



Research Article

Differential Feeding Preference and Performance of Leafworm *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) on some Cultivars of Potato (*Solanum tuberosum* L.)

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Abstract | Leafworm *Spodoptera litura* Fabricius is a highly polyphagous pest of food, forage, vegetable and horticultural crops. This sporadic species is becoming an emerging threat to the potato crop in central Punjab and is being evidenced infesting potato crop in Sargodha, Faisalabad and Okara districts. This *in-vitro* study assessed the comparative feeding preference, food consumption and utilization rates and larval development of *S. litura* on different white and red skinned potato cultivars. Feeding bioassays revealed that all parameters including leaf weight loss, larval weight gain, relative food consumption and growth rates and conversion efficiency of the ingested food were statistically significant ($P \leq 0.05$). Exotic potato cultivars Diamant, Desiree and Asterix exhibited maximum leaf consumption and larval weight gain (*i.e.* 264.61, 259.37 and 233.01 mg and 121.46, 120.17, 120.13 mg, respectively) concomitantly with maximum values of relative growth rate (RGR), relative consumption rate (RCR) and ingested food conversion efficiency (ECI). Cultivars Lady Rosetta, Cardinal, Ajax, Kuroda and Sante exhibited intermediate values. Minimum feeding preference and susceptibility to *S. litura* was shown by the native potato cultivars Faisalabad Red and Faisalabad White with minimum food consumption, larval weight gain, RGR, RCR and ECI values, and hence are recommended to indigenous potato growers for commercial cultivation in areas where *S. litura* threatens potato crop.

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Introduction

Potato (*Solanum tuberosum* L.) is one of the major staple food crops in the world and is rich in nutrients, particularly in potassium, vitamin C and dietary fiber. It is regarded as fourth most imperative food crop, after maize, wheat and rice cultivation in Pakistan (Majeed and Muhammad, 2018). It is cultivated on an area of about 0.18 million hectares with an annual production of 3.8 million tons sharing

about 27 and 40% of the area and production of vegetables in the country (Khan *et al.*, 2020). Punjab province is the leading potato producing area followed by Khyber Pakhtunkhwa, Baluchistan and Sindh (GOP, 2017). In Punjab province, districts Okara, Sahiwal, Pakpattan, Chiniot and Khanewal are the major potato growing areas.

Although Pakistan is self-sufficient in potato production, the country is far behind than other potato

producing countries regarding the potato production per unit area. Potato crop is affected by several factors including insect pests and diseases (Weber, 2012; Majeed and Muhammad, 2018; Kroschel *et al.*, 2020). Among the insect pests attacking the potato crop, leafworm *Spodoptera litura* is regarded as a sporadic serious pest of this crop. Considerable qualitative and quantitative losses are incurred to potato crop by *S. litura* infestations (Bhushan *et al.*, 2010; Kroschel *et al.*, 2020). It is a highly polyphagous pest with a wide range of host plants including maize, cotton, rice, potato, okra, tomato, cabbage, cauliflower, berseem and cucurbits (Ahmad *et al.*, 2013; Ullah *et al.*, 2016; Bragard *et al.*, 2019). Larvae of *S. litura* feed gregariously and skeletonize the potato foliage and severe infestation can cause complete defoliation of the crop. Under agro-climatic conditions of Indo-Pak regions, *S. litura* has been a detrimental pest of potato crop (Basavaraju *et al.*, 2010; Ahmad *et al.*, 2013; Bade and Chandele, 2014; Kroschel *et al.*, 2020).

S. litura is being regarded as a potentially serious threat to potato production in Pakistan. Its infestation has been reported more frequently since last few years in all potato growing areas of the country. As screening host plant material against potential insect pests has been one of the basic and essential elements of integrated pest management (Gebremdein, 2018; Selvanarayanan *et al.*, 2020), this study was carried out with an aim to determine the feeding preference and larval developmental performance of leafworm *S. litura* on different white and red skinned cultivars of potato which are commonly grown in different parts of the country. The objective was to have a comparative assessment of feeding potential and performance of the pest on different potato cultivars and to find out which potato cultivars relatively exhibit more resistance or tolerance to *S. litura* infestations.

Materials and Methods

This study was carried out in the laboratory of the Department of Entomology, College of Agriculture, University of Sargodha, Pakistan.

Potato cultivars and rearing of S. litura

Ten most commonly grown potato cultivars (varieties) including five white skinned cultivars (Ajax, Diamant, Faisalabad White, Lady Rosetta and Santé) and five red skinned cultivars (Asterix, Cardinal, Desiree, Faisalabad and Red Kuroda) were procured from the

indigenous progressive potato growers and from the Potato Research Institute, Sahiwal, Pakistan. These cultivars were sown in the farm area of the College of Agriculture, University of Sargodha, following all standard agronomic practices recommended by the Potato Research Institute.

Late instar larvae of *S. litura* were collected from the potato fields located in Chiniot, district Faisalabad (31°43'29"N and 73°03'35"E; Punjab, Pakistan). These field collected larvae were brought to the laboratory of Entomology and were reared on an artificial (chickpea flour-based) diet (Gupta *et al.*, 2005). Test population of *S. litura* larvae was ensured to be homogenous by rearing them to F₄ generations. Only healthy and active freshly molted 3rd instar larvae were used in all feeding bioassays.

Experimental layout

Feeding potential and developmental performance of *S. litura* 3rd instar larvae were determined according to the slightly modified protocol of Greenberg *et al.* (2001) and Ullah *et al.* (2016). Young and fresh leaves of above mentioned ten potato cultivars were collected from the field and were washed with clean tap water and allowed to be drained for few a minutes before these were put in sterilized 90 mm glass Petri plates. A layer of 1.5% agar was maintained at the bottom of Petri plates to ensure that leaves remained fresh for 24 h. One freshly molted healthy and active 3rd instar larva of *S. litura* was released in each Petri plate with the help of a soft camel hair brush and Petri-plates were incubated in an environmental chamber at controlled conditions *i.e.* at 25±2 °C temperature, 60±5% relative humidity and at 16h L:8h D photoperiod. Data regarding leaf consumption and larval growth were recorded at each 24 h interval. Experimental design was completely randomized with ten replications maintained for each treatment.

Determination of leaf weight loss and larval weight gain

Initially weighed 3rd instar larvae were released on a weighed leaf in a Petri plate to record the feeding. Ten independent replicates were maintained for each potato cultivar. Control treatment included a Petri plate with a potato leaf but without any *S. litura* larva. The leaves and larvae were weighed after 24 h and were replaced by the new weighed leaves. This process continued after every 24 h for four consecutive days. Daily leaf weight loss or food consumption and larval weight gain were calculated by working out the

difference of weights and were further corrected by the weight of leaves obtained in the control treatments.

Determination of larval growth and developmental parameters

Pre-ingestive parameters *i.e.* relative leaf consumption by *S. litura* larvae (RCR) and the relative growth rate of *S. litura* larvae (RGR), and the post-ingestive food utilization parameter *i.e.* the efficiency of conversion of ingested food (ECI), were calculated according to the following formula (Ullah *et al.*, 2016).

$$\text{Relative consumption rate (RCR)} = \left(\frac{I}{B} \right) \times T$$

$$\text{Relative growth rate (RGR)} = \left(\frac{\Delta B}{BI} \right) \times T$$

$$\text{Conversion efficiency of ingested food (ECI)} = \left(\frac{B}{I} \right) \times 100$$

Where; *I* is the weight of food (leaf) consumed (mg), *B* is the larval weight gain (mg) and *T* is the feeding duration (day), ΔB is the body weight change of larva (mg) and *BI* is the initial weight of larva.

Data analysis

Apart from the graphical representation, data were subjected to statistical analysis using Statistix V. 8.1® (Analytical Software, Tallahassee, Florida) software. Treatments were compared by running one-way analysis of variance (ANOVA) followed by Tukey's honestly significant difference (HSD) test at standard level of significance *i.e.* at $p = 0.05$.

Results and Discussion

A differential trend was observed regarding the feeding and performance parameters of 3rd instar larvae of *S. litura* on different red and white skinned cultivars of potato. All parameters including leaf weight loss, larval weight, relative growth and food consumption rates and conversion efficiency of ingested food were statistically significant at $p \leq 0.05$ (Table 1). Maximum leaf consumption was recorded in potato cultivar Diamant (264.61±12.91 mg) followed by Lady Rosetta (259.37±14.39 mg) and Asterix (233.01±14.57 mg), while minimum food consumption was found for the cultivar Ajax (161.79±17.06 mg), Faisalabad Red (194.47±19.24 mg) and Faisalabad White (168.79±16.44 mg) (Figure 1). Similarly, 3rd instar larvae of *S. litura* preferred and gained maximum weight while feeding on the leaves of potato cultivar Diamant (121.46± 11.92 mg)

followed by Desiree (120.17 ± 10.54 mg) and Asterix (120.13 ± 10.47 mg), while minimum larval weight gain was noted for cultivar Faisalabad Red (89.41 ± 10.02 mg), Faisalabad White (78.13 ± 10.04 mg) and Ajax (89.69 ± 10.85 mg) (Figure 1).

Table 1: Analysis of variance (ANOVA) regarding the feeding and development characteristics of 3rd instar larvae of *Spodoptera litura* on different potato cultivars.

Parameters	DF	SS	MS	F-value
Leaf weight loss (mg)	9	29144.1	3238.23	389*
Larval weight gain (mg)	9	6607.38	734.154	190**
RCR (mg/mg/d)	9	0.36693	0.0407	27.5**
RGR (mg/mg/d)	9	0.05866	0.0065	61.3***
ECI (%)	9	182.449	20.272	26.8**

F-values with symbols ***, ** and * are significant at $p \leq 0.001$, 0.01 and 0.05, respectively (one-way factorial ANOVA; HSD).

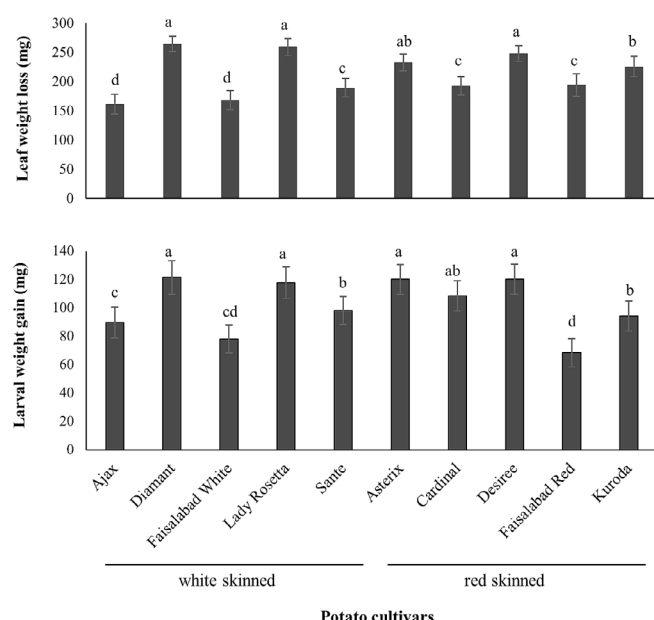


Figure 1: Leaf consumption and weight gain values (mean ± SE) of 3rd instar larvae of *Spodoptera litura* feeding on different potato cultivars. Alphabets at bar tops indicate significant difference among the treatments (one-way ANOVA; HSD at $\alpha = 0.05$).

Regarding the relative growth rate (RGR), 3rd instar larvae of *S. litura* showed maximum growth when offered leaves of potato cultivars Diamant (0.52 ± 0.04 mg/mg/day) and Desiree (0.52 ± 0.06 mg/mg/day), followed by the cultivars Lady Rosetta (0.50 ± 0.06 mg/mg/day) and Asterix (0.47 ± 0.06 mg/mg/day). However, there was no statistical difference among Diamant and Desiree ($P \leq 0.05$). Minimum relative growth rate was recorded for the cultivars Faisalabad Red (0.30 ± 0.04 mg/mg/day) and Faisalabad White (0.26 ± 0.04 mg/mg/day) (Figure 2A). In case of relative consumption rate (RCR), the highest

consumption rate was recorded for the cultivars Diamant and Desiree (*i.e.* 2.55 ± 0.17 and 2.41 ± 0.17 mg/mg/day, respectively), followed by cultivars Asterix (2.31 ± 0.15 mg/mg/day) and Lady Rosetta (2.17 ± 0.17 mg/mg/day). Cultivars Faisalabad Red and Faisalabad White exhibited minimum relative food consumption rates (*i.e.* 1.51 ± 0.10 and 1.72 ± 0.14 mg/mg/day, respectively), while potato cultivars Cardinal, Ajax and Kuroda showed intermediate consumption rates (Figure 2B). A similar trend of significance was observed regarding the efficiency of conversion of ingested food (ECI) which was significantly high in cultivars Diamant ($67.10 \pm 9.42\%$) and Desiree ($64.98 \pm 10.20\%$), followed by cultivar Asterix ($59.86 \pm 3.94\%$). Cultivars Cardinal, Ajax, Kuroda, Lady Rosetta and Sante exhibited intermediate ECI values, while minimum ECI values were recorded for cultivars Faisalabad Red and Faisalabad white (Figure 2C). Nevertheless, there was no statistical difference among white and red skinned potato cultivars for all of the measured larval feeding and performance parameters. Moreover, average food (potato foliage) consumption and larval growth (weight gain) were found positively and significantly correlated (Pearson correlation coefficients (r) = 0.934 ; $P \leq 0.001$).

Growth and development of phytophagous insects depend on certain parameters such as how efficiently the ingested food material is being transformed into insect's biomass (Waldbauer, 1968; Nathan *et al.*, 2005). Relative growth rate (RGR), relative consumption rate (RCR) and conversion efficiency of ingested food (ECI) are of prime importance regarding the assessment of host plants suitability and feeding potential and performance of insect pests (Reese, 1978).

As leafworm *S. litura* along with fall armyworm *Spodoptera frugiperda* is emerging as a potential pest of potato in all potato growing areas of Punjab, Pakistan. This study was aimed to screen out all commercially grown potato cultivars against the damage potential of *S. litura*. We assessed the relative feeding potential and development parameters (food consumption, larval weight gain, RGR, RCR and ECI) of *S. litura* larvae on ten different commercially grown potato cultivars.

Results revealed a significant difference for all studied parameters when 3rd instar larvae of *S. litura* were

fed on the leaves of different potato cultivars. Potato cultivars Faisalabad Red and Faisalabad White appeared to be least attractive and susceptible to *S. litura* infestation (Abbas *et al.*, 2014). Less pest susceptibility of these potato cultivars are probably due to their native origin because these cultivars are selected under agro-climatic conditions of Pakistan under the umbrella of Ayub Agricultural Research Institute, Faisalabad (Hassan *et al.*, 2015).

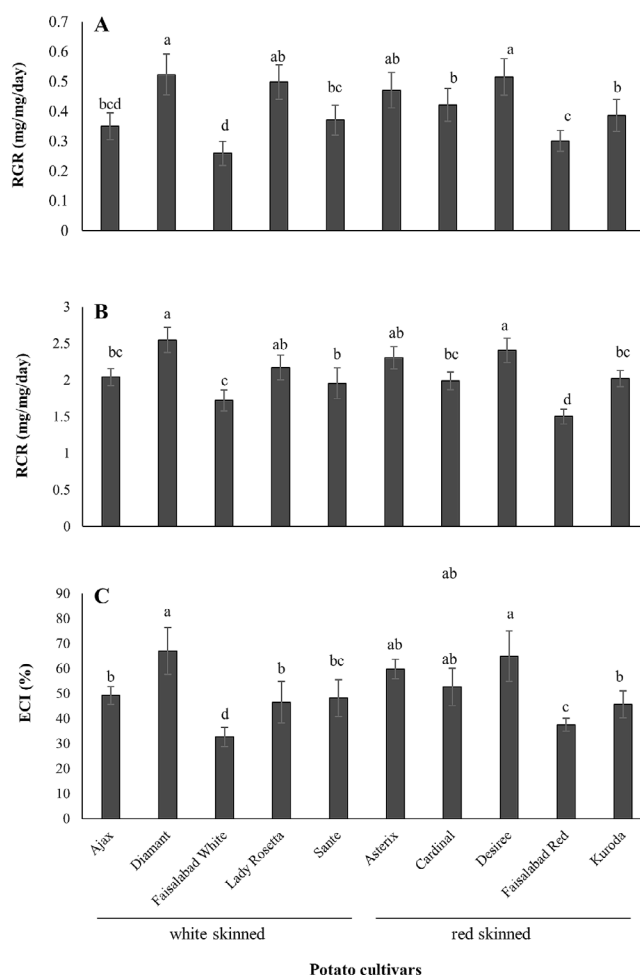


Figure 2: Food consumption and larval performance values (mean \pm SE) of 3rd instar larvae of *Spodoptera litura* feeding on different potato cultivars. (A): relative growth rate (RGR), (B): relative consumption rate (RCR) and (C): efficiency of conversion of ingested food (ECI). Alphabets at bar tops indicate significant difference among the treatments (one-way ANOVA; HSD at $\alpha = 0.05$).

On the contrary, maximum food consumption and larval weight gain was observed for the potato cultivars Diamant, Desiree and Lady Rosetta concomitantly exhibiting highest values of RGR, RCR and ECI as well. This means that the foliage of these potato cultivars was most suitable for the conversion to growth and biomass development of *S. litura* larvae, suggesting the maximum susceptibility of these cultivars to *S. litura* out in the field. These three potato

cultivars are developed in Holland and Germany (Gregoriou *et al.*, 1997). Exotic origin of these three potato cultivars would be one of the reasons for this observed high susceptibility to *S. litura* under prevailing climatic conditions of Punjab, Pakistan (Abbasi *et al.*, 2004; Howlader and Hoque, 2018). As *S. litura* is endemic to South Asian regions (EPPO, 2015), successful exploitation of exotic host plants by native insect pests may be associated with the fitness cost including reduced feeding potential on ancestral native host plants and differential plant chemistries of exotic and native plant genotypes (Atijegbe *et al.*, 2020).

Conclusions and Recommendations

In conclusion, *S. litura* larvae exhibited a differential feeding preference and growth parameters on the foliage of different potato cultivars. Exotic potato cultivars particularly Diamant, Desiree, Lady Rosetta and Cardinal showed maximum susceptibility (feeding preference) and suitability (ECI and RGR) and exhibited highest larval feeding potential and growth parameters. On the contrary, potato cultivars of native origin, particularly Faisalabad Red and Faisalabad White, appeared to be most tolerant and less attractive to *S. litura*, and hence are recommended to indigenous potato growers for the commercial cultivation in areas where *S. litura* threatens potato crop. Characterization of biochemical composition of preferred and non-preferred potato cultivars would provide more insight and better understanding of this differential feeding preference by *S. litura* as reported previously for other lepidopterous pests (Agosta, 2006; Atijegbe *et al.*, 2020).

Novelty Statement

This *in-vitro* study encompasses the first comparative assessment of the feeding preference, food consumption potential and growth performance of *Spodoptera litura* larvae on different commercially grown potato cultivars and has demonstrated that exotic cultivars exhibit more susceptibility to *S. litura* infestations as compared to indigenously developed potato cultivars.

Author's Contribution

MSA and MZM: Conceived the idea and planned the experiment.

MSA: Carried out bioassays.

MSA and MZM: Wrote the first draft of the manuscript.

SNO: Did the statistical analyses of data and technically revised the manuscript.

MA: Provided the technical assistance and proofread the manuscript.

All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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