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Population dynamics of spotted stem borer, *Chilo partellus* (Swinhoe) and its interaction with natural enemies in sorghum

K. Divya¹, K.N. Marulasiddesha², K. Krupanidhi¹and M. Sankar³ ¹*T-John College of Pharmacy, Kammanahalli, Bangalore, KA, India* ²*College of Agriculture, University of Agricultural Science, Dharwad, KA, India* ³*University of Agriculture Science, GKVK Campus, Bangalore, KA, India*. kdivya49@gmail.com, siddesh2575@gmail.com, shankarms10@gmail.com, krupanidhi_k@rediffmail.com

Abstract

Sorghum stem borer, *Chilo partellus* Swinhoe is one of the serious pests of sorghum and maize crops in Asia and throughout East and South Africa. In India, it is becoming as the most damaging insect pest particularly in Dharwad region of north Karnataka by causing economic losses during *kharif* and *rabi* seasons. The observations on population dynamics of egg masses, larvae, pupae, number of plant damaged and parasitic interactions of natural enemies with larvae and pupae of *C. partellus* were recorded at weekly interval at Dharwad (Karnataka). The stem borer population was significantly higher in *kharif* than in *rabi*-summer crop. The larval parasitoid, *Cotesia flavipes* was found to be very active in *kharif* season and maximum parasitization of 29% was recorded in November whereas *Sturmiopsis inferens* was prevalent during *rabi*-summer crop and maximum parasitization of 28% was recorded during February. A population of 2% pupal parasitoid, *Tetrastichus* sp., was also recorded during *kharif* season.

Keywords: Biological control, Chilo partellus, population dynamics, stem borer.

Introduction

Sweet sorghum, *Sorghum bicolor* (L.) Moench is grown in the rainy as well as post rainy seasons, generally by resource poor farmers in the semi-arid regions of the world particularly Asia, East and South Africa. Sorghum is the staple food crop in Dharwad region of north Karnataka districts in India. It is grown in the rainy (July-Oct), late rainy (Aug-Dec) and post rainy seasons. Sorghum crop is being attacked by nearly 150 insect species causing an annual loss of over \$1 billion in the Semi Arid Tropics (ICRISAT, 1992) and the most damaging species are *Chilo partellus*, *Busseola fusa* and *Eldana saccharina* (Songa *et al.*, 2001). De Groote *et al.* (2003) found that all stem borer species caused average annual losses of 13.5%, valued at US\$ 80 million.

In India, a number of stem borer species have been reported as serious pests of sorghum crop of which spotted stem borer, Chilo partellus (Swinhoe) (Lepidoptera: Pyralidae) is important (Jotwani et al., 1971). Durden (1953) from Kongwa recorded more than 35% infestation of C. partellus on sorghum and maize and also observed that the peak population of pests appears during middle of June. In Maharashtra, number of stem borer larvae were found to be high in winter sorghum than in *kharif* sorghum but the average number of pupae, percentage of stem tunneling and inter nodes attacked were highest only in rainy (kharif) season (Anonymous, 1987). Singh and Sharma (1984) observed 4-45% infestation of C. partellus in sorghum and maize and maximum infestation was observed during August, which declined gradually in Sep. and Oct. Mohan et al. (1990) recorded the highest seasonal incidence of *C.* partellus on variety HC-136 and JS-20 during rabisummer and kharif and larvae and pupae populations was found to be high during kharif season crop than in rabisummer. And the mean larval population varied from 10 to 32 per sq. on JS-20 and 15 to 36 per sq. on HC-136 and they also observed the peak population of the pest from 3^{rd} week of August to 2^{nd} week of Sep. During the off-season, when there are no cultivated crops in the field, in addition to the hibernating or diapausing populations in crop residues stem borers remain present on wild host plants and can infest the cereal crops.

There is no permanent solution to control this pest except chemical control. However, biocontrol agents such as, parasitoids, predators and pathogens suppressed the population outgrowth of C. partellus but their activity was not enough to reduce the pest populations below the economic damage level. Mote (1988) correlated the degree of damage by stem borer with grain yield. According to him, percent plants infested by C. partellus at harvest were 9, 5 and 9 in rabi cultivars CSH-8R, SPV-86 and M-35-1, respectively. Further he reported that there was a significant negative correlation between percent stems tunneling by larvae of C. partellus and grain yield. Now, there are reports of tremendous success by utilizing biological control methods in agricultural ecosystem (Parrella et al., 1999). During our study we have identified three indigenous endoparasitoids such as, Cotesia flavipes, Sturmiopsis inferens and Tetrastichus sp., which were found attacking the larvae and pupae of C. partellus in Kharif and rabi-summer seasons crops at

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Dharwad region of north Karnataka, India. These parasitoids are probably more habitat specific with regard to foraging for hosts than they are host-specific as they appear to have moved from their indigenous hosts to use C. partellus as a new alternative host. Devi and Raj (1996) reported 35 to 50% parasitization by Apanteles sp. on larvae of C. partellus during the second week of October in sorohum in Himachal Pradesh. The parasitic effects of larval parasitoid, S. inferens and C. flavipes on larvae of C. partellus were reported by several authors (Usman & Puttarudriah, 1955; Sharma et al., 1966; Krishnamurthy & Usman, 1954). Barpete & Shinde (1991) studied the seasonal occurrence of Apanteles flavipes on C. partellus larvae in Madhya Pradesh and observed their population from July to Nov with a peak activity during the first half of Oct in 1989 and Aug to Nov, 1990 and reported 1 to 9% parasitism during the two years. Later, Mohan et al. (1990) reported 2-33% parasitization of C. partellus larvae by A. flavipes followed by Bracon chinensis (0.2-4%) and Stenobracon sp. (0.2-4%) at Hissar and these parasitoids remained active during 3rd week of Aug to 1st week of Sep. Keeping the above problems and prospects in view, the present investigations was undertaken to study the population dynamics of C. partellus and its interaction with natural enemies in sorghum ecosystem at Dharwad region in kharif and rabi-summer seasons in the year 2005-06.

Materials and methods

The field and laboratory experiments were conducted on C. partellus, with reference to its population dynamics and interaction with their natural enemies on sweet sorghum during 2005-06 in black soil at main Research Station, Dharwad (situated at 15° 20' N latitude and 75° 07' longitude and at an altitude of 678 m above the mean sea level) Karnataka, India. The sorghum variety SSV-74 was sown in the last week of July (31st standard week) and in October (45th standard week) covering an area of 0.1 ha. The observations on population dynamics of egg masses, larvae, pupae and number of plant damaged were recorded at weekly interval. The parasitic interactions with larvae and pupae of C. partellus were recorded at weekly interval and observations were taken from one week after sowing (32nd standard week) and continued upto last week of March (13th standard week). To study the population of natural enemies from larvae and pupae, the stem borer infested sweet sorghum plants were collected from the sorghum cultivated field two times during 1st week of October (40th standard week) and 2nd week of Jan (2nd standard week) and then the larvae and pupae were carefully isolated. The collected larvae were then reared in artificial diet as described by Shorey & Hale (1965). Each larva was released in artificial diet (25 g) contain separate plastic vial (2.0 cm dia. and 7.5 cm length) and the vials were loosely closed with cotton plug and kept at $28 \pm 2^{\circ}$ C. The parasitoids thus emerged from field collected larvae and pupae were preserved and identification services



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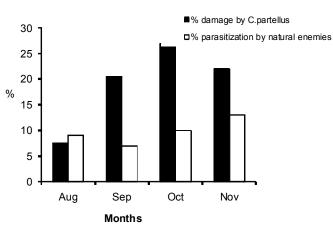
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were availed at Project Directorate of Biological Control (PDBC), Bangalore, India. Data were analysed and subjected to ANOVA or factorial analysis of variance (FANOVA) and statistical significance was judged at the level (P < 0.05).

Results

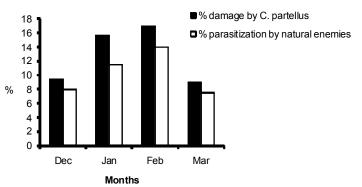
Population dynamics of sorohum stem borer

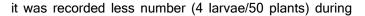
Fig 1. Percent damages caused on sweet sorghum due to C. partellus incidence and their parasitic interaction during kharif season



Three indigenous natural enemies' viz., C. flavipes, S. inferens and Tetrastichus sp. were observed in parasitized larvae and pupae of sorghum stem borer. Maximum number of egg masses was recorded on 37th standard week (7 egg masses/50 plants) which was followed by 36th standard week (5 egg masses/50 plants). Egg masses were not observed during 32nd, 45th and 47th standard week. Whereas, in rabi-summer the highest number of egg masses was collected in 50th standard week followed by 49th standard week ((4 egg masses/50 plants). However egg masses were not seen during 7th, 8th, 10th, 11th, 12th, and 13th standard weeks (Table 1 & 2). During kharif season, more number of larvae (30 larvae/50 plants) was noticed during 40th standard week followed by 39th standard week (26 larvae/50 plants) and

Fig 2. Percent damages caused on sweet sorghum due to C. partellus incidence and their parasitic interaction during rabi-summer season







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with 44th standard week. Whereas the parasitization by

pupal parasitoid, Tetrastichus sp. was observed 7% and

6% during 43rd and 45th standard week in *kharif* whereas,

in rabi-summer season crop no pupal parasitoids was

observed (Table 1). The result of our study revealed that

C. partellus population was significantly high in kharif

season than in rabi-summer season crops. Infestation

and percent damage caused by stem borers were

significantly high compared with the parasitic effect of

natural enemies in kharif than in rabi-summer season. It

may be attributed that the low temperatures are more

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 32^{nd} standard week. However larval population was more (19 larvae/50 plants) in 3^{rd} and 9^{th} standard week followed by 8^{th} standard week (17 larvae/50 plants) and was less (4 larvae/50 plants) during 49^{th} standard week during *rabi*-summer season. Maximum number of pupae (19 pupa/50 plants) were recorded during 44^{th} standard week followed by 47^{th} standard week (18 larvae/50 plants) while no pupae was collected from 32^{nd} to 35^{th} standard week during *kharif* season. Whereas, in *rabi*-summer season pupal population was observed less in number (11 pupa/plants) were collected during 9^{th} and 10^{th} standard week while no pupa were collected from 49^{th} to 52^{nd} standard week (Table 1 & 2).

Percent damage

Maximum number of plants (38%) was infested during 40th standard week followed by 39th standard week (32%)

during kharif season. However in rabi-summer it was 20% (3rd and 8th standard week) followed by 18% (9th standard week) and 4% (32nd standard week) (Table 1&2). The peak infestation (27%) was observed during October while, it was minimum (7.5%) during August (Table 1) in *kharif* season. However, in rabi-summer crop mean monthly percent incident of the pest was maximum (17%) during *kharif* while, it was minimum (9%) during March in rabi-summer (Table 2).

Natural enemies of stem borer

During the study we have observed three indigenous endoparasitoids such as, two larval parasitoids, viz. Cotesia flavipes (Cameron) (Braconidae: Hymenoptera) and Sturmiopsis inferens (Townsend) (Tachinidae: Diptera) and one from pupae Tetrastichus sp. Eulophidae: Hymenoptera) during kharif and rabi-summer seasons crop.

Larval parasitoid, *C. flavipes* was more active (35%) parasitization) during 45^{th} standard week followed by 44^{th} standard week (33%) while no activity was noticed from 32^{nd} to 34^{th} standard

weeks during *kharif.* However, in *rabi*-summer the maximum parasitic activity (32%) was noticed only in 50th standard week. Significantly, highest parasitization (37%) was recorded by the larval parasitoid, *S. inferens* on *C. partellus* larvae during 6th standard week followed by 3rd standard week (32%) in *rabi*-summer crop. But in *kharif* season crop the maximum 35% parasitization was recorded in 45th standard week which was on par (33%)

:(ollected from	n 49 th to	suitable for st	em bor	er infest	ations ar	nd it leads t	o higher	
			damage on	crop t	han pa	rasitic ir	iteraction (Fig. 1).	
			Whereas, in r						
) was infested during			infestation/ damage and the parasitic effects were on par,						
t	tandard week (32%)		it leads to low percentage of crop damage. Hence, the						
	Table 1. Population dynamics of Chilo partellus and its natural enemies in sweet sorghum								
	ecosystem during kharif.								
							% parasitiz	zation of	

		<i>ecosysie</i>		ig nitarii.		% parasitization of			
	Standard	No. Of	No.	No. of		%	natural enemies		
Date of observation	week	egg masses			damage	Cf	Si	<i>Tetra-</i> <i>stichus</i> sp.	
9-8-2005	32	0	4	0	2	4	0	0	0
16-8-2005	33	3	5	0	3	6	0	0	0
23-8-2005	34	2	8	0	5	10	0	0	0
30-8-2005	35	3	9	0	5	10	11.0	0	0
Mean		0.04	0.13	0.00		7.58	2.78	0	0
6-9-2005	36	5	12	0	7	14	16.7	0	0
13-9-2005	37	7	15	2	8	16	13.3	0	0
20-9-2005	38	3	17	3	10	20	23.5	0	0
27-9-2005	39	2	26	4	16	32	31.0	0	0
Mean		0.09	0.35	0.05		20.5	21.08	0	0
4-10-2005	40	3	30	7	19	38	26.7	0	0
11-10-2005	41	2	17	9	13	26	23.5	0	0
18-10-2005	42	3	16	13	12	24	25.0	0	0
25-10-2005	43	2	14	15	10	20	21.4	0	0
Mean		0.05	0.39	0.22		27.00	24.16	0	1.7
1-11-2005	44	1	15	19	9	18	33.3	0	0
8-11-2005	45	0	17	16	11	22	35.3	12.5	6.3
15-11-2005	46	1	10	17	10	20	30.0	0	0
22-11-2005	47	0	13	18	12	24	23.1	16.7	0
29-11-2005	48	1	9	6	13	26	22.2	0	0
Mean		0.01	0.26	0.3		22	28.8	5.9	1.3

Cf-Cotesia flavipes; Sf-Sturmiopsis inferens

parasitic interactions become more in summer crop than in winter season crop and keep the pest infestations under control (Fig. 2).

Discussion

Studies on population dynamics of stem borer indicated that the population of egg masses was more in September and Jan (0.1 egg/plant) coinciding with growth of *kharif* and *rabi*-seasons' sorghum, respectively. The larval populations are more during Oct (0.4 larvae/plant)



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during kharif season whereas, in rabisummer it was in Feb (0.3 larvae/plant). However, the larval population was more (8 %) during *kharif* than the *rabi*-summer which is in close agreement with the report of Mohan et al. (1990). Mahadevan & Chellaiah (1986) studied the population dynamics of C. partellus using light trap at Coimbatore (Tamil Nadu) and high incidence was reported in January compared to other months, especially at new moon that at the other lunar phases, and the damage was recorded more on crop sown in June or Oct. Further they reported that the maximum number of female adults was recorded than male throughout the year, it could be the reason that female insects are more attracted by light trap than male insect. A report from Maharashtra indicated that the larval population was more in winter sorghum than in rainy season sorghum, this might be due to weather condition and also the cropping pattern in that area (Annon., 1987). Further they have reported that the percentage of stem tunneling and internodes due to pupa were high (21 pupae/50 plants) only in rainy season crop. Above results were in close agreements with our records showing that the pupal population of C. partellus was higher in Nov (0.3 pupa/plant) during kharif (rainy

season) whereas, in rabi-summer (during March), it was less (0.2 pupa/plant) (Table 1 & 2). The results of our study revealed that the Chilo partellus incidence was more in Oct and Nov compared to Jan and Feb. Trehan & Butani (1947) reported maximum damage caused by C. In partellus was more (7.5 to 27%) in kharif season than in rabi-summer crop (9 to 17%). Duale (1999) reported that the percent incidence and distribution of stem borer varied in between the states.

In Maharashtra, the highest incidence (40%) of C. partellus was recorded in Amravati district followed by Yavatmal (39%) in kharif season whereas, in Andhra Pradesh, it was less in Medak (31%), followed by Mahbubnagar (30%). Further, Singh and Sharma (1984) observed that the incidence of C. partellus on sweet sorghum crop in Lucknow region ranged from 38 to 63% while it was somewhat low (7.5 to 27%) at Dharwad. The higher Getu et al. (2003) reported high percentage of parasitism of stem borers by C. flavipes in eastern Ethiopia than other surveyed regions, and the parasitism was significantly high. In India, Sharma et al. (1966) and Rao & Ali (1977) have also been recorded maximum C. flavipes parasitization on larvae of C. partellus during Kharif. Kishore (1986) recorded 21% parasitization of C. partellus larvae by C. flavipes which is in close

Table 2. Population dynamics of Chilo partellus and its natural enemies in sweet
sorghum ecosystem during rabi - summer season.

	sorgnur	n ecosysi	<u>em auril</u>	ng rabi -	- summer	season.		
Date of observation	standard week	No. of egg masses	No. of larvae	No. of pupae	No. of plant infested	% damage	% Parasiti- zation of natural enemies Cf Si	
6-12-2005	49	4	4	0	3	66	0	0
13-12-2005	50	5	6	0	4	8	20	16.7
20-12-2005	51	3	7	0	6	12	0	14.3
27-12-2005	52	3	8	0	6	12	0	12.5
Mean		0.08	0.13	0		10	5.0	10.9
3-1-2006	1	2	12	2	8	16	0	16.7
10-1-2006	2	4	15	3	8	16	0	20.0
17-1-2006	3	2	19	6	10	20	0	31.6
24-1-2006	4	3	12	5	7	14	0	25.0
31-1-2006	5	1	13	5	6	12	0	23.1
Mean		0.05	0.28	0.08		16	0	23.3
7-2-2006	6	1	16	5	8	16	0	37.5
14-2-2006	7	0	15	7	7	14	0	26.7
21-2-2006	8	0	17	6	10	20	0	23.5
28-2-2006	9	1	19	11	9	18	0	26.3
Mean		0.01	0.34	0.15		17	0	28.5
7-3-2006	10	0	10	11	6	12	0	20.1
14-3-2006	11	0	16	10	4	8	0	18.7
21-3-2006	12	0	16	9	4	8	0	12.5
28-3-2006	13	0	12	10	4	8	0	8.3
Mean		0	0.27	0.20		9	0	14.9
agreement with present study where in the mean								

agreement with present study where in the mean parasitism recorded was upto 29%. Higher rate of parasitization of C. partellus larvae by S. inferens occurred during January (23%) and February (28%) and later declined during March (15%). Several authors have recorded S. inferens parasitization up to 25% on C. partellus (Usman & Puttarudiah (1955), Butani (1957, 1958) and Sharma et al. (1966). In the present study revealed that maximum of 29% parasitization recorded during kharif season crop and it is in close agreement with the results of Chaudhary & Sharma (1987) and Kishore (1986) who were also recorded the highest percent parasitization (32%) during kharif season sorghum. The parasitic effects of pupae of *C. partellus* by Tetrastichus sp. were reported by several authors (Butani 1958; Rao 1965; Greathead 1990; Mohyuddin 1990). The pupal parasitoid, Tetrastichus sp. population upto 2% was observed in present study and it was noticed in Oct (2%) and Nov (1%) in *kharif* season.

An increased understanding of the influence of plant and associated arthropod-species diversity on pest populations will lead to the development of recommendations for utilizing natural enemies such as parasitoids and predators for C. partellus management. Future laboratory studies should be taken to evaluate the parasitic effect of these indigenous parasitoids in both the

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seasons on *C. partellus* larvae and pupae to determine the suitable weather conditions to utilize these species could be of use as recommended biological control agents in sorghum cropping systems.

References

- Anonymous (1987) Sorghum stem borer in India and Southeast Asia. In: Intl. Workshop of Sorghum Stem Borer, at Patancheru, 17-20 Nov, ICRISAT, India. pp: 19-25.
- Barpete RD and Shinde CB (1991) Seasonal occurrence of Apanteles flavipes (Cameron) on Chilo partellus (Swinhoe) in Madhya Pradesh. *J. Insect Sci.*, 4, 112-116.
- Butani DK (1957) A Tachiniid fly parasite of *Chilo* zonellus (Swin.). Ind. J. Entomol. 19, 62-63.
- 4. Butani DK (1958) Parasites and predators recorded on sugarcane pests in India. *Ind. J. Entomol.* 20, 270-282.
- Chaudhary RN and Sharma VK (1987) Parasitization in diapausing larvae of *Chilo partellus* (Swinhoe) by *Apanteles flavipes* (Cameron). *Ind. J. Ecol.* 14, 155-157.
- Devi N and Raj D (1996) Extent of parasitization of Chilo partellus (Swinhoe) on maize by *Apanteles* sp. in mid hill zone of Himachal Pradesh (India). *J. Entomol. Res.* 30, 171-172.
- De Groote HW, Overholt JO, Ouma and Mugo S (2003) Assessing the impact of Bt maize in Kenya using a GIS model. Paper presented at the International Agricultural Economics Conference, Durban, 17th -23rd, August. pp. 78-79.
- Duale AH (1999) Incidence and distribution in sorghum of the spotted stem borer *Chilo partellus* and associated natural enemies in farmers' fields in Andhra Pradesh and Maharashtra states. *Int. J. Pest Management* 45(1), 3-7.
- 9. Durden JC (1953) Stem borer of cereal crops at Kongwa, Tanganyika 1950-1952. *East Afri. Agri. J.*, 19, 105-119.
- Greathead DJ (1990) Utilization of natural enemies of Chilo sp. for management in Africa. *Insect Sci. Appl.* 11, 749-755.
- 11. Getu EA, Overholt W, Kairu E and Omwega CO (2003) Evidence of the establishment of *Cotesia flavipes* (Hymenoptera:Braconidae), a parasitoid of cereal stemborers, and its host range expansion in Ethiopia. *Bull. Entomol. Res.* 93(2), 25-129.
- 12. ICRISAT (1992) The medium term plan. Ann. Progress Report, Vol. II. ICRISAT, AP, India. pp: 312.
- Jotwani MG, Chaudhari S, Singh SP and Young WR (1971) Studies on resistance in sorghum against stem borer, *Chilo zonellus* (swin.). *Investigations on Insect Pest of Sorghum and Millets*. 31, 113-118.
- 14. Kishore P (1986) Studies on natural enemies of spotted stem borer, *Sorghum newsletter*, 29, 65-66.
- 15. Krishnamurthy B and Usman S (1954) Some insect parasites of economic importance noted in Mysore State, *Ind. J. Entomol.* 16, 327-343.
- Mahadevan NR and Chellaiah S (1986) Population dynamics of the sorghum stem borer, *Chilo partellus* (Swinhoe) in light trap, In: Behavioral and Physiological Approaches in Pest management. (Eds. Ragupathy A & Jayaraj S) Tamil Nadu Agri. Univ., Coimbatore, India. pp. 104-106.

- 17. Mohan BR, Verma AN and Singh SP (1990) Populations build up of *Chilo partellus* (Swinhoe) on forage sorghum in Haryana. *J. Insect Sci.* 3, 42-46.
- Mote UN (1988) Correlation between the degree of damage due to stem borer, *Chilo partellus* (Swinhoe) and yield of sorghum grain. *Ind. J. Entomol.* 48, 317-358.
- 19. Mohyuddin AI (1990) Biological control of *Chilo* sp. in maize. *Insect Sci. Appl.* 11, 721-732.
- Overholt WA (1998) A review of classical biological control stem borer in Africa, In: Cereal Stem Borers in Africa, Taxonomy. (Ed. Polaszek A) Natural Enemies and Control Technical Centre for Agricultural and Rural Cooperation, Wageningen, The Netherlands. pp: 545-598.
- Parrella MP, Hansen LS, Van Lenteren JC (1999) Glass house experiments In: Handbook of Biological Control. (Ed. Fisher TS) Academic Press, NY, pp. 819-839.
- 22. Rao KP (1965) Natural enemies of rice stem borer and allied species in various parts of the world and possibilities of their use in biological control of rice stem borer in Asia. *Technological Bulletin*, Commonwealth Institute for Biological Control, Bangalore, 6, 1-68.
- Rao KP and Ali M (1977) Some natural enemies of rice and sorghum stem borer (*Tryporyza incertulas* and *Chilo partellus*) in Andhra Pradesh. *Ind. J. Entomol.* 38, 191-193.
- 24. Sharma K, Saxena JD and Subba Rao BR (1966) A catalogue of the hymenopterous and dipterous parasites of *Chilo zonellus* (Swinhoe) (Crambidae: Lepidoptera). *Ind. J. Entomol.* 28, 510-542.
- 25. Shorey HH and Hale RL (1965). Mass rearing of the larvae of nine noctuid species on a simple artificial medium. *J. Econ. Entomol.* 58, 522-524.
- Singh JP and Sharma Y (1984) Incidence of *Chilo partellus* (Swinhoe) on maize and jowar in Punjab. Punjab University Science, *Res. Bull.* 34, 105-114.
- 27. Songa JM, Bergvinson D and Mugo S (2001) Impacts of Bt-gene based resistant in maize on non-target organism in Kenya. Characterization of target and non-target organisms of Bt-gene- based resistance in two major maize growing regions in Kenya. Insect resistant maize for Africa (IRMA). *Ann. Report.* 4, 16-21.
- Trehan KN and Butani DK (1947) Notes on life history bionomics and control of *Chilo zonellus* (Swin.) in Bombay Province. *Ind. J. Entomol.* 11, 47-59.
- 29. Usman S and Puttarudiah M (1955) A list of the insects of Mysore including the mites. Annual report, Department of Agriculture, Mysore, Karnataka, India. p. 85.