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Evaluation of insecticidal efficiency of Basalt powder "Farina di Basalto®" to control *Tribolium castaneum* (Coleoptera; Tenebrionidae), *Rhyzopertha dominica* (Coleoptera; Bostrichidae) and *Ephestia kuehniella* (Lepidoptera; Pyralidae) on stored wheat.

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Abstract
Background: *This work aims to evaluate under laboratory conditions the insecticidal effect of Basalte, which is a volcanic rock and a natural fertilizer rich in nutriments and employed to improve crops growth, on insect pests of stored wheat ; Tribolium castaneum (Coleoptera, Tenebrionidae), Rhyzopertha dominica (Coleoptera, Bostrichidae) and Ephestia kuehniella (Lepidoptera, Pyralidae). 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 causes the mortality of the three pest species. Regarding T. castaneum, mortality rates observed for the control were always about 0% until the fifth day of observations. However, in treated units, insect mortality rates were about 40 and 16.6% respectively for 3 and 1.5% of basalt powder just one day after the trial and increased considreably thereafter and reached 100% during the third and fourth days after treatment. Almost same results were obtained for R. dominica where mortality rates observed in control were low during the first three days and did not exceed 10%, while in treated units they reached 100% during the second and third day after treatment respectively for the doses 3% and 1.5% of basalt. Regarding larvae of E. kuehniella, mortality rates observed in control remained low until the seventh day and slightly exceeded 50% during the rest of the trial. In treated units with 3% of basalt, mortality rates were about 60% during second and third day after treatment and reached 100% during fourth day. For treated units by 1.5% of basalt, mortality rates ranked between 20 and 40% till the fifth day to reach 90% at the end of the trial.*
Keywords: *wheat, storage, insect pest, basalt, mortality rate*

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I. Introduction

In Tunisia, cereals remain one of the most important crops because of the size of the occupied areas and its importance in the economy of the country. Most cultivated cereals in Tunisia are durum wheat, soft wheat, barely and tritical. Areas reserved for soft wheat are about 1.5 million hectares, 20000 hectares for triticales, and about 46.6% of areas are destinated for durum wheat (Seddik, 1998). During storage, cereals may be attacked by many pests that cause important losses (Jarreya, 2003). Those pests are often controlled by several methods among which fumigation which is the most employed during storage (Elimem et al., 2019; Haouel-Hamdi et al.; 2020). Biological control may be also employed with success. In fact, essential oils of many plants were testified and showed important mortality rates (Mediouni Ben Jemaa et al.; 2013; Arthur, 2015; Elimem et al., 2019). On the hand, use of other components may be a promising method to control insects under storage conditions in order to preserve human health and environment. Among those components, the basalt, which is a tuff originates from volcanic projections (Rahmouni and Ourani, 2016), that has an impact on many pests and diseases that may attack crops (Elimem et al., 2020). In fact, these small fragments, that are sometimes oberved as blocks or even ashes with black, red or even dark green colour, are generally employed in different areas such as in construction, in industrial and highway engineering, mineral fiber and cast stone material production, as well as in agronomy (Formichev et al., 2010; Drobot et al., 2013; Pisciotta et al., 2014; Rahmouni and Ourani, 2016). Regarding agronomy, this mineral is known as a fertilizer which is used to improve soil nutrient richness. It is a source of natural fertilizer rich in Silicon (Si) and many other components such as feldspar, micas and zeolites since it comes from magmas and volcanic ashes (Anonymous, 2019). This rock contains many chimical components required in agronomy and soil fertilization such as 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%) (Kaya et al., 2001). Since this mineral is used to restore soils fertility, it increases lately plant growth, total yield, fruits quality and certain chemical constituents and chlorophyll rate of acacia, pepper fruits, tomato and cucumber than in untreated soils with basalt (Kaya et al., 2001; Fawzy et al., 2012; Rouz et al., 2020).

Besides, basalt was shown in many studies strengthening resistance in crops against pests and diseases by stimulating their natural defense reactions in fields and even under storage conditions (Fawez et al., 2012, Anonymous, 2019; Isnugroho et al., 2017; Elimem et al. 2020). It improves the resistance of pepper against the bacterial soft rots caused by *Pectobacterium* and the root rot disease caused essentially by the genus *Phytophtora capsici* under greenhouses and during storage conditions (Elimem et al., 2020). The powdery mildew disease is also reduced in wheat crop to very low values due to basalt because of its richness in Silicon and decreased the severity of the disease to 80% (Guével et al., 2007). Many other works mentioned that many pests may be controlled using basalt. The fertilizer exerted a repulsive effect against pests such as thrips (*Frankliniella occidentalis*) and mites (Elimem et al., 2020). Inert powders such as basalt are employed as a controlling method in order to protect stored grains (Al-Iraqi and Al-Naqib, 2006). In fact, it does not only repels insects and mites in fields, greenhouses or during storage, but it causes their death by absorption of their waxy layer surrounding their exoskeleton causing thus their desiccation (Ebeling, 1971).Other studies demonstrated that the fertilizer is very effective in reducing pest dynamic populations to very low values and even it may cause their disappearance from the infested crops (Groth et al., 2007; Elimem et al., 2020).

This work aims to study the impact of basalt powder as an insecticide and to evaluate mortality rates of three pests species on stored wheat infested by *Tribolium castaneum* (Coleoptera, Tenebrionidae), *Rhyzopertha dominica* (Coleoptera, Bostrichidae) and *Ephestia kuehniella* (Lepidoptera, Pyralidae) under laboratory conditions.

II. Material And Methods

Study location

The trial was held in the laboratory of Entomology of the Higher School of Agronomy of Mograne in Tunisia.

The bioassay

To evaluate insecticidal efficiency of basalt powder against *T. castaneum, R. dominica* and *E. kuehniella*, stored and infested wheat seeds were obtained from the storage silo of the Higher School of Engineer of Medjez El Beb, Tunisia. The three pest species were extracted from the infested wheat and placed into special vials to serve later for the bioassay.

A number of 100 unharmed wheat seeds were weighed at first and then placed into Petri dishes. In each Petri dish, a number of 10 adult individuals of *T. castaneum* was added to each Petri dish. Same trial was adopted for *R. dominica* where 10 adult individuals were added to each Petri dish containing 100 of and unharmed wheat seeds that were already weighed. Regarding *E. Kuehniella*, only larvae served for the trial where 10 larvae were added to each Petri dish already containing 100 unharmed wheat seeds.

Three treatments were adopted for the trial and repeated thrice for each pest species; three Petri dishes were considered as control (T0), three Petri dishes to which basalt has been added at a dose of 3% (T1), three Petri dishes to which basalt has been added at a dose of 1.5% (T2). Each Petri dish was enclosed by perforated lids covered with muslin to allow aeration and to prevent water droplets formation. All Petri dishes were stored in a climate room at 25±1°C, 60-70% Relative Humidity, and a photoperiod of 16:8 (L:D) h, at the Laboratory of Entomology in the Higher School of Agronomy of Mograne.

Mortality rate monitoring

Mortality rate was evaluated each 24h during five days using a paintbrush to stimulate individual of each species recording those that are alive and those that are dead.

Mortality rates of different treatments on the different pest species were estimated and corrected using the Abbott's formula (Abbott, 1925) ;

Abbot's formula = 100 x (M observed – M control) / (100-M control).

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 (Anonymous, 2019).

Component	Pourcentage
(SiO_2)	49%
(Al_2O_3)	20,5%
(K_2O)	8%
(Fe_2O_3)	7,5%
(CaO)	7,2%
(MgO)	2,8%
(Na_2O)	2,5%

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

Effect of Basalt on *T. castaneum*

Obtained results regarding *T. castaneum* (fig. 1) showed that during first and second days of observations, no mortality rates were observed in control. It was only from the sixth day were mortality rates began to increase with an average value of about 46.67% with significant differences with T1 and T2. Concerning treated plots, T1 with 3% of basalt powder exerted a mortality rate since the first day of observation of about 40% with significant differences compared with control. This value did not stop increasing to reach 100% just three days after the treatment. T2, with half basalt concentration (1.5%), showed also a mortality rate since the first day after treatment with only 16.67% and with significant difference with control and T1. This dose mortality rate reached 100% during the fourth day after treatment.

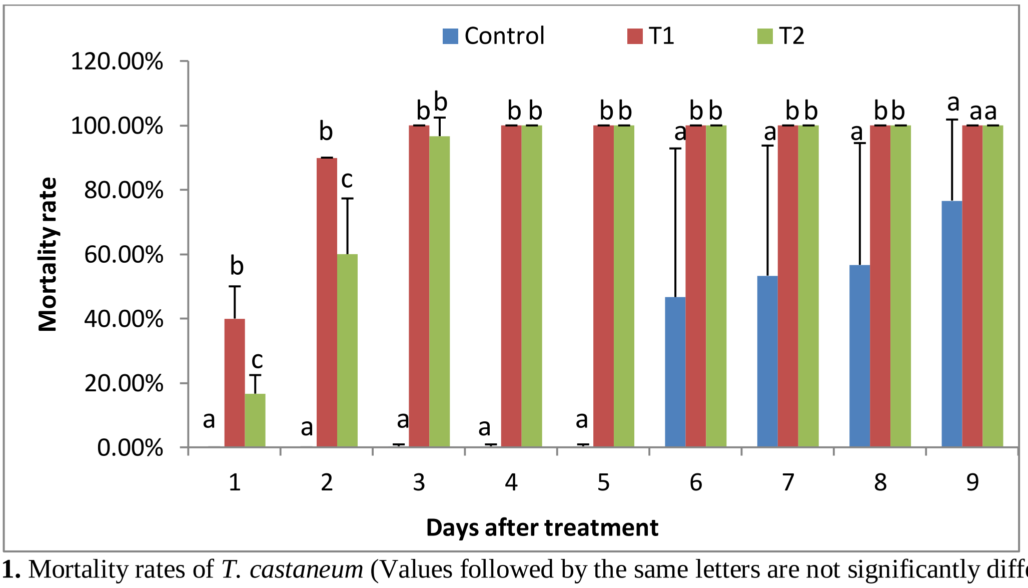

Figure 1. Mortality rates of *T. castaneum* (Values followed by the same letters are not significantly different at $p \leq 0.05$).

Effect of Basalt on *R. dominica*

Regarding *R. dominica*, obtained results (fig. 2) showed that it was more sensitive to basalt powder application than *T. Castaneum.* In fact, and in control plots, mortality rates were very low during first days of observations and ranked between 0% and 10% respectively during first and third day after treatment with significant differences with treated plots. This percentage increased lately to reach during the ninth day 86.76% and always with significant differences with T1 and T2. In regards to treated plots with basalt powder, T1 exerted a high efficiency on *R. dominica* from the first day after treatment causing a mortality rate of about 73.33%. This percentage reached 100% just two days after treatment. T2, with only 1.5% of basalt powder applied, showed almost same phenomenon. During first day, mortality rate was about 70% with no significant difference with T1. This dose reached 100% of dead insects on third day after treatment.

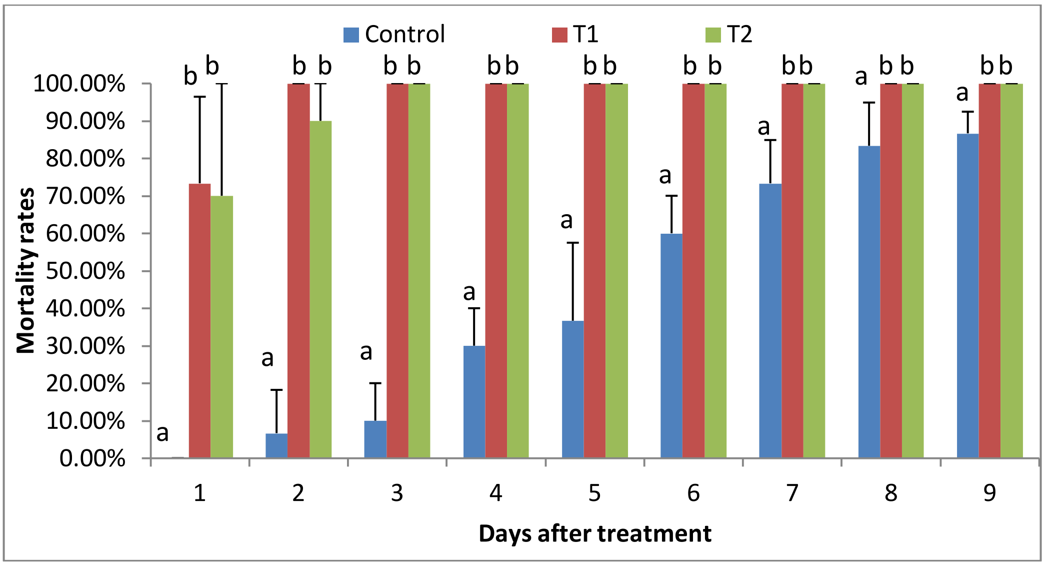

Figure 2. Mortality rates of *R. dominica* (Values followed by the same letters are not significantly different at $p \leq 0.05$).

Effect of Basalt on *E. kuehniella*

In the case of the Mediterranean flour moth *E. kuehniella,* mortality rates in control plots were very low during six first days after treatment and they ranked between 0 and 13.33% (fig. 3). It was only from the seventh day after treatment that mortality rates reached 53.33% and always with significant differences with both basalt treatments. Concerning both basalt applied doses, it was found that one day after treatment only T2 exerted an impact on *E. kuehniella* larvae with a mortality rate of about 20%. Two days after treatment, percentage of dead larvae began to increase in T1 with 53.33% and 26.67% for T2. It must be noted that mortality rates observed in T1 reached 100% during fourth day after treatment, while maximum rate recorded for T2 was about 93.33% for T2. Statistical analysis showed significant differences between both basalt treatments during all the study period.

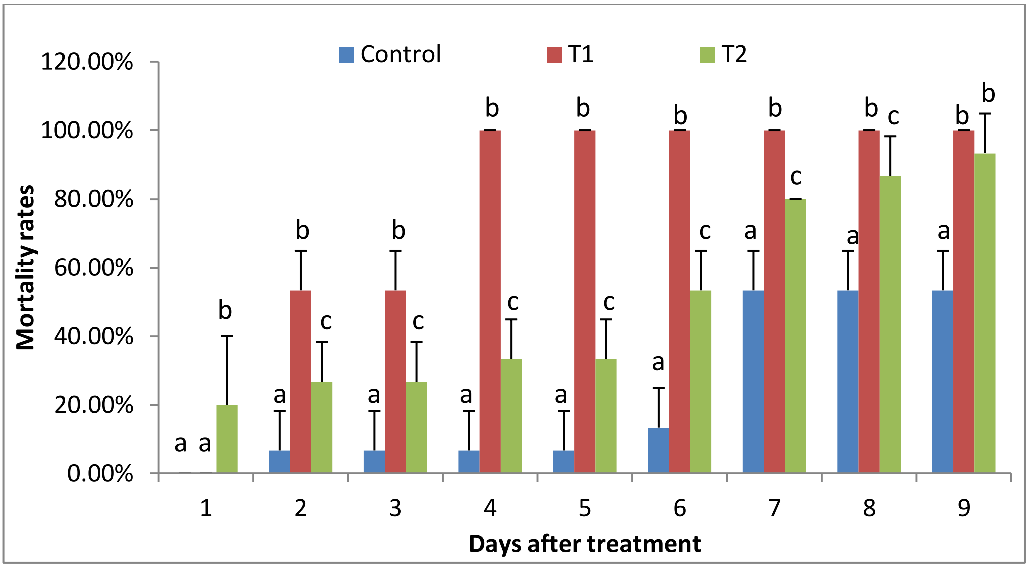

Figure 3. Mortality rates of *E. kuehniella* (Values followed by the same letters are not significantly different at $p \leq 0.05$).

During this essay, obtained results showed that basalt powder exerted an impact on different pest species of stored wheat and caused high mortality rates reaching in almost all observed cases 100%. In fact, these results concord with those mentioned by Elimem et al. (2020), where basalt reduces pests populations under greenhouses to very low values till disappearing, such as for the thrips species *Frankliniella occidentalis*. Same for the broad mite *Polyphagotarsonemus latus* syn. *Hemitarsonemus latus* Banks (1904) (Acari ; Tarsonemidae), where basalt reduces number of attacked plants by this mite species (Elimem et al., 2020). These results are similar to those found during control of stored cereals pests in this study. In fact, basalt showed an effect that may be compared to that observed using essential oils of some plants such as *Laurus nobilis* on *T. castaneum* (Haouel-Hamdi et al., 2020). Same results were observed using *Mentha puligium* and *Ricinus communis* against *T. Castaneum* and *Lasioderma serricorne*, where the plants' essential oils components exerted an insecticidal and repellent potential on the pests (Salem et al., 2018.a; Salem et al., 2018.b). Mediouni Ben Jemaa et al. (2013) indicated that *Eucalyptus* essential oils are very effective to control the date moth *Ectomyelois ceratoniae*. On the other hand, it must be noted that not only sessential oils that may have an impact on pests, some other natural siliceous sedimentary rocks, such as Diatomaceous Earth, showed an important effect. Yousfi and Mediouni Ben Jemaa (2015) showed in theire studies that this sedimentary rock had an effect on the date moth *E. ceratoniae* and especially an ovicidal potential where the percentage of emergence of adults from treated eggs did not exceed 20%. This confirms results found during this trial. Al-Iraqi and Al-Naqib (2006) mentioned that inert powders are employed as a controlling method in order to protect stored grains. These powders, such as basalt and Diatomaceous Earth exert an insecticidal and repellent effect on pests during storage, in greenhouses and in fields (Ebeling, 1971; Yousfi and Mediouni Ben Jemaa; 2015; Elimem et al., 2020). Insect death is caused by absorption of their waxy layer surrounding their exoskeleton causing thus their desiccation (Ebeling 1971).

IV. Conclusion

Basalt powder (Farina di Basalto) applied on stored wheat pests; *Tribolium castaneum* (Coleoptera, Tenebrionidae), *Rhyzopertha dominica* (Coleoptera, Bostrichidae) and *Ephestia kuehniella* (Lepidoptera, Pyralidae), with two doses; T1: 3% of "Farina di Basalto®" and T2: 1.5% of "Farina di Basalto®", caused high mortality rates reaching 100% in almost all observed cases. Both concentrations may be employed to control those pests since they showed almost same results with no significant differences. As basalt showed an important insecticidal effeciency against these pests, it may be employed as a promising way to protect stored cereals.

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