Estimation of crop losses in *Cajanus cajan* (L.) Millsp. and *Vigna radiata* (L.) Wilczek caused by blister beetle, *Mylabris pustulata* Thunberg (Coleoptera: Meloidae)

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Abstract

Losses caused by *Mylabris pustulata* Thunberg in pigeonpea and mungbean at various beetle densities were assessed under net house/caged and field conditions. The observations revealed that the blister beetle caused considerable crop losses to both the pigeonpea and mungbean crops as under net house conditions, *M. pustulata* Thunberg at 200 beetles/cage caused the maximum reduction of 54.18, 20.15 and 64.88 per cent in pod setting, seed setting and grain yield in pigeonpea, respectively. Similarly, in mungbean, *M. pustulata* Thunberg at 4 beetles/cage caused maximum reduction up to 67.14, 26.65 and 75.29 per cent in pod setting, seed setting and grain yield, respectively. However, under unprotected conditions, 46.77 and 35.90 per cent of yield losses were recorded in pigeonpea and mungbean, respectively as compared to 0% under protected conditions. Thus, justifying that *M. pustulata* Thunberg is a major threat to both pulse crops and needs to be managed efficiently to avoid the significant crop losses caused by it.

Keywords Crop losses · Mungbean · Pigeonpea · Blister beetle

Introduction

Pulses constitute an integral part of Indian agriculture on account of their vital role in enriching human diet as well as soil fertility. They are an inseparable part of the human diet as they are a good source of protein, minerals, vitamins and crude fibre. Thus, also considered as a lifeline for vast vegetarian population of India (Gajbhiye et al. 2016). Among various pulses, pigeonpea/red gram [*Cajanus cajan* (L.) Millsp.] and mungbean [*Vigna radiata* (L.) Wilczek] are the major pulse crops cultivated in India. Globally, pigeonpea is grown over an area of 8.28 million ha, of which 5.34 million ha is confined to India alone with a production of 4.29 million tones and an average yield of 967 kg ha⁻¹ [FAOSTAT 2021a, b (a(i))] while mungbean grows over an area of 4.24 million ha with a production of 2.02 million tones having an average yield of 477 kg ha⁻¹ [FAOSTAT 2021a, b (a(ii))]. Despite such massive production of pigeonpea and mungbean in India, there are still several biotic and abiotic constraints responsible for their low yields. Among the various biotic factors like insects and pathogens infesting crops, damage due to insect pests is the major constraint in their successful cultivation (Singla and Singh 2020).

More than 350 insect pest species are associated with pigeonpea all over the world (Chhabra 2008). Out of these, approximately 66 per cent of the insect species have been recorded from India only (Rolania et al. 2021). Moreover, 64 species of insects have been reported to cause damage right from the seedling stage up to pod formation and storage in mungbean (Nair et al. 2019). However, among all the insect pests infesting these pulse crops, blister beetle (*Mylabris pustulata* Thunberg) (Coleoptera: Meloidae) is reported as a major pest causing severe damage to the flower buds, flowers, tender pods and young leaves, leading to the development of few pods and very poor yield. Besides its survival ability on pigeonpea and mungbean, it can also feed on a variety of other host crops like cowpea [*Vigna unguiculata* (L.) walp.], urdbean [*Vigna mungo* (L.) Hepper], faba bean (*Vicia faba* L.), Egyptian clover (*Trifolium alexandrinum* L.), lettuce (*Lactuca sativa* L.) and pea (*Pisum sativum* L.) (Ghoneim 2013). It inflicts huge crop losses in short duration crops like pigeonpea and mungbean on account of its...
association with their flowering phase (Singh et al. 2021). The adult beetles feed on their host crop either solitarily or gregariously. Sometimes, the damage caused to the flower is so extensive that there is no pod and seed setting resulting in drastic yield reduction (Singh et al. 2021). According to Emmanuel et al. (2017), blister beetle alone can cause flower damage of more than 50 and 19.1 per cent in pigeonpea and mungbean, respectively. Damage of 31–50 per cent in pigeonpea by blister beetle was also recorded by Balikai and Yelshetty (2008). Singla and Singh (2020) also suggested appropriate control strategies for Helicoverpa armigera (Hübner) after evaluating the avoidable yield losses caused by the pest in chickpea. They found that with increase in larval density from 1–6 larvae per meter row length, avoidable yield losses also progressively increased from 17.5–73.50 per cent. Likewise, the efficient management strategies for blister beetle can only be formulated once we have enough data related to the crop losses caused by the blister beetle. As there is very meager information on crop losses caused by M. pustulata Thunberg on pigeonpea and mungbean. Thus, keeping in view the severity of damage caused by this pest, efforts were made to assess the crop losses caused by M. pustulata in two major pulse crops, pigeonpea and mungbean, so that, this pest can be efficiently managed with minimal loss to the crop and simultaneously, environment can be protected by avoiding the excessive use of insecticides.

Materials and methods

Field studies were conducted at Punjab Agricultural University (PAU), Ludhiana (30° 53.7074’N, 75° 48.7217’E) under net house/caged and field conditions using pigeonpea variety, PAU 881 and mungbean variety, PAU 911. Pigeonpea and Mungbean were sown during the second fortnight of May and July, respectively. All the agronomic practices were followed as per Package of Practices (2021) issued by PAU. Rainfall, temperature and relative humidity at the time of experiment was 30 mm, 32–38.6°C and 75–78%, respectively. The soil under the crop was of light texture with low content of organic matter (sand 78%, silt 10.2%, clay 11.8%, pH8, organic carbon 0.30%) Data was collected and analysed using ANOVA to test the significances of differences among different treatments using Randomised Complete Block design (RCBD). As the beetles are more abundant in the dry season, so the beetles were collected from the field and released in different replicated randomized blocks under net house and field conditions.

Under net house/ caged conditions

Both the crops; pigeonpea variety, PAU 881 and mungbean variety, PAU 911 were sown during second fortnight of May and July, respectively. Row to row and plant to plant spacing of 50 cm × 25 cm and 30 cm × 10 cm was maintained while sowing the pulse crops.

Pigeonpea

Pigeonpea crop was raised as per the recommended agronomic practices (Package of Practices, 2021) and the experiment was laid out in a randomized complete block design (RCBD). Hundred plants of pigeonpea variety, PAU 881 were treated as one plot. At bud initiation stage, each plot was separately caged with a plastic wire mesh net house measuring 8 m x 6 m x 3 m. At the time of 50 per cent flowering, the adult beetles of M. pustulata Thunberg (starved for 3 h) were collected from same location in a field and released in two sets (each cage representing beetle density at 100 and 200 beetles per 100 plants, respectively) (Fig. 1). Dead beetles were replaced with live ones until the completion of flowering period to maintain uniform density of 100 and 200 beetles per cage. Each treatment consisted of five replications. One plot was kept as control which was free from beetle infestation.

Mungbean

Mungbean crop was also raised as per the recommended agronomic practices (Package of Practices, 2021). A nylon
plastic wire mesh cage measuring 80 cm × 55 cm was placed on an individual plant. The plants in different treatments were exposed to field collected beetles at 1, 2 and 4 beetles per cage at flowering (Fig. 2). Three cages (each cage representing one plant) for each population were maintained until completion of the flowering period. One plot was kept as control (without beetle population). Each treatment had five replications.

At harvesting, the following observations were recorded from both crops:

(i) Total number of mature pods per plant
(ii) Total number of seeds per pod
(iii) Grain yield (g/plant)
(iv) Pest population (per plant)
(v) Yield loss (%)

The data was further compared with the observations collected from control plots to record the per cent reduction in pod setting, seed setting and losses in yield. The blister beetle population was maintained throughout the experiment as per the methodology in each crop.

Yield loss Per cent yield loss was worked out as per Pradhan (1964):

\[
\text{Yield losses (\%)} = \left( \frac{\text{Seed yield of uninfested plant (g)} - \text{Seed yield of infested plant (g)}}{\text{Seed yield of uninfested plant (g)}} \right) \times 100
\]

Under field conditions

A field trial was also conducted for assessing the crop losses caused by blister beetle under unprotected and protected plots using Randomized complete block design (RCBD) with five replications. Pigeonpea variety, PAU 881 and mungbean variety, PAU 911 were sown in five replicated plots, each measuring 10 m × 10 m as per the recommended agronomic practices (Package of Practices 2021). At flowering stage, to avoid the damage by pod borer (also regarded as a major pest) in pigeonpea and mungbean and thus, creating error in our experiment, both crops were sprayed with the recommended insecticide, spinosad 45 SC at 150 ml ha⁻¹ before proceeding with our actual investigations.

In the case of pigeonpea, 10 plants from each replication were randomly tagged and covered with muslin bags to prevent the blister beetle infestation. However, to compare the losses (due to blister beetle alone), another set of 10 randomly selected plants from each replication were tagged on which the beetles were allowed to feed freely from the initiation to the termination of flowering. The data was then analyzed on a per plant basis.

Similarly, in mungbean, 10 plants from each replication were randomly selected and tagged and covered with muslin bags at flowering to avoid the infestation of blister beetle. To compare the crop losses by blister beetle in mungbean, another set of 10 randomly selected plants were tagged in each of the five replications on which the beetles were allowed to feed freely from initiation to termination of flowers.

At harvesting, the following observations were recorded from both the crops:

(i) Number of flowers damaged (%)
(ii) Number of flowers developed into pods per plant
(iii) Number of seeds per pod
(iv) Grain yield (g/plant)
(v) Yield losses (%)

Yield loss Per cent yield loss was worked out as per the formula given by Pradhan (1964):

\[
\text{Yield losses (\%)} = \left( \frac{\text{Grain yield of protected plots} - \text{Grain yield of unprotected plots}}{\text{Grain yield of protected plots}} \right) \times 100
\]
Results

Under net house/ caged conditions

Crop losses by blister beetle in pigeonpea

Data presented in Table 1 revealed that the per cent yield loss in pigeonpea under net house condition was 37.57 per cent at beetle density of 100 beetles/cage, while a yield loss of 64.88 per cent was recorded at beetle density of 200 beetles/cage, respectively. The mean number of mature pods per plant were observed to decrease with an increase in the beetle density from 100 beetles per cage (85.60) to 200 beetles per cage (56.60) as compared to the mean number of mature pods per plant (123.54) in control with no beetle infestation. Treatment with higher beetle density (200 beetles per cage) also produced a higher per cent reduction in pod setting (54.18), while the per cent reduction at beetle density of 100 beetles per cage was 30.71, respectively. Thus, confirming that the treatment with a smaller number of matured pods per plant and higher beetle density (200 beetles per cage) reported higher per cent reduction in pod setting as compared to 30.71 per cent reduction at beetle density of 100 beetles per cage.

Moreover, the mean number of developed seeds per pod was also recorded to be higher (3.78) at lower density of pest (100 beetles per cage) as compared to 3.21 at 200 beetles per cage. However, the mean number of seeds per pod were significantly higher in control (4.02) when compared to the treatments. Even, the per cent reduction in seed setting was observed to be significantly higher (20.15) in treatment with beetle density of 200 beetles per cage as against 5.97 per cent at beetle density of 100 beetles per cage. Finally, the grain yield per plant was also reported to be notably higher (34.57 g per plant) in control as compared to 21.58 g and 12.14 g per plant in treatment with pest density of 100 and 200 beetles per cage, respectively.

Crop losses by blister beetle in mungbean

The results presented in Table 2 also revealed that with the increase in beetle density per cage, mean number of mature pods per plant, mean number of seeds per pod and grain yield significantly decreased. Among the three treatments (1, 2 and 4 beetles/cage), the highest mean number of mature pods (12.25) per plant were reported in treatment with minimum pest density of 1 beetle per cage as compared to 5.75 in treatment with 4 beetles per cage. However, when compared to control, the mean number of matured pods were significantly higher (17.50 per plant) than treatments. This showed that the per cent reduction in pod setting was 30.00 per cent at beetle density of 1 beetle per cage, 50.00 per cent reduction when beetle density was 2 beetles per cage and 67.14 per cent reduction when the beetle density was 4 beetles per cage.

Similarly, the mean number of seeds developed per pod were recorded to be 10.24 at pest density of 1 beetle per cage, 9.02 at pest density of 2 beetles per cage and 7.98 at pest density of 4 beetles per cage as compared to 10.88 number of seeds developed per pod in control. This resulted in a 5.88 per cent reduction in seed setting at beetle density of 1 beetle per cage, 17.10 per cent reduction at 2 beetles per cage and a maximum reduction of 26.65 per cent at 4 beetles per cage of mungbean.

Further, grain yield per plant was also recorded to be affected with increase in the beetle density per cage. Among all the four treatments, the highest yield of 8.50 g per plant was reported in control followed by 5.50 g at 1 beetle per cage, 3.37 g at 2 beetles per cage and lowest yield of 2.10 g at 4 beetles per cage. Thus, based on grain yield, the highest yield loss of 75.29 per cent was recorded in treatment with 4 beetles per cage followed by 60.35 per cent in treatment with 2 beetles per cage and lowest in treatment with 1 beetle per cage (35.29%).

| Beetle density  | Mean number of mature pods per plant | Per cent reduction in pod setting | Mean number of seeds per pod | Per cent reduction in seed setting | Grain yield per plant (g) | Yield losses (%) |
|----------------|-------------------------------------|----------------------------------|------------------------------|-----------------------------------|---------------------------|-----------------|
| 100 beetles/cage* | 85.60 (9.30)                      | 30.71                            | 3.78 (2.19)                  | 5.97                              | 21.58                     | 37.57           |
| 200 beetles/cage* | 56.60 (7.59)                      | 54.18                            | 3.21 (2.05)                  | 20.15                             | 12.14                     | 64.88           |
| Control (Without beetle) | 123.54 (11.16)                  | -                                | 4.02 (2.24)                  | -                                 | 34.57                     | -               |
| Critical Difference at 5% | 0.19                                | -                                | 0.04                         | -                                 | 2.20                      | -               |
| C.V             | 0.99                               | -                                | 1.35                         | -                                 | 6.63                      | -               |

Figure in parentheses are (√n + 1) transformations
*Per cage represents per 100 plants, respectively.
Yield losses by blister beetle in pigeonpea

The effect of blister beetles on pigeonpea under field conditions showed that flowers damaged by the beetle were 36.20 per cent under unprotected conditions, while no flower was damaged (0.00 per cent) in protected plots (Table 3). Therefore, the average number of flowers that developed into pods was higher (135.76) in protected plants as against 90.36 in unprotected plants. Similarly, the average number of seeds per pod was 4.39 in protected conditions but 3.45 in unprotected conditions. Grain yield per plant was lower in unprotected (21.54 g per plant) and it was significantly different from protected (40.47 g per plant) plots.

Overall, the blister beetle resulted in 46.77 per cent losses in yield of pigeonpea crop under field conditions. The differences between protected and unprotected conditions for various parameters viz., average number of flowers developed into pods per plant, average number of seeds per pod and grain yield per plant (g) were thus recorded to be statistically significant at p < 0.05.

Yield losses by blister beetle in mungbean

Losses done by blister beetle in mungbean under field conditions revealed that the flowers damaged by blister beetle were 15.80 per cent in unprotected conditions as compared to 0.00 per cent in protected ones (Table 4). The average number of flowers that developed into pods were 13.22 in unprotected and 17.94 in protected plants. Likewise, the average number of seeds per pod were recorded to be higher (10.63) in protected conditions as against 9.15 in unprotected conditions. Therefore, the grain yield per plant was also reported to be more under protected as compared to unprotected conditions with 5.16 g per plant in unprotected and 8.05 g per plant in protected conditions.

Overall, the blister beetle caused 35.90 per cent yield losses in mungbean under field conditions. Thus, the differences between protected and unprotected conditions for various parameters viz., average number of flowers developed into pods per plant, average number of seeds per pod and grain yield per plant (g) were thus reported to be statistically significant.
Discussion

Under net house/ caged conditions

Pigeonpea

Our present study revealed that the highest yield losses were recorded in treatment with 200 beetles per cage (64.88%) as compared to 37.57% in treatment with 100 beetles per cage. Thus, justifying that crop losses progressively increased with increase in the beetle density from 100 to 200 beetles per cage. The present results are in close agreement with the experiments conducted by Singla and Singh (2020) where they found that under net house conditions, with increase in the larval population of *H. armigera* (Hübner) from 1 to 6 larvae per meter row length, avoidable yield losses increased from 17.57–73.50% as compared 0% in control (uninfested crop). Similarly, Rachappa et al. (2018) also assessed the crop losses caused by leafhopper, (*Empoasca kerri* Pruthi) in pigeonpea. They found that yield losses increased from 3.12–31.91% at 2–12 pairs released plots with maximum leaf hoppers count of 26.16/3 leaves, respectively. Thus, illustrating that with increase in the population of pest, per cent yield losses increase.

Mungbean

The present study inferred that the treatment with highest beetle population of 4 beetles per cage recorded highest yield loss (75.29%) and lowest grain yield (2.10 g per plant) as compared to 35.29% of yield loss and 5.50 g of yield per plant at a beetle density of 1 beetle/cage. Similarly, the results obtained by Dhavan et al. (2014) showed that they estimated the economic threshold value of 0.4 blister beetles per meter row in mungbean after calculating the crop losses and avoidable yield losses at different beetle population varying from 1, 2, 3, 4, 5 and 8 beetles per meter row length. They found that with increase in the beetle population from 1 to 8 beetle per meter row, grain yield decreased from 1240 to 137 kg/ha with corresponding increase in avoidable losses from 9.7- 90%, respectively as compared to 1373 kg/ha of grain yield and 0% of avoidable yield losses in untreated control. Thus, demonstrating that the avoidable yield losses rise with an increase in the pest population. As there is not much recent research work done under net house/caged conditions in previous years on any pulse crop or specifically mungbean, to further support or deny our experimental results for estimation of crop losses. Thus, signifying our work on this aspect as totally novel.

Under field conditions

Pigeonpea

The present study demonstrated that the damage caused by blister beetle resulted in higher yield losses of 46.77% in pigeonpea under unprotected conditions as compared to 0% under protected conditions. Similarly, Chiranjeevi and Ramdas (2020) also found that *Melanagromyza obtusci* (Malloch) when allowed to damage the pigeonpea, infested 12 to 100% pods causing losses of 2.4–95.0% on seed or grain which is approximately 2,50,000 tones by weight. Moreover, Dabhade et al. (2012) also found that the major insect pests of groundnut can cause a yield loss of 48.57% in pod and 42.11% in fodder in untreated control plots as compared to 0% under protected conditions. The results also revealed that 94.45 and 72.74% of additional yield can be incurred from protected plots as compared to unprotected plots in pod and fodder, respectively. Thus, suggesting appropriate chemical or non-chemical management practices to be followed to avoid the yield losses caused by the pest.

Mungbean

Our present findings revealed that the blister beetle caused significant yield losses of 35.90% in mungbean under unprotected conditions as compared to 0% under protected conditions. Thus, the differences between protected and unprotected conditions for various parameters viz., average number of flowers developed into pods per plant, average number of seeds per pod and grain yield per plant (g) were thus reported to be statistically significant.

### Table 4 Crop losses in mungbean caused by *M. pustulata* under field conditions

| Treatment     | Number of flowers damaged (%) | Number of flowers developed into pods per plant | Number of seeds per pod | Grain yield per plant (g) | Yield losses (%) |
|---------------|-------------------------------|-----------------------------------------------|-------------------------|--------------------------|-----------------|
| Unprotected   | 15.80                         | 13.22                                         | 9.15                    | 5.16                     | 35.90           |
| Protected     | 0.00                          | 17.94                                         | 10.63                   | 8.05                     | -               |
| t-test value  | -                             | 13.01                                         | 6.82                    | 13.24                    | -               |
| p-value       | -                             | <0.05                                         | <0.05                   | 0.05                     | -               |
| S.D           | -                             | 2.54                                          | 0.84                    | 1.56                     | -               |
| S.E           | -                             | 0.80                                          | 0.27                    | 0.49                     | -               |

- 13.01, <0.05, <0.05, -
- 2.54, 0.84, 0.27, -
- 0.80, 0.27, 0.49, -
Likewise, Duraimurugan and Tyagi (2014) also explored the change in pest status and avoidable yield losses in mungbean and urdbean under varying climatic conditions. They found that among the various insect pests, broad mite (*Polyphagotarsonemus latus*), blister beetle (*Mylabris pustulata*), bean flower thrips (*Megalurothrips usitatus*) and spotted pod borer (*Maruca vitrata*) assumed the status of major pests of mungbean and urdbean. Moreover, the avoidable losses due to pest complex on different varieties ranged from 27.03 to 38.06% and 15.62 to 30.96% for mungbean and urdbean, respectively. Thus, demonstrating that protected conditions can decrease the significant crop losses caused by blister beetle. Thus, providing higher yield and minimum yield losses as compared to unprotected conditions. Moreover, as there is no research done on various yield parameters to support or deny our experimental results for estimation of crop losses by *M. pustulata* in mungbean under field conditions. Hence, the research work done on mungbean for determining the crop losses is completely new as against the literature already present.

**Conclusion**

The crop losses in pigeonpea and mungbean under net house/caged conditions increased from 37.57–64.88% and 35.29–75.29% with an increase in the beetle density from 100–200 and 1–4 beetles/cage, respectively. Moreover, under field conditions, crop losses due to blister beetle were found to be higher (46.77%) in pigeonpea and mungbean (35.90%), respectively under unprotected conditions as compared to 0% under protected conditions. Thus, necessitating the need for efficient chemical and non-chemical control strategies to manage the blister beetle population.

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**References**

Balikai RA, Yelshetty S (2008) Insect pest scenario of pigeonpea in Northern Karnataka. Legume Res 31:49–151

Chhabra KS (2008) New directions in the pest management of pigeonpea, pp 248

Chiranjeevi B, Ramdas PN (2020) Field screening of pigeonpea for their resistance against *Melanagromyza obtusa* (Diptera: Agromyzidae). Indian J Agri Sci 90(7):1226–1230

Dabhade PL, Bapodra JG, Jethva DM, Dabhi MV (2012) Estimation of yield losses due to major insect pests of groundnut in Gujarat. Legume Res 35(4):354–356

Dhavan SP, Wadaskar RM, Patil SC (2014) Assessment of economic threshold level for blister beetles (*Mylabris phalerata*) on greengram. Indian J Ecol 41(2):304–306

Duraimurugan P, Tyagi K (2014) Pest spectra, succession and its yield losses in mungbean and urdbean under changing climatic scenario. Legume Res 37(2):212–222. https://doi.org/10.5958/j.0976-0571.37.2.032

Emmanuel MK, Robert A, Peter OJ, Pandey AK, War AR, Nair RM (2017) A manual for mungbean (greengram) production in Uganda. National Agricultural Research Organization (NARO), p 32

FAOSTAT (2021a a(i)) https://www.indiastat.com/table/agriculture-data/2/arhar-tur/19566/1229701/data.aspx

FAOSTAT (2021b a(ii)) https://www.indiastat.com/table/agriculture-data/2/moong-green-grain/19571/1229723/data.aspx

Gajbhiye RK, Sidar YK, Nirmal A (2016) Post-Harvest Management of Pulse Innov Farm 1(4):186–189

Ghoneim K (2013) Agronomic and biodiversity impacts of the blister beetles (Coleoptera: Meloidae) in the world: A review. Int J Agri Sci Res 2(2):021–036

Nair RM, Pandey AK, War AR, Hanumantharao B, Shwe T, Alam AKMM, Malik SR, Karimi R, Mbeyagala EK, Douglas CA, Rane J, Schafleitner R (2019) Biotic and Abiotic constraints in Mungbean production- progress in genetic improvement. Front Plant Sci 10:1340. https://doi.org/10.3389/fpls.2019.01340

Package of Practices (2021) Package of Practices for Kharif Crops. Punjab Agricultural University, Ludhiana, pp 59–63 and 66–68

Pradhan S (1964) Assessment of losses caused by insect pest of crops and estimation of insect population. Entomology in India. The Entomological Society of India, New Delhi, pp 17–58

Rachappa V, Shivayogiyappa NH, Suhas Y (2018) Assessment of crop loss due to leafhopper, (*Empoasca kerrii* Pruthi) in pigeonpea. Legume Res 41:155–158. https://doi.org/10.18805/LR-3772
Rolania K, Yadav SS, Singh B, Yadav JL, Kumar N, Pilania S (2021) Assessment of losses due to pulse beetle in chickpea under stored conditions in Southern Haryana. J Agri Ecol 12:98–105

Singh G, Singh R, Singla A (2021) Seasonal abundance of blister beetle, Mylabris pustulata Thunberg on pigeonpea and mungbean. MAUSAM 72(3):645–648. https://doi.org/10.54302/mausam.v72i3.1314

Singla A, Singh R (2020) Estimation of avoidable yield losses in chickpea caused by Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae). Phytoparasitica 48(5):755–765

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