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Antibiotic Impact of Certain Hosts on A Polyphagous Pest, *Helicoverpa Armigera* Hübner Under Ambient Rearing

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Abstract

The present study has been designed with the aim to explore the impact of certain established host plants on the biology of polyphagous pest, Helicoverpa armigera Hübner under the ambient rearing. The hosts namely, Tomato (Solanum lycopersicum L), Maize (Zea mays L.), Chickpea (Cicer arietinum L.), Pigeon Pea (Cajanus cajan L.), Mungbean (Vigna radiata L.), and Cotton (Gossypium hirsutum L.) have been used. The test insect, Helicoverpa armigera has been reared under ambient on the mentioned hosts to know the host suitability and further has been evaluated for the bioattributes like feeding index, approximate digestibility (%), pupal weight, growth index and survival index. During investigation, Gram, Cicer arietinum L. [Feeding Index 0.27 {±0.25}, Approximate Digestibility per cent 61.40 {±2.14}, Pupal Weight (mg) 321.25 {±3.97}, Growth Index 0.87 {±0.20} and Survival Index 1.41 {±0.57}] followed by Maize, Zea mays L. [Feeding Index 0.21 {±0.3}, Approximate Digestibility per cent 57.07 {±3.17}, Pupal Weight (mg) 311.34 {±4.31}, Growth Index 0.79 {±0.22} and Survival Index 1.37 {±0.54}] and Pigeon Pea, Cajanus cajan L. [Feeding Index 0.13 {±0.47}, Approximate Digestibility per cent 54.54 {±3.17}, Pupal Weight (mg) 297.67 {±2.41}, Growth Index 0.61 {±0.31} and Survival Index 1.34 {±0.48}] have been found to be the most suitable on the basis of evaluated bioattributes for the development of the test insect, Helicoverpa armigera. It has been recorded that the rest host crops also showed variable performance on different bioattributes of the test insect, Helicoverpa armigera.

Keywords: *Bioattributes, Biology, Pests, pupal weight, feeding index, pod borer, gram, maize, cotton*

1. Introduction

In the nature, insects can be classified under three different categories on the basis of their feeding habit, polyphagous which feeds on variety of plants, having no any close association with each other or plants which do not have any similarity in the term of nutrient components. The other two categories represent similarities in host plants from a few to major chemical component. Our test insect, *Helicoverpa armigera* Hübner falls under the category of polyphagous pests and likely feeds on variety of vegetations including the fruit, flowers and leaves (Pomari-Fernandes *et. al*., 2015). In case of *Helicoverpa armigera* Hübner, its caterpillar falls under the category of chewing type of pest. The chewing insects that feed on plants tissues cut the food into small fragments and ingest the same. Their mouthparts are primitive biting and chewing type and mandibles are used to cut the food (Armes, *et. al*., 1992). Other appendages are used for the purpose of ingestion while the adults having siphoning type of mouth which is only able to feed on liquid diets. The pest status of an insect species is depending upon the interacting factors, like ability to breed on a variety of host plants, comparative growth rate, fecundity, population dynamics and distribution (Ananthakrishnan, 1977). Polyphagous insect feeds on a variety of food plants, which differs in their composition of organic and inorganic constituents. The hosts namely, Tomato (*Solanum lycopersicum* L), Maize (*Zea mays* L.), Chickpea (*Cicer arietinum* L.), Pigeon Pea (*Cajanus cajan* L.), Mungbean (*Vigna radiata* L.), and Cotton (*Gossypium hirsutum* L.) are some common and favorite host of *Helicoverpa armigera* Hübner and commonly available throughout the India. With regard to insect-plant interactions, it is very useful to determine the influence of different host plants/cultivars on the performance of herbivores growth and development (Azidah and Sofian-Azirun, 2006 and Saeed *et al.,* 2009).

Helicoverpa armigera Hübner, belongs to family Noctuidae of the order Lepidoptera. The order is basically characterized by having both the pair of scaly wings. *Helicoverpa armigera* Hübner is belongs to moth group and share the order Lepidoptera with two closely related Lepidopteran namely butterflies and skippers (Karim, 2000). *Helicoverpa armigera* Hübner or *Heliothis armigera* is a very serious pest of many crops grown throughout the year in India. The total life cycle of *Helicoverpa armigera* Hübner takes about 4-6 weeks according to the weather conditions. In summer the life cycle takes lesser days in compare to the winter. The life cycle includes total 4 developmental stages from eggs, larvae which are known as caterpillar, pupa and the adult stage which is called moth. Adult moths are of 30-45 mm in length, the forewings of females are of brownish/ reddish brown while light brown to dull in colour for the male moths. Males easily can be differentiated from females by having darker fore-wing margins *Helicoverpa armigera* moths have a pale patch near the center of this dark region of hind wings (Yadav *et. al*., 2021; Chen *et. al*., 2022). Moths under the family Noctuidae are commonly called owlet moths while the larval stages commonly known as Armyworms or Cutworms due to their gregarious nature of feeding (Armes, *et. al*., 1992). It was considered the largest family in Lepidoptera for a long time, but after regrouping Lymantriinae, Catocalinae and Calpinae within the family Erebidae, the latter holds this title now. Currently, Noctuidae is the second largest family in Noctuoidea, with about 1,089 genera and 11,772 species. This classification is still contingent, as more changes continue to appear between Noctuidae and Erebidae (Yadav *et. al*., 2022; Viutha *et. al*., 2013). . Early instars feed on soft portions while the late instars use to feeds on older leaves, fruits and stem as well. After all the feeding, the last instar larva goes down to the ground, make tunnel in soil and pupates. Pupal period takes likely 10-14 days and emerges as an adult moth during the evening hours (Yadav *et. al*., 2022; Das *et. al.*, 2022).

Different host plants can also play an important role in population increase and outbreak of polyphagous insect pests (Singh and Parihar, 1988). Biological parameters are important in the measuring the population growth of a species under specified conditions (Southwood, 1978). The response of an insect could be used as a marker for differences amongst the plant cultivars. Keeping all the above factors in mind, a study entitled "Antibiotic Impact of Certain Hosts on A Polyphagous Pest, *Helicoverpa armigera* Hübner Under Ambient Rearing" has been designed with aim to explore the impact of certain established host plants on the biology of polyphagous pest, *Helicoverpa armigera* Hübner (Herwade *et. al*., 2022).

2. Materials And Methods

Research locations: The insect rearing was done in the Biocontrol laboratory of Entomology Department, MS Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi Odisha and host plants were grown in university vegetable research farm, agronomy research farm during the year 2021-22. The climatic conditions are hot and dry during summer and mild to cool in winter. The average rainfall of Gajapati district is 1970 mm out of which nearly 85-90 per cent occurs during the monsoon from the middle of June to October. The average maximum temperature 42ºC during hottest month, an average minimum temperature is 24ºC. January is the coldest month with lowest average temperature around 16ºC. The nature is very good around and covered with small to medium height mountains. The agriculture in this area is mostly depends on rain water. Rice in *Rabi* and *Kharif* as well, Sesamum, Pigeon pea, Vegetables are mostly grown in this area.

Selection of Host Plants: The crops namely Tomato (*Solanum lycopersicum* L), Maize (*Zea mays* L.), Chickpea (*Cicer arietinum* L.), Pigeon Pea (*Cajanus cajan* L.), Mungbean (*Vigna radiata* L.), and Cotton (*Gossypium hirsutum* L.) have been selected for the study and have been grown in vegetable farm and agronomy farm as per the proper cultivation methods. Fresh leaves were obtained time to time for the feeding of neonate and later instar larvae as well.

Assessment: The following important bioattributes have been assessed *i.e.*, feeding index, approximate digestibility (AD%), pupal weight (mg), growth index, and survival index. These bioattributes were determined by the following formula.

$$\text{Feeding index} = \frac{\text{Pupal weight}}{\text{Total leaf consumed}}$$

(Greenberg *et al.*, 2001)

$$\text{Approximate Digestibility (\%)} = \frac{\text{Dry weight of consumed leaf} - \text{Dry weight of excreta}}{\text{Dry weight of consumed leaf}} \text{X100}$$

(Waldbauer, 1968)

$$\text{Growth index} = \frac{\text{Pupal weight (g)}}{\text{Total duration (in days)}}$$

(Komatsu *et al.*, 2008)

$$\text{Survival index} = \frac{\text{Percentage of larva pupated}}{\text{larval period in days}}$$

(Singh and Sachan, 1982)

All these formulas are used to determine the bioattributes of *H. armigera* reared on different common host crop as mentioned previously. Standardization of pupal weight gained, was done on chickpea (gram) leaves which is regarded as one of the most suitable hosts.

Material required: Sensitive electronic balance, Oven, Rearing vials, Formaldehyde, Cotton, Soft hair brush, Needle, Oviposition cages, Egg laying cages, mating cages etc.

Stock culturing of *H. armigera* and pupal weight standardization: *H. armigera* larvae were collected from sunflower field and reared in cages (39x39x44cm) at ambient condition of the laboratory. Pupae formed were kept in cages of same size for emergence. The cages were underlined with muslin cloth to prevent the entry of natural enemies and to facilitate stretching of wings of fresh emerged adults. One day old emerged moths were released in oviposition cages (50x50x70cm) for mating and oviposition. The fresh chickpea leaves were kept in the oviposition cages to provide oviposition substrate. The cotton swab soaked in 20 per cent honey solution was given daily as adult food. The castor leaves were replaced with new one every day and leaf bits cut with eggs laid by female were kept in a plastic container (9.5cmx7.5cm) for hatching and continuing rearing of initial instars. Test larvae have been transferred at an interval of every three days in fresh cages and provided with fresh chickpea leaves. The process of transferring was continued till the pupation of later stages. Harvesting of pupae have been done after two days of pupation. These collected pupae were dipped into 2 per cent NaOCl for ½ minute to sterilize them. These dipped pupae were immediately cleaned 3 times in distilled water. These cleaned pupae were kept on tissue paper for drying and were weighed for pupal weight standardization.

Laboratory Experiment layout: The neonate larvae, approximately 2 days old have been grouped into a total number of four sets and each set having 20 number of neonates. Each selected host including the control (Chickpea) was considered as different treatment and each treatment have been divided into four numbers of replications. Growing larvae were distributed singly in rearing glass vials (4cmx2cm). Thus, there were seven treatments and four replications in the experiment.

Host preparation and feeding: Tender fresh leaves of all the selected hosts have been taken for feeding to growing larvae. The selected leaves of various selected hosts were sterilized in 2 per cent NaOCl solution for 2 minutes by dipping to suppress the microbial growth. These leaves were cleaned in running distilled water for 3 minutes. Fresh water cleaned leaves were shade dried. Each group larvae were fed with sterilized leaves of Tomato (*Solanum lycopersicum* L.), Maize (*Zea mays* L.), Chickpea (*Cicer arietinum* L.), Pigeon Pea (*Cajanus cajan* L.), Mungbean (*Vigna radiata* L.), and Cotton

(*Gossypium hirsutum* L.). Before given for feeding, sterilized leaves were weighed with help of electronic balance. Same quantity of fresh leaves was kept as aliquot for computing its difference in dry weight of food consumed. The fresh leaves of food were changed daily and these eaten leaves kept for computing its dry weight. This way left over uneaten leaves was collected from all individual rearing vials. The excreta were collected daily from rearing vials and kept safely instars wise of individual vials. The process of giving fresh sterilized leaves was done till the larvae become full grown and ready to undergo pupation. After two days of pupation, pupae were collected for sterilization, cleaning and weighing. Emerged moths were released in a cage (50cm×50cm×50cm) with artificial food 20 per cent honey solution and water swab. Cages were provided with chickpea fresh and sterilized leaves as a substrate for eggs laying.

Oven drying: The consumed leaf, uneaten leaf and excreta of larvae were oven dried for 6 hours at 60^0C. The drying was repeated three times to get the constant weight of dried leaves and excreta.

Data recorded: Different inputs weight *viz.*, fresh leaves, eaten leaves, uneaten leaves, weight of dried eaten and uneaten leaves (aliquot) dry weight of excreta, mortality of larvae, pupal weight data were recorded for computation different bioattributes magnitude.

Data analysis: The different bioattributes parameters of *Helicoverpa armigera* were analyzed using one-way ANOVA (SAS Institute, 2008). Means associated with host plants for each variable were separated using the least significant difference test when significant values were obtained.

3. Results and Discussion

The results presented in the Table 1showing antibiotic impact (Feeding Index, Approximate Digestibility, Pupal Weight, Growth Index and Survival Index) of different host crops (Tomato, Maize, Chickpea, Pigeon pea, Mungbean and Cotton) on test insect, *Helicoverpa armigera*.

Table1. Antibiotic impact of certain hosts on a polyphagous pest, *Helicoverpa armigera* Hübner under ambient rearing

Name of the Treatments	Mean Values of Different Bioattributes				
	Feeding Index	**Approximate Digestibility (%)**	**Pupal Weight (mg)**	**Growth Index**	**Survival Index**
Tomato (*Solanum lycopersicum*)	0.16 (±0.12)	56.20 (±2.54)	312.50 (±4.54)	0.77 (±0.17)	0.49 (±0.12)
Maize (*Zea mays*)	0.21 (±0.3)	57.07 (±3.17)	311.34 (±4.31)	0.79 (±0.22)	1.37 (±0.54)
Chickpea (*Cicer arietinum*)	0.27 (±0.25)	61.40 (±2.14)	321.25 (±3.97)	0.87 (±0.20)	1.41 (±0.57)
Pigeon Pea (*Cajanus cajan*)	0.13 (±0.47)	54.54 (±3.17)	297.67 (±2.41)	0.61 (±0.31)	1.34 (±0.48)
Mungbean (*Vigna radiata*)	0.19 (±0.11)	54.54 (±3.11)	263.00 (±2.77)	0.73 (±0.37)	1.03 (±0.31)
Cotton (*Gossypium hirsutum*)	0.23 (±0.27)	47.00 (±4.27)	241.00 (±2.69)	0.85 (±0.64)	1.17 (±0.37)
CD	0.07	2.64	4.31	0.09	0.37
CV	0.74	5.81	7.58	0.31	1.14
SEm±	0.03	0.89	1.46	0.04	0.14

The feeding index of *Helicoverpa armigera* against different hosts have been calculated and been presented in the Table 1, which shows the maximum feeding index was recorded in the case of Chickpea (*Cicer arietinum*) with 0.27 (±0.25) followed by Cotton (*Gossypium hirsutum*) with 0.23 (±0.27) and Maize (*Zea mays*) with 0.21 (±0.3) of feeding index while the minimum was recorded in Pigeon Pea (*Cajanus cajan*) with feeding index of 0.13 (±0.47). These feeding index help researchers, entomologists, and ecologists better understand insect-plant interactions, the extent of damage caused by insects, and potential effects on ecosystems. This index involves scoring the severity of damage on a scale, ranging from no damage to severe damage. The feeding index may help scientists quantify and compare various aspects of insect feeding behavior. The choice of index depends on the research goals, the specific insects and plants being studied, and the available resources. *Helicoverpa armigera*, commonly known as the cotton bollworm or corn earworm, is well-known for its polyphagous nature. Polyphagy refers to the ability of an organism, in this case, an insect, to feed on a wide variety of host plants. *H. armigera* is one of the most economically significant and widely distributed agricultural pest insects globally, primarily due to its ability to feed on numerous plant species belonging to various families. The results shared very minor variations in the case of feeding index as the test insect is of polyphagous nature and all the plants included in this study are likely the preferred plants for this insect. The minor variations have been observed in case of chickpea which is considered as key crop for the infestation of *Helicoverpa armigera*.

The approximate digestibility was found to be maximum in case of Chickpea (*Cicer arietinum*) with 61.40 (±2.14) per cent followed by Maize (*Zea mays*) with 57.07 (±3.17) and Tomato (*Solanum lycopersicum*) with 56.20 (±2.54) per cent while the Mungbean (*Vigna radiata*) with 54.54 (±3.11) and Pigeon Pea (*Cajanus cajan*) with 54.54 (±3.17) per cent stand for the minimum approximate digestibility. The digestibility of various hosts by *Helicoverpa armigera* can vary depending on factors such as the developmental stage of the insect, the specific variety of hosts, and environmental conditions. Chickpeas, like many legumes, contain various compounds such as proteins, carbohydrates, and secondary metabolites that can influence their digestibility for insects. Generally, *Helicoverpa armigera* is known to be a polyphagous insect that can feed on a wide range of plant species. However, its feeding preference and the extent to which it can digest a particular plant can vary. Chickpea, pigeon pea, maize leaves, flowers, and pods/ cobs are commonly targeted by *H. armigera* larvae.

The study conducted by earlier researchers such as Hemanti *et. al*., 2012; Fathipour *et. al*., 2018 have investigated the nutritional indices of *Helicoverpa armigera* larvae, reared on various host plants under controlled laboratory conditions. Notably, larvae raised on potato cultivar Agria exhibited the highest efficiency of conversion of digested food (ECD) and efficiency of conversion of ingested food (ECI), indicating that potato Agria was particularly favorable for their growth and development. However, larvae feeding on chickpea cultivar Azad displayed the highest approximate digestibility (AD), signifying that chickpea Azad was the most easily digestible host among those studied. These findings highlight the significant influence of host plant choice on the nutritional performance of H. armigera larvae, offering valuable insights for pest management strategies and understanding the insect's ecology. It is seen that some particular cultivars showing greater level of susceptibility for the pest for feeding as per their morphological and nutritional features.

The pupal weight which is presented in Table 1 showed the maximum pupal weight in case of Chickpea (*Cicer arietinum*) with pupal weight of 321.25 (±3.97) mg followed by Tomato (*Solanum lycopersicum*) with 312.50 (±4.54) mg and Maize (*Zea mays*) with 311.34 (±4.31) mg while the minimum was recorded in Cotton (*Gossypium hirsutum*) with 241.00 (±2.69) mg of pupal weight. The relationship between feeding behavior and pupal weight in *Helicoverpa armigera*, the cotton bollworm, is crucial for understanding its growth and development. Larvae with access to ample and nutritious food sources tend to have higher pupal weights, indicating better overall growth. The quality of the food influences feeding behavior and subsequently impacts pupal weight. Larvae that feed optimally on high-quality food achieve greater pupal weights, while competition for limited resources or poor-quality food can lead to smaller pupal weights. Environmental conditions, host plant selection, and nutritional stress further shape this relationship, offering insights into pest management strategies.

According to Akbar *et. al*., 2016; Wang and Dong, 2001, the pupal weight of *Helicoverpa armigera* can be influenced by a multitude of factors, including the larval diet quality and quantity, environmental conditions during larval development (such as temperature, humidity, and photoperiod), genetic variability within the population, and the presence of natural enemies or competitors. Larvae that feed on nutrient-rich host plants are more likely to attain higher pupal weights, while adverse environmental conditions or resource limitations can lead to smaller pupal sizes. Additionally, genetic factors may play a role, as different populations or individuals within the species may exhibit variations in pupal weight.

Furthermore, the presence of predators, parasitoids, or interspecific competition can also impact the development and final pupal weight of *H. armigera*, as these factors can influence larval survival and resource allocation.

In the case of growth index, the data presented in the Table 1 showed the maximum growth index in Chickpea (*Cicer arietinum*) with 0.87 (±0.20) growth index followed by Cotton (*Gossypium hirsutum*) with 0.85 (±0.64) and Maize (*Zea mays*) with 0.79 (±0.22) of growth index. The minimum was recorded in Pigeon Pea (*Cajanus cajan*) with 0.61 (±0.31) of growth index. The growth index of *Helicoverpa armigera*, a significant agricultural pest, is intricately influenced by multifaceted factors. Nutrition plays a pivotal role; larvae fed with ample, nutrient-rich food exhibit robust growth, while inadequate or low-quality diets impede development. Host plant diversity and suitability are crucial; certain plants provide optimal nutrients and compounds that foster growth, while others may hinder it. Feeding behavior, encompassing feeding efficiency and frequency, shapes growth trajectories. Environmental conditions, encompassing temperature, humidity, and photoperiod, intricately modulate metabolic rates, impacting growth patterns. Intraspecific competition for resources, coupled with the presence of natural enemies like predators and parasites, can restrict growth. Larval developmental stage also influences growth responsiveness to various factors. Pesticides, both directly and indirectly, alter growth dynamics. Genetic diversity within *H. armigera* can lead to variable growth potential among individuals. Collectively, these factors intertwine to determine the growth index of *H. armigera*, offering insights for pest management strategies that consider its intricate developmental dynamics. According to Reed, 1965 and Armes *et. al.*, 1992, the growth index of *Helicoverpa armigera*, a key agricultural pest, is subject to various influencing factors. Larval growth is primarily determined by the quality and quantity of its dietary resources, with nutrient-rich host plants promoting more robust development. Environmental conditions, such as temperature, humidity, and photoperiod, also play a significant role, as they can affect metabolic rates and development rates. Genetic factors within the *H. armigera* population can lead to variations in growth potential. Additionally, exposure to pesticides or natural enemies, such as parasitoids and predators, can disrupt larval growth by increasing mortality rates or altering feeding behavior.

The Table 1 present the survival index of *Helicoverpa armigera* of various hosts which was found maximum in case of Tomato (*Solanum lycopersicum*) with 0.49 (±0.12) followed by Chickpea (*Cicer arietinum*) with 1.41 (±0.57) and Maize (*Zea mays*) with 1.37 (±0.54) of survival index. The minimum was recorded in case of Mungbean (*Vigna radiata*) with 1.03 (±0.31) of survival index. The survival index of *Helicoverpa armigera*, commonly known as the cotton bollworm or corn earworm, varies across different crops due to a combination of factors. Crops with favorable nutritional profiles and fewer natural defense mechanisms often lead to higher survival rates for larvae, as they provide optimal conditions for growth and development. Conversely, crops possessing natural defense such as secondary metabolites or physical barriers can lower survival rates by deterring feeding or impeding development (Kouhi *et. al*., 2014). The presence of natural enemies like predators and parasites on certain crops can also impact survival through predation or parasitism. Additionally, environmental conditions, including temperature and humidity, further influence larval survival (Jafari *et. al.*, 2023; Kotkar et. al., 2009).

4. Conclusion

The present study investigating the antibiotic impact of certain host plants on the polyphagous pest *Helicoverpa armigera* Hübner under ambient rearing conditions sheds light on the intricate interplay between insect herbivores and their chosen hosts. The research provides valuable insights into how specific plant species can influence the survival, growth, and overall fitness of *H. armigera* larvae. The findings underscore the significance of host plant selection as a pivotal factor in shaping the dynamics of insect-plant interactions. By identifying the antibiotic impact of certain hosts, the study elucidates the complex chemical and physiological mechanisms at play, which could potentially contribute to resistance against *H. armigera* infestations. Moreover, the investigation's focus on ambient rearing conditions is noteworthy, as it allows for a more ecologically relevant assessment of the insect's responses to different host plants in a natural context. The implications of the study extend beyond a mere understanding of the pest's ecological adaptations; they have practical implications for agricultural management and pest control strategies. The identification of host plants that exhibit antibiotic properties could potentially be leveraged in integrated pest management approaches, capitalizing on the natural defense of certain crops to mitigate *H. armigera* infestations. Furthermore, the research accentuates the complexity of insect-plant interactions and the need for a holistic approach in devising sustainable pest management solutions.

However, the study's focus on ambient rearing conditions might warrant further investigation into how these findings translate to more controlled environments or field conditions, which can present diverse ecological challenges. Additionally, while the research provides insights into the potential antibiotic effects of certain host plants, understanding the specific compounds responsible for these effects and their mode of action could be a promising avenue for future research. In essence, this study on the antibiotic impact of specific host plants on *Helicoverpa armigera* enriches our comprehension of the intricate relationship between herbivorous insects and their plant hosts. It not only contributes to the field of entomology but also offers practical implications for sustainable pest management, thereby bridging the gap between fundamental research and real-world applications in agriculture.

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