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OPTIMIZING DISEASE SUSCEPTIBILITY IN CHERRY TOMATO CULTIVARS: INSIGHTS FROM MICROCLIMATE CONTROL COVERS AND WATERING CAPACITIES

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A B S T R A C T

The global agricultural landscape has undergone a substantial shift towards sustainable and regulated cultivation practices for cherry tomatoes in recent decades, leading to the widespread adoption of greenhouse farming as a popular alternative. The research was conducted at the Bale Tatanen, Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency, from December 2022 – May 2023. The objectives of the study include identifying better cultivars (Ruby & Fortesa) in microclimate control covers (greenhouse, rain shelter and screen house) by providing watering capacities (100% ETc, 75% ETc and 50% ETc). The choice of cultivar markedly influences disease susceptibility. Notably, the "Ruby" cultivar exhibited a consistently higher vulnerability to various diseases, particularly *Fusarium oxysporum*, late blight, fruit cracking, and blossom end rot. Conversely, the "Fortesa" cultivar demonstrated lower susceptibility, underscoring the potential of cultivar selection as a disease management strategy. Various microclimate control coverings have shown varying degrees of effectiveness in disease prevention. The greenhouse environment was the most effective in protecting against fruit cracking, blossom end rot, pest infestations, and fruit ailments. In contrast, the screen house consistently displayed the highest disease susceptibility, underscoring the need to evaluate growing structures to mitigate disease risks meticulously. The study also revealed the critical role of watering capacities in disease management. Plants receiving 100% ETc consistently exhibited a lower prevalence of several illnesses, highlighting the importance of maintaining optimal soil moisture levels through precise irrigation practices in disease prevention. Cultivar selection significantly affects disease susceptibility in cherry tomato cultivation, with the "Ruby" cultivar showing higher vulnerability and the "Fortesa" cultivar demonstrating lower susceptibility. Effective disease management can be achieved by adopting greenhouse environments and a watering capacity of 100% ETc, emphasizing the importance of these factors in sustainable cherry tomato production in the agroclimatic condition of Jatinangor.

Keywords: Microclimate, Watering capacities, Disease, Cherry tomato, Cultivars.

INTRODUCTION

Cherry tomato, a native of South America's Andean area, is one of the world's most widely produced horticulture crops. It may be grown in various settings, from tropical to temperate; it can even be grown under cover when external temperatures are not ideal. The quality of the fruit is an essential consideration in greenhouse tomato Production. The total amount of tomatoes produced in Indonesia in 2022 was estimated to be 1,116.74 thousand metric tons, an increase of slightly from the year before (Adhikari *et al*., 2017). However, the current research recorded an average of 700 g/plant of cherry tomato fruit. Cherry tomatoes are a popular and versatile crop that can be grown in various conditions. The growing environment's design and the water volume can significantly impact the

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performance of cherry tomato plants, including their yield, fruit quality, and susceptibility to diseases (Kachaka *et al*., 2003). Certain factors like soil type, space, and climate can affect the watering needs of cherry tomato plants. In addition, using precision irrigation techniques can improve water use efficiency and result in higher fruit yield and quality. Increased plant water stress, whether caused by water deficiencies or reduced osmotic potential in the substrate, increases the incidence of blossom-end rot (Pill and Lambeth, 2022). Greenhouses can reduce the incidence and severity of certain tomato diseases by keeping rainfall off the plants and reducing leaf wetness. Diseases like early blight, Septoria leaf blight, bacterial spot, and bacterial canker are typically less prevalent in greenhouse-grown tomatoes than those grown in open fields (McGovern, 2015). However, greenhouse tomatoes are not free from disease; they have their own set of problems. Greenhouse tomatoes often experience high relative humidity conditions due to the structure's enclosed nature. Under high relative humidity, diseases such as gray mold are more likely to occur (Ho and White, 2005). In addition, greenhouse tomatoes grown in-ground to maturity are often not rotated with another crop, which increases disease pressure. Tomatoes grown in containers to maturity do not have the exact crop rotation requirements. Proper disease management techniques, such as crop rotation, growing environments, certified disease-free plants, and control of environmental conditions such as humidity and temperature, can help reduce the incidence and severity of these diseases (Taylor and Locascio, 2004).

In recent decades, the global agricultural landscape has witnessed a significant shift towards sustainable and controlled cultivation methods, leading to the emergence of greenhouse farming as a prominent solution. Greenhouse cultivation offers various benefits, including enhanced yield, resource efficiency, and protection against adverse environmental conditions (Ajilogba and Babalola, 2013). Among the diverse range of crops grown in greenhouses, cherry tomatoes are a popular choice due to their compact growth habit, vibrant flavor, and high nutritional value. Yet, like any cultivation method, greenhouse environments come with their own set of challenges, especially when it comes to disease management (Ehret *et al*., 2008). Diseases have always been a major threat to agricultural productivity, and their impact is even more pronounced within the controlled environment of a greenhouse. The controlled environment, in terms of shading or netting, provides a favorable atmosphere for crop growth and can also create conditions conducive to the proliferation of various pathogens (Adhikari *et al*., 2017). Factors such as high humidity, limited air circulation, and increased plant density can contribute to the rapid spread of diseases among cherry tomato plants.

Our study introduces a novel and highly significant approach to enhance the disease resistance in cherry tomato cultivars through the strategic integration of microclimate control covers and optimized watering capacities. Environmental conditions can be tailored to reduce pathogen proliferation by harnessing the potential of microclimate control covers. In contrast, precise control over watering capacities ensures that plants receive the ideal moisture levels necessary for robust disease resistance. We carefully regulate watering capacities to give plants the ideal moisture levels for solid disease resistance. This innovative integration has the potential to transform cherry tomato farming practices by improving efficiency, yield, sustainability and have a substantial impact on the larger agricultural landscape.

MATERIALS AND METHODS

Research Location and Time: This research was conducted at the Bale Tatanen Greenhouse, Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency, at an altitude of 685 meters above sea level and Field Laboratory of the Faculty of Agriculture, University of Padjadjaran in Jatinangor from December 2022 – May 2023. The quality parameters were analyzed at the Horticulture Laboratory of the Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency.

Germination/seedling: The seeds of cherry tomato cultivars “Ruby” and “Fortesa” were prepared on germination pot trays. The germination medium was a mixture of compost and fertile soil. The pot tray was according to the treatments of the experiment design. Pot tray germination was stored in the germination room or greenhouse of agronomy, Agricultural Faculty. Universitas Padjadjaran. A seedling is formed once the seed has germinated and developed three or four leaves. The seedlings were planted in a greenhouse, rain shelter, and screen house to grow as treatments of experiment design. The cherry tomato plants were watered by three treatment watering capacities: 100% ETc, 75% ETc, and 50% ETc. All plants were in optimum maintenance.

Microclimate control covers: Covering the rain shelter, screen house, and greenhouse, planting was done in the microclimate control area. The greenhouse's dimensions were 17 meters wide by 24 meters long and 6 meters high. A screen net with a density of 50 mesh was used on the greenhouse walls, while 200 microns of UV plastic material was used on the roof. The rain shelter was 18.5 x 5 x 3.5 meters (length x breadth x height) and had a 200-micron UV plastic cover. Regarding the screen home, a density of 50 mesh screen net was solely covering the roof. The screen house's dimensions (length x width x height) were 15 x 3.5 x 2.8 meters.

Planting Media: The planting medium was husk charcoal and cocopeat, with a ratio of 2:1 (v:v) and was mixed with planting media in a polybag container, then put it in a poly bag.

Application of watering capacity

Solution A	Solution B
KNO_3	$(NH4)_2PO_4$
$Ca\ (NO_3)_2$	$CuSO_4$
Fe	$MnSO_4$
	$ZnSO_4$
	$MgSO_4$
	Mo

A watering was made daily using a nutrient solution AB mixed with the composition solution. A total of 2 liters of Solution A and 2 liters of Solution B were dissolved in 96 liters of water. The nutrient solution was sprinkled on the surface of the planting medium. The difference in the watering capacity was made at the age of the plants 2 weeks after planting (WAP).

The amount of watering capacity was based on plant evapotranspiration (ETc), which was calculated by the Soil Water Balance equation (Liu *et al*., 2019):

$$\mathrm{ETc} = \mathrm{P} + \mathrm{I} - \mathrm{R} - \mathrm{D} - (\mathrm{Wn} - 1 - \mathrm{Wn})$$

Where ETc: evapotranspiration, P: Precipitation (mm), I: Irrigation (volume of water given) (mm), R: Runoff (Surface flow) (mm), D: Drainage (Percolation) (mm), W_{n-1}: Media weight on day n-1 (g), W_n: Weight of media on the nth day (g)

Analyzing tools: Once ANOVA revealed a significant effect, it was continued to the Post hoc test to find out the best treatment partially by Tukey Multiple range comparison test, in comparison LSD has a drawback, it cannot test all treatment combinations (Gaspers. 2006). The Procedure of Tukey (HSD) is as follows:

- Order treatments mean accordingly
- The formula used is as follows:

$$\omega = q_{\alpha}(p, v)\sqrt{\frac{S}{r}}$$

Where: p = treatment amount = t, v = error degree of freedom, r = replication amount, α = confident level, q_{α} (p, v) = critical value obtained from the t-student table.

- Test criteria

Compare the absolute value of two different means that distinguish the differences in HSD score.

If $|\mu_i - \mu_j| > HSD_{005}$, means the test result is significant

If $|\mu_i - \mu_j| < HSD_{005}$, means the test result is not significant

Measurements: Disease (%): Examined each fruit in the experimental sites and counted the Number of fruits showing disease symptoms. For each disease, the same procedure was applied and calculated separately by the formula:

$$\text{Disease (\%)} = \frac{\text{Number of affected fruits}}{\text{Total number of sampled fruits}} \times 100$$

Disease severity stage (Weeks after transplantation): Commencing from the moment of transplantation, each site underwent weekly assessments. An allocated severity rating was determined for each experimental site based on predefined disease severity parameters. A severity scale facilitated the quantification of the desired parameters, typically ranging from 1 (indicating mild) to 5 (indicating severe). The documentation of severity ratings was maintained for each plant at each weekly interval. As the weeks progressed, cumulative data regarding disease severity was systematically collected and analyzed.

Fruit cracking stages (Weeks after transplantation): For fruit cracking data, each sampled tomato for cracks was observed visually. Counted the number of cracked tomatoes each week and averaged.

Diseased fruits (%): A representative sample of tomatoes was collected from various parts of the crop to determine the percentage of diseased fruits per week. After identifying and classifying diseased tomatoes within the sample based on visual symptoms, counted the number of diseased tomatoes.

$$\text{Diseased fruits (\%)} = \frac{\text{Number of diseased fruits}}{\text{Total Number of sample fruits}} \; x \; 100$$

RESULTS

Disease (%): (A) Blossom end rot (%): The results revealed significant (p<0.05) effect of microclimate control on the occurrence of blossom end rot (%). Following the investigation, it was discovered that the number of cases of blossom end rot disease were higher in the screen house designs (14.18%) followed by rain shelter at (11.88%). Whereas the greenhouse had the lowest incidence of blossom end rot disease (8.57%). Whereas the watering capacities and cultivars have no significant effect of blossom end rot disease (%).

(B) Fruit cracking (%): The investigation into microclimate control covers, and cultivars reveals the significant (p<0.05) impact on fruit cracking percentages. Notably, the 'Ruby' cultivar exhibited a higher fruit cracking rate of (14.80%), whereas the 'Fortesa' cultivar displayed a notably lower rate of (7.61%). The results of the microclimate control cover highlight varying susceptibility to fruit cracking. Among the controlled environments studied, the greenhouse exhibited the lowest fruit cracking percentage (8.13%). Following this, the rain shelter demonstrated a slightly higher rate of fruit cracking at (9.45%). In contrast, the screen house displayed the most increased susceptibility to fruit cracking, with a considerable percentage of (16.03%). When considering the influence of watering capacities on fruit cracking percentages, their effect was noticed non-significant.

(C) Pest attack (%) (Tuta absoluta and fruit worm): The impact of various microclimate control covers on pest attack (%) was significant (p<0.05), while the effects of watering capacities and cultivars appear non-significant (p<0.05). The study's outcomes indicate distinct patterns in pest attacks (%) across different control covers. Specifically, the screen house exhibited the highest pest attack percentage, recording a value of 6.57% of the Tuta absoluta, fruit worms. In contrast, the rain shelter experienced a relatively lower pest attack rate of 4.63%. The greenhouse displayed the lowest susceptibility to pest attacks among the controlled environments, with a pest attack percentage of 3.85%.

A) Late blight (%): Microclimate control covers,, and cultivars significantly (p<0.05) impacted the incidence of late blight (%). When the results were analyzed, it became clear that the prevalence of late blight (%) varied significantly (p<0.05) between cultivars. To be more precise, the cultivar "Fortesa" had a greater incidence of late blight (2.39%), while the cultivar "Ruby" had a lower rate (1.60%). The greenhouse had the lowest susceptibility to tomato late blight disease (1.20%), followed by the rain shelter, which had a slightly higher rate (1.87%) regarding the growth environment. The screen house, however, showed the most significant susceptibility to late blight, with an incidence rate of (2.92%). The watering capacities effect was noticed non significant for late blight disease (%).

B) Leaf miner (%): The microclimate control covers and watering capacities significantly (p<0.05) influence the prevalence of leaf miner disease (%), while the type of cultivars has a non-significant impact (p<0.05). Among the control covers studied, the greenhouse exhibited the lowest incidence of leaf miner disease, with a rate of 5.87%. Following closely, the rain shelter environment showed a slightly higher prevalence at 7.73%, whereas the screen house experienced the most heightened susceptibility to leaf miner disease, with a recorded rate of 9.35%. Plants irrigated with 100% ETc showed the most minor vulnerability to leaf miner disease (%), with a notably low incidence of 5.13%; plants receiving 75% of ETc showed a significantly higher risk of 7.62% for the leaf miner disease. However, plants exposed to 50% ETc showed the most substantial effects, with a rate of leaf miner disease that was 10.20% higher.

C) Fusarium oxysporum (%): The microclimate control covers, and watering capacities significantly (p<0.05) influence the presence of *fusarium oxysporum* (%), a concerning pathogen causing fusarium wilt. When examining the impact of these factors, it was evident that the greenhouse demonstrated the least prevalence of fusarium wilt by *fusarium oxysporum*, with an incidence rate of 5.33%. Following suit, the rain shelter environment displayed a slightly higher rate at 5.72%. Conversely, the screen house environment was most severely affected, showing a notable susceptibility to *fusarium oxysporum* with a recorded rate of 7.65%. Regarding evaluating the effects of various watering capacities on *fusarium oxysporum* (%), it was discovered that plants getting 100% of crop ETc demonstrated the lowest vulnerability at 5.48%. Similarly, plants that received irrigation from 75% ETc showed a slightly higher rate of 5.75%. However, the infection incidence for plants exposed to 50% of ETc was

7.47%, indicating a markedly increased vulnerability to *fusarium oxysporum*.

Severity stage (Weeks after transplantation): The progression of disease severity stages, determined weeks after transplantation, is significantly (p<0.05) influenced by the arrangement of control covers, watering capacities, and cultivar selection. The ruby cultivar showed an earlier manifestation at 7.11 weeks after transplantation, unlike the fortesa cultivar, which showed a delayed disease severity beginning at 8.89 weeks post-transplantation. Different growing strategies also produced distinctive patterns in disease severity stages. Notably, disease severity stages started manifesting in the greenhouse environment 9.17 weeks after transplantation. In contrast, the disease severity stages were displayed under the rain shelter designs at roughly 8.17 weeks after transplanting. Interestingly, disease severity stages started manifesting in the screen house environment at 6.67 weeks after transplantation. Specifically, a disease severity stage was observed as early as seven weeks after transplantation in plants receiving 50% of the crop evapotranspiration (ETc). Conversely, disease severity stages later emerged around 8.50 weeks after transplantation in the 100% ETc and 50% ETc watering scenarios.

Fruit cracking stages (Weeks after transplantation): The arrangement of control covers and the selection of cultivars hold considerable (p<0.05) influence over the progression of fruit cracking stages. Watering capacity was discovered to have a negligible effect in this case. The fortesa cultivar showed a little delayed manifestation at 10.22 weeks after transplantation, but the ruby cultivar showed an earlier commencement of fruit cracking stages at 8.78 weeks after transplanting. Notably, fruit cracking stages appeared later in the greenhouse setting and first appeared about 10.50 weeks after transplantation. In contrast, the evolution was slightly faster under the rain shelter environment, with fruit cracking phases beginning about 9.50 weeks after transplantation. Intriguingly, the screen house environment exhibited an even earlier onset of fruit cracking stages, observed at 8.50 weeks post-transplantation.

Diseased fruits (%): The progression of diseased fruits is significantly (p<0.05) influenced by the cultivars, watering capacities, and microclimate control covers. The ruby cultivar showed more manifestation at 17.62%, while the fortesa cultivar showed a lower percentage of diseased fruits at 14.57%. Different growing structures also produced distinguishing patterns in diseased fruit parameters. Notably, diseased fruits manifesting in the greenhouse structure were lower by 12.85% compared to rain shelter by 15.52% and screen house having more diseased fruits by 19.92%. The percentage of infected fruits changed according to crop evapotranspiration (ETc) levels. Over 18.03% of the fruits on plants that got 50% of ETc were diseased. Under ideal circumstances with 100% ETc, the incidence of diseased fruits dropped even further to 14.47%. At 75% ETc, the percentage of defective fruits was slightly lower at 15.78.

Table 1. The table presenting critical F-value for determining the significance of these findings and offers insightful information about how these variables affect the fruit's general quality and the plant's health.

	Studied parameters								
Source	Blossom end rot (%)	Fruit cracking (%)	Pest attack (%)	Late blight (%)	Leaf miner (%)	Fusarium oxysporum (%)	Severity stages (WAT)	Fruit cracking (WAT)	Diseased fruits (%)
Cultivars (C)	7.31	45.20**	3.34	8.95*	0.05	2.51	22.26**	42.25**	18.07*
Microclimate control covers (MC)	40.95**	20.89**	46.31**	14.35*	14.74*	12.41*	14.87*	27.00**	32.86**
Watering capacities (WC)	4.07	6.02	0.05	4.98	31.13**	9.32*	7.04*	0.75	8.39*
C x MC	2.96	0.93	1.51	0.16	2.31	2.98	1.65	1.00	0.21
C x WC	1.14	1.12	0.12	1.31	0.76	1.19	1.65	1.75	0.33
MC x WC	3.37	0.22	0.57	0.56	6.15	2.71	0.39	0.75	0.31
C x MC x WC	0.38	0.81	0.51	1.21	1.59	1.29	0.24	0.71	0.43

F-critical values based on Significancy (p<0.05). *, significant at P≤0.05; **, significant at P≤0.01.

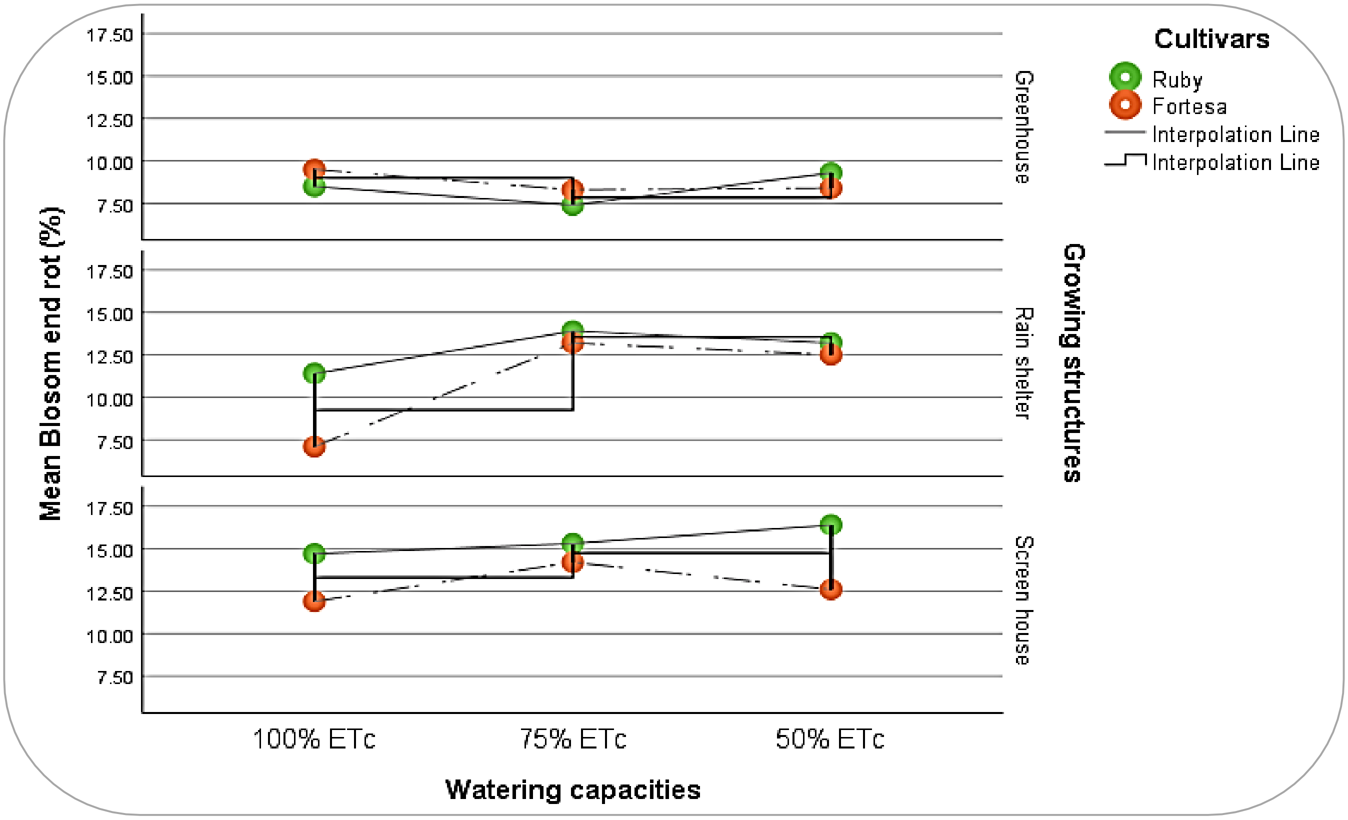

Figure 1. Mean blossom end rot (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

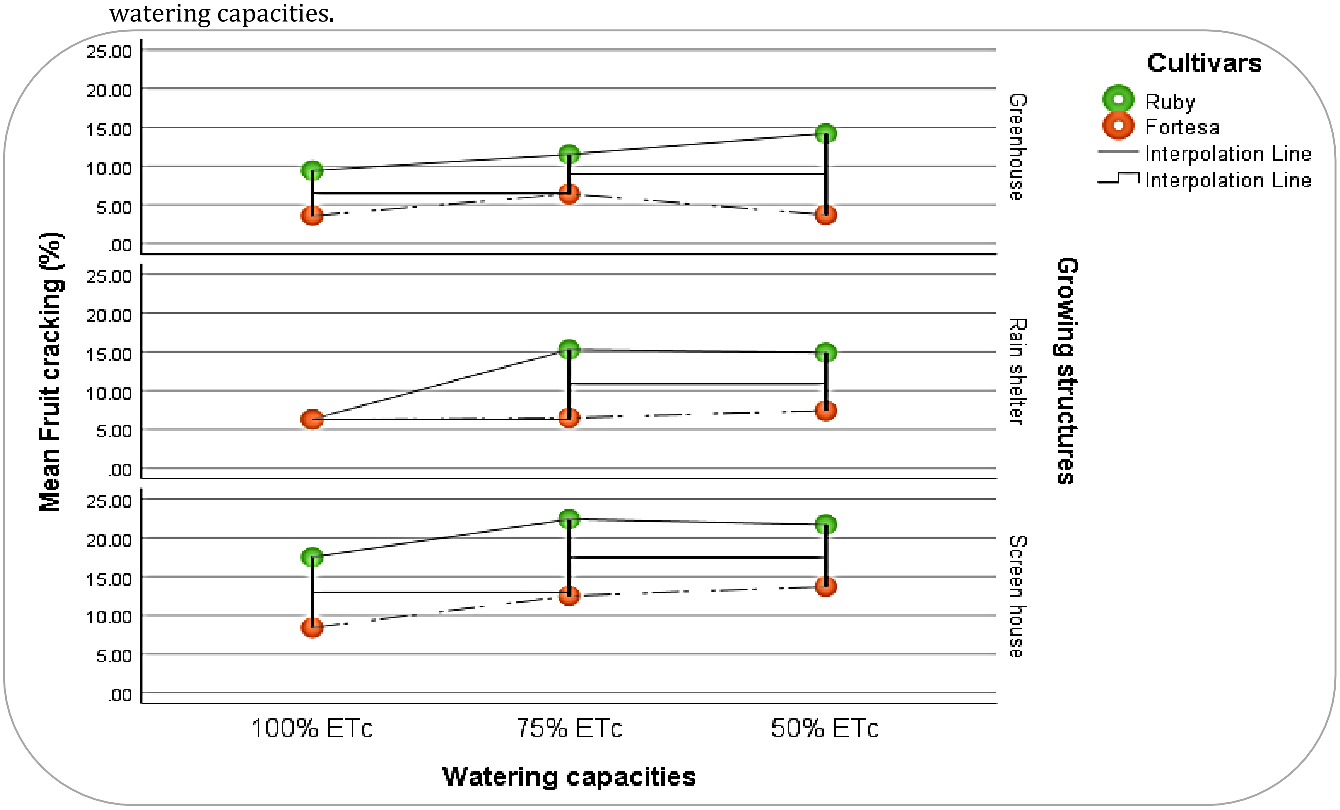

Figure 2. Mean fruit cracking (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

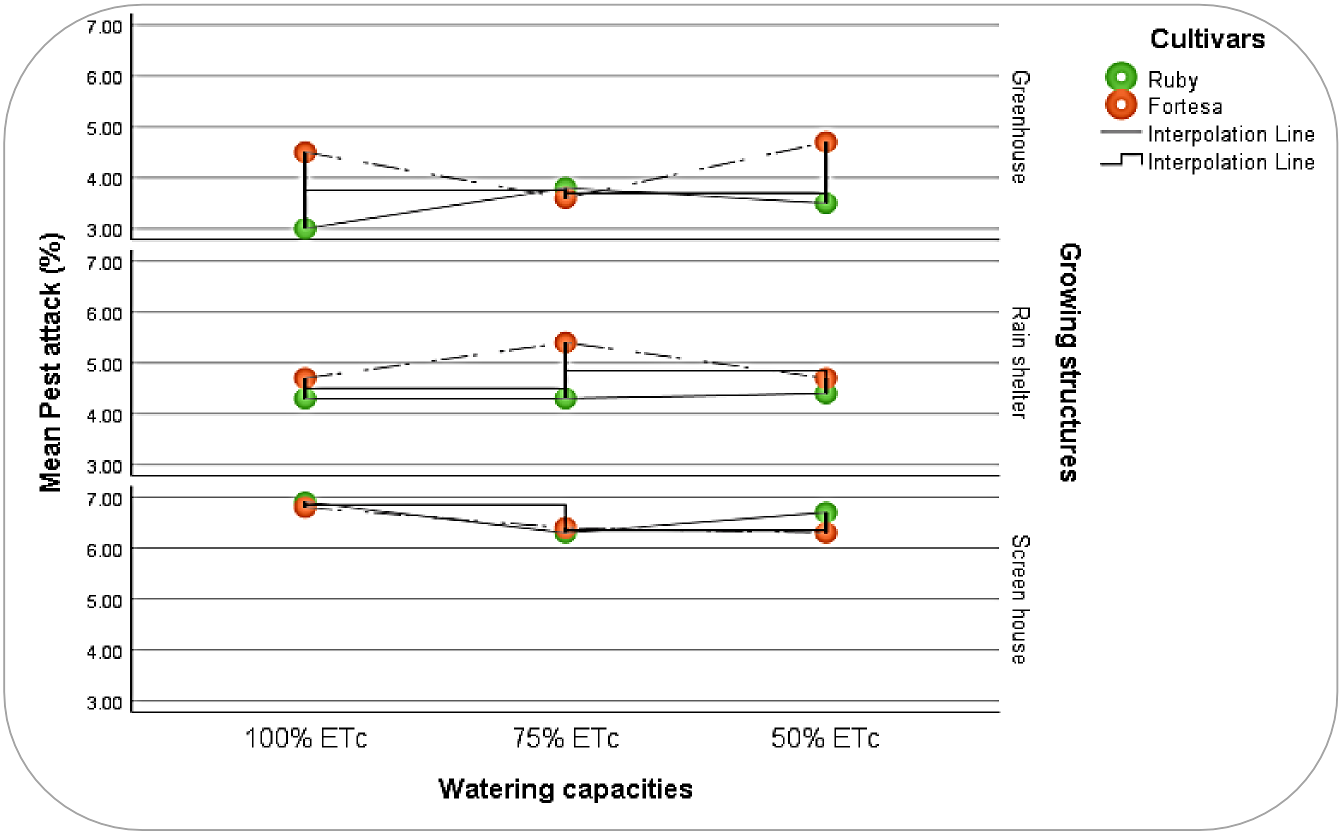

Figure 3. Mean pest attack (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

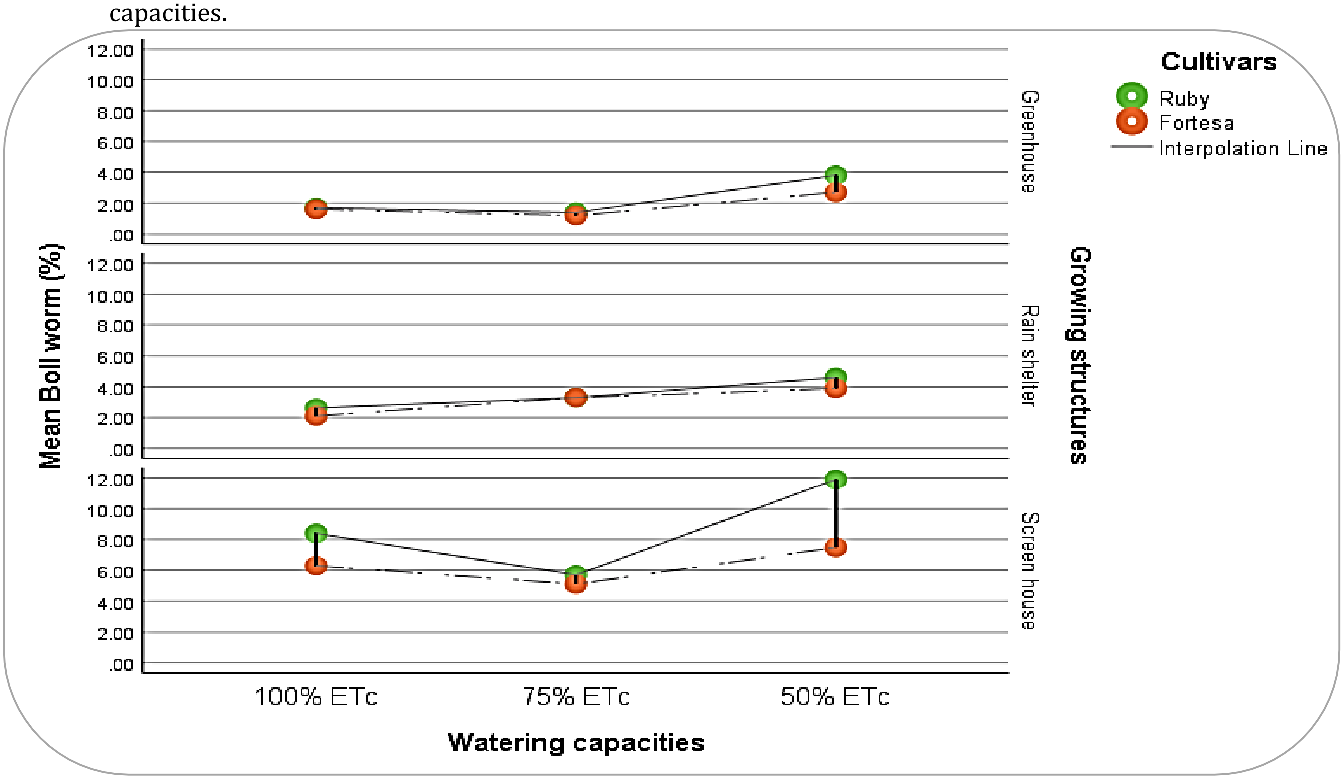

Figure 4. Mean bollworm (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

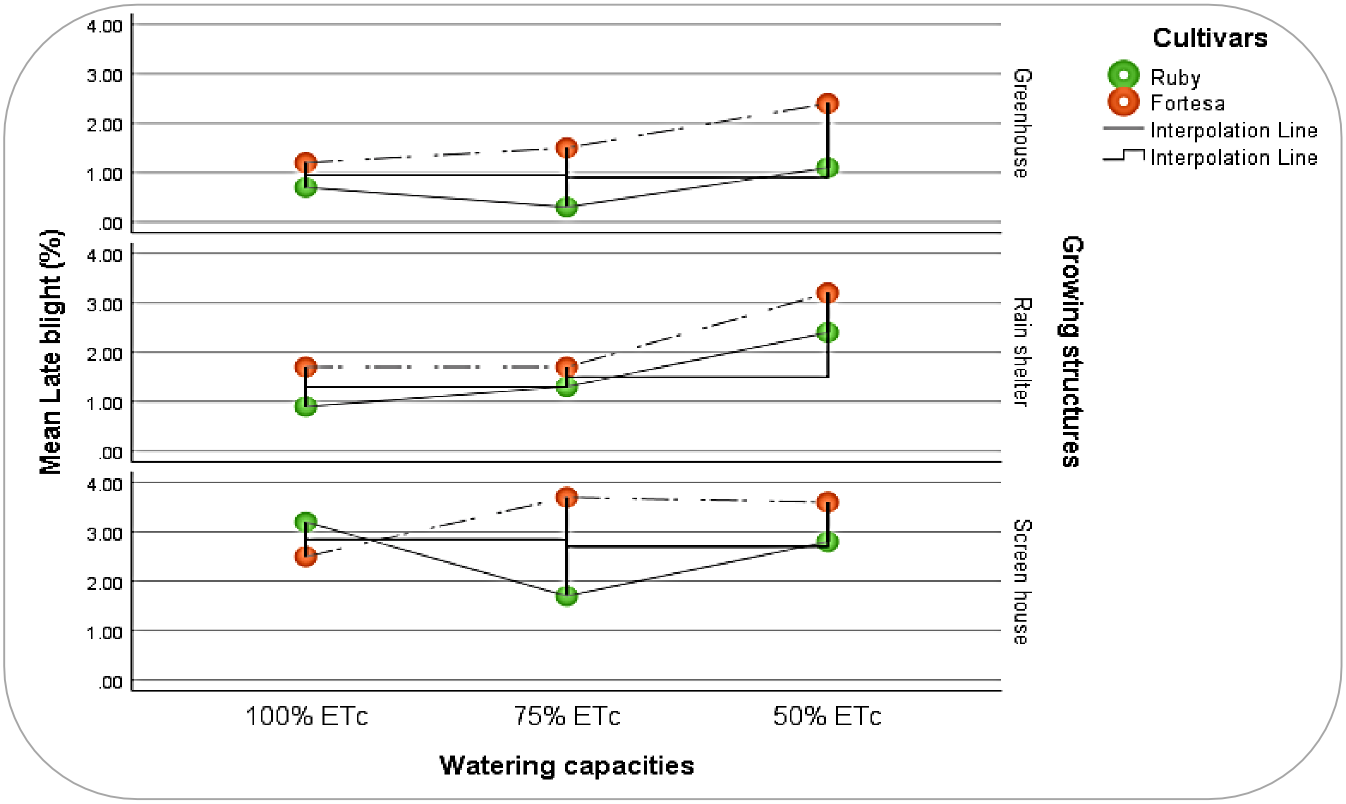

Figure 5. Mean late blight (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

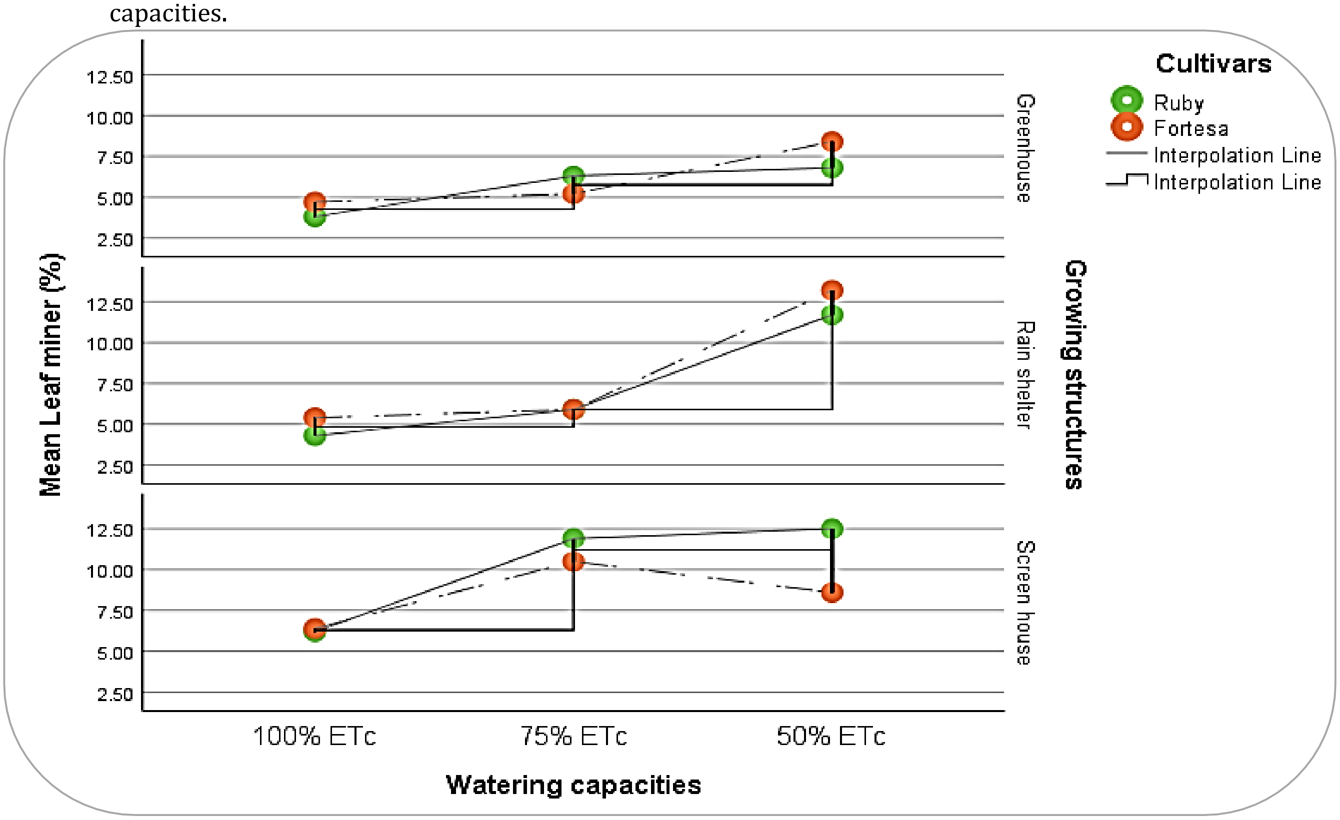

Figure 6. Mean leaf miner (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

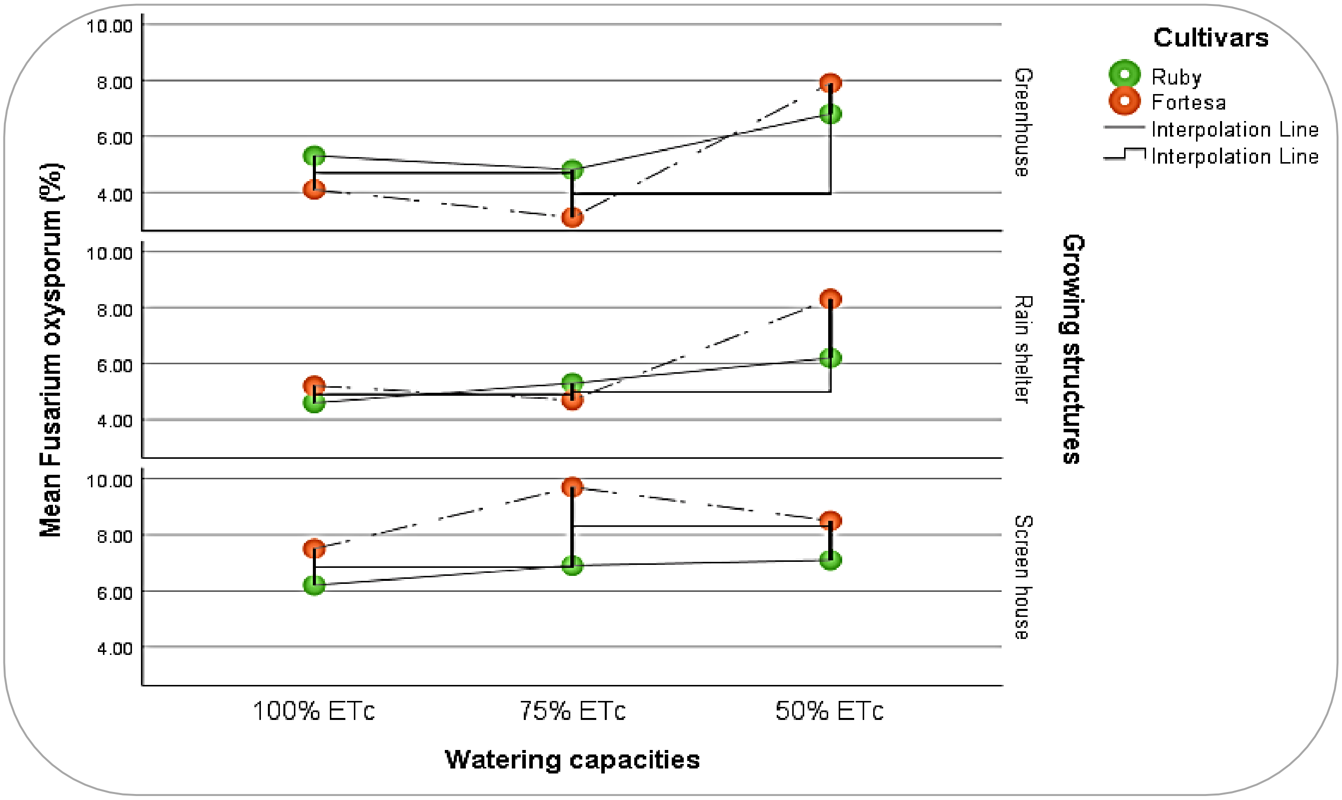

Figure 7. Mean fusarium oxysporum (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

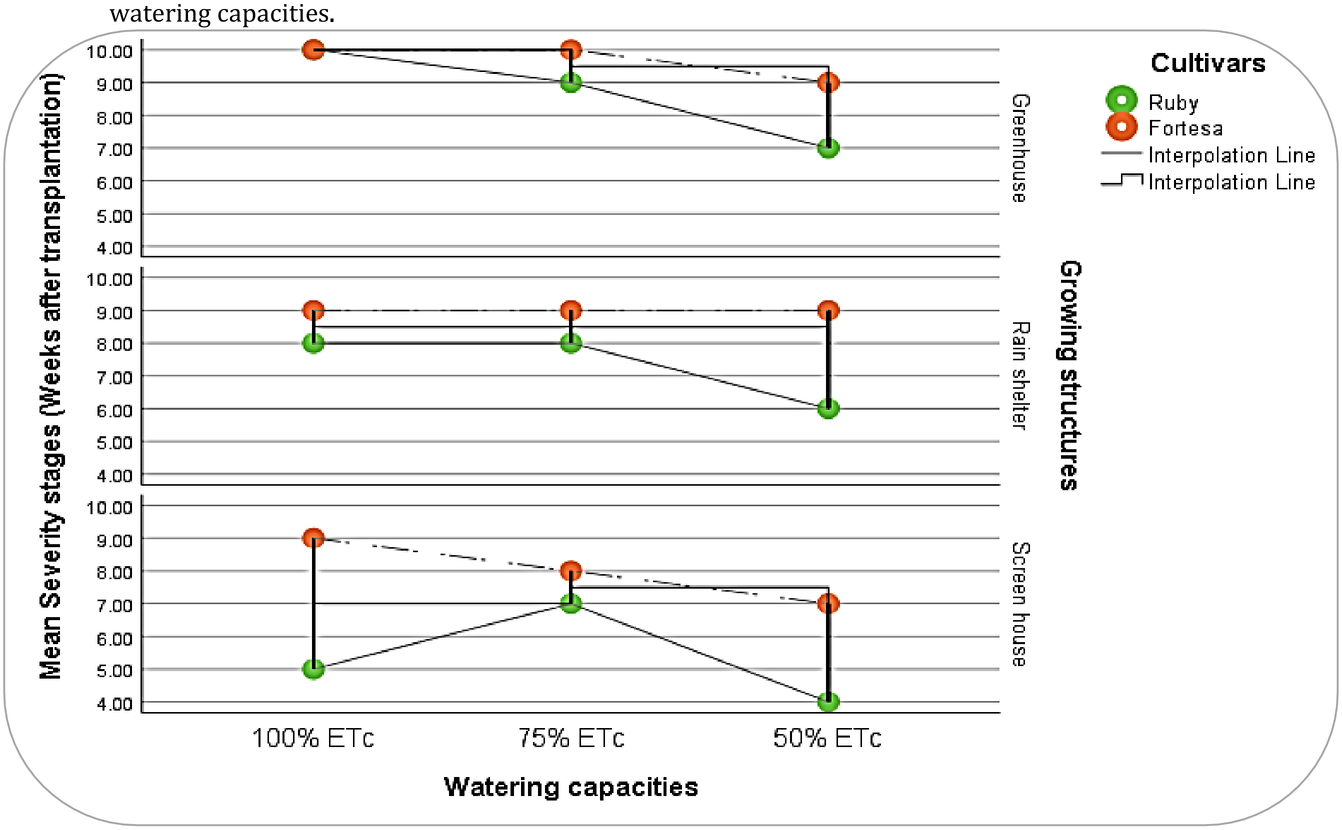

Figure 8. Mean severity stages (weeks after transplantation) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

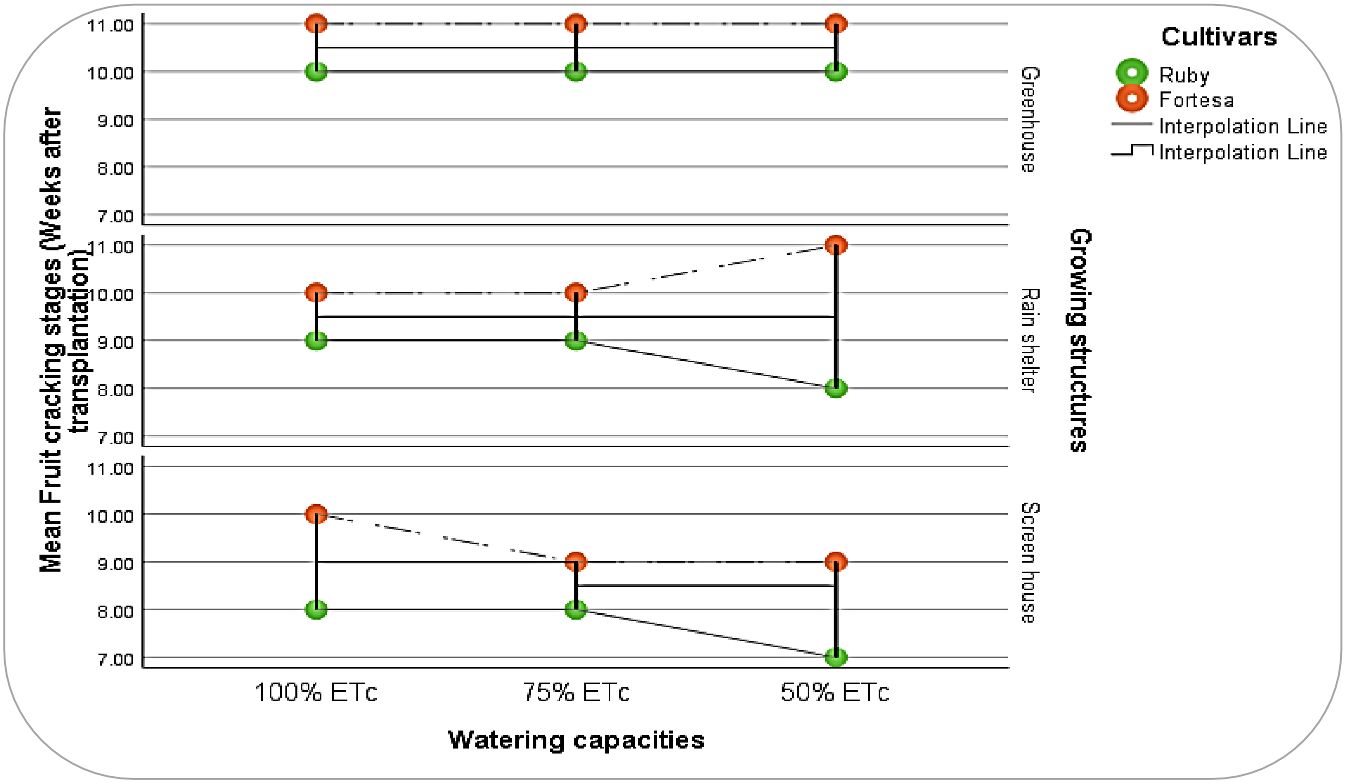

Figure 9. Mean fruit cracking stages (weeks after transplantation) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

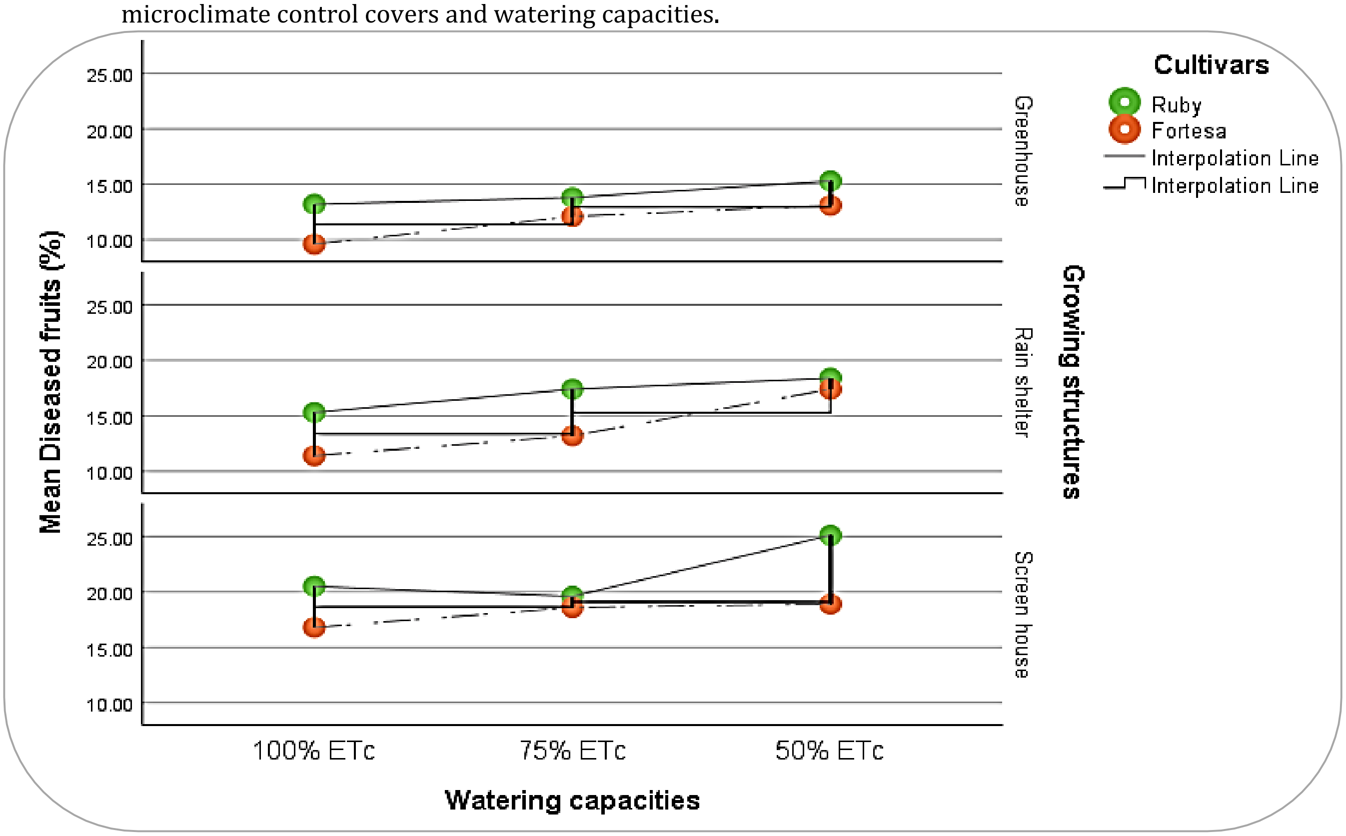

Figure 10. Mean diseased fruits (%) in cherry tomato cultivars under the study of microclimate control covers and watering capacities.

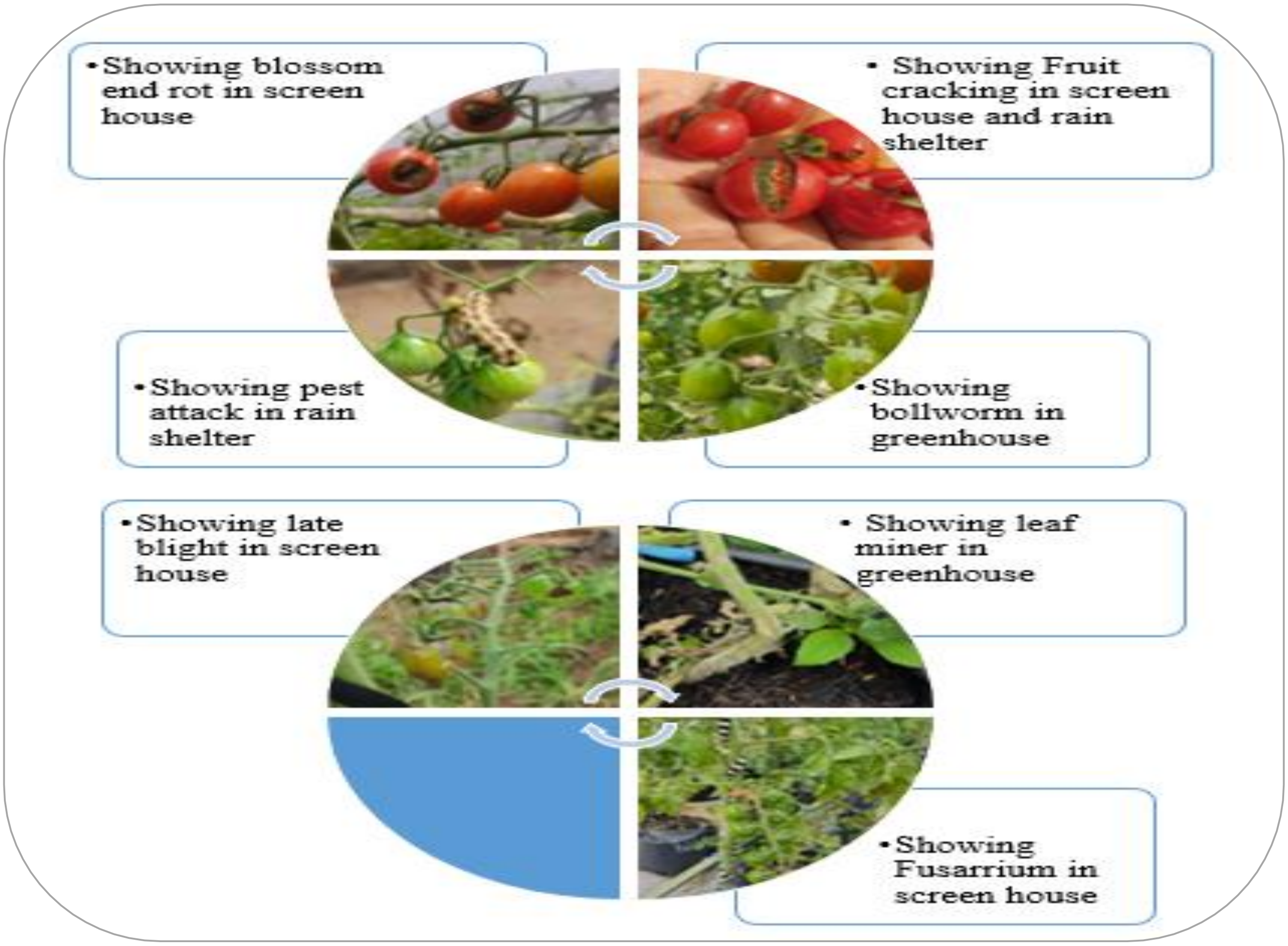

Figure 11. Showing disease symptoms in experimental sites

DISCUSSION

Blossom end rot was heavily influenced by microclimate control; screen house designs and rain shelters had greater disease occurrences than greenhouses, while cultivars and irrigation capabilities had no apparent effect. The higher screen house disease incidence rates are attributed to several harsh factors in such microclimate (Peters *et al.*, 2011). Screen houses have limited control over environmental conditions, including temperature and humidity, which create a more favorable environment for disease vectors and pathogens. These conditions have inadequate ventilation, leading to poor air circulation and increased moisture levels, conducive to disease development (Oladokun *et al.*, 2019). The screen house had the largest percentage of pest attacks, the rain shelter had a lower rate, and the greenhouse showed the lowest vulnerability. Watering capacities and cultivars had no discernible impact on pest attacks. Because screen houses lack physical barriers, external pests and diseases can more easily injure plants, resulting in stunted growth and production loss from early-stage insect attacks on tomato plants (Lai *et al.*, 2018). Greenhouses typically provide better control in microclimate, creating a more controlled and disease-resistant environment for plant growth (Zhu *et al.*, 2021). The "Fortesa" cultivar was more susceptible than the "Ruby" cultivar; the screen house exhibited the highest susceptibility to late blight; watering capacities had no discernible impact on the disease incidence. It is important to carefully select the appropriate structure for agricultural practices, as it significantly impacts disease incidence and crop yield (de Oliveira *et al.*, 2021). Screen houses typically lack sophisticated microclimate systems for the ideal growing of cherry tomatoes to overcome the incidence, making it challenging to maintain the perfect conditions for crop health (Ho and White, 2005). While 100% ETc irrigation produced the lowest vulnerability, 75% ETc had a significantly higher risk, and 50% ETc had the most increased susceptibility to leaf miner disease, the greenhouse had the lowest incidence, the rain shelter showed a slightly higher susceptibility, and the screen house was the most vulnerable. Fluctuations in temperature and humidity stress plants, weakening their immune systems and making them more susceptible to leaf miner. The absence of precise irrigation control in such structures leads to overwatering or under-watering, further exacerbating the risk of diseases like root rot, leaf miner and fungal infections (Carisse and Heyden, 2015). Reduced irrigation increases plants' water stress, making them more vulnerable to various stress-related diseases and pests. Fusarium oxysporum was found to be significantly influenced by microclimate control covers and watering capacities. The screen house was the most affected. Whereas 100% ETc irrigation produced the lowest vulnerability, 75% ETc had a slightly higher rate, and 50% ETc had the highest susceptibility. Inadequate watering results in poor nutrient uptake, affecting overall plant health and resilience against diseases (Amalero *et al*., 2003). Fluctuations in soil moisture levels associated with lower watering volumes encourage the proliferation of fungal pathogens, such as Fusarium oxysporum, and increase the attractiveness of plants to pest infestations (Ibrahim *et al*., 2016). The regulated microclimate in screen houses reduce the time plants are exposed to environmental stressors, lowering their capacity to build disease resistance (Szuvandzsiev *et al*., 2014).

The screen house exhibited the highest susceptibility among microclimate control conditions, with the 'Ruby' cultivar being more susceptible and the 'Fortesa' cultivar displaying reduced susceptibility. The variation may cause the fruit to absorb water quickly, creating internal pressure that exceeds the elastic limit of the skin and resulting in breaking. Such cultivars have genetic traits that make them more prone to cracking and may undergo faster fruit development, leading to earlier cracking. Variations in these designs' susceptibilities to fruit cracking may also be influenced by differences in temperature and airflow, with screen houses encountering more severe circumstances that hasten cracking. Ibrahim *et al*. (2016) claimed that excessive amounts of water caused a rise in fruit weight, which led to larger fruit cracking. Cultivar susceptibility to diseases can vary, with some cultivars having genetic traits that make them more vulnerable to particular pathogens. Following transplantation, control cover arrangements, and cultivar selection have a significant impact on the progression of disease severity and fruit cracking stages. The ruby cultivar exhibits earlier disease severity and fruit cracking onset, while the screen house environment shows the earliest development of both stages. Environmental conditions and cultural practices influence disease prevalence. The open design of the growing makes it easier for infections brought by wind, insects, or other vectors from the environment to enter (Singh *et al*., 2020). The ruby cultivar is more prone to disease, and the disease levels vary with crop evapotranspiration, peaking at 50% ETc and decreasing at 100% ETc. Various growing structures also impact disease rates. Plants are more likely to undergo water stress when they only receive 50% of their ETc, which weakens their immune systems thereby producing fruits infected most of diseases. Because they are less able to create molecules that can defend against infections, plants under water stress are more prone to disease. A higher water supply improved fruit yield, but a higher number of cracked fruits raised the non-marketable yield (Szuvandzsiev *et al*., 2014).

CONCLUSION

The findings highlight the critical role that specialized farming methods play in reducing crop losses and raising yield. The disease susceptibility is significantly influenced by cultivar selection. The "Ruby" cultivar repeatedly showed greater exposure to various diseases, especially fusarium oxysporum, fruit cracking, and blossom end rot. In contrast, the "Fortesa" cultivar showed lesser susceptibility, highlighting the potential for cultivar selection as a disease management method. Various microclimate control coverings have proven to be more effective in preventing disease. The environment in the greenhouse was the most protective, with a lower frequency of fruit cracking, blossom end rot, pest infestations, and viral infections. On the other hand, the screen house consistently showed the highest disease susceptibility, emphasizing the need to evaluate growing structures to reduce disease risks carefully. It was discovered that irrigation capacity was crucial for disease management. The prevalence of several diseases were consistently lower in plants that received 100% of the projected crop evapotranspiration (ETc). This shows that ensuring proper soil moisture through careful irrigation lowers the risk of disease.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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DATA AVAILABILITY

Data presented in this study will be available on a fair request to the corresponding author

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