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Mrpho-physical Factors Affecting Consumption and Coefficient of Utilization of *Helicoverpa armigera* (Hübner)

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ABSTRACT

The selected plants in order of preference on the basis of consumption were Sorghum > Maize > Bermuda grass > Tomato > Cotton (NIAB-98) > Alfalfa > Rice >Castor oil > Okra > Cattail > Cotton (CIM-446) > Horse purslane > Rape seed > Winter cherry > Calotrope. The order of the preference on the basis of Coefficient of Utilization (CU) was Sorghum > Bermuda grass > Maize > Cotton (NIAB-98) > Tomato > Winter cherry > Castor oil > Alfalfa > Okra > Rice > Cotton (CIM-446) > Horse purslane > Calotrope > Rape seed > Cattail. None of the plants was found completely resistant to *H. armigera*. The correlation between food consumption and CU was significantly positive. Moisture content showed positive while thickness of leaf lamina played negative role both for consumption and CU. Moisture percentage alone contributed 50.8% and 40.5% role towards resistance in term of consumption and CU, respectively. The cumulative effect of all the morpho-physical plant factors was 80.1% for consumption and 57.8% for CU.

Key words: Morpho-physical factors, host plants, consumption, coefficient of utilization, *H. Armigera,* Pakistan

INTRODUCTION

Helicoverpa armigera (Hb.) (Noctuidae: Lepidoptera) is highly polyphagous pest (Bilapate, 1984; Zalucki *et al.*, 1986). Mohyuddin (1989) reported 65 host plants from sub-mountainous to coastal areas. Losses caused by this pest were reported to be 20% in cotton (Ahmad and Mohsin, 1969), 35% in tomato (Latif *et al.*, 1997), 23% pod damage in gram (Rehman, 1940) and 56.22% in pigeon pea (Sharma and Pandey, 1993). Balasubramanian *et al.* (1982) reported 53% infestation of bollworms on cotton. Bhat (1986) found 29.% loss in seed cotton yield.

Complete reliance has been made on pesticides for the control of this notorious pest. The continuous and indiscriminate use of insecticides has created problems of health hazard, environmental pollution and development of resistance against insecticides (Ahmad *et al.,* 1997; Jadhav and Armes, 1996). The variation in growth is even more remarkable when different food materials are involved. Genetic diversity in density of pubescence in both wild and domesticated plants results in varying effects upon the biology of insect pests. Lukefahr *et al.* (1971) reported reduction of up to 60% in oviposition by *Heliothis* spp. on glabrous cottons. The smooth leaf cottons is a source of resistance to *Heliothis* spp. (Lukefahr *et al.*, 1975 and Robinson *et al.*, 1980). Ramalho *et al.* (1984) reported that pubescence provided a mechanism of resistance to movement of newly hatched larvae of *H. virescens* on cotton. Navasero and Ramaswamy (1993) found a significant correlation between oviposition and leaf moisture (r = -0.92) and between oviposition and pubescence (r = 0.98). Thus leaf hairiness was more important than moisture content in affecting oviposition by *H. virescens.* Satpute *et al.* (1994) found lowest damage of noctuid on cotton with greatest trichome density. Butter and Singh (1996) reported that hair length on upper surface of the leaf rather than density was positively correlated with the oviposition. Murthy *et al.* (1998) reported that the dense hairy cottons should be used as donor in bollworm resistance breeding programmes. Thimmaiah *et al.* (1994) reported that resistant genotypes of cotton possessed reduced leaf thickness.

The present study was conducted on 13 host plants along with 2 cotton genotypes to study the influence of morpho-physical factors of different selected host plants offered to the pest for consumption and coefficient of utilization by exhibiting simple correlation between them and to develop linear regression models through steps between morpho-physical plant factors and consumption and coefficient of utilization of the insect.

MATERIALS AND METHODS

Based on the data of food consumption and coefficient of utilization (CU) from preliminary screening trials (Table 1), 13 plants (out of 44) viz., calotrope, winter cherry, castor oil, cattail, horse purslane, bermuda grass, alfalfa, maize, okra, rice, rape seed, sorghum and tomato along with two cotton genotypes viz., NIAB-98 (late maturing) and CIM-446 (early maturing) were selected. These plants were offered as food to *H. armigera* to study the order of preference through consumption and CU of the pest. Eggs (white and brown) of *H. armigera* were collected from various field crops (cotton, vegetables and weeds along with their leaves and petioles) from the research area of Ayub Agricultural Research Institute (AARI), Faisalabad. The leaves along with their petioles containing eggs were brought into rearing chamber of Entomology Section, AARI., Faisalabad run at 28±2 °C, 65±5% RH. with 12: 12 day: night regime. The petioles were wrapped in wet muslin cloth and placed in glass beakers under rearing cages till larval emergence. Newly emerged larvae were collected daily carefully with camel's hair brush, released on fresh cotton (NIAB-98) leaves and kept them into rearing cages 40.86 X 32.36 X 32.36 cm. The feed was changed daily till pupation. The sex of the pest was identified at pupal stage. Ten pairs were collected from the materials and each pair was kept in a separate rearing cage providing wet soil of two cm thick layer. Cotton leaves were placed in the cages on emergence of adults. Wool plugs dipped into sugar solutions were also placed in the cages as adult diet. The leaves were checked for egg laying and changed daily for five days. The eggs were collected daily and kept them in glass beakers of ½ liter capacity along with leaves containing eggs. The petioles of the leaves were wrapped with wet muslin cloth and kept them wet for three days till larval emergence. Newly hatched larvae were picked up daily with camel's hair brush and placed them on fresh cotton leaves and released into rearing cages in counted number. The cotton leaves were replaced daily with new ones, till fourth instar.

Fresh tender leaves weighing 40 g of each selected host plant were washed with distilled water to remove dust and dirt and shade-dried for one hour. The leaves of each host plant were divided into four lots and each lot contained 10 grams leaves. These leaves were cut into small pieces. Ten grams leaves of each host plant were put into glass beaker and each host plant had four beakers (250 ml capacity). Thus, it was replicated four times in Completely Randomized Design (CRD). These beakers were kept into rearing room under controlled conditions. Uniform sized larvae of 4th instar were obtained from mass rearing cages and one larva was liberated into each beaker for feeding. The larvae were starved for 24 h before liberation and then were allowed to feed on the experimental foods for 24 h. The data on consumption were recorded. The percent coefficient of utilization was calculated according to Evans (1939).

$$\text{Coefficient of Utilization (\%)} = \frac{A - B}{A} \times 100$$

A = Dry weight of food consumed
B = Dry weight of faeces produced
The whole set of experiment was repeated thrice.

Three samples, each of 10 grams leaves of the selected plants were taken to determine moisture contents. All the leaves were cleaned with muslin cloth, weighed and kept into a drying oven run at 100±5°C for 12 h. The dry matter of leaves was weighed and put back into the oven at the same temperature for another six h. After the weight of the dry materials became constant, the moisture percentage was calculated by the following formula.

$$\text{Moisture (\%)} = \frac{A-B}{A} \times 100$$

A = Weight of fresh leaves
B = Weight of dry leaves

Three fresh leaves of each from three different plants were taken for hair density. The number of hair from three different places of each leaf from upper and lower surface was counted under microscope in a unit area of ½ cm^2 length (Ali *et al.*, 1995).

Table 1: Data Regarding Leaf Consumption in Milligrams (Dry Weight 10 Gram Fresh Leaves) and Coefficient of Utilization (%) of Various Plants Offered as Food to a 4th Instar Larvae of *Helicoverpa Armigera* (Hb.)

Food Plants	Technical Name	Consumption Mg Dry weight / 10 g Fresh leaves	Coefficient of Utilization (%)
Sorghum	*Sorghum vulgare* Pers.	374.90A*	69.33AB *
Maize	*Zea maize* L.	362.01B *	66.88A-F
Bermuda Grass	*Cynodon dactylon* Pers.	361.69B *	69.60A*
Johnson Grass	*Sorghum halepense* Pers.	345.45C	63.85CD-H
Millet	*Permiselum typhoideum* L.	333.90CD	61.70E-H
Sugarcane	*Saccharum officinarum* L.	330.70DE	67.58A-D
Cauliflower	*Brassica oleracea* Botrytis	319.38EF	64.70A-G
Berseem	*Trifolium alexandrinum* L.	312.25FG	64.20A-G
Tomato	*Lycopersicon esculentum* L.	310.76FG	68.47A-C*
Rose	*Rosa indica* L.	300.08G	60.43GH
Sesamum	*Sesamum indicum* L.	287.43H	51.09J-L
Chillies	*Capsicum annum* L.	272.77I	67.06A-E
Garden spurge	*Euphorbia pilulifera* L.	271.69I	47.94L-O
Water melon	*Citrullus vulgaris* Schard	269.03I	45.15M-P
Cotton (NIAB-98)	*Gossypium hirsutum* L.	267.33I *	66.15A-F *
Castor oil	*Ricinus communis* L.	261.71I	52.59J-L *
Sunflower	*Helianthus annus* L.	246.10J	62.70D-H
Alfalfa	*Medicago stiva* L.	246.09J	51.09J-L*
Sesbania	*Sesamum indicum* L.	241.64J	50.61J-M
Turnip	*Brassica rapa* L.	241.59J	54.66IJ
Abutilon	*AbuSesamumon bidentatum* L.	238.49J	63.92B-G
Rice	*Oryza sativa* L.	236.35JK*	48.94K-N
Horse purslane	*Boerhavia repens* L.	226.03KL*	41.62PQ
Cattaile	*Typha angustata* L.	223.52L*	27.34R*
Field bindweed	*Cirsium arvensis* L.	208.26M	45.40M-P
Green gram	*Vigna radiata* L.	199.29MN	53.84I-K
Carrot	*Dacus carota* L.	198.25MN	61.40F-H
Water Grass	*Phragmites karka* L.	197.93MN	54.36I-K
Nightshade	*Solanum nigrum* L.	196.58MN	42.78OP
Slender pigweed	*Amarantus viridis* L.	194.13NO	42.25PQ
Euphorbia	*Euphorbia pilulifera* L.	189.97NO	40.43PQ
Spinach	*Spinacea oleracea* L.	188.64N-P	37.26Q
Cotton (CIM-446)	*G. hirsutum* L.	188.23N-P*	49.76J-N *
Bitter gourd	*Legenaria vulgaris* Ser.	187.33N-P	42.22PQ
Brinjal	*Solanum melongena* L.	183.85O-Q	40.91PQ
Fenugreek	*Tiagonella foenumgraecum* L.	176.61P-R	44.53N-P
Jungli Spinach	*Rumex dentatus* L.	174.74QR	58.91HI
Sugarbeet	*Beta vulgaris* L.	169.42RS	50.59J-M
Radish	*Raphanus sativus* L.	168.98RS	53.94I-K
Pakhra	*Tribulus terristris* L.	161.42S	41.51PQ
Rape seed	Brassica compestris L.	157.22S	28.93R*
Okra	*Hibiscus esculentus* L.	131.30T*	41.49PQ
Winter cherry	*Withania somnifera* Dunal.	129.67T*	53.72I-K*
Calotrope	*Calotropis procera* Br.	127.49T*	27.49R*

Correlation coefficient value between consumption and coefficient of utilization = 0.707 **

Means sharing similar letters are not significantly different by LSD Test at P = 0.01

* = Selected host plants

Length of hair on leaf lamina from three different places of each three selected leaves from upper and lower surfaces was measured under the stereo-binocular microscope with the help of ocular micrometer (Ali *et al.*, 1995).

Three fresh leaves each from three plants of each selected host were taken into account to measure thickness of leaf lamina. A cross section of lamina of each leaf was cut with the help of a fine razor and thickness of lamina was determined from three different places of each leaf with the help of an ocular micrometer under a stereo-binocular microscope (Ali *et al.*, 1995).

The data were processed through M-Stat Package for analysis of variance, DMR or LSD tests, simple correlation and multi-variate linear regression models. An IBM-Compatible Computer was used

RESULTS AND DISCUSSION

The results (Table 2) revealed that the ranking order of preference on the basis of consumption was Sorghum > Maize > Bermuda grass > Tomato > Cotton (NIAB-98) > alfalfa > rice > castor oil > okra > cattail > Cotton (CIM-446) > Horse purslane > rape seed > Winter cherry > Calotrope. The present findings are in partial agreement with those of Saleem and Yunus (1982) who reported that amongst 41 host plants, Tomato, Maize, Gram, Tobacco, Cotton and Okra were damaged seriously by the *H. armigera* but in the present study Sorghum, Maize, Bermuda grass, Tomato and Cotton (NIAB-98) were preferred the most. This variation was existed due to different host plants studied in the present dissertation as those of included in the studies carried out by the previous authors. Ding and Zhang (1993) observed severe infestation in cotton fields. They further reported that 1st and 2nd generation caused serious damage in wheat and rice fields. But the damage may vary from variety to variety. The authors did not mentioned varieties of cotton, however the findings can partially be in accordance with the present findings.

Table 2: Leaf Consumption, Coefficient of Utilization (CU) and Various Morpho-physical Factors of Different Plants Offered as Food to 4th Instar Larvae of *H. armigera*.

Food Plants	Consum -ption (mg/ 10 gms Fresh Leaves)	CU (%)	Moisture in Leaves (%)	Hair Density on Leaf Lamina of upper leaf per½ cm^2	Hair Density on leaf lamina of lower surface per ½ cm^2	Length of hair on upper surface of fresh leaves (mμ)	Length of hair on lower surface of fresh leaves (mμ)	Thickness of Leaf Lamina of Fresh Leaves (mμ)
Calotrope	133.98J	29.06H	74.37FG	21.11D	853.25A	6.05G	3.56H	24.11A
Winter cherry	136.82J	58.01D	73.95G	3.93E	4.35C	20.67C	7.86E	3.05H
Castor oil	226.26FG	54.89E	72.30H	0.00E	0.00C	0.00H	0.00I	4.57DEF
Cattaile	214.54GH	23.97I	73.42GH	0.00E	0.00C	0.00H	0.00I	3.60FGH
Horse purslane	203.16H	44.67G	75.69F	0.00E	0.00C	0.00H	0.00I	5.70CDE
Bermuda grass	337.71B	69.60A	77.53E	0.00E	0.00C	0.00H	0.00I	3.21GH
Alfalfa	250.45E	51.36E	77.54E	152.36A	286.51B	6.28G	6.70F	3.40FGH
Maize	359.04A	67.52AB	82.56A	15.49D	25.79C	13.69D	16.87B	5.14FGH
Okra	216.96GH	51.11E	78.90DE	62.06B	23.50C	39.76A	21.00A	4.41EFG
Rice	241.28EF	48.13F	80.63BC	2.95E	0.00C	5.52G	0.00I	9.68B
Rapeseed	153.80I	24.47H	73.52GH	0.00E	0.00C	0.00H	0.00I	6.25C
Sorghum	366.85A	69.72A	83.01A	0.00E	0.00C	0.00H	0.00I	5.23CDE
Tomato	300.79C	62.45C	80.04CD	6.61E	212.70B	25.10B	4.37G	5.53CDE
Cotton (NIAB-98)	276.64D	66.17B	81.71AB	44.93C	38.96C	9.14E	11.33C	5.57CDE
Cotton (CIM-446)	205.92H	44.72G	79.66CD	60.11B	46.78C	7.62F	9.30D	5.77CD

Means sharing similar letters are not significantly different by
DMR Test at P = 0.05
Correlation Coefficient value (r) between consumption and Coefficient of utilization = 0.763**

Table 3: Effect of Morpho-physical Factors of Fresh Leaves of Various Selected Plants Offered as Food to 4th Instar Larvae of *H. armigera* on Consumption and Coefficient of Utilization (CU)

Factors	Consumption (Mg/10 gram fresh leaves)	CU (%)
Moisture Contents	0.713 **	0.637 **
Thickness of Leaf Lamina	-0.373 **	-0.375 **
Hair Density on Upper Surface	-0.048 NS	0.076 NS
Hair Density on Lower Surface	-0.241 NS	-0.198 NS
Hair Length on Upper Surface	-0.050 NS	0.293 NS
Hair Length on Lower Surface	0.011 NS	0.268 NS

** = Significant at P≤0.01. NS = Non-significant

Table 4: Multi-variate Regression Models along with Coefficient of Determination Between Leaf Consumption of Fresh Leaves of *H. Armigera* and Various Morpho-physical Factors of Various Food Plants

Multi-variate Models	R^2
Y = -58.9092 + 8.4064 X1	0.508
Y = -55.0242 + 8.2825 X1 – 1.1197 X2	0.632
Y= -62.5705 + 9.2039 X1 – 1.0894 X2 –0.1952 X3	0.697
Y= -65.8529 + 9.7379 X1 – 1.7212 X2 – 0.3214 X3 + 0.0923 X4	0.733
Y= -72.0074 + 10.559 X1 – 1.9155 X2 – 0.2427 X3 + 0.1153 X4 – 0.4128 X5	0.796
Y= - 71.6772 + 10.520 X1 – 1.9349 X2 – 0.2886 X3 + 0.1212 X4 –0.5401 X5 + 0.2582 X6	0.801

Y = Consumption (mg / 10 grams fresh leaves)

Table 5: Multi-variate Regression Models along with of Determination Between Coefficient of Utilization by *H. armigera* and Various Morpho- Factors of Various Food Plants

Multi-variate Models	R^2
Y= -23.6770 + 3.4820 X1	0.405
Y= -21.8554 + 3.4239 X1 – 0.5253 X2	0.532
Y= -23.2525 + 3.5944 X1 – 0.5197 X2 – 0.03614 X3	0.542
Y= -24.3303 + 3.7698 X1 – 0.7272 X2 – 0.0776 X3 + 0.3032 X4	0.560
Y= -22.8979 + 3.5786 X1 – 0.0682 X2 – 0.0959 X3 + 0.0249 X4 + 0.0960 X5	0.576
Y= -22.7915 + 3.5660 X1 – 0.6880 X2 – 0.1107 X3 + 0.0268 X4 + 0.0550 X5 + 0.0832 X6	0.578

Y = Coefficient of Utilization (%)
X1 = Moisture Contents in Fresh Leaves (%)
X2 = Thickness of Leaf Lamina (mμ)
X3 = Hair Density (per ½ cm^2) on Upper Surface of the Leaf Lamina
X4 = Hair Density (per ½ cm^2) on Lower Surface of the Leaf Lamina
X5 = Hair Length (mμ) on Upper Surface of the Leaf Lamina
X6 = Hair Length (mμ) on Lower Surface of the Leaf Lamina
R^2 = Coefficient of Determination

The ranking order of preference on the basis of coefficient of utilization (CU) was recorded as sorghum > Bermuda grass > cotton (NIAB-98) > maize > tomato > winter cherry > castor oil > Alfalfa > Okra > Rice > Horse purslane > Cotton (CIM-446) > Calotrope > Rape seed > Cattail. On overall basis, significant and positive correlation was found to exist between food consumption and CU. These findings are not in conformity with those of Singh (1999) who concluded that food consumption and growth rate of last instar larvae were lowest on the Maize diet while consumption rate was the lowest on the Chickpea diet. Anonymous (2000-2001) found that Horse purslane was totally refused by the pest but in the present studies it was placed at moderately resistant. The results of the same author can partially be compared with the present findings who found that Okra, Sunflower, Sesamum, Cotton, Potato and China rose were the preferred hosts. The present findings can not be compared with those of Gu and Walter (1999) and Banchhor *et al.* (2000) because of differences in their materials and methods as well as ecological conditions.

In the present studies, moisture content played positive and significant role towards consumption as well as coefficient of utilization (Table 3). The present findings are not in conformity with those of Navasero and Ramaswamy (1993) who found significant correlation with negative response on oviposition of the pest. In the present studies, thickness of leaf lamina showed negative and significant correlation with both the parameters. Contradict findings were reported by Thimmaiah *et al.* (1994). In the present studies hair density and length on upper and lower surfaces of the leaf lamina showed non-significant correlation both with consumption and Coefficient of utilization. These findings are not in conformity with those of Lukefahr *et al.* (1971) who reported that reduction of up to 60% in oviposition by *Heliothis* spp. on glabrous cotton. Similarly the findings of Lukefahr *et al.* 1975, Robinson *et al.* (1980), Ramalho *et al.* (1984), Navasero and Ramaswamy (1993), Satpute *et al.* (1994), Butter and Singh (1996) and Murthy *et al.* (1998) were not in accordance with the present findings.

Multi-variate models (Table 4 & Table 5) reveal that moisture content alone contributed 50.8% role towards resistance for consumption and 40.5% for Coefficient of utilization. In addition of thickness of leaf lamina, the role reached up to 63.2% for consumption and 53.2% for Coefficient of utilization. It means that thickness of leaf lamina played 13.2% contribution towards resistance for both the factors. With the addition of other factors, the coefficient of determination value reached up with a smaller difference in both the cases, however 80.1% role was observed in consumption while 57.8% in Coefficient of utilization when all the factors computed together.

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