Indian Journal of Entomology Online published Ref. No. e24143 DoI. No.: 10.55446/IJE.2024.2143

EFFICACY OF BOTANICALS AGAINST RICE WEEVIL *SITOPHILUS ORYZAE* (L) ON STORED SORGHUM

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ABSTRACT

A laboratory experiment was carried out to evaluate botanicals and locally available natural products against rice weevil *Sitophilus oryzae* (L). *Phytolacca dodecandra* (endod) seed, *Azadirachta indica* (neem) seed, and *Allium sativum* (garlic) led to more adult mortality as well as had a comparable effect to malathion dust (5%), which completely protected the grains against F1 progeny, while *Croton macrostachyus* leaf and seed powder caused the lowest adult mortality. However, *P. dodecandra* leaf and *A. indica* seeds led to the least amount of seed damage. The germination tests showed that none of the botanicals had an adverse effect.

Key words: *Allium sativum, Azadirachta indica*, botanical insecticides, F1 progeny, germination capacity, grain damage, mortality, *Phytolacca dodecandra,* protection of grains, *Sorghum bicolor,* storage pests, weight loss

Sorghum bicolor L. (sorghum) accounts for one third of Ethiopia's cereal diet and Ethiopia is third in Africa in terms of production. In the study area, Dejen District, it is one of the most resilient field crops (Negasa et al., 2021). In terms of yield *S. bicolor* production in Dejen District was second only to *Eragrostis tef* (Dejen District Agricultural Development Office Annual Report, 2021). The crop faces a number of challenges. Various pests attack and harm *S. bicolor* grains, resulting in loss of quality, quantity, nutrition, and viability (Abbas, 2014). One of the most serious issues with sorghum production is insect pest damage during storage. Many storage insect pests, including the *Sitophilus* spp., and *Sitotroga cerealella* (Olivier), are significant pests (Nezif et al., 2020). *Sitophilus oryzae* (L.) is an important, polyphagous insect pest that seriously harms stored *S. bicolor*. It can be responsible for up to 75% of *S. bicolar* L. seed losses when stored in conventional storage structures (Dal Bello et al., 2001). After that pest damage that weevils cause to grains may cause them to breathe more heavily because of pests, which encourages the growth of heat and moisture and creates the ideal environment for molds that make aflatoxin. After that, very high moisture levels are common for bacterial proliferation, which gradually cause total loss (Maribet et al., 2008). *Sitophilus oryzae* infestations can be reduced through management handling stored carefully. Synthetic insecticides are the most widely used to eradicate *S. oryzae* (Barre and Jenber, 2023). There have been numerous problems associated with the widespread use of insecticides and fumigants (Bhargude et al., 2021). As a result, it is vital to look for substitute sources and attention and awareness of botanicals or plant materials as grain protectants is common. These plants are simpler to obtain and less dangerous. Botanicals have no effect on non-target animals. Therefore, it is essential to study botanicals and locally accessible products as an alternative means of treating *S. oryzae*.

MATERIALS AND METHODS

The research was carried out in the Dejen District, Ethiopia (10°7 to 10°11' N, 38°6' to 38°10' E, 1071 to 3000 masl- DDARDO, 2021). Adult *S. oryzae* L were collected from naturally contaminated *S. bicolor* grains at the farmer's home and a culture was established. Disinfected *S. bicolor* grains were used to raise *S. oryzae* with 1 kg grains placed in four plastic jars along with 200 adults of *S. oryzae* L. The tops of the plastic jars were sealed with a rubber band and nylon cloth. After fifteen days of oviposition, the adult *S. oryzae* were removed and left in the *S. bicolor* until a new adult emerged. The experiment carried out using newly emerging adult *S. oryzae* that were 42 days old under laboratory conditions, and this culture kept alive. The treatments include eight botanicals: *Azadirachta indica* seed, *Azadirachta indica* leaf, *Allium sativum* *bulb, Croton macrostachyus Hochst* leaf, *Croton macrostachyus Hochst* seed, *Phytolaccadodecandra* seed, *Phytolaccadodecandra* leaf, *Zingiber officinale Roscoe* powder, and two locally available products: wood ash and *Eragrostistef* (Tef) with Malathion Dust 5% as standard check and untreated/ control. The design of the experiment was completely random design and replicated three times. The leaves, seeds, bulb, and rhizome of botanical plants collected and dried under shade, milled finely and sieved through a mesh to obtain fine and uniform dust. The powders preserved in sealed polythene bags and stored at room temperature until their use for insect bioassays (Devi et al., 2014).

"Mako", a local variety of *S. bicolor* was used as an experimental crop and grains kept in the refrigerator to disinfect the grain. Botanical plant powders were added at a rate of 5% w/w, along with locally available products such as *E. tef* seed (20% w/w) wood ash dust (10% w/w), and malathion (5%) w/w. In the experiment, 200 g of *S. bicolor* grains was maintained in a medium-sized (1 l capacity) plastic jar. For each jar, 10 g of botanical powders, 20 g of ash dust, and 40 g of E. *tef* seed were added and thoroughly mixed. Subsequently, 20 randomly selected unsexed F1 progeny of *S. oryzae* was introduced into each jar. The treated grains in the jar were preserved for 70 days, and adult mortality evaluations were made regularly at three, seven, fourteen, twenty-one and twenty-eight days after treatment. Dead *S. oryzae* were counted and discarded on each assessment day, while live weevils restored to their respective treatments. The remaining *S. oryzae* both dead and alive were counted and discarded on the seventieth day. The % data for adult *S. oryzae* were corrected using the Abbott (1925). After the removal of dead and alive *S. oryzae* the grains kept in the same experimental settings for an additional 42 days to allow for the emergency F1 progeny. At 42 days, the number of living and dead *S. oryzae* emerging were counted and recorded, and the F1 progeny used. The assessment dates were chose in accordance with Swamynarayana et al. (2014). The efficacy of treatments was calculated. El-Ghar and El-Sheikh's (1987) formula was used to compute % reduction in adult emergence or inhibition rate. The weight loss (%) was calculated using the method provided by Gwinner et al. (1996). Grain damage % translating it using Wambugu et al. (2009). The germination was estimated using the Raun et al. (2001). SAS software was used to perform ANOVA after square root transformation. The effects of the treatments was evaluated by seperating mean values using Tukey's Studentized Range (HSD- p= 0.05).

RESULTS AND DISCUSSION

There were significant differences ($p<0.05$) between treatments in causing adult mortality. Three days after treatment, 5% malathion dust resulted in 100% mortality of adult; *P. dodecandra* seed (36.67%), *A. indica* seed (26.67%) and *P. dodecandra* leaf (21.67%) caused the highest adult mortality, while *C. macrostachyus* leaf and seed (1.67%) and (3.33%), respectively, caused the lowest mortality. There was no mortality recorded when treated with *E. tef*. Seven days after treatments was with mortality maximum *P. dodecandra* seed (80.0%), *P. dodecandra* leaf (75.0%), and *A. indica* seed (71.67%). Wood ash dust (45%) had the highest *S. oryzae* L death rate among locally available products. The lowest *S. oryzae* L mortality was recorded in *E. tef* (3.33%), followed by the control (0.0%) (Table 1). Adult *S. oryzae* mortality was highest with *P. dodecandra* seed (94.92%), followed by *A. indica* seed (88.14%) and *P. dodecandra* leaf (84.75%) while the lowest found in the seed and leaf of *C. macrostachyus*. Twenty-one days after treatments, *P. dodecandra* seed (100.0%) gave significantly ($p<0.05$) highest adult mortality, which was comparable to malathion 5% dust. The botanicals *A. indica* seed (100%), *P. dodecandra* seed (100%), and *P. dodecandra* leaf (100%), significantly ($p<0.05$), gave the highest mortality 28 days after treatment. Botanicals, including *A. sativum* leaf (94.23%) and *A. indica* leaf (90.38%), were successful in lowering adult mortality rates. Treatments such as wood ash dust (78.84%) and *Z. officinale* (73.07%) showed high mortality rates; *C. macrostachyus* seed and leaf were the least effective which was less effective in adult *S. oryzae* mortality after twenty-eight days of treatment. These results revealed that botanicals, such as *P. dodecandra* and *A. indica* leaf and seed, produced results similar to malathion 5% dust, which may reduce the lifespan of *S. oryzae* L. and is more effective than other treatments on the third, seventh, fourteenth, twenty-one, and twenty-eighth days after treatment. In general, on the third, seventh, fourteenth, twenty-one, and twenty-eighth days after treatment applications, the seed parts of botanicals like *A. indica, P. dodecandra*, and *C. macrostachyus* showed maximum mortality compared to leaf part. On 28 days after treatment, however, there was no significant difference in mortality between seed and leaf parts *in P. dodecandra*. Furthermore, all the botanical treatments, including wood ash dust, significantly increase the adult mortality. These results are consistent with other findings on the effectiveness of botanical powders. According to Adane et al. (2021), botanical treatment of sorghum grain with garlic and

Table 1. Mortality of *S. oryzae* in sorghum grains treated botanical insecticides

Treatment	Mortality after treatment application (%)				
	3- DAT	7- DAT	14- DAT	21- DAT	28- DAT
A. indica seed	26.67± 1.67^{c}	71.67± 4.41^{bc}	88.14± 4.48^{b}	94.74± 3.04^{a}	100.00± 0.0^{a}
A. indica leaf	11.67± 1.67^{de}	56.67± 7.26^{d}	67.80± 6.11^{de}	77.19± 4.64^{c}	90.38± 1.92^{b}
A. sativum	15.00± 2.89^{d}	61.67± 4.41^{cd}	74.58± 5.87^{cd}	82.46± 4.64^{bc}	94.23± 3.33^{ab}
Z. officinale	5.00± 2.89^{fg}	28.33± 6.01^{f}	49.16± 5.87^{f}	59.65± 4.64^{de}	73.07± 5.09^{c}
P. dodecandra seed	36.67± 4.41^{b}	80.00± 2.89^{b}	94.92± 2.94^{ab}	100.00± 0.0^{a}	100.00± 0.0^{a}
*P. dodecandra*leaf	21.67± 1.67^{c}	75.00± 2.89^{b}	84.75± 2.94^{bc}	91.23± 3.51^{ab}	100.00± 0.0^{a}
C. chyus seed	3.33± 1.67^{fg}	20.00± 2.89^{fg}	35.60± 4.48^{g}	47.37± 6.08^{f}	59.61± 3.33^{d}
*C. chyus*leaf	1.67± 1.67^{g}	16.67± 4.41^{g}	28.83± 2.94^{g}	50.88± 3.51^{ef}	61.53± 5.09^{d}
E. tef seed 20%	0.00± 0.00^{g}	3.33± 1.67^{h}	10.19± 1.69^{h}	21.05± 3.04^{g}	36.53± 3.33^{e}
Wood ash dust 10%	8.33± 1.67^{ef}	45.00± 2.89^{e}	57.63± 1.69^{ef}	64.91± 4.64^{d}	78.84± 5.09^{c}
Malathion 5% dust	100.00± 0.0^{a}	100.00 ± 0.0^{a}	100.00± 0.0^{a}	100.00± 0.0^{a}	100.00± 0.0^{a}
Control (untreated)	0.00± 0.00^{g}	0.00± 0.00^{h}	1.13± 1.13^{h}	1.75± 1.75^{h}	2.56± 2.56^{f}
Mean	19.17	46.53	57.73	65.94	74.73
CV (%)	18.95	14.55	11.60	9.87	7.37
LSD	6.12	11.41	11.28	10.96	9.28

Means within a column followed by a different letter(s) significantly at p<0.05, Fisher least significant difference (LSD) method; CV= coefficient of variance; DAT= days after treatment.

neem seed powder was more effective; *A. indica* seed caused the highest *S. zeamais* mortality, and *A. sativum* leaves after 28th days after treatment (Jamaal and Jenber, 2022).

The effects of treatments on the emergence of adult progeny were significantly different (p< 0.05); *P. dodecandra* seed showed a small amount of F1 progeny (0.67%), while malathion 5% dust completely prevented the F1 progeny (0.0). Additionally, *A. indica* leaf 3.33, *P. dodecandra* leaf 1.67, *A. sativum* 2.67, and *A. indica* seed 1.33 all revealed strong insecticidal effects by lowering the emergence of adult progeny; adult progeny emergence was observed on grains treated with *E. tef* (20.0). Thus, *P. dodecandra* seed was successful in reducing the progeny of *S. oryzae* L. by preventing the development and reproduction of the progeny (Table 2). Botanicals have the potential to inhibit F1 progeny and these significantly reduce the emergence of *S. oryzae*. These results are supported by the findings of Kifle et al. (2017), who found that sorghum treated with 5 and 10% neem seed powder produced no progeny. Ferdu et al. (2001), found that *P. dodecandra* seed and leaf powder reduced the emergence of progeny in maize weevils. The present study revealed that all treatments were statistically superior and provided greater protection against *S. oryzae* (Table 2). The best botanicals to prevent *S. oryzae* from *S. bicolar* grains were *P. dodecandra* seed, *A. indica* seed, *P. dodecandra* leaf, *A. sativum* and *A. indica* leaf. Yeshiwork (2017) reported similar outcomes; while *C. macrostachyus* was the least efficient in protecting maize grains from F1 progeny. Maize grains treated with *A. indica* seeds almost completely protected. Jamaal and Jenber et al. (2022) with *A. sativum, A. indica, Lantana camara, Z. officinale,* and *Schinusmolle* leaves, reported similar results. The % of weight loss differed significantly (p<0.05) among treatments; the lowest weight losses were observed in malathion 5% dust (0.0%); *P. dodecandra* seed (0.63%), *A. indica* seed (0.77%) and *P. dodecandra* leaf (0.93%). The grains treated with *C. macrostachyus* leaf (3.57%), *C. macrostachyus* seed (3.13%), and *Z. officinale* (2.03%) followed by mixing with *E. tef* (4.60%), showed maximum weight loss. These results are supported by the findings of Govindan et al. (2020), on seeds treated with botanicals as compared to those untreated during storage in sorghum seeds treated with insecticidal plant powders against *S. oryzae*. According to Kalkidan (2019), maize grains treated with *P. dodecandra* seed had a considerable weight loss reduction and nearly completely protected from *S. zeamais*. According to Adugna et al. (2006), stored *S. bicolar* could lose up to 9-29% of its weight.

There were significant differences (p<0.05) between the treatments in terms of grain damage caused by *S. oryzae*. The botanical treatments that showed the most grain damage were *C. macrostachyus* seed (8.20%), *C. macrostachyus*leaf (7.73%), and *Z. officinale* (5.23%).*P. dodecandra* seed (1.67%) and *A. indica* seed (1.93%)

Table 2. Effect of botanicals on F1- progeny, protection grain damage, weight loss, and germination

Treatment	F1- progeny	Protection %	Grain damage (%)	Weight loss (%)	Germination (%)
A. indica seed	1.33± 0.88[g]	96.49± 2.32[a]	1.93± 0.47[gf]	0.77± 0.23[f]	92.67± 2.03[abc]
A. indica leaf	3.33± 1.45[efg]	91.23± 3.82[abc]	3.57± 0.72[e]	1.08± 0.17[ef]	87.00± 2.31[de]
A. sativum	2.67± 0.88[fg]	92.98± 2.32[ab]	3.23± 0.50[ef]	1.03± 0.24[ef]	88.67± 2.40[cd]
Z. officinale	6.33± 1.45[de]	83.33± 3.82[cd]	5.23± 0.98[d]	2.03± 0.38[d]	80.33± 2.60[fg]
P. dodecandra seed	0.67± 0.67[g]	98.25± 1.75[a]	1.67± 0.23[g]	0.63± 0.20[f]	95.33± 1.45[a]
*P. dodecandra*leaf	1.67± 0.88[g]	95.61± 2.32[a]	2.87± 0.15[efg]	0.93± 0.15[f]	90.00± 1.73[bcd]
C.chyus seed	8.67± 1.45[cd]	77.19± 3.82[de]	8.20± 0.72[c]	3.13± 0.27[c]	76.00± 1.73[gh]
*C.chyus*leaf	10.33± 0.88[c]	72.81± 2.32[e]	7.73± 0.35[c]	3.57± 0.15[c]	75.00± 1.15[hi]
E. teff seed 20%	22.00± 1.53[b]	42.11± 4.02[f]	12.87± 0.35[b]	4.60± 0.17[b]	70.67± 1.20[ij]
Wood ash dust 10%	5.67± 0.88[def]	85.09± 2.32[bcd]	4.33± 0.22[de]	1.60± 0.17[de]	83.00± 1.73[ef]
Malathion 5% dust	0.00± 0.00[g]	100.00± 0.0[a]	0.00± 0.00[h]	0.00± 0.00[g]	94.00± 1.15[ab]
Control (untreated)	38.00± 1.73[a]	0.00± 0.00[g]	16.67± 0.58[a]	7.53± 0.15[a]	66.67± 1.45[j]
Mean	8.39	77.92	5.69	2.24	83.28
CV (%)	23.84	6.75	15.67	16.22	3.77
LSD	3.37	8..87	1.50	0.61	5.28

Means within a column followed by different letters significantly at p<0.05, Fisher least significant difference (LSD) method; where CV= coefficient of variance.

were the treatments that resulted in least grain damage similar to malathion 5% dust. Bhargude et al. (2021) evaluated the effectiveness of various botanical products against *S. oryzae* in stored sorghum seeds. He found that *A. indica* seed at a rate of 5% recorded low seed damage Adane et al. (2021) obtained similar results using botanicals on preserved sorghum. The results of the germination showed that none of the botanical powders had an adverse effect. This suggests that the damage caused by *S. oryzae* reduced the germination. The low germination percentages recorded on *C. macrostachyus* seed (76.00%), *C. macrostachyus* leaf (75.00%), and *E. tef* seed (70.67%). The maximum rate of germination seen on *P. dodecandra* seed (95.33%), malathion 5% dust (94.00%), *A. indica* seed (92.67%), and *P. dodecandra* leaf (90.00%) (Table 2). Daniel (2020) supported this study, finding no significant difference in germination. According to Asmare (2002), *S. bicolar* seeds treated with the *P. dodecandra, A. indica, D. stramonium* and *J. curcas* against *S. zeamais* had no adverse effect on germination. Kalkidan (2019) observed similar results with botanicals in the control of maize weevil on maize.

Thus, the tested plant materials and locally available products showed insecticidal properties as grain protectants against *S. oryzae*. They were significantly different from the control in lowering the weight loss, damage emergence of progeny, and the adult mortality. Farmers should be encouraged to utilize the botanicals *A. indica, A. sativum,* and *P. dodecandra* in protecting storage insect pests.

ACKNOWLEDGEMENTS

The authors thank Dejen Agricultural and Quarantine Office for providing the laboratory facilities.

FINANCIAL SUPPORT

No funding received.

AUTHOR CONTRIBUTION STATEMENT

HMC conceived and designed the research, conducted experiments analyzed and wrote the manuscript. AJJ conceived and designed the research, supervise the experiment and edit the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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(Manuscript Received: April, 2024; Revised: April, 2024;
Accepted: April, 2024; Online Published: May, 2024)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e24143