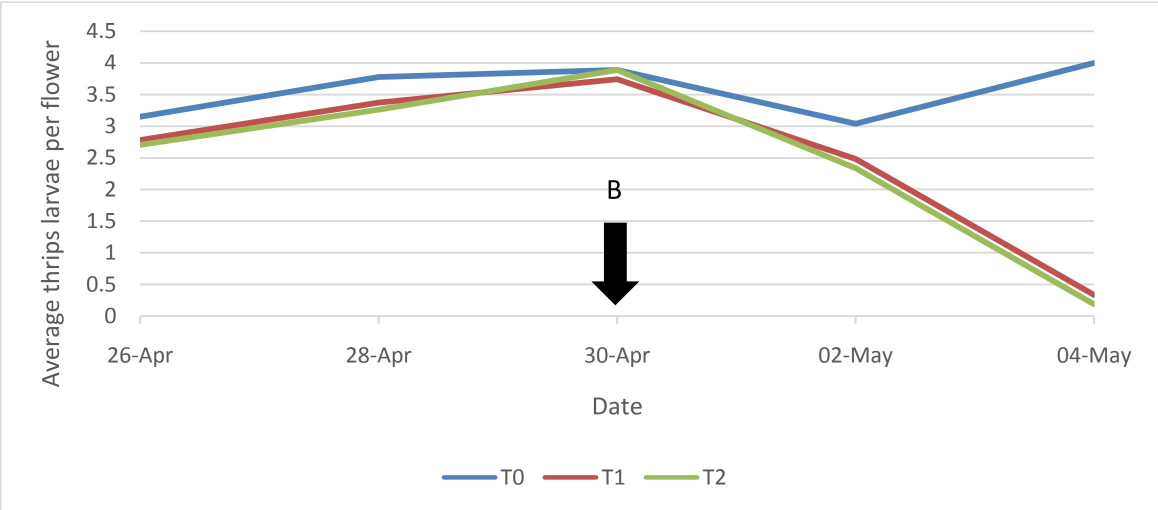


Figure 4.*F. occidentalis*larvae average values in pepper crop flowers (Legend: B; Basalt application, T0; Control, T1; 3% of Basalt, T2; 1.5% of Basalt).

Effect of Basalt on the broad mite

The broad mite is a polyphagous mite species that may attack a wide range of botanical species. It may cause several damages especially on the young leaves in the apical parts of the host plant and it may attack fruits too. On the other hand, this mite causes growth inhibition of the host plant [28, 29].

During this study, damages caused by the broad mite were observed in the pepper crop greenhouse and attacked plants were numbered in each unit plot.

Results showed that though no significant differences that were observed at $p \leq 0.05$ between different plot units (T0, T1 and T2), but in control plots we can find the most important cumulated mean values of attacked plants by the broad mite with 2 plants while in T1 and T2, only 1.22 and 1.55 attacked plants that were observed (fig. 5).

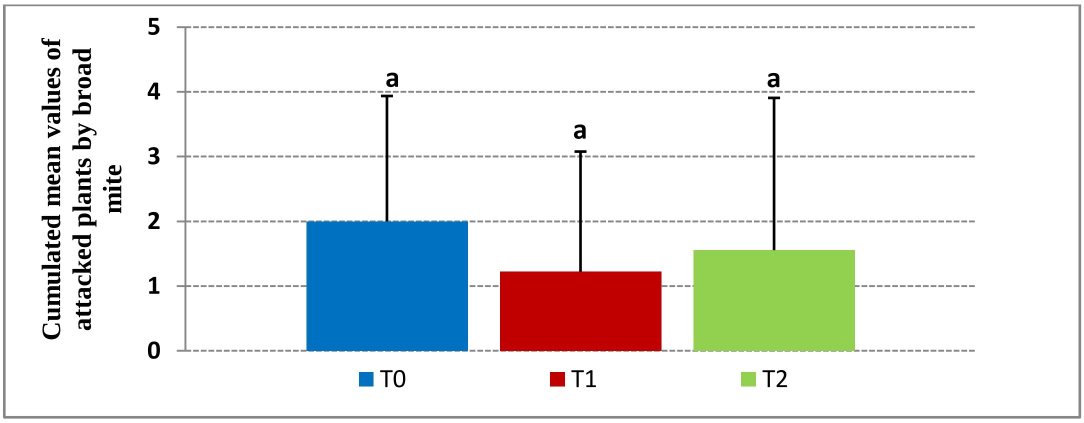


Figure 5. Cumulated mean values of attacked plants by broad mite (Values followed by the same letters are not significantly different at $p \leq 0.05$).

Effect of Basalt on the bacterial soft rots caused by *P. carotovorum*

P. carotovorum subsp. *carotovorum* (syn. *Erwiniacarotovora* subsp. *carotovora*) wa first reported in Tunisia during winters of 2005 and 2006. It is the causal agent of the bacterial soft rot, which is a severe and devastating disease that may cause important economically losses on many host plants such as potato, tomato, pepper, eggplants and cabbage [25]. In attacked pepper fruits, symptoms appears at first n the peduncle and calyx tissues and then the entire fruits turned into watery masses within 2 to 6 days [19].

During this study, pepper fruits with watery masses caused by the bacterial soft rots were observed under the experimental greenhouse. In fact, results showed that statistically there were no significant differences between control and treated plot units by basalt. However, cumulated average values of attacked plants were higher in control than in T1 and T2 with respectively 5.55, 4.66 and 3.88 attacked plants (fig. 6).

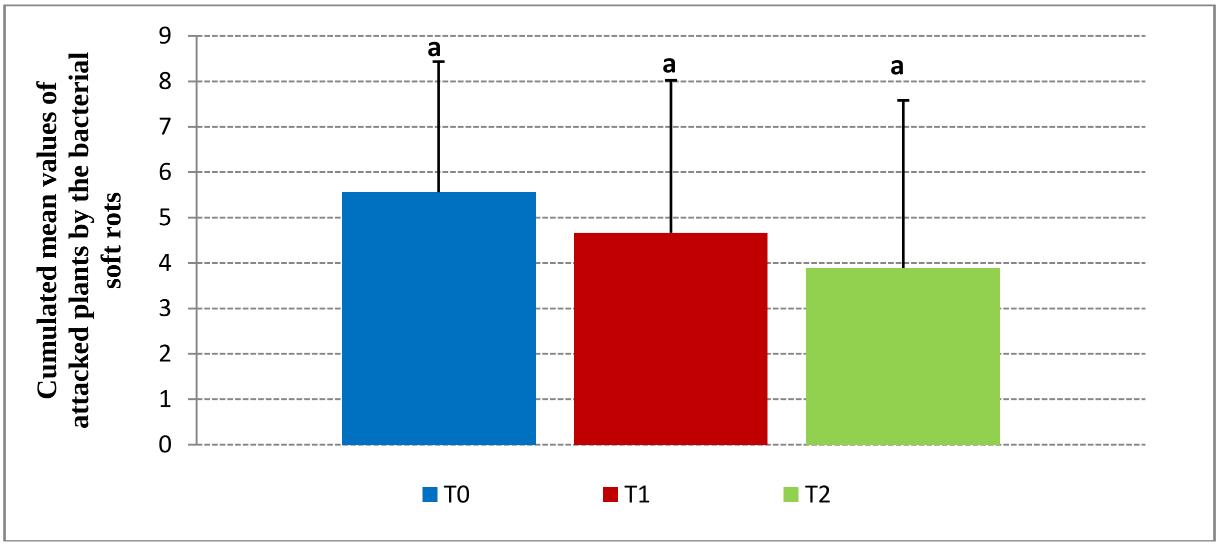


Figure 6. Cumulated mean values of attacked plants by the bacterial soft rots(Values followed by the same letters are not significantly different at $p \leq 0.05$).

Effect of Basalt on the rot disease caused by *Ph. capsici*

*Ph. capsici*is responsible of the rot disease and the most destructive pathogen of vegetables and represents a serious threat to pepper plants, it has become a serious pest to pepper production and it may cause losses up to 100% [32, 33].

Regarding effect of "Farina di Basalto®" on *Ph. capsici*, results showed that high significant difference was observed between control and treated plots at $p \leq 0.05$. In fact, in untreated plots with basalt powder average number of attacked pepper plant was about 6, while it was only 1.33 and 1 attacked plant in T1 and T2 respectively. These results showed that basalt may reduce the rot disease at low values (fig. 7).

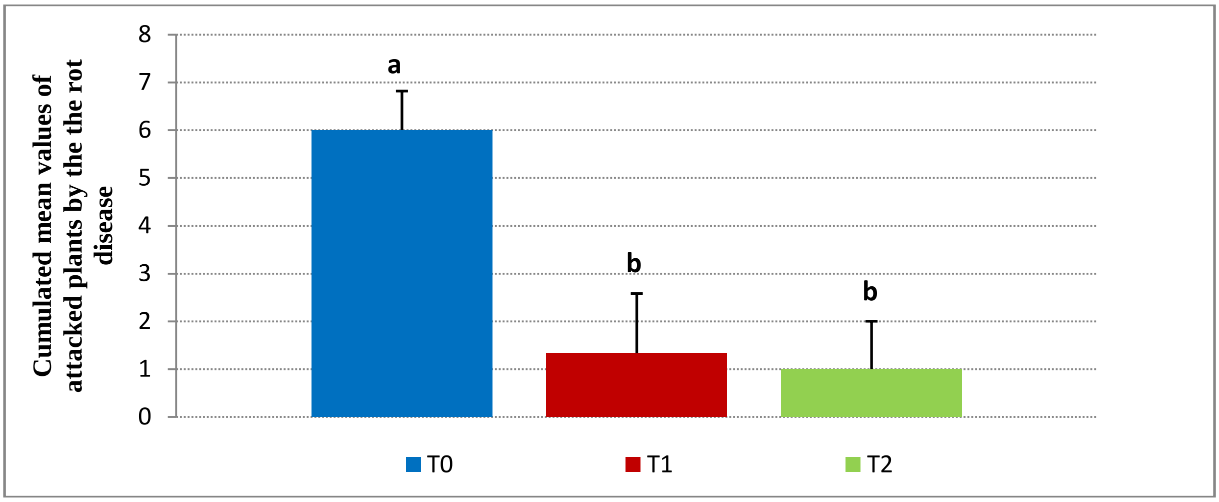
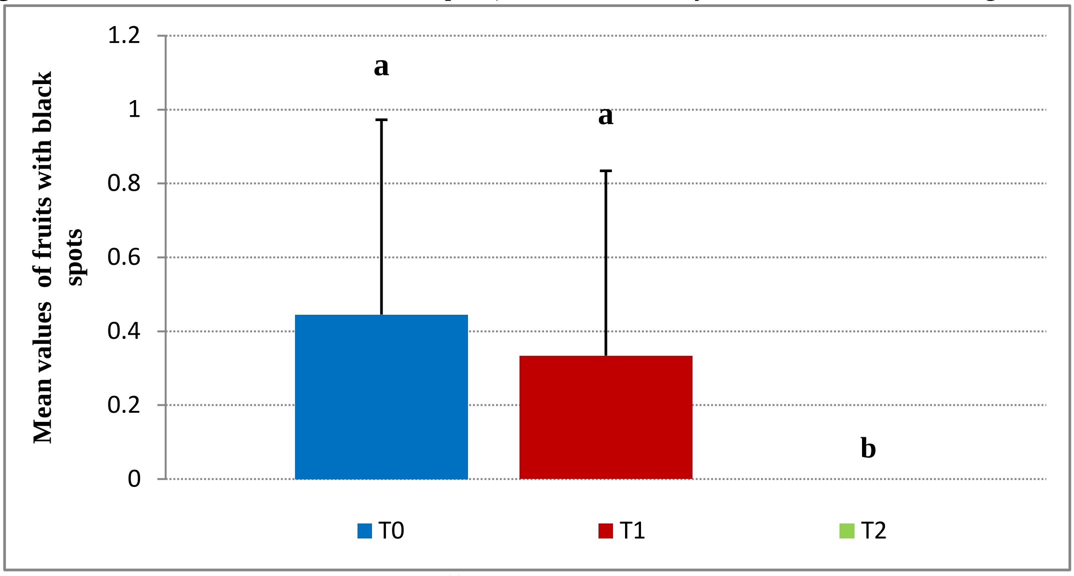


Figure 7. Cumulated mean values of attacked plants by the rot disease caused by *Ph. capsici*(Values followed by the same letters are not significantly different at $p \leq 0.05$).

Diseases monitoring during storage

During storage, damages on fruits were observed such as black spot appearance, fruits' rot and fruits with moldiness. Obtained results regarding fruits with black spots showed that in control plots average values of about 0.44 fruit followed by T1 with 0.33 fruit with no significant difference. However, in T2 no fruits with black spots were observed (fig. 8).

Figure 8. Mean values of fruits with black spots(Values followed by the same letters are not significantly



different at $p \leq 0.05$).

Concerning rotten fruits, though average fruits number in T1 and T2 were ower than control, no significant differences were observed (fig. 9).

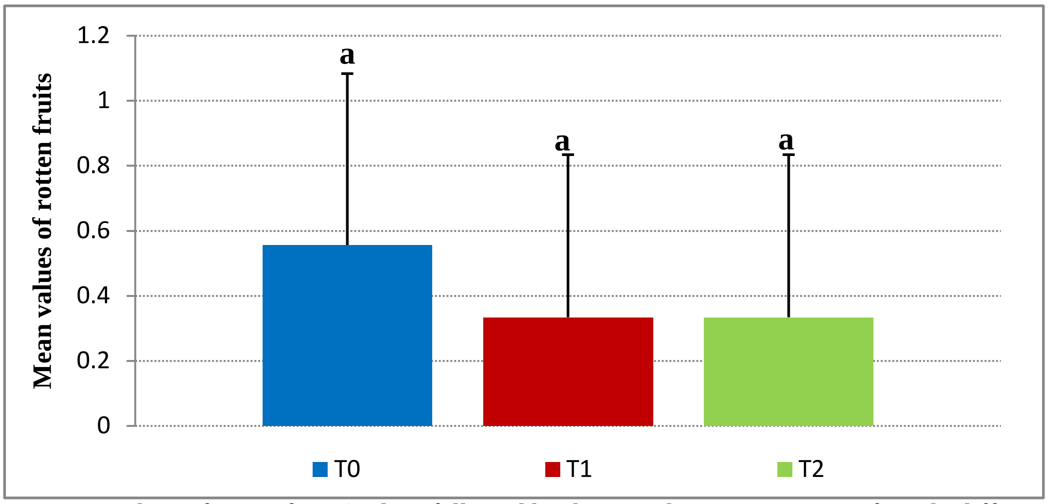


Figure 9. Mean values of rotten fruits**(**Values followed by the same letters are not significantly different at $p \leq 0.05$).

Same results were obtained in fruits with moldiness development during storage were no significant differences were observed between control, T1 and T2, though that mean values in treated fruits with basalt were lower than control (fig. 10).

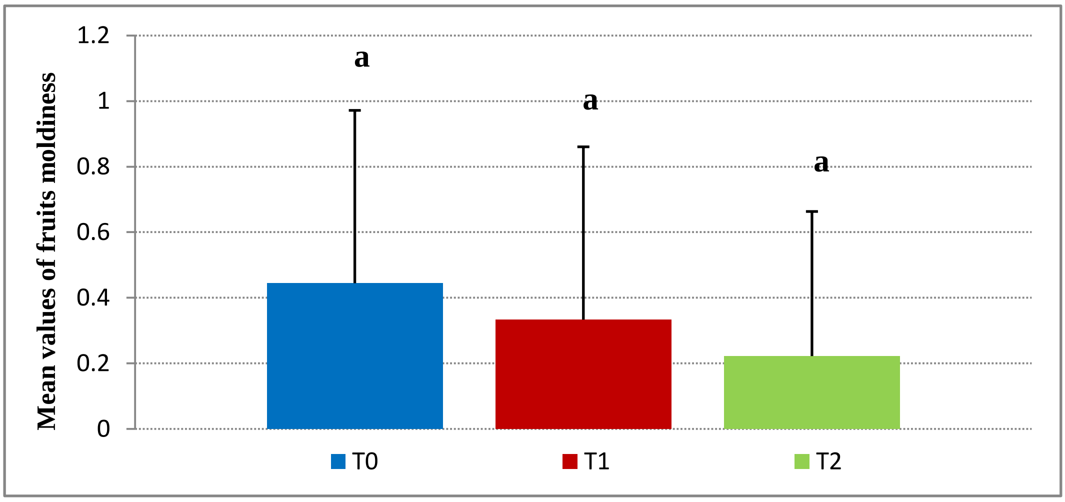


Figure 10. Mean values of rotten fruits**(**Values followed by the same letters are not significantly different at $p \leq 0.05$).

Obtained results during this study demonstrated that basalt has an effect on pests and diseases by strengthening resistance to plants by stimulating their natural defence reaction and this is due to silicon, which is the most important component of basalt powder [16, 23, 26]. In fact, results concerning *F. occidentalis*showed that basalt reduces thrips populations to very low values till disappearing completely. These results are similar to those found during chemical control, or even use of organic insecticides, traps associated with kairomones or pheromones and even when predators such as *Oriuslaevigatus*Fieber (Heteroptera; Anthocoridae) are employed during biological control against *F. occidentalis*in pepper crop greenhouses [11, 13,14, 15, 24]. Basalt powder, as other inert powders, repels insects and mites by preventing them to be installed in the crops, and reduces their populations and kills them by desiccation and absorption of the waxy layer of their exoskeleton [9, 22]

On the other hand, basalt powder had an effect on micro-organisms such as*Ph..Capsici* during this study. In fact, Silicon reduces significantly powdery mildew in wheat crop where foliar and root applications of Silicon causes the decrease of this disease to 80 % [23]. Basalt powder is characterized by a Silicon rate comprised between 40 and 60% [17]. Silicon is exploited since severe years for its prophylactic properties against plant diseases since it has an effect on plant resistance stimulating thus natural defence reactions [16, 23].

In the same context, minerals in general protect stored grains against diseases, which can explain the reduced mean number of attacked fruits treated by basalt than those in control units [20].

IV. Conclusion

Basalt powder (Farina di Basalto) spraying on pepper crop under greenhouses and during storage with two different doses (1.5 % and 3%) supresses the intensity of damages caused by diseases and pests and limited their proliferation and development compared with control plot units. Both concentrations may be employed since they gave almost same results. It is thus possible to use the concentration of 1.5% in order to minimize cost of the product and to avoid risks related to overdosing of mineral elements in the soil.

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References

[1]. Al-Iraqi R.A.,Al-NaqibS.Q.,2006. Inert Dusts to Control Adults of Some Stored Product Insects in Stored Wheat. Rafidain Journal of Science 10: 26-33.
[2]. Alford D.V., 1991.Atlas en couleur. Ravageurs des végétaux d'ornement: Arbres-Arbustes-Fleurs. INRA Editions, Paris : 464 p.
[3]. Anonyme. 2019. Fiche technique farina di Basalto.Corroborant potentialisateur des défenses végétales. p2
[4]. Ben Mbarek K., Boujelben A., 2004.Etude du comportement des cultures de tomate (Lycopersiconesculentum Mill.) et de piment (Capsicumannuum L.) conduites en lignes simples et lignes jumelées sous serre,Tropicultura(22) : 97-103.
[5]. Black L.L., Green S.K., Hartman G.L.,Poulos J.M., 1991.Pepper Diseases: A field guide. Asian Vegetable Research and Development Center. L.A., U.S.A. 98p.
[6]. Brun R., Bertaux F., Metay C., Blanc M.L., Widzienkonski C., Nuée N., 2004. Stratégie de protection intégrée globale sur rosier de serre. PHM-Revue Horticole. La Revue Technique des Pépiniéristes Horticulteurs Maraîchers 461 : 23-27
[7]. Conn K., 2006. Pepper & Eggplant Disease Guide. A Practical Guide for Seedsmen, Growers and Agricultural Advisors. 2700 Camino del Sol, Oxnard, CA 93030. Seminis Grow forward. 74pp.
[8]. Drobot N.F., Noskova O.A., Steblevskii A.V., Fomichev S.V.,Krenev K.A., 2013.Use of chemical and metallurgical methods for processing of gabbro-basalt raw material. Theoretical Foundations of Chemical Engineering 47(4) 484 - 8
[9]. Ebeling W., 1971.Sorptive Dusts for Pest Control. Annual Review of Entomology. Annual Reviews, Inc., Palo Alto, CA. 16: 123-158
[10]. Elimem M., Chermiti B., 2009. Population dynamics of FrankliniellaoccidentalisPergande (1895) (Thysanoptera: Thripidae) and evaluation of its different ecotypes and their development in a rose (Rosa hybrida) greenhouse in the Sahline Region, Tunisia. In: Tunisian Plant Science and Biotechnology I. African Journal of Plant Science and Biotechnology 3: 53–62.
[11]. Elimem M., Chermiti B., 2011.Frankliniellaoccidentalis (Pergande) (Thysanoptera; Thripidae) sensitivity to two concentrations of a herbal insecticide “Baicao 2” in a Tunisian rose crop greenhouse. Floriculture and Ornamental Biotechnology 5: 68–70.
[12]. Elimem M., Harbi A., Chermiti B., 2011. Dynamic population of FrankliniellaoccidentalisPergande (1895) (Thysanoptera: Thripidae) in a pepper crop greenhouse in the region of Moknine (Tunisia) in relation with environmental conditions. African Journal of Plant Science and Biotechnology 5: 30–34
[13]. Elimem M.,ChermitiB., 2012. Use of the predators Oriuslaevigatus and Aeolothrips spp. to control Frankliniellaoccidentalis populations in greenhouse peppers in the region of Monastir, Tunisia. Integrated Control in Protected Crops, Mediterranean Climate IOBC-WPRS Bulletin 80: 141-146.
[14]. ElimemM., Teixeira da SilvaJ.A., ChermitiB., 2014. Double-attraction method to control Frankliniellaoccidentalis (Pergande) in pepper crops in Tunisia. Plant Protect. Sci., 50: 90-96
[15]. Elimem M., Harbi A., Limem-Sellemi E., Ben Othmen S.,Chermiti B.,2018. Oriuslaevigatus (Insecta; Heteroptera) local strain, a promising agent in biological control of Frankliniellaoccidentalis (Insecta; Thysanoptra) in protected pepper crops in Tunisia. Euro-Mediterranean Journal for EnvironmentalIntegration. 3(5) : 2-6.
[16]. Fawez, A., Menzies, J. G., Chérif, M., Bélanger, R. R. 2001.Silicon and disease resistance in dicotyledons. In L. E. Datnoff, G. H. Snyder, et G. H. Korndörfer (eds.), Silicon in Agriculture. Amsterdam: Elsevier.pp 159–169.
[17]. Fawzy Z.F., El-Bassiony A.M., Yunsheng L., Zhu O., Ghoname A.A, 2012. Effect of mineral, organic and bio-N fertilizers on growth, yield and fruit quality of sweet pepper.Journal of Applied Sciences Research 8(8): 3921-3933.
[18]. Fomichev S.V., Babievskaya I.Z., Dergacheva N.P., Noskova O.A.,Krenev V.A., 2010.Evaluation and modification of the initial composition of gabbro-basalt rocks for mineral-fiber fabrication and stone castingInorganic Materials 46(10) 1121-1125.
[19]. Golkhandan E,.KamaruzamanS, Sariah M., ZainalAbidinM. Z., NasehiA., NazerianE., 2013. First Report of Soft Rot Caused by Pectobacteriumcarotovorum subsp. carotovorum on Pepper Fruits (Capsicum annuum) in Malaysia. Plant Disease.97(8): 1109.
[20]. Golob P (1997) Current Status and Future Perspectives for Inert Dusts for Control of Stored Product Insects. Journal of Stored Products Research 33:69-79.
[21]. Goreau T.J., Thomas J., Ronal W., Larson, J.C, 2014.Basalt powder restores soil fertility and greatly accelerates tree growth on impoverished tropical soils in Panama. Geotherapy: Innovative Methods of Soil Fertility Restoration, Carbon Sequestration, and Reversing CO2 Increase.p325
[22]. Groth, M.Z., BelléC., Bernardi D., da Cunha B.F.R.,2018.Pó-de-basalto no desenvolvimento de plantas de alface e nadinâmicapopulacional de insetos. Revista de CiênciasAgroveterinárias16(4): 433-440.
[23]. Guével, M.H., Menzies, J.G, Bélanger R.R., 2007. Effect of root and foliar applications of soluble silicon on powdery mildew control and growth of wheat plants. European Journal of Plant Pathology 119(4), 429–436.
[24]. Harbi A., Elimem M., Chermiti B., 2013. Use of a synthetic kairomone to control FrankliniellaoccidentalisPergande (Thysanoptera; Thrpidae) in protected pepper crops in Tunisia. African Journal of Plant Science and Biotechnology 7: 42–47
[25]. Hibar K., Daami-Remadi M., El Mahjoub M., 2007. First report of Pectobacteriumcarotovorum subsp. carotovorum on tomato plants in Tunisia. Tunisian Journal of Plant Protection 2: 1-5.
[26]. Isnugroho K, HendronursitoY, BirawidhaDC. 2017. Characterization and utilization potential of basalt rock from East-Lampung district.MineralProcessing and Technology International Conference 285 : 1-5.
[27]. Kaya C., Kirnak, H., Higgs D., 2001. Effects of supplementary potassium and phosphorus on physiological development and

mineral nutrition of cucumber and pepper cultivars grown at high salinity (Nacl). Journal of Plant Nutrition 24(9): 1457–1471.
[28]. Kousik C.S., Shepard B.M., Hassell R., Levi A., Simmons AM., 2007. Potential Sources of Resistance to Broad Mites (Polyphagotarsonemuslatus) in Watermelon Germplasm. HORTSCIENCE 42(7):1539–1544.
[29]. LebdiGrissa K.,KhoufiA., 2012. Bio-ecology of phytophagous mites on Citrus. 7th Symposium of the EURopean Association of ACarologistsJuly 9-13 2012, Vienna, Austria p92
[30]. Lewis T., 1973: Thrips. Their biology, ecology and economic importance. Acad. Press, London and New York, 349 pp.
[31]. Maaouia-Houimli S., Denden M., Dridi-Mouhandes B. Ben Mansour-Gueddes S., 2011. Caractéristiques de la croissance et de la production en fruits chez trois variétés de piment (Capsicumannuum L.) sous stress salin. Tropicultura 29(2) : 75-81.
[32]. Majid M.U., Awan M.F., Fatima K., Tahir M.S., Ali Q., Rashid B., Rao A.Q. , Nasir I.A. , Husnain T., 2016. Phytophthoracapsici on chilli pepper (Capsicum annuum L.) and its management through genetic and bio-control: a review Zemdirbyste-Agriculture 103 (4): 419–430
[33]. Mengist Y.,Birara A., 2019. Performance Evaluation of Red Pepper Varieties and Types of Seed Bed for The Management of Root Rot (PhytophtoraCapsici) Disease at Central Gondar, Northwest, Ethiopia. Journal of Advances in Agriculture 10: 1740- 1751
[34]. Pisciotta A, Perevozchikov B V, Osovetsky B M, Menshikova E A and Kazymov K P 2014. Quality Assessment of Melanocratic Basalt for Mineral Fiber Product, Southern Urals, Russia. Nat ResourRes 24: 329–337
[35]. Rahmouni H., Ouari M.T., 2016.Caractérisation et étude des propriétés d'usage des tufs de Remila. Mémoire fin d'etude. Université Abderrahmane Mira de Bejaia, Bejaia :p31.

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