International Journal of Plant & Soil Science
15(5): 1-7, 2017; Article no.IJPSS.32535
ISSN: 2320-7035

SCIENCEDOMAIN *international*
www.sciencedomain.org

Bronopol (2-Bromo-2-Nitropropane-1, 3-Diol), A Chlorine Based Chemical Compound for the Management of Bacterial Leaf Blight of Rice

D. Pramesh[1,2*], Maruti[1,2], A. Saddam[1], K. M. Muniraju[1,2] and G. S. Guruprasad[1]

[1]All India Coordinated Rice Improvement Programme, Agricultural Research Station, Gangavathi, Karnataka, Pin-583 227, India.
[2]Department of Plant Pathology, University of Agricultural Sciences, Raichur, Karnataka, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author DP designed the study, conducted the field experiments. Authors Maruti, AS, KMM and GSG performed the statistical analysis and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/32535
Editor(s):
(1) Omer Kilic, Bingol University, Turkey.
Reviewers:
(1) Levent Son, University of Mersin, Turkey.
(2) Montaser Fawzy Abdel-Monaim, Agricultural Research Center, Giza, Egypt.
(3) Wonni Issa, National Research Institute, Burkina Faso.
Complete Peer review History: http://www.sciencedomain.org/review-history/18951

Original Research Article

Received 1st March 2017
Accepted 26th April 2017
Published 6th May 2017

ABSTRACT

Aim: Present study was under taken to determine the field efficacy of a chlorine based chemical compound for the management of bacterial leaf blight (BLB) of rice.
Study Design: Randomized complete block design (RCBD).
Place and Duration of Study: All India Co-ordinated Rice improvement Programme, Agricultural Research Station, Gangavathi (5.4319° N, 76.5315° E), Karnataka, India, during *autumn* 2014 and 2015.
Methodology: Experiment was designed with six treatments of four replications each. A chlorine compound BIONOL (Bronopol 100%) was tested at 0.3-0.5 g/l along with Streptocycline (Streptomycin sulphate 90% + Tetracycline hydrochloride 10%) at 0.1 g/l, Copper oxychloride at 0.1 g/l and one treatment comprises the combination (Tank Mixture) of Streptocycline (0.1 g/l) and Copper oxychloride (0.1 g/l) for bioefficacy against BLB under field condition. Bio-efficacy was evaluated by spraying all the test chemicals after the initiation of the disease symptoms.

**Corresponding author: E-mail: parmi.iari@gmail.com;*

Results: The test chemical BIONOL at 0.5 g/l was found effective, recorded least Percent Disease Index (PDI) of 16.7 (Pooled average). BIONOL at 0.3 g/l performed statistically on par with Streptocycline at 0.1 g/l and also with tank mixture of Streptocycline at 0.1 g/l Streptocycline at 0.1 g/l + Copper oxychloride at 0.1 g/l. Significant increase in the grain yield was observed in the plots treated with test chemical BIONOL 0.5 g/l (60.31 q/h) compare to the other treatments which recorded yield in the range of 42.82-55.51 q/h.
Conclusion: Here we report the efficacy of bronopol (2-bromo-2-nitropropane-1, 3-diol), a chlorine based chemical compound at 0.5 g/l in managing the BLB disease of rice under field condition.

Keywords: Rice; bacterial leaf blight; bionol; bronopol; percent disease index.

ABBREVIATIONS

BLB : Bacterial leaf blight
RCBD : Randomised complete block design
PDI : Percent disease index

1. INTRODUCTION

Rice is a staple food crop of 60 per cent of the world's population and more than two thirds of the population of India [1]. Rice suffers from many diseases caused by fungi, bacteria, viruses, phytoplasmas, nematodes and other non-parasitic disorders. Among the bacterial diseases, bacterial leaf blight (BLB) caused by *Xanthomonas oryzae pv. oryzae* [2,3] is one of the most destructive diseases of rice in irrigated and rainfed environments in Asia [4]. The disease can cause yield loss upto 50 per cent [5-9] studied the effect of bacterial leaf blight of paddy on 12 rice cultivars in Haryana during *autumn* season and found that the yield reduction was in the range of 1.92–33.6 per cent. In India, the first report of BLB was made by Bhapkar et al. and it is one of the most devastating diseases during monsoon season and a major production constraint in rice cultivation particularly in irrigated and rainfed lowland ecosystems of rice growing states of India [9,10].

The extent of yield losses incurred due to the disease necessitates development of strategies for its management. Among the different strategies, management based on chemical application to control the disease under epidemic condition was reported by many researchers [11-18]. Most of the previous reports have described the effectiveness of the copper based chemicals and antibiotics and no reports available for bioefficacy of bronopol (2-bromo-2-nitropropane-1,3-diol), a chlorine-based compound on BLB disease management.

Bronopol has been used for the management of bacterial blotch disease of mushroom [19], bacterial diseases of potato [20] and bacterial blight of pomegranate [21]. Currently, available traditional bactericides are not very effective under field condition and can even enhance resistance target bacteria; therefore, the search for new antibacterial agents remains a daunting task in pesticide science [22-24]. In this study, we report the bio-efficacy of a chlorine based chemical compound in managing the BLB of rice under field condition.

2. MATERIALS AND METHODS

2.1 Field Layout, Chemicals and Crop Establishment

A field experiment was conducted at the experimental fields of Agricultural Research Station, Gangavathi, Karnataka (5.4319° N, 76.5315° E) during 2013 & 2014 *autumn* seasons. A popular rice variety BPT5204 which is susceptible to BLB disease was used for the study. Seeds were sown in the month of July and seedlings were planted in August. The experiment was laid out in Randomised Complete Block Design (RCBD) with a plot size of 5 × 4 m each for all treatments. Seedlings of 30 days old were planted in trail plots at 20×10 cm spacing. All standard agronomic practices were followed for crop establishment. Additional nitrogen of 50 kg ha-1 was given along with normal dose (N_2:P_2O_5:K_2O:150:75:75) to facilitate high disease pressure.

The RCBD experiment comprises six treatments with four replications each. Treatments comprises BIONOL (Bronopol 100%) at 0.3-0.5 g/l, Streptocycline (Streptomycin sulphate 90% + Tetracycline hydrochloride 10%) at 0.1 g/l, Copper oxychloride at 0.1 g/l and one treatment comprises the combination (Tank Mixture) of Streptocycline (at 0.1 g/l) and Copper oxychloride (0.1 g/l) was used. Bio-efficacy was evaluated by spraying all the test chemicals after the initiation of the disease.

2.2 Artificial Inoculation

Isolation of Bacteria: Diseased rice leaves showing typical bacterial leaf blight symptom were collected from rice fields and pathogen was isolated. After surface sterilization, leaves were cut into smaller pieces about 5 x 5 mm in size and kept in the test tube containing sterilized distilled water for about 10 to 15 minutes, to allow the bacteria to ooze out from the leaf tissue. Using the sterilized loop needle bacterial suspension was streak onto Petri dishes containing modified Wakimoto's medium (WFP) [25]. The plates were incubated in room temperature (27 ± 1℃) for 2 to 3 days. The single yellow, round and smooth margin, non flat, mucous colonies were selected and used for pathogenicity test as described previously [26].

After confirmation of the pathogenicity, colony producing more virulent symptoms was multiplied on nutrient broth. Using three day old bacterial culture, a suspension was made (10^8-10^9cfu/ml) and was artificial inoculated to 55 day old plants following leaf clip inoculation method described previously [27]. After typical symptom appearance, test chemicals with different doses were sprayed as per the treatment details (Table 1).

2.3 Disease Assessment and Statistical Analysis

20 days after the chemical application disease assessment was carried out. The disease was measured using the disease rating scale of 0-9 developed by International Rice Research Institute (IRRI, 1996) for BLB. Further, the scored data was converted into per cent disease index (PDI) using formula given below. The data on the yield were recorded by marking 3 x 2 m section within each plot using a wire frame and tillers within the frame were cut and harvested in order to determine the yield [28]. Data from *autumn* 2014 & 2015 seasons were pooled to get the average PDI and yield values. Subsequently, the data on disease severity and yield parameters were subjected to appropriate statistical analysis.

PDI = [(Sum of the scores) / (Number of Observation × Highest Number in Rating Scale)] x 100

3. RESULTS AND DISCUSSION

Due to ever continuing variation in the bacterial population under field condition, many of the chemical are becoming ineffective for bacterial disease management [29]. For bacterial blight disease of rice, only one antibiotic combination (Streptocycline (Streptomycin sulphate 90% + Tetracycline hydrochloride 10%) and copper based chemical (Copper oxychloride) are in use since many years [11-18]. Repeated use of Streptocycline and copper compounds has led to the development of resistance in many plant pathogenic bacteria including *Xanthomonas* sp. [22-23,29]. Therefore, search for the new molecule to support the other disease management strategies such as cultural, biological and host plant resistance is inevitable [29].

PDI data from the two consecutive *autumn* seasons (2013 & 2014) indicated the effectiveness of a chlorine based chemical BIONOL (Bronopol 100%) on BLB PDI under field condition. During 2013 and 2014 *autumn*, treatment BIONOL (Bronopol 100%) at 0.5 g/l recorded the least PDI of 16.17 (Pooled mean of two season) which is statistically superior over all other treatments (Table 1 and Fig. 1). Whereas, BIONOL (Bronopol 100%) at 0.3 g/l was recorded average PDI of 27.2 which statistically on par with Streptocyclin at 0.01 g/l (30.38) as well as treatment having tank mixture of two chemical (Streptocyclin at 0.01 g/l + Copper oxychloride at 0.1 g/l) (PDI 26.15).

Results from the present experiment clearly indicated the effectiveness of BIONOL (Bronopol 100%) at 0.5 g/l in managing the BLB under field condition. Effectiveness of Bronopol against the bacterial diseases of other crop such as bacterial blotch disease of mushroom [19], bacterial diseases of potato [20], bacterial blight of pomegranate [21] has been reported previously and here, we report its effectiveness in managing the BLB of rice.

Highest grain yield 60.31 q/h (Pooled average of the two seasons) was recorded in the plots sprayed with BIONOL (Bronopol 100%) at 0.5 g/l which is statistically superior over the other treatments which recorded the grain yield in the range of 42.82-55.51 q/h (Table 2). The difference in the yield is mainly due to difference in disease severity (Table 1). Previous reports on BLB management have also reported the increase in the grain yield due to reduction in the disease level after chemical application [17,18].

Presently, bacterial diseases are being managed using many strategies either singly or in

Table 1. Effect of bionol (Bronopol 100%) on rice bacterial leaf blight disease severity

Sl. no.	Treatment	Dosage (g/l)	Dose (g/h)	BLB Severity (PDI)				Pooled mean
				Autumn-2013		*Autumn*-2014		
				Before spray	20 days after spray	Before spray	20 days after spray	
T1	BIONOL (Bronopol 100%)	0.3 g/l	150	40.27 (39.41)	28.60 (32.35)	39.27 (38.80)	25.80 (30.53)	27.2 (31.44)
T2	BIONOL (Bronopol 100%)	0.5 g/l	250	42.21 (40.54)	17.52 (24.76)	40.21 (39.35)	14.82 (22.65)	16.17 (23.70)
T3	Streptocycline (Streptomycin sulphate 90% + Tetracycline hydrochloride 10%)	0.1 g/l	50	49.71 (44.86)	30.88 (33.78)	39.71 (39.06)	29.88 (33.14)	30.38 (33.44)
T4	Copper oxychloride	0.1 g/l	50	40.56 (39.54)	35.55 (36.60)	37.55 (37.80)	31.36 (34.06)	33.45 (35.33)
T5	Tank Mixture of T3+T4	(0.1+0.1) g/l	50+50	43.33 (41.17)	26.66 (31.05)	40.55 (39.56)	25.65 (30.40)	26.15 (30.75)
T6	Control	--	--	45.27 (42.31)	60.27 (50.95)	41.52 (40.13)	49.52 (44.72)	54.89 (47.81)
	Critical Difference at 5% level			NS	5.31	NS	4.56	3.58
	Co-efficient of Variation at 5% level			NS	10.72	NS	11.35	12.46

Table 2. Effect of bionol (Bronopol 100%) on grain yield

Sl. no.	Treatments	Dosage (g/ha)	Dosage formulation (g/ha)	Grain yield (q/h)		Pooled mean
				Autumn-2013	*Autumn*-2014	
T1	BIONOL (Bronopol 100%)	0.3 g/l	150	**58.12**	**51.55**	**54.83**
T2	BIONOL (Bronopol 100%)	0.5 g/l	250	**65.38**	**55.25**	**60.31**
T3	Streptocycline (Streptomycin sulphate 90% + Tetracycline hydrochloride 10%)	0.1 g/l	50	**59.38**	**46.35**	**52.86**
T4	Copper oxychloride	0.1 g/l	50	**53.65**	**41.35**	**47.5**
T5	Tank Mixture of T3+T4	(0.1+0.1) g/l	50+50	**60.80**	**50.23**	**55.51**
T6	Control	--	--	**47.88**	**37.76**	**42.82**
	Critical Difference at 5% level			3.20	3.81	2.58
	Co-efficient of Variation at 5% level			16.82	12.28	11.92

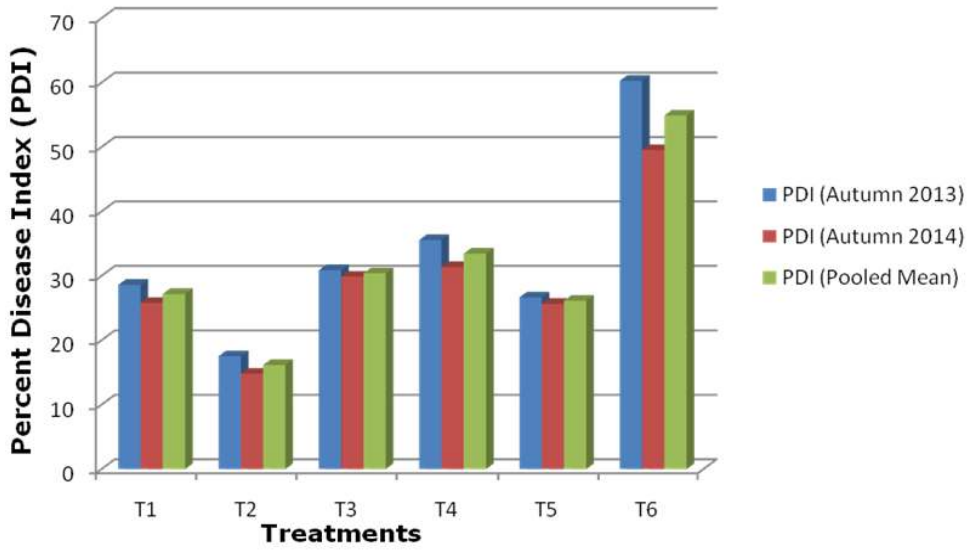

Fig. 1. Graphical representation of the effect of bionol (Bronopol 100%) on rice bacterial leaf blight disease severity

combination. An integrated management approach including the use of plant host resistance, intervention with chemical and or biological controls, and cultural practices typically represents the best overall strategy for effective and sustainable disease management. However, integrated approaches depend on the availability of suitable host plant cultivars, efficacious chemical and biological controls, and cultural practices that are physically achievable and economically suitable such that growers will deploy them [29]. Here we report the efficacy of bronopol (2-bromo-2-nitropropane-1, 3-diol), a chlorine based chemical compound at 0.5 g/l in managing the BLB disease of rice under field condition.

4. CONCLUSION

Bronopol (2-bromo-2-nitropropane-1, 3-diol) at 0.5 g/l was shown to be effective in managing the BLB disease of rice under field condition and hence, increased the total grain yield.

ACKNOWLEDGEMENT

Authors thankful to Director of Research, University of Agricultural Sciences, Raichur, Karnataka and Campus Head, Agricultural Research Station, Gangavathi for providing necessary research facilities and funding for conducting the experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tang K, Sun X, Wu A, Lin HJ, Twyman RM, Christou P, Feng T. Transgenic rice plants expressing the ferredoxin like protein (AP1) from sweet pepper show enhanced resistance to *Xanthomonas oryzae* pv. *oryzae.* Plant Cell Physiol. 2001;48:281.
2. Ishiyama S. Studies on the white leaf disease of rice plants. Report of the Agricultural Experiment Station. 1992;45:53-61.
3. Swings J, Van Den MM, Vauterin L, Hostee B, Gillis M, Mew TW, Kerster K. Reclassification of the causal agents of bacterial blight (*Xanthomoas campestris* pv. *oryzae*) and bacterial leaf streak (*Xanthomonas campestris* pv. *oryzicola*) of rice as pathovars of *Xanthomonas oryzae* (In: Ishiyama, 1922). International J Systematic Bacteriol. 1990;40:309-311.
4. Mew TW. Current status and future prospects of research on bacterial blight of rice. Ann Rev Phytopathol. 1987;25:359-382.

5. Reddy RP. Kresek syndrome of bacterial blight. In: Advances in Rice Pathology, d. S. Kannaiyan, TNAU, Coimbatore, Tamil Nadu. 1987;48.
6. Adhikari TB, Mew TW, Teng PS. Progress of bacterial blight on rice cultivars carrying different *Xa* genes for resistance in the field. Plant Dis. 1994;72:73-77.
7. Sunder S, Grakh SS, Battan KR. Effect of bacterial leaf blight of paddy on grain yield of paddy cultivar. Annals Applied Biol. 2002;20(2):207-209.
8. Rajarajeswari NVL, Muralidharan K. Assessments of farm yield and district production loss from bacterial leaf blight epidemics in rice. Crop Protection. 2006;25(3):244-252.
9. Laha GS, Reddy CS, Krishnaveni D, Sundaram RM, Prasad SM, Ram T, Muralidharan K, Viraktamath BC. Bacterial blight of rice and its management. Bulletin. DRR, Rajendranagar, Hyderabad, India. 2009;1-15.
10. Bhapkar DG, Kulkarni NB, Chavan VM. Bacterial blight of paddy. Poona Agricultural College Magazine. 1960;51: 36-46.
11. Seki M, Mizukami T. Application of antibiotics against bacterial leaf blight of rice plant [in Japanese]. Kyushu Agric. Res.1956;17:98.
12. Sulaiman M, Ahmed L. Controlling bacterial blight of paddy in Maharashtra. Indian Farming. 1965;15(8):27-29.
13. Gnanamanickam SS, Priyadarshini VB, Narayanan NN, Vasudevan P, Kavitha S. An overview of bacterial blight disease of rice and strategies for its management. Current Sci. 1999;77:1435-1444.
14. Biswas SK, Rai M, Srivastava SSL. Evaluation of antibiotics and their suitable use against bacterial blight of paddy [*Xanthomonas oryzae* pv. *oryzae* (Ishiyama) Dye]. Indian Phytopathol. 2009;62(1):126-128.
15. Chaudhary SU, Iqbal J, Hussain M. Effectiveness of different fungicides and antibiotics against bacterial leaf blight in rice. J Agriculture Res. 2012;50(1):109–117.
16. Thimmegowda PR, Arun S, Ambika DS, Prasad PS, Chandrashekar M. Efficacy of antibiotics and biorational pesticides against bacterial blight of paddy. Madras Agricultural J. 2012;99(7/9):592-596.
17. Suresh SR, Yenjerappa ST, Pavithra S. Field evaluation of bacterial blight of paddy by chemicals and biological agents. Trends in Biosciences. 2014;7(23):3905-3907.
18. Singh R, Yadav RS, Javeria S. Management of bacterial leaf blight of Basmati rice caused by *Xanthomonas oryzae* pv*. oryzae* with some available antibiotics and plant products. International J Innovative and Applied Res. 2015;3(11): 1- 6.
19. Wong WC, Preece TF. *Pseudomonas tolaasii* in mushroom *(Agaricus bisporus)* crops: Activity of formulations of 2-bromo-2-nitropropane-1,3-diol (bronopol) against the bacterium and the use of this compound to control blotch disease. J Applied Bacteriol. 1985;58:275-281.
20. Czajkowski R, Pe´rombelond MCM, van Veenbc JA, van der Wolfa JM. Plant Pathol. 2011;60:999–1013.
21. Benagi VI, Ravikumar MR. Present status pomegranate bacterial blight and its management. In: Souvenir & Abstract, II International Symposium on Pomegranate and Minor including Mediterranean Fruits, org. ISHS, Belgium, June 23-27, at UAS, Dharwad, Karnataka, India. 2009;53-58.
22. Cooksey DA. Genetics of bactericide resistance in plant pathogenic bacteria. Ann Rev Phytopathol. 1990;28:201-219.
23. McManus PS, Stockwell VO, Sundin GW, Jones AL. Antibiotic use in plant agriculture. Ann Rev Phytopathol. 2002;40: 443-465.
24. Li P, Shi L, Gao MN, Yang X, Xue W, Jin JH, Hu D, Song B. Antibacterial activities against rice bacterial leaf blight and tomato bacterial wilt of 2-mercapto-5-substituted-1,3,4-oxadiazole/ thiadiazole derivatives. Bioorganic & Medicinal Chemistry Let. 2015;25:481–484.
25. Ou SH. Rice diseases. 2nd edition. Commonwealth mycological institute, Kew, Surrey (England). 1985;61-69.
26. Shankara K, Patil MB, Pramesh D, Sunkad G, Chikkannaswamy. Isolation and characterization of bacterial leaf blight of rice (*Xanthomonas oryzae* pv. *oryzae)* isolates from Southern India. Advances in Life Sci. 2016;5(14):5625-5633.
27. Kauffman HE, Reddy APK, Heisk SPV, Maraca SD. An improved technique for evaluating resistance of rice varieties to

Xanthomonas oryzae. Plant Dis Reporter. 1973;57:537-541

28. Seebold KW, Datnof JLE, Correa–Victoria FJ, Kucharek TA, Suyder GH. Effects of Silicon and fungicides on the control of leaf and neck blast in Upland rice. Plant Dis. 2004;88:253-258.

29. Sundin GW, Castiblanco LF, Yuan X, Zeng Q, Yang CH. Bacterial disease management: Challenges, experience, innovation, and future prospects. Molecular Plant Pathol; 2016.
DOI: 10.1111/mpp.12436

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18951