THE USE OF INERT AND PLANT DUSTS TO CONTROL ONION THRIPS (*Thrips tabaci* Lindeman) AND ONION FLY (*Delia antiqua* [Meigen]) IN ONION CROPS

Monica NOVLJAN[1], Tanja BOHINC[2], Eva INDIHAR[3], Iztok Jože KOŠIR[4], Urban ŠILC[5], Aleksander HORVAT[6], Stanislav TRDAN[7]

[1-3, 7] University of Ljubljana, Biotechnical Faculty, Department of Agronomy, Ljubljana
[4] Slovenian Institute of Hop Research and Brewing, Žalec
[5] ZRC SAZU, Jovan Hadži Institute of Biology, Ljubljana
[6] Ivan Rakovec Institute of Palaeontology, Ljubljana

ABSTRACT

A two-year field experiment was conducted to study the non-chemical methods of controlling important insect pests in onion (*Allium cepa* L.), with a focus on two main insect pests, onion thrips (*Thrips tabaci*) and onion fly (*Delia antiqu*a). The trials were performed in 2022-2023 in the Laboratory Field of Biotechnical Faculty in Ljubljana with the yellow onion variety 'Sturon'. The treatments used were four types of inert dust (zeolite, quartz sand, diatomaceous earth, and wood ash of Norway spruce (*Picea abies*), plant dust (leaf powder of tree of heaven [*Ailanthus altissima*]), negative control (untreated plants) and positive control (onion, sprayed with insecticides Karate Zeon 5CS and Laser plus). The treatment applications were done in 7-10 days. During the growing season, the damage level because of the two pests were evaluated periodically, and the yields at harvest and after drying were also evaluated. In both years, the onion thrips damage was the lowest in positive control, and the severity of the attack was higher in 2022 than in 2023. In 2022, the treatment of *Ailanthus altissima* leaf powder significantly reduced the index of damage by onion thrips compared to other dust treatments. The numbers of rotting onion bulbs caused by onion fly were not statistically different between the treatments for both years and the incidence of onion fly in 2023 was far less than it was in 2022. The productivity of onions in 2022 reached 11.5 tons/ ha in the zeolite treatment, with no differences found between treatments. In 2023 the productivity of onion was doubled with a maximum of 23 tons/ ha in quartz and positive control treatments, also with no differences found between treatments. In both years, after drying, there were no differences in healthy and rotting onion yield

[1] mag. ing. hort., Jamnikarjeva 101, SI-1000 Ljubljana, email: monica.novljan@bf.uni-lj.si
[2] znan. sod., dr., ibid.
[3] mag. ing. hort., ibid.
[4] doc. dr., Cesta Žalskega tabora 2, SI-3310 Žalec
[5] izr. prof. dr., Novi Trg 2, SI-1000, Ljubljana
[6] prof. dr., ibid.
[7] prof. dr., ibid.

between the treatments. Detailed information about the efficacy of inert and plant dust in controlling pests in onions will be presented in this contribution.

Keywords: alternative control, inert dust, onion fly, onion thrips, plant dust

IZVLEČEK

UPORABA INERTNIH IN RASTLINSKIH PRAHOV ZA ZATIRANJE TOBAKOVEGA RESARJA (*Thrips tabaci* Lindeman) IN ČEBULNE MUHE (*Delia antiqua* [Meigen]) NA ČEBULI

Dvoletni poskus je bil izveden z namenom preučevanja učinkovitosti nekemičnega zatiranja dveh vrst škodljivcev čebule (*Allium cepa* L.), tobakovega resarja (*Thrips tabaci*) in čebulne muhe (*Delia antiqua*). Poskus je potekal v letih 2022 in 2023 na Laboratorijskem polju Biotehniške fakultete Ljubljani na čebuli sorte 'Sturon'. Uporabljeni so bili štirje inertni prahovi (zeolit, kremenov pesek, diatomejska zemlja in lesni pepel smreke (*Picea abies*), rastlinski prah, pridobljen iz listov velikega pajesena (*Ailanthus altissima*), negativna kontrola (netretirane rastline) in pozitivna kontrola (rastline, škropljene z insekticidoma Karate Zeon 5CS in Laser plus). Nanašanje prahov na rastline je potekalo v 7-10-dnevnih intervalih, v primeru dežja smo tretiranje ponovili. Tekom rastne dobe smo redno pregledovali rastline za poškodbe zaradi navedenih škodljivcev, prav tako smo ocenili pridelek ob spravilu in po sušenju. V obeh letih so bile poškodbe, povzročene s strani tobakovega resarja, najmanjše v pozitivni kontroli, obseg poškodb je bil večji v letu 2022 kot v letu 2023. V letu 2022 je bil indeks poškodb zaradi čebulne muhe pri obravnavanju z rastlinskim prahom rastline *Ailanthus altissima* signifikantno manjši. Število propadlih čebulic zaradi napada žerk čebulne muhe se statistično med obravnavanji v obeh letih ni razlikovalo, pojav čebulne muhe je bil v letu 2023 občutno manjši kot v letu 2022. Količina pridelka čebule v letu 2022 je znašala 11,5 t/ha v obravnavanju z zeolitom, med obravnavanji ni prišlo do razlik. V letu 2023 je bil pridelek podvojen, največji pridelek (23 t/ha) je bil pridelan v obravnavanju s kremenovim peskom in v pozitivni kontroli, med obravnavanji do statističnih razlik ni prišlo. V obeh letih po sušenju ni prišlo do razlik v zdravem in propadlem pridelku med obravnavanji. Podrobne informacije o učinkovitosti inertnih in rastlinskih prahov v našem poskusu bodo predstavljene v prispevku.

Ključne besede: čebulna muha, inertni prahovi,okoljsko sprejemljivo zatiranje rastlinski prahovi, tobakov resar

1 INTRODUCTION

Onion thrips (*Thrips tabaci* Lindeman) and onion fly (*Delia antiqua* [Meigen]) are two major insects in the production of onions around the world (Mishra et al., 2014), including in Slovenia. Control of insect pests is mostly done chemically by pesticides (Pavela, 2016). Because of the commitment of the European Union to reducing pesticides (the European Union 2023), it is important to find alternative methods to control these two pests.

Inert dust is known as an effective control tool for some insect pests, especially in controlling stored product insects (Golob 1997) and insect pests in the poultry industry (Kilpinen and Steenberg, 2009). The mode of action of inert dust in causing mortality is inducing desiccation, where water is lost because the dust removes the waxy layer of the cuticle of the exoskeleton by adsorption (Golob, 1997). The application of inert dust in vegetable fields is not yet talked about. Still, some initial reports have mentioned their efficacy in controlling the Colorado potato beetle (*Leptinotarsa decemlineata* Say) (Batistič et al., 2023), diamondback moth (DBM) (*Plutella xylostella* L.) and cabbage looper (*Trichoplusia ni* Hübner*)* (Faraone et al. 2018), in the laboratory environment.
As one of the first references, we are interested in testing the efficacy of some types of inert dust in controlling insect pests in onion crops under field conditions. In this research, we tested also the tree of heaven (*Ailanthus altissima*) leaf powder along with the inert dusts, as one of the treatments. *A. altussima* leaf powder, according to previous research in our laboratory, has high efficacy in controlling storage insect pests, namely *Sitophilus oryzae, Sitophilus zeamais,* and *Sitophilus granarius*. This research aimed to determine the efficacy of inert and plant dusts in controlling onion thrips and onion fly under field conditions and to test if the treatments affected the onion yield. In this experiment, we predicted that inert and plant dusts will be at least better than the negative control treatment in reducing damages caused by onion thrips and onion fly.

2 MATERIAL AND METHODS

2.1 Field experiment

The experiments were done in 2022 and 2023 in the Laboratory Field of Biotechnical Faculty in Ljubljana. The field used had a 240 m^2 surface field and was divided into three blocks, in which every block consisted of seven treatments/ plots. The planting line was covered with perforated black polyethylene mulch with holes placed in two rows at 25 x 25 cm and equipped with irrigation lines. The yellow onion variety 'Sturon' was planted on April 24 (2022) and April 12 (2023). During the growing season, the field experiments were maintained according to Good Agricultural Practice (GAP), meaning that the experimental plots were given proper input and maintenance, and when it is necessary, the incorporation of registered fungicides was also done, equally for the whole field surfaces.

2.2 Treatments

Seven treatments, consisting of five types of inert and plant dust from local origin, were described as follows: 1) zeolite, from Montana d.o.o., Zaloška Gorica near Žalec; 2) quartz sand, from Murexin d.o.o., Puconci, Murska Sobota, 3) diatomaceous earth, from Bela Cerkev, Šmarješke Toplice, 4) wood ash of Norway spruce (*Picea abies*), from local household in Zgornja Lipnica, near Radovljica, and 5) leaf powder of tree of heaven (*Ailanthus altissima*), from the municipality of Ljubljana. The 6th and 7th treatments, which were negative control (untreated onions) and positive control (onion, treated with insecticides Karate Zeon 5CS and Laser Plus, the registered insecticide in Slovenia), were included. The analyses of inert and plant dust were done and published (Batistič, 2023), and the inert dust chosen contained a high amount of either, or both silicon

dioxide (SiO2) or/ and calcium oxide (CaO), which can cause either desiccation or epidermal burn on insect pests. Meanwhile, the leaf powder of *Ailanthus altissima* contained nearly 20% of catechin hydrate, which according to the same source, acts as a deterrent or antifeedant for herbivore insect pests.
The application of dust was done by manually sprinkling them on onion leaves, which were wetted with dish soap water, with the help of plastic buckets, scoops, and sieves, every 7-10 days. In case of rain, the application is repeated one day after the rain. In 2022, the applications were done six times, which were on May 18, May 25, June 6, June 16, June 28, and July 8. In 2023, the applications were done seven times, which were on May 22, May 5, June 12, June 16, June 27, July 3, and July 11.
The dusts were sprinkled with a concentration of 0.13 L/ m^2. Because each dust is different in density, the amount of dust used per m^2 was also different in weight. The densities of inert and plant dust and their dosage for each treatment can be seen in Table 1.

Table 1. The densities of inert and plant dust and their dosage for each treatment.

Type of dust	Density (g/ L)	Mass of dust used per m^2 (g)
Quartz sand	1310.98	174.79
Zeolite	989.00	128
Diatomaceous earth	495.66	64.43
Wood ash	311.25	40.46
Ailanthus altissima leaf powder	320.37	41.64

2.3 Data collections

During the growing season, the damages caused by onion thrips were evaluated two times in 2022, which were on June 28 and July 8 (Figure 1), and five times in 2023, which were on June 26, July 3, July 7, July 14, and July 20 (Figure 3). The evaluation is done visually to five onion plants per experimental unit, according to the EPPO standard (EPPO, 2008), with a visual scale from 1 to 6 described in Table 1.

Table 1. The visual scale of damage to onion leaves due to the attack of the onion thrips (PP 1/267 (1)..., EPPO, 2008).

Damage index	Damaged surface on the leaves (%)
1	0
2	< 1
3	1-3
4	4-10
5	11-25
6	26-60

The damage caused by onion fly during the growing season was done by observing each experimental unit in the whole experimental plot. The rotten onion plants because of the attack of onion fly were counted and removed. In 2022, the observations were done five times, which were on May 25, June 17, June 28, July 7, and July 26. In 2023, the observations were done four times, which were on May 30, June 9, June 21, and July 3.

After the end of the growing season, we harvested the onions and immediately sorted the healthy and rotten onions at harvest, and then counted the onion average productivity and the percentage of healthy/ rotten onions. The harvest was done on August 3 in both years. After that, we dried the onions according to the principle of GAP, and after three weeks, we sorted and weighed the healthy and rotten dry onions. The average productivity of dry onions and the percentage of healthy/ rotten onions were determined on August 18 (2022) and August 21 (2023).

2.4 Statistical analysis

For data processing, we used the Statgraphics Centurion XVII program. The experiment on the right was carried out in a block design, while the experiment on the left was in a large plot demonstration trial. In both experiments, general statistical analysis was performed using multifactor analysis of variance (MANOVA), and statistical differences within individual factors in the experiment were calculated using one-way analysis of variance (ANOVA). In both analyses, we used the Student-Newman-Keuls test for multiple comparisons (P≤ 0.05) to statistically evaluate the differences in the average value for each parameter. The results of the experiment were graphically displayed using the MS Excel program.

3 RESULTS AND DISCUSSION

3.1 Effect of different treatments to damage by onion thrips

In 2022, the scoring to observe the damage by *T. tabaci* was done on two different dates. The average index of damage for the whole growing season (Figure 1) ranged between 5.1 in positive control to 5.9 in wood ash treatments. Based on the index of damage by EPPO (2006), the score 5 translated to 11-25% of damage. The leaf powder of *Ailanthus altissima* showed the lowest damage out of all the dust tested, with an average scale of 5.5.

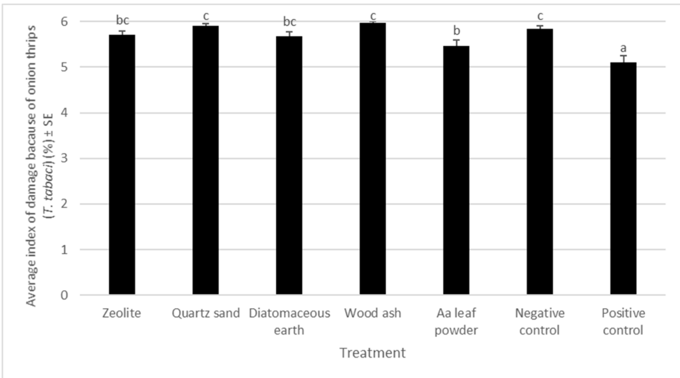

Figure 1: The average index of damage because of onion thrips *(T. tabaci)* for the whole growing season of 2022. The same letter above the bars shows no differences by the Student-Newman-Keuls test for multiple comparisons ($p \leq 0.05$).

In 2023 the observation for index of damage by *T. tabaci* was done on five different dates. In general, the positive control treatment showed the least damage on all three dates, whereas all other six treatments showed the same extent of damage (Figure 2). The average index damage for the whole season ranged between 1.8 in positive control to 2.7 in *Ailanthus altissima* leaf powder treatment. Compared to the year 2022, the damages of onion caused by *T. tabaci* in the year 2023 were a lot less significant, with the maximum damage shown around the scale of 2 (<1% damage on leaves).

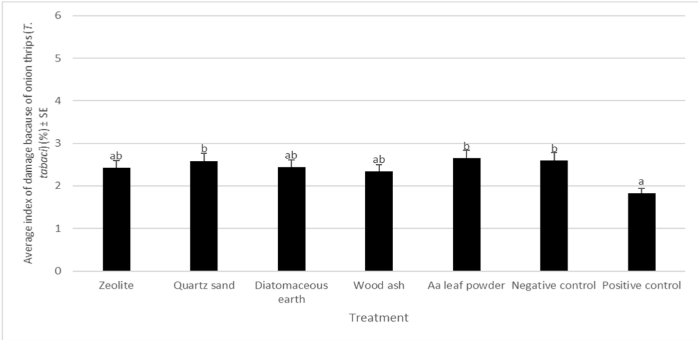

Figure 2: The average index of damage because of onion thrips *(T. tabaci)* for the whole growing season of 2023. The same letter above the bars shows no differences by the Student-Newman-Keuls test for multiple comparisons (p ≤ 0.05).

3.2 Effect of different treatments to damage by onion fly

In 2022, the counting of the total number of rotting onion bulbs because of *D. antiqua* attack was done on five different dates. The average number of rotting onions for the whole 2022 season (Figure 3) showed all treatments had the same damage by *D. antiqua.* The average of *D. antiqua* damage ranged from 1-1.9 rotten onion per observation date per experimental unit.

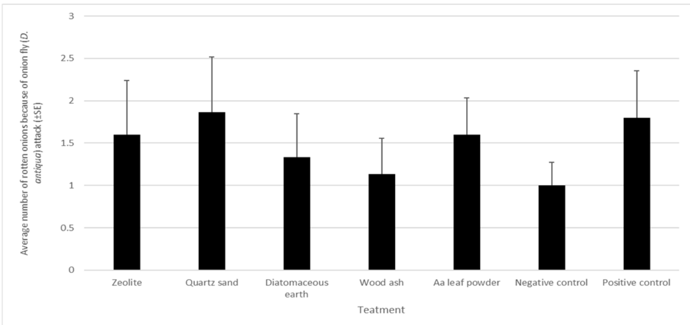

Figure 3: The average number of rotting onion bulbs because of onion fly *(D. antiqua)* for the whole growing season of 2022. There were no statistical differences between the treatments according to one-way ANOVA (p ≤ 0.05).

In 2023, the counting of the total number of rotting onion bulbs because of *D. antiqua* attack was done on four different dates, but rotten onions were only found on two dates. The average of found rotting onions for the whole 2023 season (Figure 4) showed that the attack of *D. antiqua* in our experimental plot in 2023 was really low, with up to 0.33 rotting onions per observation date per experimental unit, with no significant difference between treatments.

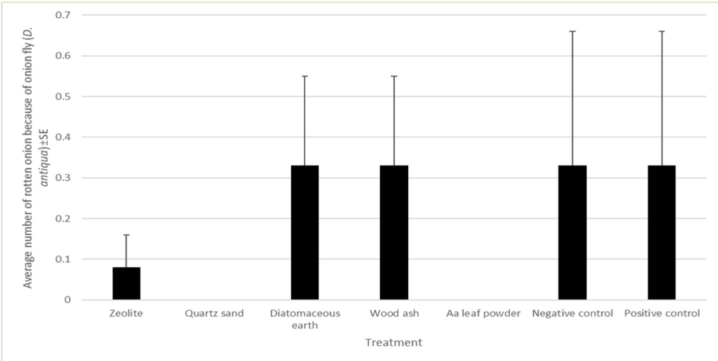

Figure 4: The average number of rotting onion bulbs because of onion fly *(D. antiqua)* for the whole growing season of 2023. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$).

3.3 Effect of different treatments on the yield of onion on harvest day

In 2022, the total yield of onions ranged between 8.9 and 11.5 tons/ ha depending on the treatment (Figure 5), but the values were not statistically different between treatments. A more detailed observation of healthy and unhealthy (rotting onion) yield at harvest (Figure 6) showed that their values were also not statistically different between treatments.

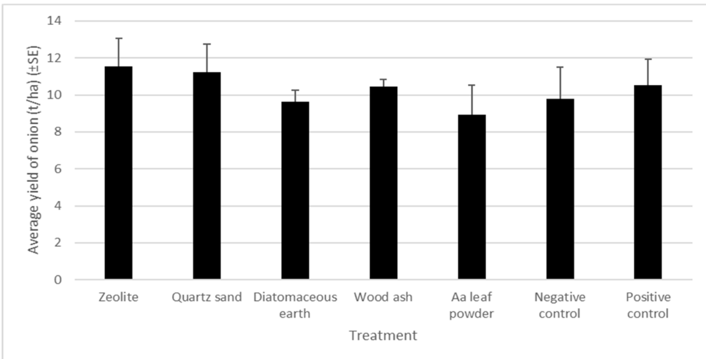

Figure 5: The average total yield of onion at harvest (t/ ha) ± SE in 2022. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$).

In 2023, the average yield of onions is almost doubled compared to the values in 2022, ranging between 14.5 to 23.7 tons/ha (Figure 7), but the values were not significantly different between the treatments. Same as the value in the year before, there were no differences in healthy and unhealthy (rotten onion) yield (Figure 8). Based on our observation, the similarity of the productivity of onion between the treatments could be a result of the low attack of insect pests. Our onions were grown with Good Agricultural Practice (GAP) and were given equal inputs on the whole surface, for example, water, fertilizer, fungicide (when necessary), and manual weed removal. According to the EPPO standard (EPPO, 2000) for *Allium* crops, the application of insecticide against onion thrips can be started as soon as the damage is seen, and damage of 5-10% is considered an economic threshold. In our experiment, the damage caused by onion thrips exceeded the threshold only in 2022 in the whole experimental plot and not in 2023.

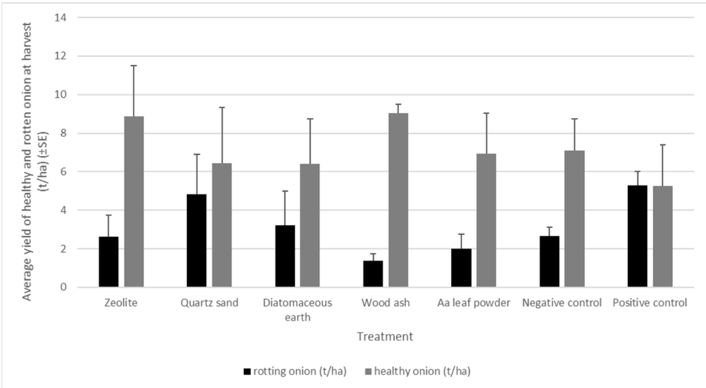

Figure 6: The average yield of healthy and rotten onion at harvest (t/ ha) ± SE in 2022. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$).

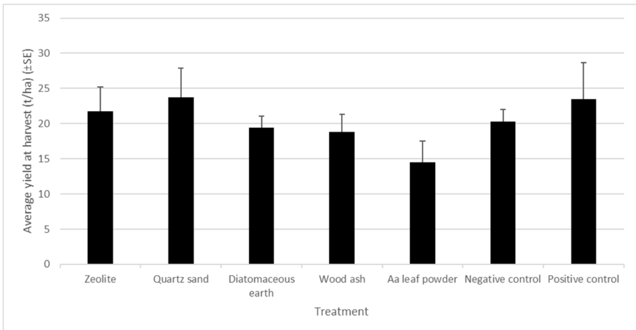

Figure 7: The average total yield of onion at harvest (t/ ha) ± SE in 2023. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$).

But, in 2022, we predicted that the productivity was generally low for all treatments also because of the dry and hot conditions in that year. Additionally, according to Loorber et al., (2002), the action threshold for onion maggots is when 5% of the seedling population has been damaged by onion maggots. In our experience, one experimental unit of 7m^2 planting surface had a population of approximately 56 onion plants, and based on this condition, the threshold will be around 2.9 rotting onions per experimental unit. The average number of rotting onion bulbs per experimental unit exceeded this threshold only on the last observation date (data unshown), with the average of maximum 1.9 rotting onions per observation unit per observation date in the 2022 season (Figure 3). The average numbers of rotting onion were never exceeded this threshold in the 2023 season.

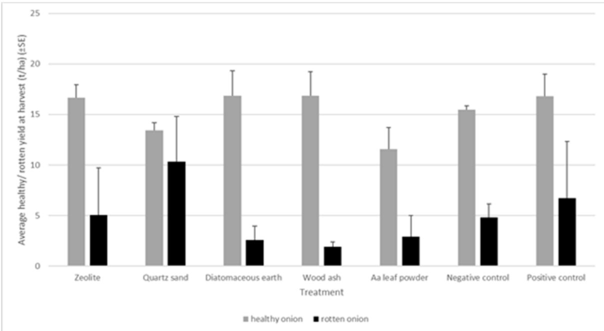

Figure 8: The average yield of healthy and rotten onion at harvest (t/ ha) ± SE in 2023. There were no statistical differences between the treatments ($p \leq 0.05$).

3.4 Effect of different treatments on the yield of onion after drying

In 2022, after three weeks of drying, the average yield of healthy and rotting dry onion is presented in Figure 9. There was no difference in the values of healthy and rotting onion yield between the treatments.

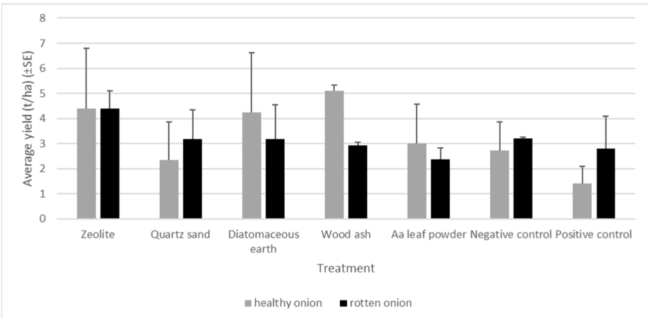

Figure 9: The average yield of healthy and rotten onion after drying (t/ ha) ± SE in 2022. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$).

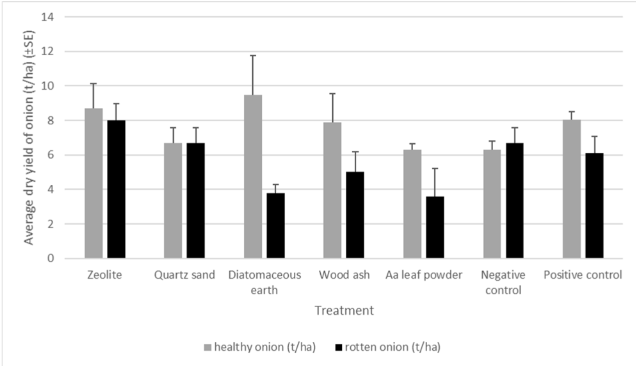

Figure 10: The average yield of healthy and rotten onion after drying (t/ ha) ± SE in 2023. There were no statistical differences between the treatments according to one-way ANOVA ($p \leq 0.05$)

The average yield of healthy and rotting dry onions in 2023 is presented in Figure 10. Just like the result in 2022, there was no difference in the values of healthy and rotting onion yield between the treatments. In both 2022 and 2023, even though there was no difference between the values of healthy and dry onion yield between treatments, the maximum values of healthy dry onions were achieved in the treatment with wood ash treatment (Figures 9 and 10). A previous study by Ogali (1994) reported the efficacy of wood ash treatment in combination with perforated polyethylene bags in controlling rotting and weight loss during 24 weeks of storage of cocoyam tubers (*Xanthosoma sagittifolium* L.). The use of wood ash might potentially reduce rotting caused by various fungi in the storage of bulbs, but this theory needs to be further investigated.

4 CONCLUSIONS

Based on our research, the inert and plant dust were inferior compared to insecticide in controlling *T. tabaci* in onion crops in 2022 and 2023 trials. In 2022, the leaf powder of *Ailanthus altissima* reduced the thrips damage significantly compared to other dust treatments. There was no proof that the dust could control *D. antiqua* in onion crops, but in both years, the damage caused by *D. antiqua* was pretty insignificant. The productivity result showed that there were no differences between the treatments in total yield, healthy yield, and rotting yield, both on harvest day and after three weeks of drying. The percentage of healthy onions after drying was the highest in the wood ash treatments in both years, but the effect of wood ash in onion storage needs to be further investigated. The onions were observed to be grown well in the whole experimental plots and the low attack of insects resulted in uniform productivity in all plots.

5 ACKNOWLEDGEMENTS

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