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Research Article

DISEASE SEVERITY AND YIELD LOSSES CAUSED BY FALSE SMUT DISEASE OF RICE IN DIFFERENT RICE ECOSYSTEMS OF KARNATAKA

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Abstract- A rowing survey was carried out during *Kharif* 2016 in different rice growing ecosystems of Karnataka to ascertain the false smut disease of rice. In different surveyed ecosystem, the mean disease severity was ranged from 4.44 to 17.12 percent. The highest disease severity was observed in irrigated Bhadra ecosystem (17.12%), whereas, irrigated Kaveri ecosystem recorded least disease severity (4.44%). Yield loss estimation due to false smut disease on different rice varieties growing in different ecosystem revealed up to 4.25 percent yield loss. Maximum disease severity was observed on the *cv*. Sriram Gold (124.58 %) with yield loss of 4.25 percent, and least disease severity was observed on *cv*. Thella Hamsa (2.64 %) with yield loss of 0.09 percent. The information generated could be useful for making the ecosystem specific management strategy to reduce the impact of false smut disease in different rice ecosystem of Karnataka.

Keywords- False smut, Survey, Ecosystem, Yield loss.

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Introduction

False smut of rice is caused by the fungal pathogen, *Ustilaginoidea virens* (Cooke) Takahashi, was first reported from Tirunelveli in Tamil Nadu [1]. The disease is also known as pseudo-smut, or green smut, has been recorded in all rice growing countries worldwide. Earlier it was regarded as a minor disease, occurring sporadically in certain regions, but now epidemics of the disease are also being reported in different parts of the world including in India [2-4]. Recently in India, the disease has been observed in severe form since 2001 in major rice-growing states, *viz*., Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu and Kashmir, Jharkhand, Karnataka, Maharashtra, Pondicherry, Punjab, Tamil Nadu, Uttar Pradesh, and Uttaranchal [5,6].

It is an important devastating disease-causing yield losses from 1.01 to 10.91 per cent [7]. From the Punjab and Tamil Nadu disease incidence of 10-20 per cent and 5-85 per cent respectively has been reported on different rice cultivars [8]. Climate change, high input cultivation, and use of hybrid varieties were anticipated for the outbreak of the disease in recent years [9].

Yield loss estimates due to *U. virens* were ranged from 0.2 to 49.0 per cent on different rice varieties in different regions of the country [10-12]. In north India, disease incidence (percentage of false smut-infected tillers) varied from 2 to 75 per cent. In Haryana, maximum infection was recorded on hybrids like PA 6444 and PA 6129, while in Punjab, 10 to 20 per cent disease incidence was recorded on popular inbred rice varieties such as PR 114, PR 116 and PAU 201. Another report says losses varying from 7 to 75 per cent in India [13]. In Punjab losses reported up to 44 per cent [14]. In Uttar Pradesh, yield losses up to 44 per cent were observed [15].

In Karnataka, like other rice growing regions of the country false smut disease is an emerging threat showing all characteristics of future epidemics. Available reviews of literature on the false smut disease are limited because of its minor importance in the past but now it is emerging as a major disease and therefore, recent information on the extent of disease incidence, severity and yield losses are essential. Therefore, present investigation was undertaken to ascertain the disease status and possible yield loss in different rice growing ecosystems of Karnataka.

Material and Methods

Survey to assess disease incidence and severity

A random roving survey was conducted during *Kharif* 2016 for the incidence of false smut of rice in different rice growing ecosystems of Karnataka [Table-1]. Each ecosystem comprises different taluks/districts. In each taluk, two to seven villages were surveyed and in each village three farmer's fields were selected randomly from both sides of the path. In each field, three random plots of 1 sq.m was selected and observations on number of infected tillers/m^2 and number of smut balls/infected panicle was recorded.

The observations recorded was further processed into percent infected tillers, per cent infected grains and disease severity using standard formulae [6,15].

$$\text{Per cent infected tillers} = \frac{\text{Number of tillers infected } /m^2}{\text{Total number of tillers } /m^2} \times 100$$

$$\text{Per cent infected grains} = \frac{\text{Number of diseased grains / panicle}}{\text{Total number of grains / panicle}} \times 100$$

Disease severity (%) = Infected tillers (%) × Smutted grains (%)

Assessment of yield loss on different rice cultivars

During survey, different rice cultivars growing in different ecosystem was recorded [Table-2] and yield loss due to false smut disease was calculated based on

previous reports [7,8,15,16]. Number of infected tillers and grains in panicles were recorded on fourteen rice varieties. Disease incidence was calculated as percentage of infected tillers while disease severity calculated by multiplying the percentage of infected tillers with percentage of infected grains [15]. Ten each smutted and un-smutted (healthy) panicles were randomly collected from each field/variety in four replications and total grain weight of 40 panicles was recorded and an average of ten panicles was calculated [16].

Yield loss in per cent due to false smut was calculated according to [7,8].

$$\text{Yield loss (\%)} = \frac{100 \times \text{reduction grain weight} *}{\text{Grain weight of un} - \text{smutted panicles}} \times 100 \frac{\text{\% infected tillers}}{100}$$

*reduction grain weight= weight of ten healthy panicles- weight of ten un-healthy panicles

Disease severity (%) = Infected tillers (%) × Smutted grains (%)

Results

Disease severity in different ecosystem

In the present study five different rice ecosystems were surveyed for false smut severity. In irrigated Bhadra ecosystem, the disease severity was ranged from 2.44 to 124.67 per cent. Highest disease severity of 124.67 per cent was recorded in Karalahalli village of Harihara taluk [Table-1]. In Hilly Upland ecosystem, the disease severity was ranged from 4.98 to 21.55 per cent where highest disease severity of 21.55 per cent was recorded in Bhadrapura village of Mundgod taluk. In transplanted and direct seeded rice (DSR) ecosystems of tungh-bhadra project (TBP) command ecosystem disease severity was ranged from 1.94 to 11.28 per cent and highest disease severity of 11.28 per cent was recorded in Neera Manavi village of Manvi taluk [Table-1]. The DSR type of cultivation was seen in Kasabe camp of Raichur district and disease severity was 5.05 per cent with 2.13 and 2.37 per cent infected tillers and infected grains respectively. Percent disease severity ranged was from 1.18 to 19.58 per cent in Upper Krishna Project (UKP) command ecosystem with highest disease severity of 19.58 per cent was recorded in Gudugunti village of Lingsuguru taluk [Table-1]. Inirrigated Kaveri ecosystem, false smut disease severity was ranged from 1.27 to 13.60 per cent [Table-1].

Table-1 *Assessment of false smut disease in different paddy ecosystems of Karnataka during Kharif 2016*

Sl. No	Ecosystems/ Districts	Taluk	Villages	No. Of fields	Infected tillers (%)	Grains infected (%)	Disease severity (%)
1	Irrigated Bhadra	Tariker	Belenahalli, Dhuglapura	6	2.85	2.48	6.93
		Bhadravathi	Barandur, Hadlagatta	6	2.29	2.17	4.96
		Shivamogga	Hebbandi, Gonibedu	6	2.48	4.38	11.00
		Channagiri	Rudrapura, Somashettihalli	6	4.23	2.10	8.76
		Davanagare	Doddabathi, Javalagatta	6	4.88	1.58	7.56
		Harihara	Dhitturu, Karalahalli, Kurubarahalli	6	7.31	4.32	47.85
		Mean			**4.25**	**2.95**	**17.12**
2	Hilly upland	Sirsi	Isloor, Hosakoppa	6	3.50	2.41	8.61
		Karwar	Mavinagundi, Halageri	6	3.16	1.62	4.99
		Sagara	Kugve, Joginamata	6	3.59	2.34	8.23
		Mundgod	Bhadrapura, Attanagi	6	6.00	3.55	21.23
		Mean			**4.05**	**2.47**	**10.73**
3	Transplanted & DSR ecosystems of Tung-Bhadra Project command	Raichur	Kasabe camp, Bijangere	7	2.42	2.34	5.63
		Hospet	Bukkasagara, Rama sagara	6	1.61	1.89	3.13
		Sindhanur	Hanchinal camp, Gorebala	6	3.84	1.94	7.58
		Manvi	Neeramanavi, AmareshwaraCamp	6	3.17	2.30	7.71
		Ganagavathi	Dasanala, Vaddarahatti, Basavapattana, Agalkera, Uleyanuru, Iliganuru, ARS Farm	24	2.07	3.25	6.71
		Mean			**2.44**	**2.64**	**6.34**
4	Upper Krishna Project command	Devadurga	Chikkahonnakunni, Ramanagara	6	1.78	1.84	3.27
		Lingsuguru	Gudugunti, Hulligudda	6	4.82	2.72	13.59
		Shahapur	Hatti guduru, Savuru	6	3.98	2.80	11.43
		Shorapur	DevapuraCross, Bandolli	6	1.03	1.36	1.41
		Mean			**2.90**	**2.18**	**7.42**
5	Irrigated Kaveri	Mandya	VC Farm, Thubinakere, Sondahalli	9	0.83	3.01	2.57
		Srirangapattana	TM Hosuru, Gananguru, K Shettihalli	9	0.95	1.49	1.41
		Madduru	MarakaraDhoddi, Gejjelagere	6	1.84	6.39	11.79
		Mean			**1.12**	**3.29**	**4.44**

Among different taluks, overall mean disease severity of false smut disease of rice ranged from 1.41 to 47.85 per cent of which highest mean disease severity was recorded from the Harihara taluk (47.85%) followed by Mundgod (21.23%), Lingsuguru (13.59%), Madduru (11.79%), Shahapur (11.43 %), Shivamogga (11.00%) and least disease severity of 1.41 per cent was recorded from both Shorapur and Srirangapattana taluks [Table-1].

In overall, mean disease severity among different paddy ecosystems of Karnataka was ranged from 4.44 to 17.12 per cent. Highest mean disease severity was observed in irrigated Bhadra ecosystem (17.12%) followed by hilly upland ecosystem (10.73%), UKP command ecosystem (7.42%), transplanted and DSR ecosystems of TBP (6.34%) and least mean disease severity was observed in irrigated Kaveri ecosystem (4.44%) [Table-1].

Disease severity data on different cultivars revealed that the highest disease severity was recorded on *cv.* Sriram Gold (124.58%) followed by *cv.* JGL (17.85%), *cv.* RNR-15048 (16.43%), *cv.* Thanu (13.13%), *cv.* Nellur Sona (10.84%) and the lowest disease severity (2.64%) was recorded in *cv.* Thella Hamsa [Table-2].

Yield losses in different paddy ecosystems of Karnataka on different varieties

Yield loss estimation was carried out in fourteen rice varieties growing in five different ecosystems of Karnataka. The estimated yield loss was ranged from 0.09 to 4.25 per cent. Maximum total loss in yield was observed in *cv.* Sriram Gold (4.25%) followed by *cv.* JGL (1.84%), *cv.* RNR-15048 (1.59%), *cv.* Jaya (1.40 %), *cv.* Thanu (1.32%) while minimum yield loss of 0.09 per cent was observed in *cv.* Thella Hamsa [Table-2].

Maximum infected tillers was observed in *cv.* Sriram Gold (13.69%), followed by *cv.* RNR-15048 (6.32%), *cv.* JGL1598 (6.07%), *cv.* Kaveri Sona (3.59%), *cv.* Barma (3.42%), *cv.* Jaya (3.23%) while minimum infected tillers were observed in *cv.* Thella Hamsa (0.82%) [Table-2].

Maximum smutted balls were recorded on *cv.* Sriram Gold (15.63), followed by *cv.* Nellur Sona (7.27), *cv.* Thanu (7.02), *cv.* MTU-1001 (6.29), *cv.* BPT5204 (6.27), *cv.* Jaya (5.71), *cv.* Amman Sona (5.59) and while minimum smutted balls were observed in *cv.* Kaveri Sona (3.13), [Table-2].

Table-2 *Severity of false smut disease and estimated yield loss in rice varieties grown in different rice ecosystems of Karnataka*

Sl. No.	Variety	Infected tillers (%)	Smut balls/ panicle	Smutted grains (%)	Disease severity (%)	Grain weight of 10 Panicles (g)		Difference in weight (g)	Loss in grain weight (%)
						Healthy	Smutted		
1	Abhilasha	3.11	3.39	2.00	6.22	53.40	40.15	13.25	0.77
2	Amman Sona	2.17	5.59	4.01	8.70	44.36	32.81	11.55	0.57
3	Barma	3.42	4.74	2.04	6.98	56.40	49.02	7.38	0.45
4	BPT-5204	2.55	6.27	2.29	5.85	40.70	31.50	9.20	0.58
5	GangavathiSona	2.80	4.53	2.47	6.92	36.50	20.30	16.20	1.24
6	Jaya	3.23	5.71	2.44	7.89	48.30	27.42	20.88	1.40
7	JGL1598	6.07	4.61	2.94	17.85	45.60	31.75	13.85	1.84
8	Kaveri Sona	3.59	3.36	1.86	6.67	40.30	28.50	11.80	1.05
9	MTU-1001	2.03	6.29	3.82	7.75	53.40	34.84	18.56	0.70
10	NellurSona	2.42	7.27	4.48	10.84	35.08	22.47	12.61	0.87
11	RNR-15048	6.32	4.66	2.60	16.43	38.06	28.46	9.60	1.59
12	Sriram Gold	13.69	15.63	9.10	124.58	48.60	33.50	15.10	4.25
13	Thanu	2.77	7.02	4.74	13.13	68.40	35.84	32.56	1.32
14	Thella Hamsa	0.82	4.20	3.22	2.64	54.26	48.47	5.79	0.09
S. Em ±		0.68	0.67	0.55					
CD at 5%		1.97	1.96	1.59					
CV (%)		29.83	19.63	27.71					

Discussion

Roving survey conducted in the present investigation revealed the present status of the false smut disease in the different rice growing ecosystems of Karnataka, India.

Results revealed that paddy grown under irrigated Bhadra command area showed more false smut disease severity of 17.12 per cent compared to other ecosystems. Irrigated Bhadra command area comprises taluks such as Tarikere, Bhadravathi, Shivamogga, Channagiri, Davanagere and Harihara. The more disease severity in this ecosystem could be attributed due to extensive cultivation of high yielding false smut susceptible cultivars such as Sriram Gold, BPT5204 and RNR14058 in two continuous seasons (both *Kharif* and *Rabi*) and moreover, this ecosystem receives more rainfall compare to other ecosystems except hilly ecosystems. In hilly ecosystem (Taluks such as Sirsi, Karwar, Sagar, Mundgod), in spite of congenial weather conditions for disease development, the disease severity (10.73 %) was less compare to irrigated Bhadra ecosystem. This comparative lower disease severity may be due to cultivation of traditional paddy varieties like Abhilash and Barma in almost all hilly regions that too for only *Kharif* season. Moreover, paddy cultivation in hilly regions is still low input based compared to irrigated regions. Previous investigations also reported that, cultivation of paddy under high input (especially high nitrogen) leads to high disease incidence [8,17-20]

Other three ecosystems, such as irrigated Kaveri, irrigated TBP (Both transplanted and DSR) and UKP command ecosystem recorded lower disease severity of 4.44, 6.34 and 7.42 per cent respectively. These three ecosystems are known for the cultivation of high yielding cultivars (such as BPT 5204, Kaveri Sona, MTU1001, MTU1010, Jaya, JGL1598, GNV-05-01 and Thella Hamsa), high input (nitrogenous fertilizers), continuous mono cropping (both *Kharif* and *Rabi*) and favourable weather condition for disease development. Despite the above favourable conditions for false smut disease, disease severity during *Kharif* 2016 was lower; it could be due to crop holiday in the previous season (summer 2016) and prevalence of extensive drought (*Kharif* 2016), which might have led to destruction of previous season inoculum and alternative survival.

Present study results showed that, the Intra-State variability in disease severity was from 1.41-47.85 per cent. This is mainly due to the difference in weather, rainfall, varietal profile and other geographical features of different ecosystems. Previous investigations were also reported the variation in disease severity within a state/region [8,19-21].

Significant loss in grain yield in false smut infected field has been reported by many previous studies and this reduction in grain yield by false smut disease could be due to diversion of the food towards the formation of smut balls and also by producing more chaffy grains in the panicles [11,13]. In the previous study, Rasi variety was shown to be highly susceptible for false smut disease in Karnataka [22] whereas, PA 6444 shown to be highly susceptible to disease was reported from Northern India [8,16,23]. However, Rasi and PA 6444 were not under cultivation in any surveyed area in the Karnataka and therefore, we are reporting Sriram Gold as a highly susceptible variety from Karnataka. Interestingly, *cv*. BPT5204 was reported to be highly susceptible in Tamil Nadu [8] was recorded lower disease severity in our study (5.85 per cent).

Conclusion

In the present investigation, we have reported the distribution and potential yield losses caused by false smut disease of rice in different rice ecosystems of Karnataka.

Application of research: The information generated could be useful for prioritizing the research activities for developing ecosystem based management strategies to reduce the impact of false smut disease of rice.

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Author Contributions: MKM and PD planned the work, conducted survey, analyzed the data, and wrote manuscript. MSB, MK and GSG gave comments and inputs to the manuscript

Abbreviations:

DSR : direct seeded rice ecosystems
TBP : Tungh-Bhadra Project
cv. : cultivar
UKP : Upper Krishna Project

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