IMPACT OF CLIMATIC CHARACTERISTICS ON VARIATION OF FRUIT PRODUCTION IN WILD ROSE (*ROSA CANINA* L.)

YAZICI, N.

Faculty of Forestry, Isparta University of Applied Sciences, Isparta, Turkey
(e-mail: niluferyazici@isparta.edu.tr; phone: +90-246-214-6500; fax: +90-246-214-6599)

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Abstract. It is known that many biotic and abiotic characteristics could affect fruit and other reproductive traits in plant species. Knowledge of this effect can play an important role in the selection of conservation and seed collection areas, also cultivation practices of plants. Impact of climatic characteristics on fruit production included minimum, maximum and average temperatures, and annual total precipitation, and together with fertility variation and effective number of parents were investigated in six natural areas of wild rose (*Rosa canina* L.) during three consecutive years (2020, 2021 and 2022) in this study. Fifty individuals from each area and year were sampled to count the numbers of mature fruits in the species. The studied years among areas, and years within area did not show significant ($p > 0.05$) differences for the climatic characteristics in contrast to among the areas ($p < 0.05$) for the minimum temperature and monthly total precipitation of pooled years. Averages of fruit productions varied for the populations and years, and among individuals within an area. Years showed significant ($p < 0.05$) differences for fruit productions of pooled areas in contrast to areas of pooled years ($p > 0.05$) based on results analysis of variance. The studied climatic characteristics had no significant ($p > 0.05$) impact on fruit productions in pooled years and areas. Estimated fertility variations were at acceptable level for the areas and years. It ranged from 1.10 (91% of fertility individuals) to 2.22 (45%) in the areas.
Keywords: *correlation, fertility, hip, variance, climate*

Introduction

Wild rose, also known as ‘dog rose’ (*Rosa canina* L.) is a member of the genus *Rosa which* including more than one hundred species in the temperate and subtropical zones of the northern hemisphere (Krussman, 1981). Wild rose, which is a hermaphroditic shrub species, occupies all parts of Turkey, individually or in small groups. Its fruits, the rose hips, are alone or together with 2-15 hips on the branch. Flowering period of the species is between May and July (Kutbay and Kilinc, 1996). The species is self-compatible, but their large flowers are designed for pollination by insects and outcrossing is common (Uggla, 2004). The fruits and fresh flowers of the species are used widely in food, cosmetics and pharmaceutical industries (User, 1967). The species keeps its hips during the winter, so this species has a significant role for wildlife as edible food by animals, and biological diversity (Bilir, 2011a). The fruit is also an important income for rural areas, because of large utilization in different industries, consisting of higher nutrient (Chai and Ding, 1995; Ercisli, 2007). Khan and Rehman (2005) reported that the rose had also valuable essential oil used in a wide range of many industries. The species is preferred in landscape planning and erosion control (Ilisulu, 1992). Ecological importance of the species has been particularly resulted from its wide spreading intensive root system and wide crown structure helping with enhancing water hold capacity in the soil, conservation the surface soil and measuring the erosion, and as an indicator plant for different environmental conditions (Ozkan and Bilir, 2008) as one of the main elements of forest vegetation. These advantages of the species are getting importance of fruit production and cultivation practices. However, limited studies were carried out on

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fruit production and its variation in Turkish wild rose (i.e., Bilir, 2011a, b; Baloglu and Bilir, 2020), while impact of climatic characteristics on the production has not been studied, yet.

It is known that fertility data have important roles in economical and biological success of breeding program such as selection purpose. Variation in fertility is also one of the major factors in the evolution and genetic management of population, forest tree breeding and gene conservation programs (Bila, 2000; El-Kassaby, 1995; Griffin, 1982; Shea, 1987; Xie and Knowles, 1992; Kang et al., 2003; Bilir and Kang, 2021; Kang and Bilir, 2021). The objectives of this study are (1) to estimate effect of some climatic characteristics on fruit production, (2) to evaluate fertility variation and effective number in the populations, (3) and to give strategic information for gene conservation, and cultivation and other practices based on three consecutive years' data of six natural areas of the species in the present study.

Materials and methods

Study area

The study was carried out in six areas (A1-A6) sampled from natural distribution of Wild rose from southern Turkey (*Fig. 1*). Some geographic details of the areas were given in *Table 1*. Altitudes of the areas were ranged from 960 m to 1260 m (*Table 1*).

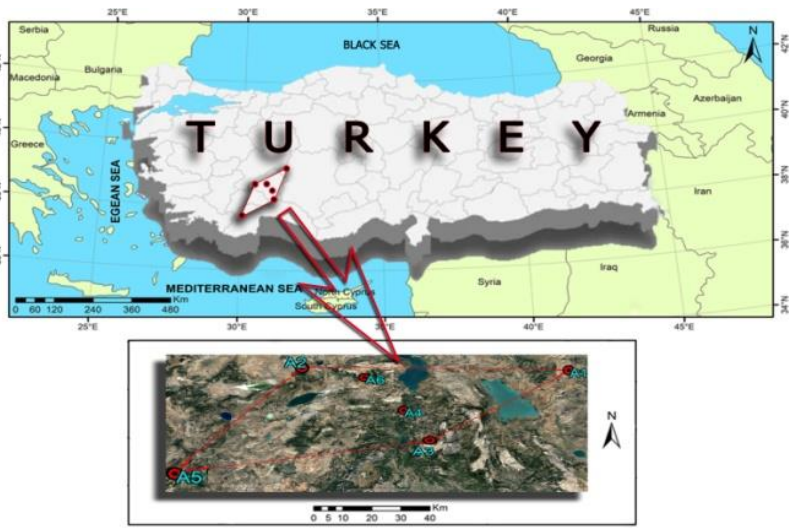

Figure 1. *Location of sampled areas*

Table 1. *Geographic details of the areas*

Areas	Latitude (N)	Longitude (E)	Altitude (m)	Exposure
A1	38°04'48"	31°55'40"	1260	South
A2	38°05'58"	30°09'62"	960	East
A3	37°23'58"	31°02'00"	1250	South
A4	37°39'12"	30°51'17"	965	South
A5	37° 01'16"	29° 22' 08"	1185	Straight
A6	37°58'28"	30°34'28"	1070	Straight

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Data collection

Fifty individuals were sampled from each area (*Fig. 2*) and each year. Numbers of mature fruits (F_N) (*Fig. 2*) were counted in the sampled individuals in each population between 15 of July and 15 of August during three consecutive years in 2020-2022 (abbreviated as 20, 21 and 22 in the study) based on maturation period of fruits. Minimum (Min.T.), maximum (Max. T.) and average temperatures (Av. T., °C), and total annual precipitation (An.TP., mm) of the areas were obtained from General Directorate of Meteorology and Climatology of Turkey (MGM, 2023) for the years.

Figure 2. *A sampled individual plant and mature fruits of the species*

Data analysis

Fruit and climatic data were performed by the SAS software (SAS, 2004) for comparison of the studied years, areas, areas within year, and years within area by linear model of the ANOVA.

The pairwise comparison of areas and years for the characteristics were performed by Games-Howell test. Besides, the relations among the characteristics were estimated by Spearman's Rank correlation. Averages of year and sides were used in estimation of the correlations.

The variation in fruit fertility (Ψ_F) representing the total contribution as zygotic parents was estimated by Kang and Lindgren (1999) and by Bilir (2011a) as:

$$\Psi_F = N \sum_{i=1}^{N} F_i^2 = CV_F^2 + 1 \quad \text{(Eq.1)}$$

where N is the census number, F_i is the fruit fertility of the i^{th} individual and CV_F is the coefficient of variation in total fertility.

The effective number of parents (N_p) was estimated based on the fruit fertility (Ψ_F) and the census number (N) as (Kang et al., 2003):

$$N_p = \frac{N}{\Psi_F} \quad \text{(Eq.2)}$$

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The relative effective number of parents (N_r) were estimated relatively compared to the effective number of parents (N_p) of census number (N) as:

$$N_r = \mathrm{N}_p / N \quad \text{(Eq.3)}$$

Results

Climatic characteristics

Year 22 was colder than years 20 and 21. It had also the highest annual total precipitation (499.5 mm) in pooled years of the areas (*Table 2*). Averages of monthly total precipitation, maximum and minimum temperatures, average temperatures of the pooled years were showed in *Figures 3–6* for the areas.

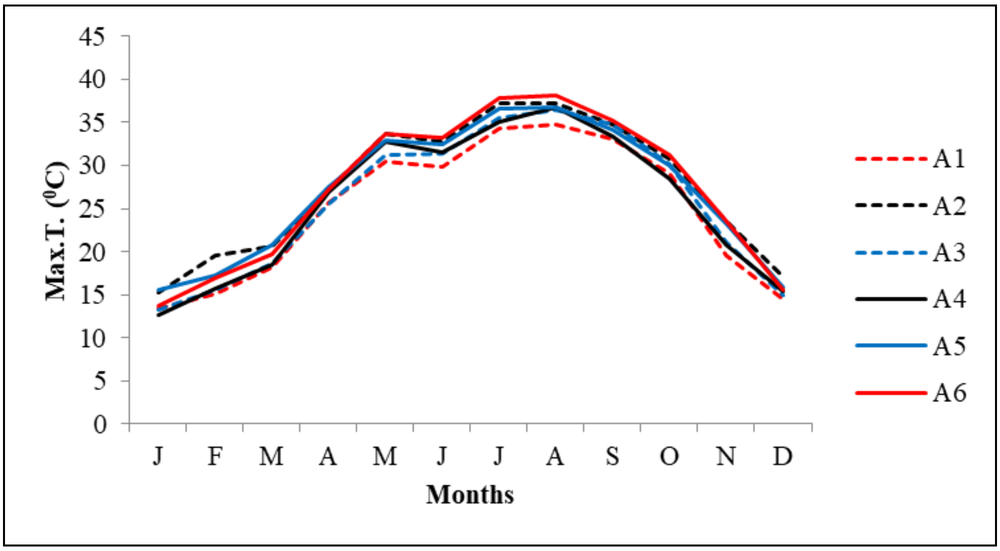

Figure 3. *Averages of maximum temperatures for months in the areas*

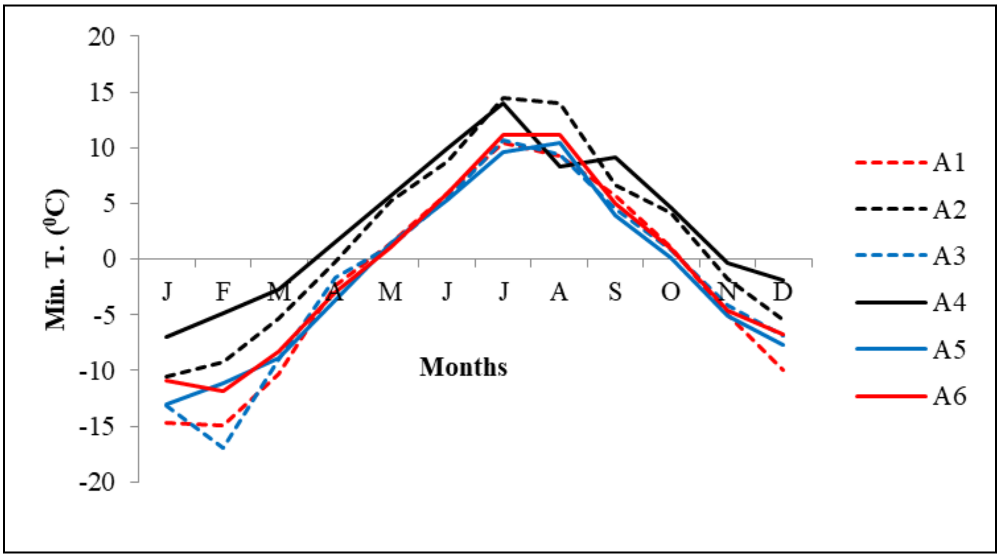

Figure 4. *Averages of minimum temperatures for months in the areas*

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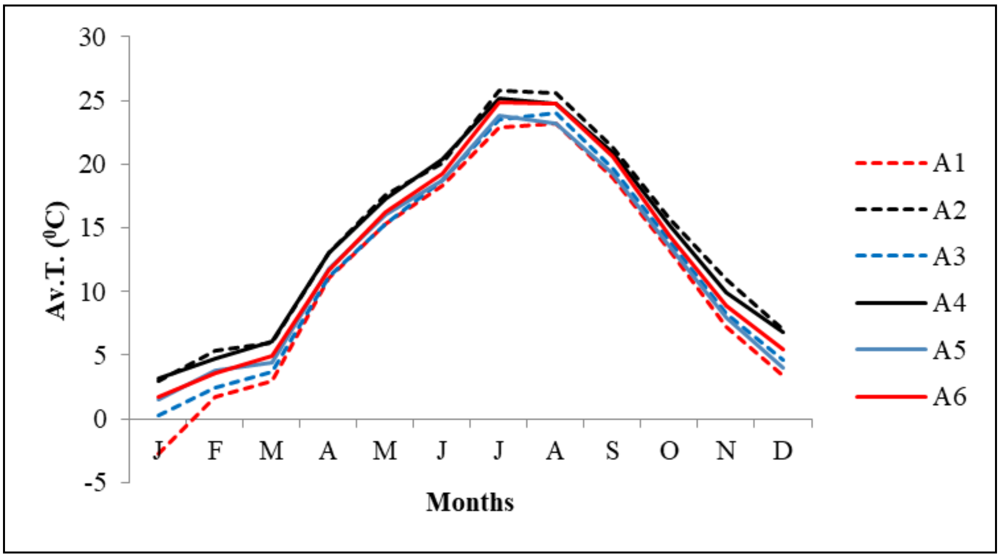

Figure 5. *Averages of temperatures for months in the areas*

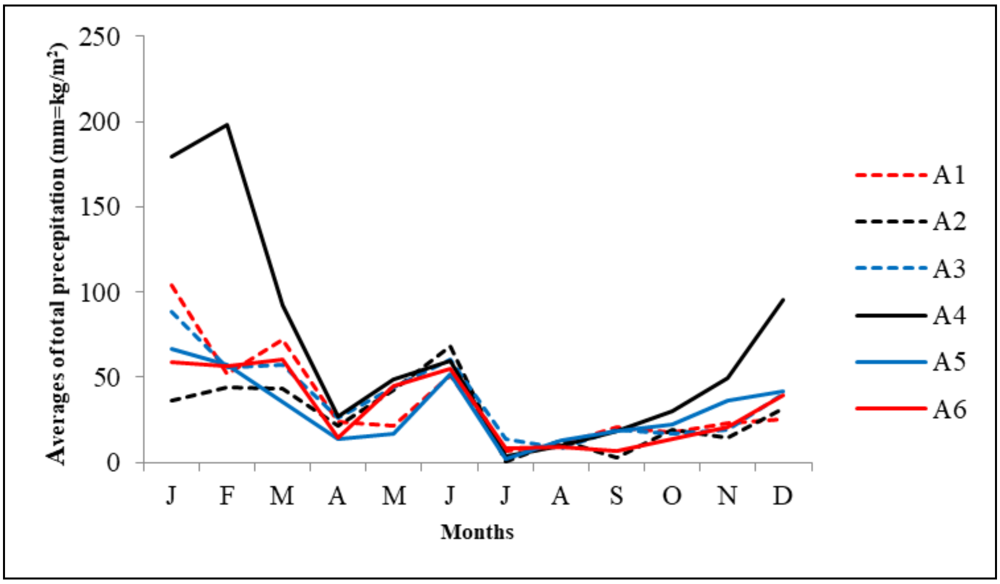

Figure 6. *Averages of monthly total precipitations in months of the areas*

Table 2. *Annual total precipitation, averages of maximum and minimum temperatures, average temperatures for the years and areas*

Areas	Max.T.* (°C)			Min. T. (°C)			Av. T. (°C)			An.TP. (mm)		
	20	21	22	20	21	22	20	21	22	20	21	22
A1	24.7	25.2	24.6	-0.5	-2.6	-2.8	11.9	11.6	10.9	434.8	466.8	469.0
A2	27.8	27.5	27.1	2.4	1.5	1.4	14.7	14.4	13.7	392.8	268.2	352.8
A3	25.2	26.1	25.7	-1.7	-1.6	-2.2	12.0	12.5	11.9	420.8	477.2	448.2
A4	25.3	25.9	25.8	4.0	3.4	1.8	13.7	14.4	13.8	904.8	688.4	845.6
A5	26.7	27.6	26.5	-0.5	-2.0	-2.3	12.5	12.6	11.8	361.1	321.2	445.0
A6	27.5	27.2	26.8	0.2	-1.0	-1.7	13.2	13.4	12.5	398.9	331.6	436.2
Average	26.2	26.6	26.1	0.7	-0.4	-1.0	13.1	13.2	12.4	485.5	425.6	499.5

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The studied years among areas, and years within area did not show significant ($p > 0.05$) differences for the climatic characteristics (*Fig. 7*). However, there were significant ($p < 0.05$) differences among the areas for the minimum temperature and monthly total precipitation of pooled years according to results of analysis of variance. Area 4 (A4) was different than other areas for the minimum temperature and total precipitation (*Table 2*). For instance, annual total precipitations were the highest (904.8, 688.4 and 845.6 mm) for the years in A4, while it was the lowest for year 20 (361.1 mm), and for years 21 (268.2) and 22 (352.8) in A5. Year 22 had the highest average of annual total precipitation by 499.5 mm (*Table 2*).

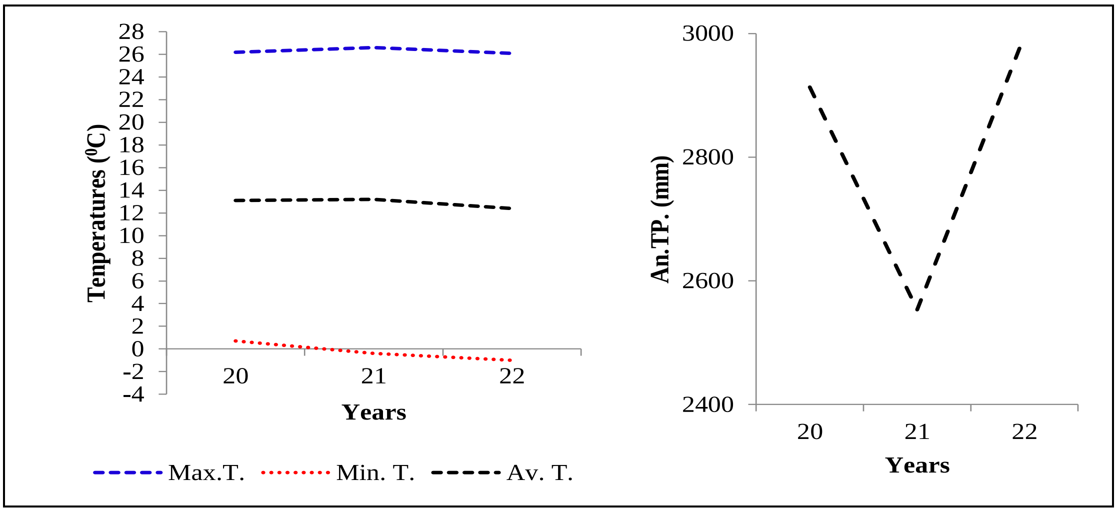

***Figure 7.** Annual climatic characteristics*

Fruit productions

Averages of fruit productions varied for the populations and years (*Fig. 8*). For instance, area A4 had the lowest fruit production (158.9) in year 21, while it was the highest (271.2) in year 22. Besides, area A5 had the highest (286.4) and lowest (158.3) fruit productions in years 20 and 22, respectively. Year 22 had higher fruit yield than other years (*Table 3*). There were major differences among individuals within area for fruit production based on coefficient of variations and ranges (*Table 3; Figs. 9* and *10*). The differences were more than 10 times in A1-A4, and A6 of year 20, in A1 of year 21, and in about all areas of year 22 (*Table 3*).

***Table 3.** Averages ($\bar{X}$), coefficient of variations (CV%) and ranges of fruit productions for the years in the areas*

	20			21			22			Total		
	$\bar{X}$	CV	Range	$\bar{X}$	CV	Range	$\bar{X}$	CV	Range	$\bar{X}$	CV	Range
A1	174.3^{a}	61.0	75-505	274.4^{c}	62.7	90-955	198.2^{a}	64.2	60-985	215.6	74.0	60-985
A2	121.4^{a}	111.8	15-675	264.9^{c}	52.8	100-655	192.8^{a}	81.5	60-810	193.0	80.4	15-810
A3	197.0^{b}	100.1	50-985	209.1^{ab}	44.2	105-400	162.4^{a}	54.0	40-400	189.5	71.7	40-985
A4	190.0^{ab}	106.1	40-985	158.9^{a}	37.3	70-350	271.2^{b}	81.0	80-985	206.7	87.4	40-985
A5	286.4^{c}	60.1	105-955	233.8^{bc}	60.9	80-650	158.3^{a}	107.2	25-955	226.2	74.8	25-955
A6	267.4^{c}	67.9	90-955	195.6^{ab}	52.0	100-600	161.0^{a}	32.4	80-290	208.0	62.9	80-955
Total	206.1^{ab}	85.9	15-985	222.8^{b}	56.5	70-955	190.1^{a}	83.0	25-985	206.5	75.7	15-985

Same letters are not significantly ($p > 0.05$) different among the areas or years

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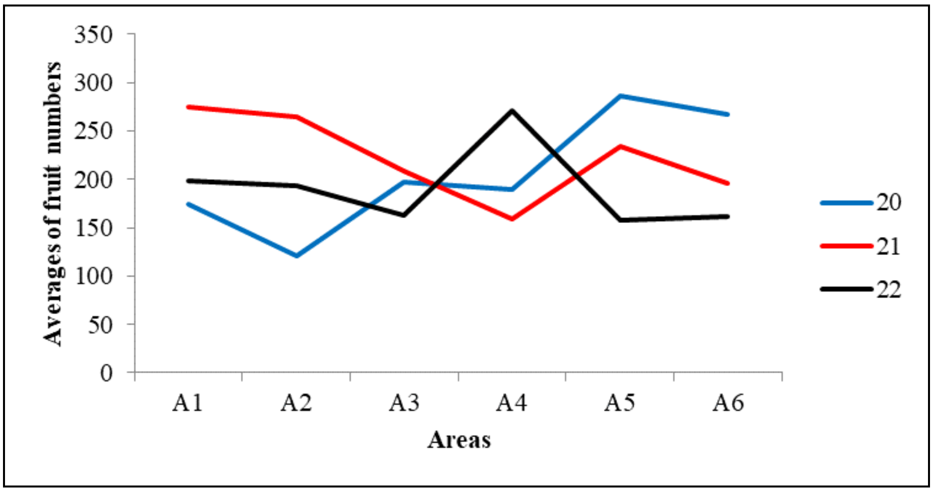

Figure 8. *Averages of fruit production for the years of the areas*

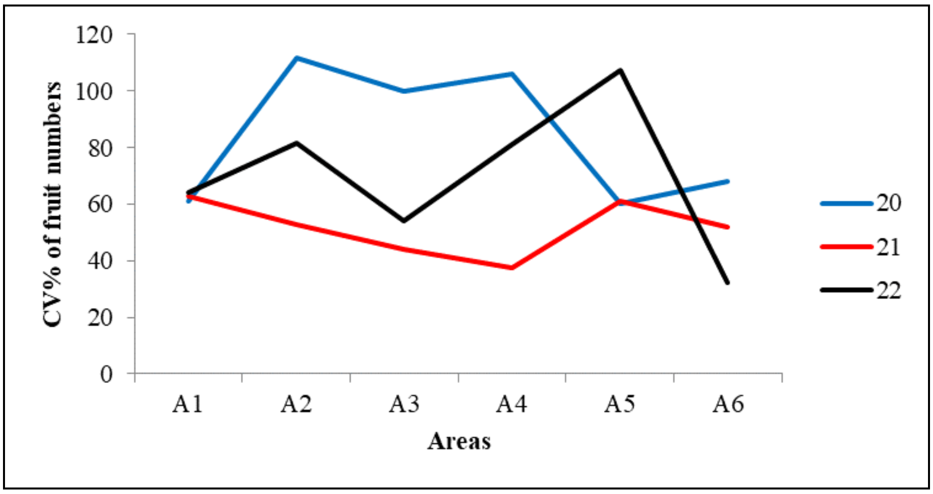

Figure 9. *Coefficient of variation of fruit productions for the years of the areas*

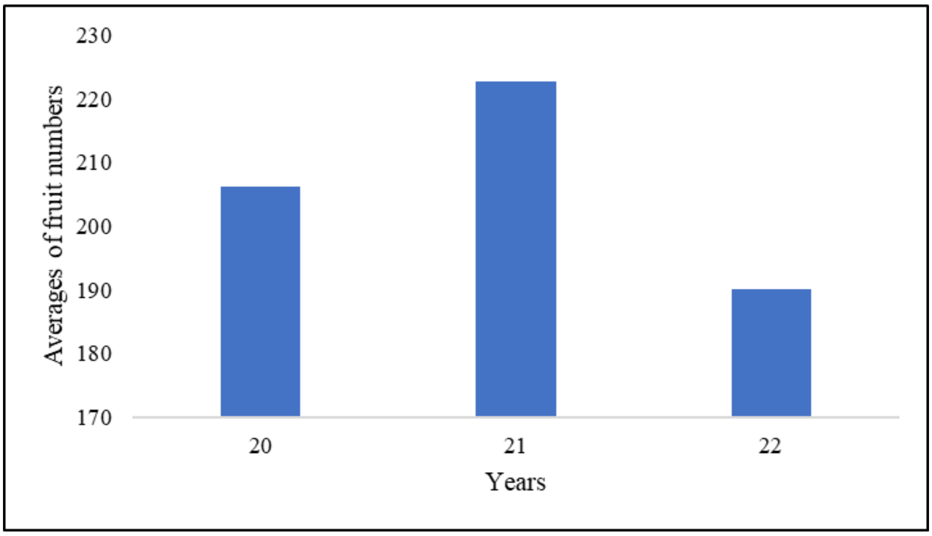

Figure 10. *Averages of fruit production for the years*

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Years showed significant ($p < 0.05$) differences for fruit productions of pooled areas opposite to areas of pooled years ($p > 0.05$) based on results analysis of variance. The difference was only between years 21 and 22 according to Games-Howell test. There were significant differences among years within area according to results of analysis of variance (*Table 4*).

Table 4. *Pairwise comparison of years within area for fruit productions*

Areas	Years					
	20 (I)- 21 (J)		20 (I)- 22 (K)		21 (J)- 22 (K)	
	I-J	Sig. (*p*)*	I-K	Sig. (*p*)*	J-K	Sig. (*p*)*
A1	-100.1	$p < 0.05$	-23.9	NS	76.2	NS
A2	-143.5	$p < 0.01$	-71.4^{*}	$p < 0.05$	72.1	$p < 0.05$
A3	-12.1	NS	36.4	NS	48.5	$p < 0.05$
A4	31.1	NS	-81.2	NS	112.3	$p < 0.05$
A5	52.6	NS	128.1	$p < 0.01$	75.5	$p < 0.05$
A6	71.8	$p < 0.05$	106.4	$p < 0.01$	34.6	NS

Indicated statistically significant difference at the probability level of 0.05 or 0.01, and NS Indicated not statistically significant difference ($p > 0.05$).

Relations among the characteristics

The studied climatic characteristics had no significant ($p > 0.05$) effective on fruit productions in pooled years and areas (*Table 5*).

Table 5. *Spearman's Rank correlation coefficients (r) among fruit numbers (FN), minimum (Max.T.), maximum (Min.T.) and average temperatures (Av.T.), and total annual precipitation (An.TP.)*

r	F_N	Max.T.	Min.T.	Av.T.
Max.T.	$.070^{NS}$	-		
Min.T.	$-.089^{NS}$	$.194^{NS}$	-	
Av.T.	$-.051^{NS}$	.579*	$.871^{**}$	-
An.TP.	$-.051^{NS}$	$-.494^{*}$	$.517^{*}$	$.194^{NS}$

* and ** indicate statistically significant at the probability levels of 0.05 and 0.01, and ^{NS} indicates non-significant

Fertility variation and parental balance curve

The individuals had similar contributions in A6 of 22 ($\Psi_F = 1.10$), while the variation of contribution was the highest in A2 of year 20 ($\Psi_F = 2.2$) to gene pool (*Table 6*; *Fig. 11*). The effective numbers of parents (N_p) were calculated as percentages of census number to 57% (A4) and 72% (A6) in total gene pool of the years in the areas (*Table 6*). It meant A6 was 25% larger than A6 based on the effective numbers of parents estimated by fertility variation of individuals in the studied areas. The cumulative contributions of individuals were so far from optimal contribution in years- 20 (A2, A3, A4 and A6) and 21 (A1 and A5) than year-21 (*Table 6; Fig. 12*).

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Table 6. *The variation in fruit fertility (Ψ_F), effective number of parents (Np) and relative effective numbers of parents (Nr) in the areas and years*

Areas	Years											
	20			21			22			Total		
	Ψ_F	N_p	N_r %	Ψ_F	N_p	N_r %	Ψ_F	N_p	N_r %	Ψ_F	N_p	N_r %
A1	1.36	36.7	73.0	1.41	35.6	71.0	1.77	28.2	56.0	1.54	97.1	65.0
A2	2.22	22.5	45.0	1.27	39.3	79.0	1.65	30.3	61.0	1.64	91.4	61.0
A3	1.99	25.1	50.0	1.18	42.5	85.0	1.29	38.9	78.0	1.51	99.3	66.0
A4	2.10	23.8	48.0	1.14	44.0	88.0	1.64	30.4	61.0	1.76	85.3	57.0
A5	1.35	36.9	74.0	1.36	36.7	73.0	2.13	23.5	47.0	1.56	96.4	64.0
A6	1.45	34.4	69.0	1.27	39.5	79.0	1.10	45.3	91.0	1.39	107.7	72.0

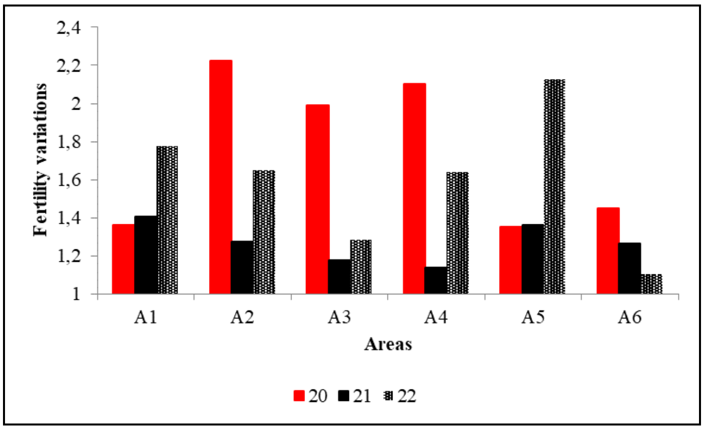

Figure 11. *Fertility variations for the years and areas*

Discussion

Climatic characteristics varied for the years and areas (*Table 2; Figs. 3–7*). However, the variation was not dramatically for maximum and average temperatures, and annual total precipitation. Three year's climatic data of a local area was performed in the present study. It showed climatic characteristics were not large changeable in short periods and local area. However, long term climatic characteristics (Atalay, 1987) were similar to studied years. The results could be used for local practices in the species. Ozkan and Bilir (2008) reported significant difference for climatic condition among habitat classes of the species in a watershed based on long term climatic data. The results emphasized importance of long-term data for detail discussion on the characteristics.

Averages of fruit productions varied for the populations and years (*Figs. 8–10; Table 3*). Averages of fruit numbers were 576 in a natural area (Baloglu and Bilir, 2020) and 158 in 158 varied between 98 and 233 in 12 natural areas of the species (Bilir, 2011a). Years showed significant ($p < 0.05$) differences for fruit productions of pooled areas opposite, while the productions were similar ($p > 0.05$) in the areas of pooled years. However, among years within area had significant ($p < 0.05$) for the fruit production (*Table 4*). Major differences among individuals with area for fruit production were found by coefficient of variations and ranges (*Table 3; Figs. 9–10*). Similar results were also found by Bilir (2011 a, b) and Baloglu and Bilir (2020). The results indicated importance of year and population/area in fruit yield of the species.

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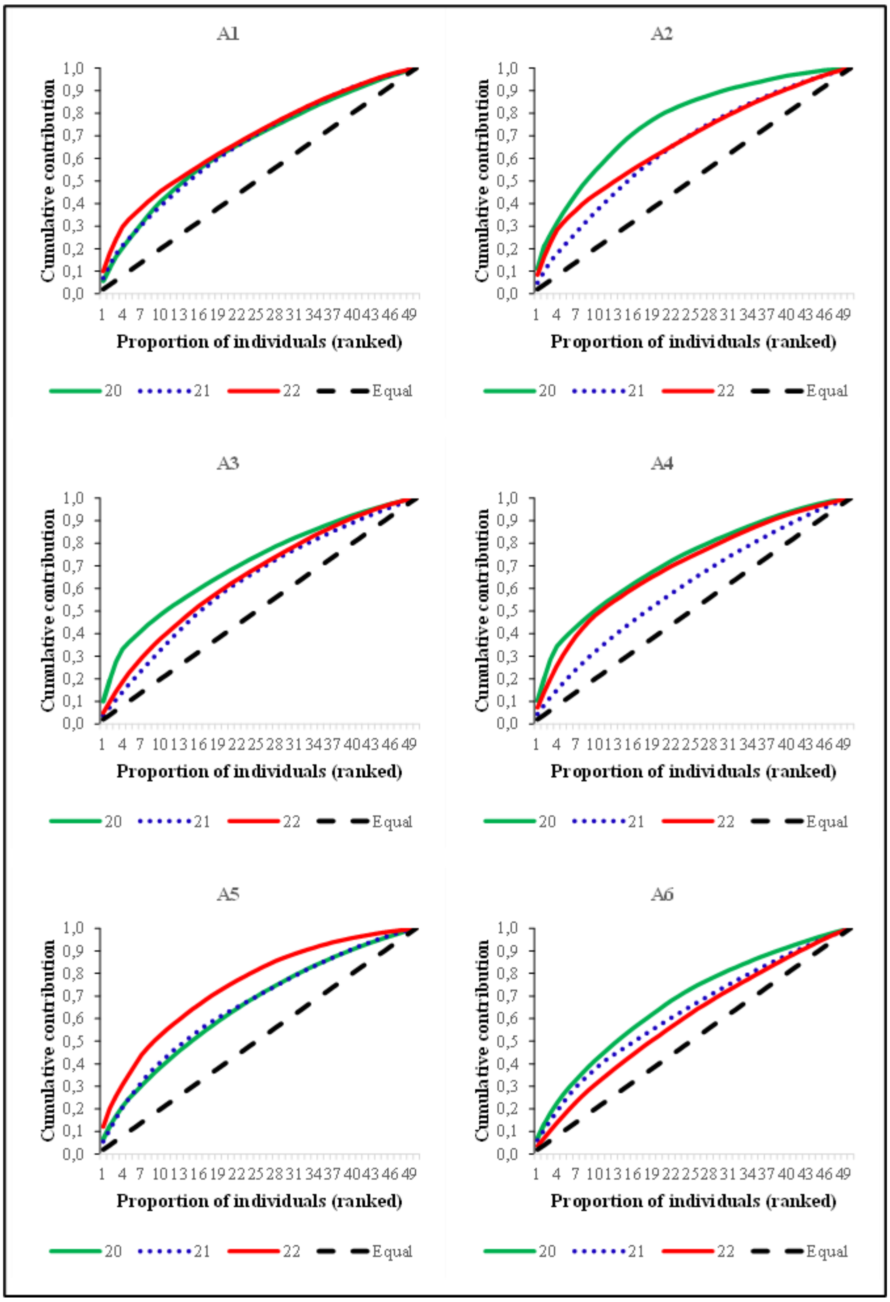

Figure 12. *Parental-balance curves for fruit output in different years of the areas*

No significant ($p > 0.05$) relations between climatic characteristics and fruit productions were calculated by Spearman's Rank correlation (*Table 5*). The present study focused on some climatic characteristics and fruit production by three years data of natural local area of the species. Sedgley and Griffin (1989) indicated that temperature, wind speed, rain during pollen dispersal, and the physical distribution of inter-pollinating individuals could be impact on successful pollination in wind pollinated species such as genus *Rosa*. However, reproductive traits could be influenced by many biotic (i.e., Eler, 1990; Bilir et al., 2017; Catal et al., 2018; Bilir and Kang, 2021; Yazıcı and Bilir, 2023) and abiotic (i.e., Bila and Lindgren, 1998; Bilir et al., 2005; Yazıcı and Bilir, 2017; Eser, 2023) characteristics in plant species. For example,

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positive and significant ($p < 0.05$) relations among height, crown diameter, number of branches and number of fruits were found in Wild rosa by Baloglu and Bilir (2020).

The fertility variations (Ψ) varied for the areas and years (*Table 6; Fig. 11*), while they were acceptable level suggested ($\Psi < 3$) by Kang et al. (2003), and Kang and Bilir (2021) for natural populations. However, it could be also balanced by parental curve (*Fig. 12*) or mixed years. For instance, fertility variation decreased from 2.13 in A4 of year 22 to 1.56 by pooled years (*Table 6*). Similar variations were also reported in wild rose (Bilir, 2011a, b) and in different plant species (e.g., Bila et al., 1998; Kang et al., 2003; Bilir and Kang, 2021; Yazıcı and Bilir, 2023). For instance, fertility variation was between 1.35 (A5) and 2.22 (A2) in year 20, and 1.14 (year 21) and 2.10 (year 20) in A4 (*Table 6*). It reflected the effective numbers of parents (N_p) decreased from 44.0 (88% of census number) to 23.8 (44% of census number) in years 20 and 21 of A4, respectively (*Table 6*). It emphasized that A4 was about 85% larger in year 21 than year 20. Gene diversity (*GD*) in seed crop could be correlated by effective number of parents (N_p) as: $GD = 1\text{-}0.5/N_p$ by Kang and Lindgren (1998). The estimated loss of gene diversity between year 20 (0.979) and 21 (0.989) could be about 0.01 in A4. The results emphasized importance of seed collection year and area for higher gene diversity in cultural practices (e.g., generative propagation).

Conclusions

The present study was conducted in limited area by limited data. However, results of the study can be used in local practices of the species such as selection of gene conservation and seed collection areas for generative propagation. New studies should be carried out in large sides and long-term data in the species to give accurate conclusions. New reproductive characteristics such as weight, size and content of the fruit should be examined as qualification of the species correlated by biotic and abiotic characteristics in future studies on the species.

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