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Technological gaps at farmer level regarding foot rot of basmati

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Abstract
Foot rot (*Fusarium moniliforme*) is a serious disease and becoming a yield limiting factor in the cultivation of Basmati rice in Punjab. It has been observed that many farmers were performing unrecommended applications for disease management which is a wasteful practice and lead to poor results. So a campaign was initiated by Farm Advisory Service (FASS) of Punjab Agricultural University (PAU), Ludhiana at Rupnagar district of Punjab during 2014 and 2015 to spread awareness and tackle some technological gaps under field conditions. A sample size of 124 farmers in four blocks of Rupnagar district was surveyed and it was observed that the disease incidence varied from 35-100 per cent (2014) and 5-75 per cent (2015) in different Basmati cultivars. An awareness campaign was initiated during 2014 and continued to 2015 along with village level trainings and field experiments at farmer fields which helped to reduce the foot rot disease incidence in surveyed villages during the second year of study. Higher rate of Nitrogen application on different varieties of Basmati rice showed more disease incidence. Most farmers used 100 kg urea per acre. At this level of fertilization the range of disease incidence was from 45-100% in 2014 and 5-50% in 2015. Even at high level of N fertilization, seed treatment was able to reduce disease incidence. The highest disease incidence was observed in the fields which were applied 150 kg urea per acre.

Keywords: Basmati rice, disease incidence, *Fusarium moniliforme*, nitrogen, seed treatment

Introduction
Rice is an important cereal crop and grown all over the world. Rice grown in India is primarily divided into Basmati rice and Non-Basmati rice. India is the major producer and exporter of Basmati rice to the world (Jain *et al.* 2014) [8]. Rice crop production is constrained by several biotic and abiotic factors (Singh *et al.* 2014) [22]. Among the various biotic factors affecting rice productivity, rice diseases caused by fungus are the most significant constraints responsible for low yield of this crop in India (Ling, 1980 [10]; Kumar *et al.* 2013[9]). Rice diseases like foot rot (Bakanae), sheath rot and neck blast were minor and occurred sporadically in the past, but now these have become important and are causing considerable yield losses (Kumar *et al.* 2013) [9]. Bakanae was first noted in 1928 by Ito and Kimura in Japan. It has been reported in many rice growing countries like Australia, Bangladesh, China, Korea, India and Thailand (Ou, 1985) [13]. Bakanae is a Japanese word which means bad or naughty seedling referring to the abnormal elongation, foolish seedling and stupid rice crop (Sun and Snyder, 1981) [23]. The fungus produces gibberellins and other secondary metabolites such as carotenoids, bikaverin and fusarin, which directly affect the growth of rice plants (Ilija *et al.* 2009) [7] and causes elongation of plant (Nyvall, 1999) [12]. The disease is caused by one or more *Fusarium* species. The symptoms of this disease include seedling blight, excessive elongation of infected plants, foot rot, seedling rot, grain sterility and grain discolouration with ultimate effect on grain yield and seed quality (Sun and Snyder, 1981) [23]. In Punjab, foot rot disease has become an economically important disease in Basmati rice (Bagga and Kumar, 2000; Pannu *et al.* 2012) [3, 14]. Foot rot incidence has been increasing over the years and yield losses ranging from 15-25 per cent have been reported from Eastern U.P., Haryana and Punjab (Rathaiah *et al.* 1991 [16]; Sunder *et al.* 1998[24]; Pannu *et al.* 2012[14]). The pathogen is soil-borne (Nishio *et al.* 1980) [11] as well as seed-borne (Saponara *et al.* 1986) [18]. The infected seeds can initiate the disease in fields previously free from the pathogen. It is difficult to develop bakanae resistant rice varieties due to the high genetic variation of the causal pathogens (Serafica and Cruz, 2009) [19]. Seed treatment with fungicide has been used for management of Bakanae disease (Gupta *et al.* 2014) [5].

However, the disease incidence threat is on increasing trend since the farmers are not adopting the proper control measures extensively. In Punjab foot rot of rice gained economic importance due to large scale cultivation of variety Pusa Basmati 1121 which is quite susceptible. Keeping in view the importance of this disease, a campaign was intiated in Rupnagar district of Punjab to spread awareness among farmers regarding control of foot rot with recommended management practices under field conditions.

Materials and Methods

A survey was conducted in four blocks of Rupnagar district of Punjab (lie between 30°-32' and 31°-24' latitude and 76°-18' and 76°-55' longitude 288 m above mean sea level) during 2014 and 2015 in Basmati rice growing season to monitor the occurrence and incidence of the foot rot disease. One hundred and twenty four (124) farmers from 38 villages from 4 blocks of the district were contacted to collect the basic information regarding seed source, seed treatment, cultivar, fertilizer dose, etc. during ongoing *Kharif* crop in 2014. The survey was fortified with an awareness campaign in which the farmers were educated through demonstrations and village level training camps about the improved disease management practices especially related to seed and seedling treatment. In 2015, these 124 farmers were again contacted for field observations. In each field, observations were recorded for the presence or absence and intensity of disease symptoms. The disease incidence was recorded from plots of 10 m^2 area selected randomly in every sampling area. Disease symptoms were observed in surveyed places at different growth stages of Basmati rice. Disease incidence in term of percentage of infected hills for each plot was calculated by the following formula (Hossain *et al*. 2011) [6].

Disease Incidence (DI) = Infected hills per plot/Total hills per plot x100

As the disease is primarily seed borne (Webster and Gunnell, 1992) [26], seed dressing represents the first way to control the spread of the disease. However, seed treatment alone fail to prevent soil-borne infection after transplanting (Bagga and Sharma, 2006) [4]. PAU recommends that before sowing, Basmati seed should be soaked in pesticide solution containing Bavistin 50 WP @ 0.2 per cent + Streptocycline 0.01 per cent for 12 hours followed by seedling root dip in Bavistin 50 WP (0.2%) for 6 hours before transplanting (Anonymous, 2017)[2]. However, the disease incidence at field level is quite high, since farmers do not properly adopt these recommendations. Seed treatment followed by nursery treatment needs to be promoted for clean cultivation of aromatic Basmati rice. The method of seed treatment followed by seedling root dip before transplanting was demonstrated at farmers' fields.

Results and Discussion

Punjab is one of the major Basmati rice producers of India and foot rot disease is posing a serious threat to sustainable Basmati rice production. The survey of this disease in Rupnagar district of Punjab, showed that disease was prevalent in nearly all the Basmati rice growing fields. The disease incidence varied from 35-100 per cent (2014) and 5-75 per cent (2015) in different Basmati cultivars.

Effect of seed and seedling treatment on foot rot incidence

The various methods being used for managing rice diseases include use of resistant varieties, cultural practices, biological and chemical control (Sharma and Thind, 2007) [20]. All these methods have varying degrees of success in managing rice diseases (Singh *et al.* 2012) [21]. The most important disease control tactics used worldwide after resistant varieties is chemical control. The bakanae disease is mainly seed borne and planting of clean inoculum-free non infested seed is most effective management method for this disease. In 2014, out of one hundred and twenty four farmers, 91.9 % farmers neither treated seed nor seedling, while after the campaign 99.1% farmers gave fungicide treatment to seed or seedling. It was observed that 95.9% farmers followed PAU recommendation by treating both seed and seedling. The number of farmers who treated both seed and seedling increased from 3 (2014) to 119 (2015) after the campaign. This helped in reducing the disease incidence, which ranged from 35-100% during 2014, to 5-75% during 2015. In 2014, some of the farmers treated both seed + seedling which had mean disease incidence 58.3% which reduced down to 27.8% in 2015 (Table 1). This gives an indication that may be the farmers knew about the practice but were not able to implement it properly due to some technological gaps. However, the range of disease incidence varied from 5-50% even after campaigning in 2015, this may also be due to the fact that some farmers may not be able to properly implement the technology.

Table 1: Effect of seed and seedling treatment on foot rot disease incidence during 2014 and 2015

Treatments	No. of farmers		Mean Disease Incidence	
	2014	2015	2014	2015
Seed treatment	1	1	35.0	35.0
Seedling treatment	6	3	69.1	28.3
Seed + seedling treatment	3	119	58.3	27.8
No treatment	114	1	71.1	75.0

Foot rot incidence in different cultivars

Mainly four aromatic Basmati rice cultivars *viz.*, Pusa Basmati 1509, Pusa Basmati 1121, Basmati 386 and Sugandha were cultivated by the farmers of the district. Out of these, Pusa Basmati 1121, Pusa Basmati 1509 and Basmati 386 are recommended by PAU for cultivation in the state. Sugandha is an unrecompensed variety also sown by farmers. All Basmati rice cultivars recorded high disease incidence ranging from 65.7 to 79.0 % during the year 2014. In 2015, after the successful initiation of the awareness campaign, a decreasing trend in mean disease incidence was observed among Pusa Basmati 1121 and Pusa Basmati 1509 (Fig. 1). None of the surveyed farmers reported sowing of Basmati 386 and Sugandha during 2015. The campaign intiated by FASS, Ropar was helpful in reducing the mean disease incidence by 41.3% in Pusa Basmati 1121 and 38.3% in Pusa Basmati 1509. Sandhu and Dhaliwal (2016)[17] also confirmed that recommended cultivars of Basmati rice being grown in the region vary in their reaction to foot-rot.

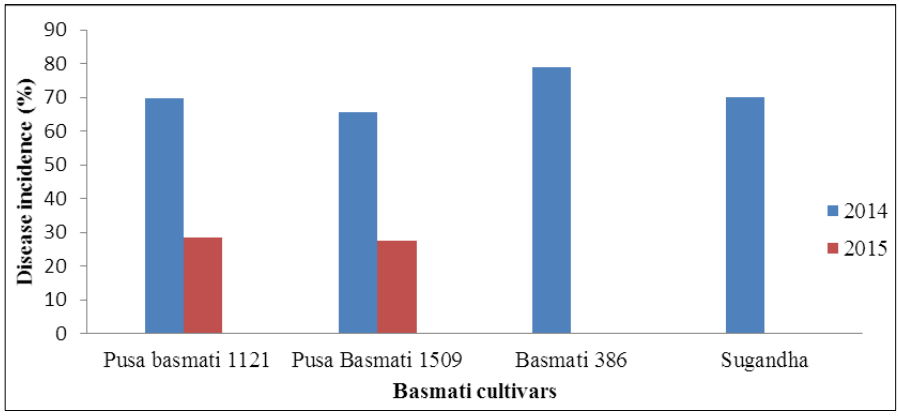

Fig 1: Foot rot disease incidence among different Basmati cultivars during 2014 and 2015

Effect of seed source on disease incidence

As foot rot is seed borne disease, so quality of seed plays an important role for cultivation of disease free crop. The data collected during survey showed that the farmers brought seed mainly from three sources *viz.*, State Agricultural University (SAU), private retailers and distributors and farmer's own seed (kept from previous crop) (Fig. 2). The data showed that source of seed had influence on disease incidence (Fig. 3). Varying degree of disease incidence was observed in fields with different seed source. Higher incidence was observed in fields where seed was purchased from private retailers than seed from SAU. Lowest disease incidence was observed in case of farmers sowing their own Basmati seed. The lower disease incidence in farmer's seed may be due to the fact that farmers prepared limited quantity of seed from disease free plots. FASS, Ropar also stressed upon importance of disease free seed prepared from farmer's own fields. The farmers were advised to apply one spray of Tilt 25 EC @ 200 ml in 200 litres of water at boot stage on seed crop, which is very effective method to prepare disease free seed (Anonymous, 2017)[2]. So, study entails that farmers should get seed from reliable source and they should try to prepare their own disease free seed also.

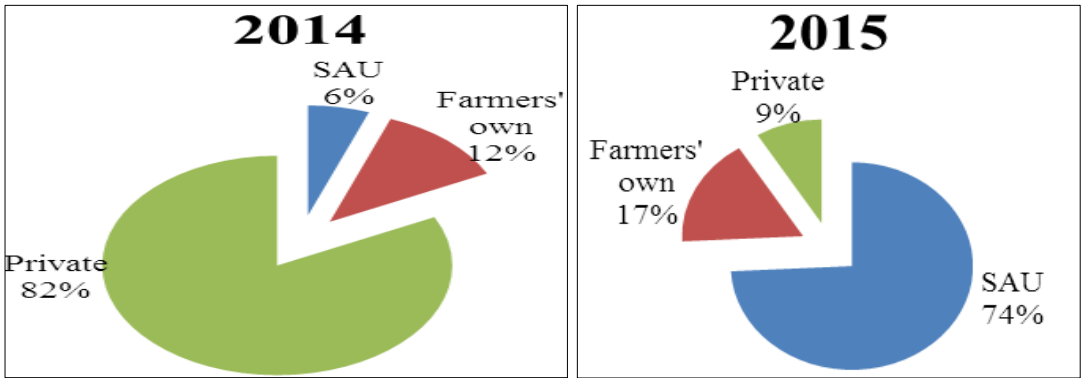

Fig 2: Variation in seed source of Basmati rice during 2014 and 2015

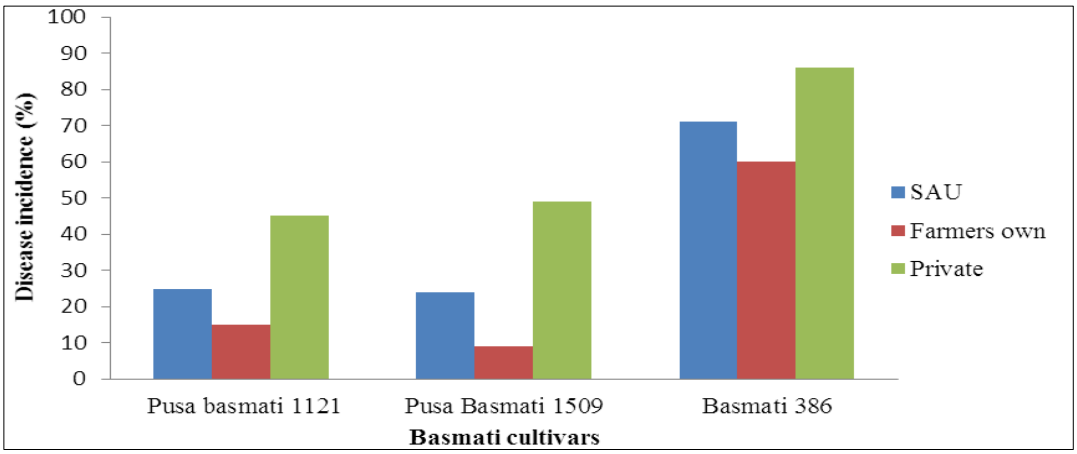

Fig 3: Foot rot disease incidence in different cultivars and seed sources during 2014

Effect of fertilization on disease incidence

Commercial fertilizers are commonly used in farming to maximize crop yield. Providing nutrients to plant growth when water and light conditions are sufficient may permit plants to grow to the maximum of their ability; however, plant ability to resist pathogen infections is also modified (Veresoglou *et al.* 2013) [25]. Higher rate of N application on different varieties of Basmati rice showed more disease incidence. Most farmers used 100 kg urea per acre, at this level of application the disease incidence range observed

during 2014 was 45-100%, while, in 2015, it reduced to 5-50%. This indicates that even at high level of N fertilization, seed treatment is able to reduce disease incidence. There was no significant increase in disease incidence up to 100 kg urea per acre application. Beyond this rate, further increase in N resulted in increase in disease incidence. The highest disease incidence was observed in the fields which were applied 150 kg urea per acre. In 2014, disease incidence for 125 to 150 kg urea was 55 to 100% which was reduced to 5 to 50% in 2015. Abiodun *et al*. (2015) [1] also concluded that the highest rate of urea fertilizer application resulted in the highest level of disease expression. The amount of urea fertilizer applied had a significant effect on *Fusarium* incidence. This creates favourable environmental condition for the pathogen to multiply. High doses of nitrogen application to Basmati cause excessive vegetative growth and plant height; this makes the crop more prone to lodging (Anonymous 2017) [2]. Increased nitrogen fertilizer dosage promotes fungal genera with known pathogenic traits, uncovering a negative effect of intensive fertilization (Paungfoo-Lonhienne *et al.* 2015) [15]. The results suggest that fertilization events do modify plant disease incidence of fungal pathogen-induced diseases.

During the campaign, stress was also laid upon balanced use of phosphorus fertilizers. Nevertheless, PAU recommends omitting the use of P fertilizers to rice crop if full dose of P is given to the preceding wheat crop, the survey revealed that only 26 % farmers did not apply P to Basmati crop. While in 2015 percentage of farmers not using P fertilizer in Basmati increased a little bit (36 %). There was no significant change in number of farmers applying more than recommended P in the year 2014 (75 farmers) as compared to 2015 (71 farmers). But it appeared that amount of P applied did decrease as it ranged from 5 to 75 kg DAP per acre in 2014, while it was in the range of 20 to 50 kg DAP per acre in 2015. However, P fertilization trends did not significantly affect the disease incidence. Percentage of farmers using zinc remained constant at 12 and 13.7 % during 2014 and 2015 respectively. There were only 3 farmers who used zinc both in 2014 and 2015, indicating that the farmers use zinc once in a period of 2-3 years or may be using it need based.

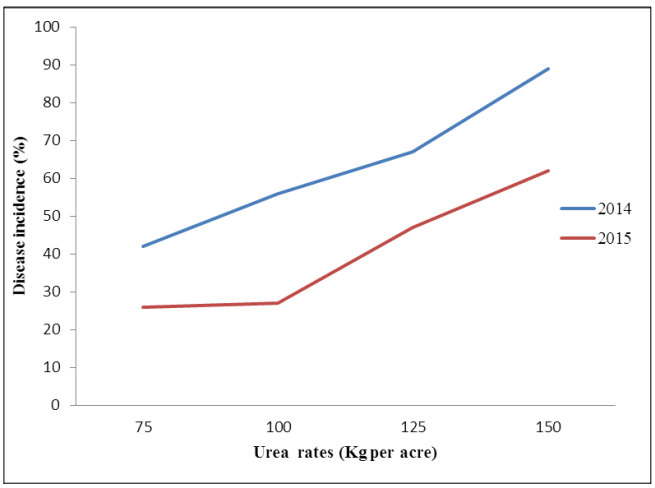

Fig 4: Effect of different urea rates on foot rot disease incidence during 2014 and 2015

Conclusion

Foot rot disease was prevalent in nearly all the surveyed Basmati fields in Rupnagar district of Punjab. The study yielded evidence in support of increased plant susceptibility to fungal pathogens with excessive use of N fertilizers. There was a significant dose-dependent effect of N fertilizer, as the disease incidence increased proportionately with the N-fertilization dose. Seed treatment + nursery treatment was effective method to control this disease, which needs to be popularized among the farmers. Apart from seed treatment, production and availability of good quality disease free seed further helps to contain this disease. Cultural practices need to be developed which can minimize the soil-borne inoculum of the pathogen and farm areas need to be identified for production of disease free seed. The aromatic rice trade has big potential in the international market, so research on foot rot should be accentuated.

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