Environment & Ecology 35 (3B) : 2071—2075, July—September 2017
Website: environmentandecology.com ISSN 0970-0420

Investigations on Survival and Host Range of *Fusarium moniliforme* Sheld Causing Foot Rot Disease of Rice

Anita Puyam, PPS Pannu, Jaspal Kaur, Shikha Sethi

Received 26 September 2016 ; Accepted 27 October 2016 ; Published online 15 November 2016

Abstract Foot rot (bakanae) disease of rice, caused by *Fusarium moniliforme* Sheld, is an important disease in all the rice growing regions of the world. The pathogen is highly cosmopolitan in nature. Primarily, they are seed borne in nature. The study has been planned to investigate the survival of *F. moniliforme* in soil and in weeds. Eight different treatments were planned (T_1 = Healthy seeds in infested soil: T_2 = Healthy seeds in non-infested soil ; T_3 = Artificially inoculated seeds in infested soil ; T_4 = Artificially inoculated seeds in non-infested soil ; T_5 = Naturally infected seeds in infested soil ; T_6 = Naturally infected seeds in non-infested soil ; T_7 = Bavistin treated inoculated seeds on infested soil ; T_8 = Bavistin treated inoculated seeds on non-infested soil and Control = inoculated infected seeds of susceptible cultivar Pusa 1121 on non-infested soil). The study revealed that *Fusarium moniliforme* causing the disease is not a strong soil inhabitant and the survival in soil under field condition reduced with passage of time and might have survive in diseased plant debris for short duration in the soil. Only the seed borne inoculum played important role as primary inoculum. Nine weeds were investigated for the possible role as the host of the foot rot pathogen. It was observed that weeds under study didn't serve as a host for the bakanae pathogen and failed to show the foot rot symptoms.

Keywords Bakanae, Seed borne, Survival, Primary inoculum, Host.

Introduction

Bakanae disease of rice (foot rot disease), caused by *Fusarium moniliforme* Sheld with perfect stage as *Gibberella fujikuroi* (Saw), was first described in Japan in 1828 [1]. In India, bakanae disease incidence has been increasing considerably and reported to cause substantial losses in grain yield. Moderate to severe yield losses ranging from 15–25% have been reported from Eastern UP, Assam, Andhra Pradesh, Tamil Nadu, Haryana and Punjab. Bakanae has emerged as an important disease of rice, particularly basmati rice in India during recent years [2]. Disease incidence on different basmati aromatic rice cultivars was recorded from 1.2–11.7% in Uttar Pradesh, 2.1–3.2% in Uttarakhand, 2.1–2.8% in Haryana, 10.5–40.0% in Punjab, 1.8–8.7% in Bihar and 2.4–13.6% in Rajasthan [3]. During the past 4-5 years, area under basmati rice has been increased due to its export potential. At present, basmati varieties occupy 20% area in Punjab and it is continuously increasing every year [4]. This tolls the concern for the disease.

A. Puyam*, P. P. S. Pannu, S. Sethi
Department of Plant Pathology, Punjab Agricultural University, India

J. Kaur
Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, India
e-mail: anitapau6243@gmail.com
*Correspondence

Table 1. Survivability of *Fusarium moniliforme* in soil.

Treatments	Treatments
T_1	Healthy seeds sown in infested soil
T_2	Healthy seeds sown in uninfested soil
T_3	Artificially inoculated diseased seeds sown in infested soil
T_4	Artificially inoculated diseased seeds sown in unifested soil
T_5	Naturally infected seeds sown in infested soil
T_6	Naturally infected seeds sown in uninfested soil
T_7	Bavistin treated inoculated seeds sown in infested soil
T_8	Bavistin treated inoculated seeds sown in uninfested soil
Control	Artificially inoculated infected seeds of susceptible cultivar Pusa 1121 in non-infested soil

Three mating populations MP-A (anamorph *F. verticilloides*), C (anamorph *F. fujikuroi*) and D (anamorph *F. proliferatum*) of the *G. fujikuroi* complex have been associated with bakanae-diseased rice [5, 6]. Among them, F. fujikuroi has been reported to cause bakanae disease of rice predominantly being more virulent than others [6]. Bakanae incidence was found very low when clean seeds were planted in fields with a histort of the disease [7]. It is a monocyclic disease and the pathogen is dispersed predominantly with infected or infested seed, although infected crop residue from the previous season may also serve as a primary source of inoculum [8]. Typical symptoms of the disease are usually characterized with infected plants that are several inches taller than normal plants in seedbed and field ; thin plants; with yellowish green leaves and pale green flag leaves ;die back seedlings at early stage partially ; filled sterile or empty grains on surviving plant at maturity ; infected seedlings with lesions on roots that die before or after emergence [9].

Materials and Methods

Survival of *Fusarium moniliforme* in soil

To investigate the soil borne nature of *Fusarium moniliforme*, an experiment was conducted by preparing the rice field, where wheat was grown before, in the last week of November, 2013 and harvested in the month of May, 2014, so as to ensure that the soil was free from the foot rot inoculum. A total of eight treatments and one control have been planned (Table 1) for sowing in the field. Eight plots were prepared. Four of the plots were artificially infested by adding straw infected with foot rot in the field and four of them were left uninfested. For artificial infestation of the field, infected plant debris was collected in October, 2013 after harvesting bakanae infected basmati cultivar Pusa [12]. The debris was chopped into small pieces of size 1 cm and dried under shade. Chopped plant debris was then added and mixed in four plots of 2×2 m^2 in the month of November 2013 and were ploughed. The nursery of basmati was then sown in these plots in July, 2014. The same treatments have been repeated in the consecutive year also.

Table 2. Weeds evaluated for studying host range of *Fusarium moniliforme*.

Common name	Scientific name
Sanni	*Sphenoclea zeylanica*
Ammania	*Ammania baccifera*
Ghuein	*Fimbristylis tenera*
Madhana	*Dactyloctenuim aegyptiacum*
Joyweed	*Alternanthra sessilis*
Chhatri wala motha	*Cyperus iria*
Narhi gha	*Paspulum distichum*
Hairsedge	*Bulbostylis barbata*
Takri gha	*Digitaria sanguinalis*

For T_3, T_4, T_7 and T_8, seeds were inoculated by dipping for 3 h in the culture suspension of *F. moniliforme* to ensure that all the seeds were infected. For T_7 and T_8, seed was treated with Bavistin @ 2g/L for 12 h before sowing. Observations on disease symptoms were recorded and the infected seedlings were counted.

Preparation of suspension of culture for artificial inoculation

Conidial suspension was prepared from 15 days old culture of *Fusarium moniliforme* multiplied on PDA by mixing in sterilized distilled water and shaken vigorously. It was then filtered through double layer of muslin cloth. The concentration of conidial suspension was adjusted to 4×10^4 conidia/ml with the help

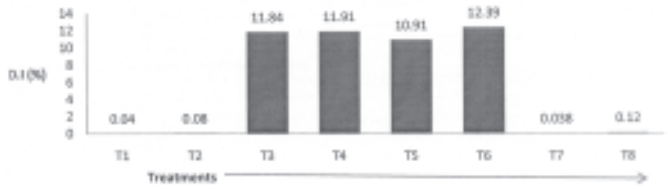

Fig. 1. Graph showing disease incidence (D.I %) for the year 2014.

of hemocytometer. The seeds were then soaked in the inoculums for 3 h before sowing.

Host range

F. moniliforme is a cosmopolitan fungus, having wide host range. There is a possibility that the major weeds in the rice field may serve as hosts. Nine different weeds found in the rice field were tested for their susceptibility to *Fusarium moniliforme* during crop season 2014 under artificial inoculation conditions (Table 2). The weeds were uprooted in seedling stage from the rice field and the roots were dipped for 3 h in spore suspension of *Fusarium moniliforme* having concentration of 4×10^4 spore/ml and transplanted in the field. The plants were then observed for the development of the symptoms.

Table 3. Survival of *F. moniliforme* in soil under field conditions

	Treatments	D.I. (%) (2014)	D.I. (%) (2015)
T_1 =	Healthy seeds on infested soil	0.04	0.01
T_2 =	Healthy seeds on non-infested soil	0.08	0.12
T_3 =	Inoculated seeds on infested soil	11.84	13.50
T_4 =	Inoculated seeds on non-infested soil	11.91	12.90
T_5 =	Naturally infected seeds on infested soil	10.91	9.75
T_6 =	Naturally infected seeds on non-infested soil	12.39	10.00
T_7 =	Bavistin treated inoculated seeds on infested soil	0.038	0.11
T_8 =	Bavistin treated inoculated seeds on non-infested soil	0.12	0.15
C =	Inoculated infected seeds of susceptible cultivar Pusa 1121 on non-infested soil	20	25

Results and Discussion

Survival of *Fusarium moniliforme* under field conditions

Investigations on survival of *Fusarium moniliforme* in soil revealed that the pathogen doesn't survive in soil up to next season. The disease incidence of T_6 (naturally infected seeds sown on non-infested soil) was the highest, showing foot rot incidence of 12.39%. It was followed by T_4 (inoculated seeds on uninfested soil) showing foot rot incidence of 11.91%. In both cases, the soil was non-infested and the seeds have the inoculums. In case of T_1 and T_2, both the seeds were healthy but the field in which T_1 was subjected, was infested. The treatment T_1 (healthy seed on infested soil) showed the disease incidence of 0.04% and T_2 (healthy seeds on uninfested soil) of 0.08%. This indicates that soil borne inoculums have little importance in causing the disease. Considering T3 and T4, the seeds were artificially inoculated and the field subjected with T_3 was infested before sowing but the disease incidence of T_3 (11.84%, 13.50%) and T_4 (11.91%, 12.90%) were almost at par. If the soil borne inoculums have role in causing the disease then, the field with T_3 might have higher disease incidence than T_4. This indicates that the disease was

Table 4. Investigations on the host range of *F. moniliforme*.

Common name	Scientific name	Disease incidence (%)
Sanni	*Sphenoclea zeylanica*	0.00
Ammania	*Ammania baccifera*	0.00
Ghuein	*Fimbristylis tenera*	0.00
Madhana	*Dactyloctenuim aegyptiacum*	0.00
Joyweed	*Alternanthra sessilis*	0.00
Chhatri wala motha	*Cyperus iria*	0.00
Narhi gha	*Paspulum distichum*	0.00

mainly caused by the inoculums present in the inoculated diseased seeds and the inoculums present in the soil have little to contribute in causing the disease. Similarly, there was not much difference in the disease incidence of T_5 (disease seeds on infested soil) and T_6 (disease seeds on non-infested soil) treatments. This shows that the infested and non-infested condition of the soil has little contribution towards the causation of the disease. If the soil borne inoculum has major role in causing the disease, then the T_5 would have surely showed higher disease incidence compared to T_6 (Fig. 1). Similar was the case of T_3 and T_4. All the results indicate the primary contribution of the disease seeds as the source of inoculums for causing the disease. The results were supported without any doubt by the treatment T_7 and T_8 which showed minimum disease incidence of (0.038%, 0.11%) and (0.12%, 0.15%) respectively. In T_7 and T_8, inoculum was present in the inoculated diseased seeds, which was put under controlled by the bavistin treatment. The result has been indicated in Table 3. Having been confirmed with the role of seed as primary source of inoculums for foot rot disease, it is wrong to say that the soil borne inoculum has nothing to do with the cause of the disease but conclusion can be made that the soil-borne inoculums may have reduced with the passage of time. The result has been supported by comparison between T_1 and T_2.

The studies revealed that the seed borne inoculum plays important role as primary inoculum. The result of the experiment is in conjunct with the findings of other researchers [10, 11]. The study also revealed that *Fusarium moniliforme* causing the disease is not a strong soil inhabitant [11]. Thus, from these findings, we can draw the conclusion that survival of *F. moniliforme* in soil under field condition reduced with passage of time and may have survive in diseased plant debris for short duration in the soil. But has little role to play in disease development for the next season and only the infected seeds serve as a primary inoculum.

Host-range of *F. moniliforme*

Nine weeds found in rice field were tested for the appearance of the disease. None of the weeds were found to be the host of foot rot disease. No plants show the long slender falcate or straight symptoms of elongation, stunting or yellowing. All the weed species under observation score zero percent disease incidence. Thus, the important weeds were not found to be the weed host of *F. moniliforme* and plays no role in pathogenesis (Table 4). However, survival of *F. fujikuroi* causing bakanae and in barnyard and early water grasses has been reported and proved Koch postulates [12]. But no bakanae symptoms were observed. They have been found susceptible to bakanae disease [12, 13]. This indicated the possibility of the grasses to be source of inoculum for the disease. The pathogen has been reported to be isolated from some grasses but no symptoms occurence have been reported yet on those plants. The same observation has been made from the present experiment. Thus, till date no grass has been reported as alternate or alternative host. Further understandings and investigations on the probability of weed as the host of *Fusarium moniliforme* is needed.

From the present study of the survival and host range of the pathogen, a general understanding of the disease cycle has been drawn. It is confirmed that the pathogen is seed borne. They were reported as both externally and internally seed borne [11]. The perusal of the findings also showed that inoculums were also present in the soil. However, infection from the soil is of less important as source of inoculums from the soil decreases with time and thus, the survival of the pathogen decreases with the passage of time. Primary infection occurs through seed and soil. However, as primary inoculum seeds are more impor-

tant than the soil borne inoculum. When the infected seeds are used for sowing, the emerging plants get infected. The infection starts from the nursery and carried to the transplanted field. Secondary infection occurs from the infected plants when they are transplanted in the field. The inoculums were then spread in other healthy plants through water dispersal. The infected plants become elongated as compared to the normal healthy plants. Some plants also remained stunted. The infection later becomes systemic by the time the plants attained the tillering stage. The infected plants then bear infected seeds and some tillers produced chaffy grains. These seeds then served as the inoculum for the next season.

References

1. Ou SH (1985) Rice diseases 2nd edn. CMI Kew, Surrey, UK, pp 262—272.
2. Pannu PPS, Kaur J, Singh G, Kaur J (2012) Survival of *Fusarium moniliforme* causing foot rot of rice and its virulence on different genotypes of rice and basmati rice. Ind Phytopathol 65 : 149—209.
3. Gupta AK, Singh Y, Jain AK, Singh D (2014) Prevalence and incidence of bakanae disease of rice in Northern India. J Agric Search 1 : 233—237.
4. Anonymous (2014) Package of practices for the crops of Punjab (*kharif*). Punjab Agric Univ Ludhiana 31 : 16.
5. Bashyal BM, Aggarwal R (2013) Molecular identification of Fusarium species associated with bakanae disease of rice (*Oryza sativa*) in India. Ind J Agric Sci 83 : 72—77.
6. Gupta AK, Solanki IS, Bashyal BM, Singh Y, Srivastava K (2015) Bakanae of rice-An emerging disease in Asia. J Anim Sci 25 : 1499—1514.
7. Karov IK, Mitrev K, Sasa, Emilija DK (2009) *Gibberella fujikuroi* (Sawada) Wollenweber-the new parasitical fungus on rice in the republic of Macedonia. Prot Nat Sci Matica Srpska Novi Sad 116 : 175—182.
8. Biswas S, Das SN (2003) Survival of *Fusarium moniliforme* in different sources. J Mycopathol Res 41 : 55—58.
9. Bashyal BM, Aggarwal R, Gupta S, Banerjee S (2012) Ecology and genetic diversity of *Fusarium* spp. associated with bakanae disease of rice, pp 1—10. Biotech books. Chawla Offset Printers, Delhi.
10. Pannu PPS, Kaur J, Kaur GB, Kaur H (2013) Effect of different media and temperature on growth of *Fusarium moniliforme* causing foot rot of basmati rice and its survival. Pl Dis Res 28 : 29—30.
11. Kumar P, Sunder S, Singh R (2015) Survival of *Fusarium moniliforme* causing foot rot and bakanae disease in different parts of rice grains. Ind Phytopath 68 : 454—455.
12. Carter LLA, Leslie FJ, Webster RK (2008) Population structure of *Fusarium fujikuroi* from California rice and water grass. Phytopathology 98 : 992—998.
13. Anderson LL, Webster RK (2005) A comparison of assays for *Gibberella fujikuroi* and their ability to predict resulting bakanae from seed sources in California. Phytopathology 95 : 4—6.