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Evaluation of some rice hybrids and high yielding varieties for their resistance to major insect pests and diseases in coastal plain of Odisha

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ABSTRACT

Biotic stress in the form of insect pest infestation and disease incidence is a major production constraint in rice contributing lower productivity and profitability. Though pesticide application continues to be the most preferred pest control strategy, its injudicious application has many undesirable effects on the human health and surrounding environment. Host plant resistance mechanism with the development of resistant and tolerant varieties against the targeted pests is gaining importance over the years to reduce the pest damage and minimize the load of harmful pesticides in the agro-ecosystem. Experiments carried out at the Regional Research and Technology Transfer Station, Ranital in 2018 and 2019 revealed that among the test hybrids and high yielding varieties of rice a significantly lower plant hopper and leaf hopper population was recorded in the hybrid BS 144 and the high yielding variety MTU-1010. The test hybrid BS 133 though had little higher population of plant and leaf hoppers, produced higher grain yield in comparison to other hybrids and varieties indicating the presence of some tolerance mechanism in this hybrid against the sucking pest complex of rice. The lowest sheath blight and BLB incidence was recorded in the variety MTU 1010, whereas among the hybrids, BS 144 and BS 133 had comparatively lower disease incidence. The hybrids Sahadri and Arize bold were found to be highly susceptible to the major insect pest and diseases of rice. The hybrids BS 144 and BS 133 and the high yielding variety MTU-1010 were found to have higher yield potential during the wet season at the coastal plain zone of Odisha and their yield performance may further increase if timely and need based plant protection measures will be adopted.

Key words : Disease resistance, HYV, pest resistance, rice varieties, screening

INTRODUCTION

Rice is the staple food of more than 50% of world's population and its sustainable production is critically essential for the global food security. Over 90 per cent of rice is grown in Asian countries with China and India being the major producing nations. Approximately 52% of the global production of rice is lost annually owing to the damage caused by biotic stress factors, of which 25% is attributed to the attack of insect pests (Yarasi et al., 2008). Similarly, around 10 to 30 per cent of the annual rice harvest is lost due to infection by many diseases (Skamnioti and Gurr, 2009). Nearly 300 species of insect pests attack the rice crop at different stages and among them 23 species cause notable damage (Pasalu and Katti, 2006) causing 30-35 % yield loss (Prakash et al., 2007). Insect pest infestation is accounting for 50 % damage in vegetative, 30 % in reproductive and 20 % in the ripening stage of rice (Gupta and

Raghuraman, 2003). There has been a changing pest scenario in the rice eco-system with the appearance of some new arthropod pests, attainment of major pest status by minor pests with higher incidence and damage potential, regular infestation of sporadic pests, development of insecticide resistance in major pests and appearance of insect biotypes to infest the resistant crop varieties. Though stem borer, gall midge and leaf folder are the major insect pest of rice, plant hoppers (brown plant hopper and white backed plant hopper) assumed serious significance in the recent years and cause widespread damage particularly to the wet season rice of coastal areas due to favourable ecological niche and injudicious use of chemical insecticides resulting in insecticide resistance and resurgence. Generally, the yield losses due to hoppers ranges from 10 to 90%, but if timely control measures are not taken up, there may be possibility of total crop loss within a very short period (Seni and Naik, 2017). A recent report from Directorate of Rice Research estimated that plant hoppers cause losses ranging from 1-2 million tons of rice annually in India. Besides, the direct damage through hopper burn, brown plant hopper (BPH) transmits viral diseases like grassy stunt, ragged stunt and wilted stunt (Bhanu et al., 2014) and therefore often considered as the most destructive insect pest of wet season rice.

The white backed plant hopper (WBPH), *Sogatella furcifera* (Horváth) (Homoptera: Delphacidae),which was earlier recognized as a minor pest of rice is emerging as a serious pest in many rice growing countries (Khan and Saxena, 1986) and the extent of yield losses ranges from 54.4 to 79.8 per cent in different rice varieties (Khan and Kushwaha, 1991). Though Green Leaf Hopper (GLH) is known for its ability to transmit rice tungro virus, its direct damage through plant sap sucking has been inconspicuous. However, in the recent years the direct damage of GLH trough sap sucking and honey dew secretion cause stunted plant growth and considerable yield loss of 15-20 % (Prakash and Rao, 1998) and the extent of damage is more serious in the susceptible varieties. The increased economic importance of these sucking insect pests of rice and less efficacy of conventional insecticide based management strategies necessitates the development of some resistance varieties by incorporating the natural resistance mechanisms in the crops. Similarly, diseases like BLB, sheath blight, brown spot, sheath rot and blast have been causing sizable yield loss in rice. Rice sheath blight, caused by the soil-borne fungal pathogen Rhizoctonia solani, is an economically important disease in rice and depending upon the severity of the disease, it may cause 25–100% yield losses (Yadav et al., 2018). Bacterial leaf blight (BLB) disease caused by *Xanthomonas oryzae pv. oryzae* Ish. is one of the serious diseases of rice worldwide and is particularly destructive in Asian countries with a yield loss potential of 30 per cent in India (Chahal, 2005).

Application of chemical pesticides is the most preferred plant protection strategy adopted by the farmers to reduce pest infestation. However, injudicious and excessive use of insecticides not only cause undesirable consequences in the agro-ecosystem but has serious adverse effect on human health. Further, indiscriminate application of pesticides leads to other undesirable consequences like resistance development, resurgence, residue deposits and environment pollution besides, most of these chemicals are expensive and there by increases the cost of production for the resource poor farmers. Host plant resistance has been increasingly recognized as one of the important components of integrated pest management as it largely minimizes the adverse impact of reckless use of pesticides. Among the three mechanisms of resistance *viz.* antixenosis, antibiosis and tolerance, the tolerance varieties have great future prospects as this mechanism does not exert any selection pressure on the pest and prevent the development of biotypes. Improving the yield potential of rice is through the introduction of hybrids is gaining prominence in many countries of the world. Hybrid rice is extensively commercialized in China where over 50% of the total land area for rice is planted to hybrids (Cheng et al., 2007). Other Asian countries like India, Philippines, Thailand, Vietnam, Indonesia, and Bangladesh have also commercialized hybrid rice (Virmani et al., 1996). Hybrid rice is a promising and sustainable technology for increasing rice production and productivity (IRRI, 1997). It has been proven practically that hybrid varieties could out-yield their inbred counterparts grown under similar conditions by 15–20% (Virmani, 1994). However, Research findings suggests that hybrid rice has been highly vulnerable to damage from a wide range of insect pests due to favourable crop phenology, higher nutrient requirement and absence of natural resistance mechanism. Therefore, a renewed focus has been initiated to develop rice hybrids with some resistance and tolerance mechanism against the biotic stresses. Keeping this in view, some medium duration high yielding varieties and hybrids (110 to 130 days) were evaluated for their productivity and resistance or tolerance to the sucking insect pest and major diseases.

MATERIALS AND METHODS

The experiments were carried out to evaluate some hybrids and high yielding varieties of rice for their yield and pest resistance during kharif seasons of the year 2018 and 2019 at the experimental plots of the Regional Research and Technology Transfer Station (RRTTS), Ranital, OUAT. The experimental plots were laid out in randomized block design with nine treatments (five hybrids and four high yielding varieties) and three replications. The seeds were sown in the nursery during the month of July (6th July, 2018 and 21st July, 2019) and the seedlings were transplanted in the experimental plots during 3rd August 2018 and 19th August 2019, respectively for both the years of investigation with a closer spacing of 15 × 10 cm to ensure higher population build up of plant hoppers and leaf hoppers. The fertilizer dose of 80 :40 : 40 kg N, P_2O_5, K_2O ha^{-1} and 120:60:60 NPK kg N, P_2O_5, K_2O ha^{-1} was applied for the HYV and hybrids, respectively with the application of nitrogen in three split doses. A boarder strip of susceptible variety Swarna with closer spacing and higher dose application of nitrogen fertilizer was maintained around the experimental plot to harbor more insect pests and disease inoculums. The crop in the experimental plot was maintained with recommended agronomic package of practices and standard intercultural operations without any plant protection measures. Observations on the population of plant hoppers (BPH and WBPH per hill), green leaf hoppers (GLH per hill) and the incidence of BLB and sheath blight were recorded at weekly interval from ten randomly selected hills from each plot starting from the appearance of insect pest and disease symptoms. Disease scoring was done by using the 0-9 rating scale recommended by the International Rice Research Institute (IRRI, 1988) and the recorded infection scores were then used for calculation of per cent disease index (PDI) as suggested by McKinny (1923).

$$\text{PDI} = \frac{\text{Sum of numerical rating} \times 100}{\text{Total no. of leaves observed} \times \text{Maximum disease grade in the score chart}}$$

The mean insect population and disease incidence were worked out by considering the cumulative pest data over the entire period of observation. The mean insect population per hill was subjected to logarithm transformation and percent disease incidence was subjected to angular transformation for statistical analysis. The plot wise grain yield (kg per plot) was recorded after the harvest of crop and the total yield was calculated by converting it into q ha^{-1} for further statistical analysis.

RESULTS AND DISCUSSION

Reaction of the test hybrids and HYVs to insect pests

The lowest plant hopper population (was recorded in the hybrid BS 144 (16.34 and 19.12 per hill, during 2018 and 2019, respectively with a mean hopper population of 17.73 per hill) which was found to be statistically superior to the rest of the varieties and hybrids (Table 1). Comparatively lower plant hopper population was also recorded in MTU 1010 (20.86 and 23.46 per hill during 2018 and 2019, respectively with a mean of 22.16 hoppers per hill), BS 133 (22.82 and 24.12 per hill during 2018 and 2019, respectively with a mean of 23.47 hoppers per hill), Gobinda (23.34 and 27.07 per hill during 2018 and 2019, respectively with a mean of 25.20 hoppers per hill), MTU 1001 (25.95 and 25.13 per hill 2018 and 2019, respectively with a mean of 25.54 hoppers per hill), Lalat (27.36 and

Table 1. Population of sucking insect pests in some HYVs and Hybrid of rice (*kharif* 2018 and 2019)

Treatments	Plant hopper* (BPH and WBPH) no. per hill			Green leaf hopper* no. per hill		
	2018	2019	Mean	2018	2019	Mean
T_1: Arize Bold	39.79 (1.6)	34.12 (1.53)	36.96 (1.57)	42.17 (1.62)	39.23 (1.59)	40.7 (1.61)
T_2: BS 144 (AZ 6453ST)	16.34 (1.21)	19.12 (1.28)	17.73 (1.25)	20.61 (1.31)	21.27 (1.32)	20.94 (1.32)
T_3: BS-133 (AZ-8433 DT)	22.82 (1.36)	24.12 (1.38)	23.47 (1.37)	30.82 (1.49)	26.67 (1.42)	28.75 (1.46)
T_4: Ajaya	30.22 (1.48)	30.04 (1.48)	30.13 (1.48)	32.13 (1.51)	33.72 (1.53)	32.93 (1.52)
T_5: KJ RTH-2 (Sahadri)	42.14 (1.62)	36.46 (1.56)	39.3 (1.59)	43.73 (1.64)	40.84 (1.61)	42.29 (1.63)
T_6: Lalat	27.36 (1.44)	24.55 (1.39)	25.96 (1.41)	30.08 (1.48)	28.06 (1.45)	29.07 (1.46)
T_7: MTU-1001	25.95 (1.41)	25.13 (1.4)	25.54 (1.41)	27.86 (1.44)	30.04 (1.48)	28.95 (1.46)
T_8: MTU-1010	20.86 (1.32)	23.46 (1.37)	22.16 (1.35)	23.84 (1.38)	25.89 (1.41)	24.87 (1.4)
T_9: Gobind	23.34 (1.37)	27.07 (1.43)	25.2 (1.4)	25.16 (1.4)	32.03 (1.5)	28.6 (1.46)
SEm (±)	0.028	0.027	0.02	0.028	0.023	0.017
CD (0.05)	0.09	0.08	0.06	0.08	0.07	0.05

*Values in the parentheses are log10 (x) transformed values

24.55 per hill during 2018 and 2019, respectively with a mean of 25.96 hoppers per hill) and all these treatments were statistically comparable with each other. However, a higher plant hopper population was observed in the hybrids Ajaya (30.22 and 30.04 per hill during both the years of investigation, respectively with a mean value of 30.13 plant hopper per hill), Arize Bold (39.79 and 34.12 per hill during 2018 and 2019, respectively with a mean hopper population of 36.96 per hill) and KJ RTH-2 (42.14 and 36.46 per hill during 2018 and 2019, respectively with a mean hopper population of 39.30 per hill).

A similar trend was observed in the GLH population among the test hybrids and varieties. The minimum GLH population was recorded in the hybrid BS 144 (20.61 and 21.27 per hill during 2018 and 2019, respectively with a mean value of 20.94 GLH per hill) which was considered to be superior to the rest of the varieties and hybrids. The high yielding variety MTU 1010 with an average 23.84 and 25.89 GLH per hill during 2018 and 2019, respectively with a mean value of 24.87 insects per hill was found to be the next best treatment. The other varieties and hybrids follow the order as Gobinda (28.60 mean GLH per hill), BS 133 (28.75 mean GLH per hill), MTU 1001 (28.95 mean GLH per hill), Lalat (29.07 mean GLH per hill). In contrast the higher GLH population was observed in the hybrids Ajaya (32.93 mean GLH per hill), Arize Bold (40.70 mean GLH per hill) and KJ RTH-2 (42.29 mean GLH per hill).

Table 2. Incidence level of Sheath blight and BLB in some HYVs and Hybrid of Rice and their yield performance

Treatments	Sheath Blight			Bacterial Leaf Blight			Yield (q ha^{-1})		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
T1: Arize Bold	15.1 (22.86)	21.24 (27.43)	18.17 (25.22)	12.48 (20.68)	22.27 (28.13)	17.38 (24.62)	35.13	42.82	38.98
T2: BS 144 (AZ 6453ST)	9.43 (17.88)	13.28 (21.36)	11.35 (19.68)	6.45 (14.71)	11.62 (19.89)	9.04 (17.49)	49.67	55.8	52.74
T3: BS-133 (AZ-8433 DT)	7.29 (15.66)	11.45 (19.77)	9.37 (17.82)	6.94 (15.22)	13.49 (21.52)	10.2 (18.61)	46.26	51.13	48.7
T4: Ajaya	14.66 (22.5)	18.86 (25.73)	16.76 (24.16)	12.13 (20.35)	20.71 (27.01)	16.41 (23.88)	38.93	43.85	41.39
T5: KJ RTH-2 (Sahadri)	15.69 (23.33)	21.87 (27.87)	18.78 (25.67)	13.07 (21.19)	23.4 (28.91)	18.24 (25.27)	33.17	41.28	37.23
T6: Lalat	6.28 (14.51)	10.3 (18.71)	8.29 (16.73)	8.76 (17.21)	15.87 (23.46)	12.32 (20.54)	42.84	48.83	45.84
T7: MTU-1001	7.86 (16.27)	10.84 (19.22)	9.35 (17.8)	8.04 (16.57)	15.06 (22.81)	11.55 (19.9)	42.07	47.23	44.65
T8: MTU-1010	4.74 (12.57)	7.34 (15.71)	6.04 (14.22)	5.32 (13.3)	8.16 (16.55)	6.73 (15.03)	47.74	54.73	51.24
T9: Gobind	11.08 (19.44)	15.42 (23.11)	13.25 (21.34)	10.63 (19.02)	18.08 (25.15)	14.36 (22.26)	39.73	41.03	40.38
SEm (±)	0.923	1.046	0.785	1.022	0.868	0.754	1.246	1.687	1.035
CD (0.05)	2.77	3.14	2.35	3.1	2.6	2.26	3.74	5.06	3.1

*Values in parentheses are Arc Sine transformed values

Reaction of the test hybrids and HYVs to diseases

All the hybrids and high yielding varieties exhibited a significant variation among themselves with respect to their reaction to sheath blight and bacterial leaf blight disease. The minimum sheath blight incidence in the variety MTU-1010 with only 4.74 and 7.34 PDI during 2018 and 2019, respectively (mean PDI of 6.04) indicated its high level of resistance to the disease. The varieties Lalat (6.28 and 10.30 PDI, respectively during 2018 and 2019 with a mean PDI of 8.29) and MTU-1001 (7.86 and 10.84 PDI, respectively during 2018 and 2019 with a mean PDI of 9.35) and the hybrid BS 133 (7.29 and 11.45 PDI, respectively during 2018 and 2019 with a mean PDI of 9.37) also offered a good level of resistance to sheath blight. The hybrid BS 144 and the HYV Gobind with a mean PDI of 11.35 and 13.25 respectively witnessed a moderate incidence of sheath blight. However, the hybrids Ajaya (mean PDI of 16.76), Arize Bold (mean PDI of 18.17) and KJ RTH-2 (mean PDI of 18.78) were found to be susceptible to sheath blight with comparatively a higher disease incidence.

Among the test hybrids and HYVs the lowest BLB incidence was observed in MTU 1010 (5.32 and 8.16 PDI during 2018 and 2019, respectively with lowest mean PDI of 6.73), which was statistically superior to rest of the treatments. A comparatively lower BLB incidence was also recorded in hybrid BS 144 (6.45 and 11.62 PDI during 2018 and 2019, respectively with mean PDI of 9.04), BS 133 (6.94 and 13.49 PDI during 2018 and 2019, respectively with mean PDI of 10.20) and the variety MTU-1001 (8.04 and 13.49 PDI during 2018 and 2019, respectively with mean PDI of 11.55) and all the treatments had statistically similar reaction to BLB. A moderate level of BLB incidence was observed in the variety Lalat (mean I of 12.32). However, the higher BLB incidence was recorded in Gobinda (14.36 mean PDI), Ajaya (16.41 mean PDI), Arize Bold (17.38 mean PDI) and KJ RTH-2 (18.24 mean PDI).

Yield performance of the hybrids and HYVs

Among the hybrids and HYVs evaluated fort their yield performance under the study, the maximum mean grain yield was recorded in the hybrid BS 144 (52.74 q ha^{-1}) closely followed by the variety MTU 1010 (51.24 q ha^{-1}) and both were found to be statistically comparable with respect to their yield performance. The hybrid BS 133 also had a comparatively good yield performance with a mean grain yield of 48.70 q ha^{-1} which was found to be statistically at par with the variety Lalat (mean yield of 45.84 q ha^{-1}). The high yielding variety MTU 1001 registered a moderate level of yield potential with a mean yield of 44.65 q ha^{-1}. However, Ajaya (mean yield of 41.39 q ha^{-1}), Gobind (mean yield of 40.38 q ha^{-1}), Arize Bold (mean yield of 38.98 q ha^{-1}) and KJRTH-2 (mean yield of 37.23 q ha^{-1}) were found to have comparatively lower yield potential. The varied yield performance of different hybrids and high yielding varieties may be due to their different level of resistance to biotic stresses and inherent yield potential. The results of the experiment derived ample support from the findings of Bhogadhi (2015) who reported that MTU1010 and MTU1001 showed moderate level of resistance to BPH. Further, Udayasree et al. (2018) also observed the moderately resistance reaction of MTU1010 and MTU1001 to rice BPH.

CONCLUSION

The rice hybrids BS 144 and BS 133 and the high yielding varieties MTU 1010 were found to be suitable for the coastal agro-climatic zone of the state of Odisha owing to their higher resistance and tolerance to the major insect pests and diseases of rice and better yield potential. A comparatively lower pest load in these hybrids and variety may substantially reduce the pesticide application level in rice which can further contribute to higher farm profitability and environment sustainability. Though the results of this investigation provided a preliminary indication about the reaction of some selected HYVs and hybrids of rice to the plant and leaf hoppers, sheath blight and BLB, further experimentation in different agro-climatic conditions is essential to validate the findings.

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