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Evaluation of Tomato Cultivars against Early Leaf Blight (*Alternaria solani)* in net greenhouse Qatar

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Abstract

The current study was conducted at the Alutouriya research station under the Agriculture Research Department in the Ministry of Municipality, Qatar, during the years 2020–2021, and 2021–2022, to test the response of various tomato cultivars against early blight. Early blight is the most devastating fungal disease of tomatoes, caused by *Alternaria solani*. It is one of the most common foliar diseases in tomatoes. The disease can occur in a wide range of climatic conditions but is most prominent in areas with moderate temperatures and high relative humidity. In this study, ten tomato cultivars were evaluated for highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), and susceptible (S) reactions under natural net greenhouse conditions. Alternaria solani produces oblivious green, gray, and brown-to-black colonies when grown on PDA medium. Assessments on the mean percent disease index and severity grade of symptoms were recorded for each cultivar. Only one cultivar, 71 (banana legs), was recorded as moderately susceptible in both years with a high PDI value and symptom severity grade. The cultivars fruit weight for each cultivar was calculated to determine the productivity of the tomato plant. The maximum and minimum temperatures with relative humidity were recorded every week from November to February for the years 2022-2021 and 2021-2020. This data revealed that most of the cultivars used for this study were resistant to early blight.

Keywords: *Alternaria solani*, Early Leaf Blight, Tomato, resistant, moderately susceptible, susceptible.

Introduction

Tomatoes are known to be a warm-season crop. It can survive some cold but is not tolerant of very low temperatures. A top-class tomato crop requires a stable temperature range with minimums and maximums that do not have too large variations. The minimum temperature required is around 10 °C, and the maximum required is 34 °C. The optimum temperature is between 26 and 29 °C. Tomato plants require low to medium rainfall. Tomatoes are the world's second-most consumed vegetable after potatoes (**Foolad, 2007**). Tomatoes are the richest source of vitamins A and C and are loaded with a substance called lycopene. It gives them their bright red color and helps protect them from the ultraviolet rays of the sun. Tomatoes also have potassium, vitamins B and E, and other nutrients. Lycopene, present in tomatoes, is an antioxidant; it fights molecules called free radicals that can damage your cells and affect your immune system. Because of that, foods high in lycopene, like tomatoes, may make you less likely to have lung, stomach, or prostate cancer. Other nutrients in tomatoes, like vitamins B and E and antioxidants called flavonoids, may boost your heart health, too. (**Van Breemen, 2008**).

In Qatar, tomatoes are produced in state and private horticultural enterprises, commercial farms, and by small farmers scattered in different parts of the country. It is produced mainly as a source of food and income, both in open fields and greenhouses. Tomatoes are among the most important vegetable crops in Qatar. In this context, developing superior-yielding varieties through appropriate breeding work is mandatory to satisfy the ever-increasing domestic demand.

The tomato is afflicted by numerous plant diseases induced by fungal, bacterial, phytoplasma, virus, and viroid pathogens due to its genetic properties and causes huge economic losses every year in terms of crop production and monetary losses to farmers, resulting in 79% of total production losses throughout the world. (**Pandey et al., 2003; Peralta et al., 2005**).

One of the most prevalent diseases infecting tomatoes and potatoes, early blight, occurs almost every season. When susceptible tomato cultivars are used and the weather is favorable, it affects leaves, fruits, and stems and can severely minimize productivity. Frequent rain, high humidity, and moderately warm temperatures (24–29 °C) are all factors that favor the early blight of tomatoes. (**Chaerani et al., 2006**), and under severe infections, it may cause up to 80% yield loss. (Adhikari et al., 2019) Mostly, disease appears in the vegetative phase of the plant's growth before flowering, is more prevalent between flowering and fruit ripening, and continues until the crop is completely senescent (Kumar et al., 2015). Early blight can be caused by two closely related species: *Alternaria tomatophila* and *Alternaria solani*. Both pathogens are capable of infecting tomatoes, potatoes, peppers, and a variety of weeds in the Solanaceae family. Disease develops at moderate to warm temperatures (59 to 80 F); 82

to 86 F is its optimum temperature range. The pathogen is more likely to spread when there is rain or heavy dew or when the relative humidity is 90% or higher. The pathogen also survives on tomato seeds or may be introduced through tomato transplants. Lower leaves become infected when they encounter contaminated soil, either through direct contact or when raindrops splash soil onto the leaves. Spores (reproductive structures) can germinate between 47° and 90° F and need free water or a relative humidity of 90% or greater. Spores infect plants and form leaf spots as small as 1/8-inch diameter in as little as five days. Wind, human interaction, or equipment can all disseminate spores throughout a field, creating multiple possibilities for reinfection throughout the growing season. (**Peralta et al., 2005; Choudhary et al., 2021**).

The damping-off of seedlings, later collar rot, leaf spots, stem lesions, and fruit rot are among the most prevalent tomato symptoms (**Rotem, 1994**). Crop rotation, crop removal and destruction of crop remnants from previous crops, staking, mulching, and timely fungicide application are among the primary approaches used to control early blight. (**Mary Ann Hansen, 2009**).

The objective of the present study is to evaluate certain cultivars of tomato for resistance to early blight caused by *Alternaria solani* under the natural net greenhouse in The State of Qatar.

Materials and Methods

The present study was conducted over two growing seasons, from October to February of 2020/2021–2021/2022, to screen ten different cultivars of tomato against the natural infection of early blight disease caused by *Alternaria solani*. The ten cultivars were selected from 243 cultivars; experiments were conducted on them for a period of three years previously to choose the best of them in terms of their tolerance to the environmental conditions of the State of Qatar, as well as their good crop and vegetative characteristics.

Screening of cultivars under natural net greenhouse conditions

The field screening experiments were carried out in 2020/2021 and 2021/2022 at the Alutouriya station under the Agriculture Research Department in the Ministry of Municipality, Qatar. The 25-day-old tomato seedlings grown in the nursery were transplanted into the main field in mid-October 2020 and 2021. Plant-to-plant spacing was kept at 45 cm, and row spacing was maintained at 60 cm. The experiment was laid out in a randomized block design with three replications. Recommended doses of fertilizer were applied. Plants in this study were not sprayed with any fungicide. Observations of early blight incidence were taken in February 2021 and 2022, coinciding with the end of the winter season and a slow rise in temperature, which is optimal for early blight incidence. The percent disease index was calculated (**Pandey et al., 2003**), and plant fruit weight per cultivar was recorded. Minimum and maximum temperature degrees, along with relative humidity, were recorded during the study periods 2020–2021 and 2021–2022, respectively, in the experimental field.

Pathogen isolation and identification

For primary isolation and identification of the disease-causing fungi, potato dextrose agar (PDA) was used. Infected leaves were collected randomly. Microscopic slides were also made directly from field samples. Samples were surface sterilized with 3% sodium hypochlorite (NaOCl) for two minutes, washed three times with sterilized distilled water (SDW), and blotted dry on sterilized filter paper before inoculation on PDA, and then incubated at 250 °C for seven days. Fungi were identified based on morphological characteristics using the mycological keys of (**Barnet and Hunter 1998**) and (**Erwin and Ribeiro 1996**).

Table:1 Screened cultivars

S. No	Selected Cultivar No	Cultivar Gene Bank No	Cultivars Seeds Details	Location
1	2	TF-0017S	Amy's Apricot - Organic Heirloom Tomato Seeds	net house 1
2	25	TF-0129	Creole - Organic Heirloom Tomato Seeds	net house 1
3	43	Pakistan	Tomato seed -2198	net house 2
4	44	Pakistan	Tomato seed -2199	net house 2
5	45	Pakistan	Tomato seed -2217	net house 3
6	29	Pakistan	Tomato seed -2230	net house 3
7	52	AVRDC	(AVTO 9001) (CL5915-206D4 -18) SD201 80315 -T5a	net house 4
8	58	Syngenta	Tomato: 413485	net house 4

9	62	Syngenta	T415271 Ind tomato	net house 5
10	71	Banana Legs	Banana Legs - Organic Heirloom Tomato Seeds	net house 5

Table 1 contains details regarding the ten cultivars selected from a total of 243 cultivars. The cultivars chosen were 2 (TF-0017S), 25 (TF-0129), 43 (Pakistan), 44 (Pakistan), 45 (Pakistan), 29 (Pakistan), 52 (AVRDC), 58 (Syngenta), 62 (Syngenta), and 71 (Banana Legs).

Disease assessment

The individual plants of different tomato cultivars were kept under close observation to determine their resistance and reaction to early blight disease and their performances. Early blight resistance was evaluated based on lesion size and leaf area in the plant. According to (**Panday et al., 2003**), described in (Table 2), disease eventually was rated on a 1:5 scale as 5 highly susceptible and 1 highly resistant.

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of individual ratings X 100}}{\text{Total No. Observation X Maximum rating grade}}$$

Table 2: Early blight screening under natural net greenhouse condition

Symptoms	Symptoms severity grade	Percent Disease index (PDI)	Reaction
Free from infection	0	0-5	Highly resistant
One or two necrotic spots on a few lower leaves of plant.	1	5.1-12	Resistant
A few isolated spots on leaves, covering nearly 5%-10% of the surface area of the plant.	2	12.1-25	Moderately Resistant
Many spots coalesced on the leaves covering 25% of the surface area of the plant.	3	25.1-50	Moderately Susceptible
Irregular, blighted leaves and sunken lesions with prominent concentric rings on the stem, petiole, and fruits, covering 40% -50% of the surface area.	4	50.1-75	Susceptible
Whole plant blighted; Leaves and fruits starting to fall; foliar part free of disease.	5	>75.1	Highly Susceptible

In Table 2, the cultivars of tomato were categorized as highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), and susceptible (S). Significant differences between different cultivars were observed based on the percent disease infection (PDI) record. Cultivars were considered highly resistant and free of infection when the PDI value ranged from 0 to 5 and the severity of symptoms was recorded as 0, whereas cultivars were categorized as resistant, showing a PDI value of 5.1 to 12 with the severity of symptoms graded as 1. Moderately resistant, moderately susceptible, susceptible, and highly susceptible represented the PDI values of 12.1 to 25, 25.1 to 50, 50.1 to 75, and greater than 75.1, respectively. Moderately resistant cultivars had symptoms graded as 2 where a few isolated spots on leaves, covering nearly 5%–10% of the surface area of the plant, were observed. Moderately Resistant cultivars exhibited many spots coalesced on the leaves covering 25% of the surface area of the plant and severity symptoms were graded as 3. Irregular, blighted leaves and sunken lesions

with prominent concentric rings on the stem, petiole, and fruits, covering 40%–50% of the surface area, were observed on susceptible cultivars with the recorded severity of symptoms as 4. Highly susceptible cultivars were screened with the whole plant as blighted, leaves and fruits starting to fall, whereas the foliar part was free of disease and severity of disease graded as 5.

Plant cultivar weight

The tomato plant fruit weight parameter was recorded per plant on 90-day-old tomato plants grown under a net greenhouse in a replicate for each cultivar. The plant fruit weight for each cultivar was calculated to determine the productivity of the tomato plant. The experimental design used in conducting this experiment was a randomized complete block design (RB) with four replicates.

Average weather parameters

Generally, The State of Qatar experiences a moderate type of climate from November to February, followed by a slow rise in temperatures during February. Soil moisture or humidity due to irrigation, along with rising temperatures, create favorable conditions for early blight incidence in tomato cultivars. The maximum and minimum temperatures with relative humidity were recorded every week from November to February for the years 2020-2021 and 2021-2022.

Results and Discussion

As the field trail was conducted in natural conditions at the Alutouriya Station Agriculture, Agriculture Research Department, Ministry of Municipality in Qatar during the years 2020-2021 and 2021-2022, early blight screening results in all ten cultivars of tomato were recorded and categorized.

Table 3: Percent disease index and disease reactions of ten cultivars for early blight disease resistance in tomato in natural net greenhouse condition recorded in the year 2020-2021 and 2021-2022

Details of selected cultivar			**PDI (%)**			**DR**	
S. N	Cultivars	Cultivar Gene Bank No	2021	2022	Mean	2021	2022
1	2	TF-0017S	16.88	18.16	17.52	MR	MR
2	25	TF-0129	15.26	15.98	15.62	MR	MR
3	43	Pakistan	6.83	7.63	7.23	R	R
4	44	Pakistan	6.06	6.47	6.27	R	R
5	45	Pakistan	19.27	22.00	20.63	MR	MR
6	29	Pakistan	21.62	22.36	21.99	MR	MR
7	52	AVRDC	22.01	22.93	22.47	MR	MR
8	58	Syngenta	11.26	11.59	11.42	R	R
9	62	Syngenta	14.12	15.11	14.62	MR	MR
10	71	Banana Legs	27.89	34.31	31.10	MS	MS
LSD at 0.05							
	Cultivar (C)			1.74			
	Season (S)			0.78			
	C × S			2.45			

Table 4: Fruit weight yield of ten cultivars exhibiting early blight disease resistance in tomato in natural net greenhouse condition recorded in the year 2020-2021 and 2021-2022

Details of selected cultivar			cultivars fruit weight (Kg)		
S. N	Cultivars	Cultivar Gene Bank No	2021	2022	Mean
1	2	TF-0017S	132.90	120.86	126.88
2	25	TF-0129	1143.99	1110.20	1127.09
3	43	Pakistan	774.75	755.60	765.17
4	44	Pakistan	713.69	694.27	703.98
5	45	Pakistan	894.35	851.28	872.81
6	29	Pakistan	1105.27	1020.15	1062.71
7	52	AVRDC	623.97	598.15	611.06
8	58	Syngenta	641.15	612.45	626.80
9	62	Syngenta	573.62	552.39	563.00
10	71	Banana Legs	388.16	362.11	375.14
LSD at 0.05					
	Cultivar (C)			209.56	
	Season (S)			93.72	
	C × S			296.37	

In Table 3, the percent disease index (PDI) and disease reactions (DR) of ten cultivars for early blight disease resistance in tomato in natural field conditions were recorded. During the years 2020–2021, the PDI percentage recorded for seven cultivars was slightly lower as compared to the years 2021–2022, and the yield of the plant fruit weight mentioned in Table 4 was comparatively higher in the years 2020–2021, in all ten cultivars, as compared to the years 2021–2022.

In 2020–2021, cultivar 2 (TF-00175), cultivar 25 (TF-0129), cultivar 45 (Pakistan), cultivar 29 (Pakistan), cultivar 52 (AVRDC), and cultivar 62 (Syngenta) were categorized as moderately resistant based on the PDI% obtained and were recorded as 11.5%, 15.26%, 19.27%, 29.5%, and 14.12%, respectively. The fruit weight yield recorded from each cultivar also varied significantly and was recorded as 132.9 kg for cultivar 2 (TF-00175), 1143.98 kg for cultivar 25 (TF-0129), 894.35 kg for cultivar 45 (Pakistan), 1105.27kg for cultivar 29 (Pakistan), 623.97 kg for cultivar 52 (AVRDC), and 573.62 kg for cultivar 62 (Syngenta). Cultivars 43 (Pakistan), 44 (Pakistan), and 58 (Syngenta) were recorded as resistant, with the PDI percentage recorded as 23%, 24%, and 11.26, respectively, and the plant fruit weight as 774.74 kg, 713.68 kg, and 641.15 kg for cultivars 43, 44, and 71, respectively. Only one cultivar, 71 (banana legs), was recorded as moderately susceptible and shown to have a PDI percentage of 27.89 and plant fruit weight of 388.163 kg.

In the years 2021–2022, cultivar 2 (TF-00175), cultivar 25 (Tf-0129), cultivar 45 (Pakistan), cultivar 29 (Pakistan), cultivar 52 (AVRDC), and cultivar 62 (Syngenta) were categorized as moderately resistant based on the PDI% obtained and were recorded as 18.1%, 15.98%, 22%, 22.93%, and 15.11%, respectively. In Table 4, the plant fruit weight yield recorded from each cultivar was also slightly reduced to 120.85 kg for cultivar 2 (TF-00175), 1110.25 kg for cultivar 25 (TF-0129), 851.32 kg for cultivar 45 (Pakistan), 1020.15 kg for cultivar 29 (Pakistan), 598.15 kg for cultivar 52 (AVRDC), and 552.46 kg for cultivar 62 (Syngenta). Cultivar 43 (Pakistan), cultivar 44 (Pakistan), and cultivar 58 (Syngenta) were recorded as resistant, with the PDI percentage recorded as 7.63%, 6.47%, and 11.59, respectively, and the plant fruit weight as 755.56 kg, 694.29 kg, and 612.45 kg, respectively. Only one cultivar, 71 (banana legs), was recorded as moderately susceptible and shown the PDI percentage as 34.31 and plant fruit weight as 362.12 kg.

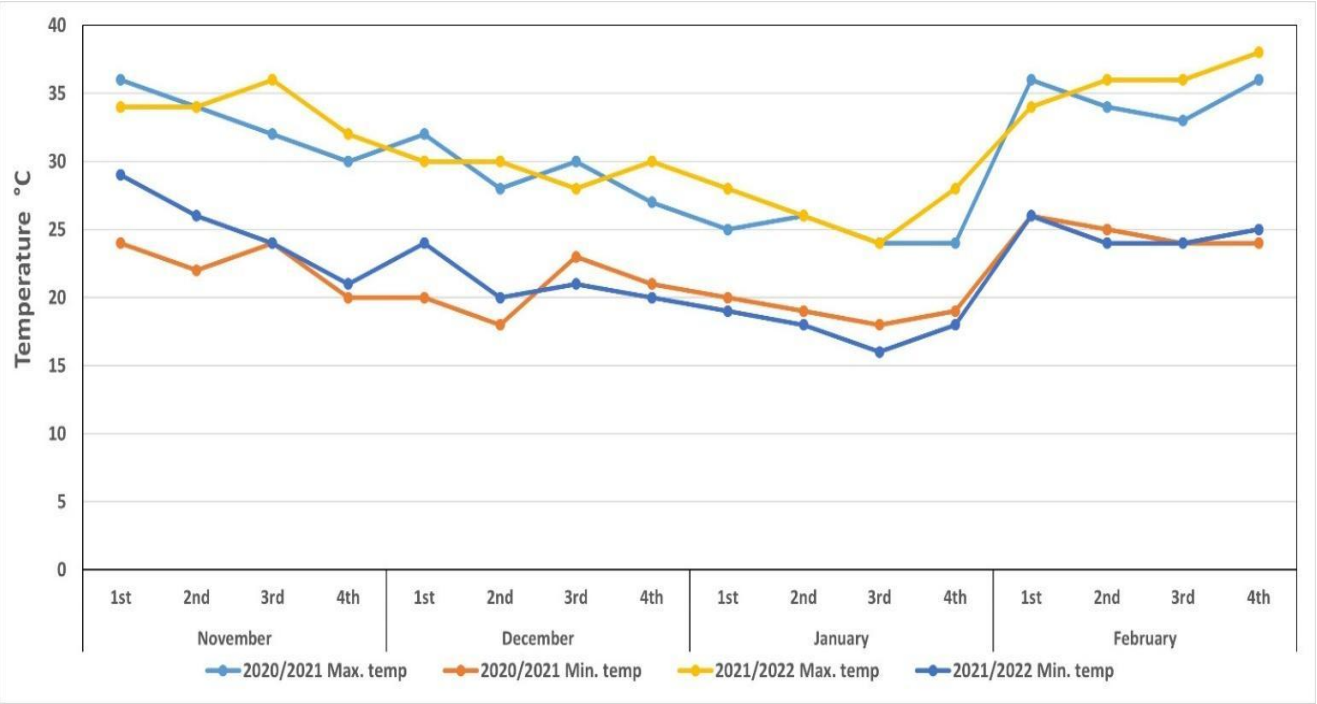

Fig. 1: Average temperature recorded during study period 2020-2021 and 2021-2022 in the experimental field.

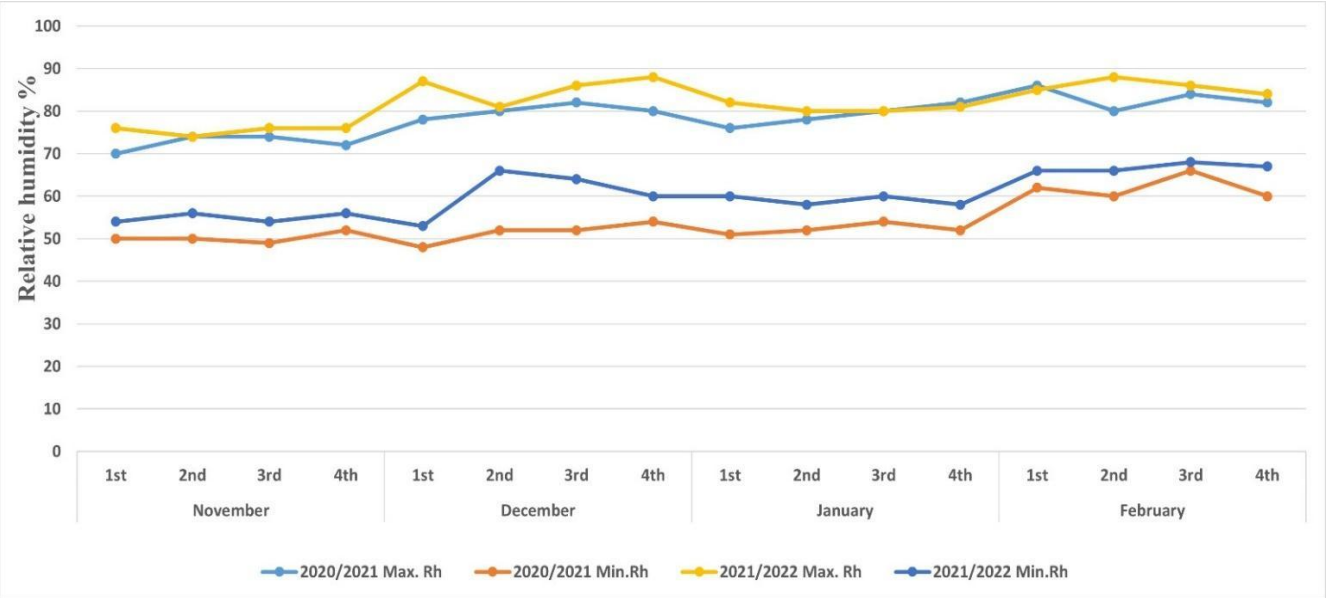

Fig. 2: Average relative humidity recorded during study period 2020-2021 and 2021-2022 in the experimental field.

In Fig. 1, the maximum temperature recorded during the experiment in the year 2020/2021 was 36 °C with a maximum recorded relative humidity of 84%, whereas in the year 2021/2022 there was a slight rise in the atmospheric temperature and relative humidity. The maximum recorded temperature was 38°C in the month of February 2022, and the relative humidity was 88% for the same month. As favorable environmental conditions persist for the development of early blight, the temperature range recorded during the life cycle of early blight was 16–38 °C, and the relative humidity also ranged from 50–88% (as highlighted in (Fig. 2).

Fig. 3: Dark brown lesions showing target like appearance of early blight on tomato.

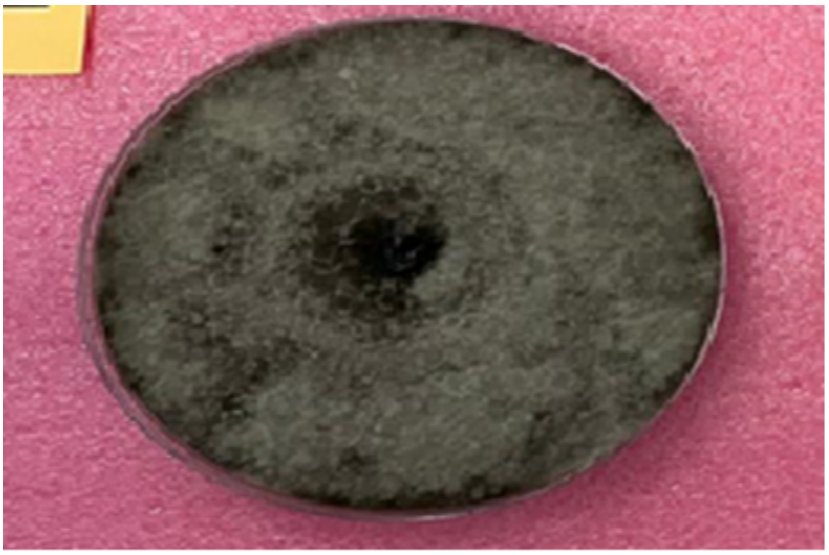

Fig. 4: Colony of Alternaria solani growing on PDA media incubated at 25°C for ten days.

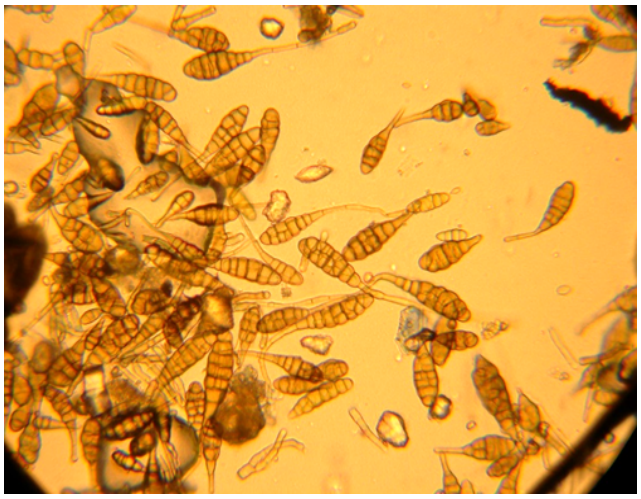

Fig. 5a: Conidia of Alternaria solani at (400X)

Fig. 5b Conidia of Alternaria solani at (1000X)

Pathogen isolation and identification were performed in the Agriculture Research Laboratory under the Ministry of Municipality, Qatar, from randomly chosen infected leaves (Fig. 3), and the morphological and microscopic characteristics of the isolated fungi were recorded for all the cultivars. The fungus produced a cottony growth that is dark gray to black on the potato dextrose agar medium (Fig. 4). The conidia were oblong, brown to olivaceous brown, and the conidiophores were formed singly or in groups, straight or flexuous. The average conidial size ranges from 27-55×10-12 µm (Fig. 5a, b), and the beak size was 2-4×8-10 µm. The number of horizontal septa ranged from 4 to 5. These features of *Alternaria solani* obtained from the tomato leaf samples matched with those of (**Barnet and Hunter; 1998**).

Discussion

In his study, ten tomato cultivars were evaluated for early blight resistance in natural net greenhouse experiments. Although none of the cultivars were immune to early blight, many resistant and moderately resistant cultivars were identified.

Weather conditions were different between the two years of this study. Early Blight developed much faster and the percentage disease index was more in 2022, due primarily to more moist environmental conditions. *Alternaria. solani* causes severe damage to all parts of the plant, including the stem, leaf, and fruit and ultimately damaging the full plant. The pathogen can survive in the form of mycelium and conidia in the soil in dry and warm weather; a 25–30 °C temperature is required for the growth of the pathogen, as reported by (**Pansuriya Dhaval et al., 2021).** It has been reported that *Alternaria* sporulates best at about 26.6°C when abundant moisture is present (**Rotem, 1994**). It was recorded that in the year 2022, the temperature was warmer than in 2021, leaf wetness time in January and February of 2022 was longer than that in January and February of 2021, and relative humidity (max. 88%) hours were longer than those in January and February of 2021, and it was during this period that the disease developed quickly. We speculate that this difference in moisture levels between the two years, along with the temperature differences, caused early blight to be more prevalent in 2022. In a previous study, (**Holley et al., 1985**) modeled early blight infection according to leaf wetness duration and air temperature and concluded that leaf wetness accounted for 85 to 89% of the variability in infection rate. Similar findings were reported by (**Gudmestad et al., 2013**) and (**Rani, 2015**) who concluded that tomato early blight is preferentially caused by hot temperatures and prolonged stages of leaf moisture due to dew or rainfall in congested cultivated areas. (**Jambhulkar et al., 2016**) also shared the information that conidia of *Alternaria* appeared in the atmosphere when the minimum temperature was 20–25 °C, the maximum temperature was 40 °C, and the mean temperature was 29–35 °C during the growing season of the tomato crop. Temperature and moisture play a significant role in *Alternaria* spores' dispersal. In the field, the early blight-infected plants display yellowing of leaves and defoliate totally near maturity. Similar results were described by (**Parsad and Naik; 2003**). Our result confirmed their conclusion, suggesting that leaf wetness duration and high relative humidity played important roles in early blight infection in all the tomato cultivars.

In 2021, cultivars 43, 44, and 52 showed a slight increase in PDI percentage as compared to the results obtained for the same cultivars in 2022. In both years, it was observed that tomato cultivars were more moderately resistant when screened for early blight symptoms in tomato plants. Similar results were observed by (**Suresh**

Kumar Sah et al., 2020) while screening fourteen tomato genotypes.

Conclusion

In this study of two years, it has been observed that in 2022, most of the cultivars had a high PDI percentage, and overall, the fruit weight was also reduced in all ten cultivars as compared to 2021. In 2021, cultivar 2 (TF-00175) and cultivar 58 (Syngenta) had the lowest PDI% and were more resistant to the early blight infection as compared to the other cultivars. Cultivar 71 (banana legs) was recorded as moderately susceptible when screened for early blight symptoms for both years and has been the major cause of crop damage in terms of reduction of yields and commercial values of production. Thus, we observed almost similar trends in both years for resistant and susceptible reactions in all ten cultivars.

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