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Species Profiling of White Grub Beetles and Evaluation of Pre and Post Sown Application of Insecticides against White Grub Infesting Soybean

Ajay Kumar Pandey, Mayank Kumar

***Abstract*—**White grub (Coleoptera: Scarabaeidae) is a major destructive pest in western Himalayan region of Uttarakhand. Beetles feed on apple, apricot, plum, walnut etc. during night while, second and third instar grubs feed on live roots of cultivated as well as non-cultivated crops. Collection and identification of scarab beetles through light trap was carried out at Crop Research Centre, Govind Ballab Pant University Pantnagar, Udham Singh Nagar (Uttarakhand) during 2018. Field trials were also conducted in 2018 to evaluate pre and post sown application of different insecticides against the white grub infesting soybean. The insecticides like Carbofuran 3 Granule (G) (750 g a.i./ha), Clothianidin 50 Water Dispersal Granule (WG) (120 g a.i./ha), Fipronil 0.3 G (50 g a.i./ha), Thiamethoxam 25 WG (80 g a.i./ha), Imidacloprid 70 WG (300 g a.i./ha), Chlorantraniliprole 0.4% G(100 g a.i./ha) and mixture of Fipronil 40% and Imidacloprid 40% WG (300 g a.i./ha) were applied at the time of sowing in pre sown experiment while same dosage of insecticides were applied in standing soybean crop during (first fortnight of July). Commutative plant mortality data were recorded after 20, 40, 60 days intervals and compared with untreated control. Total 23 species of white grub beetles recorded on the light trap and *Holotrichia serrata* Fabricious (Coleoptera: Melolonthinae) was found to be predominant species by recording 20.6% relative abundance out of the total light trap catch (i.e. 1316 beetles) followed by *Phyllognathus* sp. (14.6% relative abundance). *H. rosettae* and *Heteronychus lioderus* occupied third and fourth rank with 11.85% and 9.65% relative abundance, respectively. The emergence of beetles of predominant species started from 15th March, 2018. In April, average light trap catch was 382 white grub beetles, however, peak emergence of most of the white grub species was observed from June to July, 2018 i.e. 336 beetles in June followed by 303 beetles in the July. On the basis of the emergence pattern of white grub beetles, it may be concluded that the Peak Emergence Period (PEP) for the beetles of *H. serrata* was second fortnight of April for the total period of 15 days. In May, June and July relatively low population of *H. serrata* was observed. A decreasing trend in light trap catch was observed and went on till September during the study. No single beetle of *H. serrata* was observed on light trap from September onwards. The cumulative plant mortality data in both the experiments revealed that all the insecticidal treatments were significantly superior in protection-wise (6.49-16.82% cumulative plant mortality) over untreated control where highest plant mortality was 17.28 to 39.65% during study. The mixture of Fipronil 40% and Imidacloprid 40% WG applied at the rate of 300 g a.i. per ha proved to be most effective having lowest plant mortality i.e. 9.29 and 10.94% in pre and post sown crop, followed by Clothianidin 50 WG (120 g a.i. per ha) where the plant mortality was 10.57 and 11.93% in pre and post sown treatments, respectively. Both treatments were found significantly at par among each other. Production-wise, all the insecticidal treatments were found statistically superior (15.00-24.66 q per ha grain yields) over untreated control where the grain yield was 8.25 & 9.13 q per ha. Treatment Fipronil 40% + Imidacloprid 40% WG applied at the rate of 300 g a.i. per ha proved to be most effective and significantly superior over Imidacloprid 70WG applied at the rate of 300 g a.i. per ha.

Ajay Kumar Pandey and Mayank Kumar are with the Department of Entomology, College of Agriculture G. B. Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar – 263 145 (Uttarakhand) India (e-mail: drajay2002@gmail.com).

***Keywords*—**Bio efficacy, insecticide, *Holotrichia*, soybean, white grub.

I. Introduction

AMONG the various legumes, soybean is probably the largest source of vegetable seed oil and protein. Due to nutritional value and health benefits of soybean, growers have shown their interest toward soybean cultivation on wide area. Production of soybean in India is restricted mainly to Madhya Pradesh, Uttar Pradesh, Maharashtra and Gujarat. It is also grown on a small acreage in Himachal Pradesh, Punjab, Delhi and Uttarakhand. Among the various limiting factors in successful cultivation of soybean in Uttarakhand, white grub is a major pest of soybean grown under rain-fed condition of Uttarakhand hills.

White grub (Coleoptera: Scarabaeidae) locally known as 'Kurmula', 'Pagra', 'Chinchu', is a major destructive pest of several agricultural and horticultural crops with a wide geographical distribution. More than 30 species of white grub have been reported from Uttarakhand hills [1] of which *Holotrichia longipennis, Anomala dimidiata, H. lineatopennis, Maladera insanabilis, Brahmina* make complex problem in different area of Uttarakhand resulting in considerable losses in different crops like sugarcane, groundnut, potato, maize and upland rice [2]. It has become a major constraint in potato production in mid and higher hills of India [3]. Adults emerge in May-June [4] by following the onset of monsoon and thereafter defoliate the apple, apricot, plum, walnut during night while grubs feed on roots of crops. Various insecticides like Quinalphos, Carbaryl, Carbosulfan Monocrotophos, Fenvalerate, Chlorpyrifos, Deltamethrin, Azadirachtin, Chlorpyrifos, Phorate etc. have been proved to be very effective against white grub infesting various crops [5]-[7]. However, references on insecticidal control of white grub damaging soybean grown in rain-fed condition of Uttarakhand hills are very limited.

In light of above fact, trials were conducted on evaluation of pre and post sown application of some granular insecticides against white grub (*H. longipennis)* infesting soybean grown in western Himalayan region of Uttarakhand.

II. Material and Methods

Light trap studies were conducted in three places viz. CRC (Dr. Norman E. Borlaug Crop Research Center), HRC (Horticulture Research Center) Patharchatta and Livestock Research Center (LRC) Nagla located in Terai area of Pantnagar, Udham Singh Nagar district of Kumaon region (Uttarakhand) during March to September 2018. These study areas are located in latitude: 29° 01' 33.60" N and longitude: 79° 28' 16.19" E with elevation of 236.54 meters above mean sea level and surrounded by teak forest. Light traps were installed for collection and identification of white grub occurring in Pantnagar localities. Light traps having mercury vapour lamp [8] were kept on from 6.00 pm to 11.30 pm from March to September. Beetle attracted in collecting container of light trap were collected and brought in laboratory for identification and to prepare species profiling of white grub. Field experiments were also conducted at G. B. Pant University of Agriculture & Technology, Pantnagar. Soybean crop (variety PS – 1047) was sown during third week of June under randomized block design with plant spacing of 45 x 10 cm during 2018. The insecticides like Carbofuran 3G (@ 750 g a.i. ha^{-1}), Clothianidin 50 WDG, Fipronil 0.3 G, Thiamethoxam 25 WG, Imidacloprid 70 WG, Chlorantraniliprole 0.4 GR and mixture of Fipronil 40% and Imidacloprid 40% WG were applied at the rate of 750 g, 120 g, 50 g, 80 g, 300 g, 100 g and 300 g per hectare, respectively, at the time of sowing in pre sown experiment while same dosage of insecticides were broadcasted in row of standing crop followed by mixing of insecticide in the soil in standing soybean crop during second fortnight of July with untreated control. Each treatment was replicated thrice. All the agronomical practices recommended for this area were followed to grow healthy crop. The cumulative plant mortality data were recorded after 40, 60 and 80 days after sowing and yield of each treatment was recorded after harvesting of crops. The cumulative plant mortality and yield data were subjected to analysis through the computer software STPR3. Benefit cast ratio for each treatment was also calculated to conclude effective insecticides in gain.

III. Result and Discussion

During the study, various species of white grub were collect under the light trap with variation in time of emergence depending upon species as well as available host plant. Similarly, the performance of various insecticides for the management of white grub infesting soybean was varied. However, all the treatments were found significantly superior with untreated control.

A. Species Profiling of White Grub

In all, 23 species of white grub beetles were trapped on the light trap and all the species were identified (Table I). *H. serrata* Fabricious. (Coleoptera: Melolonthinae) was observed to be the predominant species (272 beetles, 21.9% relative abundance) out of the total light trap catch i.e., 1240 beetles followed by *Phyllognathus* sp. (193 beetles, 15.5% relative abundance). *H. rosettae* and *Heteronychus lioderus* occupied third and fourth rank with 156 beetles (12.58% relative abundance) and 127 beetles (10.24% relative abundance), respectively. The emergence of beetles of predominant species started from 15th March, 2018.

TABLE I
Average Number of Scarab Beetles Trapped on Light Trap at CRC, Pantnagar during Active Season (March to September, 2018)

Sl. No.	Scarab beetle species trapped	Light Trap Catch, 2018							Total No. of beetles
		March	April	May	June	July	Aug.	Sept.	
1	*Anomala xanthoptera (*Blanchard*)*	4	5	0	0	0	0	0	9
2	*Holotrichia serrata (*Fabricious*)*	2	205	59	6	0	0	0	272
3	*Holotrichia rosettae* Frey	13	83	54	6	0	0	0	156
4	*Brahmina coriacea* Hope	0	26	12	20	1	0	0	59
5	*Anomala* sp.	0	1	12	15	1	0	0	29
6	*Anomala bengalensis* Blanchard	0	6	11	44	9	0	0	70
7	*Adoretus* sp.	0	4	10	12	12	4	0	42
8	*Anomala rugosa*	0	11	9	32	0	0	0	52
9	*Adoretus simplex* Sharp	0	33	10	26	32	24	0	125
10	*Heteronychus lioderus Redtenbacher*	0	4	0	43	80	0	0	127
11	*Phyllognathus dionysius* F.	0	3	0	25	0	0	0	28
12	*Apongonia setosa* Arrow	0	0	0	10	0	0	0	10
13	*Phyllognathus* sp.	0	0	0	37	156	0	0	193
14	*Hemiseria nasuta* Brenske	0	0	0	6	0	0	0	6
15	*Maladera* sp.	0	0	0	24	0	0	0	24
16	*Sophorops* sp.	0	0	0	24	0	0	0	24
17	*Anomala dimidiata* Hope	0	0	0	0	3	0	0	3
18	*Oxycetonia versicolor (*Fabricius*)*	0	0	0	6	3	0	0	9
19	*Mimela* sp.	0	0	0	0	2	0	0	2
	Total Number	19	381	177	336	299	28	0	1240

PEP: 15 April – 20th June 2018. Peak Emergence of *H. serrata* started: 25th April 2018

In April, total light trap catch was 382 beetles but peak emergence of most of the white grub species was observed

during June-July i.e. 336 beetles in June followed by 303 beetles in July. On the basis of the emergence pattern of white grub beetles, it may be concluded that the PEP of *H. serrata* was second fortnight of April. During May, June and July relatively low population of *H. serrata* was observed. In July, total light trap catch was 303 beetles and thereafter a decreasing trend of light trap catch was recorded September. No single beetle of *H. serrata* was trapped on light trap from August and September onwards. The species predominance of two subfamilies in Terai area of Kumaon region belongs to *Melolonthinae* and *Rutelinae* [8] and total 19 and 23 species were reported. The predominance of species depends upon availability of desirable host and suitable environment [9]. Among predominant species of Uttar Pradesh *H. serrata* (F.) is the one of the major species of white grub.

B. Pre-Sown Application of Insecticide

From the data presented in Table II, it is evident that all the insecticidal treatments were found significantly superior protection-wise (6.49-15.56% cumulative plant mortality) over untreated control where highest plant mortality was 17.28 to 32.43%. The mixture of Fipronil 40% and Imidacloprid 40% WG applied at the rate of 300 g a.i. per ha proved to be most effective by registering lowest plant mortality (i.e. 9.29%) followed by Clothianidin 50 WDG (applied at the rate of 120 g a.i. ha^{-1}) where the plant mortality was 10.57% and both treatments were found significantly at par with each other. Imidacloprid 70 WG (applied at the rate of 300 g a.i. ha^{-1}) ranked third by recording 12.85% plant mortality and this treatment was also found statistically at par with Chlorantraniliprole 0.4% GR (120 g a.i. ha^{-1}) in respect to plant mortality. Other insecticidal treatments were not found promising in controlling the white grubs.

TABLE II
FIELD EVALUATION OF PRE SOWN APPLICATION OF DIFFERENT GRANULAR INSECTICIDES IN SOYBEAN AGAINST THE WHITE GRUB AT CRC DURING *KHARIF*, 2018

Tr. No.	Treatment	Dose (g a.i/ha)	Mean initial plant population (4 x 4 m^2)	Cumulative plant mortality (DAS)			Grain yield (qha^{-1})	Cost of treatment (Rs ha^{-1})	Net return over control (Rs ha^{-1})	B/C ratio
				20	40	60				
T_1	Carbofuran 3G	750	350.0	6.87 (15.19)	7.85 (16.26)	13.13 (21.24)	19.33	3000	40672	1.45
T_2	Clothianidin 50 WDG	120	350.0	7.64 (16.04)	10.25 (18.66)	10.57 (18.96)	21.20	3200	47230	1.68
T_3	Fipronil 0.3 G	50	336.0	8.25 (16.69)	14.10 (22.05)	16.07 (23.62)	19.75	1900	41000	1.46
T_4	Thiamethoxam 25 WG	80	355.0	7.10 (15.45)	11.67 (19.97)	15.56 (23.22)	15.00	1400	24350	0.87
T_5	Imidacloprid 70 WG	300	352.0	5.13 (13.09)	7.89 (16.31)	12.85 (21.00)	20.75	4100	46600	1.66
T_6	Chlorantraniliprole 0.4% GR	100	358.0	6.49 (14.75)	8.48 (16.92)	13.51 (21.56)	20.50	4625	46275	1.65
T_7	Fipronil 40% + Imidacloprid 40% WG	300	355.0	5.86 (14.0)	7.84 (16.25)	9.29 (17.74)	24.62	4525	60319	2.15
T_8	Untreated control	-	358.0	17.28 (24.55)	24.80 (29.86)	32.43 (34.70)	8.25	0	0	0.00
	Sem (±)		NS	1.36	2.04	2.56	1.01	-	-	-
	C.D. (5%)		-	3.90	6.61	5.03	3.45	-	-	-
	CV (%)		-	17.59	12.80	6.90	17.11	-	-	-

*Figures in parentheses are the angular transformed values. # Rate of soybean grain: Rs. 3400.0/q.

Production-wise, all the insecticidal treatments were found statistically superior (15.00-24.66 qha^{-1} grain yield) over untreated control where the grain yield was 8.25 qha^{-1} (Table III). The mixture of Fipronil 40% and Imidacloprid 40% WG applied at the rate of 300 g a.i. ha^{-1} was more effective against the white grub. It was found to be significantly superior over Imidacloprid 70WG applied at the rate of 300 g a.i. ha^{-1}. The mixture of Fipronil 40% and Imidacloprid 40% WG (@ 300 g a.i ha) with 24.66 qha^{-1} grain yield was found nonsignificantly superior over Clothianidin 50 WDG (120 g a.i. ha^{-1}) having 21.20 qha^{-1} grain yield which were statistically at par with each other in respect to grain yield. In an experiment, it has been found that Clothianidin 50 WDG applied 0.120 kg a.i. ha^{-1} proved to be most effective by registering lowest pant mortality i.e. 6.94 and 8.20% followed by imidacloprid 70 WG applied 0.30 kg a.i. ha^{-1} where the plant mortality was 8.99 and 8.5% during two consecutive years of study [10].

Highest net return (Rs. 60,319.00/ha) was obtained from the treatment Fipronil 40% + Imidacloprid 40% WG applied @ 300 g a.i. per ha followed by Clothianidin 50 WDG @ 120 g a.i. where net returns was Rs. 47,230.00 ha^{-1}. Imidacloprid 70 WG applied at the rate of 300 g a.i. per ha with net returns of Rs. 46,600.00 ha^{-1} (Table III) ranked third. Highest B/C ratio (2.15) was recorded in the treatment of Fipronil applied @ 50 g a.i. ha^{-1} followed by Clothianidin 50 WDG @ 120 g a.i. ha^{-1} where the B/C ratio was 1.68. Lowest grub population (mean 0.33grubs/pit) was recorded in the treatment of Fipronil 40% + Imidacloprid 40% WG (Table II).

C. Post-Sown Application of Insecticide

Field trial was also conducted to evaluate the effect of post-sown application of different granular insecticides against the white grub in soybean. Under the experiment, granular insecticide was applied at the first week of July when white grub beetle had emerged out. According to data presented in Table III, it is evident that all the insecticidal treatments were found significantly superior with over cumulative plant mortality of 5.90 to 17.26% as compared to control where

highest plant mortality was 20.27 to 39.65%. The mixture of Fipronil 40% and Imidacloprid 40% WG (applied 300 g a.i. ha^{-1}) proved to be most effective by registering lowest plant mortality (i.e. 10.94%) followed by Clothianidin 50 WDG (120 g a.i. ha^{-1}) where the plant mortality was 11.3% and both treatments were found significantly at par with each other. The treatment Imidacloprid ranked third by recording 12.07% plant mortality and this treatment was at par with Chlorantraniliprole 0.4% GR (applied @ 100 g ai^{-1}) with respect to plant mortality. Other insecticidal treatments were not found promising in controlling the white grubs.

TABLE III
FIELD EVALUATION OF DIFFERENT GRANULAR INSECTICIDES AS POST–SOWN SOIL APPLICATION IN STANDING CROP OF SOYBEAN AGAINST WHITE GRUB

Tr. No.	Treatment	Dose (g a.i/ha)	Mean initial plant population (4.0x 4.0m^2)	% cumulative plant mortality (DAT)			Grain yield (qha^{-1})	Cost of treatment (Rs ha^{-1})	Net return over control (Rs. ha^{-1})	B/C ratio
				20	40	60				
T_1	Carbofuran 3G	750	355.0	7.55 (15.94)	13.24 (21.35)	16.82 (24.20)	17.62	3200.00	32066.00	1.14:1
T_2	Clothianidin 50 WDG	120	350.0	9.45 (17.90)	14.52 (22.39)	11.39 (19.72)	22.25	3400.00	48008.00	1.71:1
T_3	Fipronil 0.3 G	50	345.0	7.18 (15.54)	10.63 (19.02)	14.44 (22.32)	19.80	2100.00	36488.00	1.30:1
T_4	Thiamethoxam 25 WG	80	352.0	6.69 (14.98)	9.91 (18.34)	17.26 (24.54)	17.50	1600.00	30058.00	1.07:1
T_5	Imidacloprid 70 WG	300	352.0	7.80 (16.21)	8.49 (16.93)	12.07 (20.32)	21.20	4300.00	45338.00	1.62:1
T_6	Chlorantraniliprole 0.4% GR	100	352.0	5.90 (14.05)	8.95 (17.40)	12.18 (20.42)	19.50	4825.00	40083.00	1.43:1
T_7	Fipronil 40% + Imidacloprid 40% WG	300	358.0	6.51 (14.78)	4.25 (11.89)	10.94 (19.31	24.66	4725.00	57391.00	2.05:1
T_8	Untreated control	-	350.0	20.27 (26.75)	26.49 (30.96)	39.65 (39.01)	9.13	-	-	-
	Sem (±)		NS	1.36	1.04	2.56	1.07	-	-	-
	C.D. (5%)		-	3.39	3.61	6.03	3.73	-	-	-
	CV (%)		-	17.59	19.80	16.90	9.33	-	-	-

*Figures in parentheses are the angular transformed values. # Rate of soybean grains: Rs.3400/q.

Production-wise, all the insecticidal treatments were found statistically superior (17.62-24.66 qha^{-1} grain yields) over untreated control where the grain yields was 9.13 qha^{-1} (Table III). The mixture of Fipronil 40% and Imidacloprid 40% WG applied 300 g a.i. ha^{-1} in June proved to be most effective and non-significantly superior over Clothianidin 50 WDG (120 g a.i. ha^{-1}). Clothianidin 50 WDG (120 g a.i. ha^{-1}) ranked third by recording 21.20 qha^{-1} grain yield followed by Fipronil 0.3 G (applied @ 50 g a.i. ha^{-1}). Highest net return (Rs. 57391.0 ha^{-1}) was obtained from the treatment Fipronil 40% + Imidacloprid 40% WG @ 300 g a.i. ha^{-1} followed by Clothianidin 50 WDG (120 g a.i. ha^{-1}) where the net return was Rs.48008.00 ha^{-1} (Table III). Highest B/C ratio (2.05) was recorded in the mixture of Fipronil 40% and Imidacloprid 40% WG applied 300 g a.i. ha^{-1} followed by Clothianidin 50 WDG (120 g a.i. ha^{-1}) where the B/C ratio was 1.71. Lowest grub population (mean 1.06 and 1.33 grubs/pit) was recorded in the mixture of Fipronil 40% and Imidacloprid 40% WG applied 300 g a.i. $ha^{-1}$and Clothianidin 50WDG applied @ 300 and 120 g a.i. ha^{-1}. Soil application of clothianidin 50% WDG applied 250 gm per ha was found most effective treatments against white grub in groundnut as compared to chlorpyriphos 20% EC applied at the rate of 4000 ml per ha. In same study, it was also found that seed treatment of clothianidin 50% WDG (ST) @ 2.5 gm per kg seed was the most profitable treatment (NICBR = 1:2.42) [11].

Light trap study revealed that *H. serrata* is a major white grub species in Tarie region of Uttarakhand. On the basis of present study it may concluded that mixture of Fipronil 40% and Imidacloprid 40 WG (300 g a.i. per hectare) proved to be very effective as compared to rest of the insecticide. Post sown application of insecticidal treatments gave better control of white grub with comparatively higher yield.

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