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Artificial Diets and Rearing Techniques of *Spodoptera frugiperda* (J.E. Smith)

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SUMMARY

Spodoptera frugiperda (J.E. Smith) (Lepidoptera, Noctuidae), a polyphagous pest that attacks over 350 plant species. In 2018, *S. frugiperda* was reported from the Indian subcontinent in Karnataka and Andhra Pradesh. The pest has also been reported in Bihar Chhattisgarh, Gujarat, Maharashtra, Odisha, Tamil Nadu, Telangana and West Bengal in other parts of India. Formulation of artificial diet is very essential to study the biology, behaviour, physiology, and bioassay. These studies are very helpful in management of this polyphagous pest.

INTRODUCTION

Spodoptera frugiperda (J.E. Smith) (Lepidoptera, Noctuidae), a polyphagous pest that attacks over 350 plant species. Because of its high mobility, migratory ability, and wide host range, it can cause considerable economic losses to many important staple crops including corn, rice, sorghum, millet, sugarcane, vegetable crops, and cotton. *S. frugiperda* is native to tropical and subtropical regions of the Americas. In 2016 it was reported for the first time from the African continent, in Nigeria, Sao Tomé, Benin and Togo.In 2018, *S. frugiperda* was reported from the Indian subcontinent (Sharanabasappa Kalleshwaraswamy *et al*., 2018), in Karnataka (ICAR-NBAIR, 2018a) and Andhra Pradesh (EPPO, 2018). The pest has also been reported in Bihar Chhattisgarh, Gujarat, Maharashtra, Odisha, Tamil Nadu, Telangana and West Bengal (ICAR-NBAIR, 2018).The fall armyworm is likely to remain an important pest in Asia for the foreseeable future, given its high migration and reproductive capacity, lack of diapause, and wide plant host range (Pair *et al*. 1986, Johnson 1987). It is necessary to formulate and formalise a suitable artificial diet for the fall armyworm in order to conduct research on the biology, behaviour, physiology, toxicology, and mass rearing of natural enemies of the fall armyworm.

Artificial diets are used for rearing *Spodopterafrugiperda*

The synthetic insect diet is made up of a variety of nutrients such as carbohydrates, proteins, fat, minerals, and vitamins. Each plays a specific role in the insect's development and has an impact on the constituted diet's safe shelf life. Several synthetic diets have been optimized by various institutions, including International Centre for Wheat and Maize Improvement Centre (CIMMYT), International Institute of Tropical Agriculture (IITA), International Centre of Insect Physiology and Ecology (ICIPE), and the Agricultural Research Council (ARC)-South Africa, based on local availability of ingredients.

Table: 1 Composition of the artificial diets for *Spodoptera frugiperda*

S.No	Ingredients	CIMMYT Quantity g or ml per 3 L diet	ICIPE Quantity g or ml per 3 L diet	ARC-RSA Quantity g or ml per 3 L diet
Fraction A				
1.	Maize leaf powder	75.6 g	75.0 g	-
2.	Common bean powder	265.2 g	187.5 g	-
3.	Chickpea	-	-	250 g
4.	Wheat germ	-	150.0 g	225 g
5.	Brewer's yeast	68.1 g	-	45 g
6.	Torula yeast	-	32 g	-
7.	Milk powder	-	57 g	45 g
8.	Ascorbic acid	7.5 g	9 g	-
9.	Sorbic acid	3.9 g	4.5 g	-

10.	Methyl-p hydroxybenzoate	6.0 g	7.5 g	-
11.	Vitamin E capsules	6.3 g	-	-
12.	Multivitamin drops	-	3.0 ml	-
13.	Sucrose	105.9 g	-	-
14.	Distilled water	1,209.3 ml	1350 ml	1500 ml
Fraction B				
1.	Agar (Tech No.3)	37.8 g	34.5 g	50 g
2.	Distilled water	1,209.3 ml	1200 ml	1000 ml
3.	Sorbic acid	-	-	7.5 g
Fraction C				
1.	Formaldehyde 40%	6.0 ml	6.0 ml	1.0 ml
2.	Suprapen p (Tetracycline)	-	7.5 g	-
3.	Nipagen	-	-	3 g
4.	Ether	-	-	75 L

CIMMYT Diet

Fraction A: Mix all the powdered ingredients in a clean container under a fume hood, except the methyl-p-hydroxybenzoate from Fraction A. Boil the distilled water, cool it to 60°C, and then mix with the pre-mixed ingredients using a blender for 1 minute. Add methyl-p-hydroxybenzoate (dissolved in 20ml of absolute ethanol) to the mixture in the blender, and then blend for a further 2 minutes.

Fraction B: Weigh agar powder in a separate container and then add to cold distilled water in a separate saucepan. Boil while stirring periodically, and then cool to 60°C. Add the ingredients of Fraction B to Fraction A and blend for 3 minutes.

Fraction C: Finally, add 40% formaldehyde to the ingredients of Fractions A and B in the blender and then mix for 3 minutes at room temperature.

ICIPE diet

As directed for the CIMMYT diet, prepare Fractions A-C, using the ingredients and quantities listed for the ICIPE diet (Table 1).

ARC-RSA diet

Fraction A: Mix all dry ingredients in Fraction A well with 1,500ml distilled water in a container.

Fraction B: Boil 1,000ml distilled water, add 7.5g sorbic acid, and stir periodically until the sorbic acid is dissolved. In a separate container, add agar to 1000ml water and mix well. Add agar mix to sorbic acid mix. Boil for 10 minutes. Let Fraction B cool down to 70°C, then add it to Fraction A and mix well with a blender.

Fraction C: Add formaldehyde (40%) to the mix of Fraction A and B. Dissolve Nipagen (3g) in 75ml ether. Add to the mix of Fraction A and B. Dispense an appropriate volume of the diet into plastic trays, jars, or vials.

Table: 2 Composition of the artificial diets for *Spodoptera frugiperda*(Pinto *et al* 2019)

S.No	Ingredient	Quantity		
		D1	D2	D3
1.	Bean	240 g	240 g	-
2.	Green Corn	-	-	60 g
3.	Wheat germ	120 g		120 g
4.	Corn Flour		240 g	
5.	Brewer's Yeast	72 g	72 g	72 g
6.	Ascorbic acid	7.3 g	7.3 g	7.3 g

7.	Sorbic acid	2.4 g	2.4 g	2.4 g
8.	Methylparahydroxy benzoate (Nipagin)	4.4 g	4.4 g	4.4 g
9.	Vitamin solution	10.0 ml	10.0 ml	10.0 ml
10.	Formaldehyde (40%)	6.0 ml	6.0 ml	6.0 ml
11.	Agar	20.0 g	20.0 g	20.0 g
12.	Distilled water	1.0 ml	1.0 ml	1.0 ml

Table 3:Composition of the vitamin solution used for artificial diets

S.No	Component	Amount
1	Niacinamide	4 mg
2	Calcium pantothenate	4 mg
3	Thiamine HCl	1 mg
4	Riboflavin	2 mg
5	Pyridoxine HCl	1 mg
6	Folic acid	1 mg
7	Biotin	0.08 mg
8	Vitamin B12	0.008 mg
9	Distilled Water	400 ml

Table 4 : Composition of artificial diets for *Spodoptera frugiferda* (Lekha *et al* 2019)

Constituent	D1	D2	D3	D4	D5
Cowpea flour	100g				
Chickpea flour		100g			
Black gram flour			100g		
Green gram flour				100g	
Soybean flour					100g
Yeast extract	10.0g	10.0g	10.0g	10.0g	10.0g
Methyl-p-hydroxybenzoate	2.0g	2.0g	2.0g	2.0g	2.0g
Sorbic acid	1.0g	1.0g	1.0g	1.0g	1.0g
Ascorbic acid	3.6g	3.6g	3.6g	3.6g	3.6g
Multivitamin's solution	7.0ml	7.0ml	7.0ml	7.0ml	7.0ml
Formaldehyde	5.0ml				
Agar	12.0g	12.0g	12.0g	12.0g	12.0g
Distilled water	800.0ml	800.0ml	800.0ml	800.0ml	800.0ml

Procedure for mass multiplication of Spodoptera frugiperda

Materials required

- Culture trays
- Artificial diet, vitamin solution, honey
- Plastic culture vials,bowls
- Petriplates
- Plastic jars, plastic cups
- Camel hair brush, blunt forceps
- Distilled water
- Measuring cylinder
- Filter paper
- 70% alcohol for sterilization

- Beaker

Collection of Fall army worm culture from the field: -

- Host plants infested with fall army worm were collected
- In laboratory, caterpillars were picked from infested leaves and stem of the plants. The larvae should be healthy free from any diseases

Rearing techniques (Parra *et al* 2013): -

- After collection from the field larvae are reared individually on the artificial diet (24 ± 1°C, 70% RH, 14L:10D photoperiod)
- Larvae moulted to pupae, the pupae are collected and placed in PVC cages, until adult emergence
- Egg patches deposited by these adults were inserted in glass tubes
- hatched caterpillars were transferred to disposable plastic cups which containing artificial diets
- When larvae entered into the second-instar i.e., 4–5-day-old forty caterpillars were introduced in rectangular containers filled with 200 mL of the artificial diet

MALE INSECT

FEMALE INSECT

(Fig: Lyle J. Buss, University of Florida)

Precaution: -In order to maintain the quality of laboratory reared insects, avoid microbial contamination and minimize health hazards to workers some safety measures should be followed, such as use a well ventilated fume hood for diet preparation to prevent exposure to toxic fumes, workers should wear laboratory coat, hand gloves and face mask.

CONCLUSION

Artificial diet for the fall armyworm is very essential in order to conduct research on the biology, behaviour, physiology, toxicology, and mass rearing of natural enemies of the fall armyworm. Because of the fall armyworm's polyphagous nature or its ability to feed on a variety of plant species, a variety of artificial diets have been developed for their indoor rearing.

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