Enhancing Sorghum Pest Management -Exploring Biological and Botanical Control Strategies against *Chilo partellus*

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Sorghum bicolor (L.) Moench, commonly known as jowar, is a cereal crop originating from northeast Africa. It serves as a vital source of food and fodder, particularly for disadvantaged populations in semi-arid tropics. Sorghum grain boasts a high composition of carbohydrates (72.6%), proteins (10.4%), fats (1.9%), crude fiber (1.6%), and mineral matter (1.6%). Notably, sorghum exhibits remarkable drought tolerance, enabling its cultivation in regions with higher moisture stress levels and extended durations. In India, sorghum ranks as the fourth most significant cereal crop, trailing rice, wheat, and maize. The country's sorghum production in 2019 amounted to 3.7 million tonnes from 4.09 million hectares of cultivated land, yielding an average productivity of 781.91 kg/ha. This figure falls short of the global average productivity of 1427.94 kg/ha. Additionally, sorghum plays a crucial role as a fodder source across the nation. Its cultivation is primarily concentrated in the southwestern states of Maharashtra, Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, and Rajasthan. Worldwide, the production of sorghum reached 62.20 million tons in 2022.

One of the major challenges faced in sorghum production is the presence of nearly 150 pest species. Among these, *Chilo partellus*, an infamous insect infesting the stem and causing yield and quality reduction, poses a significant threat to sorghum cultivation. The impact of *C. partellus* accounts for an estimated 18-25% loss in yield, resulting in substantial economic consequences. The annual crop losses attributed solely to *C. partellus* amount to approximately US$334 million. It is important to approach the management of *C. partellus* and other pests in sorghum cultivation through scientifically sound and integrated pest management practices to mitigate their detrimental effects on crop productivity and ensure sustainable agricultural practices.

Sorghum Stem Borer (*Chilo partellus*)

Chilo partellus, the sorghum stem borer, is a significant global pest impacting sorghum production. Understanding its biology is crucial for effective pest control. *Chilo partellus*, a member of the family Crambidae and order Lepidoptera, targets grasses and sedges, including maize and sorghum. Integrated approaches are essential for sustainable sorghum farming and food security in *C. partellus* infested regions. *C. partellus* adults have a yellow-gray coloration with scattered dark scales.

Life Cycle of *Chilo partellus*

Chilo partellus exhibits variations in its life cycle duration depending on seasonal conditions. The life cycle ranges from 44 to 64 days, with an average duration of 53.82±0.49 days. During peak summer months, it lasts around 44-48 days, while during peak winter months, it extends to approximately 60-64 days. These variations reflect the influence of seasonal factors on the development and maturation stages of *Chilo partellus*.

Fecundity

Female *C. partellus* Swinhoe has an average fecundity of approximately 150-160 eggs per female (Songa et al., 2000; Berner et al., 1993), indicating their high reproductive potential.

Oviposition Period

The oviposition period of *Chilo partellus* lasts 4-5 days, with an average of 4.2 +/- 0.13 days. This is consistent with previous studies by Chavan (2006) and others, which reported an average oviposition period of 3-5 days.

Incubation of eggs

Chilo partellus eggs are flat, oval-shaped, and milky white. They hatch within 4-7 days, mainly in the morning. Newly hatched larvae are flat, creamy white, and darken as they grow. According to Krishna et al.

(2018), stem borer eggs hatch after 5-6 days in the morning.

Larvae

Chilo partellus larvae vary in size and weight across instar stages, with lengths ranging from 2.05 +/- 0.11 to 23.38 +/- 0.55 mm, breadths from 0.34 +/- 0.03 to 3.22 +/- 0.17 mm, and weights from 1.04 +/- 0.06 to 327.5 +/- 43.3 mg. The larval phase lasts 29-36 days, with longer durations in January and February and shorter durations in May and June (Arunkumara et al., 2018).

Pupae

Chilo partellus pupae are cylindrical and light brown. Male pupae measure around 10.66 mm in length, 2.23 mm in breadth, and weigh approximately 29.15 mg. Female pupae are slightly larger, measuring about 13.13 mm in length, 2.66 mm in breadth, and weighing around 49.15 mg. Pupal durations vary, with the longest periods of 11-12 days occurring from November to February, and the shortest periods of 7-8 days observed from May to June (Arunkumara et al., 2018).

Adults

Chilo partellus, the adult sorghum stem borer, has been studied extensively. The moth has yellowish-brown forewings with black dots. Wing length ranges from 7 to 17 mm (Berger, 1992). Male adults live for 4-7 days, while females live for 5-9 days. Male adults measure approximately 13.53 mm in length, 23.55 mm in breadth, and weigh around 49.12 mg. Female adults have average measurements of 18.55 mm in length, 29.84 mm in breadth, and weigh around 57.62 mg.

Effect of botanicals

In their study, Nega and Getu (2020) investigated the efficacy of seven treatments administered to larvae in the second and/or third developmental stages. These treatments included different concentrations of *Milletia ferruginea* Hochst seed powder and aqua extract, cow urine, *Phytolacca dodecandra L.* seed powder, and their combinations. An untreated control group was also included for comparison. The results demonstrated that the highest mortality rate (100%) was achieved on the second day using 3 grams of *M. ferruginea* and 2.0 milliliters of aqua extract. Additionally, at a concentration of 3.0 milliliters, cow urine and the combination of *M. ferruginea* and cow urine showed significant efficacy, resulting in mean mortalities of 86.7% and 93.3% within a three-day period. On the other hand, the mortality rates of treatments involving *P. dodecandra L.* seed powder, aqua extract, and their combination with cow urine were comparatively lower. Overall, the study concluded that *M. ferruginea* powder and aqua extract, along with cow urine and the combination of *M. ferruginea* and cow urine, are promising alternatives to chemical pesticides for effectively combating *C. partellus.*

January et al. (2018) conducted two trials involving six treatments: two commercial biopesticides (*Beauveria bassiana* and *Metarhizium anisopliae*), two plant extracts (*Neorautanenia mitis* and *Derris elliptica*), one synthetic insecticide (Amekan 344EC) containing Cypermethrin (144 g/L) and Imidacloprid (200 g/L), and an untreated control group. Results showed that both biopesticides and botanical extracts had significant effects on reducing *Chilo partellus* damage, leading to increased mortality and improved sorghum grain yield. Yield loss was reduced from 60.01% to 19.7%, and damage incidences, such as dead heart (45% to 64.28%) and whitehead (42.01% to 76.19%), were minimized. The treated samples demonstrated a stem borer mortality rate ranging from 57.51% to 78.12%.

Saranya and Samiayyan (2017) evaluated botanicals as ovicides against *Chilo partellus* eggs. Neem oil 5% showed the highest efficiency, preventing egg hatching with a success rate of 95%. Chlorpyriphos 0.2% (86%), neem oil 1.0% (79%), NSKE 5%, and Jatropha leaf extract 5% followed with decreasing efficacy. Neem leaf extract 5% effectively discouraged oviposition by C. partellus, recording only 16.6% of oviposition. Jatropha leaf extract 5% (19.2%), neem oil 5% (22.6%), neem oil 1.0% (28.3%), and NSKE 5% (28.7%) also exhibited some deterrent effects. Notchi leaf extract 5% was ineffective as an ovicide and oviposition deterrent.

Effect of biological control agents

Jalali and Singh (2006) found that releasing *Trichogramma chilonis* parasitoids at three to five-day intervals resulted in parasitism rates of 75.2% and 62.6% in the first generation, and 90.4% and 78.4% in the second generation on *Chilo partellus* eggs in fodder sorghum. Larvae in plots where parasitoids were released every three and five days had stem burrowing measurements of 1.8 cm and 2.4 cm, respectively, compared to 7 cm in untreated control plots. Combining *T. chilonis* with *Bacillus thuringiensis* significantly reduced insect infestation and stem tunnelling compared to individual treatments. For cost-effective control, it is recommended to release *T. chilonis* at five-day intervals, three times during the first generation and two times during the second generation.

Koji et al. (2007) studied the role of Guinea grass, Panicum maximum Jacq. field boundaries in managing the spotted stem borer, *Chilo partellus* Swinhoe. The research revealed that Guinea grass acted as a reservoir for arthropod predators and a trap plant for the pest. Abundant populations of earwigs and spiders, known predators of stem borer eggs and larvae, were observed in the Guinea grass strips. However, only young larvae were found, indicating that the low density of *C. partellus* larvae in the grass strips throughout the season suggested an unsuitable environment for stem borer larvae. These findings highlight the effectiveness of Guinea grass as a habitat management tool to enhance specific stem borer predators and serve as a sink for the pest.

Jiang et al. (2004) studied the effectiveness of *C. flavipes*, a parasitoid, in controlling *C. partellus*, a cereal crop pest. They investigated their survival and development at different temperatures (22, 26, and 30 °C) using third and fourth instars of *C. partellus*. Results showed that larval mortality was highest at the lowest temperature for non-parasitized hosts and at the highest temperature for parasitized hosts in the third instar. Development time of *C. flavipes* decreased with host instar and temperature. Sex ratio shifted towards females as temperature increased. Parasitized *C. partellus* larvae gained more weight, and food consumption was reduced at 26 °C for both parasitized and non-parasitized larvae. These findings contribute to understanding the performance of *C. flavipes* under different climatic conditions.

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