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Spectrum of root rot *(Rhizoctonia solani)* incidence in ajwain (*Trachyspermum ammi*) in southern parts of Rajasthan

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ABSTRACT

The present investigation was done with the objective of proper understanding of occurrence and distribution of root rot and subsequent loss assessment in ajwain (*Trachyspermum ammi* L.). To have a comprehensive view of the disease severity, diseased fields were surveyed in 40 villages of different districts, viz. Udaipur, Rajsamand, Chittorgarh and Pratapgarh of southern Rajasthan in the year of 2015–16 and 2016–17. The study revealed that the per cent plant mortality ranged in between 12.80–32.50 and 15.00–35.50% at 45 days after sowing (DAS) in both the years, respectively. The maximum and minimum per cent plant mortality was recorded in Bhatewar (Udaipur) and Phoonkiya (Rajsamand) in both the years, respectively. The overall per cent plant mortality was observed more in the year 2016–17 as compared to 2015–16. Losses caused by the root rot disease were studied by incorporating various levels of inoculum densities of *Rhizoctonia solani* @ 50, 100 and 150 g/plot individually as well as in different combinations in soil before sowing of local susceptible cultivar. The results were compared with uninoculated protected plots and demonstrated that among the treatment, the maximum yield losses (70.90%) were recorded with inoculum @ 150 g/plot followed by inoculum @100 g/plot (47.27%) inoculated plot. The minimum yield losses of 40.85% were observed in plots inoculated @ 50 g/plot with *R. solani*. The disease was found to cause severe losses on a wide area under ajwain cultivation in southern Rajasthan.

Key words: Ajwain, Inoculum density, Plant mortality, *R. solani*, Root rot, Yield loss

Ajwain (*Trachyspermum ammi* L.) also known as bishop's weed and carom seed, is one of the most important seed spice crop, of the family Apiaceae and is a native of Egypt. It is widely grown in arid and semi-arid regions where soils contain high levels of salts. In India, it is widely distributed and its production is concentrated mainly in Rajasthan followed by Gujarat, Madhya Pradesh, Bihar, Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh and West Bengal. Since ancient time the states of Rajasthan and Gujarat have emerged as Seed spices bowl. In Rajasthan, it is cultivated in the districts of Chittorgarh, Udaipur, Jhalawar, Baran, Rajsamand, Bhilwara and Kota covering an area of 11658 ha with the production and productivity of 4672 tonnes per annum and 401 kg/ha, respectively (Anonymous 2015, 16). The roots are diuretic in nature and the seeds possess excellent aphrodisiac properties. The volatile components of essential oils mainly constitute of monoterpenes, sesquiterpenes and their oxygenated derivatives such as alcohols, aldehydes, ketones, acids and esters (Suntar *et al.* 2014).

In general, terpenes having a diverse variety of structures with specific functions constituted the largest amount (71.10%) of essential oil (Zule *et al.* 2003). Essential oil possesses various biological activities such as antioxidant, antibacterial, antimutagenic, and antimicrobial. The essential oils rich in antioxidants are generally recognized as safe natural substances and inhibit lipid oxidation in food thus providing natural food additives to food products (Dadalioglu and Evrendilek 2004).

Healthy seeds have economic value in the market but a large number of biotic stresses are affecting the ajwain crop in the field, subsequently causing huge damage after post harvest. Root rot is a most common and destructive disease of ajwain and leads to losses in yield (10-100%) as well as quality of the crop (Dhanbir 2000, Meena *et al.* 2009, Lal *et al.* 2012). Keeping in mind the importance of this crop and severity of this disease in the region, the present investigation was designed to develop a suitable and sustainable integrated management module to combat this disease and reduce losses caused to ajwain by root rot.

MATERIALS AND METHODS

Occurrence and distribution of root rot in ajwain: Extensive and intensive surveys were conducted from September 2015 to December 2015 and September 2016 to December 2016 to know the occurrence and distribution of root rot of ajwain on farmer's fields in ajwain growing areas of southern districts of Rajasthan including Udaipur,

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Rajsamand, Chittorgarh and Pratapgarh. In the surveyed fields, both prevalence and severity of disease in the form of per cent plant mortality was recorded. Observations on per cent plant mortality were taken at 45 days after sowing of ajwain crop and counting 10 infected plants in randomly selected 25 sqm area at 4 random spots (100 sqm) in each field. From each district, 10 villages were selected and in each village 4 fields were selected and 10 infected plants were examined randomly. In the surveyed fields, per cent plant mortality was calculated and diseased samples were collected from different locations for isolation and identification of the pathogens.

Assessment of yield losses: The losses caused by a disease vary with host pathogen interaction and disease severity. Field trials were conducted in two consecutive years during *rabi* 2015 and 2016 to assess germination percentage, root rot incidence, grain yield and reduction in yield under different disease severity (generated by different inoculums densities) and calculated the benefit cost ratio (B:C ratio). This region has a semi-arid climate. The soil of experimental fields was sandy-loam in texture, slightly alkaline (pH 7. 9), having low organic carbon (0.42) and electrical conductivity (0.85 d S/m). Un-inoculated plots were maintained as control. The yield of inoculated plots was compared with the yield of un-inoculated plots. The seeds were sown in 3×3 m plots, keeping 10 rows, with 30 seeds in each row, at 10 cm distance. Applied recommended dosage of fertilizers (N-40, P_2O_5-50 and K_2O-50 Kg/ha) before sowing and weed management through mechanical operation was followed, but no weedicide was used in this trial. For inoculation, the culture of *R. solani* was multiplied on autoclaved corn meal sand (2:1) medium for 10 days and culture was incorporated in the field soil and allowed for establishment of the pathogens before sowing. The experiment was conducted using a susceptible cv. Ajmer ajwain-93 and 3 inoculums densities were applied viz. @ 50 g/plot, 100 g/plot and 150 g/plot. For each treatment 3 replications and a control were maintained. All the plots were lightly irrigated immediately after inoculation for proper establishment of the pathogen before sowing. The sowing was done in the late evening followed by heavy irrigation to provide adequate moisture for infection. Observation for seed germination was recorded at 15 days after sowing. The observations for plant mortality were recorded 45 days after sowing by using the given formula.

$$\text{Mortality \%} = \frac{\text{Total number of infected plants}}{\text{Total number of plants assessed}} \times 100$$

The per cent losses in fasciculate grain yield were determined as:

$$\text{\% loss in yield} = \frac{\text{Yield in control (protected uninoculated plots)} - \text{Yield in inoculated unprotected plots}}{\text{Yield in control plots}}$$

RESULTS AND DISCUSSION

The present study was undertaken to study the occurrence, distribution and loss incurred due to root rot of ajwain caused by *R. solani* in southern districts of Rajasthan. Forty fields were intensively surveyed in 4 districts, viz. Udaipur, Rajsamand, Chittorgarh and Pratapgarh. It was revealed that plant mortality appeared in most of the surveyed fields from 12.80-32.50 and 15.00-35.50% mortality at 45 DAS and 23.60-49.50 and 24.80-48.50% mortality at 75 DAS in the year of 2015–16 and 2016–17, which indicated its wide distribution and occurrence in large areas. The per cent plant mortality data indicated that the disease was initiated on 45 DAS. The similar results were also reported by Ghosh *et al.* (2013) in dry root rot of chickpea. Furthermore, Lodha *et al.* (1986) reported 31% disease severity in cluster bean, 64.50% in cowpea and 43.89% in sesame.

Ten villages were surveyed in Udaipur district during *rabi* 2015–16 and 2016–17. At 45 DAS, the maximum plant mortality was recorded in Khokharwas (35.50%) and Bhatewar with local cultivar (32.50%), whereas minimum in Menar with Pratap ajwain (16%) in both years. Similarly, at 75 DAS, the maximum plant mortality (49.50%) was recorded in Khokharwas with local cultivar whereas, minimum in Amarpura with Pratap ajwain (21%) in both years (Table 1 and 2). The overall plant mortality mean of Udaipur district was recorded as 29.81 and 31.99% with local cultivar in both years (Fig 1). The similar results were

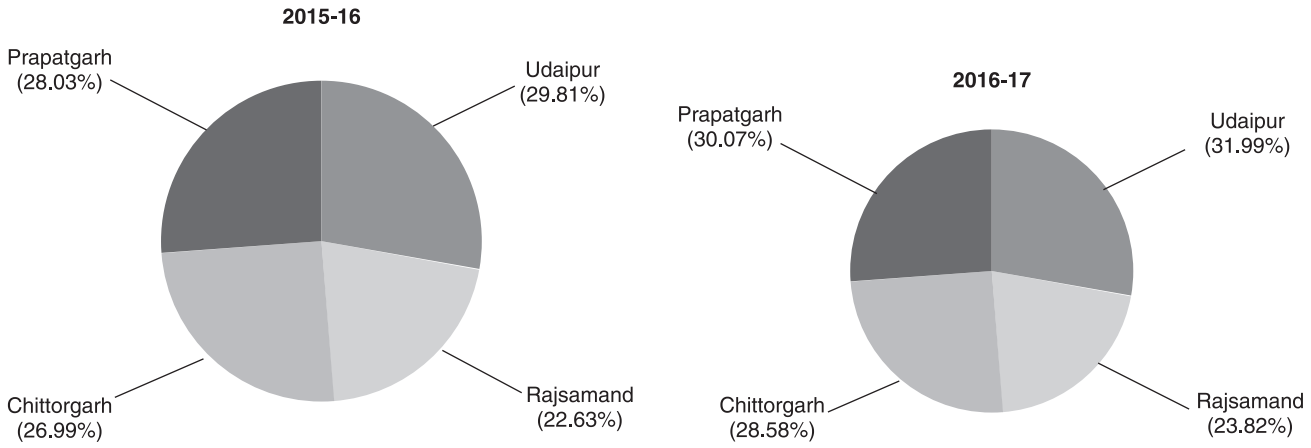

Fig 1 Distribution and prevalence of ajwain root rot in different districts of southern Rajasthan during *rabi* 2015-16 and 2016-17.

Table 1 Distribution and prevalence of ajwain root rot mortality in different villages of southern Rajasthan districts during *rabi* 2015–16

Village name	Host variety	Area (ha)	Plant mortality* (%)		Mean
			45th DAS	75th DAS	
			Udaipur		
Bhatewar	Local	2.3	32.50 (34.75)	42.50 (40.68)	37.50 (37.76)
Kheroda	Local	1.5	25.02 (30.01)	40.50 (39.52)	32.76 (34.91)
Nawaniya	Pratap Ajwain	1.9	21.00 (27.27)	38.01 (38.06)	29.50 (32.90)
Khokharwas	Local	0.5	31.00 (33.83)	49.50 (44.71)	40.25 (39.38)
Kundai	Local	2.6	27.70 (31.75)	41.00 (39.81)	34.35 (35.88)
Daulatpura	Local	1.8	20.30 (26.78)	34.00 (35.67)	27.15 (31.40)
Menar	Pratap Ajwain	2.5	16.00 (23.58)	27.50 (31.63)	21.75(27.80)
Amarpura	Pratap Ajwain	0.6	19.20 (25.98)	31.00 (33.83)	25.10 (30.06)
Rundera	Local	0.9	17.00 (24.35)	27.00 (31.30)	22.00 (27.97)
Kheta Khera	Local	1.7	23.00 (28.65)	32.60 (34.82)	27.80 (31.82)
			Rajsamand		
Gilund	Local	0.8	20.00 (26.56)	28.00 (31.94)	24.00 (29.33)
Kotrii	AA-93	1.9	15.00 (22.78)	24.50 (29.66)	19.75 (26.38)
Kundiya	AA-93	0.5	14.50 (22.37)	24.20 (29.47)	19.35 (26.10)
Kabra	AA-93	0.7	16.70 (24.12)	23.60 (29.06)	20.15 (26.67)
Damodarpura	AA-93	0.8	20.00 (26.56)	27.80 (31.82)	23.90 (29.26)
Jawasya	Local	1.0	24.00 (29.33)	25.00 (30.00)	24.50 (29.67)
Phoonkiya	AA-93	2.5	12.80 (20.96)	30.20 (33.33)	21.50 (27.62)
Pachhmata	Local	2.6	21.00 (27.27)	27.00 (31.30)	24.00 (29.33)
Laxmipura	AA-93	2.9	18.50 (25.47)	29.30 (32.77)	23.90 (29.27)
Khar-Bamaniya	Local	2.0	20.50 (26.92)	30.00 (33.21)	25.25 (30.16)
			Chittorgarh		
Anoppura	AA-1	0.5	22.50 (28.31)	27.20 (31.43)	24.85 (29.90)
Babariya Khera	Local	0.2	26.00 (30.66)	35.50 (36.57)	30.75 (33.68)
Danta	Local	0.4	25.60 (30.39)	33.00 (35.06)	29.30 (32.77)
Jaisinghpura	Local	0.9	20.20 (26.71)	31.30 (34.02)	25.75 (30.49)
Kalyanpura	Local	1.0	15.50 (23.18)	28.00 (31.94)	21.75 (27.79)
Kanwarpura	AA-1	2.1	17.00 (24.34)	29.00 (32.58)	23.00 (28.66)
Lalawas	Local	0.6	13.80 (21.80)	25.50 (30.33)	19.65 (26.31)
Pandoli	Local	0.8	21.70 (27.76)	30.30 (33.40)	26.00 (30.66)
Rajpura	Local	2.0	18.30 (25.33)	29.00 (32.58)	23.65 (29.10)
Raghunathpura	Local	1.9	17.50 (24.73)	27.00 (31.30)	22.25 (28.14)
			Pratapgarh		
Tanda	Local	3.0	20.00 (26.56)	31.20 (33.96)	25.60 (30.40)
Nagdi	Local	2.7	26.50 (30.98)	39.00 (38.64)	32.75 (34.91)
Kanad	Local	2.6	21.00 (27.27)	36.50 (37.17)	28.75 (32.42)
Fatehgarh	AA-93	0.8	18.60 (25.55)	35.30 (36.45)	26.95 (31.27)
Lal Garh	Local	1.5	24.80 (29.86)	40.20 (39.35)	32.50 (34.75)
Sankheli	Local	2.3	28.00 (31.95)	42.50 (40.68)	32.25 (36.42)
Dhanot	Local	2.5	15.00 (22.78)	32.00 (34.44)	23.50 (28.99)
Badi Santheli	Local	0.6	17.20 (24.49)	33.60 (35.42)	25.40 (30.26)
Sukhana	Local	0.9	20.80 (27.13)	34.00 (35.66)	27.40 (31.56)
Moida	Local	2.3	19.40 (26.13)	31.00 (33.83)	25.20 (30.13)
SEM ±			0.370	0.473	0.302
CD at 5%			1.042	1.333	0.849

Table 2 Distribution and prevalence of ajwain root rot mortality in different villages of Southern Rajasthan districts during *rabi* 2016–17

Village name	Host variety	Area (ha)	Plant mortality* (%)		Mean
			45th DAS	75th DAS	
			Udaipur		
Bhatewar	Local	2.5	30.80 (33.70)	45.00 (42.12)	37.90 (38.00)
Kheroda	Local	1.3	26.50 (30.98)	40.80 (39.70)	33.65 (35.46)
Nawaniya	Pratap Ajwain	2.1	21.80 (27.83)	37.00 (37.46)	29.40 (32.83)
Khokharwas	Local	0.8	35.50 (36.57)	47.00 (43.28)	41.25 (39.96)
Kundai	Local	1.9	30.00 (33.21)	48.50 (44.14)	39.25 (38.79)
Daulatpura	Local	1.6	24.00 (29.33)	36.50 (37.17)	30.25 (33.37)
Menar	Pratap Ajwain	3.0	20.50 (26.92)	30.00 (33.21)	25.25 (30.16)
Amarpura	Pratap Ajwain	0.5	21.00 (27.27)	29.20 (32.71)	25.10 (30.06)
Rundera	Local	0.8	23.20 (28.79)	30.00 (33.21)	26.60 (31.04)
Kheta Khera	Local	1.5	25.00 (30.00)	37.50 (37.76)	31.25 (33.99)
			Rajsamand		
Gilund	Local	0.6	21.00 (27.27)	30.50 (33.52)	25.75 (30.49)
Kotrii	AA-93	2.3	18.00 (25.10)	26.00 (30.65)	22.00 (27.97)
Kundiya	AA-93	0.6	15.50 (30.00)	24.80 (29.86)	20.15 (26.67)
Kabra	AA-93	0.9	16.90 (24.27)	25.00 (30.00)	20.95 (27.24)
Damodarpura	AA-93	0.7	21.50 (27.62)	27.00 (31.31)	24.25 (29.50)
Jawasya	Local	1.3	26.30 (30.85)	29.30 (32.77)	27.80 (31.82)
Phoonkiya	AA-93	2.7	18.00 (25.10)	31.00 (33.83)	24.50 (29.67)
Pachhmata	Local	2.5	25.00 (30.00)	29.50 (32.89)	27.25 (31.47)
Laxmipura	AA-93	2.7	15.40 (23.10)	25.00 (30.00)	20.20 (26.71)
Khar-Bamaniya	Local	2.8	20.80 (27.13)	30.00 (33.21)	25.40 (30.26)
			Chittorgarh		
Anoppura	AA-1	0.6	20.00 (26.56)	28.00 (31.94)	24.00 (29.33)
Babariya Khera	Local	0.5	25.50 (30.32)	31.50 (34.14)	28.50 (32.26)
Danta	Local	0.3	28.80 (32.45)	35.00 (36.27)	31.90 (34.39)
Jaisinghpura	Local	0.9	25.00 (30.00)	32.80 (34.94)	28.90 (32.52)
Kalyanpura	Local	1.3	20.50 (26.92)	30.00 (33.21)	25.25 (30.16)
Kanwarpura	AA-1	2.6	15.00 (22.78)	30.50 (33.51)	22.75 (28.49)
Lalawas	Local	0.8	20.25 (26.74)	35.40 (36.51)	27.82 (31.83)
Pandoli	Local	1.0	28.20 (32.07)	41.50 (40.10)	34.85 (36.18)
Rajpura	Local	2.3	22.50 (28.31)	38.50 (38.35)	30.50 (33.52)
Raghunathpura	Local	2.5	30.20 (33.33)	32.60 (34.81)	31.40 (34.08)
			Pratapgarh		
Tanda	Local	3.3	25.00 (30.00)	35.00 (36.27)	30.00 (33.21)
Nagdi	Local	2.9	24.50 (29.67)	30.50 (33.52)	27.50 (31.63)
Kanad	Local	2.7	27.20 (31.43)	39.00 (38.64)	33.10 (35.12)
Fatehgarh	AA-93	1.4	15.20 (22.94)	30.50 (33.52)	22.85 (28.55)
Lal Garh	Local	1.7	25.00 (30.00)	41.20 (39.93)	33.10 (35.12)
Sankheli	Local	2.5	30.80 (33.70)	42.50 (40.69)	36.65 (37.26)
Dhanot	Local	2.5	27.00 (31.30)	35.00 (36.27)	31.00 (33.83)
Badi Santheli	Local	0.8	18.00 (25.10)	34.00 (35.66)	26.00 (30.66)
Sukhana	Local	0.7	21.00 (27.27)	38.30 (38.23)	29.65 (32.99)
Moida	Local	2.4	24.30 (29.53)	37.50 (37.76)	30.90 (33.77)
SEM ±			0.618	0.876	0.555
CD at 5%			1.792	2.536	1.608

reported by Koli *et al.* (2014) in a survey of root rot disease of pea with incidence from 18.22 to 32.43%.

In Rajsamand district, at 45 DAS, the maximum plant mortality was recorded in Jawasya (26.30%) in 2016–17 and (24%) with Local cultivar in 2015–16 and minimum was recorded with Ajmer ajwain-93 (14.50%) in Kundiya 2015–16. At 75 DAS, the maximum (31%) and minimum (23.60%) plant mortality was observed in Ajmer ajwain-93 in Phoonkiya and Kabra villages respectively, in both years (Table 1 and 2). The overall plant mortality mean in Rajsamand district was recorded as 22.63 and 23.82% with Ajmer ajwain-93 in both of years (Fig. 1). Similar results were found in *Rhizoctonia* root rot disease of soybean by Belkar and Gade (2016).

For Chittorgarh district, at 45 DAS, the maximum plant mortality was recorded in Raghunathpura (30.20%) and Babariya Khera (26%) with Local cultivar in both years. Whereas, minimum plant mortality was found in Lalawas with local cultivar (13.80%) and Kanwarpura with cultivar Ajmer ajwain-93 (15%) in both years. At 75 DAS, the maximum plant mortality was recorded in Pandoli (41.50%) whereas, minimum in Lalawas (25.50%) with local cultivar in both years (Table 1 and 2). The overall plant mortality mean of Chittorgarh district was recorded as 26.99 and 28.58% with local cultivar in both years (Fig. 1).

In Pratapgarh district, maximum plant mortality at 45 and 75 DAS was found in Sankheli (30.80 and 42.50%) with local cultivar in both years. Whereas, the minimum value for plant mortality was observed in Dhanot (15%) and Nagdi with local cultivar (30.50%) in both years (Table 1 and 2). The overall plant mortality mean of Pratapgarh district was recorded as 28.03 and 30.07% with local cultivar in both of years (Fig. 1).

The plant mortality varied in 4 surveyed districts of southern districts of Rajasthan during the *Rabi* 2015–16 and 2016–17. The maximum plant mortality 29.81% and 31. 99% was found with local cultivar in Udaipur where minimum mortality was recorded in Rajsamand (22.63 and 23.82%) with cultivar Ajmer ajwain-93 in both years (Table 1 and 2). The overall per cent mortality was higher in 2016–17 as compared to 2015–16 (Fig 1). The mortality may also increase at maturity under favorable weather conditions as the disease progress was fast, which ultimately affects the yield. Hence, mortality ranges indicate that favorable climate along with infected seed and crop residue is important. The similar results were reported by Jetawat (2016) who made an intensive roving survey in southern part of Rajasthan and reported the occurrence of dry root rot of chilli due to *R. solani*. Mohan and Balabaskar (2012) also conducted survey on the incidence of groundnut root rot disease in Tamil Nadu and reported the maximum incidence of the disease (31.68%) registered in Vengatakuppam (MP_{18}) location.

To estimate the losses on ajwain by *R. solani* at varied inoculums densities, field experiments were conducted for two consecutive *Rabi* seasons i. e. 2015-16 and 2016-17. Different disease levels were created through application of varied inoculums densities of *R. solani,* viz. 50, 100 and 150 g/plot with Ajmer ajwain-93. Whereas, maximum plant mortality (68.89%) was recorded with increase in inoculum levels (150 g/plot) and significant reduction in grain yield (0.17 kg/plot) was observed at all the inoculum levels, as compared to the un-inoculated control (Table 3). These observations suggest that root rot of ajwain has good potential of damaging the crop and may become limiting factor in realization of good yield. Similar results have been reported by Padamini (2014) who observed mortality due to root rot caused by *R. solani.* Mostly, seed spices are grown as a dry land crops on residual moisture and such conditions helps in proliferation of *R. solani* (Sneh *et al.* 1992). Further, Sharma and Bhowmik (1986) found 100% yield losses in groundnut at the pre-emergence, 94% yield losses at pre-pod and 63% yield losses at pod filling stages. Prevalence of root rot had been reported earlier from other crops like coriander (Yadav 2003), soybean (Tetarwal 2011) and safed musli (Sharma 2012) in Rajasthan.

The study revealed that plant mortality in most of the surveyed fields is in the range of 12.80–35.50% at 45 DAS and 23.60–49.50% at 75 DAS during both years, which

Table 3. Effect of various doses of *Rhizoctonia solani* inoculum on seed germination, plant mortality and yield losses in ajwain under field conditions

Inoculum density	Seed germination (%)			Plant mortality (%)			Grain yield* kg/plot			Yield losses (%)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
50 g/plot	46.80 (43.16)	50.00 (45.00)	48.40 (44.08)	40.00 (39.22)	39.00 (38.64)	39.50 (38.93)	0.32	0.34	0.33	41.82 (40.28)	39.88 (39.15)	40.85 (39.71)
100 g/plot	40.00 (39.23)	41.00 (39.81)	40.50 (39.52)	50.80 (45.46)	51.00 (45.57)	50.90 (45.52)	0.29	0.31	0.30	46.98 (43.26)	45.91 (42.62)	46.44 (42.94)
150 g/plot	30.50 (33.52)	32.50 (34.75)	31.5 (34.14)	65.00 (53.74)	64.50 (53.44)	64.75 (53.59)	0.16	0.19	0.17	70.91 (57.36)	66.86 (54.88)	68.89 (56.12)
Control (Un-inoculated)	75.00 (60.00)	76.50 (61.00)	75.75 (60.50)	21.00 (27.27)	24.00 (29.33)	22.50 (28.30)	0.55	0.57	0.56	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
SEM ±	0.786	0.507	0.428	0.822	0.581	0.471				1.342	0.989	0.788
CD at 5%	2.719	1.521	1.284	2.843	1.742	1.411				4.613	2.966	2.361

indicates its wide distribution and occurrence in large areas. The plant mortality data indicated that the disease was initiated on 45 DAS. The maximum plant mortality and per cent loss in form of grain yield was observed in plots which were inoculated with higher inoculum density of 150 g/plot. It was found the plant mortality increased with the increase in inoculum density levels and significant reduction in grain yield occurred at all the plant mortality levels.

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