The Bioscan 8(1): 165-168, 2013
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

NITROGENOUS FERTILIZATION AFFECTS LEAF CONSUMPTION AND UTILIZATION BY PLUTELLA XYLOSTELLA LINN (LEPIDOPTERA: PLUTTELLIDAE)

G. M. BANSODE* AND M. S. PUROHIT
N. M. College of Agriculture, Navsari Agricultural University Navsari, 396 450 (Gujrat)
e-mail:ganeshban@rediffmail.com

KEYWORDS
Plutella xylostella
Nitrogen fertilizer
Consumption and utilization

Received on :
25.09.2012

Accepted on :
19.01.2013

***Corresponding author**

ABSTRACT
Food consumption and utilization influence metabolism, enzyme synthesis, nutrient storage and other activities. The nutritional ecology of the *Plutella xylostella* was studied using nitrogenous fertilized leaves as the source of food. In order to have a detailed picture of food utilization, daily measurement of food ingested, faeces produced and weight gain by larva were recorded. The results revealed that amount of food ingested and consumption index were increased proportionally with the increasing level of N applied to host plants. The amount of food ingested was increased gradually with advancement of age, while consumption of food had decreased with advancement of age. Approximate digestibility, efficiency of conversion of ingested food and efficiency of conversion of digested food increased in younger larvae and declined with the advancement of age.

INTRODUCTION

Nitrogen is a mineral nutrient required by all organisms, being the main component of the body, the genetic code and the metabolism (Scriber, 1984; Simpson and Raubenheimer, 1993; Simpson *et al*., 1995). Fertilizer application to enrich soil increases not only the nitrogen content of crops but also plant consumption by insects (Tingey and Singh, 1980). Since, nitrogen contents of phytophagous insects are several times higher than those of plants and because food is the only source of water and nitrogen for most insects, feeding on plants with good accumulation of nitrogen and water is obligatory for herbivorous insects (Scriber, 1977). The consumption and utilization of food in insects facilitate the understanding of the adaptability of insects to the environment.

Insects that feed on diets or host plants high in N generally have greater growth rates, higher efficiency of conversion of ingested food and shorter developmental times as reported by Chen *et al*. (2004). Similarly, Southwood (1972) revealed that reproductive success of insects depend to a large extent on their ability to ingest, digest and convert plant nitrogen efficiently and rapidly. However, Scriber (1984) compiled 115 studies on herbivorous insects response to plant fertilization with nitrogen, showing that many of these responses are contradictory. For instance, there was an increment on some performance components of species fed with fertilized plants and in 44 cases the latter were less attacked by herbivores. On the other hand, in some cases there were decreases in the populations of the herbivores in sites with low nitrogen content. Furthermore, both the positive and negative correlation between host plant nutrition and insect have been reported by Brewer *et al*. (1985) on *Choristoneura occidentalis,* Carnevalli *et al*. (1990) on *Spodoptera frugiperda* and Setamous *et al*. (1993) on *Sesamia calamistis*. Therefore, the existing knowledge on the relationship between host plant nitrogen and food utilization in herbivorous insects is not conclusive. Insect-host relationships can be better understood by knowing the rate of food consumption, its digestibility and conversion of food eaten to body tissue. However, similar line of work on diamondback moth (*Plutella Xylostella*) is not attended. The present study therefore examines the influence of different N fertilization on leaf consumption and utilization by *Plutella xylostella*.

MATERIALS AND METHODS

The experiment was laid out at Department of Entomology, N. M. College of Agriculture, Navsari, Gujarat in a completely randomized design (CRD) with four levels of nitrogenous fertilizers (N_3-160 kg N/ha, N_2-80 kg N/ha, N_1- 40 kg N/ha and N_o-no fertilizers) replicated five times. The cauliflower leaves collected from plot applied with different fertilizer regime were brought to laboratory and cut in to 5 x 5cm piece. These pieces were placed singly in to the petridish and single first instar larva obtained from insect culture released in each pertidish. For each replication, ten larvae were released. Treatment wise fresh foods were supplied to the larvae until pupation. The weight of individual full grown larva as well as pupa was taken with electronic balance. The observations on the following growth parameters were recorded.

Weight of food ingested

Was calculated by subtracting the weight of leftover food from the amount of food introduced.

Consumption index (C. I.)

Was calculated by formula proposed by Waldbauer (1968).

$$C.I. = \frac{\text{Fresh wt. of food eaten}}{\text{Duration of feeding period in days} \times \text{Mean fresh wt. of insect during feeding period}}$$

Approximate digestibility (A.D.)

was calculated by formula proposed by Waldbauer (1968).

$$A.D. = \frac{\text{Wt. of food ingested} - \text{Wt. of faeces}}{\text{Wt. of food ingested}} \times 100$$

Efficiency of conversion of ingested food (E.C.I.)

was calculated by following formula proposed by Waldbauer (1968).

$$E.C.I. = \frac{\text{Wt. gained by insect}}{\text{Wt. of food ingested}} \times 100$$

Efficiency of conversion of digested food (E.C.D.)

The efficiency with which digested food is converted to body substance was calculated from following formula proposed by Waldbauer (1968).

$$E.C.D. = \frac{\text{Wt. gained by insect in given time}}{\text{Wt. of food ingested} - \text{Wt. of faeces}} \times 100$$

All the above growth parameters were worked out for 5th, 6th, 7th and 8th day's old larvae. The latter being fully grown larvae. The data was analyzed using completely randomized design.

RESULTS AND DISCUSSION

The weight of the food ingested differed significantly P value among the treatments at all 4 days of observation (Table 1). Significantly higher food ingested by 5 days old larvae was recorded in treatment N_3 (33.73mg) followed by in treatment N_2 (32.00mg) and N_1 (30.54mg). In untreated food, consumption was significantly less (30.03mg). Though, the quantity of food consumption increased with the advancement of age, the trend in food ingested remained same by 6, 7 and 8 days (full grown) old larvae. Full-grown larvae consumed higher quantity (75.48 mg) of food and it differed significantly from N_2 (62.05mg) and N_1 (61.19mg). The quantity of food ingested by larva was significantly lower (54.12mg) when fed with food obtained from N_0 regime.

From the above results, it is seen that amount of food ingested increased proportionally with the increasing level of N applied to host plants. The result also showed that amount of food ingested was increased gradually with advancement of age.

The data recorded for 5 days old larvae showed that significantly higher C.I. (Table 1) was observed in treatment N_3 (1.56) and it was at par with treatment N_2 (1.54) and N_1 (1.46). However, lower C.I. was observed in treatment N_0 (1.44) which did not differed statistically from treatment N_1. The C.I. due to different nitrogen levels in 6 days old larvae was significantly higher in N_3 (1.62) and it was at par with N_2 (1.54). The other two treatments recorded lower C.I. and differed significantly P value from the above treatment.

The C.I. due to different N levels had decline with advancement of age. However, trend of influence of N levels on C.I. of 7 days old larvae remained similar as in previous case. The C.I. of full-grown larvae was significantly higher in N_3 treatment (1.46) and it was at par with treatment N_2 (1.39) and N_1 (1.38). However, lower C.I. was observed in N_o (1.31).

The consumption index, which is used to determine the capacity to consume food in relation to their body weight also influenced by N levels and increased gradually with increasing N levels. Though, the capacity of consumption of food had decreased with advancement of age, the significant influence of N level in C.I. continued up to the full grown stage. Dandapani and Balasubramanian (1980) stated that the consumption index decreased with an increase in age in *Heliothis armigera* Hubner (Noctuidae).

Approximate digestibility (Table 2) differed significantly among the treatments in 5 days old larvae. It was significantly higher in N_3 (49.54%) and was at par with N_2 (48.45%) and N_1 (47.40%). N_0 recorded significantly lower (45.07%) A. D. In general, the A.D. of 6 days old larvae had increased in all treatments. However, the difference among the treatments was significant, wherein N_3 gave higher A.D. (51.84%), but it was at par with N_2 (51.55%) and N_1 (51.40%). A.D. of 7 days old larva and full grown larvae did not differ significantly and it was almost equal in all the treatments. The data further showed the gradual decline in A.D. from 6 days onwards and the extent of reduction was between 20 to 25 per cent of full grown larva.

Approximate digestibility, which indicates utilization of food by diamondback moth larvae, was also significantly influenced by levels of nitrogen supplied to food plants, but only in 5 and 6 days old larvae. The capacity of utilization of food by younger larvae increased with increasing the levels of nitrogen supplied to host plant increased. In subsequent larval stages, nitrogen levels did not exert any effect on A.D, which declined in general. The increasing A.D. in younger larvae is associated with chewing off small pieces of leaf or selective feeding than the older age larvae, which fed on large piece of leaf containing undigestible fibres that contribute to decline in A.D.

Digestibility is affected by nutritional deficiency or imbalanced diet, high content of crude fiber or deficiency of water in food (Waldbauer, 1964). The higher assimilation efficiency or approximate digestibility is certainly a racial character, as higher food intake does not necessarily result in higher digestibility (Magdum *et al*., 1996).

The E.C.I. of 5 days old larvae (Table 2) showed significant difference due to N level fertilization to host plant. Treatment N_1, N_2 and N_3 recorded 18.12, 18.74 and 19.32 per cent E.C.I, respectively and they differed significantly from N_0 (15.04%). The E.C.I. due to different N levels had increased in the 6 days old larvae. However, the trend of influence of N levels on E.C.I. remained similar as it was found in 5 days old larvae. The E.C.I. of 7 and 8 days old larvae did not influenced by different nitrogen regime. The gradual reduction in E.C.I.

Table 1: Effect of nitrogen levels on the weight of food ingested and consumption index by the *P. xylostella* larvae

Treatments	Weight of food ingested (mg) Days old larvae				Consumption index (C.I.) Days old larvae			
	5	6	7	8	5	6	7	8
N_{0} (No fertilizer)	30.03	42.92	48.96	54.12	1.44	1.46	1.40	1.31
N_{1} (40Kg N/ha)	30.54	45.30	53.96	61.19	1.46	1.48	1.40	1.38
N_{2} (80Kg N/ha)	32.00	46.20	56.26	62.05	1.54	1.54	1.43	1.39
N_{3} (160Kg N/ha)	33.73	52.00	63.00	75.48	1.56	1.62	1.51	1.46
S.Em ±	0.49	0.93	0.94	1.16	0.04	0.04	0.03	0.03
C.D. 5%	1.46	2.80	2.82	3.49	0.11	0.11	0.08	0.08
C.V.%	3.46	4.48	3.79	4.11	5.36	5.60	4.44	4.54

Table 2: Effect of nitrogen levels on the approximate digestibility and efficiency of conversion of ingested food by the *P. xylostella* larvae

Treatments	Approximate digestibility (A.D. %) Days old larvae				Efficiency of conversion of ingested food (E.C.I.%) Days old larvae			
	5	6	7	8	5	6	7	8
N_{0} (No fertilizer)	45.07	48.80	44.86	40.90	15.04	18.68	14.27	11.00
N_{1} (40Kg N/ha)	47.40	51.40	46.31	41.10	18.12	19.82	14.86	11.40
N_{2} (80Kg N/ha)	48.45	51.55	44.66	40.36	18.74	19.87	14.95	11.57
N_{3} (160Kg N/ha)	49.54	51.84	46.06	41.36	19.32	20.33	15.01	11.87
S.Em ±	0.85	0.78	0.46	0.48	0.75	0.33	0.23	0.40
C.D. 5%	2.57	2.33	NS	NS	2.24	1.00	NS	NS
C.V.%	4.03	3.41	2.25	2.61	9.40	3.81	3.50	7.93

Table 3: Effect of nitrogen levels on the efficiency of conversion of digested food by the *P. xylostella* larvae

Treatments	Efficiency of conversionof digested food (E.C.D.%) Days old larvae			
	5	6	7	8
N_{0} (No fertilizer)	33.25	38.20	31.90	27.30
N_{1} (40Kg N/ha)	38.13	38.57	32.10	27.73
N_{2} (80Kg N/ha)	38.67	38.67	31.92	28.70
N_{3} (160Kg N/ha)	38.80	39.28	32.78	28.84
S.Em +	1.21	0.44	0.49	0.84
C.D. 5%	3.63	NS	NS	NS
C.V.%	7.27	2.55	3.44	6.65

was also noticed in all the treatments, which was to the tune of 50 per cent in full-grown larvae compared to E.C.I. of 6 days old larvae.

E.C.I. denotes the ability of insects to utilize ingested food for its development. In all the treatments, the E.C.I. of latter age larvae was found to be reduced to some extent as compared to early stage larvae. The results showed that the food treated with higher N level (N_3) efficiently utilized by younger (5 and 6 days old) diamondback moth larvae than the other N levels and untreated food.

E.C.D. recorded in 5, 6, 7 and 8 days old larvae (Table 3) showed significant influence of treatments only in 5 days old larvae. Wherein N_3 (38.80%), N_2 (38.67%) and N_1 (38.13%) gave equal effect on E.C.D. of 5 days old larvae. Thereafter, E.C.D. started declining from 33.25 to 27.30 per cent in N_0, 38.13 to 27.73 per cent in N_1 38.67 to 28.70 per cent in N_2, 38.80 to 28.84 per cent in N_3, with the advancement of age without significant difference due to treatments.

The efficiency with which digested food is converted to body substance (E.C.D) also significantly influenced by N levels only in 5 days old larvae. The N level had no influence on E.C.D. of older and full-grown larvae and declined with the advancement of age. However, comparatively higher E.C.D. was recorded in larvae fed with leaves having higher nitrogen level. Waldbauer (1964) reported that higher the food intake tends to mobilize the gut contents faster and provide less time for enzyme activity and food absorption making digestive efficiency poor.

Hence, it is proved that as the nitrogen levels increased, foliage become more digestible and efficiency of ingested and digested food also increased in early age larvae. Muthukrishnan and Selvan (1993) reported that higher nitrogenous fertilization doses were correlated with increased consumption and utilization of leaf by *Porthesia scintillans*. The declining in efficiency of conversion of ingested and digested food in older larvae, observed in present investigation is supported by Montgomery (1982) who found that declining food nitrogen utilization efficiency with age of gypsy moth larvae fed on food with high nitrogen content. Similarly, analysis of nitrogen in the faeces showed that *H. armigera* larvae in latter stage had lower rate of N intake and utilization than the 2nd and 3rd instar larvae (Wu *et al*., 1988). Furthermore, Slansky and Scriber (1985) analyzed the results of several hundreds of experiments on 25 insect species and found that the rates and efficiencies of host plants utilization in penultimate and final larval instars declined with decreases in plant nitrogen.

ACKNOWLEDGEMENTS

Authors are grateful to the Principal, N.M. College of Agriculture, G.A.U., Navsari for providing necessary facilities.

REFERENCES

Brewer, J. W., Capinera, J. L., Deshon, R. E. and Walmsley, M. L. 1985. Influence of foliar nitrogen level on survival development and reproduction of western spruce budwarm, *Choristoneura occidentalis*. *Can. Ent.* **117(1):** 23-22.

Chen, Y. Z., Lin, L., Wang, C. W., Yeh, C. C. and Hwang, S. Y. 2004. Response of two *Pieris* (Lepidoptera: Pieridae) species to fertilization of a host plant. *Zoological Studies*. **43:** 778–786.

Caranevalli, P. C., Adde-M, F. V. and Calafiori, M. H. 1990. Effect of nitrogen in maize on *Spodoptera frugiperda*. *Ecossistema*. **18:** 108-118.

Dandapani, N. and Balasubramanian, M. 1980. Consumption and utilization of food plants by *Heliothis armigera* (Hubner) (Noctuidae: Lepidoptera). *Entomon.* **5:** 99-103.

Magdum, S .B., Ramadevi, O. K., Shiva, S. and Datta, R. K. 1996. Nutritional indices in some bivoltine breeds of silkworm, *Bombyx mori* L. *India J. Seric*. **35:** 95 – 98.

Montgomery, M. E. 1982. Lifecycle nitrogen budget for gypsy moth *Lymantria dispar* reared on artificial diet. *J. Insect Physiol*. **28:** 437-442.

Muthukrishan, J and Selvan, S. 1993. Fertilization affect leaf consumption and utilization by *Porthesia scintillans* Walker. *Ann. Ent. Soc. America*. **86(1):** 73-78.

Scriber, J. M. 1984. Host plant suitability. In Bell W. and Card and R. T. (Eds.), Chemical Ecology of Insects pp. 159-202. *Chapman and Hall*, London.

Scriber, J. M. 1977. Limiting effects of low leaf water content on nitrogen utilization, energy budget, and larval growth of *Hyalopora cecropia* (Lepidoptera: Saturniidae). *Oecologia*. **28:** 269-287.

Setamous, M., Schulthess, F., Bosque-Perez, N. K. and Odjo-Thomas, A. 1993. Effect of plant nitrogen and silica on the bionomics of *Sesamia calamistis. Bull. Entomol. Res.* **83(3):** 405-411.

Simpson, S. J., Raubenheimer, D. and Chambers, P. G. 1995. The mechanisms of nutritional homeostasis,. In R. F. Chapman and G. De Boer (Eds.), Regulatory mechanisms in insect feeding. New York, Chapman and Hall. pp. 251-278.

Simpson, S. J. and Raubenheimer, D. 1993. The central role of the haemolymph in the regulation of nutrient intake in insects. *Physiol. Entomol*. **18:** 395-403.

Slansky, F. J. and Scriber J. M. 1985. Food consumption and utilization. In: G. A. Kerkuit and L. I. Gilbert (Eds.), Comprehensive insect physiology, *biochemistry and pharmacology.Pergamon, Oxford*. pp. 87-164.

Southwood, T. R. E. 1972. The insect/plant relationship - an evolutionary perspective. In: Van Emden, H.F., (Eds.), Insect/Plant Relationship. Symposium. *Review of Entomological Society*, London. pp.3-30

Tingey, W. M. and Singh, S. R. 1980. Environmental factors influencing the magnitude and expression of resistance. *In F.G. Maxwell and P.R. Jennings (Eds.) Breeding plants resistant to insects*. J. Wiley, New York. pp. 89-113.

Waldbauer, G. P. 1964. The consumption, digestion and utilization of solanaceous and non-solanaceous plants by larvae of the tobacco horn-worm, *Protoparea extra* (Lepidoptera: Sphinigidae). *Entomol. Exp. Appl*. **7:** 252-259.

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

Wu, K. J., Gong, P. Y. and Li, X. Z. 1988. The intake and utilization of dietary nitrogen by cotton bollworm *H. armigera*. *Acta Ent. Sinica*. **31(1):** 1-7.