

Germination capacity and seedling vigour of chickpea (*Cicer arietinum*) seeds damaged either by Adzuki bean beetle (*Callosobruchus chinensis*) or rice weevil (*Sitophilus oryzae*)

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Research Article

Keywords: Adzuki bean beetle, chickpea, decayed seeds, farmers' saved seed, seed quality

Posted Date: May 9th, 2025

DOI: <https://doi.org/10.21203/rs.3.rs-6428943/v1>

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Additional Declarations: No competing interests reported.

Abstract

Stored chickpea is infested by the Adzuki bean beetle and occasionally by the rice weevil, *Sitophilus oryzae* (L.). However, in Ethiopia, the association between the level of damage done to chickpea seed by each insect species and germination capacity of damaged seeds has not been determined. Thus, a laboratory experiment was conducted in the Seed Laboratory at Debre Zeit Agricultural Research Center using the chickpea cultivars Arerti and Natoli. The seeds that Adzuki bean beetle were damaged were categorized based on the number of holes per seed as 0 = no hole 1 = one hole per seed and so on; whereas seeds that were damaged by rice weevil were classified as either damaged or undamaged. The sand method was followed to test the germination capacity and vigor of the different categories of insect damaged chickpea seeds. All seeds that were damaged by adult rice weevil did not germinate. Moreover, in Adzuki bean beetle damaged seeds, the proportion of normal seedlings, seedling shoot length, seedling root length, seedling fresh weight, seedling dry weight, vigour and speed of germination significantly decreased as the number of holes per seed increased; whereas the proportion of abnormal seedlings and decayed seeds increased as the number of holes per hole increases. Therefore, seed damaged by both Adzuki bean beetle and the rice weevil should not be used as a seed by farmers due to deterioration of seed quality.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the most widely well-known food legume in South Asia, with production in over 50 countries (89.7% in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in the Americas, and 0.4% in Europe). India is the largest country producing chickpeas, accounting for 64% of global production (Gaur et al., 2010). Chickpeas are a major carbohydrate and protein source for millions of people in developing countries. The seeds contain high levels of all necessary amino acids, minerals (phosphorus, calcium, magnesium, iron, zinc, folic acid), and β -carotene. The lipid element is rich in unsaturated fatty acids (Gaur et al., 2010; Jayakumar et al., 2025).

In Ethiopia, chickpea is produced by several hundreds of thousands of subsistence farmers who have no access to improved technologies. For instance, close to 649, 000 households in the 2019/20 and 783,000 in the 2020/21 cropping season have grown desi type of chickpea in an area of close to 177, 000 and 176, 000 ha, respectively (CSA, 2020; 2021). Out of these households, only 0.51% in 2019/20 and 0.99% in 2020/21 cropping season have sown improved chickpea seed in a negligible area. This is because both the private and the public seed producers opt to produce seeds of cereal crops, mainly maize and bread wheat than pulse crops (Sisay et al., 2017). As a result, most farmers use their own saved or seeds obtained from colleague farmers.

However, farmers' saved seeds are poor in quality because they reclaimed them from grain produced for home consumption (Kabeere et al., 2002). Thus, some of these seeds are infected by major diseases of chickpea such as *Fusarium oxysporum* (Alemu and Sinclair 1979; Getaneh et al., 2020) and Ascochyta blight (*Ascochyta rabiei* (Pass.) Labr.) (Nene 1982). Similarly, according to Boxall (1998) the nationwide damage by storage insect pests, particularly *Callosobruchus* sp. in stored pulses can reach up to 18%. The Adzuki bean beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae) is the major storage insect pest in stored chickpea throughout the world. It is also a major storage insect pest of cultivated pulses in low and mid-altitude (1500–2200 m a.s.l.) areas of Ethiopia. For instance, in stored chickpea, it causes up to 50% weight loss within six months of storage (Tebkew and Geteneh, 2020).

Although the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) is major storage insect pest of cereals, but due to the existence of distinctive geographical strains, it is also capable infesting and breeding on stored pulses including chickpea (Holloway and Smith 1985; Holloway 1986; Grenier et al., 1997). Furthermore, the rice weevil has long been known to infest stored chickpea in Ethiopia (Walker and Boxall 1974).

The effect of insect damage on seed germination capacity of different crops such as common bean (*Phaseolus vulgaris* L.) damaged by bean weevil, *Acanthoscelides obtectus* Say (Baier and Webster 1992), chickpea damaged by cowpea weevil (*Callosobruchus maculatus* (Fab.)) (Allali et al., 2020) and wheat damaged either by the granary weevil, *Sitophilus granarius* (L.), or the rice weevil, *S. oryzae* (L.) (Sinha 1984) have been studied. In Ethiopia, information on the extent of weight losses

that the rice weevil causes in stored chickpea and the germination capacity of damaged seeds are unavailable. Moreover, the Adzuki bean beetle has multiple generations in a year. Consequently, a grain can be infested several times as the duration of infestation continues. However, multiple infestations, which resulted in several number of holes per seed, effect on germination and seedling vigor of chickpea has not been investigated. Thus, the objective of this study was to determine the association between level of damage done by each insect species and germination capacity of chickpea under laboratory conditions.

2. MATERIALS AND METHODS

The experiment was conducted in August 2021 in the Seed Laboratory at Debre Zeit Agricultural Research Center, Bishoftu, Ethiopia. As showed on Fig. 1, chickpea cultivars included in the experiment were Arerti and Natoli. Natoli is desi type with Tuberculated seed coat texture and weighs 26 g per 100 seeds; whereas Arerti is Kabuli type with smooth seed coat texture and weighs 22 g per 100 seeds. The rice weevil and the Adzuki bean beetle were obtained from infested chickpea seeds at Debre Zeit seed laboratory and from entomology laboratory, respectively. For each cultivar, there were two jars each filled with 350 g of seeds. One jar was infested with rice weevil, while the other jar was infested with Adzuki bean beetle. The infested jars were left in the seed laboratory at a room temperature until the seeds were damaged by each insect (rice weevil and the Adzuki bean beetle). Then, the seeds that damaged by Adzuki bean beetle were categorized based on the number of holes per seed as 0 = no hole, 1 = one hole per seed and so on; while seeds that were damaged by rice weevil were classified as either damaged or undamaged.

Germination test

The sand method was followed to test the germination capacity and vigor of insect damaged chickpea seeds. The sand was washed to remove dust and was sterilized with electrical heat before use. Also, the germination box (10 cm deep, 18 cm wide and 27cm long) was sterilized by wiping the inside surface with 95% alcohol. Then each germination box was filled with 4 kg of sterilized river sand and 100 ml distilled water was applied once per box at the time of planting. From each damaged seed category, 30 seeds were randomly selected and a seed was planted per hole at a depth of 3 cm. To avoid seed contact with each other, rows and columns were spaced 5 cm and 3 cm apart, respectively. After planting the seeds, the box was closed with its cap and placed in the seed laboratory at room temperature (20–25°C). The treatments were arranged in two factors nested (hole number nested within cultivar) design with four replications.

Data collection

Seeds that germinated from each damage category were counted and recorded every 24 h for about eight days i.e. until no seed germinates. Moreover, the seedling shoots and root length were measured from randomly selected five plants per replication eight days after planting. To get the fresh and dry weight of seedlings, only normal seedlings were severed at the sand level; weighed to obtain fresh weight; and then dried for 24 h at 80°C. After drying the dry weight of seedlings was measured.

At the end of germination test, data were noted on the number of normal seedlings, abnormal seedlings and dead seeds. Furthermore, data on vigour index I and vigour index II were derived from shoot length, root length and standard germination using the formulae indicated below.

$$\text{Vigour index I} = \text{standardgermination}(\%) \times (\text{shootlength} + \text{rootlength}(\text{cm}))$$

$$\text{Vigour index II} = \text{standardgermination}(\%) \times \text{dryweight}(g)$$

Data Analysis

Data analysis was carried out using Proc NESTED of SAS. However, before analysis all the percentage data were transformed to arc sine to stabilize the variance; but only the original data were reported. The mean comparison was done using Tukey minimum significant difference test at appropriate level of significance.

3. RESULT AND DISCUSSION

Effect of rice weevil

The rice weevil bores hole and lays egg in the hole. Then, the hole is plugged with a substance similar in colour with the seed coat, which makes it unidentifiable with naked eye. Besides, the larva is an internal feeder and it was difficult to identify seeds that contain larvae inside them. Thus, only seeds damaged by the adults were tested and found that all seeds damaged by adult rice weevil did not germinate. The complete germination failure was due to the consumption of the whole content of a chickpea seed by the adult rice weevil. This result was in agreement with Sinha (1984) who affirmed that the rice weevil feeds on both embryo and endosperm of wheat seed which in turn leads to complete losses of germination capacity.

Effect of Adzuki bean beetle

The proportion of normal seedlings, abnormal seedlings and dead seeds were highly significantly ($P < 0.01$) affected by the number of holes per seed; whereas the effects of cultivar were statistically non-significant ($P > 0.05$). Thus, the number of holes per seed accounted for 98.8% of the total variation in the proportion of normal seedlings among the different seed damage categories. Although the proportion of normal seedlings continuously declined as the number of holes per seed increased (Table 1), the relationship was not linear. Rather the quadratic function ($y_i = 84.55 - 28.40x_i + 3.11x_i^2$, $r^2 = 0.928$, $df_1 = 2$, $df_2 = 4$, $\alpha = 0.01$) explained better the relationship between hole number (x_i) and proportion of normal seedlings (y_i). Thus, on both cultivars, the proportions of normal seedlings from undamaged seeds were greater than 90% but it decreased nearly by half when there was one hole per seed. Similarly, half of the seedlings from seeds with one hole were normal seedlings but this proportion decreased, depending upon cultivar, by 10 to 15% when there were two holes per seed. Moreover, seeds with four or more holes per seed had the lowest proportion of normal seedlings.

The number of holes per seed also accounted for 80.51% of the total variation in the proportion of abnormal seedlings among the different seed damage categories. Thus, in both cultivars undamaged seeds had the lowest proportion of abnormal seedlings; while the highest proportion of abnormal seedlings was found from seeds with one hole in cultivar Natoli and from seeds with three holes in cultivar Arerti (Table 1). Moreover, chickpea seed damaged by insects on average seeds with six holes had less proportions of abnormal seedlings than seeds with one or more holes per seed (Fig. 2). However, it should be noted that although statistically significant the actual difference might not have biological meaning because the differences in the proportion of abnormal seedlings among the different seed damage categories or between cultivars was at most 4.5%.

Table 1
Germination capacity of Adzuki bean beetle damaged seeds of two chickpea cultivars

Number of holes per seed	Normal seedlings (%) ($\pm$ SE)			Abnormal seedling (%) ($\pm$ SE)			Decayed seeds (%) ($\pm$ SE)		
	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*
0	92.49 $\pm$ 0.83	92.49 $\pm$ 0.83	92.49 ^a	3.33 $\pm$ 0.00	3.33 $\pm$ 0.00	3.33 ^c	4.17 $\pm$ 0.84	4.17 $\pm$ 0.84	4.17 ^d
1	50.00 $\pm$ 1.36	45.83 $\pm$ 1.59	47.92 ^b	10.83 $\pm$ 1.59	17.50 $\pm$ 0.83	14.17 ^a	39.17 $\pm$ 1.59	36.67 $\pm$ 1.36	37.92 ^c
2	37.50 $\pm$ 1.59	35.00 $\pm$ 0.96	36.25 ^c	10.83 $\pm$ 0.83	15.84 $\pm$ 0.84	13.33 ^a	51.67 $\pm$ 2.15	49.17 $\pm$ 1.59	50.42 ^b
3	33.33 $\pm$ 2.36	30.00 $\pm$ 1.36	31.67 ^c	12.49 $\pm$ 0.83	12.49 $\pm$ 0.83	12.49 ^{ab}	54.17 $\pm$ 2.50	57.50 $\pm$ 1.59	55.84 ^b
4	25.00 $\pm$ 0.96	25.83 $\pm$ 1.59	25.42 ^d	10.83 $\pm$ 1.59	11.67 $\pm$ 0.96	11.25 ^b	64.17 $\pm$ 1.59	62.50 $\pm$ 2.09	63.33 ^a
5	23.33 $\pm$ 1.36	21.67 $\pm$ 0.96	22.49 ^d	11.67 $\pm$ 0.96	11.67 $\pm$ 0.96	11.67 ^b	64.99 $\pm$ 1.67	66.67 $\pm$ 1.36	65.83 ^a
6	21.67 $\pm$ 0.96	22.50 $\pm$ 1.59	22.08 ^d	9.17 $\pm$ 0.83	10.00 $\pm$ 0.00	9.58 ^b	69.17 $\pm$ 1.59	67.50 $\pm$ 1.59	68.33 ^a
Mean	40.48	39.05		9.88 ^b	11.79 ^a		46.64	49.17	
CV (%)	6.07			17.6			6.58		
Notes: * = means in a column or row followed by the same letter are not statistically different at $p = 0.01$									

Similar to the proportion of normal and abnormal seedlings, the number of holes per seed accounted for 97.88% of the total variations in the proportion of dead seeds among the different seed damage categories. Furthermore, regression analysis revealed that although the proportions of dead seeds increased as the number of holes per seed increased (Table 1), the relationship was not linear. Rather the quadratic function ($y_i = 9.39 + 23.76x_i - 2.41x_i^2$, $r^2 = 0.960$, $df_1 = 2$, $df_2 = 4$, $\alpha = 0.01$) explained better the relationship between hole number (x_i) and proportion of dead seeds (y_i). Thus, in both varieties, the proportion of dead seeds from undamaged seed category was on the average less than 5%; however, it increased by seven and ten folds when there were one and two holes per seed, respectively. Seeds that had four or more holes per seed had the highest proportions of dead seeds.

The proportion of normal seedlings decreased as the number of holes per seed increased. On the contrary, the proportion of abnormal seedlings and the proportion of decayed seeds increased as the number of holes per seed increased. This finding is in agreement with Baier and Webster (1992) who found significant reduction in common bean (*Phaseolus vulgaris* L.) seed germination as the number of bean weevil (*Acanthoscelides obtectus*) exit hole per seed increases. Similarly, according to Allali et al. (2020) germination capacity of chickpea seeds that were damaged by cowpea weevil (*Callosobruchus maculatus*) declined as the number of holes per seed increased.

In this study, Adzuki bean beetle damage chickpea seeds had decayed seeds proportional to the number of holes per seed. According to Wood et al. (2011) the embryo of chickpea seed is located in the chickpea “beak”. The Adzuki bean beetle lays eggs on the entire surface of chickpea seed except in the “beak” region (own observation). Moreover, the Adzuki bean beetle larvae are internal feeders and are legless. Thus, they have no chance to attack the embryo of chickpea. Therefore, seed decaying might be due to seedling “starvation” resulted from the physical removal of food and the nutritional losses in damaged seeds.

The effects of Adzuki bean beetle seed damage on shoot length, root length, fresh weight and dry weight are shown in Table 2. The number of holes per seed did highly significantly ($P < 0.01$) affect shoot length, root length, fresh and dry weight

of seedlings; whereas the effects of cultivar were statistically non-significant ($P > 0.05$). Thus, it was found that about 95.32%, 92.44%, 94.71% and 94.34% of the total variation among the different damaged seed classes in shoot length, root length, fresh weight and dry weight, respectively, was due to the differences in hole number per seed. Generally, the seedling shoot length decreased continuously as the number of holes per seed increased in a nonlinear fashion, but the relationship between seedling shoot length (y_i) and hole number per seed (x_i) was best explained by quadratic function ($y_i = 9.48 - 2.20x_i + 0.22x_i^2$, $r^2 = 0.928$, $df_1 = 2$, $df_2 = 4$, $\alpha = 0.01$). Thus, in both cultivars, the seedlings from undamaged seeds had the longest shoot length, which was followed by seedlings from seeds with one-hole pre seed. On the other hand, seedlings from six holes per seed had significantly shorter shoot length than seedlings from seeds that had four or five holes per seed.

Also, the seedling root length decreased continuously as the number of holes per seed increased in quadratic fashion ($y_i = 12.09 - 2.56x_i + 0.26x_i^2$, $r^2 = 0.941$, $df_1 = 2$, $df_2 = 4$, $\alpha = 0.01$). Thus, the seedling root lengths from undamaged seeds of both cultivars were the longest, which was followed by seedlings from one hole per seed and two holes per seed in both cultivars Arerti and Natoli, respectively. The seedlings from the remaining seed damage categories had statistically equal root lengths.

Table 2

Effects of Adzuki bean beetle seed damage on shoot length, root length, fresh weight and dry weight of two chickpea cultivars

Number of per seed	Shoot length (cm) ($\pm$ SE)			Root length (cm) ($\pm$ SE)			Fresh weight (g) ($\pm$ SE)			Dry weight (g) ($\pm$ SE)		
	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*
0	9.29 $\pm$ 0.21	10.92 $\pm$ 0.33	10.11 ^a	12.98 $\pm$ 0.06	12.62 $\pm$ 0.29	12.80 ^a	4.55 $\pm$ 0.16	3.35 $\pm$ 0.06	3.95 ^a	0.89 $\pm$ 0.01	0.89 $\pm$ 0.01	0.89 ^a
1	7.48 $\pm$ 0.46	6.18 $\pm$ 0.12	6.83 ^b	10.02 $\pm$ 0.38	7.35 $\pm$ 0.36	8.69 ^b	4.10 $\pm$ 0.22	2.38 $\pm$ 0.05	3.24 ^b	0.81 $\pm$ 0.01	0.67 $\pm$ 0.03	0.74 ^b
2	6.05 $\pm$ 0.34	4.50 $\pm$ 0.17	5.28 ^c	7.18 $\pm$ 0.27	8.55 $\pm$ 0.31	7.86 ^{bc}	2.03 $\pm$ 0.05	3.25 $\pm$ 0.06	2.64 ^c	0.57 $\pm$ 0.03	0.68 $\pm$ 0.01	0.62 ^c
3	5.50 $\pm$ 0.29	5.03 $\pm$ 0.21	5.26 ^c	6.60 $\pm$ 0.57	7.20 $\pm$ 0.45	6.90 ^{cd}	2.23 $\pm$ 0.18	1.95 $\pm$ 0.06	2.09 ^d	0.57 $\pm$ 0.03	0.59 $\pm$ 0.01	0.58 ^c
4	4.52 $\pm$ 0.22	4.55 $\pm$ 0.24	4.54 ^{cd}	6.50 $\pm$ 0.22	6.48 $\pm$ 0.35	6.49 ^d	1.78 $\pm$ 0.11	1.88 $\pm$ 0.09	1.83 ^d	0.50 $\pm$ 0.01	0.51 $\pm$ 0.02	0.51 ^d
5	3.88 $\pm$ 0.11	4.88 $\pm$ 0.22	4.38 ^{cd}	5.18 $\pm$ 0.41	6.53 $\pm$ 0.28	5.85 ^d	1.73 $\pm$ 0.11	1.78 $\pm$ 0.08	1.75 ^d	0.48 $\pm$ 0.02	0.47 $\pm$ 0.01	0.47 ^d
6	3.68 $\pm$ 0.15	3.65 $\pm$ 0.17	3.66 ^d	5.72 $\pm$ 0.33	5.60 $\pm$ 0.50	5.66 ^d	1.73 $\pm$ 0.11	1.73 $\pm$ 0.11	1.73 ^d	0.44 $\pm$ 0.01	0.48 $\pm$ 0.02	0.44 ^d
Mean	5.77	5.67		7.76	7.74		2.59	2.33		0.61	0.61	
CV (%)	8.58			9.27			9.38			6.53		

Notes

* = * = means in a column or row followed by the same letter are not statistically different at $p = 0.01$

The seedling fresh weight and dry weight of both varieties decreased as the number of holes per seed increased. Thus, seedling fresh weight and dry weight from undamaged seeds were the heaviest, which were followed by seedling fresh weight and dry weight from seeds with one hole per seed. On the other hand, seedlings from five or six holes per seed had the lowest seedling fresh weight and dry weight.

Seedling shoot and root length were also affected by the number of holes per seed. It is apparent that upon feeding the insect removes substantial amount of food from the cotyledon. For instance, Duan et al. (2014) affirmed that Adzuki bean beetle significantly reduces thousand-seed weight, nutritive value, and germination rate. Moreover, according to Modgil and Mehta (1993) and Allali et al. (2020) an increased damage level by Adzuki bean beetle leads to proportional deterioration in chickpea grain protein quality. Furthermore, the mineral content (calcium, magnesium, potassium, sodium, iron, copper, and zinc) and vitamin content of chickpea grains damaged by the related species cowpea weevil is much less than the contents of undamaged grains and the magnitude of nutritional losses increase as the number of holes per seed increases (Allali et al., 2020). Thus, the short shoot and root length of Adzuki bean beetle damaged seeds might be attributed to the physical removal of food and the nutritional losses in chickpea seeds.

The hole number per seed also highly significantly ($P < 0.01$) affected seedling vigour (vigour index I and vigour index II) and speed of germination; however, the effect of cultivars was statistically ($P > 0.05$) non-significant. As was the case in other variables, hole number per seed accounted for the larger proportions (99%) of the total variation in seedling vigour and speed of germination among the different damaged seed categories than the variation contributed by cultivars. Both seedling vigour and speed of germination decreased as the number of holes per seed increased (Table 3). Thus, the seedling vigour of undamaged seeds was nearly threefold greater than the vigour of seedlings from one or more holes per seed. On the other hand, seedlings from six holes per seed were the weakest. Similarly, speed of germination of undamaged seeds was nearly twofold greater than the speed of germination of seeds with one hole per seed (Table 3). On the other hand, seeds with six holes per seed had the slowest speed of germination.

Table 3
The effect of Adzuki bean beetle damage on seedling vigour of two chickpea cultivars

Number of holes per seed	Vigour index I			Vigour index II			Speed of germinations		
	Arerti	Natoli	mean*	Arerti	Natoli	Mean*	Arerti	Natoli	Mean*
0	2058.75 ± 2.05	2177.84 ± 2.20	2118.29 ^a	81.85 ± 0.48	81.85 ± 0.81	81.85 ^a	4.60 ± 0.07	4.48 ± 0.10	4.54 ^a
1	873.08 ± 1.15	617.75 ± 1.21	745.42 ^b	40.34 ± 0.81	30.69 ± 0.35	35.51 ^b	2.45 ± 0.06	2.25 ± 0.04	2.35 ^b
2	493.25 ± 1.38	455.75 ± 1.10	474.50 ^c	21.03 ± 0.42	23.69 ± 0.43	22.36 ^c	1.86 ± 0.08	1.79 ± 0.03	1.82 ^c
3	397.75 ± 1.03	364.67 ± 1.99	381.21 ^d	18.71 ± 0.63	17.93 ± 0.92	18.32 ^d	1.56 ± 0.11	1.39 ± 0.11	1.48 ^d
4	274.42 ± 1.19	282.00 ± 1.89	278.21 ^e	12.54 ± 0.32	13.06 ± 0.21	12.80 ^e	1.14 ± 0.08	1.21 ± 0.09	1.18 ^e
5	209.08 ± 1.36	245.58 ± 0.71	227.33 ^f	11.03 ± 0.41	10.09 ± 0.19	10.56 ^f	0.91 ± 0.04	0.99 ± 0.03	0.95 ^{ef}
6	202.58 ± 1.11	205.00 ± 1.55	203.79 ^g	9.55 ± 0.19	9.75 ± 0.37	9.65 ^f	0.88 ± 0.02	0.93 ± 0.04	0.89 ^f
Mean	644.13 ^a	621.22 ^b	-	27.86 ^a	36.72 ^b	-	1.91	1.86	-
CV (%)	1	.00		3.88			7.19		

Seedling vigor also decreased as the number of holes per seed increased. A similar result was reported by Baier and Webster (1992) who stated that seedlings from damaged seeds of common bean have significantly reduced vigor than seedlings from undamaged seed. They attributed these reductions of seedling vigor to the loss of food reserves that resulted from consumption of cotyledons by bean weevils. Similarly, the decrease in speed of germination as the number of holes per seed increases might also be ascribed to the losses of food reserves and energy that would have been otherwise used for rapid germination.

4. CONCLUSION

Adzuki bean beetle damaged chickpea seeds had poor germination capacity; reduced vigor; and slower speed of germination than undamaged seeds. Thus, if a farmer uses seeds with one hole per seed, she/he is required to double the seed rate since seeds with a hole had on average 50% less normal seedlings, vigor, and speed of germination than undamaged seeds. On the other hand, for a good crop establishment and yield a germination capacity of 100% is required. Therefore, seed damaged by both the Adzuki bean beetle and the rice weevil should not be used as a seed by farmers due to deterioration of seed quality.

Declarations

COMPETING INTERESTS

Authors have declared that no competing interests exist.

Author Contribution

Author Contributions Statement Both authors credit for a research contributions to a study on the title: Germination capacity and seedling vigour of chickpea (*Cicer arietinum*) seeds damaged either by Adzuki bean beetle (*Callosobruchus chinensis*) or rice weevil (*Sitophilus oryzae*). Responsibilities of each author involved in the research and publication process. It ensures transparency and accountability by requiring who contributed to aspects such as: Conceptualization and study design; Data collection and analysis; Writing—original draft and revisions; Supervision and project administration and Funding acquisition.

Acknowledgement

The authors acknowledge Enabling Next-generation Agricultural Researchers through Engaging Seasoned Scientists (ENARESS) project for the financial support during the conception and execution of this laboratory experiment the experiment.

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Figures



Figure 1

Desi (left) and Kabuli (right) type chickpea

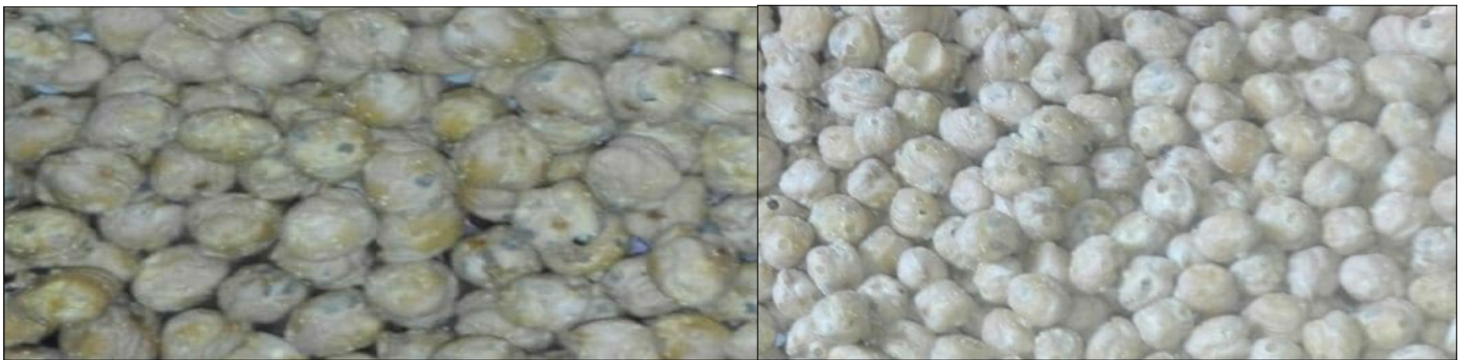


Figure 2

Chickpea seeds damaged by insect