Assessment and evaluation of different treatment schedules against plant and tuber damage caused by soil pests on potato

Biplab Kahar1*, Amitava Konar2 and Palash Mondal3

Visva-Bharati University, Department of Plant Protection,
P.O. Santiniketan and Faculty of Panchakot Mahavidyalaya, Purulia-723 121, India.

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ABSTRACT
Bio-efficacy of various treatment schedules, viz T1 (phorate + chlorpyriphos + imidacloprid + cartap hydrochloride), T2 (imidacloprid + acephate + chlorpyriphos + cypermethrin), T3 (phorate + chlorpyriphos + azadirachtin + Bacillus thuringiensis var. Kurstaki), T4 (Bacillus thuringiensis var. Kurstaki + azadirachtin), T5 (phorate + imidacloprid + chlorpyriphos + cypermethrin), T6 (phorate + azadirachtin + Bacillus thuringiensis var. Kurstaki) and T7 (control) were evaluated against Agrotis ipsilon (Hufner) and mole cricket, Gryllotalpa africana, P.de. Beau. in single potato variety, Kufi Chandramukhi during rabi season of two potato-growing years in 2013-2014 and 2014-2015 from November to February. The percentage of plant (shoot) damage was found low in T1 (5.82 – 5.87%), than by T2 (6.12 – 6.49%), T3 (6.86 – 6.92%), T4 (7.31 – 7.62%), T5 (8.21 – 8.81%), T6 (8.61 – 9.32%) and T7 (10.70 – 11.13%) respectively. Similarly percentage of tuber damage of potato was noted highest in T7 (34.29 – 43.90 %) and it was lowest in T1 (13.15 – 15.66 %). Maximum marketable yield (t/ha) of potato tubers was obtained in T1 (26.28 – 26.80 t/ha), which was succeeded by T2 (26.19 – 26.92 t/ha) than other treatments and it was recorded minimum in control T7 (11.17 – 12.69 t/ha). Maximum cost-benefit ratio (CBR) was recorded in T1 (1:2.03 – 1:2.04) while it was found minimum in T6 (1:1.11 – 1:1.17). Among the different treatment schedules T1 and T2 were most effective in increasing marketable yield of potato tubers and reduction of soil pest incidence over control T7 and also over other treatments.

Key words: Damage, Effectiveness, Insecticidal treatment, Potato, Soil pest, Yield.

INTRODUCTION
Among the vegetable crops, the family solanaceae forms an important group, which includes potato (Solanum tuberosum L.) along with other essential vegetables of our daily diet. Potato is the fourth most important food crop in the world after wheat, rice and maize in terms of production and India loses about 30% of its crops every year due to pests and diseases (Sharma and Rao, 2012). The insect pests inflict crop losses to the tune of 40 per cent in vegetable production (Simpson, 1977). Among these insect pests, cutworm, Agrotis ipsilon (Hufner) (Noctuidae: Lepidoptera); Mole cricket, Gryllotalpa africana, P.de. Beau. (Gryllotalpidae: Orthoptera) and potato tuber moth (PTM), Phthorimaeae operculilla (Zeller) (Gelechiidae: Lepidoptera) are the most important soil pests cause tuber damage, as a result to reduce more than yield of potato tubers. In addition to tubers, they also cause damage to the foliage of the crop (Konar et al. 2003; Konar and Paul, 2005). They cut the tender shoots near the ground level and feed on the cutted

1*Corresponding author’s e-mail: biplab.kahar1984@gmail.com
2Visva-Bharati University, Department of Plant Protection, P.O. Santiniketan, and Faculty of Panchakot Mahavidyalaya, Purulia, West Bengal, India.
3Bidhan Chandra Krishi Viswavidyalaya, Department of Agricultural Entomology, P.O. Mohanpur, West Bengal, India.
4Visva-Bharati University, Department of Plant Protection, P.O. Santiniketan, West Bengal, India.
leaves. Therefore, to minimize shoot damage and tuber damage caused by soil pests on potato, a number of synthetic insecticides are applied randomly, but with limited success. Therefore, keeping in view, the present investigation was conducted to assess the efficacy of different treatment schedules against soil pests of potato.

**MATERIALS AND METHODS**

The present field investigation was undertaken to find out the bio-efficacy of different insecticidal treatment schedules against shoot and tuber damage caused by soil pests on potato (Kufri chandramukhi) for two potato growing seasons from November to February in 2013-2014 and 2014-2015, at District Seed Farm (situated at 23.2324° N latitude 87.8615° E longitudes and 30 m altitude above mean sea level), Department of Agriculture, Government of West Bengal, P.O. - Burdwan, Dist. – Burdwan, West Bengal. Potato seed tubers of cv. Kufri chandramukhi was planted in late November in randomized block design (RBD). All standard agronomic practices, recommended for the state, were strictly followed during raising the crop (Anonymous, 2012). The crop was dehaulmed at an age of 85 days and 10 days after dehaulming, potato tuber was harvested from the field.

During the crop season, after seedling weekly observations were recorded on the shoot damage on potato caused by soil pests in each plot. The percentage of plant damage (on the basis of cutted leaves and shoots) by soil pests (cutworm, mole cricket and PTM) was worked out accordingly. Similarly the extent of infestation in tuber by different soil pests was recorded by counting the number of healthy and damaged tubers in each plot at the time of harvesting. The weight of healthy and damaged tubers for each treatment were also taken and thereafter, the data were analyzed after converting them into necessary forms.

### Table 1: Insecticidal treatment schedules against soil pests of potato

<table>
<thead>
<tr>
<th>Treatment Schedules</th>
<th>Insecticides with dose and time of application</th>
</tr>
</thead>
</table>
| T<sub>1</sub> | 1. Soil application of phorate 10 G @ 1.5 kg a.i/ha at planting.  
2. Foliar sprays with chlorpyrifos 20 EC @ 2.5 ml/l water at 40 DAP.  
3. Foliar sprays with Imidacloprid 17.8 SL @ 1.5 ml/7.5 l water at 55 DAP.  
4. Foliar sprays with cartap hydrochloride 50 SP @ 1 g/l of water at 70 DAP. |
| T<sub>2</sub> | 1. Seed treatment with imidacloprid 17.8 SL @ 1.5 ml/7.5 l water at planting.  
2. Foliar sprays with acephate 75 SP @ 0.75 g/l water at 40 DAP.  
3. Foliar sprays with imidacloprid 17.8 SL @ 1.5 ml/7.5 l water at 55 DAP.  
4. Foliar spray with chlorpyrifos 20 EC + Cypermethrin 5 EC @ 1.5 ml/l water at 70 DAP. |
| T<sub>3</sub> | 1. Soil application of phorate 10 G @ 1.5 kg a.i./ha at planting.  
2. Foliar spray with chlorpyrifos 20 EC @ 2.5 ml/l water at 40 DAP.  
3. Foliar spray with azadirachtin 1 EC @ 4 ml/l water at 55 DAP.  
4. Foliar spray with *Bacillus thuringiensis* var. *Kurstaki* 5 WP @ 2.0 g/l water at 70 DAP. |
| T<sub>4</sub> | 1. Seed treatment with *Bacillus thuringiensis* var. *Kurstaki* 5 WP @ 2.0 g/l water at planting.  
2. Foliar spray with azadirachtin 1 EC @ 4 ml/l water at 40 DAP.  
3. Foliar spray with azadirachtin 1 EC @ 4 ml/l water at 55 DAP.  
4. Foliar spray with *Bacillus thuringiensis* var. *Kurstaki* 5WP @ 2.0 g/l water at 70 DAP. |
| T<sub>5</sub> | 1. Soil application of phorate 10 G @ 1.5 kg a.i./ha at 30 DAP.  
2. Foliar sprays with imidacloprid 17.8 SL @ 1.5 ml/7.5 l water at 55 DAP.  
3. Foliar spray with chlorpyrifos 20 EC + Cypermethrin 5 EC @ 1.5 ml/l water at 70 DAP. |
| T<sub>6</sub> | 1. Soil application of phorate 10 G @ 1.5 kg a.i./ha at 40 DAP.  
2. Foliar spray with azadirachtin 1 EC @ 4 ml/l water at 55 DAP.  
3. Foliar spray with *Bacillus thuringiensis* var. *Kurstaki* 5WP @ 2.0 g/l water at 70 DAP. |
| T<sub>7</sub> | 1. Only water spray (control) |
RESULTS AND DISCUSSION

Per cent plant (shoot) and tuber damage caused by soil pests on potato under different treatment schedules:

In the first year (2013-14) of study, the per cent plant emergence was highest in T₁ (94.32%) and lowest in T₇ (93.21%) in response to different schedules (T₁-T₇) (Table 2). The percentage of shoot and tuber damage by the soil pests like cutworm, mole cricket, potato tuber moth (PTM) was maximum in T₁ (10.70% and 34.29%, respectively) where as shoot damage was minimum in T₅ (5.87%) and tuber damage was minimum in T₂ (13.15%) (Table 2).

In the second year of study during 2014-2015, the percent plant emergence was highest in T₁ (94.07%) and lowest in T₃ (93.17%) in response to different schedules (T₁-T₉) (Table 2). The percentage of shoot and tuber damage by the soil pests was maximum in T₁ (11.13% and 43.90%, respectively) where as shoot damage was minimum in T₇ (5.82%) and tuber damage was minimum in T₂ (15.66%) (Table 2).

Economics of different insecticidal treatment schedules against plant and tuber damage caused by soil pests: The marketable tuber yield (t/ha) of potato in 2013-2014 was found highest in Tₗ (26.28 t/ha) and lowest in T₇ (12.69 t/ha) (Table 3). Maximum cost-benefit ratio (CBR) was found in Tₗ (1:2.02) and was minimum in T₅ (1:1.11) (Table 3).

During 2014-15 the highest marketable yield (t/ha) of potato tuber was found in Tₗ (26.80 t/ha) and lowest in T₇ (11.17 t/ha) (Table 3). Maximum CBR was found in T₅ (1:1.99) and was minimum in T₇ (1:1.17) (Table 3).

Percent plant (shoot) and tuber damage caused by soil pests on potato under different treatment schedules: In the first year (2013-14) of study, the percent plant emergence was insignificant with each other [F_Calculated (6,12 df) is 2.93] (Table 2). In 2014-15 emergence was also insignificant with each other [F_Calculated (6,12 df) is 2.97] (Table 2). In 2013-14, percent shoot and tuber was significant among the treatment schedules [F_Calculated (6,12 df) is 3.16 and 3.26 respectively] (Table 2). Similarly in 2014-15, percent shoot and tuber was also significant among the treatment schedules [F_Calculated (6,12 df) is 3.43 and 3.18, respectively] (Table 2).

It was observed from the both years of study, that the percentage of plant damage was minimum in T₁ (5.82 – 5.87) and maximum in T₇ (10.70 – 11.13). Because in T₁, the crop was protected from planting to harvesting by chemical insecticides which were both contact (chlorpyrifos

Table 2: Efficacy of different treatment schedules against the soil pests causing shoot and tuber damage of potato during 2013-14 and 2014-15

<table>
<thead>
<tr>
<th>Treatment Schedules</th>
<th>Mean Plant Emergence (%)</th>
<th>Mean Shoot Damage (%)</th>
<th>Mean Tuber damage (%)</th>
<th>Pooled Mean (Shoot+Tuber damage) % Reduction Over Control#</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>94.32</td>
<td>93.21</td>
<td>93.77</td>
<td>5.87</td>
</tr>
<tr>
<td></td>
<td>(76.21*)</td>
<td>(74.90*)</td>
<td>(75.55*)</td>
<td>(14.02*)</td>
</tr>
<tr>
<td>T₂</td>
<td>93.89</td>
<td>92.86</td>
<td>93.38</td>
<td>6.92</td>
</tr>
<tr>
<td></td>
<td>(75.69*)</td>
<td>(74.50*)</td>
<td>(75.09*)</td>
<td>(15.24*ab)</td>
</tr>
<tr>
<td>T₃</td>
<td>93.21</td>
<td>93.37</td>
<td>93.29</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td>(74.90*)</td>
<td>(75.08*)</td>
<td>(74.99*)</td>
<td>(14.75*ab)</td>
</tr>
<tr>
<td>T₄</td>
<td>93.71</td>
<td>94.07</td>
<td>93.89</td>
<td>7.61</td>
</tr>
<tr>
<td></td>
<td>(75.48*)</td>
<td>(75.91*)</td>
<td>(75.69*)</td>
<td>(17.06*)</td>
</tr>
<tr>
<td>T₅</td>
<td>93.97</td>
<td>93.68</td>
<td>93.83</td>
<td>7.62</td>
</tr>
<tr>
<td></td>
<td>(75.79*)</td>
<td>(75.44*)</td>
<td>(75.62*)</td>
<td>(16.02*bc)</td>
</tr>
<tr>
<td>T₆</td>
<td>93.58</td>
<td>93.88</td>
<td>93.73</td>
<td>8.21</td>
</tr>
<tr>
<td></td>
<td>(75.32*)</td>
<td>(75.68*)</td>
<td>(75.50*)</td>
<td>(16.64*)</td>
</tr>
<tr>
<td>T₇</td>
<td>94.17</td>
<td>93.17</td>
<td>93.67</td>
<td>10.70</td>
</tr>
<tr>
<td></td>
<td>(76.03*)</td>
<td>(74.85*)</td>
<td>(75.43*)</td>
<td>(19.09*)</td>
</tr>
<tr>
<td>SEM</td>
<td>0.46</td>
<td>0.53</td>
<td>0.34</td>
<td>0.43</td>
</tr>
<tr>
<td>F_Calculated (6,12 df)</td>
<td>2.93NS</td>
<td>2.97NS</td>
<td>2.88NS</td>
<td>3.16*</td>
</tr>
</tbody>
</table>

NS: Non-significant at p<0.05; *: Significant at p<0.05; Figures in parentheses indicate angular transformed values

In a column, means followed by same letter are not significantly different by DMRT (p<0.05)

#: (Control-Treatment)x100/Treatment
Table 3: Cost effectiveness of different treatment schedules against the soil pests of potato during 2013-14 and 2014-15

<table>
<thead>
<tr>
<th>Treatment Schedules</th>
<th>Cost of Production (Rs/ha)</th>
<th>Net Gain (Rs/ha)</th>
<th>CBR</th>
<th>Cost-Benefit ratio</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>45,038</td>
<td>41,207</td>
<td>110,016</td>
<td>115,930</td>
<td>115.35</td>
</tr>
<tr>
<td>T₂</td>
<td>44,228</td>
<td>41,463</td>
<td>126,144</td>
<td>131,590</td>
<td>122.65</td>
</tr>
<tr>
<td>T₃</td>
<td>44,940</td>
<td>41,795</td>
<td>104,016</td>
<td>109,420</td>
<td>84.56</td>
</tr>
<tr>
<td>T₄</td>
<td>43,968</td>
<td>41,139</td>
<td>92,112</td>
<td>97,326</td>
<td>62.00</td>
</tr>
<tr>
<td>T₅</td>
<td>44,553</td>
<td>41,856</td>
<td>82,600</td>
<td>87,812</td>
<td>50.97</td>
</tr>
<tr>
<td>T₆</td>
<td>44,182</td>
<td>41,978</td>
<td>72,000</td>
<td>77,212</td>
<td>42.54</td>
</tr>
<tr>
<td>T₇</td>
<td>41,297</td>
<td>39,363</td>
<td>62,500</td>
<td>67,708</td>
<td>36.54</td>
</tr>
</tbody>
</table>

2014-15

<table>
<thead>
<tr>
<th>Treatment Schedules</th>
<th>Cost of Production (Rs/ha)</th>
<th>Net Gain (Rs/ha)</th>
<th>CBR</th>
<th>Cost-Benefit ratio</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>25,555</td>
<td>24,163</td>
<td>26,54a</td>
<td>32,090</td>
<td>25.92a</td>
</tr>
<tr>
<td>T₂</td>
<td>26,333</td>
<td>24,875</td>
<td>19,444</td>
<td>24,990</td>
<td>22.00b</td>
</tr>
<tr>
<td>T₃</td>
<td>19,444</td>
<td>17,978</td>
<td>19,444</td>
<td>19,444</td>
<td>19.31c</td>
</tr>
<tr>
<td>T₄</td>
<td>24,467</td>
<td>23,000</td>
<td>19,444</td>
<td>24,467</td>
<td>24.67d</td>
</tr>
<tr>
<td>T₅</td>
<td>18,667</td>
<td>17,197</td>
<td>19,444</td>
<td>18,667</td>
<td>18.66e</td>
</tr>
<tr>
<td>T₆</td>
<td>12,694</td>
<td>11,197</td>
<td>12,694</td>
<td>12,694</td>
<td>12.69f</td>
</tr>
<tr>
<td>T₇</td>
<td>12,694</td>
<td>11,197</td>
<td>12,694</td>
<td>12,694</td>
<td>12.69f</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td></td>
<td>0.51</td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td>F(5,12)</td>
<td></td>
<td></td>
<td>3.11</td>
<td>3.27</td>
<td>3.18</td>
</tr>
</tbody>
</table>

Economics of different insecticidal treatment schedules against plant and tuber damage caused by soil pests:

Among the seven treatment schedules, T₂ and T₅ were most effective treatment schedules by recording the highest tuber yield (26.28 – 26.80 and 24.25 – 24.67 t/ha respectively). The marketable yields was significant among the seven treatment schedules [F(6,12) = 3.11 and 3.27, respectively] (Table 3).

From the result of the present field study it might be said that among the different treatment schedules, T₂ and T₅ were most effective in increasing marketable yield of potato tubers and net profit over control than other treatments. The results of Tripathi et al. 2003 support the findings of the present study.

CONCLUSION

It can be concluded from the both years (2013-2014 and 2014-2015) of study, that the per cent reduction of plant (shoot) plus tuber damage by the soil pests was highest and most effective in T₂ (134.84%) (Table 3) over control T₇, and also may be concluded from the results of both the years that all the chemical treatment schedules were significantly and cartap hydrochloride) and systemic (phorate and imidacloprid) in nature. Konar et al. (2003) also recorded lower plant damage, when the crop was treated with phorate and chlorpyriphos individually. Next to T₁, T₃ was most effective against the soil pests due to application of chemical insecticides during early growth stage, when the intensity of damage by soil pest (cutworm) was high (Konar and Mohasin, 2003). Similarly T₂ and T₅ were more or less equally suffered by pests and among these T₂ (6.86 – 6.92 percent plant damage) was slightly better than T₅ (7.31-7.62 per cent plant damage). This is because of the fact that in T₅, the crop remained unsprayed up to 40 DAP. Spraying of chlorpyriphos at 40 DAP in T₂ was more effective than seed treatment with chlorpyriphos at planting in T₅. The other treatment schedules, which were consisting of mainly bio-pesticides, were not so effective in minimizing the plant damage, caused by soil pests. The finding were in agreement with those of reported earlier by Konar et al. (2003); Konar and Chettri, (2003).

It can be said from the results of both the years that all the treatment schedules were significantly superior over control in reducing the tuber damage caused by soil pests. Out of seven treatment schedules, T₂ and T₅ were most effective treatment schedules by recording less percentage of tubers damage (13.15 – 15.66 and 13.31 – 16.09 per cent respectively). It was because of the fact that in both the schedules phorate and chlorpyriphos were applied along with other chemical insecticides and it was reported by Konar et al. 2003; Konar et al. 2005 and Konar and Paul, 2005; that only chlorpyriphos and phorate plus chlorpyriphos achieved better result in reducing the tuber damage caused by cutworm and mole cricket.
superior over control and also over the bio-pesticide treatment in reducing the tuber damage caused by soil pests. From the result of the present field study it can be concluded that among the different treatment schedules, T5 and T2 were most effective in increasing marketable yield of potato tubers and net profit over control than other treatments.

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