Research Paper

Effect of Inoculums Level of Common Scab of Potato (Solanum tuberosum L.) Caused by Streptomyces scabies on Progeny Tubers

M.I. Tajul1,2*, M. Hossain1, M.I. Hossain1, K. Naher2 and T.K. Dey3

1Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
2Institute of Agriculture, Tokyo University of Agriculture and Technology (TUAT), Tokyo 183-8509, Japan
3Breeder Seed Production Centre, Bangladesh Agricultural Research Institute, Panchagar, Bangladesh
*Tel: +81-80-4804-7182; *Fax: +81-42-367-5775
*E-Mail: talukder.taj@gmail.com

Abstract

Potato common scab, caused by Streptomyces scabies, is one of the most important diseases of potato worldwide. To identify the effect of inoculums levels of common scab on progeny tubers, field experiments were conducted at Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh using the infected seed tubers of variety 'Diamant'. There were 6 inoculums levels (0, 5, 10, 20, 50 and 100%) of common scab used as infected tubers. The crop was grown during Rabi season (December-March). Data on percent foliage coverage, plant emergence, scabby tubers and tuber yield were collected and analyzed statistically. Results revealed that the effect of different inoculums level of common scab did not influence plant emergence significantly. Percent scabby tuber ranged 14.13-38.83 by weight. Substantially lowest (14.13%) scabby-tuber was recorded in the untreated-control and it was maximum (38.83%) in 100% inoculums level treatment. Regarding yield, although different treatments significantly influenced yield, there was no direct correlation with the percent inoculums level on yield of the potato. This study suggests that the inoculums from infected seed tubers can produce disease on progeny tubers the next season and inoculum on seed tubers, even those without visible lesions, seem to be important in the disease outbreaks.

Keywords: Infection, Pathogen, Plant Emergence, Scabby Tuber, Yield

1. Introduction

Potato (Solanum tuberosum L.) is the world's fourth most important food crop after wheat (Triticum aestivum L.), maize (Zea mays L.) and rice (Oryza sativa L.) (New World, Encyclopedia, 2006), and provides a balanced source of starch, vitamins and minerals to many communities in the global village (Rowe, 1993). Of all primary food crops, potatoes suffer the greatest losses due to disease (Agrios, 1997). Among various diseases, potato common scab caused by the soil-borne bacterium- Streptomyces scabies (synonym S. scabies), Common scab is one of the oldest and is an important tuber disease that occurs throughout the potato growing regions of the world (Lambert & Loria, 1989; Slack, 1992; Faucher et al, 1993 and 1995). Common scab is caused by several soil-dwelling plant pathogenic bacterial species in this genus i.e. S. scabies and S. turgidiscabies. In particular, S. scabies has been well documented as causing scab lesions. S. scabies infects a number of root-grown crops including radish (Raphanus sativus), parsnip (Pastinaca sativa), beet (Beta vulgaris), carrot (Daucus carota), turnip (Brassica rapa L.) as well as potato tubers (acid scab). It causes great threat to the potato seed production in the potato growing areas and its impact appears to be increasing. Although scab does not usually affect total yields, since the economic losses are greatest when
tubers infected for tablestock and processing varieties, since appearance is important for this market (Loria et al., 2006 and Wanner, 2009).

The occurrence of scab and its severity varies from cultivar to cultivar, field to field and year to year (Goyer et al., 1996). There has been no clear explanation for the apparently erratic and uneven distribution of this disease, even within a field or cultivar (Conn et al., 1998). The symptoms of common potato scab are quite variable and are manifested on the surface of the potato tuber. Depending on pathogen strain, cultivar susceptibility, environmental conditions, symptoms of scab can appear as lesions of variable sizes and depth on tuber surfaces (Lorang et al., 1995). The disease forms several types of cork-like lesions including surface, raised, and pitted lesions. Sometimes surface lesions are also referred to as russetting, particularly on round whites, as the general appearance resembles the skin of a russet-type tuber (Figure 1). Pitted lesions vary in their range of depth, although on average they extend 3 to 4 mm deep. The type of lesion formed on a tuber is thought to be determined by a combination of host resistance, aggressiveness of the pathogen strain, time of infection, and environmental conditions (Labruyere 1971; Hooker, 1986 and Babcock et al., 1993).

The pathogen is distributed by infected seed tubers or soil and survives well in the absence of host plants (Loria et al., 1997 and Wang & Lazarovits, 2004). Therefore, once established, it is very difficult to eliminate from a field. Spread is considered to occur in the way of wind-blown soil, running water or diseased seed tubers. Hypal-like growth is limited to small local areas (Agrios, 1997). Infected seed tubers probably provide the greatest potential for dissemination of the pathogens over long distance. There has been little work carried to determine the means by which **Streptomyces** spp. spread to new field and their distribution from field to field.

No single measure provides effective control of scab. However, the disease can be managed using an integrated approach that combines the use of host resistance and cultural control methods (Lapwood & Adams, 1975). Chemical control methods have met with limited success because **S. scabies** can survive for many years in the absence of potatoes due to its ability to live saprophytically and infect other plants (De Klerk & Engelbrecht, 1996). Use of disease free seed tubers is also important in producing healthy potato (Lazarovits et al., 2001). The present study was conducted to find out the effect of inoculum level of scabby tuber on progeny tuber production. In this study, field experiments were conducted to determine if common scab in potato tubers caused by **S. scabies** could be spread by inoculum level. We hypothesized that the scab at less inoculum level would prove less beneficial to **Streptomyces** growth. We examined the growth of **Streptomyces** (infection) in progeny tubers. In addition to that, germination and yield of tubers were evaluated.

1a. Superficial Scab

1b. Deep-Pitted Scab

1c. Russet/Netted Scab

Figure 1. Lesion Types of Common Scab on Diamant Potato Tubers in Bangladesh

2. Materials and Methods

Field experiments were conducted during the 'Rabi' season (December-March; potato growing season) of 2006-2007 in the experimental field of BARI farm, Gazipur in Bangladesh (Figure 2). The experimental site is geographi-
cally situated at 23°N latitude and 91° E longitudes with an elevation of 6 m from sea level at the North-Eastern part of Bangladesh. The soil of the experimental plot [belonging to Chhiata series under agro-ecological zone (AEZ-28)] was silty-clay loam having pH 5.8, organic C content was moderate, 1.13%, total N (% 0.08, available P (Olsen) 9 ppm, exchangeable K (meq100 g⁻¹ soil) 0.20, exchangeable Ca (meq 100 g⁻¹ soil) 4.5, available S 14 ppm, Zn 10 ppm and Fe was 370 ppm. The experimental field was cleared and weeds were manually removed. The soil was ploughed and harrowed with power-tiller, levelled carefully to get a well pulverized soil, and divided into plots.

The experimental filed was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 3.0 × 3.0 m and plant spacing was 60 x 25 cm. Each plot was surrounded by 20 to 25 cm high mud plastered levee to protect entering of irrigation water. The variety used for the experiment was ‘Diamant’. We chose “Diamant” because it is one of the popular potato varieties in Bangladesh. The land was irrigated with water and weeds were manually controlled as and when necessary.

The land was fertilized with BARC (1997) recommended doses of fertilizers (N:P₂O₅:K₂O:S @ 160:100:160:20 kg/ha). One third of the Nitrogen (N) and whole amount of P₂O₅, K₂O and Sulphur (S) were applied at the time of final land preparation (i.e. 1 week prior to sowing) while the remaining N was spitted equally and top-dressed at 28 and 53 days after sowing (DAS). The treatments included 6 inoculums levels of common scab (0, 5, 10, 20, 50 and 100 %) used as infected tubers.

Data on percent foliage coverage, plant emergence, tuber yield and scabby tubers were collected. The severity of scab infestation was visually evaluated on individual tubers on each plot. The numbers of scab infection and tuber yield were recorded after harvesting of the plant. All data collected were analyzed using analysis of variance procedures (ANOVA) followed by Duncan Multiple Range Test (DMRT). The means were separated by the least significant difference (LSD p < 0.05). Correlation analysis was performed on inoculums levels and the analyzed factors (e.g. plant emergence, tuber yield and scabby tubers).

3. Results and Discussions

3.1. Effect of Germination

Figure 3a shows the effect of different inoculums level of common scab germination of potato plants. Results revealed that the effect of different inoculums level did not influence plant emergence significantly, though the germination percentage was markedly higher in 20% inoculums level treatment (96.11%) and it was lowest in 100% inoculums level treatment (83.89%). The correlation figure showed that there was a weak correlation (r = 0.27) between the inoculums level and germination (Figure 3b).

Germination of infected seed tubers did not significantly differed depending on the level of inoculums of seed tubers. A weak correlation between the inoculums level and germination indicating that germination suppression based on inoculum would only not be expected to be Streptomyces- dependent, other factors could also be involved. This discrepancy remains to be solved. We thought that the seed tubers of higher inoculums level to those planted might have been quickly released majority of
pathogenic bacteria (Streptomyces) into the soil column. This study, however, shows that the germination was hampered by Streptomyces when the inoculums levels on seed tubers were higher (>50%). Further analysis of population density of Streptomyces in rhizosphere soil (after transplanting of seed tuber) could prove the fact.

3.2. Effect of Scabby Tuber

The results of percent of scabby tuber are presented in Figure 4a. Results demonstrate that percent of scabby tuber ranged 14.13-38.83% by weight. Significantly lowest (14.13%) scabby tuber was recorded in the control (without inoculums) and it was maximum (38.83%) in 100% inoculums level treatment. Using higher inoculums level of seed tuber significantly influenced the scabby progeny tubers. Thus, there appeared to be a relationship between the inoculums level of seed tuber and disease incidence of progeny tubers. The high percent of scabby tuber from the field shows that the bacteria (from infected seed tubers) multiply in rhizosphere and follow the growth of roots and tubers which causes infection on progeny tubers. Our results support the findings Keinath & Loria (1991) and Lynch & Whipps (1991) who conducted experiments on “plant pathogenic bacteria Streptomyces initiating potato common scab”.

A higher correlation \( r = 0.83 \) was found between the treatments inoculum level of seed tubers and infection on progeny tuber (Figure 4b). A higher correlation between the inoculum levels of seed tuber and the infection on progeny tuber indicating that the population density of Streptomyces from the infected seed tubers can serve as an excellent predictor of scab disease (Figure 4a). Our results corroborated the results of Nortje et al (2000) who reported that the percentage of bags containing scab-infected seed tubers averaged 32%, with a corresponding rejection or decertification of the seed. Therefore, in accordance with these reports, we concluded that the reductions of pathogenic Streptomyces inoculum loads on seed tubers may prove to be an effective and economical strategy of potato common scab disease management for some growers.

3.3. Effect of Yield

Regarding yield, different treatments significantly influenced the yield of tuber (Figure 5a). The total tuber yield was found to be higher (22.07 ton/ha) in the 100% inoculums level treatment, where the infection level on progeny tubers was higher (38.82%). Virtually, there was no direct correlation between the percent inoculums level of scab tubers and the tuber yield (Figure 5b).

The disease causes a reduction in yield and a decrease in
root quality, which can be more severe during dry weather and poor in soils (Loria et al. 1997). Similar results were made by Narayanasamy et al (1972) who observed that cotton plants infected by stenosis disease showed growth abnormalities. Our results are in agreement with their studies. Therefore, it appears that the yield loss is related with the cause of reduced individual tuber weight and tuber number per plant, which might be the severity of the disease.

4. Conclusion

The results of the study strongly suggest that the inoculum from infected seed tubers can produce disease on progeny tubers the next season. Inoculum on seed tubers, even those without visible lesions, seems to be important in disease outbreaks. The limited infected seed tubers can give low inoculum densities and make favourable condition, so, it is necessary to avoid use of scabby-tubers as seed potato in order to produce healthy seed tuber production. Using resistant varieties could also be an effective tool for management of scab. In this study, we do not know how scab disease (from infected seed tubers) spread the progeny management of scab. In this study, we do not know how scab disease resistant varieties could also be an effective tool for managing. Studies in progress are designed to determine the mechanism(s)/or mode(s) of action of Streptomyces in the field and effect on progeny tubers.

Acknowledgements

The authors express their sincere thanks to Assoc Prof. Brenda Bushell, The University of Sacred Heart, Hiro, Tokyo, Japan for critically reading the manuscript. This research was partly supported by the project “Strengthening of Tuber Crops Research Program”, Ministry of Agriculture (MoA), Bangladesh.

References


Available online at www.scientific-journals.co.uk


