Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 767-770
Received: 08-11-2019
Accepted: 12-12-2019

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Integrated disease management strategies in false smut of rice (*Oryza sativa* L.)

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Abstract
False smut disease of rice caused by the fungus *Ustilaginoidea virens* (Cooke), has recently been found in agroclimatic conditions of Uttar Pradesh and is sporadic where rice is cultivated. Rain and high humidity (>90%), temperature ranging from 25-35 ºC and intensive method of rice cultivation with use of heavy nitrogenous fertilizers resulted into the severe form of disease. The incidence of this disease is becoming a major constraint to adoption of rice cultivars in Gorakhpur district which is situated in North Eastern Plains regions. Considering the facts, integrated disease control approaches were comprised under farmer's participatory on-farm trial for false smut management in two consecutive years in *kharif* 2017 and 2018. Technological gap between improved management package and farmers practices were studied based on survey and group discussion with farmers. Full gap was observed in case of use of seed/seedling treatment and partial gap was in use of varieties, method of transplanting, number of hill/m^2, use of fertilizers, weed management and plant protection measures, which definitely was the reason of not achieving potential yield. The average incidence of false smut in paddy i.e. 5.75% was recorded in demonstrated plot while it was 10.25% in farmers practice. On an average disease reduction was 42.65 per cent noticed with the use of integrated disease management approach over farmer's practice respectively. Average infected panicle/hill i.e. 1.38 and average infected panicle/m^2 i.e. 2.25 was observed with use of integrated approach while it was noticed 2.38 and 3.25 in existing practices. The recommended rice cultivar yielded 50.25q/ha yield during kharif 2017 while 49.50q/ha was noticed in kharif 2018, it was 19.64 and 20.15 per cent more over farmer's practice. The average net returns i.e. Rs. 49793.75/ha was received in demonstrated plots while farmers were obtained Rs. 38785.00/ha by their own practices. On an average benefit cost ratio 2.74 was found under demonstrated technologies while it was 2.45 in farmer's practices. The outcome of the trial inspired the farming communities to adopt area wise recommended varieties with judicious use of nitrogenous fertilizer and other technological options including integrated disease management approach which are being adopted in their cultivation.

Keywords: *Ustilaginoideavirens*, integrated approach, rice, fungicides, net returns, BCR

Introduction
Agriculture is the mainstay of our rural economy and substance of life of the people. Rice (*Oryza sativa* L.) covers about 69 per cent of cultivated area and is the major crop covering about 63 per cent of total area under food grains. It is one of the most important food crops of India in term of area, production and preferred food item throughout the country. India is the second largest producer and consumer of rice in the world and also fulfil food demand for more than two third of Indian population. In order to meet the domestic demand of the increasing population, the present-day production 112.91 million tons from 43.79 million hectares with productivity of 25.78 q/ha (2017-18) and has to be increased to 125 million tons by the year 2030. It is also one of the most important food crops of Uttar Pradesh and mostly grown in North Eastern plain regions in rice-wheat cropping system. In Uttar Pradesh, rice occupies an area of 5.89 million ha with annual production of 15.93 million tons and average productivity 2700 kg/ha (Anonymous 2018) [2]. The area, production and productivity of rice in Gorakhpur district of Uttar Pradesh are 150.56 (000'hectares), 401.68 (000' tons) and 2670 kg/ha, respectively (Anonymous 2018) [2]. The productivity of rice in the district, state and country also continues to be quite low on account of several biotic and abiotic stresses besides, unavailability of quality seed of improved varieties in time and poor crop management. Therefore, to sustain the self-sufficiency in rice, additional production of 1.5 million tons is needed every year.

In the present climatic change scenario rice crop is facing the tough competition of new diseases which were otherwise not touching the economic threshold level. False smut (*Ustilaginoideavirens*) is emerging as one of the potential threats to rice cultivation under North Eastern Plains regions of rice-wheat cropping system. The incidence of this disease is

becoming a major constraint to adoption of modern rice cultivars in Gorakhpur district which is situated in Indo-Gangatic plains regions. Rain and high humidity (>90%), temperature ranging from 25-35 ºC and soils with high nitrogen content also favor disease development. The pathogen also survives through alternate host *viz*., barnyard grass (*Echinochloa crus galli*) and common rice weed *Digitaria marginata*. The pathogen completely converts the grains into spore balls, unfit for consumption and seed production. The fungus overwinters in the soil by means of sclerotia and chlamydospores. Sclerotia produce ascospores, which are primary source of infection to rice plants, whereas secondary infection may come from air-borne chlamydospores. The disease affects the grains and the symptoms produced are visible only after flowering. *U. virens* infects the young ovary of individual spikelets and converts them into large velvety green smut balls. Infected rice during the flowering stage inhibited flower fertility and development of adjacent spikelets. The lower part of spikes is generally more severely infected than upper part. Smut balls are initially yellow in colour and are covered by a membrane, later the membrane bursts and the colour changes to yellowish green and finally greenish black (Bhagat and Prasad 1996; Yashoda *et al.* 2000) [4, 14]. Late sowing and high nitrogen doses favour the development of disease (Ahonsi *et al.* 2000; Li *et al.* 1986) [1, 6]. This has also been reported from other rice growing countries of the world and has emerged in recent years as one of the most devastating grain diseases (Zhou *et al.* 2008) [15]. The disease causes both quantitative and qualitative losses. The losses in grain yield occur due to chaffiness, reduction in test weight and sterility of the spikelet's neighboring smut balls. The yield loss estimates ranged from 0.2 to 49 per cent in different regions with different rice varieties (Biswas 2001; Singh *et al.* 1992) [5]. Keeping this in view, a farmer's participatory trial was conducted by Mahayogi Gorakhnath Krishi Vigyan Kendra Gorakhpur, Uttar Pradesh regarding to assess the site-specific integrated approach to control false smut of rice in two consecutive years i.e. *Kharif* 2017 and 2018.

Methodology

The on-farm trials (OFTs) on integrated approach to control false smut in rice were carried out by Mahayogi Gorakhnath Krishi Vigyan Kendra Gorakhpur (UP) during kharif 2017 and 2018 at eight farmer's fields. Technological gap between improved management package and farmers practices were studied based on survey and group discussion with farmers' interactive group (FIG) of rice growers in selected villages. The rice growers of these villages had small and marginal land holdings. Out of 100 farmers, 20 farmers were chosen randomly from selected villages and discussions were held on nine improved management packages to study the technological gap. The gap between demonstration technologies and existing technologies was identified and categorized into three levels *viz*., full (7-10), partial (4-6) and non-adoption (less than 3). Details improved technology and technological gaps are depicted in Table 1. The integrated approach to control false smut in rice i.e. recommended dose of nitrogen (120:60:40: N:P:K:ZnSo4 kg/ha), weed management with Bispyribac-sodium 10% EC @ 250ml/ha at 20 days after transplanting (DAT), removal of infected panicle carefully and spraying of Propiconazole 25% EC @ 500ml/ha at booting stage were comprised under on farm trial. The control plots were farmer's practices (use of hybrid varieties and most susceptible variety Damini, Moti, BPT 5204, Swarna, no seed treatment, improper transplanting methods, injudicious use of pesticides and poor crop management practices).Performance of yield and economics of rice crop was observed in terms of yield parameter and net returns in site-specific trials as well as existing practices (farmers' practice). Benefit cost ratio of each treatment was also assessed. Farmers reactions were also observed with the help of personal interview and data on quantitative parameters were recorded and per cent increase yield was calculated by using following formula.

$$\text{Per cent increase yield} = \frac{\text{Demonstrated Yield -Farmers Practice Yield}}{\text{Farmers Practice Yield}} \text{ X } 100$$

Results and Discussion

Technological gap

The major differences were observed between improved technology and farmers' practices of rice cultivation in the Gorakhpur district of North Eastern Plain Zone of Uttar Pradesh is presented in table 1. Full gap was observed in case of use of seed/seedling treatment and partial gap was in use of varieties, method of transplanting, number of hill/m^2, use of fertilizers, weed management and plant protection measures, which definitely was the reason of not achieving potential yield. Farmers were not aware about improved technological interventions. Farmers' are used most susceptible variety Damini, Moti, BPT 5204, Swarna and other hybrids with high doses of nitrogen in their cultivation practices instead of high yielding resistant cultivars. Very few farmers were able to arrange seeds of high yielding varieties. Farmers applied wide planting and higher number of old age seedlings than the recommended and they were using injudicious use of pesticides for control of weeds, diseases and pests. The farmers were much concerned about importance of tillage and time of transplanting. The results are similar with the findings of Singh and Barman (2011) [11], Sharma and Ladher (2013) [10] and Singh *et al.* (2019) [12].

Table 1: Technological gap between improved production technology and farmer practices in rice

S.N.	Practices	Improved technology	Farmer's practices	Gap
1.	Preparation of field (Tillage)	Deep ploughing with mould board plough in summer and 2-3 ploughing with cultivator and proper puddling also	Deep ploughing with mould board plough in summer and 2-3 ploughing with cultivator and proper puddling also	Nil
2.	Cultivars	NDR 2065, HUR 105, HUBR-2-1, PRH 10, MTU 7029, BPT 5204, Pusa 1509, 1612, Arize 6444, DRRH 3, Pant Dhan 10	Swarna, 27P63, Moti, Damini, Sarju 52, Arize 6444, BPT 5204	Partial gap
3.	Time of transplanting	Third week of June to 2nd week of July in irrigated condition	Third week of June to 2nd week of July in irrigated condition	Nil
4.	Transplanting method (Line transplanting)	20 x 15 cm (R x P)	Improper transplanting	Partial gap
5.	Number of hill/m^2	33/m^2	16-18/m^2	Partial gap
6.	Seed/seedling treatment	Carbendazim 50% WP/Vitavax power 75% WP @ 2 g/kg seed or	No seed treatment	Full gap

	for seed borne and root diseases management	Carbendazim 50% WP + Thiram 75% WP @ 1:2 g/kg seed or Vitavax + *Trichoderma viride* @ 1:4 g/kg seed. Carbendazim 50% WP @ 2g/liter water or Trichderma powder 1% WP @ 10g/liter water for seedling treatment		
7.	Application of Fertilizer Nitrogen (N) Phosphorous (P) Potash (K) Zinc sulphate (Zn)	120 kg/ha 60kg/ha 40 kg/ha 25 kg/ha	Use of imbalance fertilizer	Partial gap
8.	Weed management (For broad and narrow leaves weed)	Bispyribac-sodium10% EC @ 250 ml/ha at 20 DAT or Azimsulfuron 50% WP @70g/ha at 20 DAT or Pretilachlor 50% EC @ 1500ml/ha at 3-7 DAT	Improper chemical weed management	Partial gap
9.	Plant protection	Chlorothalonil 75% WP @ 2g/liter water or Trifloxistrobin + Tebuconazole 75WG @4g/10 liter water or Propiconazole 25% EC @ 500ml/ha at booting stage	Injudicious use of fungicides	Partial gap

Disease reduction and yield enhancement

Performances of improved production technology with integrated approach to control false smut in rice are shown in table 2. The minimum infected panicle/hill, infected panicle/m^2 and disease incidence were recorded in demonstrated technology as compare to farmers practice. The average incidence of false smut in paddy was recorded 5.75% in demonstrated plot while it was 10.25% in farmers practice. The maximum disease incidence i.e. 12.00 per cent was noticed during kharif 2018 due to prevailing high humidity (>90%) with cloudy weather, medium temperature (25-30 ^{0}C) and high dose of nitrogenous fertilizer. The maximum reduction in disease incidence was 50.00 per cent during kharif 2018 followed by 35.29 per cent in 2017. On an average disease reduction was 42.65 per cent received with the use of integrated approach. These findings corroborate with the results of Raji *et al.* (2016) [8]. A comparison of productivity levels between improved practices in demonstrated trials and farmers' practices is depicted in table 2 revealed that yield of rice varieties increased successively over the farmers practice during both the crop season. The demonstrated integrated approach on false smut management in rice crop enhanced the average yield 19.89 per cent over farmer's practice. The recommended rice cultivar yielded 50.25q/ha yield during kharif 2017 while 49.50q/ha was noticed in kharif 2018. This huge variation in yield was due to changes in weather, differences in land fertility in an area wise and differences in farmers' practices in different area. The results are in conformity with the findings of Yan *et al.* (2014) [9] and Singh *et al.* (2019) [12].

Table 2: Performance of integrated approach on yield enhancement and false smut disease reduction in rice during kharif 2017 and 2018

Year	Avg. infected panicle/hill		Avg. infected panicle/m^2		Disease incidence (%)		% reduction in disease incidence	Yield (q/ha)		% increase in yield over FP
	IT	FP	IT	FP	IT	FP		IT	FP	
2017	1.25	2.00	2.50	3.50	5.50	8.50	35.29	50.25	42.00	19.64
2018	1.50	2.75	2.00	3.00	6.00	12.00	50.00	49.50	41.20	20.15
Avg.	1.38	2.38	2.25	3.25	5.75	10.25	42.65	49.88	41.60	19.89

IT= Improved Technology; FP= Farmer's Practice; Avg. = Average

Economic Performance

The economics performances of rice under demonstrated technologies were estimated and the results have been presented in table 3. The use of improved technologies with integrated approach to control false smut in rice required more cost for crops production than farmers' practice during both the crop season. The economic analysis reveals that the average net returns of demonstrated plots was Rs. 49793.75/ha in comparison to farmers practice Rs. 38785.00/ha. The higher net returns obtained under demonstrations could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. Thereafter, the benefit cost ratio was also calculated that shows higher value under demonstration than the farmers practice during all the years. Average benefit cost ratio 2.74 were found under demonstrated technologies while it was 2.45 in farmer's practices. These results are in accordance with the findings of Balai *et al.*, (2013) [3], Rajiv and Singh (2014) [9] and Singh *et al.* (2019) [12].

Table 3: Economic performance in rice using integrated approach for false smut management

Year	Gross cost (Rs/ha)		Gross return (Rs/ha)		Net returns (Rs/ha)		BCR	
	IT	FP	IT	FP	IT	FP	IT	FP
2017	28250.00	26500.00	77887.50	65100.00	49637.50	38600.00	2.76	2.45
2018	29250.00	26950.00	79200.00	65920.00	49950.00	38970.00	2.71	2.45
Avg.	28750.00	26725.00	78543.75	65510.00	49793.75	38785.00	2.74	2.45

IT= Improved Technology; FP= Farmer's Practice; BRC= Benefit Cost Ratio; Avg. = Average

Conclusion

There was a technological difference between improved technology and farmers practices in rice crop. The adoption of integrated disease management with good agronomical practices was poor. Full gap was received in use of seed/seedling treatment and partial gap was in use of varieties, method of transplanting, number of hill/m^2, use of fertilizers, weed management and plant protection measures, which definitely was the reason of not achieving potential yield. Farmers were not fully aware about improved production/protection package and practices. The on-farm trial programme was an effective in changing attitude skill and knowledge of integrated approach for false smut management in rice. This also improved the relationship

between farmers and KVK scientists and built confidence between them. Based on farmer's feedback, it was observed that the use of integrated approach to control false smut in rice was highly acceptable, easily compatible in existing production and cropping systems.

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