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# Analysis of Benefit Cost Ratio (BCR) of synthetic fungicides and bioagent (*Pseudomonas fluorescens*) against brown spot disease of rice caused by *Helminthosporium oryzae*

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## Abstract

BCR analysis for five selected fungicides and bioagent (*Pseudomonas fluorescens*) recorded highest in Propiconazole (1.72:1) followed by Propineb (1.47:1), bioagent (*P. fluorescens*) (1.46:1), Myclobutanil (1.45:1), Carbendazim (1.34:1), Thiopanate (1.33:1) and in Control (1.13:1). This inferred that in treatment Propiconazole investment of Re.1.00 will generate gross income of Rs.1.72 or net return (Re.0.72) and net return following other treatments i.e, Propineb (Re. 0.47*), P. fluorescens* (Re.0.46), Myclobutanil (Re.0.45), Carbendazim (Re.0.34), Thiophanate (Re.0.33) and in case of control (Re.0.13).

**Keywords:** *Helminthosporium oryzae*; Synthetic fungicides; Bioagent; *Pseudomonas fluorescens*; Benefit cost ratio; Gross return; Net profit

## 1. Introduction

Rice is the staple food for more than half of the world population and its global demand is increasing day by day and expected to reach 852 million tonnes from present status of 676 million tones by the year 2035 and in order to fill a deficit gap of 176 million tonnes. It is necessary to raise the productivity level from 10tonnes/ha to 12.5 tonnes/ha [1]. Rice plants suffer from various pathogenic diseases of fungal, bacteria and virus origin which deprive the potential productivity level. Among the fungal diseases brown spot disease caused by *Helminthosporiumoryzae* (Breda de Haan) is known to cause considerable qualitative and quantitative losses in rice growing countries of Asia, America and Africa [2]. In India the disease is widespread and known to cause 4.6-29.0% losses in grain yield [3]. Brown spot has attained economic significance in Northern India since last decade [4] and [5]. The pathogen has found to cause stalk rot in addition to leaf spot and grain discouration in non scented high yielding varieties of rice in Haryana [6]. Various synthetic pesticides have been taken up as mandatory for managing brown spot disease. Mancozeb and Zineb have been found to impart insufficient control of the disease whereas triazole group of fungicides such as Propiconazole 0.1% and Hexaconazole 0.2% were found most effective with per cent disease control upto 22.34% [7] while [8] reported Propiconazole as the most effective fungicides against brown spot which provided 75.30% disease control followed by Hexaconazole. Some of the non-conventional chemicals have also been tested to induce resistance in rice plants against different diseases including brown spot [9] and [10]. It is necessary to assess how far these chemicals with different index of disease control and cost of application, increase of yield index and margin of profit or net return etc., need to be worked out statistically to sustain economy of the grower. Keeping this in view,present investigation was undertaken to ascertain the actual benefit and loss of all chemical fungicides applied in managing of brown spot disease under field conditions.

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## 2. Material and methods

### 2.1. Isolation, identification of bio-agent (*Pseudomonas fluorescens*) and in-vitro test

Bioagent *Pseudomonas fluorescens* was isolated from root zone of paddy plant cultivated at the experimental field of Sam Himmingbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. Loosely adhering soil of paddy root zones was collected and shade dry and finely powdered and 10 g of this powdered soil was added into 90 ml sterile distilled water to make 1:10 dilution ($10^{-1}$) and shaken vigorously and then 1 ml of the suspension (1:10 dilution) transfer to another 9 ml sterilized distilled water to make 1:100 dilution $10^{-2}$. Thus likewise prepare serial solution $10^{-3}$ upto $10^{-7}$ as earlier and then a loopfull of this last dilution suspension was spread on plated King's medium B (KMB) agar Petriplate and incubated at 37±1ºC for 24 hrs. Thus, pick up the individual colony with sterilized loop & transfer on to fresh King's medium and then single colony of bacteria was transfered into King's medium B (KMB) slants to obtain pure culture and store in refrigerator at 4ºC and then sub-cultured periodically at 15 days intervals on the same KMB medium. Morphological characteristics of *P. fluorescens* observed are given below (Table 1).

**Table 1** Characteristic of *Pseudomonas fluorescens*

| Sl. No. | Observed morphological characteristics |
|---|---|
| 1 | Cells are single, straight or curved and no helical |
| 2 | Gram negative (retains crystal violet stain during alcohol wash) |
| 3 | Culture produces diffusible fluorescent (Yellow-green) pigment on King's medium B |

### 2.2. Counting of Cfu and preparation of different Cfu concentrations of bio-agent (*P. fluorescens*)

The pure culture of *P. fluorescens* isolates was grown in 50 ml of King's medium B (KMB) broth and waiting to reach $1x10^9$ cfu/ml for determination of *P. fluorescens* cfu/ml from stock culture of King's B broth was done by following the formula [11]:

$$\text{CFU/ml} = \frac{\text{Number of colonies x Dilution factor}}{\text{Volume of culture}}$$

Different cfu concentration was obtained by serial dilution technique [12]. 1 ml suspension *Pseudomonas fluorescens* from 250 ml of stock culture having reached cfu strength ($1x10^9$ $ml^{-1}$) was taken with the help of sterilized pipette and then transferred into 9 ml sterile distilled water to make 1:10 or ($10^{-1}$) dilution then vigorously shake the dilution and now this first dilution will have $1x10^8$ cfu $ml^{-1}$. Then transfer 1 ml of suspension of this first dilution to another 9 ml sterilized distilled water to make second dilution of 1:100 or ($10^{-2}$) which will contained $1x10^7$cfu $ml^{-1}$ likewise prepare serial dilution of $10^{-3}$, $10^{-4}$ etc. till the desire cfu concentration per millilitre ($ml^{-1}$) of dilution was obtained. For preparation of different bacteria cells concentration methods [13] was followed**.** *P.fluorescens* isolate was grown in 5 litres fermenters on nutritive broth and allow reaching ($1x10^9$) cfu $ml^{-1}$ concentration and then dilute with water to achieve the desired bacterial density. Foliar application was done with bacterial suspension of cell concentration @ $1.37x10^8$/ litre of water or 500 litres $ha^{-1}$ of area.

### 2.3. *In-vitro* evaluation of antagonistic effect of *Pseudomonas fluorescens* isolates

The *in-vitro* evaluations of antagonistic effect of *P. fluorescens* isolate against the test fungi *H.oryzae* was done by dual culture technique. The petriplates was poured with 15 ml PDA without antibiotic and the fresh loopfull of *P. fluorescens* stock culture ($1x10^9$) cfu/ml concentration was streaked leaving 1 cm from the margin. Then 5 mm mycelial disc of *H.oryzae* taken from 5 days old culture with the help of sterilized cork borer was placed at the centre of each petriplates and incubated at 28±1ºC for 4 days. The distance between fungal growth and bacterial colonies was recorded as inhibition zone given in Table 2. (Figure 1).

**Table 2** Antagonistic effect of bioagent (*Pseudomonas fluorescens*) isolates on linear growth of pathogenic fungi *Helminthosporium oryzae (in-vitro* test)

| ***P. fluorescens* isolates** | **Linear growth of *H. oryzae* at 120 hours (cm)*** | **Actual zone of inhibition (cm)*** | **% growth inhibition over control** |
|---|---|---|---|
| Pf | 4.29 | 1.2 | 39.80 |
| Control | 7.47 | 0.8 | - |
| CD(0.05%) | 0.43 | 0.28 | - |

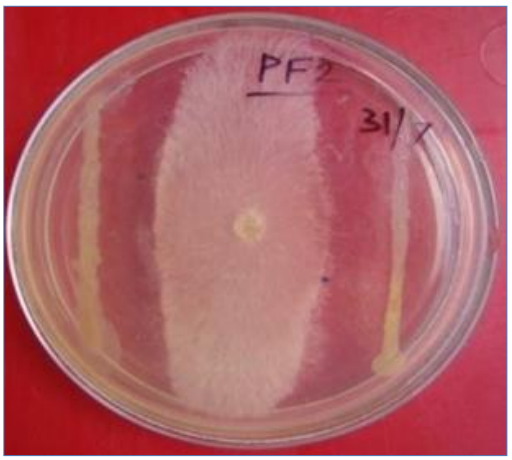


**Figure 1** Antagonistic studies of *P. fluorescens*

### 2.4. *In-vivo* test

Field trial was conducted at the experimental plot of Department of Plant Pathology, Allahabad School of Agriculture, SHUATS, Prayagraj, Uttar Pradesh during Kharif season from 2014 to 2016 on a susceptible Manipur local paddy cultivar viz. Daram-phou using randomize block design (RBD) with plot size (2x3) sq.m. Paddy seedlings 25 days old were transplanted with spacing (20x15)cm row x row and plant x plant and 2-3 seedlings/hill. Five selected fungicides viz. Thiophanate, Carbendazim, Myclobutanil, Propineb, Propiconazole at 1000 ppm and bio-agent (*Pseudomonas fluorescens*) isolate (Pf) @ cell conc.($1.37x10^8$/ml) perlitres of water was sprayed at 10 days intervals at 48,58 and 68 days after transplantation when prominent disease symptoms start appearing. Observations regarding disease severity was recorded one day ahead of every schedule spray and 10 days after the final spray. The per cent disease incidence was calculated by using the following same formula mentioned above [14].The disease scoring scale and disease rating were also done same as in botanical trials as mentioned earlier.

$$\text{PDI (\%)} = \frac{\text{Summation of numerical ratings}}{\text{Total number of leaves observed X Maximum rating grade}} \times 100$$

### 2.5. Cost benefit ratio

Cost benefit ratio is the ratio of gross return to Total cost of cultivation which can also be expressed as return per rupee invested. This index provides an estimate of the benefit farmer derives from the expenditures he incur in adopting particular cropping system. Cost: benefit ratio is an indicator of the relative economic performance of the treatments and ratio of more than one indicates the economic viability of the treatment compared with the control treatment [15]. The benefit cost ratio (BCR) was calculated using the following formula [16].

$$\text{BCR} = \frac{\text{Gross Return (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

### 2.6. Gross returns

The total monetary value of economic produce and by-products obtained from the crop raised in the cropping system was calculated based on the local market prices.

### 2.7. Cost of cultivation

Cost of cultivation is the total expenditure incurred for raising crops in cropping systems. The cost included for this purpose consists of own or hired human labour, value of seed, manure, fertilizers pesticides and herbicides and irrigation charges.

### 2.8. Net returns

Net return is obtained by subtracting cost of cultivation from gross return. It is a good indicator of suitability of a cropping system since this represents the actual income to the farmers.

**Table 3** Effect of fungicides & per cent disease severity index of brown spot of Rice & grain yield

| Sl.No. | Treatment | PDI | % disease reduction | Yield t/ha. | %yield increase |
|---|---|---|---|---|---|
| 1 | **$T_0$** Control | 27.12 | - | 3.46 | - |
| 2 | **$T_1$** Thiophanate | 16.00 | 41.00 | 4.21 | 22.09 |
| 3 | **$T_2$** Myclobutanil | 8.84 | 67.40 | 4.68 | 35.60 |
| 4 | **$T_3$** Carbendazim | 10.96 | 59.58 | 4.27 | 23.74 |
| 5 | **$T_6$** *Pseudomonas fluorescens* | 10.57 | 61.02 | 4.63 | 34.14 |
| 6 | **$T_4$** Propineb | 7.91 | 70.83 | 5.46 | 58.36 |
| 7 | **$T_5$** Propiconazole | 7.39 | 72.75 | 5.60 | 61.74 |
| | S.Ed (±) | 0.23 | 0.21 | 0.06 | 0.78 |
| | CD | 0.49 | 0.53 | 0.26 | 3.40 |

**Table 4** Effect of synthetic fungicides and bioagent *Pseudomonas fluorescens* on marginal benefit cost ratio (BCR) in the management of brown spot disease of rice

| Treatment | Total cost of cultivation (Rs./ha) | | | Gross return (Rs./ha) | | | Net profit (Rs./ha) | | | Benefit cost ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pool mean | 2014-15 | 2015-16 | Pool mean | 2014-15 | 2015-16 | Mean | 2014-15 | 2015-16 | Pool mean |
| $T_0$ Control | 30658 | 30727 | 30692 | 34823 | 34926 | 34874.5 | 4165 | 4199 | 4182.0 | 1.26:1 | 1.13:1 | 1.19:1 |
| $T_1$ Thiophanate | 32035 | 32246 | 32140 | 42894 | 42900 | 42897.0 | 10859 | 10654 | 10756.5 | 1.33:1 | 1.33:1 | 1.33:1 |
| $T_2$ Myclobutanil | 32456 | 32563 | 32509 | 47410 | 47520 | 47465.0 | 14954 | 14957 | 14955.5 | 1.46:1 | 1.45:1 | 1.45:1 |
| $T_3$ Carbendazim | 32174 | 32308 | 32241 | 43901 | 43101 | 43501.0 | 11727 | 10793 | 11260.0 | 1.36:1 | 1.33:1 | 1.34:1 |
| $T_6$ *Pseudomonas flourescens* | 32188 | 32418 | 32825.0 | 47386 | 47392 | 47389 | 15198.0 | 14974.0 | 15086.0 | 1.47:1 | 1.46:1 | 1.46:1 |
| $T_4$ Propineb | 32500 | 32674 | 32587 | 47904 | 47989 | 47946.5 | 15404 | 15315 | 15359.5 | 1.47:1 | 1.47:1 | 1.47:1 |
| $T_5$ Propiconazole | 32621 | 32605 | 32613 | 56187 | 56278 | 56232.5 | 23566 | 23673 | 23619.5 | 1.72:1 | 1.72:1 | 1.72:1 |

The data presented in the above Table 3 is the per cent disease severity index of brown spot disease of rice. It revealed that among the selected fungicides and bioagent (*P. fluorescens*) treatments minimum brown spot disease incidence was recorded in Propiconazole(7.39) with 72.75% disease control followed by Propineb (7.91) with 70.83% disease control, Myclobutanil (8.84) with 67.40% disease control and bioagent *P. fluorescens* (10.57) with 61.02% disease control, Carbendazim (10.96) with 59.58% disease control and Thiophanate with 41% disease control over untreated Control (27.12). Data of grain yield revealed all treatments were statistically significant on grain yield parameter as compared with the untreated Control. However, among the treatments maximum grain yield was recorded in Propiconazole (5.6 t/ha.) with 61.74% increase over untreated control followed by Propineb (5.46 t/ha.) with 58.36% increase, Myclobutanil (4.68 t/ha.) increase of 35.60%, *P. fluorescens* (4.63 t/ha.) increase of 34.14%, Carbendazim (4.27 t/ha.) increase of 23.74% and least significant grain yield was recorded in Thiophanate (4.21 t/ha.) increase of 22.09% over untreated Control (3.46 t/ha.).

The data presented in the above Table 4 is the benefit cost ratio (BCR) of selected five synthetic fungicides and bioagent (*P. fluorescens*) application against brown spot disease of rice. Keeping others input as constant the inclusive estimated cost of cultivation of selected fungicides and bio-agent treatments as indicated by pool mean of two consecutive crops season (2014-15) and (2015-16) was recorded. Highest cost was observed in bioagent (*P. fluorescens*) (Rs.32825) followed by Propiconazole (Rs.32613), Propineb (Rs.32587), Myclobutanil (Rs.32509), Thiophanate (Rs.32140) and Control (Rs.30692). The higher cost involvement in case of bioagent (*P. fluorescens*) at present finding is due to higher cost of processing since it is isolated from the paddy rhizosphere and being not a readily formulated market product. However, once if it is formulated in commercialise form cost of production will be much lower than those of synthetic fungicides. It is also further revealed that among the selected fungicides and bioagent pool mean benefit cost ratio (BCR) was found highest in Propiconazole (1.72:1) followed by Propineb (1.47:1), *P. fluorescens* (1.46:1), Myclobutanil (1.45:1), Carbendazim(1.34:1), Thiophanate (1.33:1) and the lowest mean net return was obtained in Control (1.19:1). Thus, this inferred that in treatment with Propiconazole investment of a sum of Re.1.00 will generate a net return of Re.0.72 followed by Propineb (Re.0.47) *P. fluorescens* (Re.0.46), Myclobutanil (Re.0.45), Carbendazim (Re.0.34), Thiophanate (Re.0.33) and the lowest mean net returned was obtained in Control (Re.0.13) only. A cost: benefit ratio of more than one indicates the economic viability of the treatment compared with the control treatment [17].

Shabozoi NUK et.al., Obtained a cost: benefit ratio of 1:4.1 and were biologically effective and resulted in significant return on investment in plant from application of a neem-based botanical. [19] reported much less favourable ratio of 1:1.33 which was lower than that in this study. This could be because this study and others analysed only the cost of plant protection and calculated the cost: benefit ratio based on the income of the control treatment. From the above analysis it was seen that application of synthetic pesticides and biopesticides increases the overall grain yield and consequently increases the net return as compared with untreated control. Our present work is justified by [20] who claimed that during crop production if you do not use control precautions against diseases, pests and weeds there will be about 65% production losses.

## 3. Conclusion

In the present investigation, it can be concluded that judicious and meaningful pesticides usage is inevitable in modern agriculture for quantitative and qualitative production and will continue to play an important role in food security.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

Both the authors have contributed in the manuscript and both have interest for getting the research paper published for use of scientific community.

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