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ESTIMATION OF YIELD LOSSES IN CORN DUE TO STALK ROT PATHOGENS

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Abstract

Pathogenicity of *Fusarium moniliforme, F. graminearum* and *Macrophomina phaseolina* isolated from stalk rot disease of corn were tested on a susceptible corn cv. Shaheen in different seasons and at different stages of plant growth at the National Agricultural Research Centre (NARC), Islamabad, Pakistan. *F. moniliforme* and *M. phaseolina* in combination produced 77.9 and 89.0% infection with respectively 21.7 and 25.9% reduction in grain yield during spring and summer seasons of 1988, whereas *F. graminearum* produced 32.8 and 49.4% disease severity with 0.9 and 1.4% reduction in grain yield during the same spring and summer seasons.

Introduction

Stalk rot of corn (*Zea mays* L.) is the most destructive disease all over the world causing serious losses in yield (Christensen & Wilcoxson, 1966; De Leon & Pandey, 1989; Shurtleff, 1980). The disease caused by many soil-borne and residue-borne fungi (Byrnes & Carroll, 1986; Dodd, 1980; Gilbertson *et al.*, 1985; Kommedahl *et al.*, 1987) is highly influenced by low moisture (Christensen & Wilcoxson, 1966; Dodd,1980; Schneider & Pendery, 1983). Apart from drought stress, mechanical injury, high plant density, foliar diseases and insect infestation also predispose the corn stalk rot disease (Dodd,1980; Pappelis & Bemiller, 1984). In Pakistan, stalk rot which is prevalent in Islamabad Capital Territory (ICT), in the Punjab and northern areas is mainly caused by *Fusarium* spp., followed by *Macrophomina phaseolina* (Tassi) Goid. The present report describes the reduction in yield in a susceptible corn cultivar after infestation of stalk rot pathogens viz., *Fusarium moniliforme* Sheld., *Fusarium graminearum* Schwabe and *M. phaseolina* (Tassi) Goid used alone as well as in combinations during spring and summer.

Materials and Methods

Corn cv. Shaheen (source from North Dakota, USA crossed with Canadian material) was hill-planted in 7.5 m^2 plots during spring (February-June, 1988) and summer (July-October, 1988) at the NARC, Islamabad. Hills were spaced 0.25 m apart with 0.75 m spaced rows. The trial was a split plot arrangement in randomized complete

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Table 1. Effect of inoculation of different pathogens on the development of corn stalk rot disease and loss in yield during spring and summer seasons.

Treatments	Spring season: Infection[x] (%) At tasseling	Spring season: Infection[x] (%) 2 wks[y] after tasseling	Spring season: Infection[x] (%) Mean	Spring season: Yield Grain yield[z] (Kg ha^{-1})	Spring season: Yield Yield loss (%)	Summer season: Infection (%) At tasseling	Summer season: Infection (%) 2 wks after tasseling	Summer season: Infection (%) Mean	Summer season: Yield Grain yield (Kg ha^{-1})	Summer season: Yield Yield loss (%)
Fusarium moniliforme	58.3	51.3	54.8 de	3648.4 a	6.2	76.4	79.0	77.7 bc	2587.1 d	32.3
Fusarium graminearum	30.1	35.6	32.8 f	3855.9 a	0.9	39.9	59.0	49.4 e	3768.0 a	1.4
Macrophomina phaseolina	70.8	81.0	75.9 bc	3462.5 abc	11.0	82.4	87.0	84.7 ab	2857.1 d	25.2
F. moniliforme + *F. graminearum*	62.3	54.6	58.4 d	3689.2	5.1	81.4	77.9	79.6 bc	2976.1 cd	22.1
F. moniliforme + *M. phaseolina*	74.9	81.0	77.9 bc	3044.5 bcd	21.7	90.2	87.8	89.0 a	2830.7 d	25.9
F. graminearum + *M. phaseolina*	67.7	76.3	72.0 c	3542.1 ab	8.9	83.8	84.5	84.1 ab	3052.7 bcd	20.1
F. moniliforme + *F. graminearum* + *M. phaseolina*	75.4	78.3	76.8 bc	3663.1 a	5.8	89.3	91.1	90.2 a	2996.1 cd	21.6
Control	17.7	17.3	17.5 g	3889.6 a	0.0	13.0	13.0	13.0 g	3820.0 a	0.0

Means with the same letter are not significantly different (P = 0.01) according to Duncan's multiple range test.

*Infection = Stalk rot infection was scored on 0-5 scale (Hooker, 1957).

$$^{x}\text{Grain yield (kg ha}^{-1}) = \frac{\text{Field weight (100 - moisture \%) 0.8 x 10.000}}{\text{Area harvested x 85}}$$

block design with four replications. Seasons, times of inoculation and pathogens were main plots, sub-plots and sub-sub-plots, respectively.

Corn plants were inoculated at tasseling stage (7 weeks after planting) and two weeks after tasseling (9 weeks after planting) with *F. moniliforme, F. graminearum* and *M. phaseolina* alone as well as in combinations using toothpick method of inoculation (Young, 1943). Round toothpicks, 6 cm long, were washed 5 times in boiling water, air dried and soaked in potato dextrose broth (potato 200 g; dextrose 20 g; water 1000 ml) contained in 300 ml glass jars and sterilized at 120 °C for 20 min. These were acidified with 25% lactic acid @ 5 drops per 100 ml (Tuite, 1969) to inhibit bacterial growth and then inoculated with test fungi @ 30,000 cfu ml^{-1} and stored at 25 °C for 3 weeks before use. Infected tooth picks carrying inoculum were inserted into holes drilled in the first elongated basal internode. Either one, two or three tooth picks were inserted per internode according to treatment.

The severity of disease was determined by measuring the lesions around the inserted tooth picks at harvesting (8 weeks after inoculation) by splitting the stalks lengthwise and recording the extent of the spread of rot on a 0-5 scale (Hooker,1957). Grain yield was also recorded 8 weeks after inoculation in the month of June and October 1988, for spring and summer plantings, respectively. Yield was based on weight of shelled grains at 15% moisture. Disease data on 0-5 scale were then transformed to percentages for statistical analysis as follows:

$$\text{Disease index} = \frac{\Sigma \text{ Disease rating in plants examined}}{\text{Total no. of plants examined}}$$

$$\text{Disease severity \%} = \frac{\text{Disease Index}}{5} \times 100$$

Data were analysed by analysis of variance (ANOVA), Duncan's multiple range test (DMRT), and correlation was calculated to examine the relationship between disease severity and grain yield losses.

Results and Discussion

Of the pathogens used, *F. moniliform* in combination with *M. phaseolina* increased the disease severity by 77.9 and 89% during spring and summer seasons, respectively. *M. phaseolina* used alone showed an average disease severity of 75.9 and 84.7% followed by *F. moniliforme* with 54.8 and 77.7% and *F. graminearum* with an average disease severity of 32.8 and 49.4% during spring and summer seasons, respectively (Table 1). *F. moniliforme* showed greater reduction in grain yield (32.3%) when used alone during summer and by 21.7 and 25.9% when used in combination with *M. phaseolina* during spring and summer seasons, respectively. Mean loss in grain yield due to infection by *M. phaseolina* was 11.0 and 25.2% whereas *F. graminearum* caused only 0.9 and 1.4% reduction in grain yield during spring and summer seasons, respectively (Table 1).

Table 2. Average climatic conditions of NARC experimental plot during spring and summer 1988.

	Seasons	
	Spring	Summer
Air temperature (°C)	29.6	31.4
Relative humidity (%)	56.6	79.8
Wind speed (km day^{-1})	101	80
Sun shine (hrs.)	5.8	8.3
Solar radiation (Ly^x day^{-1})	374.4	15.5
Rainfall (mm)	58.0	293

^{x}Ly = Langley = 1 cal cm^{-2} min^{-1}

There are reports where *F. graminearum* [*Gibberella zeae*] isolates were more virulent than *F. moniliforme* [*Gibberella fujikuroi*] in Colorado (Gilbertson *et al.*, 1985). In the present studies *F. moniliforme* [*G. fujikuroi*] was found to be more virulent than *F. graminearum* [*G. zeae*]. This may presumably be due to differences in strain and environmental conditions in Islamabad, Pakistan, where air temperature (31.4°C), relative humidity (79.8%), sun shine (8.3 hrs.) and rainfall (293 mm) during summer 1988 was found more in comparison with spring season at NARC (Table 2). Highly significant seasonal effect on disease was found in our studies which confirmed the findings of Dodd (1980), while Chambers (1987) reported that there was no significant seasonal effect on disease.

Our results also showed positive correlation between disease severity and grain yield losses in both crop seasons at different growth stages i.e., during spring at tasseling ($r = 0.42$, $P < 0.01$); 2 weeks after tasseling ($r = 0.45$, $P < 0.01$) and during summer at tasseling ($r = 0.38$, $P < 0.05$) and 2 weeks after tasseling ($r = 0.53$, $P < 0.01$) (Fig.1). Lipps (1991) reported positive correlation between stalk rot and yield in 1987 ($r = 0.73$, $P < 0.01$) but the correlation coefficient in 1988 was low and negative ($r = -0.21$, $P = 0.06$), which indicated considerable variation in the relationship while Chambers (1987), Michaelson (1957) and Wilcoxson (1962) reported a negative correlation between stalk rot and grain yield loss.

It is interesting to note that the incidence of *Fusarium* spp., in stalks increased over time as the season progressed. Our results confirm the reports of Kommedahl *et al.*, (1979), Lipps & Deep (1991) and Windels & Kommedahl (1984) which showed that the major stalk rot pathogens colonized corn tissues near the end of the growing season. Fu & Zhang (1988) observed that virulence was greater where *F. graminearum* [G. zeae] and *F. moniliforme* [G. fujikuroi] were inoculated together but in our studies seasonal variation in the performance of these two pathogens did not affect either disease severity or reduction in grain yield during spring while they became more destructive during summer in causing the disease as well as in reducing the grain yield due to the availability of suitable hot and humid environmental conditions.

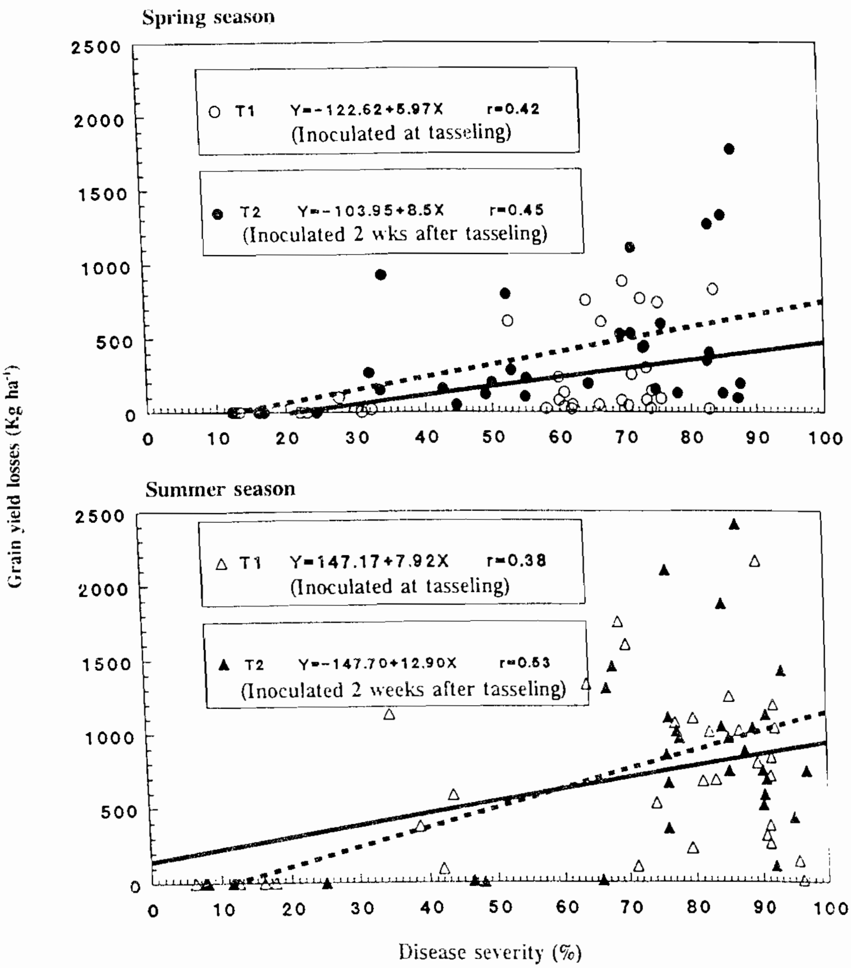

Fig.1. Relationship between corn stalk rot disease severity and grain yield losses during spring and summer seasons, 1988.

Since a relatively higher disease incidence and also higher grain yield losses were observed in various treatments during summer than in spring 1988, it could be concluded that tested pathogens became more destructive during summer, especially when the plants were inoculated at later growth stages (2 weeks after tasseling). There is need to carry out experiments at different locations to get a better insight into host-parasite-environment interactions in the development of corn stalk rot disease.

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