

Survey and symptomatology of false smut [*Ustilaginoidea virens* (Cooke) Takahashi] of rice

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Abstract

False smut of rice is one of the major emerging and destructive diseases especially in high yielding rice varieties of many rice growing regions of the India. False smut disease infection may initiate at the booting/flowering stage and visible symptoms appear at the grain filling stage. For tracking the disease status, we undertook a survey to assess the disease incidence and severity levels in the rice growing areas of South Gujarat. Rice growing areas *viz.*, Navsari, Surat, Valsad, Tapi and Dang and NAU farm were surveyed at grain maturity stage during the *kharif* 2017 and *kharif* 2018. In a random survey, two villages were selected in each district and per cent disease incidence, average smutted ball per panicle and disease severity index were recorded in each season. During field visits, we also recorded the symptoms of false smut on the basis of changing the colour of smut balls. Among the eleven surveyed locations, Jamalapada recorded maximum per cent disease incidence *i.e.*, 12.15, 10.06 and 11.11 during 2017, 2018 and mean of two years, respectively. The maximum average smutted ball per panicle recorded was 2.80 per cent in Jamalapada, during 2017 and 2.52 per cent in Khatal, during 2018, while the mean maximum average smutted ball was 2.63 per cent in Jamalapada. Maximum disease severity index, observed in Jamalapada was 34.02, and 24.65 and during 2017 and 2018, respectively with a mean of 29.15. Infected spikelets of the panicle transformed into yellowish-orange to olive-green colour smut ball, almost double the size of the normal rice grains and unfertilized florets infection led to the production of chaffy grains. In severe cases, complete chaffy panicles with numerous smut balls were observed.

Keywords: False smut, Rice, Symptomatology, Survey, *Ustilaginoidea virens*

Introduction

Rice false smut is also known as “pseudo-smut”, “green smut” and “Lakshmi (goddess of wealth and prosperity) disease” because the occurrence of this disease was recognized as a symbol of bumper harvest. False smut of rice caused by *Ustilaginoidea virens* (Cooke) Takahashi, was first reported from Tirunelveli in Tamil Nadu (Cooke, 1878). False smut disease has been observed in severe form since 2001 due to extensive cultivation of high fertilizer responsive cultivars and hybrids, excess application of nitrogenous fertilizer and an apparent change in climate. In recent years, it has emerged as the most devastating grain disease in majority of rice growing

areas of the world (Singh *et al.*, 2014). The disease occurs in more than 40 countries, especially in the rice producing countries of Asia and U. S. In India, the disease has been observed in severe form since 2001 in major rice-growing states, *viz.*, Haryana, Punjab, Uttar Pradesh, Uttaranchal, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar, Jharkhand, Gujarat, Maharashtra, Jammu and Kashmir and Pondicherry (Dodan and Singh, 1996; Mandhare *et al.*, 2008). In Gazipur, Bangladesh, 136 smut balls and 53.9 per cent infected grains were recorded per panicle (Nessa *et al.*, 2016). In India, disease incidence of 10 to 20 and 5 to 85 per cent has been reported, respectively from Punjab and Tamil Nadu on different rice cultivars (Ladhakshmi *et al.*, 2012). False smut causes a

reduction in seed germination up to 35 per cent. In damp weather, the disease can be severe and losses can reach more than 25 per cent. Recently in India, false smut has been found to cause heavy yield loss up to 75 per cent (Rashmi and Gokulapalan, 2014). The symptoms of the disease become discernible in the field at hard dough to the mature stage of the crop. The effects of the pathogen on the host are clearly seen only after flowering stage. In this stage pathogen grows in the ovary of an individual's kernel and transforms them into large, velvety greenish to black balls (pseudomorph) (Singh and Singh, 1987). Sometimes this pseudomorph is more than twice the diameter of the normal grains. In the initial stage, the balls are small and remain confined between the glumes and then they gradually enlarge and enclose the floral parts (Singh *et al.*, 2008). Young spore balls are flattened, smooth, light yellow colour and covered by a membrane and later when the membrane bursts the colour changes to orange-yellowish, olive-green, green and finally the greenish-black. The pathogen also causes sterility of neighboring spikelets (Hashioka, 1971), ultimately leading to reduction in the grain weight (Dhindsa *et al.*, 1990). In general, only a few grains of a panicle are affected although sometimes several grains adjacent to smut balls may remain sterile resulting in chaffiness of the panicle (Rashmi *et al.*, 2016). The false smut pathogen can infect rice florets at the booting/flowering stage where it destroys the ovary and leaves the style, stigma and anther buried intact in the spore mass. The typical symptom is the formation of a false smut ball that is attributable to the growth of a white fungal mass in a spikelet, protruding out from the gap between the palea and the lemma and eventually forming a ball-like colony, which produces numerous yellow or greenish-black chlamydospores sometimes covered by sclerotia (Guo *et al.*, 2012). Keeping in view, the continuous occurrence and widespread distribution of false smut disease, the extent of damage and economic losses caused by it, limited work has been done in this region on this disease. Hence, the present investigation was undertaken with the survey of false smut in rice growing areas of South Gujarat and study of the symptomatology of the disease.

Materials and Methods

Survey of rice false smut

Rice growing areas of South Gujarat were surveyed at grain maturity stage during the *kharif* 2017 and *kharif* 2018. A total of two surveys were conducted of five districts *viz.*, Navsari, Surat, Valsad, Tapi and Dang of South Gujarat and NAU farm. In a random survey for each district, two villages with two fields in each village were selected and in each field, four random sites (1m x 1m) were marked for observation. During each season, affected fields were surveyed for assessing the per cent disease incidence (PDI), average smutted ball (ASB) per panicle and disease severity index (DSI) of false smut disease of rice. Diseased plants showing false smut symptoms (pseudomorph) were collected in a paper bag from different rice growing areas of South Gujarat. The samples were subjected to further processing in the laboratory. The disease incidence parameters were worked out as per the following formula given by Singh and Dube (1978).

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

$$\text{Per cent infected grains} = \frac{\text{Total number of infected grains/panicles}}{\text{Total number of grain/panicles}} \times 100$$

$$\text{Disease severity} = \text{Per cent infected tillers} \times \text{Per cent infected grains}$$

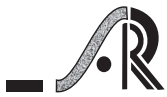
Symptomatology of false smut

During the field visits, colours of the smut balls *viz.*, (i) White, (ii) Orange, (iii) Olive green to greenish-black were also recorded.

Results and discussion

Survey of rice false smut in rice growing areas of South Gujarat

Field surveys were conducted during *kharif* 2017 and *kharif* 2018, at five districts *viz.*, Navsari (Partapor and Zari), Dang (Jamalapada and Khatal), Valsad (Balchondhi and Parvasa), Tapi (Panchol and Bhanwadi) and Surat (Haripura and Mahudi) and NAU farm (Navsari) for assessing the per cent disease incidence (PDI), average smutted ball (ASB) per panicle and disease severity index (DSI) of rice false smut disease. The results of the surveys revealed



that disease incidence ranged from 1.49 to 11.11 per cent. The average smutted ball per panicle ranged from 1.07 to 2.63 while the disease severity index varied between 1.97 and 29.15.

Per cent disease incidence of false smut of rice

Among eleven surveyed locations, the mean per cent disease incidence was 7.22 per cent in 2017. The maximum per cent disease incidence of 12.15 per cent in Jamalapada and minimum incidence of 1.71 per cent was recorded in Mahudi. In 2018, similar trend was observed. The mean disease incidence was 6.44 per cent with maximum incidence of 10.06 per cent in Jamalapada and minimum incidence of 1.27 per cent in Mahudi. The average per cent disease incidence across the two years was 6.83 per cent.

Average smutted ball per panicle of rice

The smutted balls per panicle were maximum in Jamalapada (2.80) and minimum average in Haripura

(1.12) during 2017. The mean number of smutted balls per panicle was 1.88. In 2018, the mean smutted ball per panicle was 1.69 with maximum smutted balls per panicle of 2.52 observed in Khatal and minimum smutted ball per panicle recorded in Haripura (1.18). However, the average smutted ball per panicle over the two years was found to be 1.79.

Disease severity index of false smut of rice

Among eleven surveyed locations, the mean average disease severity index was found 14.86 in 2017. The maximum disease severity index was 34.02 in Jamalapada whereas, minimum disease severity index was recorded 2.34 in Mahudi. In 2018, the mean average disease severity index was 11.85 with maximum disease severity index of 24.65 in Jamalapada and minimum disease severity index of 1.63 in Mahudi (**Table 1**). The average disease severity index across the years was 13.34 per cent.

Table 1: Surveys on the per cent disease incidence, average smutted ball and severity of false smut of rice during *kharif* 2017 and *kharif* 2018

District	Places	Per cent disease incidence (PDI)			Average smutted ball (ASB) / panicle			Disease severity index (DSI)		
		2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Navsari	Partapor	6.38	5.75	6.07	1.53	1.23	1.38	9.76	7.07	8.37
	Zari	7.36	6.84	7.10	1.60	1.40	1.50	11.78	9.58	10.65
Dang	Jamalapada	12.15	10.06	11.11	2.80	2.45	2.63	34.02	24.65	29.15
	Khatal	11.44	9.37	10.41	2.38	2.52	2.45	27.23	23.61	25.49
Valsad	Balchondhi	7.90	8.88	8.39	2.49	1.92	2.21	19.67	17.05	18.50
	Parvasa	8.11	6.68	7.40	2.10	2.26	2.18	17.03	15.10	16.12
Tapi	Panchol	7.28	6.12	6.70	1.61	1.57	1.59	11.72	9.61	10.65
	Bhanwadi	8.16	7.91	8.04	1.88	1.26	1.57	15.34	9.97	12.61
Surat	Haripura	2.39	1.99	2.19	1.12	1.01	1.07	2.68	2.01	2.33
	Mahudi	1.71	1.27	1.49	1.37	1.28	1.33	2.34	1.63	1.97
NAU Farm	Navsari	6.54	5.93	6.24	1.81	1.70	1.76	11.84	10.08	10.94

During the surveys, it was observed that the disease was found to be more severe in *viz.*, Jamalapada and Khatal of the Dang district. It may be due to favourable climatic conditions *i.e.*, high humidity, cloudy weather, low temperature and continuous cultivation of the hybrid and high yielding rice

cultivars susceptible to false smut disease and recurrent appearance of the disease. The disease was found more severe in fields with the previous record of false smut over the years. Perusal of the literature revealed that false smut incidence was emerging as one of the major diseases of rice in Gujarat and its

incidence varied widely from one place to another place. Present results conform to the findings of Kapse *et al.*, (2012) who recorded higher disease incidence in MTU-1010 variety (12.00%), with the incidence ranging from 0 to 12 per cent. Singh *et al.*, (2012) reported highest disease incidence of 61.2 per cent in Pusa-1121 under late sown condition followed by late sown Sugandha-3 (58.40%) and timely sown Pusa-1121 (48.60%) while, least disease incidence was observed in timely sown Kranti variety (20.00%). Sanghera *et al.*, (2012) reported that disease incidence ranged from 6.92 to 18.94 per cent in 2010 and 10.47 to 25.46 per cent in 2011 in different districts viz., Kulgam, Anantnag, Pulwama, Budgam of Kashmir. Higher disease incidence was recorded in Budgam followed by Kulgam. Ladhakshmi *et al.*, (2012) found that the incidence of infected tillers ranged between 2 and 75 per cent in Haryana, 10 to 20 per cent in Punjab during 2009, and 5 to 85 per cent in Tamil Nadu during 2010. Rashmi and Gokulapalan (2014) recorded a maximum of 31.10 per cent infected tillers and 138.8 disease severity index in Upper Kuttanad of Kerala during 2011-2012 and the same trend was observed during 2012-13 with 42.00 per cent infected tillers and 123.9 disease severity index. Singh *et al.*, (2014) recorded 80 per cent disease incidence in Gaur Block of Basti district in Uttar Pradesh. Quintana *et al.*, (2016) recorded 40.0 per cent disease incidence in panicles and observed that the infected panicles had grains replaced by globose yellowish green masses of spores, with at least 2 to 3 smut balls per symptomatic panicles in IRGA-424 variety. Baite *et al.*, (2017) reported highest disease incidence, infected tillers, smutted balls and disease severity index of 55.61, 8.77, 6.47 per cent and 359.82, respectively in Pooja variety, in Cuttack (Odisha).

Symptomatology of the false smut disease of rice

The pathogen causing false smut disease of rice, *U. virens* initiated infection in the rice plants at the booting stage of the crop and visible symptoms appeared only after flowering at the grain filling stage of the rice crop. Due to the infection by the pathogen, the individual spikelets of the panicle were transformed in to yellowish-orange to olive-

green colour ball-like structures called “smut ball or pseudomorph or pseudosclerotia” which were almost double the size of the normal rice grain (**Figure 1**). Infection in unfertilized florets resulted in most of the glumes remaining sterile without any visible sign of infection, and finally to production of chaffy grains.



Figure 1: Infected smutted balls and uninfected healthy seeds of rice: (i) Smutted balls (ii) Healthy seeds

The pathogen *U. virens* produced distinct symptoms after blooming when it infected the floret and transformed it into a large, velvety, yellow to orange pulverulent mass (pseudomorph) changing to olive-green to dark greenish in colour [**Figure 2: (A) and (B) i, ii and iii**]. The smut balls, at the initial stage of infection by the fungus transformed individual grains of the panicle into a white dense mycelium which resembled the normal grain. After that it emerged out from the lemma and palea as whitish smut ball, covered by silvery white membrane [**Figure 3: (i) and (ii)**]. During the later stages, the covering membrane ruptured exposing the yellow dust-like spores, technically the chlamydospores of the pathogen [**Figure 3: (iii) and (iv)**]. The yellowish smut ball transforming from yellowish-orange to olive-greenish in colour [**Figure 3: (v) and (vi)**], then to olive-green colour and later, from dark-green to greenish black colour and finally at maturity stage sclerotia detached from smut balls [**Figure 3: (vii) and (viii)**].

The pathogen was also found to cause chaffiness of the panicle and in severe cases, completely chaffy panicles with numerous smut balls were observed. Severely affected panicles appeared blackened by the time of harvest due to the presence of the black coloured chlamydospores of the pathogen.

Hu *et al.*, (2013) also observed that the smut balls were first covered by a silvery-white membrane that ruptured and changed colour from yellow-orange to olive-green and then greenish black at maturity. Rashmi *et al.*, (2016) observed that false smut was found to infect the rice plants at the flowering stage of the crop. Due to the infection by the pathogen, the individual spikelets of the panicle were found to get transformed into yellow to orange coloured smut balls which were almost double the size of the normal rice grains. Kannahi *et al.*, (2016) reported that the false smut symptoms appeared on the spikelet at maturity. Sanghera *et al.*, (2012), Kumar *et al.*, (2014), Singh *et al.*, (2014) and Lin *et al.*, (2018) found that, the false smut of infected grain balls (smutted ball) initially become a yellowish or orange in colour and changed to green or olive-green colour.

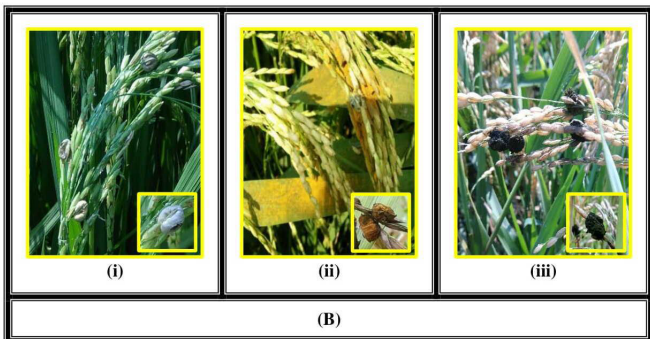


Figure 2: Symptoms of false smut disease of rice in field

- (A) False smut balls in the field
 (B) Change of colour of smut ball (i) White (ii) Orange (iii) Olive green

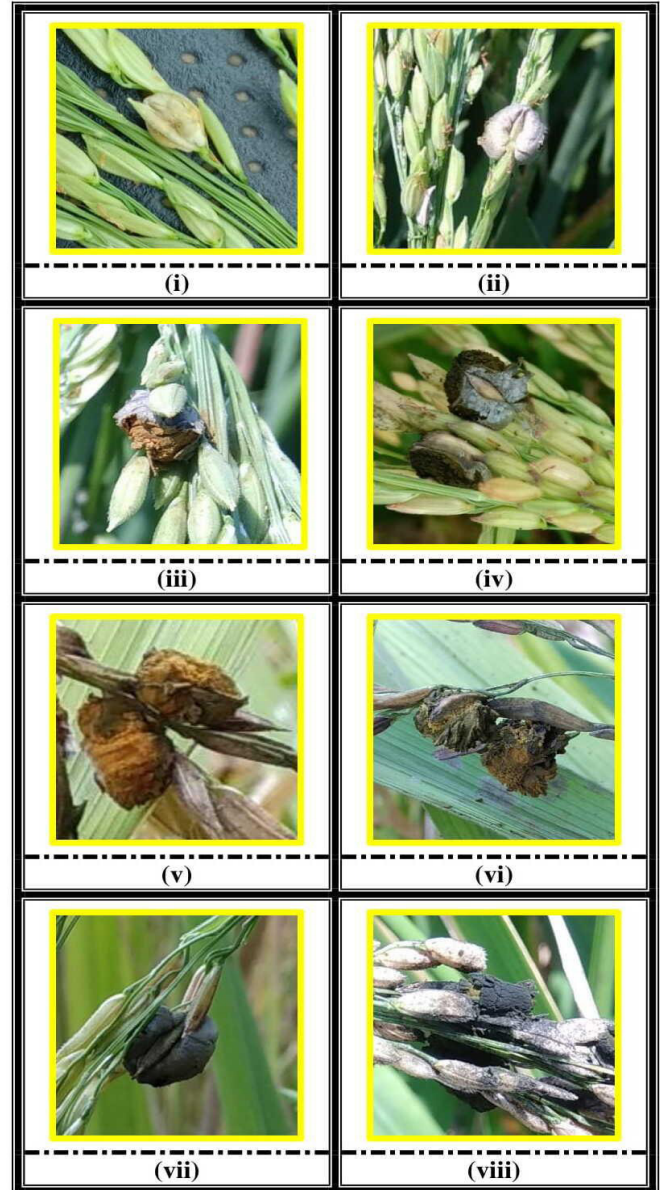


Figure 3: Developmental stages of false smut balls in infected rice panicles

- (i) Development of mycelium inside the grain (ii) Emerging of mycelium with silvery white membrane and developing of light yellow chlamydospores inside the membrane (iii) & (iv) Bursting of silvery white membrane and spread of chlamydospores (v) Colour changing from yellow to orange smut ball (vi) Transformation of orange smut ball into olive-greenish (vii) Developed olive-greenish to black smut ball (viii) Sclerotia detaching from smut balls

Conclusions

The information showed that due to infection of *U. virens*, spikelets of the panicle were transformed into yellowish-orange to olive-green colour ball-like structures called “smut balls”. *U. virens* attacked

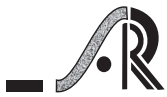
almost all the rice growing areas of South Gujarat and maximum in Dang district because of favorable climatic conditions like high humidity, cloudy weather, low temperature and continuous cultivation of the hybrid and high yielding rice cultivars susceptible to false smut disease. It was evident from survey data that false smut is evolving as one of the major threats to the rice-producing areas of Gujarat.

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References

- Baite MS, Raghu S, Lenka S, Mukherjee AK, Prabhu Karthikeyan SR and Jena M. 2017. Survey of rice false smut caused by *Ustilagoidea virens* in Odisha. *The Bioscan*, 12(4): 2081-2085.
- Cooke MC. 1878. Some Extra-European Fungi. *Grevillea*, 7: 13-15.
- Dhindsa HS, Aulakh KS, Raina GL and Saini RK. 1990. Estimation of yield losses due to false smut of rice. Directorate of Rice Research, Hyderabad, India. pp. 466.
- Dodan DS and Singh SR. 1996. False smut of rice: present status. *Agricultural Review*, 17(4): 227-240.
- Guo X, Li Y, Fan J, Li L, Huang F and Wang W. 2012. Progress in the study of false smut disease in rice. *Journal of Agricultural Science and Technology*, 2: 1211-1217.
- Hashioka Y. 1971. Rice disease in the world, VIII. Diseases due to hypocreals, Ascomycetes (Fungal Diseases, No. 5). *Riso*, 20: 235-258.
- Hu JK, Chen ZY, Gu ChH, Yu MN, Yu JJ, Nie YF, Huang L, Qiao JQ, Huang X, He J and Liu YF. 2013. Isolation and characterization of promoter from rice false smut fungus *Ustilagoidea virens*. *Journal of Plant Pathology*, 95(3): 539-547.
- Kannahi M, Dhivya S and Senthilkumar R. 2016. Biological control of rice false smut disease using *Trichoderma* species. *International Journal of Pure and Applied Biosciences*, 4(2): 311-316.
- Kapse VV, Bhale MS and Jogi MJ. 2012. Prevalence of disease in rice in the Jabalpur region. *International Journal of Plant Protection*, 5(1): 16-19.
- Kumar A, Sahu TK, Bhalla A and Solani S. 2014. Influence of *Trichoderma* spp. against *Ustilagoidea virens* inciting false smut of rice. *Environment and Ecology*, 32(1): 163-168.
- Ladhalakshmi D, Laha GS, Singh R, Karthikeyan A, Mangrauthia SK, Sundaram RM, Thukkaiyannan P and Viraktamath BC. 2012. Isolation and characterization of *Ustilagoidea virens* and survey of false smut disease of rice in India. *Phytoparasitica*, 40: 171-176.
- Lin X, Bian Y, Mou R, Cao Z, Cao Z, Zhu Z and Chen M. 2018. Isolation, identification, and characterization of *Ustilagoidea virens* from rice false smut balls with high ustilotoxin production potential. *Journal of Basic Microbiology*, 58(8): 670-678.
- Mandhare VK, Gawade SB, Game BC and Padule DN. 2008. Prevalence and incidence of bunt and false smut in paddy (*Oryza sativa* L.) seeds in Maharashtra. *Agricultural Science Digest*, 28(4): 292-294.
- Nessa B, Salam MU, Haque AHMM, Biswas JK, Jahan QSA, Khan MAI, Bhuiyan MR, Ara A, Munir MR, Galloway J, Kabir MS and Ali MA. 2016. Density and distribution of false smut balls on infected rice panicles. *Bangladesh Rice Journal*, 20(2): 73-79.
- Quintana L, Gutierrez S, Maidana M and Morinigo K. 2016. Rice false smut [*Ustilagoidea virens* (Cooke) Takah.] in Paraguay. *An International Journal Tropical Plant Research*, 3(3): 704-705.
- Rashmi CR and Gokulapalan C. 2014. False smut, an emerging disease of rice in Kerala. In: National symposium on “Plant diseases: new perspectives and innovative management strategies” organized by University of Agricultural Sciences, Dharwad and Indian Phytopathological Society (South



- Zone) - IPS (SZ), 11-12 December 2014. pp. 122-123.
- Rashmi CR, Gokulapalan C, Girija VK and Surendran M. 2016. On the off-season survival of *Ustilaginoidea virens*, the pathogen causing false smut of rice in Kerala. *International Journal of Applied and Pure Science and Agriculture*, 2(3): 80-82.
- Sanghera GS, Ahanger MA, Kashayp SC, Bhat ZA, Rather AG and Parray GA. 2012. False smut of rice (*Ustilaginoidea virens*) under temperate agro-climatic condition of Kashmir, India. *Elixir Bio Technology*, 49: 9827-9830.
- Singh AK, Kasana BS, Kumar P and Singh BK. 2012. Occurrence of rice false smut in Bundelkhand region. *International Journal of Plant Protection*, 5(2): 283-285.
- Singh G, Kumar A, Shahi UP and Kumar K. 2008. Response of rice varieties to nitrogen levels and false smut in mid-western plain zone of U.P. *Journal of Farming Systems Research and Development*, 14(1): 138-139.
- Singh NI and Singh SR. 1987. Aerobiology and epidemiology of certain fungal diseases of rice in imphal. First national seminar on aerobiology, epidemiology and plant disease forecasting. (19-21 Nov.). Marathwada University, Aurangabad, Abstract. pp. 24.
- Singh RA and Dubey KS. 1978. Assessment of loss in seven rice cultivars due to false smut. *Indian Phytopathology*, 3: 186-188.
- Singh S, Lal AA, Simon S, Singh A, Yaduman R, Kamaluddin and David AA. 2014. Survey of false smut (*Ustilaginoidea virens*) of rice (*Oryza sativa* L.) in selected districts of Uttar Pradesh, India. *The Bioscan*, 9(1): 389-392.