Assessment of efficacy of pesticides applied singly and in combination on rice sheath blight disease development

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ABSTRACT: Efficacy of commonly used pesticides namely carbendazim (0.1%), hexaconazole (0.1%), endosulfan (0.042%), chlorpyriphos (0.02%), thiobencarb (0.3%) and butachlor (0.4%) applied singly and in combination were evaluated against rice sheath blight (Rhizoctonia solani), during kharif 2010 and 2011 under pot culture conditions. Among the various pesticide combinations, carbendazim (0.1%) applied along with endosulfan (0.042%) was found to be the most effective against sheath blight, where the lowest mean disease severity was 17.36% and the relative vertical spread (RVS) was 14.18%. This combination increased the grain yield and straw yield by 85.68% and 111.73%, respectively in comparison to R. solani inoculated control without any pesticide. This was followed by hexaconazole (0.1%) combined with endosulfan (0.042%), where the mean disease severity was 19.84% and the relative vertical spread was 16.34%. It increased the grain yield by 72.21% and straw yield by 104.37% when compared to R. solani inoculated control without any pesticide. In case of individual application of carbendazim, the mean disease severity and relative vertical spread were observed to be 24.81% and 22.37%, respectively. Per cent increase in grain yield and straw yield were recorded as 29.86% and 61.94%, respectively. Treatment with hexaconazole alone reduced the mean disease severity up to 27.71% and relative vertical spread of 25.06%. It increased grain yield up to 28.10% and straw yield up to 60.35%. Thus, it is evident that, combined application of pesticides not only shows higher efficacy in controlling the disease, but also increases grain yield and straw yield.

Key words: Disease severity, pesticides, relative vertical spread, rice, sheath blight, yield parameters

Rhizoctonia solani Kuhn., is a soil borne fungus and genetically a diverse causal agent of rice sheath blight that occurs in all rice production regions of the world (Ou, 1985; Savary et al., 2006). With the introduction of high yielding rice cultivars, the crop is prone to attack by several diseases, among which sheath blight have assumed serious problem in the last few decades (Lore et al., 2009). In terms of economic concern and food security, it causes up to 25% yield losses (Kumar et al., 2009). Steps taken to develop resistant cultivars through conventional as well as molecular breeding techniques for sheath blight could not be very encouraging (Lin et al., 1995; Liu et al., 2013). Hence, the management of the versatile disease is very difficult not only because of its complexity but also its wide host range and its high competitive saprophytic ability.

The practice of cultural and biological methods in subsiding the sheath blight disease occurrence and its severity is also not promising due to its wider negativities. Hence pesticides (fungicides, insecticides and herbicides) are used as an alternative weapon to counteract the problems caused by R. solani. Pesticides are applied concurrently against biotic constraints of rice production in intensive agriculture. It is well known that when pesticides are applied to plants and soil to control pests, diseases or weeds they affect soil properties, microorganisms and hosts, thereby influencing the disease incidence (Aktar et al., 2009). Under such situation, it is essential to know the interaction between various pesticides for effective management of diseases.

Various studies under Indian conditions proved that carbendazim and hexaconazole are the more efficient systemic fungicides in controlling rice sheath blight disease (Lore et al., 2012; Kumar et al., 2009). Other than fungicides, certain herbicides or insecticides also show inhibition of R. solani under in vitro as well as field conditions (Prakash et al., 2013; Hua et al., 2002). In these studies, emphasis has been given to the individual effects, but not the combined effects of the pesticides. Therefore, an understanding on the interactive influence of various pesticides used in rice culture on sheath blight is essential for devising effective management approaches to reduce the damage caused by the disease. In the present study, the effect of some selected fungicides, insecticides and herbicides on rice sheath blight was investigated, so as to frame a comprehensive methodology in utilization of pesticides especially in an integrated and sustainable manner in combating the disease.

MATERIALS AND METHODS

Mass multiplication of inoculum

Virulent isolate of R. solani Kuhn. (RS-4500) fungal culture was mass multiplied on Typha grass (Bhaktavasalam et al., 1978). Typha stem pieces of 4-5cm long were washed thoroughly and soaked in a peptone sucrose solution for 5 minutes. Then they were placed loosely to one third volume of 500 ml Erlenmeyer flask and double autoclaved at 121°C for 20 minutes for two consecutive days. The sterilized Typha pieces were
inoculated with 7mm diameter PDA disc of actively growing mycelia of *R. solani* and incubated for 15 days. These colonized *Typha* pieces were used as an inoculum for further experiments.

**Pot culture experiment**

Commonly used fungicides (carbendazim, hexaconazole), insecticides (endosulfan, chlorpyriphos) and herbicides (thiobencarb, butachlor) were selected for testing their efficacy singly and in combination, against sheath blight disease of rice crop grown in pots under glasshouse conditions in Division of Plant Pathology, ICAR-IARI, New Delhi. The treatments were replicated thrice using completely randomized design (Table 1).

**Method of inoculation**

The seedlings of Pusa Basmati-1 were raised in the nursery and after 21 days, transplanting was done in 30 cm earthen pots (5 seedlings/pot). Judicious water supply and recommended fertilizers were provided to maintain the seedlings in the glasshouse. The plants at the maximum tillering stage (45 DAT) were inoculated with colonized water sedge (*Typha angustata*) pieces multiplied. Two to three pieces of colonized *Typha* pieces were placed between tillers in the central region of rice

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Disease severity (%)</th>
<th>Mean of 2010 and 2011</th>
<th>% reduction over control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 DAI 35 DAI 20 DAI 35 DAI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2010</td>
<td>2011</td>
</tr>
<tr>
<td>T1: Carbendazim (0.1%)</td>
<td>21.26(27.47) a</td>
<td>26.16(30.83) a</td>
<td>23.41(28.95) a</td>
</tr>
<tr>
<td>T2: Hexaconazole (0.1%)</td>
<td>23.43(28.97) a</td>
<td>29.33(32.80) a</td>
<td>26.58(31.05) a</td>
</tr>
<tr>
<td>T3: Endosulfan (0.042%)</td>
<td>30.64(33.63) b</td>
<td>38.04(38.10) b</td>
<td>32.22(34.60) b</td>
</tr>
<tr>
<td>T4: Chlorpyriphos (0.02%)</td>
<td>33.49(35.38) c</td>
<td>45.69(42.64) c</td>
<td>30.21(33.36) c</td>
</tr>
<tr>
<td>T5: Butachlor (0.3%)</td>
<td>41.59(40.18) d</td>
<td>55.79(48.88) d</td>
<td>38.40(38.32) d</td>
</tr>
<tr>
<td>T6: Thiobencarb (0.4%)</td>
<td>43.71(41.41) e</td>
<td>62.21(52.10) e</td>
<td>45.34(42.35) e</td>
</tr>
<tr>
<td>T7: Carbendazim (0.1%) + endosulfan (0.042%)</td>
<td>14.32(22.25) a</td>
<td>16.62(24.07) a</td>
<td>18.25(25.31) a</td>
</tr>
<tr>
<td>T8: Carbendazim (0.1%) + chlorpyriphos (0.02%)</td>
<td>19.76(26.40) a</td>
<td>24.66(29.79) a</td>
<td>22.92(26.61) a</td>
</tr>
<tr>
<td>T9: Carbendazim (0.1%) + butachlor (0.3%)</td>
<td>21.51(27.65) c</td>
<td>26.11(30.46) c</td>
<td>24.54(29.71) c</td>
</tr>
<tr>
<td>T10: Carbendazim (0.1%) + thiobencarb (0.4%)</td>
<td>18.47(25.47) c</td>
<td>20.26(26.76) c</td>
<td>22.59(26.39) c</td>
</tr>
<tr>
<td>T11: Hexaconazole (0.1%) + endosulfan (0.042%)</td>
<td>17.26(24.56) b</td>
<td>18.43(25.43) b</td>
<td>20.34(26.82) b</td>
</tr>
<tr>
<td>T12: Hexaconazole (0.1%) + chlorpyriphos (0.02%)</td>
<td>21.68(27.77) f</td>
<td>26.58(31.05) f</td>
<td>24.30(29.55) f</td>
</tr>
<tr>
<td>T13: Hexaconazole (0.1%) + butachlor (0.3%)</td>
<td>23.18(28.80) b</td>
<td>29.08(32.65) b</td>
<td>26.68(31.11) b</td>
</tr>
<tr>
<td>T14: Hexaconazole (0.1%) + thiobencarb (0.4%)</td>
<td>24.48(29.67) h</td>
<td>29.28(32.77) h</td>
<td>26.63(31.08) h</td>
</tr>
<tr>
<td>T15: Endosulfan (0.042%) + chlorpyriphos (0.02%)</td>
<td>30.22(33.37) c</td>
<td>37.62(37.85) c</td>
<td>31.57(34.21) c</td>
</tr>
<tr>
<td>T16: Endosulfan (0.042%) + butachlor (0.3%)</td>
<td>33.40(35.32) a</td>
<td>41.60(40.18) a</td>
<td>34.46(35.96) a</td>
</tr>
<tr>
<td>T17: Endosulfan (0.042%) + thiobencarb (0.4%)</td>
<td>37.52(37.79) b</td>
<td>46.82(43.20) b</td>
<td>34.48(35.98) b</td>
</tr>
<tr>
<td>T18: Chlorpyriphos (0.02%) + butachlor (0.3%)</td>
<td>33.59(35.43) b</td>
<td>45.79(42.60) b</td>
<td>37.24(37.62) b</td>
</tr>
<tr>
<td>T19: Chlorpyriphos (0.02%) + thiobencarb (0.4%)</td>
<td>42.53(40.73) c</td>
<td>54.73(47.74) c</td>
<td>38.92(38.62) c</td>
</tr>
<tr>
<td>T20: Butachlor (0.3%) + thiobencarb (0.4%)</td>
<td>45.74(42.58) b</td>
<td>59.94(50.76) b</td>
<td>40.41(39.49) b</td>
</tr>
<tr>
<td>T21: Inoculated control</td>
<td>53.20(46.86) e</td>
<td>67.50(55.28) e</td>
<td>56.73(48.90) e</td>
</tr>
</tbody>
</table>

SE(d) 0.113 0.729 0.767 0.687
CD (0.05%) 0.227 1.472 0.276 1.549 1.387

#Figure in parentheses are arcsine transformed values; Figures followed by the same alphabetical letters are not significant by DMRT

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hills, just above the water level. All agronomic practices were followed as per the standard requirement. High relative humidity was maintained 24 hrs prior and after inoculation by covering the plants with polyethylene sheets which were profusely sprayed with water. Five days after inoculation, the selected pesticides were sprayed (individually and in combination) at commercially recommended dose. The plants inoculated with pathogen alone and not sprayed with any pesticide served as control. Water level was maintained constantly for ensuring optimum humidity to facilitate disease development.

Observations recorded

The vertical spread of lesion (cm) was recorded from base of the plant to the crown level of the sheath at 20 and 35 days after inoculation (DAI). The relative vertical spread (RVS) and disease severity were recorded by following scale of IRRI (1996). Yield attributing parameters were also assessed by recording grain yield/pot, straw yield/pot and 1000 grain weight.

Relative vertical spread

The vertical spread and total plant height were measured and relative vertical spread (RVS) was calculated using the formula given by Ahn et al. (1986).

\[
\text{RVS} = \frac{\text{Vertical spread}}{\text{Plant height}} \times 100
\]

Rice sheath blight grade chart (IRRI, 1996)

<table>
<thead>
<tr>
<th>Disease grade</th>
<th>Vertical spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No infection observed</td>
</tr>
<tr>
<td>1</td>
<td>Lesion limited to lower 20 per cent of the height of the plant</td>
</tr>
<tr>
<td>3</td>
<td>Lesion limited to 21-30 per cent of the height of the plant</td>
</tr>
<tr>
<td>5</td>
<td>Lesion limited to 31-45 per cent of the height of the plant</td>
</tr>
<tr>
<td>7</td>
<td>Lesion limited to 46-65 per cent of the height of the plant</td>
</tr>
<tr>
<td>9</td>
<td>Lesion more than 65 per cent of the height of the plant</td>
</tr>
</tbody>
</table>

Disease severity

The severity of the disease was calculated by using the following formula (Mew et al., 1985).

\[
\text{Severity} = \frac{0(N0)+5(N1)+10(N3)+30(N5)+50(N7)+100(N9)}{\text{Total number of tillers observed}}
\]

where,

N0-N9 = Number of tillers classified as grade 0-9

Statistical analysis

The observations recorded in the various experiments of this study were statistically analysed by SPSS statistical package.

RESULTS AND DISCUSSION

Effect of pesticides applied singly and in combination on disease severity and yield parameters

The experimental results obtained during 2010 and 2011 clearly delineates that the application of a fungicide (carbendazim) combined with insecticide (endosulfan) followed by another fungicide (hexaconazole) combined with insecticide (endosulfan) as effective in reducing disease severity, relative vertical spread and augmented grain yield as well as straw yield.

Individual application of fungicides, carbendazim and hexaconazole reduced disease severity up to 59.74% and 55%, respectively. These fungicides additionally diminished RVS of 60.58 and 55.86%. It also increased grain yield (29.86% and 28.10%) and straw yield (61.94% and 60.35%), respectively when contrasted with unsprayed inoculated control.

A combination of fungicide (carbendazim) and insecticide (endosulfan) proved more efficacious in controlling sheath blight disease. This combination reduced disease severity up to 71.87%, RVS up to 75% furthermore indicated significant increase in grain yield of 85.68% and straw yield to 111.73%. This was trailed by another combination of fungicide (hexaconazole) with insecticide (endosulfan), which recorded 67.84% reduction in disease severity, 71.11% reduction in RVS and expanded grain yield up to 72.21% and straw yield up to 104.37% when compared to inoculated control without any pesticide.

Results recorded in other combination of insecticides with fungicides (carbendazim + chlorpyriphos, hexaconazole + chlorpyriphos) and herbicides with fungicides (carbendazim + butachlor, carbendazim + thiobencarb, hexaconazole + butachlor, hexaconazole + thiobencarb) were at par with individual treatments of carbendazim and hexaconazole on disease severity and RVS of sheath blight as well as yield parameters of rice. The insecticides, (endosulfan, chlorpyriphos) and herbicides, (butachlor, thiobencarb) which were applied individually as well as in combination between (insecticides + herbicides) and within themselves (insecticides + insecticides, herbicides + herbicides) showed some effect on sheath blight disease development and recorded the results in the range of 12.42 to 42.97% on disease severity and 2.65 to 31.65% on RVS but no effect on yield parameters when compared with inoculated control (Table 1, Fig. 1,2). In both seasons (2010 and 2011) of pot culture experiments, there was no significant increase in the 1000 grain weight irrespective of the treatments.

The cultivated and wild rice genotypes do not possess complete resistance to sheath blight disease. Even the attempts with biological and cultural methods prove unyielding results. Hence, alternative and cost effective methodology like use of chemical pesticides gains advantage for controlling the disease as expected.
In case of integrated pest management, farmers are advised to have combined approach as occurrence of disease and pests together in rice demands the necessity of fungicidal, insecticidal and herbicidal application at the same place and time. In many endemic areas, sheath blight, brown planthopper (BPH), leaf folder and stem borer occur at the same stage of crop growth. In addition, weeds are plenty during whole rice season. Hence, combined application of fungicides, insecticides and herbicides in an effective and efficient manner is the need of hour to overcome the complexity.

Even, the compounds used together in this study have been reported to have advantage of synergism, additive effects and also enhance the efficacy level of individual compounds together (Thind, 2012). In view of this, attempts have made in this study to assess the effect of pesticides in various combinations on sheath blight disease development. Carbendazim as an effective foliar fungicide in controlling Rhizoctonia diseases in other crops including sheath blight of rice (Ali and Archer, 2003; Kumar et al., 2009; Lore et al., 2012; Divya et al., 2013; Patro and Madhuri, 2014). Certain insecticides (endosulfan, chlorpyriphos) and herbicides (thiobencarb, butachlor) significantly inhibited the mycelial growth of Rhizoctonia solani at 5 and 10 ppm concentration under in vitro condition (Prakash et al., 2013).

Most of the above studies were conducted under laboratory conditions and very few experiments carried out in pot culture condition or field situation. Quinclorac, oxyfluorfen, oxadiazon, butachlor and cinmethylin effectively inhibited the occurrence and development of rice sheath blight in a pot trial (Hua et al., 2002). This study provides an experimental proof of insecticides (endosulfan, chlorpyriphos) and herbicides (thiobencarb, butachlor) that could reduce the disease severity of sheath blight disease. Thus it is evident that these pesticides when applied to control specific insect pests
or weeds may also to check the sheath blight pathogen as well.

There are limited studies in India, wherein combination effects of different fungicides, insecticides or herbicides have been reported. The combination product of imidacloprid + ethiprole @ 0.8 g/l + hexaconazole @ 2.0 ml/l has recorded less sheath blight incidence (7.3%) severity (14.4%) as observed by Bhuvaneswari and Krishnam Raju (2013). Singh et al. (2010) studied the combination effects of fungicides (tricyclazole and iprobenphos) and insecticides (indoxacarb and cartap hydrochloride) that were biologically as effective as their individual treatments against neck blast, leaf folder and stem borer of rice, respectively along with corresponding grain yield in Taraori Basmati. The outcome of combination was found significantly as effective as individual treatments in controlling sheath blight and stem borer and increased the grain yield by 66.4% as compared to 35.3% in hexaconazole and 46.7% in flubendiamide treated plots without any phytotoxic problem. RIL-060/F, 8.5WG was equally effective against sheath blight and stem borer confirming the perfect compatibility of the test fungicide with the insecticide (Pal et al., 2013).

The outcome of the results revealed that various combinations of fungicides with herbicides and insecticides resulted in possibility of delineating a selective combination of a fungicide, namely carbendazim, with an insecticide (endosulfan) for effective management of sheath blight disease. The rationale in conducting this study is not to replace a fungicide with an insecticide or an herbicide, but to examine and put forward the further advantage of the commonly used insecticide or herbicide upon controlling the fungal pathogen to a considerable extent without incurring additional cost. Also, it can reduce the excessive use of fungicide which may otherwise be posing threat to environment. The combined application of pesticides in this study, has demonstrated a definite advantage over individual application of fungicides in terms of better control of pathogen and feasibility of reducing dosage of fungicides without any decline in its efficacy. Additionally, it offers better management of pests or weeds together that occur in rice eco system. As the occurrence of pests, diseases and weeds is not a single event, it is essential to have combined application of pesticides to protect the crop from various biotic stresses in a holistic manner. Thus, the research taken up helps in providing realistic, economical, effective and sustainable protective measures in the management of sheath blight disease in an integrative and environment friendly manner. The present study exemplifies the advantage of combined application of pesticides (carbendazim and hexaconazole with endosulfan) over individual application of fungicides in terms of effective control of sheath blight.

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