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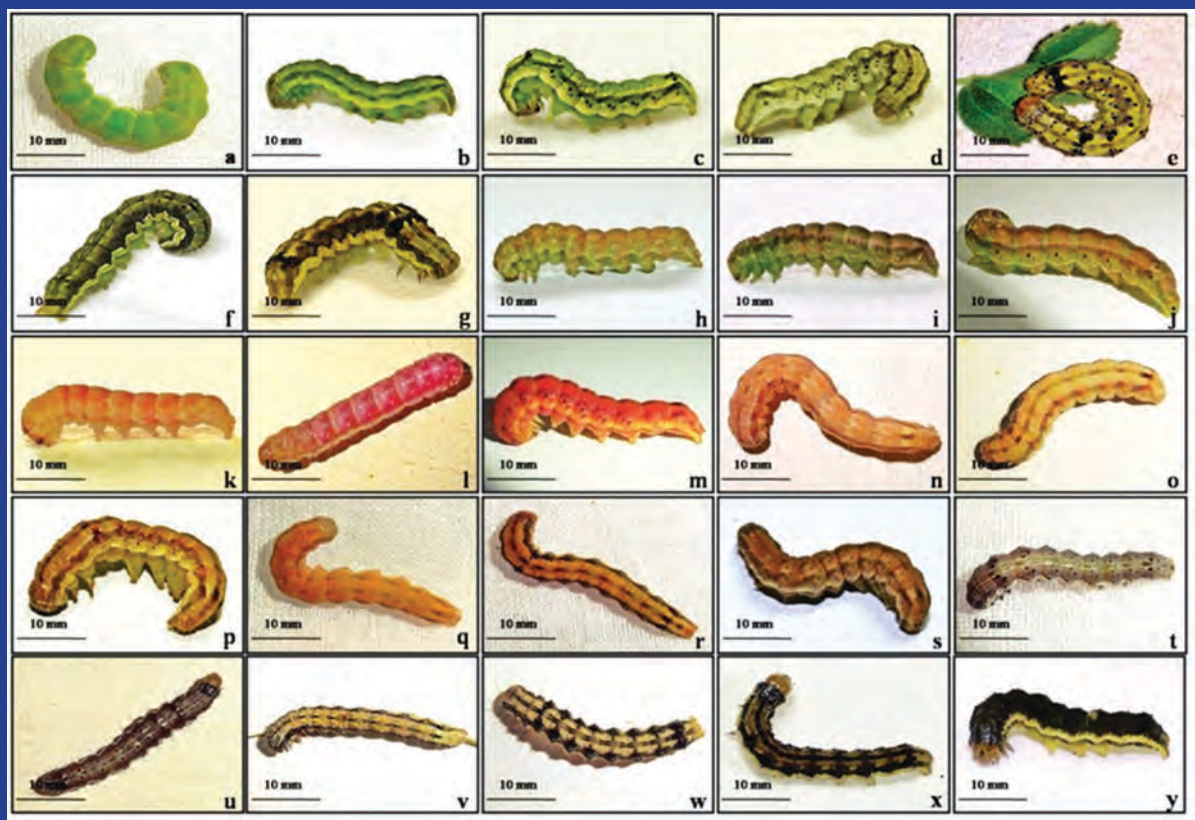

Larval body colour polymorphism in the gram pod borer *Helicoverpa armigera* (Hubner)
(for legends / details refer Snehal Chakravarthy et al., pp. 415-422, this issue)

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BIOLOGY OF FALL ARMY WORM *SPODOPTERA FRUGIPERDA* (J. E. SMITH) ON ARTIFICIAL DIETS

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ABSTRACT

Fall army worm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is one of the important invasive pests causing economic losses to maize, sorghum and other millets. This study aims to develop suitable cost-effective crop based artificial diet for its rearing and evaluates the biology under laboratory conditions. Study revealed that the least life cycle period (egg to adult) was obtained with sorghum+ chickpea based diet (D1: 31-39 days) as compared to sorghum based diet(D2: 37-44 days) and maize+ chickpea based diet (D3: 40-48 days). Fully developed larvae measured longer, broader and heavier when reared on D1, also the fecundity was maximum. A cheap artificial diet to rear *S. frugiperda* is thus developed in this study.

Key words: *Spodoptera frugiperda*, artificial diet, sorghum, chickpea, maize, fecundity, biology, morphometrics, length, width, weight, lifecycle

Fall army worm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is a polyphagous and destructive pest. Its hosts include maize, millets, wheat, potato, soybean, cowpea, peanuts, sorghum, rice, sugarcane, vegetables and cotton (CABI, 2017; Pogue, 2002; Jaba, 2018). Maize and sorghum are its preferred hosts, and it is native to tropical and subtropical regions of the Americas and damaging mostly maize in tropical regions. Severe incidence of FAW was reported from African countries such as Sao Tome Nigeria, Benin and Togo (Goergen et al., 2016). Its occurrence was reported for the first time from India by Sharanabasappa et al. (2018a) and had been reported as pest on sorghum (Venkateswealu et al., 2018) and sugarcane (Chromule et al., 2018). Because of its economic importance many studies have been done on its rearing. Walters (1937) reared FAW in the laboratory on corn and bean leaves. First artificial diet used to rear this was the wheat germ diet developed for the European corn borer *Ostrinia nubilalis* (Hubner), where first instar larvae were started on corn leaf and transferred to artificial diet in the second instar (Revelo and Haun 1964). Burton (1967) was the first to develop a mass rearing technique solely on an artificial wheat germ diet. The more economical modified pinto bean diet, developed for rearing the corn earworm *Heliolhis zea* (Boddie) (Burton 1969) was subsequently used for rearing, and many rearing attempts had been made. However, the modified pinto bean diet remains the standard diet of choice (Perkins 1979).

Parra and de Carvalho (1984) studied the development and quantitative nutrition of FAW reared on seven varieties of pinto bean as ingredients in artificial diets. Differences in larval developmental time were observed, and larvae reared on variety Branco-de-Uberlandia completed development in 18.7 days sooner than when reared on 'Monma'. The differences in digestibility of the diet and development were attributed to differences in tannin content of the bean varieties. Guillermo (l986) reared it on an artificial diet similar to the modified pinto bean diet; soybean flour replaced pinto bean as the primary ingredient diluting the soybean flour diet by 60% with water resulted in more economical and efficient rearing. For laboratory studies, it is difficult to maintain the insect cultures on natural host for a long period and there exists a need to identify, standardize and suitable composition/crops-based diets for cost effective mass rearing. In this study, the biology of FAW is evaluated on crop based artificial diets with varied substitute ingredients. Sorghum + chickpea and sorghum- based diets are standardized for the first time.

MATERIALS AND METHODS

The biology of FAW on artificial diets was evaluated with experiments in the laboratory of Department of Entomology and, Division of Integrated Crop Management, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (26 ±

1°C, 70 ±10%RH, and photoperiod of 12 L: 12 D hr). The diets evaluated include: sorghum + chickpea based diet (D1), a diet in which only sorghum flour known as sorghum based diet (D2) and a diet with the substitution of sorghum flour for maize named as a maize +chickpea based diet (D3) (Table 1). The nucleus culture was collected from maize fields at the farm of ICRISAT, Patancheru, and reared on natural host till adult emergence. The adults were released in oviposition cages (60x5 cm dia) and in these cages, rolled paper towels were placed as an oviposition substrate and provisioned on opening with muslin cloth for eggs collection. Adults in the cage were fed with 10% sucrose solution soaked on cotton pads offered in small plastic cups.

The newly hatched neonate larvae were reared on the selected artificial diets, and morphometrics of larvae and pupae (length and width) were measured using digital caliper. The larvae were reared in plastic cell well boxes with square shaped artificial diet pieces (2g), covered with wrapping film and lid. In the crop based artificial diets larvae after reaching the pupal stage, were transferred into vermiculite containing jars separately, to maintain the moisture until the adult emergence. Later adults were allowed in a wooden cum glass made oviposition cages (60 x 5 cm dia). In these cages, rolled paper towels were placed as an oviposition substrate and provisioned with an opening with muslin cloth for eggs collection and food supply. In each cage, a pair of male and female adults were released. The adults were fed 10% sucrose soaked on cotton pads offered in small plastic cups, replaced daily. Eggs were collected and kept in a plastic cups separately for hatching, with examination at every 12 hr interval for hatching. After hatching, the larvae (n = 100) were transferred individually on fresh artificial diets, with changes done every two days. Male and female longevity were observed with their release in a rearing cage. The larval and pupal periods, and fecundity were observed. These were replicated thrice and the data were statistically analyzed by Completely Randomized Design (CRD) using Gen STAT statistical software.

RESULTS AND DISCUSSION

Newly hatched caterpillars are green in their first to second instar and turn brown to black from third to sixth instars. Caterpillars have a dark head with a pale, upside down Y-shaped mark on the front and six distinct instars. The diets evaluated revealed significant differences, with fully developed sixth instar being of maximum length, width and weight on sorghum + chickpea based diet (D1); these morphometrics were 34.03 mm, 4.92 mm and 560 mg, respectively as compared to those of maize + chickpea based diet (D3) and sorghum based diet (31.28, 3.69,440 and 33.69,4.74, 530 mg), respectively. Each larva passed through six instars over

Table 1. Artificial diets (compositions) for *S. frugiperda*

Sl. No.	Diet composition	Sorghum +chickpea based diet (D1) (g or ml)	Sorghum based diet (D2) (g or ml)	Maize +chickpea based diet type (D3) (g or ml)
		Part-A		
1	Maize leaf powder	-	-	100.0
2	Sorghum leaf powder	75.0	270.0	-
3	Chickpea powder	265.0	-	240.0
4	Bavistin	1.0	1.5	1.0
5	Ascorbic acid	7.5	9.4	7.5
6	Methyl-p-hydroxybenzoate	6.0	6.0	4.0
7	Multi vitamin	2 capsules	3 capsules	3 capsules
8	Vitamin E	5 capsules	3 capsules	5 capsules
9	Streptomycin	_	0.5	_
10	Sorbic acid	4.0	3.5	4.0
11	Formaldehyde (40%)	5.0	5.0	6.0
12	Water	1210.0	800.0	1210.0
		Part-B		
13	Yeast	68.0	96.0	68.0
14	Agar	38.0	28.0	38.0
15	Water	1210.0	1300.0	1210.0

a period of 20, 18 and 17 days on (D3), (D2) and sorgum + chickpea based diets (D1), respectively (Figs. 1-3). These results are similar to those of Pitre and Hogg (1983) and Sharanabasappa et al. (2018b), who reported the larval period as 14-30 days.

Pupa was reddish brown and oval transforming from larva which stopped feeding before forming cocoon. The mean body length, width and weight of pupae were maximum in sorghum + chickpea diet (D1) 17.47, 5.24 and 249 followed by sorghum (D2), 16.89, 4.73 and 216; while in (D3) diet at was 16.37, 4.52 and 215 mg (Fig. 4). Pupal period was short with sorghum + chickpea diet (D1), 8-9 while on sorghum diet (D2) and maize + chickpea diet (D3) were 9-10 and 10-11

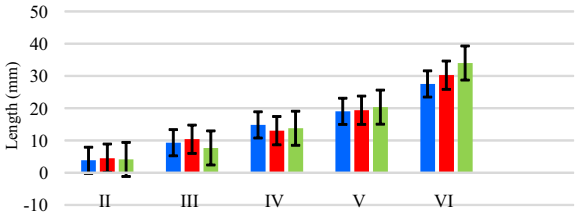

Fig. 1. Larval length of FAW on diets

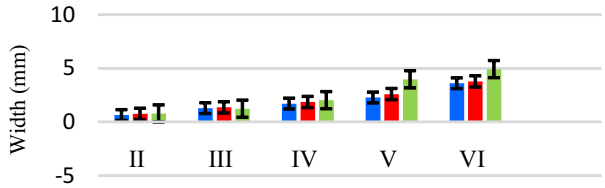

Fig. 2. Larval width of FAW on diets

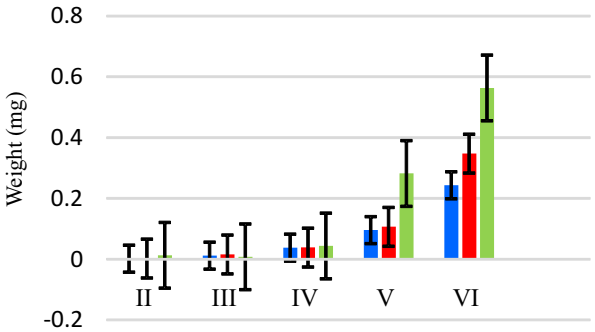

Fig. 3. Larval weight of FAW on diets

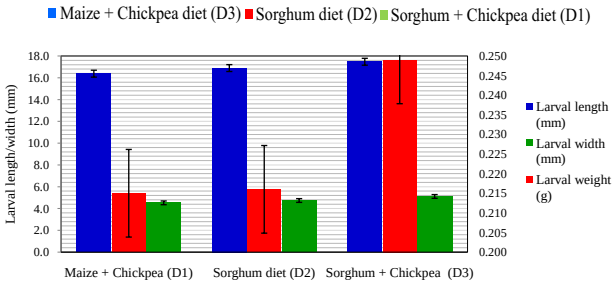

Fig. 4. Morphometrics of pupae of FAW on diets

days, respectively. These findings agree with those of Debora et al. (2017).

Adults male forewings are shaded with grey and brown, with triangular white patch at the apical region and circular spot at the center of the wing. The forewings of females have uniform greyish brown to a fine mottling of grey and brown. The hind wing is silver-white with a narrow dark border in both male and female. These characters are similar as reported earlier (Oliver and Chapin, 1981; Sharanabasappa et al., 2018b). Adult female reared on sorghum + chickpea diet (D1) showed maximum fecundity in comparison with those reared on sorghum (D2), and maize + chickpea diets (D3). The total lifecycle ranged from 31- 48 days, with maximum being with D3 diet (40-48 days) followed by sorghum (D2: 37-44 days) and least with sorghum + chickpea diet (D1: 31-39 days (Fig. 5). These findings corroborate with those of Sharanabasappa et al. (2018b) on maize as a host. There was no significant difference in the adult longevity of male and female in the diets (Fig. 6).

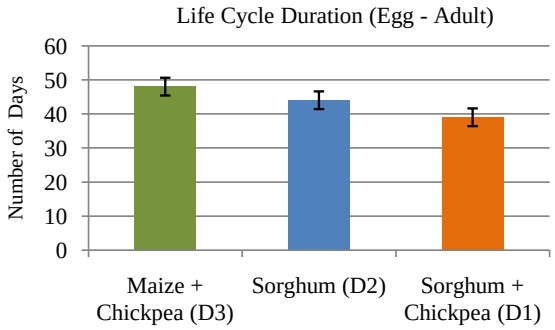

Fig. 5. Lifecycle of FAW on diets

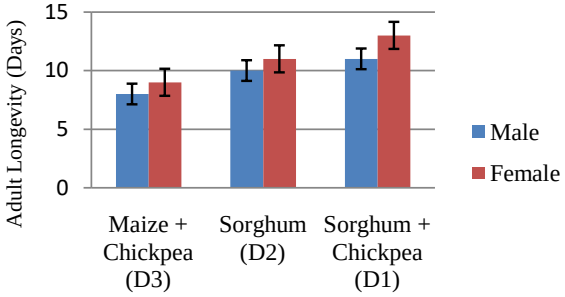

Fig. 6. Adult longevity of FAW on diets

Eggs were dorsoventrally flattened, pale green for a day and turned golden yellowish and ultimately turned to black before hatching. The female covered a layer of scales on the egg mass and this gave moldy appearance. Incubation period was 2.61 days, with number of eggs laid being maximum with sorghum + chickpea diet (D1: 984). The reared adult's fecundity was observed on the

under or upper surface of the paper liners in oviposition cage (Fig. 7).

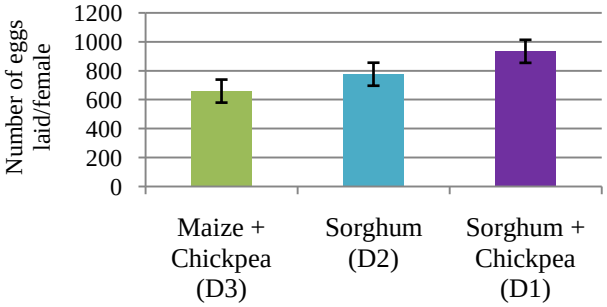

Fig. 7. Fecundity of FAW on diets

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