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Effect of different tillage practices and different amendments on disease dynamics in Kharif Rice and Boro Rice

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The purpose of the investigation was to explore the influence of various agricultural conservation techniques such as fertilization levels, tillage methodologies on disease dynamics in the Gangetic plains of eastern India during 2019 and 2020. The research followed a randomized complete block design with four replications and included five treatments. The findings showed that reduced tillage was the most effective in minimizing the development of Blast and Bacterial leaf blight diseases of rice, followed by conventional tillage and zero tillage. Similarly, zero tillage had the least occurrence of Sheath blight disease of rice in the Kharif season, followed by reduced tillage and conventional tillage. Furthermore, the study revealed that greater crop residue and low NPK fertilizer had an adverse impact on the progression and development of Blast, Bacterial leaf blight, and Sheath blight diseases of rice.

Keywords : Conservation Agriculture, Disease dynamics, Tillage

INTRODUCTION

Global food production has been achieved more than doubled in the past 65 years through land use change and use of mineral fertilizers, pesticides, breeding of new crop varieties, and other technologies of the "Green Revolution" (Tilman *et al.* 2002). However, increased use of agrochemicals, land conversion, farm expansion, and farm specialization have a negative impact on the environment and have caused habitat and biodiversity loss, pollution, and eutrophication of water bodies, increasing greenhouse gases emissions and reduced soil quality (Mäder*et al.* 2002). Thus, one of the main challenges for the future of agriculture is to produce sufficient amounts of food with minimal environmental impact, without further depleting soil and water resources, restoring soil fertility, increasing the resilience of farming systems to climate risk and improving their capacity to sequester carbon and mitigate climate change.

For effective utilisation of all resources, maintaining stability in production and obtaining high net returns system approach is inevitable in agriculture. An illustrative change from crop to cropping system approach in agricultural research development and extension has taken place from reductionist to holistic philosophy. A large number of new concepts have been evolved and older concepts have been modified in this process. There are different tillage management practices such as Zero tillage (ZT), Conventional tillage (CT), and Reduced tillage (RT) make new horizon for conservation agriculture and sustainable agriculture.

Interest in no-tillage and conservation tillage systems is increasing due to scarcity and increasing cost of fossil fuels, periodic food

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shortages, inclement weather conditions and concerns over soil erosion. Changing the tillage practice can lead to changes in the physical and chemical properties of soil which in turn is likely to influence the occurrence of plant diseases. Key factors in the occurrence of plant diseases include the survival and activity levels of pathogens, host susceptibility and the population of other soil microorganisms. Keeping this background in mind, an investigation was undertaken to study the disease dynamics of Kharif rice and Boro rice to compare the occurrence of disease in Conservation Agriculture treatments with farmers practice (Prabhavathi *et al.* 2015). Effect of crop residues and management practices on soil quality, soil nitrogen dynamics and recovery and crop yield has been reviewed by Kumar and Goh (2000). Crop residues have some significant effect on chemical, physical and biological functions as well as on soil water and quality of soil. Surface mulch helps to reduce the evaporation of soil water and maintains the soil temperature. This enhances biological activity and nitrogen mineralisation, mainly in the surface layers.

An early study set forth that fungi, bacteria, actinomycetes, earthworms and nematodes were higher in residue mulched fields than residue incorporated fields. Mulching or ground cover increases biological diversity not only below ground but also above ground and these also help keep insect pest in check by increasing number of beneficial insects (Jaipal *et al.* 2002). Agricultural practices such as cropping sequence, different tillage practices, fertilization inputs and irrigation have significant effects on soil physical and chemical properties but a little data available regarding its effect on biological properties of the soil.

Release of exudates by plants activate and keep up specific rhizobacterialcommunities that enhance nitrogen fixing, nutrient recycling, bio-control of plant pathogens, disease resistance in plants and plant growth stimulations which ultimately affect crop health, yield and soil health. This study was therefore conducted to determine the effect of various conservation agriculture practices, especially fertilizer levels, tillage practices and cropping systems, on disease dynamics in Kharif rice and Boro rice cropping at the Gangetic plains of West Bengal.

MATERIALS AND METHODS

Study site

The experimental investigation took place in the Balindi Research Complex (BRC) of Bidhan Chandra Krishi Viswavidyalaya, situated in West Bengal, India. The experimental site was located in the Gangetic plains of eastern India, at a latitude of 22°95'N and a longitude of 88°52'E. The region experiences a tropical, wet, and humid climate, with significant rainfall during the monsoon season and scarce rainfall during other times of the year. The climatic records for the study period, spanning from 2019 to 2020, show that the yearly average precipitation was more than 1200 mm, with 75% of it received during the primary growing season. The maximum temperatures were relatively consistent throughout the year, whereas the minimum temperatures were lower during the winter season than the other two seasons. The general weather during the experimental period remained close to the long-term averages. There has been a minor illuviation of clay to the lower layer; metals, alkaline earths, sesquioxides, and slight leaching from the top all point to a slight buildup at the bottom.

Experimental design and treatments

To conduct the study, a randomized complete block design was implemented, comprising three replications with rice cultivar *Ajit*. Each replication consisted of five distinct treatments with plot size 33m x 20m. The treatments included three different tillage practices: zero tillage (ZT), minimum tillage (MT), and conventional tillage (CT). Zero tillage involved the creation of a single slot for sowing or transplanting, while minimum tillage employed a power tiller to plow the soil at a consistent depth of 6-8 cm. Conventional tillage mirrored the minimum tillage approach but reached a greater depth of 14-16 cm. The study encompassed the examination of five specific treatments, which were as follows:

I) 0% Crop residue + 100% N:P_2O_5:K_2O, II) 100% Crop residue + 50% N:P_2O_5:K_2OIII), 100% Crop residue + 75% $N:P_2O_5:K_2O$, IV) 50% Crop residue + 100% $N:P_2O_5:K_2O$., V) 50% Crop residue + 75% $N:P_2O_5:K_2O$

represents the disease incidence of the i+1st evaluation, and ti+1 - ti indicates the number of days between the two evaluations. By applying this formula, the AUDPC was calculated, providing valuable insights into the progression and severity of the disease over time.(Simko and Piepho, 2011)

CROP	$N:P_2O_5:K_2O$ (kg/ha)	Time of application
Kharif-I (Rice)	80:40:40	Basal: ¼ N + Full P_2O_5+ Full K_2O 1st TD: ½ N(at AT); 2nd TD: ¼ N (at PI)
Rabi(Boro rice)	120:60:60	Basal: ¼ N + Full P_2O_5+ ¾ K_2O 1st TD: ½ N(at AT); 2nd TD: ¼ N (at PI)+ ¼ K_2O(at PI)

Fertilizer Application: In each treatments, required amount of fertilizer dose was calculated on the basis of the recommended dose of fertilizer and each required dose of fertilizer was applied at recommended crop growth stages.

Sampling Procedure

Data on diseases affecting Kharif rice and Boro rice were collected by recording observations from three different spots in each plot, following a zigzag pattern. The area covered by each spot was one square meter.

Disease Assessment

The disease onset date and subsequent symptom development of bacterial leaf blight of rice, rice blast and sheath blight of rice were monitored regularly in the morning. The disease spread was observed visually from the disease's onset at fourteen -day intervals until the final harvest. Fungal diseases were evaluated on a scale of 0 to 9 (Jenkins and Wehner 1983), depending on the percentage of symptomatic leaf area. Bacterial diseases were evaluated on a scale of 0 to 9 based on the percentage of symptomatic leaf area (Standard Evaluation System of Rice, IRRI 1988). The percent disease index (PDI) was calculated using the formula given by Wheeler (1969):

The total leaf count for each scale ranging from 1 to 9 was used to assess the disease spread across various generations.

In order to determine the area under the disease progress curve (AUDPC), the following formula was employed: Y = Ó[(Xi + Xi+1) / 2] * (ti+1 - ti), where Y represents the AUDPC. Here, Xi refers to the disease incidence of the ith evaluation, Xi+1

Collection of the disease sample

Samples of the disease were obtained from Bidhan Chandra Krishi Viswavidyalaya'sBalindi Research Complex (BRC). Each sample was placed in individual polythene bags and transported to the laboratory, where they were washed with distilled water. Fungal samples were examined under a microscope after teasing the affected portion of the leaves, while bacterial samples underwent an ooze test.

RESULTS AND DISCUSSION

Effect of Conservation Agriculture on disease dynamics of rice

The findings showed that Blast disease, Bacterial leaf blight, and Sheath blight exhibited considerable variations in reduced, conventional, and zero tillage practices during both Kharif and Rabi seasons of 2019. Among these diseases, the average Area Under Disease Progress Curve (AUDPC) of Blast disease of rice during Kharif 2019 was found least in reduced tillage (120.67), followed by conventional tillage (153.00) and zero tillage (281.00). Moreover, the AUDPC of Blast disease of rice in Kharif 2019 was the lowest with treatments of 100R50N:P_2O_5:K_2O (158.89), followed by 100R75N:P_2O_5:K_2O (171.67), 50R75N:P_2O_5:K_2O (173.33), 50R100N:P_2O_5:K_2O (203.33), and 0R100N:P_2O_5:K_2O (217.22) (Table1; Fig.1). A similar pattern was observed during Rabi 2019, though with higher AUDPC and disease severity compared to Kharif 2019 season. Reduced tillage had the lowest disease progress (149.67), while zero tillage showed maximum disease development (324.33). Soil treatments 100R50NPK exhibited the lowest disease progress and development (186.11), while the highest development of Blast disease was found in the case of soil amendment 0R100NPK (251.11) (Table2; Fig.2).

Significant differences in the occurrence of Blast disease, Sheath blight, and Bacterial leaf blight were noted in reduced, conventional, and zero tillage throughout the Kharif and Rabi 2019 seasons.The results showed that reduced tillage had the lowest average Area Under Disease Progress Curve (AUDPC) for Bacterial leaf blight in Kharif 2019 (81.00), followed by conventional tillage (102.33) and zero tillage (255.67). Similarly, soil amendments of 100R50N:P_2O_5:K_2O had the least average AUDPC (130.00), followed by 100R75N:P_2O_5:K_2O (145.00), 50R75N:P_2O_5:K_2O (147.22), 50R100N:P_2O_5:K_2O (149.44), and 0R100N:P_2O_5:K_2O (160.00). (Table3).However, during Rabi 2019, the AUDPC and disease severity of Bacterial leaf blight were higher than in Kharif 2019, and reduced tillage had the least disease progress (155.00), followed by conventional tillage (207.33) and zero tillage (339.00). The soil amendment 100R50N:P_2O_5:K_2O had the lowest disease progress and development (205.00), whereas the soil amendment 0R100N:P_2O_5:K_2O had the highest Bacterial leaf blight development (264.44) (Table4).

The Kharif season of 2019, the Average Area Under Disease Progress Curve (AUDPC) of Sheath blight disease in rice was found to vary significantly across different tillage methods. Zero tillage showed the lowest AUDPC (22.33), followed by reduced tillage (39.00) and conventional tillage (140.67). Similarly, in the case of soil amendments, the AUDPC of Sheath blight disease was found to be the least (47.78) in 100R50N:P_2O_5:K_2O, followed by 57.22 in 100R75N:P_2O_5:K_2O, 68.33 in 50R75N:P_2O_5:K_2O, 76.67 in 50R100N:P_2O_5:K_2O, and 86.67 in 0R100N:P_2O_5:K_2O (Table5).

Numerous studies have presented similar findings in relation to disease incidence and severity in

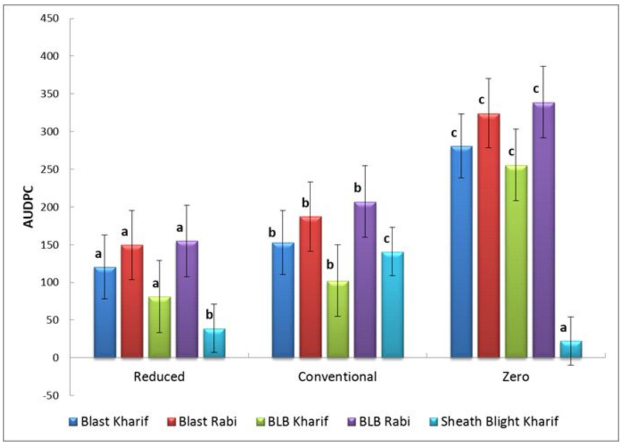

Fig.1. Effect of tillage on various diseases of rice in the Kharif and Rabi seasons of the year 2019. (Alphabets on top of the bars indicate mean comparison (individual diseases are analysed separately) expressed by Duncan's Multiple Range Test. Error bars summing both values represent standard deviation of AUDPC data according to the severity of diseases).

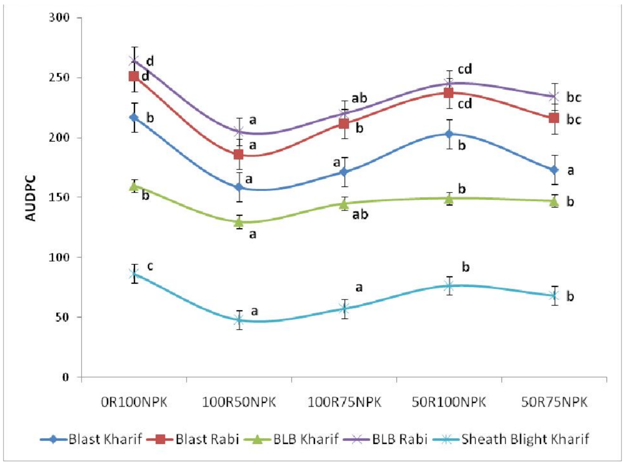

Fig. 2. Influence of amendment supplementation in soil on various diseases of paddy in the Kharif and Rabi seasons of 2019. Small letters alphabets represent Duncan's Multiple Range Test in various diseases and seasons analysed individually.

both foliar and root pathogens. In a study conducted by Sester*et al*. (2014), it was discovered that the conventional tillage system with mineral fertilization exhibited the highest level of blast disease. Interestingly, the no-tillage system with mineral fertilization showed a similar level of disease incidence as the conventional tillage system without mineral fertilization. Additionally, Long *et al.*(2000) highlighted that excessive nitrogen fertilization contributed to an increase in blast severity.

Dusserre*et al.* (2017) found that in the CA cropping system and without N fertilizer, blast was less severe when the amount of blast was high.A study by Prasad *et al.*(2020) demonstrated that

Table 1. Effect of different amendments in soil and tillage practices on Blast disease of rice in Kharif 2019 (in AUDPC).

	Tillage			
Amendments	Reduced	Conventional	Zero	Average
0R100NPK	136.67	183.33	331.67	217.22 b
100R50NPK	110.00	116.67	250.00	158.89 a
100R75NPK	113.33	130.00	271.67	171.67 a
50R100NPK	125.00	173.33	311.67	203.33 b
50R75NPK	118.33	161.67	240.00	173.33 a
Average	120.67 a	153.00 b	281.00 c	-
Parameters	Tillage	Amendments	Tillage x Amendments	-
SE(m)±	5.04	6.51	11.27	-
CD*	14.60	18.85	32.64	-

Table 2. Effect of different amendments in soil and tillage practices on Blast disease of rice in Rabi 2019 (in AUDPC).

	Tillage			
Amendments	Reduced	Conventional	Zero	Average
0R100NPK	170.00	213.33	370.00	251.11 d
100R50NPK	131.67	158.33	268.33	186.11 a
100R75NPK	143.33	173.33	318.33	211.67 b
50R100NPK	156.67	198.33	356.67	237.22 cd
50R75NPK	146.67	193.33	308.33	216.11 bc
Average	149.67 a	187.33 b	324.33 c	-
Parameters	Tillage	Amendments	Tillage X Amendments	-
SE(m)±	5.93	7.66	13.26	-
CD*	17.18	22.18	Not significant	-

Table 3: Effect of different amendments in soil and tillage practices on Bacterial leaf blight disease of rice in Kharif 2019 (in AUDPC).

	Tillage			
Amendments	Reduced	Conventional	Zero	Average
0R100NPK	85.00	98.33	296.67	160.00 b
100R50NPK	83.33	101.67	205.00	130.00 a
100R75NPK	73.33	103.33	258.33	145.00 ab
50R100NPK	85.00	103.33	260.00	149.44 b
50R75NPK	78.33	105.00	258.33	147.22 b
Average	81.00 a	102.33 b	255.67 c	-
Parameters	Tillage	Amendments	Tillage x Amendments	-
SE(m)±	4.08	5.27	9.13	-
CD*	11.83	15.28	26.46	-

Table 4. Effect of different amendmentsin soil and tillage practices on Bacterial leaf blight disease of rice in Rabi 2019 (in AUDPC).

Amendments	Tillage			Average
	Reduced	Conventional	Zero	
0R100NPK	180.00	228.33	385.00	264.44 d
100R50NPK	133.33	185.00	296.67	205.00 a
100R75NPK	138.33	193.33	328.33	220.00 ab
50R100NPK	163.33	216.67	355.00	245.00 cd
50R75NPK	160.00	213.33	330.00	234.44 bc
Average	155.00 a	207.33 b	339.00 c	-
Parameters	Tillage	Amendments	Tillage x Amendments	-
SE(m)±	5.43	7.01	12.15	-
CD*	15.74	20.31	NS	-

Table 5. Effect of different amendments in soil and tillage practices on Sheath blight disease of rice in Kharif 2019 (in AUDPC).

Amendments	Tillage			Average
	Reduced	Conventional	Zero	
0R100NPK	53.33	173.33	33.33	86.67 c
100R50NPK	26.67	103.33	13.33	47.78 a
100R75NPK	31.67	121.67	18.33	57.22 a
50R100NPK	45.00	160.00	25.00	76.67 b
50R75NPK	38.33	145.00	21.67	68.33 b
Average	39.00 b	140.67 c	22.33 a	-
Parameters	Tillage	Amendments	Tillage x Amendments	-
SE(m)±	2.64	3.40	5.90	-
CD*	7.64	9.86	17.08	-

increasing the amount of phosphorus and nitrogen reduced the length of time that sheath blight took to incubate and increased the severity of the disease.

When considering conventional tillage, sclerotia tended to remain deeply buried and did not undergo germination. However, in the case of minimum tillage, surface disturbance could release sclerotia from host stems and retain them at or near the surface, leading to higher levels of inoculum, as noted by Workneh and Yang (2000).

The findings of the present study indicate that Blast disease, Bacterial leaf blight, and Sheath blight varied significantly among reduced, conventional, and zero tillage systems in both the Kharif and Rabi seasons of 2019. The average Area Under Disease Progress Curve (AUDPC) of Blast disease and Bacterial leaf blight in rice was the lowest in reduced tillage, followed by conventional tillage and zero tillage. Meanwhile, the AUDPC of Sheath blight disease in rice during Kharif 2019 was the lowest in zero tillage, followed by reduced tillage and conventional tillage.

The findings of the current investigation indicate that the use of soil amendments with a composition of 100% Crop Residue + 50%N:P_2O_5:K_2O resulted in the lowest AUDPC of Blast disease in rice, which was recorded at

158.89 in Kharif 2019 and 186.11 in Rabi 2019. Furthermore, the progress and development of Bacterial leaf blight disease in rice was significantly lower (205.00) when soil amendment of 100% Crop Residue+50%N:P_2O_5:K_2O was used in Rabi 2019, whereas the use of soil amendment with 0% Crop Residue+100% N:P_2O_5:K_2O led to the highest development of Bacterial leaf blight disease (264.44). The AUDPC of Sheath blight disease in rice was lowest (47.78) during Kharif 2019 when soil amendments with 100% Crop Residue+50% N:P_2O_5:K_2O were used, followed by 57.22 with 100% Crop Residue+75%N:P_2O_5:K_2O soil amendments. Overall, the results suggest that the use of increased crop residue and decreased NPK fertilizer negatively impacted the progress and development of Blast, Bacterial leaf blight, and Sheath blight disease in rice.

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DECLARATION

Conflict of Interest. Authors declare no conflict of interest.

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