Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(1): 1562-1565

Received: 25-10-2020
Accepted: 22-12-2020

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Development of low cost protection technology for shoot fly and stem borer in pearl millet crop

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DOI: https://doi.org/10.22271/j.ento.2021.v9.i1v.8360

Abstract
Field experiment was conducted at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during *Kharif* 2016 to 2018 to find out the effective and economical control measures against shoot fly and stem borer in pearl millet crop. The results showed that the seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% at 35 days after germination was found effective against shoot fly. Whereas, the seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of chlorantraniliprole 20 SC @ 0.006% at 35 days after germination was found effective against stem borer. The highest additional income (Rs. 17940/-) and net return (Rs. 15975/-) was recorded with the seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% at 35 days after germination.

Keywords: pearl millet, shoot fly, stem borer, clothianidin, chlorantraniliprole

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the staple nutritious food of the poor and small land holders, as well as feed and fodder for livestock in rainfed regions of the country. Pearl millet excels all the cereals due its unique features-C_4 plant with high photosynthetic efficiency, high dry matter production capacity and is grown under the most adverse agro-climatic condition with less inputs in short duration where other crops like sorghum and maize fail to produce economic yields. The major pearl millet growing states are Rajasthan, Maharastra, Gujarat, Uttar pradesh and Haryana which account for more than 90% of pearl millet acreage in the country and commonly grown in rainfed season. It occupies an area of 6.93 million ha with an average production of 8.61 million tonnes and productivity of 1243 kg/ha (Directorate of Millets Development, 2020; Project Coordinator Review, 2020) [1]. Pearl millet is rich source of energy, carbohydrate, fat, ash, dietary fibers, iron and zinc. It is a rich source of vitamins like thiamine, riboflavin and niacin and minerals like potassium, phosphorus, magnesium, iron, zinc, copper and manganese. With low prolamine fraction pearl millet is gluten free grain and is the only grain that retains it's alkaline properties after being cooked which is ideal for people with gluten allergy. Even though, it was part of the traditional diet pattern, but, now a days, due to changing cropping pattern and consumption pattern, such crops are disappearing from the field and diet as well.

Twenty six insects and two non-insect pests were found feeding on pearl millet (Balikai, 2010) [2]. Out of these, shoot fly, *Atherigona approximate* malloch and stem borer, *Chilo partellus* Swinhoe are comparatively more serious pests attacking at vegetative as well as at ear head stages of the crop. Losses in yield of pearl millet crop due to shoot fly estimated to the tune of 23.3 to 36.5% in grain and 37.55% in fodder, while the estimated losses in *Bajra* yield due to stem borer is 20 to 60% (Prem kishore, 1996) [8]. Chemical insecticides are the most effective control measure against insect pests on pearl millet. However, some insecticides are expensive, toxic and when used extensively, may be harmful to human health and the environment. Thus, there is a need to design alternate pest management options that have limited adverse effects on the environment and are effective against target insect pests. One such option is the use of seed treatment with systemic insecticides, which is an easy, economic and feasible method to manage insect pests during early stage of the crop growth without

causing any harmful effect on natural enemies. Objective of the study was to determine the effectiveness of the seed dressing chemicals with foliar application of pesticides to reduce load of the chemical pesticides pearl millet agro ecosystem. Hence the present research work for the management of these pests was under taken.

Materials and Methods

The experiment was conducted in randomized block design with ten treatments including control in three replication at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during *Kharif* 2016 to 2018. The pearl millet hybrid variety GHB-558 was sown at 60 × 10 cm spacing for this purpose. The gross plot size was 5.0 × 3.6 m and net plot size was 4.0 × 2.4 m. Seed treatments were given initially at the time of sowing. While, foliar application was given at 35 days after germination. At vegetative stage, observations were recorded from 20 plants randomly selected plants by counting dead hearts and thus, percentage dead heart was worked out for shoot fly. For stem borer, plants showing parallel holes due to stem borer larvae in the leaves were considered as damaged plants and per cent damaged plants were calculated by observing 20 randomly selected plants. At ear head stage, numbers of ear heads showing shoot fly and stem borer damage were recorded separately from randomly selected 20 ear heads in each treatment from net plot and thus per cent ear head damage was worked out. Grain and fodder yield was recorded from net plot area at harvest and data thus, obtained was analyzed statistically (Panse and Sukhatme, 1989) [5].

Treatment details

T_1	Seed treatment with clothianidin 50 WDG @ 7.5 g/kg seed followed by clothianidin 50 WDG @ 0.025% spray at 35 DAG.
T_2	Seed treatment with clothianidin 50 WDG @ 7.5 g/kg seed followed by fipronil 40%+ imidacloprid 40% WG @ 0.04% spray at 35 DAG.
T_3	Seed treatment with clothianidin 50 WDG @ 7.5 g/kg seed followed by fipronil 5 SC @ 0.01% spray at 35 DAG.
T_4	Seed treatment with clothianidin 50 WDG @ 7.5 g/kg seed followed by chlorantraniliprole 18.5 SC @ 0.006% spray at 35 DAG.
T_5	Seed treatment with fipronil 40% + imidacloprid 40% WG @ 2.5g /kg seed followed by clothianidin 50 WDG @ 0.025% spray at 35 DAG.
T_6	Seed treatment with fipronil 40% + imidacloprid 40% WG @ 2.5g /kg seed followed by fipronil 40% + imidacloprid 40% WG @ 0.04% spray at 35 DAG
T_7	Seed treatment with fipronil 40% + imidacloprid 40% WG @ 2.5g /kg seed followed by fipronil 5 SC @ 0.01% spray at 35 DAG.
T_8	Seed treatment with fipronil 40% + imidacloprid 40% WG @ 2.5g /kg seed followed by chlorantraniliprole 18.5 SC @ 0.006% spray at 35 DAG.
T_9	Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by imidacloprid 17.8 SL 0.009% spray at 35 DAG
T_{10}	Control

Results and Discussion

Shoot fly

Data presented in Table-1 indicated that differences of percent incidence of shoot fly at vegetative stage were found significant during the year 2016, 2017, 2018 and pooled. During 2016, least shoot fly incidence was recorded in T_3 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% at 35 DAG) with 7.79% incidence and it was at par with T_1 (8.23%), T_2 (8.195), T_4 (8.99%), T_5 (10.74%), T_6 (11.29%), T_7 (11.45%) & T_9 (10.32%). During 2017, again least shoot fly incidence was recorded in T_3 (1.23%) and it was at par with T_1 (1.90%). During 2018, again least shoot fly incidence was recorded in T_3 (5.83%). However, it was at par with T_1 (6.25%), T_2 (6.88%), T_4 (7.29%) & T_7 (7.50%). So far as pooled data concerned, least incidence was recorded in T_3 (4.95%) and, it was statistically at par with T_1 (5.46%), T_2 (5.02%) & T_4 (5.92%). Whereas, it was 12.51% in control. At ear head stage, Data showed that differences in shoot fly infestation were found significant in all the years as well as in pooled. Moreover, during all the years, least shoot fly incidence was recorded in T_3. Whereas, during 2018, it was at par only with T_1 (2.36%). The pooled data revealed that the least incidence (6.88%) was recorded in T_3 and it was statistically at par with T_1 (7.84%).

Stem borer

Data presented in Table-2 indicated that differences in stem borer incidence during 2016, 2017, 2018 and in pooled were found significant at vegetative stage. During 2016, least stem borer incidence (1.49%) was recorded in T_1 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of clothianidin 50 WDG @ 0.025% at 35 DAG) and it was at par with T_2 (1.93%) and T_3 (2.28%). During 2017, least stem borer incidence was recorded in T_4 (2.68%) and it was at par with T_8 (3.40%). During 2018, least stem borer incidence was again recorded in T_4 (7.08%) and it was statistically at par with most of the treatments except T_9 & T_{10}. In case of pooled data, least stem borer incidence (4.09%) was recorded in T_4 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of clorantraniliprole 18.5 SC @ 0.006% at 35 DAG) and it was at par with T_1 (4.33%) & T_2 (4.87%). Data indicated that difference of stem borer incidence at ear head stage was found significant in all the years as well as in pooled analysis.

At ear head stage, least stem borer incidence was recorded in T_1 during 2016 (2.38%). However, it was statistically at par with all the treatments except T_9 (3.90%) & T_{10} (6.63%). During 2017, T_4 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of clorantraniliprole 18.5 SC @ 0.006% at 35 DAG) recorded least stem borer incidence (7.14%). However, it was statistically at par with T_1 (9.10%), T_5 (9.22%), T_6 (10.86%) & T_8 (7.83%). During 2018, again least stem borer incidence was observed in T_4 (2.92%) and it was statistically at par only with T_1 (4.17%). In case of pooled of three years, T_4 recorded least stem borer incidence (4.45%). However, it was statistically at par with T_1 (5.22%), T_3 (6.92%) & T_8 (5.46%).

Yield and economics

Data of grain yield presented in Table-3 indicated that differences in grain yield in all the individual years and pooled were found significant. The pooled data showed that T_3 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01%) at 35 DAG recorded highest grain yield (2999 kg/ha). However, it was at par with majority of the treatments except T_7, T_9 & T_{10}. In case of fodder yield, the results were found significant during all the years as well as in pooled. In case of pooled data, highest fodder yield was recorded in T_3 (5674 kg/ha) and it

was at par with the most of the treatments except T_7, T_9 & T_{10}. Economics of the various treatments (Table-4) indicated that highest additional income (Rs. 17940/-), net return (Rs. 15975/-) and ICBR (1:9.13) was recorded in T_3 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% at 35 DAG.

Seed treatment of clothianidin WDG was found effective for the control of shoot fly in wheat crop (Patil *et al*., 2007) [7]. Omprakash *et al* (2017) [4] reported that the treatment with chorantraniliprole 18.5% SC @ 150 ml/ hectare was found the most effective in controlling the rice yellow stem borer damage. Bidisha *et al.* (2018) [3] evaluated the bio-efficacy of pesticides against insect pest complex of rice crop. Results of the experiment revealed that, highest reduction in dead hearts/white ears was recorded in the treatment of fipronil 5% SC @ 75 gm a.i./ha. Whereas in maize cultivation, the least percent leaf injury and per cent dead heart damage by maize stem borers was recorded with the application of chlorantraniliprole 18.5% SC @ 150 ml/ha at 7 and 14 days after germination (Sudha Rani *et al.*, 2018) [9]. According to Pateliya *et al.* (2019) [6] the seed treatment of clothianidin WDG @7.5 g/kg seed followed by spray of *B. bassiana* WP @ 0.007% recorded lower infestation of shoot fly and stem borer in pearl millet crop.

Table 1: Statement showing incidence of shoot fly in pearl millet

No	Treatments	% Shoot fly incidence at vegetative stage (28 DAG)				% Shoot fly incidence at ear head stage			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	T_1	16.66* (8.23)	7.91 (1.90)	14.47 (6.25)	13.01 (5.46)	21.01 (12.89)	16.63 (8.28)	8.79 (2.36)	15.47 (7.84)
2	T_2	16.61 (8.19)	7.48 (1.80)	15.19 (6.88)	13.09 (5.02)	21.52 (13.61)	17.48 (9.08)	14.41 (6.25)	17.80 (9.65)
3	T3	16.08 (7.79)	6.37 (1.23)	13.95 (5.83)	12.13 (4.95)	19.93 (11.89)	15.09 (6.80)	7.94 (1.94)	14.32 (6.88)
4	T_4	17.28 (8.99)	6.92 (1.48)	15.66 (7.29)	13.29 (5.92)	21.34 (13.29)	17.45 (9.17)	12.52 (4.86)	17.10 (8.77)
5	T_5	18.85 (10.74)	8.10 (1.99)	16.08 (7.71)	14.35 (6.81)	21.43 (13.35)	17.50 (9.14)	14.61 (6.39)	17.85 (9.63)
6	T_6	19.51 (11.29)	9.10 (2.52)	16.55 (8.13)	15.05 (7.31)	21.97 (14.03)	15.63 (7.29)	16.30 (7.92)	17.96 (9.75)
7	T_7	19.51 (11.45)	9.12 (2.61)	15.88 (7.50)	14.84 (7.19)	22.63 (14.88)	17.77 (9.49)	14.75 (6.53)	18.38 (10.30)
8	T_8	19.81 (11.63)	8.74 (2.35)	17.38 (8.96)	15.31 (7.65)	22.32 (14.45)	17.69 (9.23)	15.41 (7.22)	18.47 (10.30)
9	T_9	18.63 (10.32)	9.78 (2.91)	18.96 (10.63)	15.79 (7.95)	21.57 (13.56)	19.87 (11.55)	17.58 (9.17)	19.67 (11.43)
10	T_{10}	24.70 (17.47)	13.54 (5.47)	22.42 (14.58)	20.22 (12.51)	27.84 (21.81)	22.57 (14.74)	22.53 (14.72)	24.31 (17.09)
T	S.Em. ±	1.21	0.77	0.70	0.53	1.26	0.98	0.74	0.95
	C.D. at 5%	3.59	2.28	2.07	1.50	3.75	2.93	2.21	2.81
	C.V.%	11.15	15.25	7.24	10.81	9.86	9.60	8.89	9.73
Y	S.Em. ±	--	--	--	0.29	--	--	--	0.32
	C.D. at 5%	--	--	--	0.82	--	--	--	0.91
YXT	S.Em. ±	-	-	-	0.92	-	-	-	1.02
	C.D. at 5%	--	--	--	NS	--	--	--	2.89

* indicates arcsine transformed values, figure in parentheses are original values, DAG - Days After Germination

Table 2: Statement showing incidence of stem borer in pearl millet

No	Treatments	% Stem borer incidence at vegetative stage				% Stem borer incidence at ear head stage			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	T_1	6.99* (1.49)	11.49 (4.01)	15.79 (7.50)	11.42 (4.33)	8.41 (2.38)	17.52 (9.10)	11.53 (4.17)	12.49 (5.22)
2	T_2	7.99 (1.93)	12.04 (4.36)	16.78 (8.33)	12.27 (4.87)	10.67 (3.44)	20.17 (11.97)	14.36 (6.25)	15.07 (7.22)
3	T3	8.64 (2.28)	12.48 (4.69)	16.96 (8.54)	12.69 (5.17)	9.10 (2.62)	20.42 (12.18)	14.12 (5.97)	14.55 (6.92)
4	T_4	9.11 (2.51)	9.38 (2.68)	15.44 (7.08)	11.31 (4.09)	10.41 (3.29)	15.46 (7.14)	9.70 (2.92)	11.86 (4.45)
5	T_5	9.48 (2.72)	12.09 (4.41)	17.19 (8.75)	12.92 (5.29)	9.93 (3.06)	17.31 (9.22)	13.31 (5.42)	13.52 (5.90)
6	T_6	10.94 (3.61)	11.40 (3.96)	17.55 (9.17)	13.30 (5.58)	10.80 (3.54)	19.23 (10.86)	15.10 (6.81)	15.04 (7.07)
7	T_7	11.10 (3.76)	11.86 (4.23)	18.22 (9.79)	13.73 (5.93)	10.70 (3.46)	20.63 (12.41)	14.31 (6.11)	15.21 (7.33)
8	T_8	11.60 (4.07)	10.62 (3.40)	16.90 (8.54)	13.04 (5.34)	10.62 (3.40)	16.23 (7.83)	13.06 (5.14)	13.30 (5.46)
9	T_9	10.30 (3.19)	13.96 (5.82)	18.99 (10.63)	14.41 (6.55)	11.38 (3.90)	21.42 (13.47)	17.76 (9.44)	16.85 (8.94)
10	T_{10}	14.75 (6.54)	17.53 (9.05)	22.26 (14.58)	18.18 (10.06)	14.91 (6.63)	28.00 (22.12)	25.64 (18.75)	22.85 (15.83)
T	S.Em. ±	0.57	0.61	1.01	0.44	0.95	1.32	1.09	0.96
	C.D. at 5%	1.70	1.80	2.99	1.24	2.81	3.93	3.25	2.87
	C.V.%	9.81	8.56	9.89	9.80	15.32	11.67	12.72	13.00
Y	S.Em. ±	--	--	--	0.24	--	--	--	0.36
	C.D. at 5%	--	--	--	0.68	--	--	--	1.02
YXT	S.Em. ±	-	-	-	0.75	-	-	-	1.13
	C.D. at 5	--	--	--	NS	--	--	--	3.21

* indicates arcsine transformed values, figure in parentheses are original values, DAG- Days After Germination

Table 3: Effect of different treatments on yield of pearl millet

No.	Treatments	Grain yield kg/ha				Fodder yield kg/ha			
		2016	2017	2018	Pooled	2016	2017	2018	Pooled
1	T_1	2335	3083	3477	2965	4595	4960	6658	5405
2	T_2	2293	2884	3266	2815	4804	5002	6229	5345
3	T3	2388	2887	3724	2999	5023	5089	6911	5674
4	T_4	2117	3136	3539	2930	4830	5138	6793	5587
5	T_5	2224	2795	3432	2817	4826	4884	6540	5417
6	T_6	2119	2743	3387	2750	4811	5007	6594	5470

7	T_7	2105	2755	2968	2609	4601	4798	6104	5168
8	T_8	2087	2887	3490	2821	4946	4951	6191	5363
9	T_9	2050	2364	3005	2473	4600	4544	5665	4937
10	T_{10}	1883	2137	2745	2255	4071	3744	4618	4144
T	S.Em. ±	91.75	161.28	153.34	85.25	166.23	242.31	369.07	140.10
	C.D. at 5%	272.63	479.22	455.61	253.29	493.91	719.96	1096.61	416.28
	C.V.%	7.36	10.10	8.04	8.77	6.11	8.72	10.26	8.98
Y	S.Em. ±	--	--	--	46.69	--	--	--	76.74
	C.D. at 5%	--	--	--	138.73	--	--	--	228.01
YXT	S.Em. ±	-	-	-	138.98	-	-	-	272.37
	C.D. at 5%	--	--	--	394.27	--	--	--	772.69

Table 4: Economics of various treatments for the management of shoot fly and stem borer in pearl millet

Treats	Yield increase over control kg/ha		Additional Income (Rs.)	Total Expenditure (Rs.)	Net return (Rs.)	ICBR
	Grain	fodder				
T_1	710	1261	16722	4840	11882	1:3.45
T_2	560	1201	13602	4075	9527	1:3.34
T3	744	1530	17940	1965	15975	1:9.13
T_4	675	1443	16386	3347	13039	1:4.90
T_5	562	1273	13786	4499	9287	1:3.06
T_6	495	1326	12552	3734	8818	1:3.36
T_7	354	1024	9128	1624	7504	1:5.62
T_8	566	1219	13758	3006	10752	1:4.58
T_9	218	793	5946	1109	4837	1:5.36

Conclusion

From the above study, it is quite clear that the seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% at 35 days after germination was found effective against shoot fly. Whereas, seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of clorantraniliprole 20 SC @ 0.006% at 35 days after germination was found effective against stem borer in pearl millet crop.

Acknowledge

The authors are highly thankful to Junagadh Agriculture University, Junagadh for providing necessary facilities to carry out this work. Authors are also thankful to Project Coordinator, Pearl millet for providing funds under the AICRP project during the course of study.

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