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Effects of Climate Changes on Rose Fungal and Bacterial Diseases in Landscape Areas of Konya Province, Türkiye

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ABSTRACT

Rose, a plant belonging to the family Rosaceae, is one of the most popular and versatile flowering shrubs in urban landscape areas. In recent years, rose bacterial diseases are getting to increase and they cause significant economic losses. The severity and distribution of these problems change every year according to the changing climatic factors, growing areas, the type of roses and the level of being affected by biotic and abiotic factors. In this study, on the 106 rose cultivars located in landscape areas of Konya province was determined different diseases symptoms at various levels by carried out survey studies in 1998-2022 years. As a result of the diagnosis of obtaining bacterial and fungal isolates, bacterial blights (*Pseudomonas syringae* pv. *syringae* and *P. s.* pv. *morsprunorum*), *Xanthomonas hortorum*, fire blight (*Erwinia amylovora*) and crown gal (*Rhizobium radiobacter*), downy mildew (*Peronospara sparsa*), rust (*Phragmodium mucronatum*), black spot (*Diplocarpon rosae*), powdery mildew (*Sphaerotheca pannosa* var. *rosae*), gray mold (*Botrytis cinerea*) were determined as the pathogen on the rose cultivars. It is thought that the findings obtained from the study will contribute to the future development of rose cultivation by revealing the different pathogens and disease levels in roses as a result of the changing climatical conditions.

1. Introduction

The rose (*Rosa* spp.) is often called the "Queen of Flowers" and is the world's most popular garden and landscape plant. Many rose cultivars are susceptible to a range of pests, diseases and environmental influences that reduce their value in use. Most of the biotic and abiotic problems affecting roses are closely related to climatic conditions (Ross, 1985). It is known that some rose varieties are naturally more resistant to certain pests and diseases than others (McLeod, 2002).

Important fungal and bacterial diseases seen in roses used in landscape areas and for cut flower cultivation, downy mildew (*Peronospara sparsa*), rust (*Phragmodium mucronatum*), black spot (*Diplocarpon rosae*), powdery mildew (*Sphaerotheca pannosa* var. *rosae*), gray mold (*Botrytis cinerea*), fungal wilt (*Verticillium* spp.), crown gal (*Rhizobium radiobacter*), bacterial blight (*Pseudomonas syringae* pv. *syringae* and *Pseudomonas syringae* pv. *morspurunorum*), bacterial wilt (*Ralstonia solanacearum*), fire blight (*Erwinia amylovora*), bacterial canker (*Xanthomonas hortorum*) can cause significant economic losses. The severity and distribution of these problems changes every year according to climatic factors, growing areas and type of roses (Douglas, 2022).

Climate change is one of the most important environmental problems of our time. Plant growth and yield are significantly affected by high atmospheric carbon dioxide concentration, temperature, changes in precipitation regime and extreme weather phenomena. In addition, climate change; human-induced processes such as pollution of air, water and soil, along with factors such as long-distance transport of exotic species and urbanization, will further affect plant diseases. These factors will contribute to the rapid spread of diseases. Temperature affects many life chains in the disease cycle of many pathogens, such as survival, spread, penetration, development and reproduction. In general, the increase in temperature facilitates the wintering of pathogens, increases their productivity, accelerates population development, increases the ability to cause disease, and allows them to spread over wide geographical areas by providing better spread. Increasing temperature increases spore germination especially of rust fungi. It has also been reported to cause an increase in some leaf spot diseases. Temperature also plays a vital role in the

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localization of some bacterial diseases. Bacterial infections can be seen to start in places where temperature-related diseases are not seen. High humidity creates favorable conditions for the development of many foliar diseases and soil-borne fungal pathogens. High CO_2 concentration results in better reproduction of fungal spores. As the increased CO_2 increases photosynthesis, it reduces the plant's use of water effectively and ozone damage. Therefore, with the increase of CO_2, plant growth and yield increase. In addition, physiological changes in the host plant cause an increase in host resistance against the pathogen. In general, the effect of increased CO_2 concentration on plant diseases can be positive or negative, but in most cases it increases disease severity. Disease development is the cumulative result of host and pathogen influencing factors. Microbial populations and control agents affect the plant-pathogen relationship. The effects of climate change may differ in different plant-pathogen systems. Due to the changing climatic conditions, plants need more pesticide applications (Akbaş, 2018).

As the world becomes warmer and climate events stronger, we need roses that can perform well in the garden and landscape. For this reason, in our trials, which were initiated to determine the disease levels of different rose varieties in areas and regions with different climatic characteristics, the situation for the last 24 years in roses grown under the conditions of the Central Anatolia Region was first revealed. It is aimed to contribute to the future development of rose cultivation by revealing the findings obtained from the study, the pathogens and disease levels that differentiated in roses as a result of the changing climate crisis.

2. Material and Metot

2.1. Plant Material

The rose varieties that have been grown in the landscape areas of Konya province in the last 24 years and examined in the survey studies for disease detection are given in Table 1.

2.2. Isolation and identification of bacterial and fungal pathogens

The roses showing disease symptoms were taken together with their branches, flowers and leaves, and isolated on nutrient agar (NA), King B (KB) media for identification of the bacterial agents. The isolates were stored at -20 °C until identification. Bacterial diagnostic tests, biochemical, morphological, physiological and molecular, were made according to Kovacs, 1956, Thornley, 1960, Klement et al., 1963, Lelliot and Stead, 1987; Klement et al., 1990; Bouzar et al., 1995; Schaad et al., 2001. In addition, the isolates were analyzed by MALDI-TOF MS technique.

Also, leaf, branch, shoot and stem samples were also taken for fungal agents and isolated on potato dextrose agar (PDA) medium (Warcup, 1958). Developed colonies were transferred to petri dishes containing fresh medium and pure cultures were obtained. All isolates taken from here to the skewed agar in tubes were examined microscopically and their microscopic diagnoses were made according to Barnett and Hunter (1972).

2.3. Pathogenicity tests of bacterial and fungal isolates

Pathogenicity tests were performed on Zwergenfee rose cultivar in 4 year-old according to Lelliot and Stead, 1987, Nameth et al., 1999 for the bacteria and Cai et al., 2009; Talgø and Stensvand, 2013; Li et al., 2017 for the fungi. Evaluations were made taking into account typical disease symptoms 30 days after inoculations.

2.4. Soil structure in landscape areas of Konya province

The results of the analysis of the existing soils in the landscape areas of Konya province are given in Table 2.

Accordingly, the soils where roses are grown are clay loam or loamy, alkaline, poor in organic matter, and chalky. These soils do not pose a problem for rose cultivation.

2.5. Meteorological characteristics of Konya province

In Konya province, summers are warm, dry and clear, and winters are very cold, snowy and partly cloudy, and the temperature varies between -4 and 31 °C throughout the year. The warm season is 3.3 months long and the hottest month is July; the highest temperature in this month is 30 °C and the lowest temperature is 17 °C. The cold season is 3.4 months long and the coldest month is January; In this month, the average low temperature is -4 °C, while the high temperature is 4 °C. The rainy season in Konya lasts for 7.8 months, from October 12 to June 7, and the rainiest month is December, with an average precipitation over 37 mm. The dry season starts on June 7 and the month with the least rain is August with an average of 0.8 days and at least 1 mm of precipitation (Table 3).

3. Results and Discussion

From past to present, roses are one of the most popular plants, not only for ornamental or aesthetic purposes, but also for religious, social, economic, health and cultural purposes, in short, they have an important place in our daily lives. In terms of their use, roses are not only indispensable for indoor spaces, but also have great importance in landscaping, garden art, plastic and phonetic art (Altıntaş, 2010; Quest and Ritson Quest, 2003; Özçelik and Orhan, 2014).

There are very few studies on the detection, prevalence and diagnosis of bacterial diseases in roses. Aysan and Şahin (2003) reported that *R. radiobacter* caused an epidemic in roses in the Eastern Mediterranean Region in the early 2000s in our country. Examining 6 different rose greenhouses in Adana and Mersin provinces, they observed that approximately 40% of them formed galls. Depending on the age and variety, seedling losses in rose varieties in rose nurseries in Kenya vary between 5% and 60% due to *R. radiobacter* (Maina et al., 2011). Tumor symptoms caused by *R. radiobacter* are frequently encountered worldwide on roses (Gümrükçü and Gölkçü, 2005). Mohan and Bijman (2010) detected *P. s.* pv. *syringae* and *P. s.* pv. *morspurunorum* in their study on roses. Pernezny et al. (2008) investigated the susceptibility of rose cultivars against *Xanthomonas* spp. and reported that RADrazz and RADtco cultivars were more susceptible to the disease. In the province of Konya, *E. amylovora* was detected in different hosts belonging to the Rosaceae family at a rate of 67% in fire thorn, 100% in medlar, 80% in hawthorn and 27% in ornamental apple (Atasagun and Bastas, 2018). *E. amylovora* from *Rosa rugosa* has been isolated from Dachau and Miesbach in southern Germany (Vanneste et al., 2001). The Dutch Food Safety Authority observed symptoms of *Ralstonia solanacearum* on roses grafted on potatoes (Anonymous, 2015).

When the climatic data of the years 1998-2022 during the collection of roses showing symptoms of disease from the landscape areas of Konya province are examined, the monthly average maximum temperature increased from 18.49 °C to 20.28 °C and, the monthly total precipitation decreased from 32.30 to 25.92 (mm=kg). ÷m²). When these climatic data were examined in terms of the development criteria of pathogens, it showed that suitable environments for some new pathogens were formed (Table 4).

In our study, landscape roses were scanned in 106 different rose varieties in landscape areas in 298 different regions in Konya province between 1998-2022. Isolations were made from plants with wilting, yellowing, shoot blight, leaf spots, gall formation, root collar blight, discharge on roots and stems, swellings, flower blight, stem cracks and scar tissue on roses. After morphological, biochemical and molecular identification and pathogenicity tests, fungal and bacterial pathogens were identified for the last 25 years (between 1998 and 2022) are presented in Table 5.

Climatic changes are highly influential on host susceptibility or resistance to pathogens. As a result of climatic changes, about 250 new disease records have been created in ornamental plants and pathogens cause a serious problem (Waage et al., 2007). Another factor affecting plant health is the increase in the amount of CO_2. Increasing air pollution reduces the resistance of the plant and makes the plant susceptible to pathogens (Davies et al., 2011).

There is a dynamic relationship between plant diseases and regional climate and flora. Therefore, in order for phytopathogens to multiply and spread, the environment, host and pathogen must coexist under suitable conditions. Along with climate change, changes in air temperatures and seasonal extremes will cause new pathogens to disperse to different locations that will affect the spread of the pathogen, and will lead to changes on the epidemiology of many phytopathogens (Chakraborty and Newton 2011; Garret et al. 2011). Climatic factors, especially temperature, are important for the development of fungal and bacterial pathogens, and any change in temperature during the developmental stages of the pathogen affects the severity of infection and the duration of the pathogen to maintain its viability in the soil (Vary et al., 2015).

Temperature, humidity, precipitation and other factors affect the spread of the agents (Patterson et al. 1999). The increased amount of CO_2 will encourage vegetative development in plants; It will increase the moisture density between the leaves and this will cause rust, powdery mildew, cancer, bacterial exudate, leaf spots, blight symptoms on leaves, shoots and flowers (Manning and Tiedemann, 1995).

With the climate change, the moving of the areas where the plants spread to different locations causes the phytopathogens to be carried along with them (Cammel and Knight, 1992). Irregularities in precipitation regimes cause delays in the harvest date, and problems in pollination when it coincides with the flowering and pollination period. Due to prolonged rainfall, the moisture content in the leaves and soil increases, creating a suitable environment for plant pathogens (Anonymous, 2008).

As a result of unconscious irrigation in the areas where roses are planted, which need water in increasing hot weather conditions and dry conditions, the moisture rate in the leaves and soil increases, and accordingly, there is an increase in fungal and bacterial diseases in increasing intensity and in different species.

Disease prediction models based on meteorological data can help identify meteorological factors that are significantly associated with disease. Such disease prediction models can be combined with a general modeling to simulate future scenarios of disease outbreaks, although general epidemic models operate at larger resolution scales.

Considering the adverse environmental conditions due to climate change, this research can be a guide source because it is the first study thought to be done for fungal and bacterial diseases in roses. Our study, which was carried out by considering the differences on the basis of varieties, was carried out in the climatic values and soil characteristics of Central Anatolia. Disease development in rose varieties should be examined in other regions and countries similar to the climatic values in Konya conditions. In addition, preventing varieties that are sensitive to changing climatic conditions and disease factors from causing problems in terms of both visuality and cost necessitates the use of resistant varieties or the breeding of new rose varieties

Table 1
Rose varieties examined in terms of diseases in the landscape areas of Konya province

1	Abracadabra	28	Crimson F.c	55	Larissa	82	Rosenstadt Freising
2	Afrodit	29	Cubana	56	Lavender F.c	83	Rugelda
3	Alexandra	30	Diamant	57	Lemon F.c	84	Salita F.c
4	Amore F.c	31	Dornröscheschloss Sababurg	58	Lions Rose	85	Sangerhauser
5	Andolusian	32	Escimo F.c	59	Marango	86	Solero
6	Angel F.c	33	Flaming F.c	60	Mariandel	87	Sunbeam F.c
7	Angela	34	Foxy F.c	61	Memoire	88	Sunny
8	Apricot F.c	35	Garten Spass	62	Nicole	89	Tatiana
9	Bad Birnbach	36	Gebrüder Grimm	63	Patricia	90	Valencia
10	Bad Wörishofen	37	Gerber Engel	64	Pepita	91	Vulcano F.c
11	Blush F.c	38	Jugendliebe	65	Petticoat	92	Zwergenfee
12	Brillant	39	Königin Der Rosen	66	Planten Un Blomen	93	Sevillana (Meillant)
13	Cheryy Girl	40	Mon Petit Chou	67	Pompenella	94	Bahçe Gülü
14	Chica F.c	41	Neue Revue	68	Queen Of Hearts	95	Beverly
15	Cinderella	42	Champs Elysees	69	Romantic Antike	96	Lynda
16	Esmeralda	43	Reve De Paris	70	Adolf Horstmann	97	Laguna
17	Grafin Diana	44	Rayon De Soleil	71	Bingo Meillandecor	98	Eden Rose
18	Zepeti	45	Scarlet Bonica	72	Popcorn Drift	99	Donatella
19	Frıendly	46	Creme Chantilly	73	Cherry Bonica	100	Meryem
20	Pretty	47	Pink Double Knock Out	74	Sophia Romantica	101	Picasso
21	Livia	48	Double Knock Out	75	Abbaye De Cluny	102	Princess
22	Traviata	49	White Knock Out	76	Lady Romantica	103	Gülfem
23	Summertime	50	Sunny Knock Out	77	Ruban Rouge	104	Teodora
24	Michelangelo	51	Baie Des Anges Romantica	78	Salvador Dali	105	Vivald
25	Allegro	52	Princesse C. De Monaco	79	Harlequin	106	Sultana
26	Rustica	53	Harmonie	80	Zelal		
27	Laperla	54	Blue River	81	Rose Dot		

Table 2
Soil structure in rose-planted landscape areas of Konya province

Depth	Saturation with water (%)	pH	EC (mmhos/cm)	Salinity (%)	$CaCO_3$	Organic matter (%)	Class
0-30	49,5	7,69	1,4	1,5	49,33	0,94	CL
30-60	50,6	8,02	1,6	2	55,77	0,66	L
60-90	48,4	7,9	2,2	2,9	60,06	1,05	L

L; Loamy soil

CL; Clay loam soil

Table 3
Average meteorological data determined on months basis between 1929 and 2021 years in Konya province

	Jan.	Feb.	March	April	May	June	July	Agust	Sept.	Oct.	Nov.	Dec.	Yıllık
Avarage Temperature (°C)	-0.2	1.5	5.6	11.1	15.9	20.1	23.5	23.3	18.8	12.8	6.5	1.7	11.7
Average Maximum Temperature (°C)	4.6	7.0	11.8	17.5	22.4	26.7	30.2	30.2	26.0	20.0	13.0	6.6	18. 0
Average Lowest Temperature (°C)	-4.2	-3.3	-0.2	4.3	8.6	12.6	15.9	15.6	11.0	5.9	0.8	-2.3	5.4
Average Insolation Time (Hours)	3.3	4.6	5.9	7.2	9.0	10.7	11.8	11.4	9.7	7.3	5.3	3.2	7.4
Average Monthly Total Rainfall (mm)	38.1	28.5	29.3	32.0	43.1	26.1	7.5	6.4	13.5	29.5	32.2	43.2	329.4
Highest Temperature (°C)	19.9	23.3	28.9	30.9	34.4	36.7	40.6	39.0	38.8	31.6	25.4	21.8	40.6
Lowest Temperature (°C)	-28.2	-26.5	-16.4	-8.6	-1.2	1.8	6.0	5.3	-3.0	-8.4	-20.0	-26.0	-28.2
Daily Total Highest Rainfall (mm)						22.02.1945 73.7							
Daily Fastest Wind (m/sn)						18.04.2012 32.4							
Highest Snow (cm)						22.02.1945 66							

Table 4
Monthly average meteorological values between 1998 and 2022 in which disease detections were made in roses in the landscape areas of Konya province (Meteorology Regional Directorate of Konya)

Monthly Average Meteorological Values	Years (1998-2022)		Situation
Soil Temperature (°C) in 5 cm	12,80	15,40	2,6 (+)*
Soil Temperature (°C) in 10 cm	12,70	14,31	1,61 (+)
Above Ground Min. Temperature (°C)	1,48	1,95	0,47 (+)
Actuel Pressure (hPa)	899,82	898,38	1,44 (-)**
Max. Temperature (°C)	18,49	20,28	1,79 (+)
Min. Temperature (°C)	7,40	9,80	2,40 (+)
Temperature (°C)	12,51	14,93	2,42 (+)
Wind Speed (m÷sn)	1,43	1,18	0,25 (-)
Areal Precipitation (mm=kg÷m²)	32,30	25,92	6,38 (-)
Number of Rainy Day	7,50	6,80	0,7 (-)

* incresing

** decreasing

Table 5

Fungal and bacterial diseases on roses between 1998-2022 years and differences at the last 10 years in Konya province

Fungal Diseases (1998-2012)	Fungal Diseases (2013-2022)
Mildew (*Peronospara sparsa)*	-
Rust (*Phragmidium mucronatum*)	Rust (*P. mucronatum*)
Black spot (*Diplocarpon rosae*)	-
Powdery mildew (*Sphaerotheca pannosa* var. *rosae*)	Powdery mildew (*S. p.* var. *rosae*)
Gray mold (*Botrytis cinerea*)	-
Bacterial Diseases (1998-2012)	Bacterial Diseases (203-2022)
Crown gal (*Rhizobium radiobacter*)	Crown gal (*R. radiobacter*)
Bacterial blight (*Pseudomonas syringae* pv. *syringae*)	Bacterial blight (*P. s.* pv. *syringae*)
-	Bacterial blight (*P. s.* pv. *morspurunorum*)
-	Bacterial wilt (*Ralstonia solanacearum*)
Fire blight (*Erwinia amylovora*)	Fire blight (*E. amylovora*)
-	Bacterial canker (*Xanthomonas hortorum*)

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