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Real-Time Contingency Measures as a Sustainable Strategy for Managing Biotic Stress in Rice Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice is grown in 2.0 lakh ha in Srikakulam district of Andhra Pradesh. Unpredictable weather conditions, low socio-economic status of farmers and various nutritional imbalances are the factors affecting the agricultural productivity in rain-fed agriculture in North coastal regions of Andhra Pradesh. With the effects of climate change, crops are sometimes affected by floods and sometimes by drought. Under such flood conditions, biotic stress including many fungal, bacterial, viral, nematode and non-parasitic diseases and among such diseases, blast, sheath blight are major and a limiting factors for the rice production. Considering these bottlenecks, KVK, Srikakulam assessed the realtime contingency measures against the biotic stress in rice crop at Kondavalsa and Ponnam villages of Srikakulam district in 2020 and 2021. Integrated pest and Disease management practices were implemented in real time against Blast, Sheathblight and BPH. The results showed that 70-75 per cent reduction in the incidence of blast among the management measures adopted plots in both the selected locations during 2020 and 2021. But only a 50%

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reduction was noted in the farmers approach. Similarly, PDI of Sheath blightwas reduced 78%. Also Brown plant hopper population was brought under control by using the management practices. In 2020, the grain yield of Kondavalasa and Ponnam villagesin the demo plots were 5580 and 5690 kg/ha at, respectively, while grain yield in farmers practice were 5090 and 5210 kg/, respectively. During 2021, demo plots at Kondavalasa and Ponnam also, recorded highest grain yields of 5630 and 5850 kg/ha, respectively. The higher severity of diseases like Blast, Sheath blight and pests such as, BPH has lead to poor yields in case of farmers approach. This study clears that adoption of certain measures *viz*., sowing of tolerant varieties, Seed treatment, Alleyways formation, optimized Nitrozen fertilizer application which promotes the better crop growth and reduce the occurrence of pests and diseases. Additionally, the timely spraying of highly efficient chemicals to control biological stresses such as Blast, Sheath blight and BPH will minimize crop yields and improved grains quality and quantity.

Keywords: BPH; blast; sheath blight; rice; real time contingency measures; biotic stress.

1. INTRODUCTION

Rice is the staple food for more than half of the world's population. It is a source of carbohydrates, protein, dietary fiber and minerals. In India, more than 16 million hectares are covered with rainfed lowland rice [1]. Unpredictable weather conditions, low socio-economic status of farmers and various nutritional anomalies are factors affecting agricultural productivity in rain-fed agriculture in North coastal regions of Andhra Pradesh. Rice is grown in an area of 2.0 lakh ha in Srikakulam district of Andhra Pradesh. Climate change remains the greatest challenge facing the world, affecting densely populated countries like India where agricultural production is essential. Irregular rainfall and flooding, intermittent and long-lasting droughts, as well as the appearance of various diseases and pests due to changes in temperature and relative humidity are key factors that reduce crop yields. Such weather anomalies lead to crop vulnerability and risk through the evolution of disease occurrence in crop ecosystems. Due to the effects of climate change, crops are sometimes affected by floods and sometimes by drought. Under such flooding conditions, biotic stress occurs and involves a large number of fungal, bacterial, viral, nematode and non-parasitic diseases, among which blast, sheath blight are the main biotic stresses and a limiting factor for the production rice.

Blast is the deadliest disease, affecting rice crops and destroying around 35% of the harvest [2]. Blast disease can cause yield loss up to 80%, [3] and is an infectious disease that reduces seed quality and yield [4]. Sheath blight was first reported in Japan in 1910 and has since spread worldwide [5]. Sheath blight is considered the second most destructive disease of temperate and tropical rice, with the potential to cause 25% yield loss [6] and Losses due to sheath blight disease may vary from 30 to 40 per cent and could be even 100 per cent in endemic areas [7] In terms of rice pests, the brown plant hopper (*Nilaparvata lugens*), BPH is a major pest that occurs in humid and temperate climates, mainly from panicle germination to grain development stages of rice crop. Widespread outbreaks of N. *lugens* during the rice growing season have been observed in recent years, resulting in massive yield losses. Global climate change is a reality in the current context, and adverse climate changes are having a positive impact on insect populations, especially phloem-sucking insects like BPH [8].

Managing all these biotic stresses is very difficult for farmers and is often confusing in identifying damage from different pests and diseases. Previous research has shown that preventive measures against pests and diseases will reduce damage to seed quality and loss of grain yield. The preventive measures were effective, reducing the incidence of blast and sheath blight and recored higher yields [9]. In this context, Krishi Vigyan Kendra of Srikakulam conducted field research on preventive and real-time contingency measures against biotic stress in 2020 and 2021 to inform farmers on preventive measures against pests and diseases.

2. MATERIALS AND METHODS

Krishi Vigyan Kendra, Amadalavalasa of Srikakulam district conducted field research on real-time emergency measures to manage biotic stress in paddy fields in Kondavalasa, Sarubujjili Mandal and Ponnam, Amadalavaalsa Mandal, Srikakulam Dist, Andhra Pradesh. These selected villages are more prone to flooding

Chart 1. Treatment details

Realtime Contingency measures / Prophylactic measures	Farmers approaches
• Selection of flood tolerant variety, Indra (MTU 1061);	• Variety: Swarna (MTU 7029)
• Seed treatment with Pseudomonas @ 5g/Kg seed;	• Non adoption of Seed treatment
• Alleyways formation;	• Dense population with no alleys
• Optimized Nitrozen fertilizer application; Spraying of Tricyclazole @ 0.6g/l against leaf blast;	• Spraying of Carbendazim + Mancozeb @ 3g/l
• Spraying of Trifloxystrobin + Tebuconazole 75 WG @ 0.4g/l against Sheath blight;	• Spraying of Hexaconzole @ 2ml/l
• Spraying of Dinotefuran 20% SG@ 0.5g/l against BPH.	• Spraying of Acephate @ 2g/l

during the heavy rains of the Kharif season, when the paddy fields are completely submerged or partially damaged. Later, diseases such as sheath blight and blast appeared on the crops, which reduced yields and grain quality. Also due to the sudden increase in temperature and population density, BPH has become a threat to farmers. This study evaluates the effectiveness of real-time emergency measures in rice ecosystems to reduce the incidence of blast and sheath blight, BPH population by reducing the cost of crop protection products.

At each location/village five farmers were selected and implemented the treatments. Data collected on per cent disease incidence using the formula

$$Per\ cent\ Disease\ Incidence\ (PDI) = \frac{No.of\ leaves\ infected}{Total\ No.of\ leaves\ examined} X\ 100$$

BPH population was recorded randomly on five hills per each sq.m and collected on five sq.m randomly in one acre field. Collected rainfall, temperature and other weather parameters data pertaining to the crop period and correlated. Further, data on yield parameters were collected and analyzed. Benefit Cost Ratio (B:C) was calculated using the cost of cultivation (including all the test chemicals) and product market price.

3. RESULTS AND DISCUSSION

3.1 Disease Management in Paddy

This study showed that the incidence of diseases such as blast and sheath blight was high due to high relative humidity during monsoons, while the BPH population was increased after floods due to sudden increase in temperature and humidity in the crop microclimate.Blast disease was noticed in the tillering stage of the crop during august – September. In Kondavalasa village, the incidence of blast disease was 27.2 and 25.5 per cent in 2020 and 2021, respectively which was reduced by 70.2and 76.8 per cent immediately after one spraying of Tricyclazole @ 0.6g/l. In the farmers approach, the disease reduction in Kondavalasa village was 56.7 and 45.2 per cent in 2020 and 2021, respectively (Table 1). In the other location, Ponnam village the blast incidence was decreased to 68 and 74.6per cent during 2020 and 2021, respectively in demonstrated plots. Whereas, in the farmers approach, disease reduction was below 50 per cent. Immediate spraying of effective chemicals has brought down the disease severity and crop loss. These results are in correlation with the earlier studies conducted several research workers. Raj and Pannu, [10] found that the fungicide Tricyclazole at 0.06% was most effective and provided disease control of 67.9% under *in-vitro* conditions. Seed treatment with tricyclazole @ 3 g/kg and foliar spraying with tricyclazole @ 0.6 g/l is the best treatment against leaf blast and neck blast, reducing leaf blast and neck blast by up to 74% and 72.3%, respectively [11]. Similarly, Mohiddin et al., [12] reported tricyclazole proved the most effective against rice blast and recorded a leaf blast incidence of only 8.41%. Tricyclazole being systemic natured, prophylactic spray safeguards plants from infection by preventing the entry of the fungus into the epidermis [9].

Sheath blight incidence was noticed during the late vegetative/ tillering stage at both the selected locations. Disease incidence was 24.4 and 28.4 per cent in 2020 and 2021, respectively at Kodavalasa village. Spraying of Trifloxystrobin + Tebuconazole @ 0.4 g/l was highly effective against the sheath blight pathogen and reduced the disease incidence to 74.0 and 76.0 per cent in 2020 and 2021, respectively (Table 2). In the farmer approach, (spraying of Hexaconzole @ 2ml/l) the disease reduced upto 68.4 per cent in 2020 and 62.2 per cent in 2021. Similarly, Sheath blight incidence was recorded 26.2 and 26.9 per cent in Ponnam village during 2020 and

2021, respectively. The PDI was reduced upto 67.7 and 60.0 per cent after spraying of Trifloxystrobin + Tebuconazole during 2020 and 2021, respectively. This is in line with the previous studies conducted several research workers. New combination of chemical belongs to strobilurin group, Trifloxystrobin + Tebuconazole has recorded the lowest PDI of blast and sheath blight compared to untreated control [2,13,14].

Table 1. PDI of Blast in rice at Kondavalasa, Ponnam villages during kharif 2020 and 2021

Village	Demo (% DI)		% Decrease	Farmers approach		% Decrease
	Pre	Post		Pre	Post	
Kharif, 2020						
Kondavalasa	27.2	8.2	70.2	28.0	12.1	56.7
Ponnam	35.0	11.2	68.0	35.0	16.8	52.0
Kharif, 2021						
Kondavalasa	25.5	5.9	76.8	25.2	13.8	45.2
Ponnam	30.5	7.2	74.6	31.8	15.6	50.0

Table 2. PDI of Sheath blight in rice at Kondavalasa, Ponnam villages during kharif 2020 and 2021

Village	Demo (% DI)		% Decrease	Farmers approach		% Decrease
	Pre	Post		Pre	Post	
Kharif 2020						
Kondavalasa	24.4	4.8	80.3	34.2	10.8	68.4
Ponnam	26.2	5.5	79.0	38.4	12.4	67.7
Kharif, 2021						
Kondavalasa	28.4	7.2	75.0	30.5	11.5	62.2
Ponnam	26.9	5.6	79.1	32.5	13.0	60.0

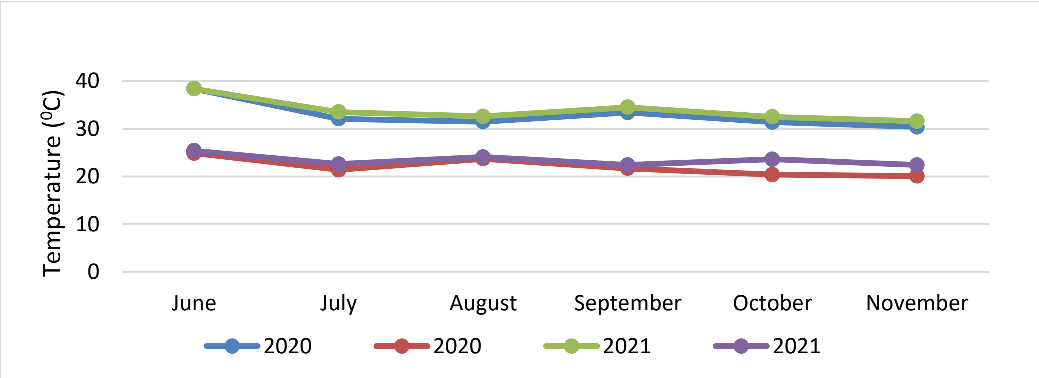

Fig. 1. Temperature recoded during 2020 and 2021 in Kondavalasa village of Sarubujjili

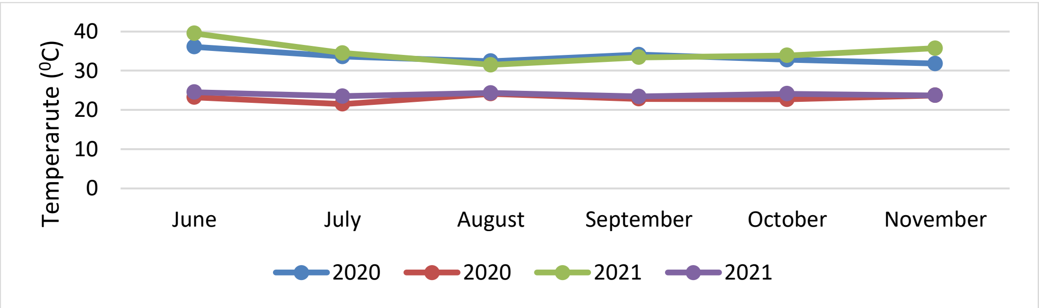

Fig. 2. Temperature recoded during 2020 and 2021 in Ponnam village of Amadalavalsa

3.2 Integrated Management Practices against Diseases

Seed treatment with pseudomonas decreases the blast incidence in the early stage of the crop and recorded lowest disease intensity in the present study. When the formulation was applied as a seed treatment, the bacteria established well in the rice rhizosphere and protects from the fungal growth. Jeyalakshmi *et al*, [15] proved that, the combination of seed treatment, soil application and foliar spray with P. *fluorescens* recorded the minimum disease incidence of bacterial leaf blight (1.11 %) with maximum yield (4.1 t/ha) in comparison with the chemical treatment and control. Rice variety MTU 1061 which has tolerance to diseases like blast and sheath blight was selected in this study and was recorded lowest PDI of blast and sheath blight compared to the wide spread variety MTU 7029 used in the Srikakulam district. The variety has played a major role in the decreased spread of disease among the crop. Also optimized nitrogen application reduced the intensity of the diseases which regulated the loss to the crop. Rini and Dipankar, [10] also found that there was a progressive increase of leaf blast severity with total nitrogen fertilizer application as compared to the application of two-thirds of the recommended dose in the susceptible variety Swarna. Two to three applications of Tricyclazole 75 WP @0.6 g/l along with two thirds of the recommended dose of N showed the highest increase in yield (43.74% in dry season and 59.96% in wet season) in the susceptible variety. Leaf blast was significantly more severe on the susceptible and very susceptible cultivars when N fertilizer was applied as a single application at pre-flood than in the split application treatment [16].

3.3 Management of BPH Population

BPH population was noticed in the paddy crop during the later stages of the crop. Table 3 indicted that, the BPH population was reduced to 82.0 and 85.2 per cent in Kondavalsa and Ponnam villages, respectively during 2020 in the IPM adopted fields. Whereas in the farmers approach, the BPH population was high and reduced to 71.6 and 72.5 per cent only in Kondavalasa and Ponnam villages. Due to high humidity in the micro climate, in 2021 also same trend was noticed. The BPH population was reduced to 82.7 and 81.0 per cent in Kondavalasa and Ponnam villages, respectively. Only 71.8 and 68.3 percent reduction in BPH population was recorded in case of farmers approach in Kondavalsa and Ponnam villages, respectively. This study reveals that, the higher temperature and high humidity due to the immediate floods in paddy fields, favours the BPH population. The same was explained by the earlier researchers. Sarkar et al. [17] who found that the population of BPH was significantly influenced by the weather parameters in particular, temperature and relative humidity. Chaudhary et al. [18] reported the similar results that, temperature was positively correlated with BPH population. Chittibabu et al. (2021) also reported a positive correlation between BPH populations with temperature.

The present study also revealed that, timely management of BPH can reduce the damage per cent in production in rice. Optimized 'N' fertilizer and creation of alley ways has played a major role in decreasing the pest population. Also spraying of effective chemical, Dinotefuran 20% SG @ 0.5g/l has completely kept BPH population under control. Simlarly, Hurali et al. [19] also indorsed Dinotefuran 70% WG was superior in suppressing the BPH population in Rice. Sarao and Randhwa, [20] also revealed that BPH population was reduced by Dinotefuran 20% SG and recorded higher yields in paddy.

3.4 Yield Attributes

Results indicated that, the higher grain yields were recorded in the timely management practices adopted fields compared to the farmers approach. In 2020, the grain yield recorded was 5580 and 5690 kg/ha at Kondavalasa and Ponnam villages, respectively in the demo plots compared to 5090 and 5210 kg/ha in the farmers practices. Nearly 10 percent in the yield was noticed in the demo plots compared to the farmers approach. The higher severity of diseases like Blast, Sheath blight and BPH has lead to poor yields in case of farmers approach. Similarly in 2021 also the same results were obtained. The highest grain yield was recorded in the demo plots, 5630 and 5850 kg/ha in Kodavalasa and Ponnam villages, respectively. An average of Rs.8500/- increase in the net income was noticed at both the villages. This proved that timely adoption of management practices against pest diseases can reduce the risk of crop loss and increases the net returns for the farmers. Similar results were demonstrated by Katsube et al. [21] who advocated that there was 6 per cent yield reduction for every 10 per cent blast incidence and 5 percent increase in chalky kernals, which lowered the rice quality. Amarajyothi and Chinnamnaidu, [9] also stated that, decline in quality and quantity was strongly correlated with disease occurrence, suggesting that real time protective measures should be implemented to limit the yield loss and spread of disease, particularly rice grown in flood-prone area [22].

Table 3. BPH population in rice at Kondavalasa, Ponnam villages during kharif 2020 and 2021

Village	Demo		% Decrease	Farmers approach		% Decrease
	Pre	Post		Pre	Post	
Kharif, 2020						
Kondavalasa	63.4+1.74	11.4+1.08	82.0	65.6+1.93	18.6+0.77	71.6
Ponnam	70.2 +1. 9	10.2+0.63	85.2	70.6+1.18	19.4+0.66	72.5
Kharif, 2021						
Kondavalasa	56.6+1.61	9.8+0.76	82.7	54.6+1.90	15.4+0.91	71.8
Ponnam	49.4+1.45	10.4+0.45	81.0	51.8+1.33	16.6+0.72	68.3

Table 4. Economics parameters recorded in rice crop

Treatments	2020				2021			
	Grain yield (kg/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio	Grain yield (kg/ha	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio
Kondavalasa village								
Demo	5580	52625	51163	1: 1.97	5630	53200	56022	1:2.05
Farmers practice	5090	51200	43474	1: 1.84	5060	50875	47289	1:1.92
Ponnam village								
Demo	5690	52705	53129	1: 2.00	5850	54625	58865	1:2.07
Farmers practice	5210	52100	44806	1: 1.86	5330	52438	50965	1:1.97

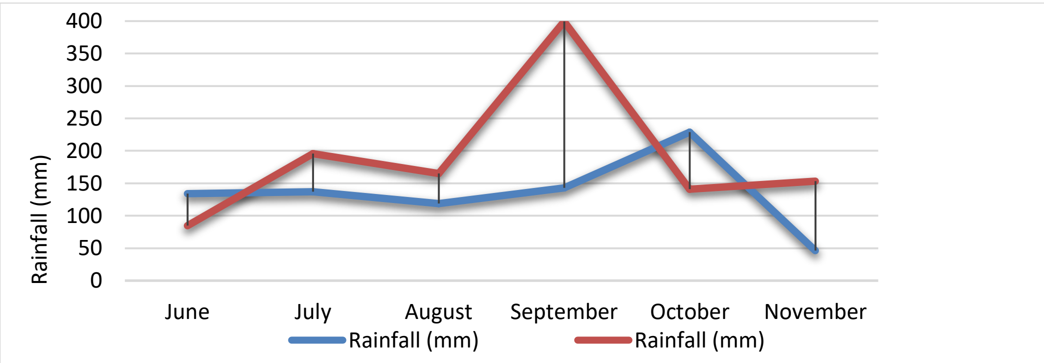

Fig. 3. Rainfall received during 2020 and 2021 in Kondavalasa village of Sarubujjili

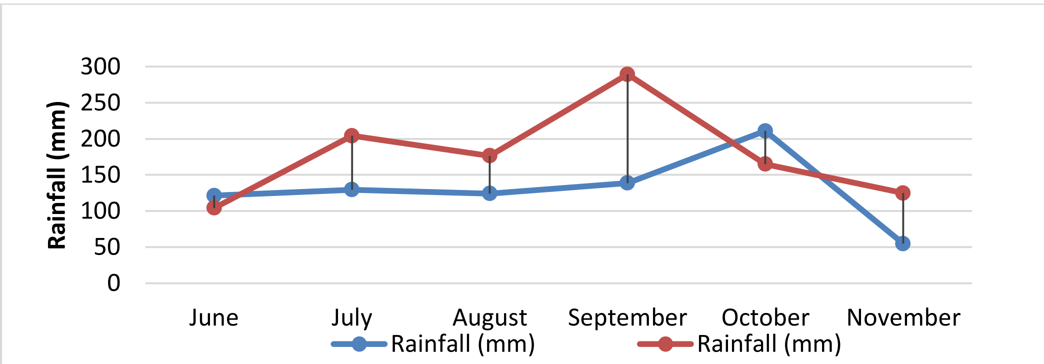

Fig. 4. Rainfall received during 2020 and 2021 in Ponnam village of Amadalavalsa

4. CONCLUSIONS

Rice crop grown in low lying areas always experience frequent flooding, triggers severe outbreak of diseases like blast and sheath blight. In such cases the yield and quality of grain will decrease and yields poor returns to the farmers. This study clears that adoption of certain measures *viz*., sowing of tolerant varieties, Seed treatment, Alleyways formation, optimized Nitrozen fertilizer application which promotes the better crop growth and reduce the occurrence of pests and diseases. Additionally the timely spraying of highly efficient chemicals to control biotic stress like Blast, Sheath blight and BPH will minimize crop loss and increase quality and quantity of grains. The higher yields will give more returns to the farmers, thereby improving socio economic status of the farmers will be improved. Therefore, real time protective measures should be implemented to limit the yield loss and disease spread, especially for rice grown in flood-prone area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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