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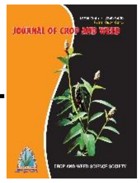

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***Research Article***

# Evaluation of fungicides, antibiotics and antagonists against *Xanthomonas oryzae* pv. *oryzae* under field condition

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## ABSTRACT

*Xanthomonas oryzae* pv. *oryzae causes bacterial leaf blight, which is a serious rice disease. Plant disease control requires the use of agrochemicals. In order to do this, researchers investigated the effectiveness of fungicides, antibiotics and antagonists against Xoo in the field condition and found that two spray of Streptomycin sulphate 90% + Tetracycline hydrochloride 10% w/v + Copper oxychloride 50% WP at 500 ppm + 1.25% recorded with minimum disease intensity (16.27%) with maximum disease control (47.99%) followed by, Copper oxychloride 50% WP at 1.25%, Streptomycin sulphate 90% w/v + Tetracycline hydrochloride 10% w/v at 500 ppm ,Copper hydroxide 53.8% DF at 1.65%, Streptomycin sulphate 15% w/v + Terramycin 5% w/v at 200 ppm, Pseudomonas fluorescens at $10^8$ cfu/ml, Trifloxystrobin 25% + Tebuconazole 50% (75WG) at 0.03%, Kresoxim-methyl 50% SC at 0.05% and Bacillus subtilis at $10^8$ cfu/ml. Similarly, significantly higher grain yield (10.08 kg plot$^{-1}$) was obtained from Tetracycline hydrochloride 10% w/v + Copper oxychloride 50% WP at 500 ppm + 1.25% followed by Copper oxychloride 50% WP at 1.25%. The disease severity in Southern Gujarat has been devastated by the BLB infection. The goal of this study was to determine the best grain yield (6173 kg ha$^{-1}$) and straw yield (7544 kg ha$^{-1}$) with an effective management strategy for bacterial leaf blight disease in rice crop by employing antibiotics, fungicides and antagonists.*

***Keywords*:** Antibiotics and antagonists, BLB, fungicides, *Oryza sativa* and Xoo

Paddy, a vital cereal crop cultivated worldwide, holds significant importance in global agriculture. The USDA's projection for global rice production in 2022–23 is 503.0 million tons, representing a 2 per cent decrease compared to the previous year (USDA, 2023). The existing situation in the Navsari district highlights the necessity for an advanced and precise method for predicting rice crop yields. Rice holds paramount importance as a staple food in many Asian countries and is a critical food crop globally, catering to the dietary needs of over half of the world's population (Akhtar *et al*., 2008). The escalating demand for rice due to population growth has intensified the significance of rice production. However, the cultivation of rice faces a significant challenge in the form of diseases caused by fungi, bacteria and viruses, leading to substantial crop losses (IRRI, 2006). Among these, bacterial leaf blight (BLB) disease, induced *by Xanthomonas oryzae pv. oryzae* (*Xoo*) (Swings *et al.*, 1990), stands out as a major hindrance to achieving high productivity in rice cultivation (Zhang *et al.*, 2009). The impact of BLB disease on grain yield varies based on factors such as crop stage, cultivar susceptibility and environmental conditions (Akhtar *et al.*, 2011). Known for causing severe yield losses ranging from 50% to 100%, BLB poses a significant threat to rice crops (Mew *et al.*, 1993; Singh *et al.*, 1997; Zhai and Zhu, 1999). Globally, the impact of bacterial leaf blight disease has led to an estimated yield loss of around 50%, as reported by Kulkarni and Jahagirdar (2011). In the context of India, Prasad *et al*. (2018) and Swati *et al*. (2015) documented a staggering yield loss of 81.3%. Globally, plant diseases result in significant yield reductions, with bacterial leaf blight disease caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) being recognized as a highly severe bacterial infection in rice, causing substantial yield losses (Koduru *et al*., 2020; Latz *et al.*, 2016).

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Initially, Bordeaux mixture was recommended as the primary chemical control measure against *Xoo*, with application suggested before the onset of the disease (Hashioka, 1951). Subsequently, experiments were conducted to assess the efficacy of copper and mercuric compounds in controlling the same disease (Nakazawa, 1959). While chemical control is a common approach for disease management, its efficacy is often strain-dependent, highlighting the limitations associated with the excessive reliance on chemical control methods (Sahu *et al.*, 2018). The effectiveness of bacterial antagonists in mitigating fungal-origin rice diseases has been assessed, showing varying degrees of success in different studies (Vasudevan *et al.,* 2002). Streptomycin and its derivatives were more effective than the other chemicals. However, when sprayed at the heading stage, these antibiotics caused injurious effects on rice yields (Yoshimura *et al.,* 1961). *Xanthomonas oryzae* pv. *oryzae*, commonly called *Xoo*, causes rice bacterial leaf blight (BLB). Rice farmers all around the world suffer enormous output losses as a result of it. Rice bacterial leaf blight, which is endemic to the epidemic in the southern part of Gujarat, arises every year. Various experts from N.A.U., Navsari have documented an annual bacterial leaf blight outbreak in South Gujarat in their survey reports (Anon., 2018). Bacterial leaf blight of rice (*Xoo*) is one of the most aggressive plant diseases of rice, causing economic losses in terms of yield and grain quality. During every growing season, the pathogen destroys millions of hectares of rice. As a result, pathogen management using fungicides, antibiotics and antagonists is required, where drugs block or kill pathogens to limit bacterial development and avoid plant loss.

## MATERIALS AND METHODS

A field experiment was carried out in 2020 at the rice research farm of Navsari Agriculture University, Navsari, Gujarat, India to evaluate the efficacy of some fungicides, antibiotics and antagonists against BLB in rice cv. GR-11. The experiment was designed in a Randomised Block Design comprising ten treatments comprising of fungicides, antibiotics and antagonists along with water spray as an untreated control (Table 1). Each treatment was replicated thrice. Rice seedlings were transplanted at a spacing of 20cm × 15cm in a plot of 19.44 sq. m. The crop was fertilized with N:P:K @ 100:30:0 kg ha$^{-1}$.

The first spray was administered during the start of the disease and the second spray was administered 15 days after the first spray. Thirty hills per plots were randomly chosen and tagged to record the disease severity of bacterial leaf blight. The disease severity of was assessed by using the standard assessment system (IRRI, 2013).

The formula for calculating % disease index

$$PDI = \frac{\text{Sum of score}}{\text{No.of observation} \times \text{Highest number of rating scale}} \times 100$$

The PDI of bacterial leaf blight was measured using the standard rice disease assessment technique, and grain and straw yields were calculated from the net plot area after harvest.

## RESULTS AND DISCUSSION

All the treatments were found significantly superior to control in reducing BLB disease intensity (Table 1). Among the treatments adopted, foliar spray of streptomycin sulphate 90%SP + tetracycline hydrochloride 10%w/v + copper oxychloride 50%WP at 500 ppm + 1.25% recorded lowest disease intensity (23.77%) which was found significantly superior over the rest of the treatments. The next effective treatment was copper oxychloride 50%WP at 1.25% (28.63%), which was statistically at par with streptomycin sulphate 90%w/v + tetracycline hydrochloride 10%w/v at 500 ppm (28.97%), copper hydroxide 53.8%DF at 1.65% (29.70%) and streptomycin sulphate 15%w/v + terramycin 5%w/v at 200 ppm (30.38%) followed by *Pseudomonas fluorescens* @ 10 ml per litre of water (32.17%), trifloxystrobin 25 + tebuconazole 50% (75WG) at 0.03% (34.33%), kresoxim methyl 50%SC at 0.05% (34.85%) and *Bacillus subtilis* 10 ml per litre of water (36.04%), respectively.

The disease control in streptomycin sulphate 90%SP + tetracycline hydrochloride 10%w/v + copper oxychloride 50%WP at 500 ppm + 1.25% was maximum (47.99%) in comparison to control. That was closely followed by the application of copper oxychloride 50%WP @ 1.25%, streptomycin sulphate 90%w/v + tetracycline hydrochloride 10%w/v @ 500 ppm and copper hydroxide 53.8%DF @1.65%. Two sprays of streptomycin sulphate (50 ppm) + copper oxychloride (500 ppm) or paushamycin (100 ppm) + copper oxychloride (500 ppm) @ 1000 liter ha$^{-1}$, applied at tillering and three weeks later, shown to be efficient in reducing *Xoo* (Anon.,1983).

The grain yield (Table 2) was significantly maximum (6173 kg ha$^{-1}$) in streptomycin sulphate 90% SP @ 500 ppm + tetracycline hydrochloride 10%w/v + copper oxychloride 50% WP @ 1.25% but was statistically at par with copper oxychloride 50%WP @ 1.25% (5913 kg ha$^{-1}$). Next best in order of merit were streptomycin sulphate 90% w/v + tetracycline hydrochloride 10%w/v @ 500 ppm (5316 kg ha$^{-1}$) followed by, copper hydroxide 53.8% DF @ 1.65% (5285 kg ha$^{-1}$), streptomycin sulphate 15% w/v + terramycin 5% w/v @ 200 ppm (5208 kg ha$^{-1}$), *P. fluorescens* at 10 ml per litre of water (5155 kg ha$^{-1}$), trifloxystrobin 25% + tebuconazole 50% (75WG) at 0.03% (5147 kg ha$^{-1}$), kresoxim methyl 50%SC @ 0.05 per cent (4986 kg ha$^{-1}$) and *B. subtilis* @ 10ml per litre of water (4105 kg/ha) in respect of grain yield. According to Sinha and Sinha (2000) copper oxychloride + streptomycin sulphate was the most effective treatment in terms of disease severity decrease and grain production. Streptocycline (0.5g $l^{-1}$) + copper oxychloride (2.5 g $l^{-1}$) had the lowest disease severity (24.50%), followed by Bacterinashak (0.5g $l^{-1}$), Kasugamycin (2 ml $l^{-1}$) and Agrimycin 100 (0.2g $l^{-1}$) with 26.67%.

The highest straw yield of 75.44 kg $ha^{-1}$ was obtained in the treatment comprised of streptomycin sulphate + tetracycline hydrochloride + copper oxychloride but was statistically at par with copper oxychloride (Table 2). Shekhar *et al*. (2020) evaluated several compounds and discovered that streptocycline at 0.5% + Copper oxychloride at 2.5% was the most effective against bacterial leaf blight of rice. Chemical control of *Xoo* using antibiotics such as Kanamycin, Ampicillin, Sinobionic, Benzylpenicillin and Chloramphenicol (Khan *et al.*, 2012).

**Table 1: Performance of pesticides against bacterial leaf blight under field condition**

| Tr.No. | Treatment | Concentration | Dose (per litre) | PDI | Disease Control (%) |
|---|---|---|---|---|---|
| $T_1$ | Streptomycin sulphate 90% w/v + Tetracycline hydrochloride 10% w/v | 500 ppm | 0.5 g | (23.50) 28.97 | 36.62 |
| $T_2$ | Streptomycin sulphate 15% w/v +Terramycin 5% w/v | 200 ppm | 0.2 g | (25.60) 30.38 | 33.53 |
| $T_3$ | Copper oxychloride 50% WP | 1.25 | 2.5 g | (22.98) 28.63 | 37.36 |
| $T_4$ | Streptomycin sulphate 90% SP + Tetracycline hydrochloride 10% w/v + Copper oxychloride 50% WP | 500 ppm + 1.25 | 0.5 g + 2.5 g | (16.27) 23.77 | 47.99 |
| $T_5$ | Copper hydroxide 53.8% DF | 1.65 | 3.0 g | (24.57) 29.70 | 35.03 |
| $T_6$ | Trifloxystrobin 25% + Tebuconazole 50% (75WG) | 0.03 | 0.4 g | (31.83) 34.33 | 24.91 |
| $T_7$ | Kresoxim methyl 50% SC | 0.05 | 1.0 ml | (32.67) 34.85 | 23.75 |
| $T_8$ | *Bacillus subtilis* | $10^8$ cfu/ml | 10.0 ml | (34.63) 36.04 | 21.15 |
| $T_9$ | *Pseudomonas fluorescens* | $10^8$ cfu/ml | 10.0 ml | (28.37) 32.17 | 29.61 |
| $T_{10}$ | Control (Water spray) | - | - | (51.23) 45.71 | 0.00 |
| **SEm (±)** | | | | **0.84** | **-** |
| **LSD (0.05)** | | | | **2.50** | **-** |
| **CV (%)** | | | | **4.49** | **-** |

*Note: Figures in parentheses are original values. Figures outside the parentheses are arc sine transformed values.*

**Table 2: Effect of treatments on grain and straw yield of rice (cv. GR-11)**

| Treatment | Conc. | Dose $litre^{-1}$ | Grain yield | | Straw yield | |
|---|---|---|---|---|---|---|
| | | | kg $plot^{-1}$ | kg $ha^{-1}$ | kg $plot^{-1}$ | kg $ha^{-1}$ |
| Streptomycin sulphate 90% w/v+ Tetracycline hydrochloride 10% w/v | 500 ppm | 0.5 g | 8.68 | 5316 | 10.50 | 6434 |
| Streptomycin sulphate 15% w/v +Terramycin 5% w/v | 200 ppm | 0.2 g | 8.50 | 5208 | 10.38 | 6357 |
| Copper oxychloride 50% WP | 1.25 | 2.5 g | 9.65 | 5913 | 12.00 | 7353 |
| Streptomycin sulphate 90% SP + Tetracycline hydrochloride 10% w/v + Copper oxychloride 50% WP | 500 ppm +1.25 | 0.5 g + 2.5 g | 10.08 | 6173 | 12.31 | 7544 |
| Copper hydroxide 53.8% DF | 1.65 | 3.0 g | 8.63 | 5285 | 10.48 | 6419 |
| Trifloxystrobin 25% + Tebuconazole 50% (75WG) | 0.03 | 0.4 g | 8.40 | 5147 | 10.25 | 6281 |
| Kresoxim methyl 50 SC | 0.05 | 1.0 ml | 8.14 | 4986 | 10.13 | 6204 |
| *Bacillus subtilis* | $10^8$cfu/ml | 10.0 ml | 6.70 | 4105 | 9.23 | 5653 |
| *Pseudomonas fluorescens* | $10^8$cfu/ml | 10.0 ml | 8.41 | 5155 | 10.33 | 6327 |
| Control (Water spray) | - | - | 6.43 | 3937 | 8.88 | 5438 |
| **SEm (±)** | | | **0.39** | | **0.46** | |
| **LSD (0.05)** | | | **1.20** | | **1.33** | |
| **CV %** | | | **10.89** | | **8.74** | |

## CONCLUSION

The present investigation indicated that among the treatments, streptomycin sulphate 90%SP @ 500 ppm + tetracycline hydrochloride 10 w/v and copper oxychloride 50%WP @ 1.25% fetched maximum disease control followed by copper oxychloride 50 WP @ 1.25%. The aforesaid treatment also received maximum grain yield and straw yield and hence considered to be promising in controlling BLB disease in rice.

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