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Effect of different semi-synthetic diets on biology of Fall armyworm, *Spodoptera frugiperda* (Smith)

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ABSTRACT

Spodoptera frugiperda, an exotic and highly polyphagous generalist herbivore has an exceptional migratory capacity. Pinto bean based diet is best composed diet, which remains as best diet of choice for various researcher. However, Pinto beans are expensive, making pinto bean diet rather a predicament in rearing fall armyworm larvae. Therefore, we evaluated four different diets *i.e.*, a standard bean-based diet (D1), and diets substituting beans with soya meal (D2), potato (D3) and corn (D4), respectively against *S. frugiperda* larvae. The biological parameters *viz.,* larval and pupal duration; larval and pupal weight; sex-ratio and fecundity, growth and fitness index were evaluated. Larval and pupal development was observed; for the diets D1 and D4, duration was minimum and weights were maximum; for the D2 and D3, duration was maximum with less weight. More number of females were observed from, D1 and D3. Larval and pupal fitness index was maximum for the diet D1, followed by D4 and was the least for D4. Hence, we report that the diet D1 is the top pick while D2 can also be a good substitute for D1 for laboratory rearing. Nevertheless, D3 can also be used in appropriate quantities to augment female moth population for sustaining the cultures.

1. Introduction

Spodoptera frugiperda, a highly noxious exotic pest that is native to tropical and subtropical areas of the Western Hemisphere, which commonly known as the "fall armyworm", reported in India by Kalleshwaraswamy *et al,* 2018 from Shivamogga, Karnataka. Owing to its high migration capacity, it had migrated to many parts of the Indian subcontinent and other regions of Asia. Fall armyworm is known to feed on more than 80 plant species (Pashley, 1988), causing major damage to Maize, Soybean, Cotton, Potato etc., and has the capacity to cause 55-100% losses during various stages of crop growth (Chimweta *et al.* 2020). Because of its economic importance, studies on the biology, behaviour and insecticide toxicity are being undertaken. It requires mass multiplication in the laboratory for smoothly carrying out the research. Mass multiplication through natural food is prone to contamination, and maintaining the culture will be laborious as well as profligate. So as to mass multiply this insect pest in laboratory, suitable artificial diets are necessary.

In the past several attempts have been made to develop semi synthetic diets, where Revelo and Raun, 1964 were the progenitors of laboratory rearing of fall armyworm. They successfully reared fall armyworm on wheat germ-based diet which is used for rearing *Ostrinia nubilalis.* Burton (1972) was progenitors in developing mass rearing technique for fall armyworm, later he used wheat germ diet for mass multiplication, later economically modified pinto bean diet was developed by Burton 1989, for rearing *Heliothis zea,* which subsequently used for rearing of *S. frugiperda* as well. Nalim (1991) combined above two components (pinto beans and wheat germ) and developed standard modified pinto bean

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diet, which was the best standard diet of choice for rearing fall armyworm. Pinto *et al,* (2019) had substituted pinto bean with green corn. Hiking prices of the pinto bean that represents a major constituent of the diet will eventually lead to increased cost of diet ingredients and this is an ingredient that can be readily substituted (Lynch *et al,* 1989). Our current research was done to assess the impact of alternative components that are more readily available and less expensive than pinto bean on the growth and fitness index of Fall armyworms.

2. Matrials and Methods

Different larval, pupal stages of Fall armyworm were collected from the corn fields of CPGSAS, CAU(I), Umiam, Meghalaya and were kept in controlled conditions at a temperature of 26±1 ℃ and 65±5% RH. The laboratory experiments were conducted in Entomology Laboratory at School of Crop Protection, CPGSAS, Umiam, Meghalaya.

2.1 Artificial diets evaluated

Four different artificial diets were evaluated *i.e.,* diet based on beans (D1 which is used as standard diet) (Nalin, 1991) and soya meal (D2), potato (D3) and corn-based diet (D4), respectively were prepared by substituting the beans from standard diet. Various dietary compositions were described in Table 1.

2.2 Rearing Procedure

For each diet, 50 larvae were used in 5 replications with 10 larva per replication. Plastic vials (6 cm diameter x 2cm height) were used for rearing the larvae and the vials were sterilized with 70 per cent ethyl alcohol and kept in UV light for 30 min. Diet was cut into small pieces weighing approximately 5 g each and placed into the vials at the rate of one piece per vial. After 2nd moult larvae were transferred to single vials to avoid cannibalism and vials were kept in BOD incubator at 26±2 ℃ , 70±5 per cent RH and 14:10 of L:D. The pupae were sexed into male and female based on visual observations present in 8th and 9th abdominal segments and grouped accordingly.

2.3 Observations recorded.

Larval, pupal and adult longevity period was recorded for each individual from the time of neonate transfer until adult formation in terms of days. Mean larval and pupal weights (in milligrams) were calculated in 6th instar. Adult emergence (%), fecundity data, growth and fitness index were calculated using the formula given by Itoyama *et al.,* 1999.

$$\text{Larval growth index} = \frac{\text{Pupation(\%)}}{\text{Larval period(days)}} \text{x100}$$

$$\text{Pupal growth index} = \frac{\text{Emergence (\%)}}{\text{Pupal period (days)}} \text{x100}$$

$$\text{Fitness index} = \frac{\text{Pupation (\%)} \times \text{Pupal weight}}{\text{Larval period+pupal period}} \text{x100}$$

3. Results

The diets D1 and D4 are significantly superior compared to the diet D2 and D3 with a shorter larval period, higher larval and pupal weights. The larval periods were 15.32 and 15.76 days, while the larval weights were 376.76 and 361.63 mg, and pupal weights were 249.57 and 240.43 mg, respectively in the diets D1 and D4. Whereas, D2 and D3 diets produced lower pupal and larval weights, measuring 324.61, 319.25, and 203.79, respectively, and longer larval periods (17.48 and 17.80).

The highest pupation and adult emergence percentage was obtained in D1 and D4 diets with 92; 97.5 and 90; 94, respectively. D2 and D3 diets had lowest pupation and adult emergence percentage of 84.8; 88 and 65.6; 84, respectively. Females outnumbered males in D1 and D3 diets whereas, males outnumbered females in D2 and D4 diets.

Depending on its nutrition, *S. frugiperda* has varying fecundities. The females produced the significantly highest number of eggs/females in D1 diet (1563.08), followed by D4 diet (1124.01) and least number of eggs/females were observed in D3 diet (459.47). with 2 oviposition peaks; first was observed between 3rd and 5th day while another was observed between 7th and 10th day.

3.1 Growth and fitness index

Fall armyworm, fitness and growth index were observed to be the highest in D1 diet (955.09) and least in D3 diet (486.41). The larval growth index was found to be the highest on D1 diet (6.005) and least in D3 based diet (3.68). Similarly, pupal growth index had the same trend *i.e.,* D1 (11.181) and D4 diets (10.633) were higher but surprisingly, D3 diet (10.14) also showed better pupal growth index than that of D2 diet (4.81). The larvae were found to have higher growth index when reared on D1 diet as compared to other diets.

4. Discussion

Our findings on the pinto bean-based diets' larval duration, percentage of larval survival, mean pupal weight, and percentage of female emergence are consistent with those published by Pinto et al. (2019) who reported the values as 15.36 days, 92 Per cent, 253.3mg and 56 per cent for larval duration, percentage larval survival, mean pupal weight and percentage female emergence, respectively. However, Pinto *et al.* (2019) found that green corn-based diet was better over pinto bean, the probable reason may be the difference in quantity of diet ingredients as quantity of wheat germ used was more than the green corn.

Gupta *et al.* (2005) reared *S. litura* larvae on rajma based diet and found percentage pupation and percentage emergence to be 89.2% and 97.2%, respectively, and these values were similar to our studies. The values of larval (4.31) and pupal growth index (9.92) were higher because the *S. frugiperda* takes lesser larval period compared to the *S. litura.*

Lynch *et al.* (1989) compared soya meal and pinto bean based diets for rearing fall armyworm and found that pinto bean based diet was better when compared to soya meal diet. When Whitford et al. (1992) replaced the pinto beans in the modified pinto bean diet with 90% soy protein, they discovered that the larval growth rates of the fall armyworm's rice and maize strains were suppressed. This is in conformity with our findings whereas Elvira *et al.* (2010) found soy protein-based diet satisfactory for rearing of *S. exigua* compared to wheat germ-based diet.

Pupal weights on diets D1 and D4 were higher as compared to that of D2 and D3 which is a good indication according to Bernardi et al. (2014), heavier pupae produced females with higher fecundities. We noticed that the Benrey and Denno (1997) "slow growth high-mortality" hypothesis and our investigation were similar. Populations reared on D1 and D4 took lesser time period to complete larval and pupal stages, and also recorded higher percent pupation and percent adult emergence. Whereas in case of D2 and D3, larvae took more time to complete larval and pupal stage, but recorded lower pupation and adult emergence. Therefore, D1 and D4 are comparatively better for rearing *S. frugiperda* than D2 and D3.

Silva et al. (2017) discovered that sex ratios ranged from 0.37 to 0.54 while examining the effects of five hosts and an artificial diet on the development of *S. frugiperda*. Additionally, Murua et al. (2008) found a sex ratio of 0.35 to 0.54 while growing populations of *S. frugiperda* on various hosts, which is comparable to the results of the current investigation.

On diets D2 (corn-based) and D4 (soyabean-based), the fecundity found was 1124 and 526.07 eggs/female, respectively. This is greater than the values reported by Murua et al. (2008), i.e., 955.05 and 519.83 eggs/female for populations reared on maize and soyabean, respectively. Siloto (2002) reported that in maize genotypes fecundity values varied from 1121.20 to 11247.86 eggs/female which were on par with our studies.

5. Conclusion

Considering the damage potential, polyphagous nature and invasiveness of *S. frugiperada,* the present study “Effect of different semi-synthetic diets on biology of Fall armyworm, *Spodoptera frugiperda* (Smith)” was conducted from the investigation, it can be inferred that the rajma-based diet was ideal for *S. frugiperda* mass rearing, while corn based diet could also be a good substitute and nevertheless potato can also be incorporated to the diet in appropriate quantities to get more female emergence percentage.

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7. References

Benrey B, Denno RF (1997). The slow-growth–high-mortality hypothesis: a test using the cabbage butterfly. Ecol. 78(4):987-99.

Bernardi O, Sorgatto RJ, Barbosa AD, Domingues FA, Dourado PM, Carvalho RA, Martinelli S, Head GP, Omoto C (2014). Low susceptibility of *Spodoptera cosmioides*, *Spodoptera eridania* and *Spodoptera frugiperda* (Lepidoptera: Noctuidae) to genetically-modified soybean expressing Cry1Ac protein. Crop prot. 58:33-40.

Burton RL, Perkins WD (1972). WSB, a new laboratory diet for the corn earworm and the fall armyworm. J. Econ. Entomol.1;65(2):385-6.

Burton RL and Perkins WD (1989). Rearing the corn earworm and fall armyworm for maize resistance studies. Proceedings of International Symposium on Methodologies for Developing Host. Res. Maize Insect. 141-170.

Chimweta M, Nyakudya IW, Jimu L, Bray Mashingaidze A (2020). Fall armyworm [*Spodoptera frugiperda* (JE Smith)] damage in maize: management options for flood-recession cropping smallholder farmers. Inter. J. Pest Manag. 66(2):142-54.

Elvira S, Gorría N, Muñoz D, Williams T, Caballero P (2010). A simplified low-cost diet for rearing *Spodoptera exigua* (Lepidoptera: Noctuidae) and its effect on S. exigua nucleopolyhedrovirus production. J. Econ. Entomol. 1;103(1):17-24.

Gupta GP, Rani S, Birah A, Raghuraman M (2005). Improved artificial diet for mass rearing of the tobacco caterpillar, *Spodoptera litura* (Lepidoptera: Noctuidae). Int. J. Trop. Insect Sci. 25(1):55-8.

Itoyama K, Kawahira Y, Murata M, Tojo S (1999). Fluctuations of some characteristics in the common cutworm, Spodoptera litura (Lepidoptera: Noctuidae) reared under different diets. Appl. Entomol. Zool. 34(3):315-21.

Kalleshwaraswamy CM, Maruthi MS, Pavithra HB (2018). Biology of invasive fall army worm *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) on maize. Indian J. Entomol. 80(3):540-3.

Lynch RE, Nwanze KF, Wiseman BR, Perkins WD (1989). Fall armyworm (Lepidoptera: Noctuidae) development and fecundity when reared as larvae on different meridic diets. J. Agric. Entomol. 6(2).

Murúa MG, Vera MT, Abraham S, Juarçz ML, Prieto S, Head GP, Willink E (2008). Fitness and mating compatibility of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) populations from different host plant species and regions in Argentina. Annals Entomol. Soc. Am. 101(3):639-49.

Nalim DM. 1991. Biology, quantitative nutrition and quality control of populations of *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae) in two artificial diets.

Pashley DP (1988). Current status of fall armyworm host strains. Florida Entomol. 1:227-34.

Pinto JRL, Torres AF, Truzi CC, Vieira NF, Vacari AM and De Bortoli SA (2019). Artificial corn-based diet for rearing *Spodoptera frugiperda* (Lepidoptera: Noctuidae). J. Insect Sci. 19(4):2.

Revelo MA and Raun ES (1964). Rearing the fall armyworm under greenhouse conditions. J. Econ. Entomol. 57(6):1000-1000.

Siloto RC (2002). *Danos e biologia de Spodoptera frugiperda (JE Smith, 1797)(Lepidoptera: Noctuidae) em genótipos de milho* (Doctoral dissertation, Universidade de São Paulo).

Silva DMD, Bueno ADF, Andrade K, Stecca CDS, Neves PMOJ and Oliveira MCND. 2017. Biology and nutrition of Spodoptera frugiperda (Lepidoptera: Noctuidae) fed on different food sources. Sci. Agri. 74:18-31.

Whitford F, Quisenberry SS, Moellenbeck DJ (1992). Nutritional response by rice and corn fall armyworm (Lepidoptera: Noctuidae) strains to dietary component substitution in artificial diets. J. Econ. Entomol. 85(4):1491-6.

Table 1. Composition of artificial diets for *Spodoptera frugiperda*

Constituent	D1	D2	D3	D4
Bean (Kidney bean)	240 gm	-	-	-
Soya meal	-	240 gm		
Potato		-	240 gm	-
Corn		-	-	240 gm
Wheat germ	120 gm	120 gm	120gm	120 gm
Brewer's yeast	72 gm	72 gm	72 gm	72 gm
Ascorbic acid	7.3 gm	7.3 gm	7.3 gm	7.3 gm
Sorbic acid	2.4 gm	2.4 gm	2.4 gm	2.4 gm
Methyl parahydroxybenzoate	4.4 gm	4.4 gm	4.4 gm	4.4 gm
Vitamin solution	10.0 ml	10.0 ml	10.0 ml	10.0 ml
Formaldehyde (40%)	6.0 ml	6.0 ml	6.0 ml	6.0 ml
Distilled water	1 l	1 l	1 l	1 l
Agar	20.09 gm	20.09 gm	20.09 gm	20.09 gm

*D1 - Bean diet; D2 - Soya meal diet; D3 - Potato diet; D4 - Corn diet6

Table 2. Growth and fitness index

Sl No.	Treatment	Larval growth index	Pupal growth index	Fitness index
1	**D1**	6	11.18	955.09
2	**D2**	4.85	10	657.58
3	**D3**	3.68	10.14	486.41
4	**D4**	5.71	10.63	879.62

Table 3. Mean values of different biological parameters of *Spodoptera frugiperda* (Smith) fed on various artificial diets

	Larval		**Pupal**				**Adult**			
Life stages	**Duration (days)**	**Weight (mg/larva)**	**Duration (days)**	**Weight (mg / larva)**	**Per cent pupation**	**Adult emergence**	**Female emergence**	**Male emergence**	**Fecundity**	**Sex ratio**
D1	15.32^{d}	376.76^{a}	8.72^{a}	249.57^{a}	92^{a} (73.59)	97.5^{a} (82.59)	56 (48.44) a	44 (41.52) b	1563.08a	1:1.27
D2	17.48^{b}	324.61^{c}	8.80^{a}	203.79^{c}	84.8^{c} (67.07)	88^{c} (69.91)	42 (40.31) b	58 (49.64) a	526.07c	1:0.72
D3	17.80^{a}	319.25^{d}	8.28^{b}	193.38^{d}	65.6^{d} (54.07)	84^{ab} (66.66)	52 (46.13) a	48 (43.82) b	459.47d	1:1.08
D4	15.76^{c}	361.63^{b}	8.84^{a}	240.43^{b}	90^{b} (71.57)	94^{bc} (78.90)	38 (38.01) b	62 (51.95) a	1124.01b	1:0.612
SE ± M	0.060	1.01	0.07	0.57	0.66	3.46	1.79	1.798	2.0	
CD at 5%	0.179	2.999	0.224	1.696	1.957	5.390	5.390	5.39026	5.98	
C.V.	0.80	0.647	1.93	0.57	2.109	10.324	9.30	8.60	0.49	

* Mean in a column followed by "arcsine" transformed values
Different letters indicate significant differences
ANOVA, $P \leq 0.05$