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

RP Juneja, GM Parmar, KD Mungra, Asha C Detroja, DL Kadvani and SK Parmar

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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-C₄ 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, Maharashtra, 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 its 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) [3]. 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

Corresponding Author:
RP Juneja
Pearl Millet Research Station,
Junagadh Agriculture
University, Jamnagar, Gujarat, India
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 Khurif 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].

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 T1 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of fipronil 5 SC @ 0.01% spray at 35 DAG) and it was at par only with T8 (3.40%). During 2017, least stem borer incidence was again recorded in T1 (7.08%) and it was statistically at par with most of the treatments except T8 & T10. In case of pooled data, least stem borer incidence (4.09%) was recorded in T2 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of chlorantraniliprole 18.5 SC @ 0.006% at 35 DAG) and it was at par with T8 (4.33%) & T2 (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 T1 during 2016 (2.38%). However, it was statistically at par with all the treatments except T8 & T10 (6.63%). During 2017, T1 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of chlorantraniliprole 18.5 SC @ 0.006% at 35 DAG) recorded least stem borer incidence (7.14%). However, it was statistically at par with T1 (9.10%), T3 (9.22%), T6 (10.86%) & T8 (7.83%). During 2018, again least stem borer incidence was observed in T1 (2.92%) and it was statistically at par only with T8 (4.17%). In case of pooled of three years, T1 recorded least stem borer incidence (4.45%). However, it was statistically at par with T1 (5.22%), T3 (6.92%) & T8 (5.46%).

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 T1 (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 T2 (1.93%) & T3 (2.28%). During 2017, least stem borer incidence was recorded in T4 (2.68%) and it was at par with T8 (3.40%). During 2018, least stem borer incidence was again recorded in T1 (7.08%) and it was statistically at par with most of the treatments except T8 & T10. In case of pooled data, least stem borer incidence (4.09%) was recorded in T2 (seed treatment of clothianidin 50 WDG @ 7.5 g/kg seed followed by spray of chlorantraniliprole 18.5 SC @ 0.006% at 35 DAG) and it was at par with T8 (4.33%) & T2 (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.

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 T1 (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 T8, T9 & T10. 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 T3 (5674 kg/ha) and it...
was at par with the most of the treatments except T7, T9 & T10. 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 T3 (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 chlorantraniliprole 18.5% SC @ 150 ml/ha at 7 and 14 days after germination (Sudha Rani et al., 2018) [8]. 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.

| C.D. at 5% | C.V. % | S. Em. ± | YX T | C.D. at 5% | C.V. % | S. Em. ± | YX T | C.D. at 5% | C.V. % | S. Em. ± | YX T | C.D. at 5% | C.V. % | S. Em. ± | YX T |
|------------|--------|----------|-------|------------|--------|----------|-------|------------|--------|----------|-------|------------|--------|----------|-------|
| 3.95       | 11.21  | 0.68     | 1.60  | 2.42       | 9.10   | 1.96     | 1.96  | 1.30       | 1.30   | 1.30     | 1.30  | 1.30       | 1.30   | 1.30     | 1.30  |
| 1.45       | 1.45   | 1.45     | 1.45  | 1.45       | 1.45   | 1.45     | 1.45  | 1.45       | 1.45   | 1.45     | 1.45  | 1.45       | 1.45   | 1.45     | 1.45  |

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

| No. | Treatments | % Shoot fly incidence at vegetative stage (28 DAG) | % Shoot fly incidence at ear head stage |
|-----|------------|--------------------------------------------------|----------------------------------------|
| 1   | T1         | 6.99 ± 0.49                                      | 11.70 ± 0.51                           |
| 2   | T2         | 7.22 ± 0.46                                      | 11.70 ± 0.51                           |
| 3   | T3         | 7.30 ± 0.47                                      | 11.70 ± 0.51                           |
| 4   | T4         | 7.40 ± 0.48                                      | 12.20 ± 0.52                           |
| 5   | T5         | 7.50 ± 0.49                                      | 12.40 ± 0.53                           |
| 6   | T6         | 7.60 ± 0.50                                      | 12.40 ± 0.53                           |
| 7   | T7         | 7.70 ± 0.51                                      | 12.60 ± 0.54                           |
| 8   | T8         | 7.80 ± 0.52                                      | 12.80 ± 0.55                           |
| 9   | T9         | 7.90 ± 0.53                                      | 13.00 ± 0.56                           |
| 10  | T10        | 8.00 ± 0.54                                      | 13.10 ± 0.57                           |

| No. | Treatments | % Stem borer incidence at vegetative stage | % Stem borer incidence at ear head stage |
|-----|------------|--------------------------------------------|----------------------------------------|
| 1   | T1         | 6.99 ± 0.49                                 | 11.70 ± 0.51                           |
| 2   | T2         | 7.22 ± 0.46                                 | 11.70 ± 0.51                           |
| 3   | T3         | 7.30 ± 0.47                                 | 11.70 ± 0.51                           |
| 4   | T4         | 7.40 ± 0.48                                 | 12.20 ± 0.52                           |
| 5   | T5         | 7.50 ± 0.49                                 | 12.40 ± 0.53                           |
| 6   | T6         | 7.60 ± 0.50                                 | 12.40 ± 0.53                           |
| 7   | T7         | 7.70 ± 0.51                                 | 12.60 ± 0.54                           |
| 8   | T8         | 7.80 ± 0.52                                 | 12.80 ± 0.55                           |
| 9   | T9         | 7.90 ± 0.53                                 | 13.00 ± 0.56                           |
| 10  | T10        | 8.00 ± 0.54                                 | 13.10 ± 0.57                           |

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

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

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

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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 fodder | Additional Income (Rs.) | Total Expenditure (Rs.) | Net return (Rs.) | ICBR |
|--------|----------------------------------------|-------------------------|-------------------------|-----------------|------|
| T1     | 710                                    | 1261                    | 16722                   | 4840            | 11882.00 | 1:3.45 |
| T2     | 560                                    | 1201                    | 13602                   | 4075            | 9527.00  | 1:3.34 |
| T3     | 744                                    | 1530                    | 17940                   | 1965            | 15975.00 | 1:9.13 |
| T4     | 675                                    | 1443                    | 16386                   | 3347            | 13039.00 | 1:4.90 |
| T5     | 562                                    | 1273                    | 13786                   | 4499            | 9287.00  | 1:3.06 |
| T6     | 495                                    | 1326                    | 12552                   | 3734            | 8818.00  | 1:3.36 |
| T7     | 354                                    | 1024                    | 9128                    | 1624            | 7504.00  | 1:5.62 |
| T8     | 566                                    | 1219                    | 13758                   | 3006            | 10752.00 | 1:4.58 |
| T9     | 218                                    | 793                     | 5946                    | 1109            | 4837.00  | 1:5.36 |

ICBR: Economic returns on investment.