Balkh International Journal of Natural Science

ISSN – P 0000 -0000 E: 0000- 0000
Vol. 1 NO.1 2025
URL: https://bjns.ba.edu.af/index.php/bjns

Effect of Irrigation Schedule on the development of charcoal rot of maize under artificial inoculation conditions

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Received: 26/6/2025 Accepted: 31/10/2025 Published: 20/12/2025

Abstract

This experiment was conducted in Field Experimental Area, Maize Section, Department of Plant Breeding and Genetics, Punjab Agriculture University (PAU), Ludhiana during spring seasons 2018 and 2019 to investigate the Effect of irrigation schedules on the development of charcoal rot of maize under artificial inoculation conditions. In this experiment, PMH 10 hybrid was sown in three replications. Three Irrigation schedules were used. Level I=Excess irrigation (additional irrigation at tasseling and silking stage), Level II = Local practice, Level III = Stress at tasseling and silking stage, with randomized block design. Results showed that minimum mean disease severity (36.28%) and maximum mean grain yield (72.61q/ha) was recorded in irrigation schedule level I (additional irrigation at tasseling and silking stage) followed by irrigation schedule level II (Local practices). Maximum mean disease

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severity (50.81 %) and minimum mean grain yield (60.25 q/ha) was recorded in irrigation schedule level III (Stress at tasseling and silking stage). Hence, water stress at tasseling stage aggravated the disease severity, resulting in reduction in grain yield.

Keywords: charcoal rot, disease severity, irrigation, maize.

1.Introduction

Maize (Zea mays L.) is an important cereal crop and an ideal forage crop. It is grown under a wide range of climatic conditions, throughout the world. Maize ranked fifth in area and fourth in production among the major cereals in India. It has production of 27.15 million metric tons and occupied an area of about 9.60 million hectares with average productivity of 2.83 metric tons per hectare during 2017-18 (Anonymous, 2018a).

Maize is vulnerable to about 112 diseases, it is estimated that the annual losses due to maize diseases are to be 14 per cent in West Africa, 4 per cent in Northern Europe, 12 per cent in Asia and 9.4 per cent worldwide (Oerke, 2005 and Mahuku, 2010). In India, 29 diseases are reported on maize caused by fungi, bacteria and viruses. Leaf blight, downy mildews, stalk rots and rusts are the serious diseases. Among these, post flowering stalk rots (PFSR) caused by different pathogens is a serious biotic constraint. This disease (PFSR) is a complex disease caused by Fusarium verticillioides, Macrophomina phaseolina and Cephalosporium maydis (Khokhar et al., 2014 and Kaur et al., 2012). Out of these, in the drier region of India, Macrophomina phaseolina causing charcoal rot is a major constraint, and it is estimated, that can reduce yield up to the tune of 63.5 per cent (Desai and Hegde 1991).

Recently Costa et al., (2019) conducted a study to assess yield losses due to post flowering stalk rot and identification of the main fungal pathogen responsible for the disease in maize hybrids, during the off season in Brazil. They have found that the most common pathogens were: Macrophomina phaseolina, Fusarium graminearum and Stenocarpella maydis. According to them there were average losses of 30.6 per cent in 2015 and 34.4 per cent in 2016 so, all yield parameters were significantly lower in post flowering stalk rot-infected plants and observed the highest yield losses in hybrids with the highest grain/ear weight ratio.

Macrophomina phaseolina is a very important soil borne fungus and can survive for 18 months as sclerotia in maize stalk residues (Sen and Bandopadhyaya 1988). Low soil moisture and high temperature are the favorable conditions for colonization of this fungus on host tissue (Dhingra and Sinclair 1974). It is reported that the growth and survival of the pathogen increase with Low soil moisture (Short et al., 1980 and Mulrooney 1988). Severity of charcoal rot is more when soil moisture is limiting, and when air and soil temperatures are high (Gary et al., 1991 and Pearson et al., 1984).

The scarcity of water particularly after flowering stage of the crop, Leads more damage. Grain yield is reduce directly by affecting various physiological pathways of plant resulting in pre-mature lodging (Ledencan *et al.,* 2003). Drought and high plant density coupled with insect or hail damage and heavy nitrogen fertilizer doses leads to post flowering stress thus promoting the disease development.

This experiment was conducted to evaluate the effect of water stress on the development of the disease during spring season. To find how water management can control the disease development.

2.Materials and methods

2.1.Raising of the crop**:** This experiment was conducted in Field Experimental Area, Maize Section, Department of Plant Breeding and Genetics, PAU, Ludhiana during spring seasons 2018 and 2019. In this experiment, PMH 10 hybrid was used and planting was done with plant to plant and row to row spacing of 20 cm and 60 cm respectively in three replications, the plot size was 4 m^2 (four rows of 2 meter each in one plot). Three Irrigation schedules were used.

- Level I = Excess irrigation (additional irrigation at tasseling and silking stage)
- Level II = Local practice (12-15 irrigations)
- Level III = Stress at tasseling and silking stage

With randomized block design during spring seasons 2018 and 2019. The sowing was done as per standard package of practices (Anonymous 2018b).

2.2.Mass culturing and inoculations: Freshly growing culture of *Macrophomina phaseolina* was mass multiplied on toothpicks (Hooda *et al*., 2018). Inoculations were done at flowering stage of maize crop. By using toothpick inoculation technique, all the plants were inoculated (Jardine and Leslie 1992).

2.3.Data recording and analysis: Disease symptoms start appearing after about 2-3 days after inoculation in the inoculated plants. The plants were split open longitudinally to see the extent of the pith damage in form of blackish discoloration. By using 1-9 rating scale given by Payak and Sharma (1983), the disease severity and intensity were recorded. Grain yield from each plot harvested was recorded. Average data were estimated on the basis of three replications. Data was subjected to two way analysis of variance (ANOVA).

3.Results

3.1.Pathogenicity test: The culture of *M. phaseolina,* isolated and purified from infected stalk of maize plant was tested for pathogenicity on maize hybrid PMH 2 under field condition during *Kharif* season 2017. The result revealed that after 3 to 4 days of inoculation, brownish lesion was observed around the inserted toothpicks. Data was recorded at the time of harvesting by splitting open the stalks longitudinally. Data revealed all inoculated plants were infected with charcoal rot disease and disease reaction was recorded.

3.2.Disease severity: Per cent disease severity of charcoal rot of maize hybrid at different irrigation schedules under artificial inoculation conditions during spring 2018 and 2019 seasons is depicted in Table 1. Statistically significant difference was observed between mean value of different levels of irrigation and different years and no significant interaction was observed between level of irrigation and years, depicting that effect of different levels of irrigation is independent of years. Disease severity was comparatively more in all the treatments during spring 2018 than spring 2019. Among the treatments, minimum mean disease severity of charcoal rot (36.28 %) was recorded in irrigation schedule level I followed by irrigation schedule level II (43.65 %). Maximum mean disease severity (50.81 %) was recorded on PMH 10 hybrid in irrigation schedule level III. Water stress at tasselling and silking stages of the crop aggravated the disease development.

Table 1 Per cent disease severity of charcoal rot of maize hybrid at different irrigation schedules under artificial inoculation conditions during spring seasons 2018 and 2019

Irrigation schedules	Per cent disease severity*		Mean
	2018	2019	
Level I	39.83	32.72	36.28 [c]
Level II	46.56	40.74	43.65 [b]
Level III	53.42	48.20	50.81 [a]
Mean	46.60 [a]	40.55 [b]	
			LSD
Irrigation level			3.01

Year						2.46
Irrigation level x Year						NS

Mean of three replications

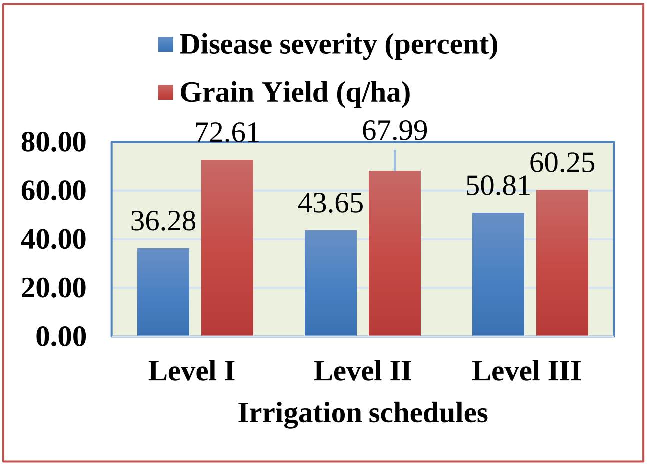
Grain yield: Grain yield of maize hybrid PMH 10 at different irrigation schedules under artificial inoculation of *M. phaseolina* during spring seasons 2018 and 2019 is depicted in Table 2. Statistically significant difference was observed between mean value of different levels of irrigation and different years, and no significant interaction was between levels of irrigation and years, depicting that effect of different levels of irrigation is independent of years. Mean grain yield were significant different during spring 2018 and 2019 seasons. Grain yield were comparatively less in spring 2018 than spring 2019. Maximum mean grain yield (72.61 q/ha) were recorded in irrigation schedule level I followed by irrigation schedule level II (67.99 q/ha). Minimum mean grain yield (60.25 q/ha) were obtained in irrigation schedule level III. Hence water stress at tasseling stage aggravated the disease severity, resulting in reduction in grain yield (Fig 1).

Table 2 Grain yield of maize hybrid PMH 10 at different irrigation schedules under artificial inoculation of *Macrophomina phaseolina* during spring 2018 and 2019

Irrigation schedule	**Grain yield (q/ha)***		**Mean**
	2018	**2019**	
Level I	70.96	74.27	72.61 [a]
Level II	65.01	70.98	67.99 [b]
Level III	57.66	62.84	60.25 [c]
Mean	64.54 [b]	69.36 [a]	
			LSD
Irrigation level			3.06
Year			2.50
Irrigation level x Year			NS

Mean of three replications

Figure 1 Effect of different irrigation schedules on mean disease severity of charcoal rot and grain yield of maize hybrid under artificial inoculation condition during both the spring seasons 2018 and 2019



4.Discussion

Diourte et al., (1995) studied the effect of water stress on the development of charcoal rot in sorghum. They found that the plant which were subjected to water stress showed greater development of charcoal rot symptoms than those not subjected to water stress. Kendig *et al.*, (2000) studied microsclerotia density of the pathogen *M. phaseolina* on soybean at four irrigation schedules (full season irrigation, irrigation after flowering, irrigation until flowering, and not at all) and concluded that the microsclerotia densities reached maximum (2.35 microsclerotia / gm dry root) in non-irrigated fields and minimum (1.35 microsclerotia / gm dry root) in full-season irrigated field. These result indicated that water management can limit the colonization of soybean by M. phaseolina. However in above mentioned two researches regarding charcoal rot disease, the hosts are different but the results are in accordance to our findings in case of maize. Nischwitz *et al.*, (2004) studied the incidence of charcoal rot of melon under three types of irrigation *viz.* subsurface drip with plastic mulch, furrow irrigations and subsurface drip without plastic mulch. They found that in the furrow-irrigated field the inoculum density were significantly lower at all three depths compared to other types of irrigation. They suggest according to differences in inoculum densities of M. phaseolina that drip irrigation contribute to higher disease incidence.

Arora and Pareek (2013) studied the severity of charcoal rot of sorghum at different soil moisture levels, under artificial inoculation conditions and reported that the average disease rating decreased with increasing soil moisture level from 40 to 100 per cent. Thus, soil moisture is one of important factor for development of the disease. Recently, Khokhar *et al.*,

(2014) studied the effect of water stress on the incidence of post flowering stalk rot on maize. Their investigations revealed that application of two additional irrigations at tasselling and silking stages reduced the disease severity from 60.37 to 15.03 per cent. They further found that with additional irrigation at tasseling and silking reduced inoculum density of *Fusarium verticillioides* from 15.9 to 7.1 and disease rating from 7.3 to 3.2 and increased grain yield from 0.93 to 1.45 kg/10 plants. Thus, it indicated the necessity of water stress at these stages for development of post flowering stalk rot of maize. These findings are in accordance with our results that disease severity of maize decreased with excess irrigation at time of tasseling.

5.Conclusions

The present investigation entitled "Effect of Irrigation Schedule on the development of charcoal rot of maize under artificial inoculation conditions" as part of etiology of the disease, was carried out in the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana during 2017 to 2019.

Results on effect of three irrigation schedules on the development of charcoal rot of maize on PMH 10 hybrid during spring seasons 2018 and 2019 showed that minimum disease severity and maximum mean grain yield was recorded in irrigation schedule level I (additional irrigation at tasseling and silking stage) followed by irrigation schedule level II (Local practices). Maximum mean disease severity and minimum mean grain yield was recorded in irrigation schedule level III (Stress at tasseling and silking stage). Hence, water stress at tasseling stage aggravated the disease severity, resulting in reduction in grain yield. For controlling or minimizing this disease in arid or semi-arid region, properly and in timely irrigation especially at tasseling and silking stage of the crop is suggested.

Macrophomina phasiolina the causal agent of charcoal rot of maize is an important soil born fungus and due to its large host range and wide geographical distribution, *M. phaseolina* causes significant economic losses worldwide. On the other hand, chemical control is difficult and environmentally not save. Hence considering and conducting more researches on etiology of this disease on different hosts under different agro climatic conditions in the future is suggested.

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