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Effectiveness of Cultural Practices in Managing Helicoverpa Armigera Infestation in Tomato Varieties of Khyber Pakhtunkhwa

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Abstract

Helicoverpa armigera (Hubner) is a highly destructive polyphagous pest of the tomato crop in the world, which is responsible for significant economic losses and augmenting dependence on chemical pesticides. The management of this pest is thus of great relevance in integrated pest management (IPM) systems with the view of mitigating the environmental risks and production costs. The current experiment was aimed at assessing the effectiveness of the target cultural practices in combination with the varietal susceptibility in the field conditions in Peshawar, Pakistan, between March and May 2021. The experiment was designed with the help of a randomized complete block design (RCBD) to compare the effect of early sowing, deep ploughing, weeding, hand picking of larvae, removal of infested fruits, and pupal bursting on two tomato varieties, Rio Grande (preferred) and Sahel (less preferred). Early sowing (T2) was the most effective treatment, which suppressed the population of eggs by 26.0 and 17.7 in Rio Grande and Sahel, respectively, when compared to the control. In the same way, the population of the larvae dropped by 24.6 percent and 9.2 percent in Rio Grande and Sahel, respectively. Yield parameters were much better with T2, and the number of fruits rose by 13.1 and 10.8 percent under T2 compared to control plots (Rio Grande and Sahel, respectively). Mean plant yield rose to 1.27 kg (Rio Grande) and 1.42 kg (Sahel), which is an 8.5 percent and 11.8 percent increase in yield, respectively. On the whole, Sahel responded less to infestation and was more responsive to treatments. These results reveal that an ecologically friendly and sustainable approach to the management of H. armigera involves early sowing, as well as low-preference or resistant varieties. The incorporation of these cultural practices in the IPM programs will assist in minimizing the reliance on pesticides, as well as improve the yield of tomatoes and the sustainability of production.
Keywords: Helicoverta armigera, tomato, integrated pest management, cultural practices, early sowing.

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1. **Introduction**

Tomato is the most significant vegetable in the world, following potato (Solanum lycopersicum L.). Reports indicate that the overall land which is being used around the world to produce tomatoes is around 4.85 million hectares, with an average production per hectare of 37.60 tons/ha. The fruit borer, Helicoverpa armigera (Hubner), can be regarded as the most damaging and a primary pest which has many abiotic and biotic effects on tomato production (Ali et al., 2019).

H. armigera is a very polyphagous pest and a significant threat to tomato crops, resulting in significant losses in yields. The impact of this pest on the economy around the world has been estimated at approximately 5 billion US dollars every year. Tomato infestation rates in Pakistan are as high as 32 35, and the yield is damaged as much as 53 percent, in areas like Peshawar, Khyber Pakhtunkhwa (Usman et al., 2013). The seriousness of the pest incidence is emphasized by the fact that in the region, the H. armigera is the subject of about 80 percent of the total insecticide use.

Swat, Peshawar, Mansehra and Bajaur are the key vegetable-producing areas in Khyber Pakhtunkhwa, Pakistan. The regions are natural offseason vegetable cultivating regions because of all the high altitudes and a variety of climatic conditions, except for Peshawar. These regions produce tomato as the main crop of vegetables. At elevated altitudes, there is minimal pest attack because of low temperatures. There is very little literature about tomato pests in these regions, and thus, this study aims to determine the extent of infestation and availability of pests in tomato plants (Ishtiaq et al., 2017).

Other crops that are infested by H. armigera include maize, chickpea, cotton, alfalfa, and tobacco. In Central Asia, the threshold damage of this pest on staple cotton by larvae is three to five larvae of long-staple cotton and eight or twelve larvae of medium-staple cotton. Attack of pests may lead to premature abortion of the flowers before they grow to bear fruit, and hence empty bolls. The bolls which have been damaged are vulnerable to secondary infections of fungi and bacteria, thereby interfering with the growth and delaying the maturity of the fruit (Sigsgaard et al., 2002). H. armigera is a polyphagous, seasonally migratory, and diapausative insect, which explains its abundance in the world as one of the most significant pests (Feng et al., 2009; Zalucki, Furlong & Downes, 2020).

The successful management of H. armigera must be accompanied by complete knowledge of the population dynamics, intensity of infestation and the dispersal patterns of the pests associated with the environmental conditions, such as weather conditions (Muhammad Ashfaq, 2012). Various tomato varieties have different levels of pest resistance that determine the choice of control method of Integrated Pest Management (IPM). The knowledge of such dynamics can be utilized to create specific interventions to handle outbreaks in both highly preferred and less preferred forms.

Cultural control methods that limit the population of the overwintering pests are important in the prevention of H. armigera infestations in the later cropping seasons. Other methods, like bursting the pupae, will decrease the population of the pests by exposing them to the natural predators and unfavourable weather conditions. Moreover, the management of the weeds in the crops and the vegetation around the crops inhibits the pest accumulation. Premature sowing reduced the larval infestation levels through evading peaks of pests as well as exposing the pupa to increased mortality (Dillon, 1998; Fitt, 1989). Breaking pest cycles is also caused by the destruction and removal of crop residues and alternate hosts.

These strategies have been strengthened by recent studies done internationally. As an illustration, field assessments showed that genotypes of tomatoes with high density of trichomes, thick pericarp and higher phenolic concentration had fewer instances of H. armigera infestation and therefore varietal resistance is important in IPM programs (Bisht, Sharma and Yadav, 2022; Sharma, Kiran and Sreedevi, 2022). Also, bio-rational pesticides like Bacillus thuringiensis, Metarhizium anisopliae, spinosad, and botanical extracts are effective in reducing the number of larvae but have minimal environmental impact (Khanal, Nepal & Shrestha, 2025; Srinivasan and Durairaj, 2021).

A combination of cultural, varietal resistance, biological and judicious use of chemicals is a holistic and sustainable H. armigera management system in tomato crops. These strategies are able not only minimize pest damage but also to minimize environmental and economic costs related to the high usage of pesticides, which is consistent with local research and the current global IPM practices.

Research Objectives:

Major Objective: This research was aimed at a comparative assessment of the effectiveness of the process of particular cultural practices in the management of H. armigera under the field conditions of tomatoes in Khyber Pakhtunkhwa, Pakistan. These particular goals were to:

1. Compare the infestation of H. armigera in preferred and less-preferred tomatoes, which are Rio Grande and Sahel, under natural field conditions.
2. Compare the relative effectiveness of individual cultural practices: early sowing, deep ploughing, weeding, larvae hand picking, pupal hatching, and picking of infested fruits in decreasing the egg and larval populations.
3. Determine the relative effectiveness of cohesive (combined) cultural practices, solitary practices, and uncontrolled control plots in the suppression of pest infestation, and in enhancing yield.
4. Determine the most economical and friendly cultural management approach that can be used in the integrated pest management (IPM) programs in tomato production in the area.

2. Materials And Methods

The experiment was carried out having Randomized Complete Block Design (RCBD). The least and most preferred varieties of tomato resulted from the previous experiment were selected for sowing and replicated 3 times at district Peshawar during March- May. 2021. Cultural practices, i.e., ploughing before sowing (T1), early sowing (T2), weeding (T3), hand picking of larvae (T4) and disposal of infested fruits (T5), pupal bursting (T6) before and after sowing, were gradually applied to check their efficacy against H. armigera. Blocks were allocated to selected varieties, and treatments were assigned to all replications. All these practices were applied individually and in combination to check the differences in their efficacy in comparison to the control plot (T7) with no treatments applied at all. The experimental plots were 3 m x 4 m (12 m 2). Plants were kept 75 cm apart in rows and 45 cm apart in plants, which is a normal distance for tomato crops that are cultivated in the field. The size of the plot was such that there was sufficient population of plants per treatment to provide reliable pest incidence and yield evaluation and reduce border effects. One deep plough was done to pupal bursting during the overwintering of H. armigera before sowing the selected Varieties. The seeds were sown as per the protocols mentioned in the 1st experiment, a bit early to manipulate the timespan to avoid reaching the crops to maturity when the environment is suitable for a dense population of H. armigera. Three times weeding at an interval gap of one day in a week was practiced. The larvae of H. armigera were handpicked, and the infested fruits were discarded to prevent the spread to healthy fruits. Pupal Bursting was done once at an interval of a week, and data was collected with an interval of 7 days (Reddy and Manjunatha, 2020).

2. 1**Treatments:**

1. Ploughing before sowing (T1)
2. Early sowing (T2)
3. Weeding (T3),
4. Hand picking of larvae (T4)
5. Disposal of infested fruits (T5)
6. Pupal bursting (T6)
7. Control (T7)

The selected treatments were based on their ecological role in disrupting the life cycle of H. armigera and reducing pest pressure without chemical intervention.

1. Deep ploughing (T1) was carried out once before sowing to expose and destroy overwintering pupae present in the soil.
2. Early sowing (T2) was adopted to manipulate crop phenology and avoid peak pest population periods.
3. Weeding (T3) reduces alternate host plants and oviposition sites.
4. Hand picking of larvae (T4) directly reduces larval population density.
5. Disposal of infested fruits (T5) prevents larval development and secondary infestation.
6. Pupal bursting (T6) was conducted once weekly to mechanically destroy soil-borne pupae

2.2 **Parameters**

1. No of eggs per plant
2. No of Infested fruits per Plant
3. Total No of fruits per plant
4. No of larvae per plant
5. Average yield of each variety

2.3 **Statistical Analysis**

Statistix 8.1 software was used in analyzing the data, as it is suitable for RCBD. The Least Significant Difference (LSD) test with 5% probability level ($p \leq 0.05$) was used to separate treatment means. There were also 95 percent confidence intervals that were estimated to improve the accuracy of treatment estimates. The magnitude of the treatment effect on pest infestation and yield parameters was taken into consideration to enhance the strength of statistical interpretation. (Sujana et al., 2008).

3. **Results**

The effectiveness of various cultural practices, such as early sowing, deep ploughing, weeding, handpicking of larvae, and removing of infested parts, as compared to a control plot from March to May 2021. The impact of these practices on the population of H. armigera (a pest) was studied on selected tomato varieties.

3.1 **Infestation Level**

Table 3.1 showed that the number of eggs per plant was determined in the plots that were planted with the least preferred and most preferred tomato varieties, and applied the cultural practices T1, T2, T3, T4, T5, T6, and the control (T7). In the case of Rio Grande, the egg population of the various treatments was between 1.68 and 2.27 eggs per plant. The population of the eggs was the greatest in the control plot (T7) (2.27 eggs per plant) and the lowest in the plot receiving early sowing (T2) (1.68 eggs per plant). In the case of the Sahel variety, the number of eggs per plant was found to be between 1.16 and 1.46 in various treatments. The control plot (T7) had the highest population of eggs (1.41

eggs per plant), and the lowest population of eggs (1.16 eggs per plant) was recorded in the plot which was treated with T2. In the same way, the larval population per plant trended in the same direction as the egg population, with the variety Rio Grande always having an egg and larval population higher than that of Sahel. All in all, treatment T2 always led to the lowest egg and larval population of the two tomato varieties, which means that early sowing was effective in minimizing the infestation of tomatoes with H. armigera (Table 3.1).

3.2 **Mean Fruit Number**

Table 3.2 represents the average of fruits per plant of the various plots treated with the least preferred tomato varieties and most preferred tomato varieties, and cultural practices T1 to T6, and the control (T7). In the case of the Rio Grande variety, the mean number of fruits was 17.09 to 19.33 fruits per plant at the treatment. The mean fruit per plant in the plot, which was sown at an early period (T2), was the highest (19.33 fruits per plant), and the lowest mean fruit per plant (17.09 fruits per plant) was recorded in the control plot (T7). In the case of Sahel, the average quantity of fruits was between 24.15 and 26.77 fruits per plant. The largest mean fruit number (26.77 fruits per plant) was observed in the plot with T2 treatment, and the lowest mean fruit number (24.15 fruits per plant) was observed in the plot with T4 treatment. Similar patterns were observed in the number of infested fruits per plant in both varieties, and treatment T2 tended to give the lowest number of infested fruits, and the control plot (T7) tended to have the highest number of infested fruits (Table 3.2).

The outcomes also indicate that every treatment had an effect on the size of the fruits of the two tomato varieties. In the case of Rio Grande, the maximum mean size of fruit was obtained in pupal bursting treatment (T6) with a mean size of 184 cm and then early sowing (T2) with a mean size of 168 cm. Other interventions, such as deep ploughing (T1) and removal of infested parts (T4), produced slightly smaller sizes of the fruits of 172 cm and 177 cm, respectively. T7 control treatment gave the least mean fruit size (165 cm). In Sahel, the size of fruits was mostly larger than that of Rio Grande, and early sowing (T2) had produced the largest fruit size (6.14 cm), whereas deep ploughing (T1) had produced the smallest fruit size (6.05 cm). The net effect of the treatments is that proactive pest management, like early sowing and pupal bursting, worked more to yield larger fruits, though the differences were more evident in the less esteemed Sahel variety (Table 3.2).

3.3 **Impact of Cultural Practices on yield**

Table 3.3 shows the average yield per plant and yield per plot of the various plots planted with least preferred tomatoes and most preferred tomatoes, and subjected to T1 to T6 cultural practices and the control (T7). With the Rio Grande variety, the average yield per plant was moving between 1.13 and 1.27 kg in treatments. The maximum yield per plant (1.27 kg) was observed in the treatment that had early sowing (T2), and the minimum yield per plant was in the control (T7) plot. Different treatments had a yield per plot varying between 41.94 and 48.03 kg, with the maximum yield being in T2 and the minimum in T7.

Mean yield per plant of the variety Sahel was between 1.32 and 1.42kg. The best yield per plant (1.42 kg) was earned in the plot cultured in all practices of culture, and the worst one (1.32 kg) was gained in the control plot (T7). The yield per plot was found to be 50.95 to 56.61 kgs across the treatments, with the highest being in the combined treatment and the lowest being in T1.

Generally, these findings reveal that cultural practices, especially early sowing (T2) and mixture of treatments, were useful in decreasing H. armigera population and increasing the output in both varieties of tomatoes. The variety of Sahel actually showed better results compared to Rio Grande, both in the case of lower pest infestation and high yield (Table 3.13.3).

This current investigation has shown that cultural practices like early sowing, deep ploughing, elimination of infested parts of the plants, hand picking of the larvae, and weeding highly minimized the number of eggs and larvae of H. armigera in both varieties of tomatoes (Rio Grande and Sahel). The same results have been attested in several agro-ecological regions over an earlier decade, which further supports the applicability of cultural control measures across the globe as a part of the Integrated Pest Management (IPM) systems.

Recent studies in semi-arid areas of India by Sharma et al. (2017) also found that manipulation of the sowing date had a significant effect in suppressing the H. armigera population in tomato and chickpea plants. Their data showed that crops that were planted early were able to avoid peak pest pressure because they had disrupted the synchronism of crops with the oviposition periods of the moth. This process is quite similar to the current experiment, in which early sowing (T2) led to the lowest number of eggs, the number of larvae and the highest fruit yield in both tomato varieties.

Likewise, Kumar et al. (2019) tested cultural control within the vegetable systems in the northern region of India and discovered that early transplanting and field sanitation played an important role in preventing larval attack and fruit damage in tomato crops. They laid stress on the fact that by early crop set-up, exposure is minimized in seasons when pests are most active, and therefore measurable enhancements in marketable yield have been realized. Such results confirm the high effectiveness of the T2 therapy, which was observed in this study.

Deep ploughing that was successful in the current research has also been confirmed in recent studies. In legume-based cropping systems in South Asia, Yadav et al. (2020) also found that summer deep ploughing had a significant negative effect on the survival of pupa H. armigera overwintering. Raised on desiccated and predatory soils, early infestations were suppressed. Similar findings were also demonstrated by Meena et al. (2018), who discovered that the initial pest build-up was lower in fields that were exposed to pre-season tillage activities.

Contemporary research has also supported field sanitation and mechanical control practices, including the gathering of infested fruits and the picking of larvae by hand. Sarkar et al. (2018) found that regular cleaning of the destroyed fruits in tomato farms tremendously decreased the second generation of larvae, besides capping the number of pests' population. In addition, Abbas et al. (2021) conducted a study in Pakistan, under semi-arid agro-ecological conditions, and demonstrated that manual larvae removal, combined with the weed management method, decreased the H. armigera infestation by over 30% in comparison with the untreated controls.

The varietal disparities recorded in the current research, where Sahel had lower rates of infestation than the Rio Grande, are in line with the recent research on host plant defences. Nawaz et al. (2017) found that genotypes of tomatoes that had a higher number of trichomes and a thicker pericarp of fruits had a significantly reduced oviposition and penetration of larvae. Similarly, Rashid et al. (2022) determined morphological characteristics, including epidermal hardness and biochemical compounds, to be factors of resistance that determined pest preference and larval survival in a tomato cultivar.

In sub-Saharan Africa, such integrated cultural strategies have proven to be promising. In their work with tomato production systems in East Africa, Chidege et al. (2019) found that timely planting, high field hygiene, and weed control were associated with a great reduction in the population density of H. armigera and damage to fruits. Also, as noted by Adeniran et al. (2023), using cultural practices in conjunction with resistant varieties amplified the suppression of pests and increased yield stability in tropical environments.

Although cultural practices have proved to be effective consistently, the current reviews of the world reveal that these strategies are not very likely to ensure the total eradication of pests in an isolated manner. Both Rehman et al. (2020) and Khan et al. (2021) identified that cultural methods can be used to significantly reduce H. armigera populations, but they concluded that the most effective way of managing these insects is to combine cultural methods with biological control agents, pheromone traps, and selective insecticides, as part of IPM. This is a similar conclusion to that of the current findings, where infestation levels were lowered considerably but not totally in treated plots.

The higher yield per plot and number of fruits per plant in the treated plots of the present study regarding the level of yield performance are in agreement with other studies that have recorded an enhancement in tomato productivity with early sowing and sanitation-based management systems (Kumar et al., 2019; Chidege et al., 2019). The less pest loss directly correlated to the extra fruit retention and commercial crop. The high effectiveness of the Sahel type in this study is an additional confirmation of the recent reports, which indicate that varietal resistance coupled with cultural control would lead to improved pest control as well as productivity.

Generally, the overlap with the results of South Asia, sub-Saharan Africa, and other semi-arid tropical areas reinforces the global applicability of the current study. Early sowing, deep ploughing, field sanitation and manual larval removal were among the cultural practices that have been found to be consistently effective across agro-ecological settings. Nevertheless, as it is backed up by modern literature, its best value is in the framework of holistic IPM, modified to the requirements of local environmental conditions and the system of crops.

These strategies would be validated by further experiments on tomatoes in the future in regions with differing agro-ecological conditions and adapted to fit all tomato production systems in the world.

4. Conclusions

According to the findings, the researcher found a steady pattern in the performance of cultural practices among the most popular and the least popular types of tomatoes. Precisely, the practice of early sowing (T2) was found to be the best practice for reducing the population of H. armigera eggs and larvae in both types of tomatoes, and it performed better than the control group.

Also, the least preferred tomato type, Sahel, was shown to perform better than the most preferred one, Rio Grande, in the level of suppressing the population of H.

armigera. The lowest numbers of eggs and larvae were continuously reported in Sahel between the two varieties, signifying a greater degree of natural resistance or undesirable features of the pest.

Overall, the research believes that the early sowing is an effective cultural practice in the control of H. armigera in tomato crops, and the Sahel variety is more resistant to this pest than Rio Grande.

5. Recommendations:

Based on these findings, tomato farmers in Peshawar (as well as other regions of Khyber Pakhtunkhwa) are encouraged to:

1. Use early sowing of tomato plantations to evade the highest population of H. armigera.
2. Planting of less-preferred tomato varieties, such as Sahel, in areas that are susceptible to the infestation of fruit borers is preferable.
3. Planting early together with other cultural activities, e.g. deep ploughing, weeding, larvae hand-weeding and stripping off the infested fruits to get maximum reduction in the pest population and better yield.
4. These practices should be encouraged by extension services by giving farmer trainings, field demonstrations, and advisories that are more localized to climatic conditions to Increase Adoption And Effectiveness.

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