Management of shoot fly damage in barnyard millet by seed treatment for higher monetary return in hills of Uttarakhand

Laxmi Rawat, AK Karnatak, BP Nautiyal, TS Bisht and Anchala Nautiyal

Abstract
A field experiment was conducted over two consecutive growing seasons (Kharif-2018 and Kharif-2019) and the recorded data were pooled to find out the best seed treatment as a control measure for shoot fly incidence and its influence on grain as well as fodder yield of barnyard millet (variety PRJ-1) was estimated. Six different seed dressing treatments viz., imidacloprid 600 FS @ 5ml/kg seed, carbosulfan 25 ST @ 20g/kg seed, neem oil @ 5ml/kg seed, thiamethoxam 70 WS @ 2g/kg seed, acetamiprid 20 SP @ 2g/ kg seed, chloropyriphos 20 EC @ 5ml/kg seed, were imposed on barnyard millet seeds. The pooled data from both the years revealed significant reduction in dead hearts (ranged from 4.38 to 44.44 per cent) across the treatments including untreated control. Minimum (0.46) number of eggs laid per plant was recorded when the seeds were treated with imidacloprid 600 FS @ 5ml/kg seed followed by thiamethoxam 70 WS @ 2g/kg seed (0.53) whereas, maximum (1.69) number of eggs per plant was found in plants raised from untreated seeds. The pooled grain yield data showed 56.97 per cent increase over control when seeds were treated with imidacloprid 600 FS @ 5ml/kg seed along with highest net return (Rs. 47,412.00) and B:C ratio (1.75) which was followed by 46.90 per cent increase in grain yield when seeds were treated with thiamethoxam 70 WS @ 2g/kg seed with net return of Rs. 42,720.08 and B:C ratio 1.58. Two consecutive years’ investigation revealed seed treatment with imidacloprid 600FS @ 5ml/kg as a promising treatment to control the shoot fly damage and at the same time resulted in higher yield of grain and fodder in barnyard millet in Uttarakhand hilly areas.

Keywords: Shoot fly, seed treatment, imidacloprid, thiamethoxam and dead heart

Introduction
Small Millets occupy unique position in hill agriculture. These are the crops of small and marginal farmers requiring little inputs. These crops are considered as gods own crop because they can be cultivated in scarcity conditions. Probably no other crop withstands biotic and abiotic stresses as efficiently as the small millets. Small millets are known for their resilience, which is helpful in adjusting to diverse ecological situations. Small millets grown in India are finger millet, barnyard millet, kodo millet, foxtail millet, proso millet, little millet and brown top millet. Realizing the nutritional superiority of these grains they are now considered as nutri-cereals as they constitute a major source of energy and protein for millions of people. Among these, barnyard millet is an important small millet crop grown in many countries like China, Japan, Malaysia, East Indies, Africa and United States of America. In India, it is grown in Madhya Pradesh, Uttarakhand, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Bihar. It is grown in diverse soils, varying rainfall regimes and in areas widely differing in thermo and photo-periods. Barnyard millet is a major crop grown in hills of Uttarakhand during Kharif season under rainfall conditions by the small and marginal farmers in difficult conditions of cultivation. The resilience exhibited by this crop is helpful in its adjustment to different kinds of ecological niches and have made it quite indispensable to rainfall, fragile, vulnerable, tribal and hilly areas of Uttarakhand where crop substitution is difficult. Although, this crop is known to cope up with abiotic and biotic stresses, nevertheless, under vulnerable conditions some of the insects cause heavy losses and can even damage entire crop. Among the insect-pests harboring barnyard millet crop, shoot fly and stem borer have been found as most damaging insect-pests in Uttarakhand. The shoot fly ranks first among the insect pests that attack millet crop and often resulting in cent per cent loss to the crop. Infestation usually begins during the seedling stage (1-5 leaf stage) and damage occurs at one to four weeks after seedling emergence.
Maggots upon hatching from the eggs bore into the central shoots of seedling and kill the active growing point, producing “Dead Hearts”. They feed on the decaying core of the shoots and subsequently cause death of the central shoot, plant gives out tillers and gets bushy appearance and in some cases the seedlings are killed. Tillers are produced excessively after late attacks \cite{13}. Fletcher \cite{7} for the first time reported its incidence in south India in 1914. Ballard and Rao \cite{6} described some aspects of its behaviors and biology. Shoot fly assumed the status of major pest in 1970s, with the introduction of high yielding hybrids. However, several pre and post emergent insecticides have been recommended for the control of shoot fly \cite{9}. Since, the pest is restricted to seedling stage, it may not be feasible for many farmers to strictly adhere for spray schedule on time, as they are costly and cumbersome and it becomes limiting factor to farmers. Farmers generally ignore strict schedules due to low economic returns from this crop also. It is inevitable to know the best suitable insecticide and simplest application against this insect pest. Keeping all these back drops in focus, the present investigation pertaining to pre emergence control measures through seed treatment with different insecticides for management of shoot fly damage on barnyard millet and its influence on yield and its net return was planned and executed to find out the best treatment.

**Materials and Methods**

The present study was conducted for two consecutive years during Kharif - 2018 and Kharif -2019 with seven treatments including different insecticides and botanical as seed treatment and one control (untreated check i.e. no seed treatment) under the station trial of ICAR- All India Coordinated Research Project on Smal Millets at Entomological Research Block, College of Forestry, Ranichauri, Tehri Garhwal, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand. The experiment was replicated thrice in RBD design, with a row to row distance of 22.5 cm, plant to plant distance 10.00 cm, row length of 3.00 m (with a plot size of 6 m²), recommended dose of FYM @ 10 tonnes/ha was provided before sowing for optimum plant growth.

**Seed treatments**

Seeds were kept in petri plates containing the respective treatment solution for two to three minutes and taken out and dried under shade to about three-four hours. All seeds were sown after proper drying. The experiment consists of seven treatments including control and was replicated thrice. The details of seed treatments used in the present study are as follows:-

T1- Seed treatment with imidacloprid 600 FS @ 5ml/kg of seed  
T2- Seed treatment with carbosulfan 25 ST@ 20g/kg of seed  
T3- Seed treatment with neem oil @ 5ml/kg of seed  
T4- Seed treatment with thiamethoxam 70 WS @ 2g/kg of seed.  
T5- Seed treatment with acetamiprid 20 SP @ 2g/ kg of seed.  
T6- Seed treatment with chloropyriphos 20 EC @ 5ml/kg of seed.  
T7- Control (no seed treatment)

Observations on number of eggs and the infestation or damage per cent caused by shoot fly (dead heart per cent) were recorded per plot.

**Number of eggs**

In each plot, 10 plants were randomly selected and numbers of shoot fly eggs were counted from each plant. Total number of eggs on ten plants (sum of eggs in 10 randomly selected plants) were taken and averaged to represent the eggs present per plant. Egg count was taken at 7, 14 and 21 days after emergence (DAE) of plants.

**Dead hearts (%)**

In each plot, total number of plants and the number of plants showing dead hearts were recorded and per cent dead hearts was calculated by using the following formula:-

\[
\text{Per cent dead hearts} = \frac{\text{Number of plants showing dead hearts}}{\text{Total number of plants in the plot}} \times 100
\]

Per cent decrease in dead hearts over control was calculated by using following formula:-

\[
\text{Per cent decrease in dead hearts over control} = \frac{\text{Treatment} - \text{Control}}{\text{Control}} \times 100
\]

**Benefit: Cost ratio (B:C ratio)**

The benefit-cost ratio of each treatment was calculated taking into account the prevailing market price of inputs, produce and the labour wages. The benefit: cost ratio obtained was worked out by following formula:-

\[
\text{B: C ratio} = \frac{\text{Net return (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}
\]

**Grain yield per hectare (q/ha)**

The grain yield of five earlier tagged plants was added to the grain yield of net plot area for recording the observation of grain yield per plot. The grain yield per ha was calculated in kilograms on the basis of net plot grain yield and finally mentioned as quintal per hectare.

Per cent increase in grain yield over control was calculated by using following formula: -

\[
\text{Per cent increase in yield over control} = \frac{\text{Treatment} - \text{Control}}{\text{Control}} \times 100
\]

**Statistical Analysis**

The data on egg counts, infestation parameters (dead heart %) and yield from individual trials year wise and pooled data were analyzed using STPR 3. The economic analysis of different treatments was done by taking into account the prevailing prices of grain, fodder, cost of treatment and net return.

**Results and Discussion**

The efficacy data in terms of number of eggs and dead hearts against shoot fly obtained over two years (2018 and 2019) were pooled. It reflected that all the seed treatments on variety PRJ -1 varied significantly in efficacy and proved to be superior over untreated control which had the highest infestation (egg deposition and dead heart formation) and lowest yield. The number of eggs was recorded at different interval (7, 14 and 21 DAE) and the pooled data of year 2018 and 2019 on the number of eggs per plant revealed that it
ranged from 0.46-1.69 eggs per plant in all the treatments. A significantly lower proportion of oviposition i.e. eggs deposited per plant was observed in the pooled data recorded from seed treatment with imidacloprid 600 FS @ 5ml/kg of seed (0.33, 0.47 and 0.60 at 7, 14 and 21 DAE respectively) followed by Thiamethoxam 70 WS @ 2g/kg of seed (0.40, 0.50, 0.70 at 7, 14 and 21 DAE respectively) while the maximum oviposition was observed in control (1.37, 1.60 and 2.12 at 7, 14 and 21 DAE respectively) followed by neem oil @ 5ml/kg of seed (0.94, 1.09 and 1.47 at 7, 14 and 21 DAE respectively) as depicted in Table 1.

The extent of dead hearts observed under different synthetic insecticidal and botanical treatments revealed significant differences. The pooled data of 2018 and 2019 as mentioned in Table 2 revealed that all the treatments varied significantly in efficacy and proved superior over control (no seed treatment). Seed treatment with imidacloprid 600 FS @ 5ml/kg of seed proved to be significantly better than all other treatments and showed least dead heart per cent (mean pooled data= 4.38 per cent dead heart) followed by thiamethoxam 70WS @ 2g/kg of seed (mean pooled data= 6.02 per cent dead heart) which was, however, at par with chloropyriphos 20 EC @ 5ml/kg of seed (mean pooled data= 6.11 per cent dead heart). The highest per cent of dead heart was recorded in control (mean pooled data= 44.44 per cent dead heart) which was followed by seed treated with neem oil, in which the mean dead heart per cent was 31.08% (Table 2).

The data pertaining to number of eggs and per cent dead hearts due to shoot fly recorded at different days after emergence of the crop showed increasing trend as the age of the plant increased (Table 1 and Table 2). However, the mean pooled data of two consecutive years on number of eggs per plant and per cent dead heart from observation of all the treatments revealed the superiority of seed treatment with imidacloprid 600 FS @ 5ml/kg of seed followed by thiamethoxam 70 WS @ 2g/kg of seed. The present results are in conformity with Sandhu [14] who suggested that seed treatment with thiamethoxam 30 FS @ 5 ml/kg seed and imidacloprid 600 FS@ 7ml/kg seed were effective in reducing shoot fly incidence. Whereas, Aggarwal et al. [1] reported that mean shoot fly incidence (leaf injury and dead hearts) was significantly lower in imidacloprid 600 FS (8.79% leaf injury and 2.28% dead hearts) and carbofuran 3G (16.96% leaf injury and 7.49% dead hearts) treatments as compared to the incidence in thiamethoxam 30 FS @ 6 g per kg seed (27.97% leaf injury and 15.71% % dead hearts). Mote et al. [11] also reported that the seed treatment with imidacloprid 3% was quite promising in checking the shoot fly incidence during normal sowing period as no dead hearts were noticed. In late sown condition also, the most effective treatment was found imidacloprid 4% and the average numbers of eggs/plant were relatively less in imidacloprid treatment than untreated control [11].

The pooled data (Table 3) of seed yield and fodder yield of all the treatments also revealed superiority of imidacloprid 600 FS @ 5ml/kg of seed amongst all the treatments as imidacloprid 600 FS @ 5ml/kg of seed proved to be the best treatment in reducing infestation of shoot fly and also resulted in increased mean grain yield (23.64 q/ha) and mean fodder yield (109.00 q/ha). It was followed by thiamethoxam 70 WS @ 2g/kg of seed with the mean grain yield of 22.12q/ha and mean fodder yield of 102.00 q/ha and remained at par with chloropyriphos 20 EC @ 5ml/kg of seed with the mean grain yield of 20.80 q/ha and mean fodder yield of 101.00 q/ha. The highest infestation of shoot fly and lowest mean grain yield (15.06 q/ha) and mean fodder yield (81.00 q/ha) was recorded in control (no seed treatment) which was followed by seed treatment with neem oil @ 5ml/kg of seed, with mean grain yield of 15.77q/ha and mean fodder yield of 86.00 q/ha. The present findings are in agreement with the findings of Anon [3] wherein, imidacloprid 70 WS at Hisar, carbofuran 25 ST (160 g/kg of seed) and carbofuran 3G (2g/m row) at Palan proved to be significantly effective in controlling infestation by reducing the dead hearts. Sharma et al. [15] also indicated that imidacloprid emerged as the most effective insecticide to control shoot fly attack which was evident by lowest per cent of dead hearts observed on 21st day. Further, Balikai [5] found that seed treatment with imidacloprid 70 WS @ 10 g/100g seeds recorded the highest yield (29.10 q/ha) followed by carbofuran 3G @ 2 g/m. Again, Balikai [4] reported that seed treatment with imidacloprid 70 WS @ 7 per cent recorded highest yield of 32.4 q/ha followed by imidacloprid 70 WS @ 3.5 per cent seed treatment. Whereas, Karibasavaraja et al. [8] obtained significantly highest yield with seed treatment of thiamethoxam @ 5 g a.i/kg of seed (31.54 q/ha grain yield) and 4 g a.i./kg of seed (30.00 q/ha grain yield).

The economic evaluations in terms of advantages in grain yield and fodder yield along with total return, net return and B:C ratio have been presented in Table 3. Total cost of cultivation of var. PRJ-1 with different seed treatments varied from Rs. 27,000.00/ha to Rs. 27,210.00/ha. The pooled data revealed that the lowest value of total return was Rs. 50,360.00 /ha (control) and the highest value of total return was Rs. 74,520.00 /ha (imidacloprid 600 FS @ 5ml/kg of seed). The value of net return was again highest in treatment with imidacloprid 600 FS @ 5ml/kg of seed (Rs. 47,412.00/ha) and it was recorded lowest in control (Rs. 23,360.00/ha). The benefit per rupee investment was highest (1:1.75) in the seed treatment with imidacloprid 600 FS @ 5ml/kg of seed because of its highest net return. This was followed by seed treatment of thiamethoxam 70 WS @ 2g/kg of seed (1:1.58), chloropyriphos 20 EC @ 5 ml/kg of seed (1:1.47), acetamiprid 20 SP @ 2g/ kg of seed (1:1.32), carbofuran25 ST @ 20g/kg of seed (1:1.21). The benefit per rupee investment was lowest (1:0.87) in control followed by the seed treatment with neem oil @ 5ml/kg of seed (1:0.96). Balikai et al. [4, 5] also recorded higher benefit cost ratio of 1:1.27 due to seed treatment with imidacloprid 70 WS.

Per cent decrease in dead hearts and per cent increase in grain yield over control was highest in seed treatment with imidacloprid 600 FS @ 5ml/kg of seed with 89.99% decreased dead hearts in 2017 and 90.30% in 2018 over control and maximum percent increase in grain yield (55.84% increase in 2018) and 58.10% increase in 2019. It was closely followed by seed treatment with thiamethoxam 70 WS @ 2g/kg of seed with 85.71% decrease in dead hearts over control in 2018 and 87.26% decrease in dead hearts in 2019 and 45.04% increase in grain yield in 2018 & 48.75% increase in grain yield in 2019 (Table 4). Similar to the present findings, Karibasavaraja et al. [8] also reported additional yield over control and higher per cent avoidable losses in thiamethoxam @ 5 g a.i./kg seed (22.95 q/ha and 72.70% respectively) and in thiamethoxam @ 4 g a.i./kg seed (21.42 q/ha and 71.30% respectively) followed by imidacloprid 3 g a.i./ha seeds with respective values of 16.01 q/ha and 65.00 per cent.

Therefore, from the present investigation, it is advocated that the seed treatment before sowing is a useful option to control...
shoot fly damage in barnyard millet. Seed treatment is also useful in achieving higher grain and fodder yield as compared to untreated control. Although all the treatments showed significant reduction in dead heart and significant increase in grain yield and fodder yield over control but imidacloprid 600 FS @ 5ml/kg of seed showed most promising results amongst all the studied treatments during both the studied years. Seed treatment with imidacloprid 600 FS @ 5ml/kg of seed emerged as a good option for the shoot fly control with lesser incidence of dead hearts and higher grain as well as fodder yield. Managing the pest in established barnyard ecosystem through chemical spraying has limited scope as repeated applications of insecticides is required to achieve desirable control level and it may also lead to increase in the cost of production and phyto-toxicity effect on plant foliage. Therefore, seed treatment at the time of sowing may be advocated for shoot fly management as a part of integrated pest management strategy against shoot fly damage in barnyard millet crop in hills of Uttarakhand.

### Table 1: Number of shoot fly eggs recorded per plant in barnyard millet under different seed treatments during Kharif -2018 and Kharif -2019

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Symbol</th>
<th>Treatment details</th>
<th>Dose (ml or g /kg seed)</th>
<th>7 DAE</th>
<th>14 DAE</th>
<th>21 DAE</th>
<th>MEAN</th>
<th>7 DAE</th>
<th>14 DAE</th>
<th>21 DAE</th>
<th>MEAN</th>
<th>Pooled data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₁</td>
<td>Seed treatment with imidacloprid 600 FS.</td>
<td>5ml</td>
<td>0.37 (3.41)</td>
<td>0.53 (4.18)</td>
<td>0.63 (4.56)</td>
<td>0.51 (4.05)</td>
<td>0.28 (2.99)</td>
<td>0.41 (3.65)</td>
<td>0.57 (4.30)</td>
<td>0.42 (3.64)</td>
<td>0.33 (3.25)</td>
</tr>
<tr>
<td>2.</td>
<td>T₂</td>
<td>Seed treatment with carbosulfan 25 ST</td>
<td>20g</td>
<td>0.83 (5.00)</td>
<td>0.97 (5.62)</td>
<td>1.03 (5.55)</td>
<td>0.94 (5.46)</td>
<td>0.67 (4.68)</td>
<td>0.77 (5.02)</td>
<td>0.83 (5.15)</td>
<td>0.75 (5.24)</td>
<td>0.73 (5.24)</td>
</tr>
<tr>
<td>3.</td>
<td>T₃</td>
<td>Seed treatment with neem oil</td>
<td>5ml</td>
<td>0.97 (5.64)</td>
<td>1.17 (6.17)</td>
<td>1.57 (7.15)</td>
<td>1.24 (6.32)</td>
<td>0.90 (5.43)</td>
<td>1.00 (5.65)</td>
<td>1.37 (6.70)</td>
<td>1.09 (5.92)</td>
<td>0.94 (5.54)</td>
</tr>
<tr>
<td>4.</td>
<td>T₄</td>
<td>Seed treatment with thiamethoxam 70 WS</td>
<td>2g</td>
<td>0.43 (3.73)</td>
<td>0.53 (4.17)</td>
<td>0.77 (5.01)</td>
<td>0.58 (4.30)</td>
<td>0.37 (3.46)</td>
<td>0.47 (3.89)</td>
<td>0.63 (4.51)</td>
<td>0.48 (3.95)</td>
<td>0.40 (3.61)</td>
</tr>
<tr>
<td>5.</td>
<td>T₅</td>
<td>Seed treatment with acetamiprid 20 SP</td>
<td>2g</td>
<td>0.76 (5.01)</td>
<td>0.93 (5.53)</td>
<td>1.06 (5.92)</td>
<td>0.92 (5.49)</td>
<td>0.60 (4.43)</td>
<td>0.73 (4.91)</td>
<td>0.83 (5.23)</td>
<td>0.72 (4.85)</td>
<td>0.68 (4.73)</td>
</tr>
<tr>
<td>6.</td>
<td>T₆</td>
<td>Seed treatment with chlorpyriphos 20 EC</td>
<td>5ml</td>
<td>0.73 (4.90)</td>
<td>0.93 (5.4)</td>
<td>1.00 (5.73)</td>
<td>0.89 (5.34)</td>
<td>0.49 (3.98)</td>
<td>0.60 (4.40)</td>
<td>0.73 (4.91)</td>
<td>0.66 (4.85)</td>
<td>0.61 (4.46)</td>
</tr>
<tr>
<td>7.</td>
<td>T₇</td>
<td>Control (no seed treatment)</td>
<td>-</td>
<td>1.60 (4.17)</td>
<td>1.80 (4.43)</td>
<td>2.50 (5.23)</td>
<td>1.97 (4.61)</td>
<td>1.13 (6.09)</td>
<td>1.40 (7.74)</td>
<td>1.73 (6.79)</td>
<td>1.42 (6.79)</td>
<td>1.37 (6.21)</td>
</tr>
</tbody>
</table>

General mean - 4.58 3.09 5.63 - 2.92 3.66 4.36 - 4.54 3.03 5.58 -
SEm - 0.26 0.20 0.26 - 0.15 0.14 0.13 - 0.17 0.23 0.24 -
LSD (0.05) - 0.83 0.64 0.81 - 0.46 0.44 0.41 - 0.53 0.72 0.76 -
CV (%) - 10.19 7.07 8.08 - 8.98 6.74 5.36 - 6.60 8.09 7.69 -

Figures in parenthesis are angular transformed value
DAE= Days after emergence

### Table 2: Dead heart percent due to shoot fly under different seed treatments during Kharif -2018 and Kharif -2019

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Symbol</th>
<th>Treatment details</th>
<th>Dose (ml or g /kg seed)</th>
<th>14 DAE</th>
<th>21 DAE</th>
<th>28 DAE</th>
<th>MEAN</th>
<th>14 DAE</th>
<th>21 DAE</th>
<th>28 DAE</th>
<th>MEAN</th>
<th>Pooled data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₁</td>
<td>Seed treatment with imidacloprid 600 FS.</td>
<td>5ml</td>
<td>2.22 (1.78)</td>
<td>4.63 (2.36)</td>
<td>7.04 (2.81)</td>
<td>4.63 (2.31)</td>
<td>2.04 (1.73)</td>
<td>4.07 (2.24)</td>
<td>6.30 (2.68)</td>
<td>4.14 (2.21)</td>
<td>2.13 (2.30)</td>
</tr>
<tr>
<td>3.</td>
<td>T₃</td>
<td>Seed treatment with neem oil</td>
<td>5ml</td>
<td>18.33 (4.32)</td>
<td>33.52 (5.84)</td>
<td>47.04 (6.92)</td>
<td>32.96 (5.69)</td>
<td>18.70 (4.41)</td>
<td>29.07 (5.47)</td>
<td>39.81 (6.38)</td>
<td>29.19 (5.42)</td>
<td>18.52 (25.24)</td>
</tr>
<tr>
<td>4.</td>
<td>T₄</td>
<td>Seed treatment with thiamethoxam 70 WS</td>
<td>2g</td>
<td>3.89 (2.20)</td>
<td>6.30 (2.69)</td>
<td>9.63 (3.25)</td>
<td>6.61 (2.71)</td>
<td>2.78 (1.93)</td>
<td>5.37 (2.51)</td>
<td>8.15 (3.02)</td>
<td>5.43 (2.48)</td>
<td>3.34 (10.58)</td>
</tr>
<tr>
<td>5.</td>
<td>T₅</td>
<td>Seed treatment with acetamiprid 20 SP</td>
<td>2g</td>
<td>6.11 (2.66)</td>
<td>9.26 (3.20)</td>
<td>13.70 (3.83)</td>
<td>9.69 (3.23)</td>
<td>5.19 (2.48)</td>
<td>7.96 (2.99)</td>
<td>11.67 (3.55)</td>
<td>8.27 (3.03)</td>
<td>5.65 (13.73)</td>
</tr>
<tr>
<td>6.</td>
<td>T₆</td>
<td>Seed treatment with chlorpyriphos 20 EC</td>
<td>5ml</td>
<td>4.07 (2.24)</td>
<td>5.56 (2.55)</td>
<td>9.63 (3.25)</td>
<td>6.42 (2.68)</td>
<td>3.33 (2.07)</td>
<td>5.57 (2.52)</td>
<td>8.70 (3.10)</td>
<td>5.80 (2.56)</td>
<td>3.70 (11.06)</td>
</tr>
<tr>
<td>7.</td>
<td>T₇</td>
<td>Control (no seed treatment)</td>
<td>-</td>
<td>27.78 (5.36)</td>
<td>44.07 (6.71)</td>
<td>66.83 (8.22)</td>
<td>46.23 (6.76)</td>
<td>25.00 (5.09)</td>
<td>41.85 (6.54)</td>
<td>61.11 (7.87)</td>
<td>42.65 (6.50)</td>
<td>26.39 (30.90)</td>
</tr>
</tbody>
</table>

General mean - 3.13 3.94 4.71 - 2.92 3.66 4.36 - 16.63 21.88 27.13 -
SEm - 0.25 0.19 0.18 - 0.15 0.14 0.13 - 1.26 1.12 1.17 -
LSD (0.05) - 0.77 0.59 0.56 - 0.46 0.44 0.41 - 3.90 3.46 3.62 -
CV (%) - 13.89 8.54 6.75 - 8.98 6.74 5.36 - 3.19 8.90 7.50 -

Figures in parenthesis are angular transformed value
DAE= Days after emergence
or all the facilities and resources. The study was carried out under IACR funded All India Coordinated Research Project on Small Millets. We are grateful to the anonymous reviewers for useful critical comments that improved the manuscript and statistical analysis.

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**References**


### Table 3: Pooled data (*Kharif* - 2018 and *Kharif* - 2019) on efficacy of different seed treatments on yield and economics in barnyard millet variety PRJ-1.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Symbol</th>
<th>Treatments</th>
<th>Grain yield (q/ha)</th>
<th>Fodder yield (q/ha)</th>
<th>Value of grain (Rs/ha)</th>
<th>Value of fodder (Rs/ha)</th>
<th>Total return</th>
<th>Net return</th>
<th>B:C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₁</td>
<td>Seed treatment with imidacloprid 600 FS@ 5ml/kg of seed</td>
<td>27.108</td>
<td>109.00</td>
<td>47,270.00</td>
<td>27,250.00</td>
<td>74,520.00</td>
<td>47,412.00</td>
<td>1.75</td>
</tr>
<tr>
<td>2.</td>
<td>T₂</td>
<td>Seed treatment with carbosulfan 25 ST @ 20g/kg of seed</td>
<td>27.210</td>
<td>81.54</td>
<td>37,070.00</td>
<td>23,125.00</td>
<td>56,310.00</td>
<td>32,985.00</td>
<td>1.21</td>
</tr>
<tr>
<td>3.</td>
<td>T₃</td>
<td>Seed treatment with neem oil @ 5 ml/kg of seed</td>
<td>27.066</td>
<td>15.77</td>
<td>31,540.00</td>
<td>21,500.00</td>
<td>53,040.00</td>
<td>25,974.00</td>
<td>0.96</td>
</tr>
<tr>
<td>4.</td>
<td>T₄</td>
<td>Seed treatment with thiamethoxam 70 WS @ 2g/kg of seed</td>
<td>27.019</td>
<td>22.12</td>
<td>44,240.00</td>
<td>25,500.00</td>
<td>69,740.00</td>
<td>42,720.08</td>
<td>1.58</td>
</tr>
<tr>
<td>5.</td>
<td>T₅</td>
<td>Seed treatment with acetamiprid 20 SP @ 2g/kg of seed</td>
<td>27.017</td>
<td>19.49</td>
<td>38,980.00</td>
<td>23,750.00</td>
<td>62,730.00</td>
<td>35,712.72</td>
<td>1.32</td>
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<tr>
<td>6.</td>
<td>T₆</td>
<td>Seed treatment with chloropyriphos 20 EC @ 5 ml/kg of seed</td>
<td>27.012</td>
<td>20.80</td>
<td>41,600.00</td>
<td>25,250.00</td>
<td>66,850.00</td>
<td>39,838.00</td>
<td>1.47</td>
</tr>
<tr>
<td>7.</td>
<td>T₇</td>
<td>Control (no seed treatment)</td>
<td>27.000</td>
<td>15.06</td>
<td>30,110.00</td>
<td>20,250.00</td>
<td>50,360.00</td>
<td>33,360.00</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Market price of grain = Rs. 2000/q
Market price of fodder = Rs. 250/q
Cost of cultivation = [(Cost of land preparation + Cost of fertilizer + Cost of weeding + Cost of harvesting + Cost of labour for all the activities) + Cost of seed treatment]

### Table 4: Per cent decrease in dead hearts and per cent increase in grain yield over control during *Kharif* - 2018 and *Kharif* - 2019

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T₁</td>
<td>Seed treatment with imidacloprid 600 FS@ 5ml/kg of seed</td>
<td>89.99</td>
<td>90.30</td>
<td>90.15</td>
<td>55.84</td>
<td>58.10</td>
<td>56.97</td>
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<tr>
<td>2.</td>
<td>T₂</td>
<td>Seed treatment with carbosulfan 25 ST @ 20g/kg of seed</td>
<td>65.15</td>
<td>75.54</td>
<td>70.35</td>
<td>21.13</td>
<td>25.03</td>
<td>23.08</td>
</tr>
<tr>
<td>3.</td>
<td>T₃</td>
<td>Seed treatment with neem oil @ 5 ml/kg of seed</td>
<td>28.70</td>
<td>31.56</td>
<td>30.13</td>
<td>3.65</td>
<td>5.81</td>
<td>4.73</td>
</tr>
<tr>
<td>4.</td>
<td>T₄</td>
<td>Seed treatment with thiamethoxam 70 WS @ 2g/kg of seed</td>
<td>85.71</td>
<td>87.26</td>
<td>86.49</td>
<td>45.04</td>
<td>48.75</td>
<td>46.90</td>
</tr>
<tr>
<td>5.</td>
<td>T₅</td>
<td>Seed treatment with acetamiprid 20 SP @ 2g/kg of seed</td>
<td>79.04</td>
<td>80.60</td>
<td>79.82</td>
<td>26.67</td>
<td>32.15</td>
<td>29.41</td>
</tr>
<tr>
<td>6.</td>
<td>T₆</td>
<td>Seed treatment with chloropyriphos 20 EC @ 5 ml/kg of seed</td>
<td>86.11</td>
<td>86.40</td>
<td>86.26</td>
<td>33.36</td>
<td>42.81</td>
<td>38.09</td>
</tr>
<tr>
<td>7.</td>
<td>T₇</td>
<td>Control (no seed treatment)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

14. Market price of grain = Rs. 2000/q
15. Market price of fodder = Rs. 250/q
16. Cost of cultivation = [(Cost of land preparation + Cost of fertilizer + Cost of weeding + Cost of harvesting + Cost of labour for all the activities) + Cost of seed treatment]
millets diseases. Project Coordination Cell. All India Coordinated Small Millets Improvement Project. UAS, GKV/K Campus, Bangalore, 2007, 80.

