The Bioscan 11(3): 1531-1535, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

NUTRITIONAL INDICES OF *SITOPHILUS ORYZAE* L. FEEDING ON SPLIT PULSES

S.VIJAY* AND K. BHUVANESWARI
Department of Agricultural Entomology,
Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, INDIA
e-mail: entovijay@gmail.com

KEYWORDS
Nutritional indices
Sitophilus oryzae L
adult
larva

Received on :
10.05.2016

Accepted on :
27.08.2016

***Corresponding author**

ABSTRACT
An experiment was carried out at the Entomology Laboratory, Horticultural College and Research Institute for Women, TNAU, Trichy in November-December 2013 to estimate the nutritional indices in *Sitophilus oryzae* L. under room temperature condition. A completely randomized design (CRD) was used with seven treatments (T1= sorghum, T2 = red gram, T3= chick pea, T4 = black gram, T5 = green gram, T6= fried gram and T7= lentil) each replicated four times. The assessed parameters were food consumption, weight gained, relative growth rate (RGR), efficiency of conversion of ingested food (ECI), efficiency of conversion of digested food (ECD), approximate digestibility (AD), consumption index and coefficient of metabolism. Among the split pulses adult weight gained (18.96), food consumption (26.90), AD (84.02), ECI (78.78) and ECD (87.97) was recorded maximum red gram followed by green gram, chick pea, black gram, fried gram and lentil. In case of larva, weight gained (20.78 mg), RGR (43.34) and AD (72.50) was recorded maximum in lentil followed by other hosts. Based on the observation was made, the adult weight gained and RGR was maximum in redgram, while larva it was higher in lentil.

INTRODUCTION

The rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), is one of the most destructive pest of stored cereals worldwide. It is classed as a primary pest, cosmopolitan in nature and is known to infest sound cereal seeds (Hill, 1990) and causes severe loss in rice, maize, barley and wheat (Bhatia *et al.,* 1975; Singh *et al.*, 1980; Neupane, 1995). Though the storage grain loss is caused by insect pests, pathogens and rodents it is generally believed that half of the storage loss is usually caused by insects (FAO, 1968). Considering the loss caused by storage insect pests, effective methods of control are of paramount importance.Control often depends on a sound knowledge of the ecology and on the effects of a multitude of environmental factors on the life history of a pest.

Reports about its occurrence on legumes are scanty. Pemberton *et al.* (1981) studied its breeding behaviour on carob, *Ceratonia siliqua* (L.), a tree legume native to the Mediterranean region. Coombs *et al.* (1977) reported the successful development by Trinidad strain of *S.oryzae* on yellow split pea. In India, the pest was recorded for the first time to feed on red gram at Coimbatore. We collected a population of rice weevil feeding on split red gram dhal was sent to IARI, identified as *Sitophilus oryzae* by Dr. V.V. Rama moorthy, Principal Scientist, Entomology Division (Personal communication, 2011). Determining the nutritional indices of an insect is a tool for evaluating host plant resistance mechanisms that could improve pest management programs. Of the tools of pest management, host plant resistance is important in terms of being both economically and environmentally acceptable (Latha and Naganagoud, 2015). Therefore, as a method of controlling pest insects, host plant resistance is not only favorable to the environment, but also reduces expenses for growers (Li *et al*, 2004). Keeping in this view, the present study to observe and calculate the nutritional indices of pulse breeding population of *S.oryzae* were studied in comparison to normal population that occurs on sorghum.

MATERIALS AND METHODS

The two population of rice weevil, *S. oryzae*, was mass cultured on their respective hosts namely sorghum and red gram dhal under laboratory. The development of population reared on split pulses was studied in comparison to that of sorghum. The experiment was laid out in a completely randomized design (CRD) with seven treatments *viz.,* T1 = sorghum, T2 = split red gram, T3 = split chick pea, T4 = split black gram, T5= split green graml, T6= split fried gram and T7= split lentil and each replicated four times. The experiment was conducted under room temperature (26.5 - 30.35ºC, RH 65 - 73%) condition.

The experiment was conducted in order to determine the different nutritional indices of adult and larvae of *S.oryzae* based on consumption and utilization of food.

The pre weighed grains (sorghum and split pulses) were placed in separate plastic containers (4.0cm height and 4.0 cm dia.) along with 10 pair of adults. Observations on quantity of food consumed, excreta voided and the weight gained by the adult were recorded daily to a maximum of 2l days feeding period. In order to estimate the larval nutritional indices 20 infested grains were taken and observed to a maximum of 22 days feeding period. Each host was considered as a treatment and replicated four times.

Using the observed values the following nutritional indices were calculated as described by Waldbauer (1968), Slansky and Scriber (1985) and Deml *et al*. (1999).

Consumption (C) = Initial fresh weight of food – Final fresh weight of food

Production (P) = Final fresh weight of adult- Initial fresh weight of adult

Assimilation (A) = Fresh weight of food ingested- Fresh weight of faeces

$$\text{Relative Growth Rate(RGR)} = \frac{\text{Fresh weight of adult /larva}}{\text{Duration of feeding period(Days) X Mean frsh weight of adult during feeding period}}$$

$$\text{Approximate Digestibility(AD)} = \frac{\text{Weight of food indested - Fresh weight of faeces}}{\text{Weight of food ingested}} \text{X100}$$

$$\text{Efficiency of Conversion of Ingested food(ECI)} = \frac{\text{Weight gained}}{\text{Fresh weight of food ingested}} \text{X100}$$

$$\text{Efficiency of conversion of Digeted food (ECD)} = \frac{\text{Weight gained}}{\text{Fresh weight of food ingested - Fresh weight of faeces}} \text{X 100}$$

$$\text{Consumption Index(CI)} = \frac{\text{Fresh weight of food consumed}}{\text{Mean fresh weight of adult during feeding period X Duration of feeding period(days)}}$$

$$\text{Coefficient of Metabolism(COM)} = \frac{\text{Fresh weight of digeted food - increase in weight of larva}}{\text{Fresh weight of digested}}$$

RESULTS AND DISCUSSION

Among the split pulses the adult weight gained was higher in redgram (18.96 mg) and was on par with chick pea (18.77 mg), green gram (18.76 mg), fried gram (18.31 mg) and black gram (18.19 mg) under room temperature condition (26.5 to 30.35ºC and 65 to

73 % RH). The food consumption was significantly maximum in redgram (26.90 mg) followed by green gram (23.65mg) and were on par with chick pea (23.13 mg)

(Table 1).The assimilation rate was significantly higher in fried gram (9.82g) followed by chick pea (7.30 g), lentil (4.33g) and redgram (3.80 g) respectively. Under room temperature condition (26.5 to 30.35ºC, 65 to 73% RH) the adult weight gained (18.96), food consumption (26.90 mg) (Fig. 1) were higher in redgram. The assimilation rate (9.82) was higher in fried gram. A legumes used in the present study were comparatively rich in proteins. But the deviation in present results is might be due to presence of some food attractants in redgram. The quality and quantity of food consumed might affect growth, development and reproduction of insets (Scriber and Slansky, 1981).

Significantly maximum RGR was recorded in redgram (53.97) followed by chick pea (53.38) and green gram (53.35) were on par with each other. Among the split pulses lowest RGR was recorded in fried gram (48.64). The AD was maximum in redgram (84.02) followed by green gram (81.88), black gram (81.88) and lentil (81.22) were on par with each other. Among the split pulses, ECI and ECD in adult was significantly higher in redgram (78.78 and 87.97) followed by lentil (73.73 and81.28) respectively. CI was significantly maximum in redgram (38.31) and on par with lentil (37.97) followed by other hosts. COM was maximum in grains of green gram (0.96) and were on par with black gram (0.95) followed by lentil (0.87) respectively. Significantly maximum Relative Growth Rate (RGR) was recorded in redgram (53.97) followed by other hosts. The lowest RGR was recorded on fried gram. Hwang *et al*. (2008) reported that when insect feed on high nutrient food growth and development were increased. Lower fitness of hosts might be due to the presence of some secondary phytochemicals in these food grains or absence of primary nutrients necessary for growth and development. Among the split pulses values of Approximate Digestibility (AD) was maximum in redgram (84.02) under room temperature condition. AD depends on a number of factors like quantity of food intake, retention time in the mid gut, nature and efficiency of digestive enzymes and digestibility of the complex nutritive components in the diet (Sabhat *et al*., 2011).

In case of sorghum the values of adult weight gained (16.83 mg), food consumption (16.62 mg), assimilation rate (2.84 g), RGR (41.54) was significantly minimum feeding by the respective population when compared to red gram population feeding on split pulses.ECI and ECD values were 70.05 and 82.53 in sorghum feeding by the respective population. In

Table 1 : Nutritional indices studies of *S.oryzae* adult feeding on sorghum and split pulses (November to December 2013)

S.No	Treatments	Consumption* (mg)	Weight gained* (mg)	Assimilation* (g)	RGR*	ECI#	ECD#	AD#	CI*	COM*
1	Redgram	26.90±0.21 (5.19)a	18.96±0.16 (4.10)a	3.80±0.02 (1.95)d	53.97±0.25 (7.35)a	78.78±0.09 (62.57)a	87.97±0.37 (69.71)a	84.02±0.38 (66.44)a	38.31±0.04 (6.19)a	0.86±0.03 (0.93)b
2	Chick pea	23.13±0.48 (4.08)b	18.77±0.04 (4.33)a	7.30±0.07 (2.70)b	53.38±0.06 (7.31)a	55.04±0.01 (47.90)e	58.08±0.08 (49.65)e	79.94±0.63 (63.39)c	32.93±0.15 (5.74)c	0.79±0.01 (0.89)d
3	Black gram	21.05±0.10 (4.59)c	18.19±0.04 (4.27)a	2.42±0.14 (1.56)f	51.59±0.07 (7.18)b	47.14±0.02 (43.36)g	58.53±0.18 (49.91)e	81.25±0.36 (64.34)b	36.23±0.75 (6.02)b	0.95±0.04 (0.98)a
4	Green gram	23.65±0.07 (4.86)b	18.76±0.09 (4.33)a	1.29±0.02 (1.13)g	53.35±0.15 (7.30)a	54.17±0.02 (47.39)f	74.37±1.54 (59.59)d	81.88±0.53 (64.81)b	33.44±0.34 (5.78)c	0.96±0.07 (0.98)a
5	Fried gram	16.73±0.28 (4.09)d	18.31±0.07 (4.28)a	9.82±0.06 (3.13)a	51.96±0.11 (7.21)b	71.00±0.01 (57.41)c	74.01±0.07 (59.35)d	81.88±0.53 (64.81)b	33.01±0.34 (5.74)c	0.65±0.02 (0.81)e
6	Lentil	19.86±0.17 (4.46)c	17.21±0.07 (4.15)b	4.33±0.03 (2.08)c	48.64±0.10 (6.97)c	73.73±0.02 (59.17)b	81.28±0.19 (64.36)c	81.22±0.77 (64.32)bc	37.97±0.11 (6.16)a	0.87±0.01 (0.93)b
7	Sorghum	16.62±0.13 (4.81)d	16.83±0.06 (4.35)c	2.84±0.03 (1.68)e	41.54±0.08 (6.45)e	70.05±0.01 (56.82)d	82.53±0.15 (65.29)b	72.88±0.47 (58.62)d	22.84±0.17 (4.78)d	0.87±0.07 (0.93)c

Mean of four replications * Figures in parentheses are square root transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05). # Figures in parentheses are arc sin transformed values. Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05). RGR- Relative growth rate, AD- Approximate Digestibility, ECI-Efficiency of conversion of ingested food, ECD- Efficiency of conversion of digested food, CI- Consumption index, COM- Coefficient metabolism. Room temperature ranges from 26.5 to 30.35ºC, RH ranges from 65 to 73%

Table 2 : Nutritional indices studies of *S.oryzae* larva feeding on sorghum and split pulses (November to December 2013)

S.No	Treatments	Consumption* (mg)	Weight gained* (mg)	Assimilation* (g)	RGR*	ECI#	ECD#	AD#	CI*	COM*
1	Redgram	230.25±18.89 (15.17)b	19.45±0.88 (4.41)b	0.78±0.03 (0.88)d	40.10±0.72 (6.33)b	27.79±1.26 (31.81)d	42.09±1.48 (40.45)c	71.88±2.98 (57.97)a	31.08±2.55 (5.58)b	0.54±0.02 (0.73)bc
2	Chick pea	227.75±35.17 (15.09)b	20.08±0.29 (4.48)ab	1.45±0.01 (1.21)b	40.44±1.00 (6.36)b	13.38±0.19 (21.46)f	19.37±1.48 (26.11)e	65.67±3.38 (54.13)b	30.75±3.75 (5.54)b	0.79±0.03 (0.89)a
3	Black gram	162.50±35.00 (12.75)c	19.33±0.81 (4.40)b	0.48±0.01 (0.69)f	38.43±0.66 (6.20)c	38.65±1.61 (38.44)b	40.69±1.37 (39.63)c	55.00±2.58 (47.87)c	21.94±3.72 (4.68)c	0.57±0.04 (0.75)bc
4	Green gram	157.00±9.09 (12.53)c	19.25±0.87 (4.39)b	0.26±0.01 (0.51)g	40.23±0.87 (6.34)b	48.13±2.17 (43.93)a	52.07±2.35 (46.19)b	69.17±3.19 (56.27)ab	21.20±1.23 (4.60)cd	0.63±0.11 (0.79)b
5	Fried gram	118.00±15.64 (10.86)e	19.63±1.03 (4.43)ab	1.99±0.03 (1.41)a	38.56±0.63 (6.21)c	9.81±0.52 (18.26)g	10.80±0.61 (19.19)f	64.75±2.40 (53.58)b	15.93±2.11 (3.99)e	0.47±0.08 (0.69)c
6	Lentil	128.00±16.47 (11.31)d	20.78±0.45 (4.56)a	0.88±0.01 (0.94)c	43.34±1.05 (6.58)a	23.08±0.50 (28.71)e	30.57±1.31 (33.57)d	72.50±3.78 (58.37)a	17.28±2.22 (4.16)de	0.54±0.06 (0.73)bc
7	Sorghum	281.25±23.77 (16.77)a	18.75±0.87 (4.33)c	0.56±0.01 (0.75)e	33.75±1.19 (5.81)d	31.25±1.44 (33.99)c	78.44±2.40 (62.33)a	66.25±2.10 (54.48)b	37.97±3.21 (6.16)a	0.77±0.07 (0.88)a

Mean of four replications * Figures in parentheses are square root transformed values. Mean followed by same letter (s) in a column are not significantly different by DMRT (P=0.05). # Figures in parentheses are arc sin transformed values. Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05). RGR- Relative growth rate; AD-Approximate Digestibility; ECI-Efficiency of conversion of ingested food; ECD- Efficiency of conversion of digested food; CI- Consumption index; COM- Coefficient metabolism. Room temperature ranges from 26.5 to 30.35°C; RH ranges from 65 to 73%

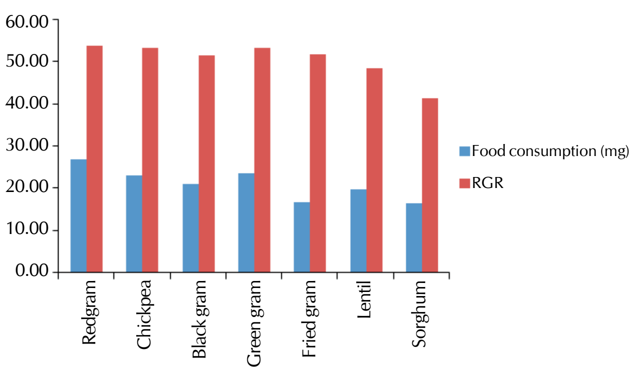

Figure 1: Adult food consumption of *S.oryzae* feeding on sorghum and split pulses

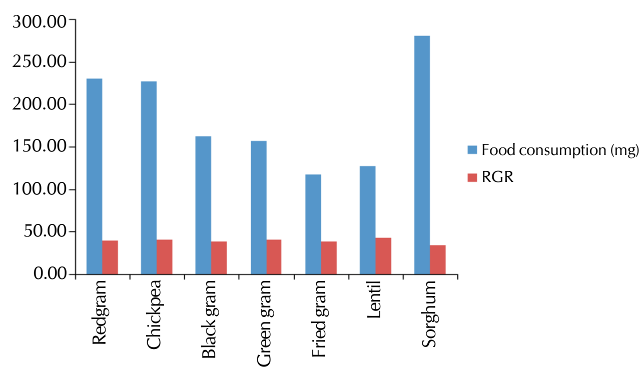

Figure 2 : Larval food consumption of *S.oryzae* feeding on sorghum and split pulses

case of sorghum population AD and CI values was minimum (72.88 and 22.84) when compared to redgram population feeding on split pulses and COM was 0.87 in sorghum (Table 1).

Efficiency of Conversion of Ingested food (ECI) (78.78) and Efficiency of Conversion of Digested food (ECD) (87.97) was higher in redgram while adult feeding on different hosts. The lowest ECI and ECD values were recorded in fried gram. It might be due to the imbalance of proteins, amino acids and fibres (Naseri *et al.,* 2010). Consumption Index (CI) was higher in redgram (38.31 and 42.05) followed by lentil (37.97 and 38.03) under room temperature condition.Coefficient of Metabolism (COM) was maximum in green gram (0.96 and 0.97) and black gram (0.95 and 0.94) respectively. Analysis of nutritional indices can lead to understanding of the behavioral and physiological basis of insect response to food grains (Lazervic and Peric-Mataruga, 2003).

Larva

Among the split pulses the food consumption was significantly maximum in redgram (230.25mg) and chick pea (227.75 mg) followed by other hosts at room temperature (26.5 to 30.35° C and 65 to 73 % RH). The larval weight gained was higher in lentil (20.78 mg) and was on par with chick pea (20.08 mg) followed by redgram (19.45 mg).The assimilation rate was 1.99 g in fried gram followed by chick pea (1.45 g), lentil (0.88 g) and redgram (0.78 g) feeding on redgram population. The larval weight gained (20.78 mg) was maximum in lentil room temperature condition (26.5 to 30.35 °C, 65 to 73% RH). The food consumption was maximum in redgram (230.25mg) and chick pea respectively (Fig. 2). According to Ernst (1992) the amount of food consumed by the larva of bruchid-*Specularius impressithorax* L. ranged between 15.1 and 48.7 mg while feeding on redgram.

RGR was significantly higher in lentil (43.34) followed by chick pea (40.44), green gram (40.23) and redgram (40.10) and were on par with each other. The values of AD was maximum in lentil (72.50) and red gram (71.88) followed by green gram (69.17). ECI was maximum in green gram (48.13) followed by black gram (38.65) and redgram (27.79). ECD was significantly higher in green gram (52.07) and redgram (42.09) followed by other hosts. The CI was 31.08 in redgram and was on par with chick pea (30.75) followed by other hosts.COM was maximum in grains of chick pea (0.79) followed by green gram (0.63) and black gram (0.57) (Table 2). The assimilation rate was higher in fried gram followed by chick pea, lentil and redgram respectively. RGR was maximum in lentil (43.34) followed by chick pea, green gram and redgram. The lowest RGR was recorded on fried gram. Kotkar *et al.* (2009) reported that legumes such as redgram, chickpea, and pea had the highest protein content and were favourable for insect growth and development. Govinda raj (2012) studied the RGR of

Oryza ephilus surinamensis and maximum (42.10) was recorded on neem seed kernel followed by dates (36.0). The difference in survival, growth and development of insects on different hosts might have been caused by antibiotic effects, poor nutritional quality of the food and secondary metabolites (Sharma *et al.*, 1982; Samraj and David, 1988).

In case of sorghum, food consumption (281.25 mg) was significantly maximum feeding by the respective population when compared to redgram population. The larval weight gained was least in sorghum (18.75mg) feeding by the respective population as compared to redgram population feeding on split pulses. Assimilation rate was 0.56 in sorghum grains feeding by the respective population. The lowest RGR was recorded in sorghum grains (33.75) when compared to redgram population feeding on split pulses. AD and ECI values sorghum was 66.25 and 31.25 as compared to split pulses feeding by the respective population.ECD value was maximum in sorghum (78.44) feeding by the respective population when compared to redgram population feeding on split pulses. In case of sorghum CI and COM (37.97 and 0.77) was significantly superior to all the treatments feeding by the respective population (Table 2).

The values of AD was maximum in lentil (72.50) followed by of redgram and green gram respectively. ECI was maximum in green gram followed by black gram respectively. The ECD in larva was maximum in green gram and redgram respectively. The higher ECD values of green gram suggest higher food efficiency and low cost maintenance. The low ECI and ECD values of fried gram might be due to some physiological adoptions to over come nutritional imbalance at the time of feeding. Similar results were reported by Nath *et al.* (1990) and Tzenov (1993) in silkworm. The changes of ECI and ECD value might be due to depend on the level of digestive enzymes of insects (Patankar *et al.,* 2001). ECI and ECD values, of *S. oryzae* reared on different food grains were significantly different, suggesting that the various host had different nutritional values (Naseri *et al.,* 2010). ECI is a general index of an insects ability to use the food consumed for the growth and development and ECD is an index of the efficiency of conversion of digested food into growth (Nathan *et al.,* 2005). Physiological changes among penultimate and ultimate instar larvae reared on food grains were partially responsible for the differences in such decreases in ECI and ECD (Nation, 2001).

Consumption Index was higher in sorghum followed by redgram and chick pea. Coefficient of Metabolism (COM) was maximum in chick pea followed by sorghum, respectively. According to Munro (1996) the food type and content of nutrient affect the biological parameters of stored product insects. Lecato and Flaherty (1973) showed the quantity and quality of food media of are capable of affecting the life cycle of an insect.

REFERENCES

Bhatia, S. K., Singh, V. S. and Bansal, M. G. 1975. Varietal resistance in barley grain to laboratory infestation of rice weevil and lesser grain borer. *Bulletin of Grain Technology.* **13(2):** 69-72.

Coombs, C. W., Billings, C. J. and Porter, J. E. 1977. The effect of yellow split-peas (*Pisum sativum* L.) and other pulses on the productivity of certain strains of *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and the ability of other strains to breed thereon. *J Stored Prod Res.* **13:** 53–58.

Deml, R., Meise, T. and Dettner, K. 1999. Effe ts of *Bacillus thuringiensis* delta- endotoxins on food utilization, growth and survival of selected phytophagous insects. *J. Appl. Entomol.***123:**55-64

Ernst, W. H. O. 1992. Food consumption, life history and determinants of host range in the bruchid beetle *Specularius impressithorax* (Coleoptera : Bruchidae). *J. Stored Prod. Res.* **29:** 53-62.

FAO, 1968. Rice grain of life. International Rice Year 1966: Freedom from hunger. World Food Problems No. 6. Food and Agriculture Organization of the United Nations, Rome, Italy p.65.

Govindaraj, R. 2012. Studies on the biology and management of saw toothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae). *M. Sc. (Agri.) Thesis*, Tamil Nadu Agricultural University, Coimbatore.

Hill, D. S. 1990. Pests of stored products and their control, Belhaven press, London

Hwang, S. Y., Liu, C. H. and Shen, T. C. 2008. Effects of plant nutrient availability and host plant species on the performance of two *Pieris* butterflies (Lepidoptera: Pieridae). *Biochem. Systematics Ecol.* **36:** 505-513.

Kotkar, H. M., Sarate, P. J., Tamhane, V. A., Gupta, V. S. and Giri, A. P. 2009. Responses of midgut amylases of *Helicoverpa armigera* to feeding on various host plants. *J. Insect Physiol.* **55:** 663-670.

Latha, H. C. and Naganagoud, A. 2015. Effect of sweet flag rhizome, *Acorus calamus* L. Formulations against *Sitophilus oryzae* in sorghum. *The Bioscan.* **10(3):**1213-1218.

Lazarevic, J. and Peric-Mataruga, V. 2003. Nutritive stress effects on growth and digestive physiology of *Lymantria dispar* larvae. *Yugoslav Medical Biochemistry.* **22:** 53-59.

Lecato, G. L. and Flaherty, B. R. 1973. *Tribolium castaneum* (Herbst) progeny production and development in diets supplemented with eggs or adults of *Plodia interpunctella* (Hubner) *J. Stored Prod. Res.* **9:**199-203.

Li, Y, Hill, C. B and Hartman, G. L. 2004. Effect of three resistant soybean genotypes on the fecundity, mortality and maturation of soybean aphid (Homoptera, Aphididae). *J. Economic Entomology.* **97:** 1106-1111.

Munro, J. W. 1996. Pests of stored products. The Rentokil library. Hutchinson of London.

Naseri, B., Fathipour, Y., Moharramipour, S. and Hosseininaveh, V. 2010. Nutritional indices of the cotton bollworm, *Helicoverpa armigera*, on 13 soybean varieties. *J. Insect Sci.***10:**151-158.

Nath, T., Nath, S., Shamsudin, M. and Rao, G. 1990. Effect of food depreviation on dry matter utilization, shell and coccon weight and fecundity of multi voltine silk worm, *Bombyx mori* Race Nistari. *Indian J. Seric.* **29:**174-181.

Nathan, S. S., Chung, P.G .and Murugan, K. 2005. Effect of biopesticides applied separately or together on nutritional indices of the rice leafolder *Cnaphalocrocis medinalis*. *Phytoparasitica.* **33:** 187-195.

Nation, J. L. 2001. Insect Physiology and Biochemistry. CRC Press.

Neupane, F. P. 1995. Agricultural Entomology in Nepal. *Review of Agricultural Entomology.* **83(12):** 1291-1304.

Patankar, A.G., Giri, A. P., Harsulkar, A. M., Sainani, M. N., Deshpande, V. V., Ranjekar, P. K. and Gupta, V. S. 2001. Complexity in specificities and expression of *Helicoverpa armigera* gut proteinases explains polyphagous nature of the insect pest. *Insect Biochem. Mol. Biol.* **31:** 453-464.

Pemberton, G. W. and Rodriguez, A. D. 1981. The occurrence of a rice strain of *S.oryzae* (L.) (Col. Curculionidae) breeding in Portugese kibbled carobs. *J. Stored Prod. Res.* **17:**37-38.

Sabhat, A., Malik, M. A., Firdose, A. M., Sofi, A. M. and Mir, M. R. 2011. Nutritional efficiency of selected silk worm breeds of *Bombyx mori* L. reared on different varieties of mulberry under temperate climate of Kashmir. *Afr. J. Agric. Res.* **6(1):** 120-126.

Samraj, D. A and David, B. V. 1988. Life table studies on the spotted bollworm, *Earias vittella* (Fabricious) (Lepidoptera: Noctuidae) in cotton ecosystem. *J. Bombay Nat. Hist. Soc.* **85:** 637-641.

Scriber, J. M. and Slansky, F. 1981. The nutritional ecology of immature insects. *Annu. Rev. Entomol.* **26:** 183-211.

Sharma, H. C., Agarwal, R. A. and Singh, M. 1982. Effect of some antibiotic compounds in cotton on post embryonic development of spotterd bollworm (*Earis vittella* F.) and the mechanism of resistance in *Gossypium arboretum. Proc. Indian Acad. Sci. - Animal Sci.* **1:** 67-77.

Slansky, F. J. and Scriber, J. M. 1985. Food consumption and utilization. In: Kerkut, G. A., Gilbert, L.I., Editors. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*, volume. **4:** pp.87-63

Tzenov, P. 1993. Study on the food utilization in generic sex limited breeds for egg and larval traits of the silk worm, *Bombyx mori* L., at moderate, reduced and excess feeding amounts, *Sericologia*. **33:**247-256.

Waldbauer, G. P. 1968. The consumption and utilization of food by insects. *Advances in Insect Physiology*. **5:** 229-288.

Tiwari, K. K. and Chandra, A. 2010. Use of degenerate primers in rapid generation of microsatellite markers in *Panicum maximum*. *J. Envir. biol*. **31:** 965-968.

Upadhyaya, H. D., Ortiz, R., Bramel, P. J. and Singh, S. 2002. Phenotypic diversity for morphological and agronomic characteristics in chickpea core collection. *Euphytica*. **123:** 333-342.

UPOV, 2007. TG/248/1 Common millet. 1-37.

Wouw, M. V. D., Jorge, M. A., Bierwirth, J. and Hanson, J. 2008. Characterization of a collection of perennial *Panicum* species. *Tropical Grasslands*. **42:** 40-53.