J. Agric. Res. Technol., 47 (2) : 205-211 (2022) https://doi.org/10.56228/JART.2022.47216

Effect of Abiotic Factors on the Incidence of Dry Root Rot in Chickpea (*Cicer arietinum* L.)

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(Received : 21.11.1021 Accepted : 30.12.2021)

Abstract

An investigation was conducted on chickpea (*Cicer arietinum* L.) genotype JG-62 to study the effect of different abiotic factors on the incidence of dry root rot. Maximum disease incidence was observed at 35°C temperature while minimum disease incidence was observed at 20°C. More disease incidence was observed at low moisture conditions while low at high moisture conditions. Soil pH also influenced the disease incidence. Maximum disease incidence was observed at pH 4.5 while minimum disease incidence was observed at pH 7.5. The results are useful for managing the incidence of dry root rot in chickpea.

Key words : Dry root rot, chickpea, *Rhizoctonia bataticola*, *M. phaseolina*, Temperature, Soil moisture, pH.

Chickpea (*Cicer arietinum* L.) is one of the important grain legume crops which is high in protein, fibre, vitamins, and amino acids and low in fat, and cholesterol. Grain legumes also improve soil quality by fixing nitrogen from the atmosphere. Chickpea is an important legume crop grown in Asia during the rabi seasons. Chickpea (2n = 2x = 16) is a self pollinated and annual diploid grain legume which evolved from Cicer reticulatum by selection (Van der Maesen 1987). Chickpeas are valuable because they provide food for both humans and livestock. It has a protein content of 22%, a carbohydrate content of 63%, a fat content of 4.5 percent, a crude fibre content of 8.0 percent, and an ash content of 2.7 percent (Miao *et al*., 2009).

Yield is the complex trait that results from the interactions of several yield contributing characters and is significantly influenced by environmental changes. With the constantly changing climatic conditions, various production constraints *viz*., biotic and abiotic stresses are adversely affecting the yield potential. Amongst the biotic stresses dry root rot (DRR), fusarium wilt, ascochyta blight, bacterial blight, collar rot, filiform virus and root nematode severely impact chickpea, resulting in economic yield loss.

In recent years, DRR is becoming a serious threat to chickpea production. DRR of chickpea which is caused by necrotrophic fungus *Rhizoctonia bataticola* (Taub.) is a seed and soil borne and is saprophytic and produce microsclerotia as primary source of inoculum and can persist in soil for 3 years (Dhingra and Sinclair, 1978). The DRR symptoms are most commonly observed in chickpea around flowering and poding time as scattered dried plants and drooping of petioles and leaflets which is confined to top of the plant (Haware 1990; Sharma *et al*., 2015). Infected plants appear as straw colored and tap roots are devoid of fine and lateral roots and turn black with rotting. On exposed roots and inside of bark dark minute sclerotia can be seen. In DRR affected plants, plugging of xylem vessels and destruction of epidermal cells areobserved which collapses the plant during pod filling stage.

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Growth and viability of *R. bataticola* is affected by environmental conditions like temperature, soil moisture and pH (Khan, 2012). While, low water potential in soil increases the viability of *R. bataticola* to produce microsclerotia, high water potential reduces the viability of pathogen to produce microsclerotia (Olaya *et al.*, 1996). For developing effective management strategies against DRR, study of independent effects of abiotic factors on plant disease is essential. With this background, the present investigation was undertaken to study the effect of differential temperature, soil moisture and pH regimes on the incidence of DRR in chickpea cultivar JG-62.

Material and Method

Effect of temperature on DRR in chickpea : Effect of four temperature regimes (20°C, 25°C, 30°C and 35°C) was studied on DRR susceptible cultivar JG-62 in incubator using paper towel technique. Seven-day-old seedlings of JG-62 were grown in germinator chamber and roots were inoculated by dipping in the broth for 1 min. Potato dextrose broth medium was prepared for multiplication of fungus. Inoculated seedlings were placed in folded, moist blotting paper and then incubated at four different temperatures (20°C, 25°C, 30°C and 35°C) with a 12 h photoperiod. The experiment was conducted in three replications in completely randomized block design (CRBD) and each replication consisted of 10 plants. Ten seedlings of each replication were treated with fungus while ten seedlings were kept as control. After seven days of treatment, disease severity was recorded on 1-9 scale as per Nene *et al*. (1981).

Effect of soil moisture on DRR in chickpea : Influence of soil moisture was examined on the DRR of chickpea in the sick pot. Effect of four soil moisture regimes, i.e. 25, 50, 75 and 100 per cent was studied on the development of DRR under controlled environment. The experiment was conducted on susceptible cultivar JG-62 in green house. Each treatment was replicated three times and each replication consisted of four pots (10 plants pot^{-1}). Soil was inoculated with R. bataticola grown on sand sorghum media. Soil moisture was recorded by hot-air oven drying method (Sharma and Pande, 2013). Soil samples were collected in aluminium container. Before sampling, empty container (heat resistant) including cover was weighed (M_1), after that soil sample was collected from the pot and soil was placed in the container and weighed together with the container (M_2) and containers were placed in to hot air oven at 60 for 2 hour. After cooling of containers, soil plus container were weighed again (M_3). Soil moisture was observed weekly and the disease incidence was calculated after 40 days.

The moisture per cent was calculated by the following formula

$$\text{Moisture (\%)} = \frac{(M2-M3)}{(M3-M1)} \times 100$$

Effect of soil pH on DRRin chickpea : Effect of different pH levels (4.5, 5.5, 6.5 and 7.5) on development of DRR was studied in green house on the susceptible cultivar JG-62. Seeds of JG-62 were sown in pots inoculated with R. bataticola grown on sand sorghum media. Experiment was conducted in three replications with control using CRD design. Ten seeds of genotype were sown in each pot. Five gram of soil was taken and suspended in 40 ml sterile distilled water in 250 ml conical flask and stirred for 30 min. The soil pH was estimated and was adjusted at 4.5, 5.5, 6.5 and 7.5 by using NaOH and HCl (Kulkarni, 2007). Data on percent mortality were recorded 30 days after sowing as per Reddy *et al*. (2016).

Results and Discussion

Effect of temperature was studied to know the favourable condition for development of R. bataticola. Effect of four temperature *viz*. 20, 25, 30 and 35°C was studied on disease development through paper towel method on chickpea genotype JG-62. Infected and completely discoloured roots were observed at 35°C while dark lesions on roots were observed at 30°C. Very few lesions were observed at 20 and 25°C which showed minimum disease incidence. The maximum disease severity (76.67%) was observed at 35°C and was graded in highly susceptible category, whereas 43.34 per cent disease incidence was observed at 300C and was grouped under susceptible category (Table 1). Low disease severity was observed at 20°C (23.34%) and 25°C (26.67%) and categorized into moderately susceptible category. No any symptoms were observed in control plants.With the increase in temperature, disease incidence also increased (Fig. 1).

Effect of soil moisture was studied on DRR in green house condition on chickpea variety JG-62 through sick pot method. Four soil moisture regime 25, 50, 75 and 100% were maintained in pot through oven dry method. Disease incidence at different moisture was categorized into various groups (Table 1). Higher mortality was reported in plants which were subjected to low soil moisture (25 and 50%) than plants subjected to high soil moisture (75 and 100%). Mortality per cent was used to categorize the plants into different category. As moisture level increased in soil, reduced disease incidence was observed in plants. Disease progressed slowly in high soil moisture as compared to low soil moisture. Control plants

Table 1. Effect of different abiotic factors on development of dry root rot in chickpea variety JG-62

Abiotic factor	Dry root rot incidence									Average	Reaction (%)
	Replication I			Replication II			Replication III				
	Infected plants	Healthy plants	DRR incidence (%)	Infected plants	Healthy plants	DRR incidence (%)	Infected plants	Healthy plants	DRR incidence (%)		
Temperature											
20°C	2	8	20	3	7	30	2	8	20	23.34	MS
25°C	3	7	30	2	8	20	3	7	30	26.67	MS
30°C	4	6	40	5	5	50	4	6	40	43.34	S
35°C	7	3	70	8	2	80	8	2	80	76.67	HS
Moisture (%)											
25	8	2	80	9	1	90	9	1	90	86.67	HS
50	7	3	70	6	4	60	8	2	80	70.00	HS
75	3	7	30	4	4	50	4	6	40	40.00	S
100	3	7	30	3	7	30	2	8	20	26.67	MS
pH											
4.5	8	2	80	9	1	90	9	1	90	86.67	HS
5.5	7	3	70	6	4	60	8	2	80	70.00	HS
6.5	4	6	40	4	6	40	5	5	50	43.33	S
7.5	3	7	30	3	7	30	2	8	20	26.64	MS

MS-Moderately susceptible, S-Susceptible, HS-Highly susceptible.
Note-Total 10 plants were taken in each treatment.

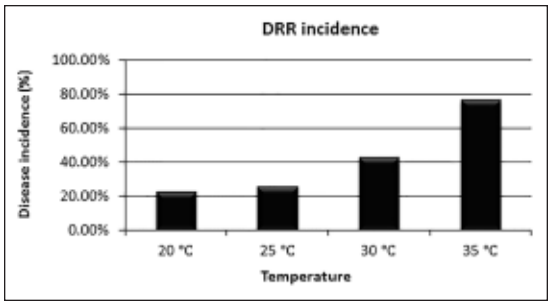

Fig. 1. Effect of different temperature levels on the development of dry root rot on chickpea variety JG-62

did not show any symptoms at high soil moisture while wilted plants were observed at low soil moisture (physiological stress). After 40 days of sowing, DRR symptoms appeared at 25 per cent soil moisture while at high soil moisture (50, 75 and 100%) disease progressedslowly. Maximum disease incidence (86.67%) was reported in 25 % soil moisture stress which was followed by 70% incidence at 75 % soil moisture, 40% incidence at 50% moisture and 26.67% incidence at 100% moisture level (Table 1). These investigations revealed that pathogen cause higher disease incidence at moisture stress condition (Fig. 2). Plants become more prone to DRR at low soil moisture and manifested higher disease incidence.

In addition to study the effect of various regimes of temperature and soil moisture levels, the experiment was performed to know favourable pH for development of DRR in

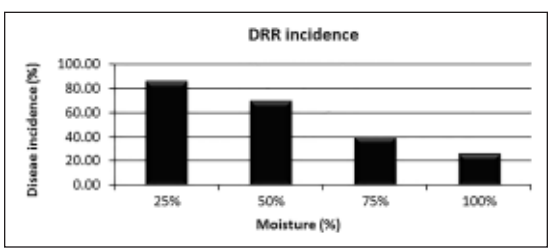

Fig. 2. Effect of different moisture levels on development of dry root rot on chickpea variety JG-62

chickpea variety JG-62. Soil was made sick by inoculating soil with pathogen grown on sorghum: sand medium. Four pH level viz. 4.5, 5.5, 6.5 and 7.5 were maintained in soil to study effect on pathogen to cause disease. Different disease incidence was observed at different pH levels (Table 1). Highest mortality of plants was observed at pH 4.5 which caused 86.67% disease incidence. Least mortality of plants was observed at pH 7.5 with 26.64% disease incidence which was followed by pH 5.5 (70%) and pH 6.5 (43.33%). Significant differences were observed in all treatments. Increased incidence of DRR was observed at low pH while decreased incidence was observed at high pH (**Fig. 3**).

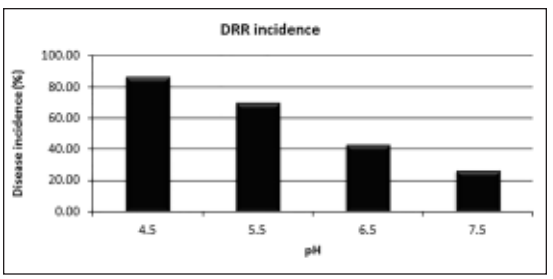

Fig. 3. Effect of different pH levels on development of dry root rot on chickpea variety JG-62

Discussion

Plants require suitable environmental conditions for improved growth, development, and better production. Study of biotic and abiotic factors are important to know the different level of disease intensity. Crop diseases are more likely to be triggered by certain environmental factors. Viability of pathogen is affected by environmental factors such as temperature, soil type, moisture and soil pH. Various climatic factors are associated with development of pathogen of DRR in plants. Change in climatic condition in future will increase the incidence of DRR in chickpea at epidemic level. Interaction among pathogen, host and environment invariably respond to plant disease (Garrett *et*

al., 2016).Increased viability of microsclerotia is observed on low water potential while viability decreases under high water potential (Olaya *et al.*, 1996). On analysis of the weather data (2000-2010), Khambadkar (2013) observed higher incidence of disease when temperatures increased more than 33.

In this study, maximum disease incidence was observed at 35°C while minimum disease incidence was observed at 20°C. Disease incidence was observed higher at low moisture (25%) while low at high moisture (100%). Maximum disease incidence was observed at pH 4.5 while minimum disease incidence was observed at pH 7.5. As soil pH and soil moisture increased, decrease in disease incidence was observed.

The results of the present investigation support the work done by Singh and Mehrotra (1980); Sharma and Pande (2013) and De-sousa *et al*. (2020) on DRR caused by *R. Bataticola*. They exhibited higher disease incidence at higher temperatures. Singh and Mehrotra (1980) increased incidence of DRR when plants were exposed to temperature more than 300C. Sharma and Pande (2013) reported higher incidence of DRR at temperature 35°C and De-Sousa *et al.* (2020) observed severe symptoms of disease with increased temperature. Temperatures also affect the mycelia growth and sclerotia formation of pathogen. Patel and Patel (1990) observed 35°C as the optimum temperature for sclerotial formation and growth of M. phaseolina. Chowdary and Govindaiah (2007) reported highest growth at 40°C which was followed by 35°C and 30°C. Savary *et al*. (2011) found more incidence of dry root rot observed with increased temperature. Csondes *et al*. (2012) reported temperature between 25 and 35°C was the most favourable for development of pathogen. Sukanya *et al*. (2016) reported more growth of pathogen at higher temperature. The optimum temperature of 35°C was observed by Srinivas (2016) for development of DRR. Parmar *et al*. (2018) found 30°C temperature as ideal for growth of fungus while 25 to 30°C temperature optimum for sclerotia formation.

Husain and Ghaffar (1995) and Maheswari and Ramakrishnan (1999) observed high saprophytic activity and colonization of R. bataticola at moisture stress which support the present investigation. Raj et al. (1999) observed that disease incidence increased when pots were irrigated at seven days interval than pots irrigated daily. Wokocha (2000) reported low soil moisture was favourable for growth of pathogen and pathogenicity while high moisture was unfavourable. Patel and Anahosur (2001) also observed maximum infection of M. phaseolina at 25% soil moisture and less incidence at high soil moisture (75% and 100%). Singh and Sharma (2002) reported severe development of disease on pulse crop in deficit soil moisture conditions. Savary *et al.* (2011) observed increased intensity of DRR in tropical humid area on increasing moisture stress. Sharma and Pande (2013) also found more severity of DRR in moisture stress conditions. Similarly, Srinivas (2016) observed that plants showed wilting and drooping under low moisture conditions (40 and 50%).

In the past several studies have been conducted to study the effect of soil pH on the incidence of DRR. The results of soil pH study showed similar findings as that of Srivastava and Dhawan (1980) who reported maximum mortality of plants at soil pH 5.5 and decreased intensity of disease with increase in soil pH. Singh and Chohan (1982) found optimum pH 5.0-6.0 for development of mycelium of M. phaseolina.Jha and Sharma (2005) reported good growth of pathogen at pH 5.5 to pH 7.5. Chowdary and Govindaiah (2007) observed most favourable pH for pathogen growth was 7.0 while least favourable pH was 8.0. Khan *et*

al., (2012) observed maximum growth of R. bataticola on pH 5.5 which was followed by pH 6.0 and again increased up to pH 7.0. Parmar (2013) observed maximum growth of R. bataticola at pH 6.5 and minimum growth was observed at pH 8.0. Srinivas (2016) reported higher growth of colony of R. bataticola at pH 5.0. Sukanya et al. (2016) showed more growth of pathogen at low pH.

Conclusions

Abiotic factors affect the incidence of diseases in chickpea. It was found that DRRincreased with increase in temperature with more incidence at 35°C while minimum disease incidence was observed at 20°C. Incidence of DRR was directly proportional to the soil moisture levels and it was higher at low moisture while low at high moisture levels. Soil pH also influenced the DRR incidence directly withmaximum disease incidence observed at pH 4.5 while minimum incidence was observed at pH 7.5. The results of present study can help in managing the DRR in chickpea more effectively by maintaining the proper conditions in the field.

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