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Influence of different host plants on developmental biology and utilization indices of *Spodopterafrugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)

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Abstract
Developmental biology on *Spodopterafrugiperda*using eleven different host plants with maize as a control was studied under laboratory condition. The neonates were fed with hosts of grain sorghum, blackgram, greengram, cowpea, castor, amaranthus, papaya, fodder sorghum, bermuda grass, *Cyperus* and maize. The duration of larva, pupa and adult and mean larval and pupal were recorded. The lowest larva-adult duration was found in castor and sorghum and highest in Bermuda grass. The highest mean larval and mean pupal weight wasfound in castor and lower in pulses. The further study deals with the consumption, digestion and utilization indices of *S. frugiperda* larvae fed with five hosts. Though *S. frugiperda* is a polyphagous pest, it feeds on many host but in this study, it showed more preference for castor. This study reveals the adaptability and utilization ability of*S. Frugiperda* larvae on various hosts.

Keywords: developmental biology, *Spodoptera frugiperda,* food utilization indices

1. Introduction
*Spodopterafrugiperda*is a polyphagous pest and found in countries like eastern and central North America and South America [1, 2]. It has high migratory behaviour and reaches the Indian subcontinent during the middle of July 2018 in Shivamogga and then spread to the Indian states *viz.* Bihar, Chattisgarh, Gujarat, Maharashtra, Odisha, Tamil Nadu, Telangana and West Bengal [3, 4]. Two sympatric strains of*S. frugiperda*was found,which are morphologically identical and it could be distinguished using DNA barcodes[5].These two races of *S.frugiperda*namely a 'rice strain' (R strain) and a 'maize strain' (C strain). The 'R' strain preferentially feed on rice and various pasture grasses and the 'C' strain on maize, cotton and sorghum [6].
FAW has a wide host range and over 80 different crop species such as corn, rice, sorghum, peanut, alfalfa, cotton, sudan grass, soybean, tobacco, oat, wheat, sugar beet and pasture grasses such as bermuda grass andjohnson grass [2, 7] are considered as hosts of FAW. Horticultural crops like cabbage, tomato, potato and onion are also the hosts of FAW [8, 9, 10]. Finally, a document of 353 host plants belonging to 76 plant families, mainly concerned with the family Poaceae (106 taxa), followed by Asteraceae and Fabaceae (31 taxa each) [11].
In tropical region, this harmful pest threatens the annual crops [7, 12]. The availability of different hosts' in the tropical region leads to the selection of various feeds by FAW populations [13]. The exposure of this pest to different crops cause economic losses. The attack of FAW varies with different crop phenologies and the season of crop growth.
The biology of *S. frugiperda*varies based on the nutritional composition of different crops [13, 14]. A huge work has been carried out for the biological study of *S. frugiperda* [15, 16]. It has been reported that the variation in the development period of FAW on weeds, such as *Ipomoea* sp., or crops, such as rice, maize, and other grasses [17]. Therefore it is necessary to study the consumption and host preference of FAW regarding various host plants for better understanding of the survival and growth. The work has been carried out to study the developmental biology on eleven different hosts namely grain sorghum, blackgram, greengram, cowpea, castor, amaranthus, papaya, fodder sorghum, bermuda grass, *Cyperus*and maize as a control. Along with this study, consumption, digestion and utilization indices for the larvae of *S. frugiperda*fed on five hosts (maize, blackgram, castor, Bermuda grass and papaya) were studied.

2. Materials and Methods
2.1 Culturing of *S. frugiperda*
The egg masses collected from the infested field were placed in plastic cups (200ml capacity) along with pieces of fresh maize leaf and covered by nylon mesh. Upon hatching, the larvae were transferred to plastic buckets (7 L capacity) @ 25 larvae per bucket, covered by gada cloth and secured with elastic band. The culture was maintained at 25± 2 °C, 65 ± 5% RH and a photoperiod of 12:12h L:D.
Every day the larvae were fed with fresh maize shoots. From third instars, due to cannibalistic behavior, larvae were reared individually in multi-cavity trays of 24 cells. Until pupation, maize shoots/leaves were supplied twice a day. The larvae about to pupae were collected from the multi-cavity trays and placed in the plastic cups (200ml capacity) containing vermiculate.
After emergence, the adults were sexed and released in the oviposition cages @ 1:1 ratio. Five per cent honey solution in a cotton wicked vial was kept as food. After 24h, maize shoots kept in a conical flask containing water was placed in the cage. The egg masses collected from the oviposition cages were incubated for 24h and surface sterilized with sodium hypochlorite (0.05%)

2.2 Biology studies
Newly hatched instars from the laboratory culture were reared under the controlled conditions (25± 2 °C, 65 ± 5% RH and a photoperiod of 12:12h L: D) on various host plants as mentioned in the table below.

There were 11 treatments (10 hosts and maize as control) and three replications. Ten hosts were grain sorghum, castor, blackgram, greengram, cowpea, *Cyperus*,amaranthus, Bermuda grass, papaya and fodder sorghum. Each replicate contained 15 larvae and a total of 45 larvae per treatment. The hosts raised in the pot culture yard of the Department were collected and the leaves were cleaned using 0.1% sodium hypochlorite for 15 seconds, rinsed in distilled water and air dried. Further, the leaves were fed to the larvae and maintained upto adult emergence. The biological traits such as the larval duration (days), larval weight (final instar), per cent pupation, pupal weight (g) after 24h of pupation, pupal period (days), per cent adult emergence, adult longevity and sex ratio were recorded [18].

2.3 Nutritional indices of *S. frugiperda*

Theexperiment was carried under controlled condition (25± 2 °C, 65 ± 5% RH and a photoperiod of 12:12h L: D). Firstly, the larvae were maintained on five different hosts (maize, blackgram, castor, bermuda grass and papaya) upto third instar. After third instar, 25 larvae per host were separated and weighed (initial weight). The host leaves were weighed daily and provided as a feed. The remaining waste foods and feces were removed and stored separately. Finally, the larvae were weighed on reaching the final sixth instar. After dehydration, wasted food and feces should be weighed separately.

1. **Growth rate (GR)**

GR = Weight gained by larvae (mg)/Duration of feeding period (days)

Growth rate is expressed as mg/day.

2. **Consumptive rate (CR)**

CR = Weight of food eaten (mg)/Duration of feeding period (days)

3. **Assimilation efficiency (AE)**

AE= Weight of food ingested (mg) -Weight of faeces (mg) x 100/Weight of food ingested (mg)

4. **Efficiency of conversion of digested food (ECD)**

The ECD measures the efficiency of conversion of assimilated food to the insect biomass.

ECD = Weight gained by larvae (mg) x 100/Weight of food eaten (mg) - Weight of faeces (mg)

5. **Efficiency of conversion of ingested food (ECI)**

The ECI measures the overall efficiency of conversion of ingested food to insect biomass.

ECI = Weight gained by larvae (mg) x 100/Weight of food eaten by larvae (mg)

Statistical analysis

The data were transformed in order to meet the assumptions of the analysis of variance (ANOVA). Treatment means were compared using DMRT (P<0.05).

3. Results and Discussion

3.1 Developmental biology of *S. frugiperda*

Developmental biology of *S. frugiperda* was studied under controlled conditions on 11 host plants,amongthis maize as standard check (control). Larval duration was lengthier when reared on *Cyanadon dactylon* (22 days) and the lower (13 days) on hosts such as sorghum, *Cyperus* and castor. This extended duration in *Cyanodon* may be explained as a compensatory action that the larvae fed on low quality hosts. More than six instars were observed when released on *Cyperus* and this is coinciding with the findings of [19]. Normally, the larval development is based on the quality of food intake as suggested by [13]. In the control (maize) larval duration was 15 days which is contradicted with the assessment of [20] as he recorded the larval duration of 16.5 days for caterpillar fed on corn as he recorded the larval duration as a mean from several places. It was equivalent to green gram (14.67 days), black gram (15.3 days) and fodder sorghum (15 days). The larval duration on amaranthus, cowpea and papaya were 16, 18 and 20 days respectively.

The pupal duration fell between 9 and 14 days. The pupal stage was prolonged (13.67 days) in the larvae fed with castor and *Cyperus* and it was 13 days in papaya. The shorter pupal duration (9.67) was recorded on greengram. *Cyanodon*, Cowpea, amaranthus and fodder sorghum recorded the pupal duration of around 12 days. Maize, sorghum and blackgram recorded around 11 days as pupal period.Normally, the pupal duration of *S. frugiperda* was between 8-9 days[21]. But the pupal period was more than the recorded days in all the eleven hosts.

The fall armyworm larvae fed with *Cyperus* exhibited lengthier adult longevity of 13.33 days and shortest was found on papaya (8.67 days). As per [21], the adult longevity varies between 7 to 21 days and coincide with our findings.

Among the eleven host plants, the larvae fed with castor has gained maximum (137.04 mg) weight in the final instar and followed by *Cyperus* (121.23 mg). In sorghum and fodder sorghum, the larval weight (final instar) were 92.13 and 95.21 mg respectively. When fed with pulses, such as greengram, blackgram and cowpea, the final instar weighed about 76.61, 75.23 and 71.12 mg respectively. It is in accordance with the findings of [22, 23, 24], who reported FAW preferred C_4 plants (maize, sorghum, grasses) when compared with C_3 plants (legumes). The reason may be the nutritional balance (carbohydrates, proteins, sterols, etc) of the hosts as explained by [25]. The treatment with other host plants such as maize (control), amaranthus, bermuda grass and papaya recorded 89.27, 81.09, 80.25 and 73.19 mg of final instars respectively.

The pupal weight ranged from 0.250 to 0.141 mg when fed with eleven different host plants. The pupal weight crossed 0.2 mg in maize (0.241 mg), sorghum (0.250 mg), blackgram (0.201 mg) and castor (0.243 mg). The pupal weight was similar in the case of maize and sorghum but it is contradicted with the findings of [26], who reported lower pupal weights for insects fed on sorghum than those on corn. The lower pupal weights were observed in the culture reared on grasses such as *Cyanodon*(0.127mg) and *Cyperus* (0.141 mg). Pupal weight observed in the larvae fed with papaya and fodder sorghum was equal (0.163 mg) and in amaranthus it was 0.171 mg. The treatments with greengram and cowpea showed the pupal weight of 0.183 and 0.191 mg respectively (Table 1).

3.2 Nutritional indices of *S. frugiperda*

The larvae fed with bermuda grass shown the longer duration of 15.27 days from 3rd instar to final instar, followed by papaya (13.20 days). The lowest duration was observed in castor (9.12 days). The larvae were fed with maize and blackgram for 11.21 and 10.06 days respectively. The consumption of feed was higher in castor (905 mg) and lower in papaya (375 mg). In blackgram and grass, the food consumption was 502.37 and 698.18 mg respectively when compared with control (479.85 mg). The discharge of faeces was maximum in bermuda grass (292.08 mg) and minimum

in blackgram (141.20 mg). Faeces weight observed with the hosts, such as maize, castor and papaya were 146.21 mg, 225.70 mg and 197.52 mg respectively (Table 2).

Among the five hosts, castor shown the growth rate of 14.87 mg/day and the consumptive ratio was 99.24 mg/day. AE, ECD and ECI recorded in castor were 75.06%, 19.97% and 15.00% respectively. The growth rate observed in maize and blackgram were 7.86 and 7.25 mg/day. Around 5 mg/day was found as growth rate in Bermuda grass and papaya. The consumptive rates were 42.81, 49.94, 45.72 and 28.43 mg/day in maize, blackgram, Bermuda grass and papaya respectively. The efficiency recorded such as AE, ECD and ECI in control were 69.53, 26.40 and 18.36% respectively. Assimilation efficiency observed in blackgram, Bermuda grass and papaya were 71.89, 58.17 and 47.37%. Treatment on blackgram showed ECD of 20.60% and ECI of 14.81%. ECD on Bermuda grass and papaya were 19.59 and 39.63% respectively (Table 3).

The results on food consumption, digestion and utilization indices of *S. frugiperda* on maize, blackgram, castor, bermuda grass and papaya revealed that, Castor (Euphorbiaceae) has high growth rate and consumptive rate in compared with other grasses. It may be due to the nutritional composition of these plants from different botanical famailies as reported by [27]. The biochemical substance present in the hosts may have influence on the development of insects as highlighted by [28].

Table 1: Influence of hosts on Developmental duration of *S. frugiperda*

Treatment No	Host plants	Duration (days)			Mean larval weight (final instar in mg)	Mean pupal weight (mg)
		Larva	Pupa	Adult		
1	Maize	15.00 (3.872) ^{de}	11.67 (3.415) ^{bc}	11.33 (3.366) ^{bc}	89.27 (9.505) ^{g}	0.241 (1.114) ^{i}
2	Sorghum	13.00 (3.604) ^{e}	11.33 (3.366) ^{c}	9.67 (3.108) ^{d}	92.13 (9.647) ^{gh}	0.250 (1.118) ^{ijk}
3	Greengram	14.67 (3.826) ^{de}	9.67 (3.108) ^{d}	11.33 (3.366) ^{bc}	76.61 (8.822) ^{bcd}	0.183 (1.088) ^{f}
4	Blackgram	15.30 (3.914) ^{d}	11.33 (3.366) ^{c}	11.66 (3.366) ^{bc}	75.23 (8.749) ^{bcd}	0.201 (1.098) ^{h}
5	Cowpea	18.00 (4.242) ^{bc}	12.33 (3.509) ^{abc}	11.00 (3.314) ^{c}	71.12 (8.518) ^{a}	0.191 (1.091) ^{fg}
6	Castor	13.00 (3.604) ^{e}	13.67 (3.693) ^{a}	9.67 (3.108) ^{d}	137.01 (11.710) ^{k}	0.243 (1.115) ^{ij}
7	Papaya	20.00 (4.468) ^{ab}	13.00 (3.604) ^{ab}	8.67 (2.943) ^{d}	73.19 (8.614) ^{bc}	0.163 (1.079) ^{cd}
8	Amaranthus	16.00 (3.999) ^{cd}	12.33 (3.511) ^{abc}	11.66 (3.415) ^{bc}	81.09 (9.076) ^{ef}	0.171 (1.082) ^{cde}
9	Fodder sorghum	15.00 (3.867) ^{de}	12.00 (3.462) ^{bc}	11.00 (3.314) ^{c}	95.21 (9.822) ^{i}	0.163 (1.078) ^{c}
10	Bermuda grass	22.00 (4.687) ^{a}	12.67 (3.558) ^{abc}	12.67 (3.558) ^{ab}	80.25 (9.037) ^{de}	0.127 (1.061) ^{a}
11	*Cyperus*	13.00 (3.604) ^{e}	13.67 (3.693) ^{a}	13.33 (3.648) ^{a}	121.23 (11.053) ^{j}	0.141 (1.068) ^{b}
	C.D	0.293	0.228	0.199	0.212	0.004

Table 2: Influence of different hosts on food intake of *S. frugiperda*

Treatment	Initial weight of 3rd instar larvae (mg)	Final weight of the final instar larvae (mg)	Food consumed (mg)	Faeces weight (mg)	Feeding time (days)
Maize	1.18 (1.475) ^{d}	89.27 (9.501) ^{d}	479.85 (21.928) ^{b}	146.21 (12.133) ^{b}	11.21 (3.494) ^{c}
Blackgram	0.83 (1.353) ^{c}	75.23 (8.731) ^{b}	502.37 (22.436) ^{c}	141.20 (11.925) ^{a}	10.06 (3.326) ^{b}
Castor	1.31 (1.520) ^{e}	137.01 (11.748) ^{e}	905.10 (30.102) ^{e}	225.70 (15.057) ^{d}	9.12 (3.181) ^{a}
Bermuda grass	0.70 (1.306) ^{ab}	80.25 (9.014) ^{c}	698.18 (26.442) ^{d}	292.08 (17.119) ^{e}	15.27 (4.034) ^{e}
Papaya	0.67 (1.292) ^{a}	71.12 (8.493) ^{a}	375.28 (19.398) ^{a}	197.52 (14.090) ^{c}	13.20 (3.765) ^{d}
CD Value	0.014	0.003	0.001	0.002	0.011

Table 3: Consumption, digestion and utilization indices for the larvae of *S. frugiperda*on various hosts

Treatment	Growth Rate (GR) (mg/day)	Consumptive Rate (CR) (mg/day)	Assimilation Efficiency (AE) (%)	Efficiency of conversion of digested food (ECD) (%)	Efficiency of conversion of ingested food (ECI) (%)
Maize	7.86	42.81	69.53	26.40	18.36
Blackgram	7.25	49.94	71.89	20.60	14.81
Castor	14.87	99.24	75.06	19.97	15.00
Bermuda grass	5.21	45.72	58.17	19.59	11.39
Papaya	5.34	28.43	47.37	39.63	18.77

4. Conclusion

The influence of eleven host plants on the development of FAW was identified. The larval and pupal duration was longer in *Cyanodon* and shorter in castor and sorghum. The larval and pupal weight were also maximum in castor as compared with pulses.In Castor, growth rate and consumptive rate also high. The efficiency in conversion of ingested and digested was maximum in papaya as compared with castor. However, it is concluded that among the host plants used for feeding *S. frugiperda* larvae, castor has high influence for the development of FAW.

References

1. Luginbill P. The fall armyworm. U.S. Department of Agricultural. Technical Bulletin, 1928; 34:1-91.
2. Sparks AN. A review of the biology of the fall armyworm. The Florida Entomologist, 1979; 62:82-87.
3. ICAR-NBAIR. *Spodoptera frugiperda* (J. E. Smith). Insects in Indian Agrosystems. ICAR-National Bureau of Agricultural Insect Resources (NBAIR), India, 2018. http://www.nbair.res.in/insectpests/Spodoptera_frugiperda.php. 4 Jan, 2020.
4. EPPO. *Spodoptera frugiperda* continues to spread in

Asia. In: EPPO Reporting Service, (No. 2019/053). Paris, France: EPPO, 2019. https://gd.eppo.int/reporting /article-6483. 4 Jan, 2020.
5. Nagoshi RN, Goergen G, Tounou KA, Agboka K, Koffi D, Meagher RL, *et al*. Analysis of strain distribution, migratory potential, and invasion history of fall armyworm populations in northern Sub-Saharan Africa. Science Reports. 2018; 8(1):3710.
6. Pashley DP, Johnson SJ, Sparks AN. Genetic population structure of migratory moths: the fall armyworm (Lepidoptera: Noctuidae). Annals of the Entomological Society of America, 1985; 78:756-762.
7. Andrews KL. The whorlworm, *Spodoptera frugiperda*, in Central America and neighboring areas. Florida Entomologist, 1980; 63:456-467.
8. Day R, Abrahams P, Bateman M, Beale T, Clottey V, Cock M, *et al*. Fall armyworm: impacts and implications for Africa. Outlooks Pest management, 2017; 28:196-201.
9. Chapman JW, Williams T, Martinez AM, Cisneros J, Caballero P, Cave RD, Goulson D, *et al*. Does cannibalism in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) reduce the risk of predation. Behavioural Ecology and Sociobiology. 2000; 48(4):321-327.
10. CABI. Datasheet. *Spodoptera frugiperda* (fall army worm). Invasive Species Compendium, 2016. http:// www.cabi.orglisc/datasheet129810. 11 Dec, 2019.
11. Montezano DG, Specht A, Sosa-Gomez DR, Roque-Specht VF, Sousa-Silva JC, Paula-Moraes SV, *et al*. Host Plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. African Entomology, 2018; 26:286-300.
12. Cruz I, Figueiredo MLC, Oliveira AC, Vasconcelos CA. Damage of *Spodoptera frugiperda* (Smith) in different maize genotypes cultivated in soil under three levels of aluminium saturation. International Journal of Pest Management, 1999; 45:293- 296.
13. Barros Lepidoptera: Noctuidae) fed on different EM, Torres JB, Bueno AF. Oviposition, development, and reproduction of *Spodoptera frugiperda* (JE Smith) (hosts of economic importance. Neotropical Entomology. 2010; 39(6):996-1001.
14. Scriber JM, Slansky JRF. The nutritional ecology of immature insects. Annual Review of Entomology, 1981; 26:183-211.
15. Ball OJP, Coudron TA, Tappe BA, Davies E, Trently D, Bush LP, *et al*. Importance of host plant species, neotyphodium, endophyte isolate, and alkaloids on feeding by *Spodoptera frugiperda* (Lepidoptera: Noctuidae) larvae. Journal of Economic Entomology, 2006; 99:1462-1473.
16. Storer NP, Babcock JM, Schlenz M, Meade T, Thompson GD, Bing JW, *et al*. Discovery and characterization of field resistance to *bt*maize: *Spodoptera frugiperda*(Lepidoptera: Noctuidae) in Puerto Rico. Journal of Economic Entomology, 2010; 103:1031-1038.
17. Nabity PD, Zangerl AR, Berenbaum MR, Delucia EH. Bioenergy crops *Miscanthus*× *giganteus* and *Panicum virgatum* reduce growth and survivorship of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Journal of Economic Entomology, 2011; 104:459-464.
18. Debora MDS, Adeney DFB, Karine A, Cristiane DSS, Pedro MOJN, Maria CNDO, *et al*. Biology and nutrition of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on different food sources. Scientia Agricola. 2015; 74(1):18-31.
19. Pencoe NL, Martin PB. Development and reproduction of fall armyworms on several wild grasses. Environmental Entomology, 1981; 10:999-1002.
20. Giollo FP, Grutzmacher AD, Garcia MS, Busato GR. Biological parameters of *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) from different locations and hosts. RevistaBrasileira de Agrociencia, 2002; 8:221-224.
21. Capinera JL. Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) (Insecta: Lepidoptera: Noctuidae). EENY-098, University of Florida IFAS Extension, 1999, 6 pp. http://edis.ifas.ufl.edu/IN255. 1 Jan, 2020.
22. Buntin GD. A review of plant response to fall armyworm, *Spodoptera frugiperda* (J.E. Smith), injury in selected field and forage crops. Florida Entomologist, 1986; 69:549-559.
23. Lewter JA, Szalanski AL, Nagoshi RN, Meagher RL, Owens CB, Luttrellm RG, *et al*. Genetic variation within and between strains of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Florida Entomologist, 2006; 89:63-68.
24. Nagoshi RN, Adam JJ, Meagher J, Gore RL, Jackson R. Using stable isotope analysis to examine fall armyworm (Lepidoptera: Noctuidae) host strains in a cotton habitat. Journal of Economic Entomology, 2007; 100:1569-1576.
25. Behmer ST. Insect herbivore nutrient regulation. Annual Review of Entomology, 2009; 54:165-187.
26. Piedra F. Effect of different forage diets on the biology of *Spodoptera frugiperda.* Cuban Journal of Agricultural Science, 1974; 8:99-103.
27. Pashley DP. Current status of fall armyworm host strains. Florida Entomologist, 1988; 71:227-234.
28. Fischer DC, Kogan M, Paxton J. Effect of glyceollin, a soybean phytoalexin, on feeding by three phytophagous beetles (Coleoptera: Coccinellidae and Chrysomelidae): dose versus response. Environmental Entomology, 1990; 5:1278-1282.