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Determination of the Genotoxicity of the Soil in the Aydın Region Irrigated by Büyük Menderes River by the Allium Test System

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Abstract: Nowadays, one of the most important problems is environmental pollution. Environmental pollution in the Büyük Menderes River-basin, which is one of the agricultural fields in Turkey, has reached important dimensions. B. Menderes River which waters B. Menderes River-basin and fields around it is contaminated by various sources.

In this study the genotoxicity of the soil samples taken from three different regions in two different months (September 2006 and March 2007) in the Aydın region of B. Menderes River-basin was researched with the *Allium* test.

The soil samples were taken from the lands watered by the B. Menderes River and Çine Stream; the fields near the B. Menderes Bridge (on the Muğla main road), the Çine Stream, and the Koçarlı Bridge in September and March. 25%, 50%, 100% concentrations were prepared diluting these samples and onions (*Allium cepa* L.) were rooted. At the end of the studies, the decrease in the mitotic index was found to be statistically important according to the control in all the doses except 25% of the Çine doses in September and March.

The study soil samples taken from the three different regions in two different months caused structural chromosomal aberrations such as anaphase bridge, fragment, stickiness, and polar deviation in the *Allium cepa* L. root tip cells. It has been emphasized that the difference in all the doses except for 25% Menderes, 25% Koçarlı, 50% doses in September and 25% Çine, 25% Menderes, 25%, 25% Koçarlı, Koçarlı, 50% doses in March are important according to the control in the total chromosomal aberrations.

***Keywords*:** Genotoxicity, Mitotic index, Chromosome aberrations, *Allium* test

Büyük Menderes Nehri ile Sulanan Aydın Bölgesi'ndeki Toprakların Genotoksisitesinin Allium Test Sistemi ile Belirlenmesi

Özet: Günümüzün en önemli sorunlarından biri çevre kirliliğidir. Ülkemizin önemli tarım alanlarından biri olan Büyük Menderes Havzasındaki çevre kirliliği önemli boyutlara ulaşmıştır. Büyük Menderes Havzasını sulayan Büyük Menderes Nehri ve çevresindeki topraklar çeşitli kaynaklar tarafından kirletilmektedir.

Bu çalışmada Büyük Menderes Havzasının Aydın bölgesinde üç farklı bölgeden iki farklı ayda (Eylül 2006, Mart 2007) alınan toprak örneklerinin genotoksisitesi *Allium* test ile araştırılmıştır.

Büyük Menderes Nehri ve Çine Çayının sularıyla sulanan topraklardan; Büyük Menderes Köprüsü (Muğla Yolu üzeri), Çine Çayı ve Koçarlı Köprüsü yanındaki tarlalardan Eylül ve Mart aylarında toprak örnekleri alınmıştır. Bu örnekler sulandırılarak %25, %50 ve %100'lük konsantrasyonlar hazırlanmış ve soğanlar (*Allium cepa* L.) bu sularda köklendirilmiştir.

Yapılan incelemeler sonunda Eylül ve Mart ayları Çine %25'lik dozlar dışındaki tüm dozlarda kontrole göre mitotik indeksteki düşüş istatistiki olarak önemli çıkmıştır.

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Çalışmamızda iki farklı ayda üç farklı bölgeden alınan toprak örnekleri *Allium cepa* L. (soğan) kök ucu hücrelerinde anafaz köprüsü, fragment, kromozom yapışması ve yanlış kutuplaşma gibi yapısal kromozom anormalliklerine yol açmıştır.

Toplam kromozom aberasyonları bakımından Eylül ayı Menderes %25, Koçarlı %25, Koçarlı %50 ve Mart ayı Çine %25, Menderes %25, Koçarlı %25, Koçarlı %50 dozları dışındaki tüm dozlarda farkın kontrole göre önemli olduğu belirlenmiştir.

***Anahtar Kelimeler*:** Kromozom aberasyonları, Mitotik indeks, *Allium* test, Genotoksisite

1. INTRODUCTION

Like air and water, soil is also one of the indispensable elements for the survival of living things. Soil is the main repository of resources that feed vegetation. Since the beginning of the twentieth century, with the transition into modern agriculture and the acceleration of industrialization, soil pollution has begun to emerge as an environmental problem. The main causes of pollution in soil are fertilizers and pesticides used for agricultural activities as well as domestic and industrial waste. The pollutants in the soil pose serious health risks to humans through a variety of ways such as; direct ingestion of contaminated food, drinking contaminated groundwater, skin contact, and the food chain. Contaminants in the soil cause acute toxicity not only for humans, but also for various soil organisms in flora and fauna. Therefore, it is necessary to make an assessment of agricultural soil in terms of potential risks of contaminants in biological systems. Analytical approaches cannot fully solve the problem, so, bioassays form an alternative since they provide a measure of toxicity related to the environment. Cytogenetic tests in plants are well-established systems for the monitoring and screening of genotoxicity. Plant bioassays are relatively inexpensive, can be easily done, and are simpler and more sensitive than other methods used to determine the genotoxicity of environmental pollutants. Plant biosynthesis tests, done especially using *Tradescantia* and *A. cepa*, are validated tests to determine the mutagenicity of agricultural soils contaminated with various pollutants, soil solutions, and wastewater samples [1, 2].

The Aydın province has extensive agricultural land irrigated by the B. Menderes River. The lands near the B. Menderes River are usually of first class agricultural property. The river is fed by numerous streams and creeks such as Çine, Dandalas, Akçay, and İkizdere. The water flowing in the B. Menderes River and the streams and creeks in its tributaries is used for irrigation of the agricultural land around them. The B. Menderes River, in all parts from its source to the sea, is polluted by waste water discharges, industrial activities, agricultural activities, and natural releases from the geothermal origin. When this water is mixed up with the irrigation water used in agriculture without any treatment, it indirectly leads to soil pollution [3].

Many physical and chemical analyses to determine the contamination of soil and water have been conducted. However, these analyses are not sufficient alone. To determine the effects of these pollutants on organisms, genotoxicity studies must be carried out. A variety of animal and plant systems are used in genotoxicity tests [4]. To not lose sight of the alarming consequences of pollution in agricultural soil in Aydın, the genotoxic potential of the soil samples taken from three different regions in Aydın were evaluated in this study.

2. MATERIALS and METHODS

Study area and taking the soil samples: soil samples used in this study were taken from three different regions in September 2006 and March 2007; the samples from the first region were taken from a field near the B. Menderes Bridge on the Muğla main road (prior to the joining of the B. Menderes River with Çine Stream); the second samples from

the field near the Çine Stream (the Ortaova location); and the third samples from the corn fields near the Koçarlı bridge (after the joining of B. Menderes and Çine Stream) from a depth of 20 cm. The periods in this study were chosen as the September period, when there were few precipitation and there was a lot of agricultural irrigation by the water of B. Menderes River; and March period, when agricultural activities were low and precipitation was high. In this way soil conditions in both periods have been compared. The soil samples taken were put into plastic bags and kept in the refrigerator (+4 0C) until the study commenced.

Preparation of soil extracts and application for the onions for the *Allium* test: Soil extracts was prepared according to Cotelle et al. [5]. The soil samples of 100 grams from each region were weighed, and 1000 ml of distilled water was added to them to obtain a homogeneous mixture. This homogeneous mixture was marinated in the refrigerator for 24 hours (+4 ° C). After 24 hours; concentrations of 25%, 50%, and 100% were prepared from the filtered water for each region. Then, the test tubes, with 12 onions for each dose, were prepared, and the peeled onions were placed in tubes with their roots touching the water. A separate control group was prepared for each region, and distilled tap water was used as the control group. The prepared tubes were placed in an oven at 23 ± 2ºC temperature. Water in their own dose was added to the tubes with a reduced level of water on a daily basis. All the samples were displaced from the ovens after 72 hours, and the most suitable 10 onions were selected for each dose. The roots were then cut, and retained in ethyl alcohol-glacial acetic acid at a ratio of 3:1 at +4 ºC for 24 hours. After 24 hours, the roots were refrigerated until the examination under the microscope in a 70% alcohol solution.

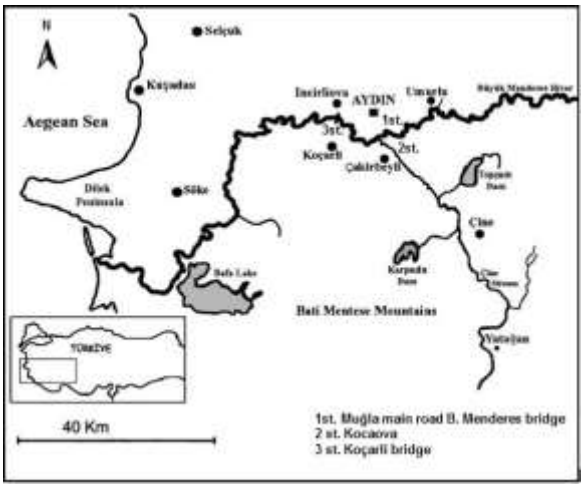

Figure 1. Map showing the Büyük Menderes River and sampling locations.

Preparation and microscopic examination: The roots were first hydrolyzed with 0.2 N HCl and then stained with aceto orcein. An Olympus BX51 microscope was used in our study. The total cells and dividing cells were randomly selected from each of the three regions at a 10 x 40 magnification rate, and the damaged cells in them were also counted and noted. Since 6 roots from each onion, 500 cells from each root and 10 onions from each dose were used, a total of 30,000 cells were counted for each dose. After the counting process, the mitotic index was calculated for each dose. Also, photographs of chromosomal abnormalities encountered during the census were taken. All the data obtained was statistically evaluated with the Independent Samples t-test in SPSS 15.0 software and the values satisfying $p < 0.05$ were considered significant.

3. RESULTS

Effects of soil genotoxicity on the cell division in *A. cepa*

Effect on mitotic index: The *A. cepa* root tip meristem cells and the effects of the soil samples taken from three different regions on the mitotic index were also investigated. As shown in Table 1, it can be understood that the mitotic index decreased in all the doses when compared to the control group. This decrease was found statistically significant in all the doses except in Çine,

September 25% and in Çine, March 25% ($p < 0.05$) (Table 2).

When comparing the 25%, 50%, and 100% doses of the samples taken during the same month; the difference in the mitotic index was found to be statistically significant in doses; Çine, 25% - 100%; Menderes, 25% - 100%; Menderes, 50% - 100%; Koçarlı, 25% - 100; Koçarlı 50% - 100% for September; and Çine, 25% - 100%; Menderes, 25% - 100%; Koçarlı, 25% - 50% and 25% - 100% for March (Table 3).

When comparing the mitotic index from the same doses (i.e. Çine, September, 25%; Çine, March, 25%) in September-March, no statistical difference was observed ($p < 0.05$), (Table 4).

When comparing the mitotic index of the same concentration of the samples taken from the different regions in the same month; the difference in the mitotic index between Çine, 50% and Koçarlı 50%; Çine, 100% and Koçarlı, 100% for September and Çine 50% and Koçarlı, 50% for March was found statistically significant, while the differences between the other groups were not (Table 5).

Effect on chromosomes: as shown in Table 1, as a result of the examination; damages such as bridge formation, fragments, chromosome fragmentation, and polar deviation were observed in all the groups (Fig. 1). As a result of the comparison of the groups to the controls in terms of the total chromosomal abnormalities; it was determined that the difference in the concentrations of the September Menderes 25%, Koçarlı 25%; and March Çine 25%, Menderes 25%, Koçarlı 25%, Koçarlı 50% were not statistically significant, while the difference was found to be significant compared with the control groups for all the other doses ($p < 0.05$) (Table 2).

As a result of the statistical calculations made between the 25%, 50%, and 100% groups of the samples taken during the same month: the differences between September, Çine 25% - 100%; March, Çine 25% - 50%, Çine 25%-100, Menderes 25% -100%, Menderes 50% - 100%, Koçarlı 25% - 100% and Koçarlı 50% - 100% were found to be statistically significant($p < 0.05$) (Table 3).

Table 1. Effects of soil genotoxicity on MI and frequency of chromosome aberration in *A. cepa.*

	Groups	Tcs	Dcn	MI	Fr.	Br.	Pd	St	Tac	% Ac
SEPTEMBER	Control	30000	2794	9.31	28	3	35	14	80	2.86
	Çine %25	30000	2584	8.61	31	4	89	15	139	5.37
	Çine %50	30000	2434	8.11	45	1	118	26	190	7.80
	Çine %100	30000	2216	7.39	57	14	97	35	203	9.16
	Menderes %25	30000	2446	8.15	33	4	75	0	112	4.57
	Menderes %50	30000	2321	7.74	25	3	90	22	140	6.03
	Menderes %100	30000	2081	6.94	42	6	77	14	139	6.67
	Koçarlı %25	30000	2380	7.93	29	5	68	0	102	4.28
	Koçarlı %50	30000	2166	7.22	23	0	73	20	116	5.35
	Koçarlı %100	30000	1931	6.44	43	5	66	10	124	6.42
MARCH	Control	30000	2817	9.39	19	3	41	7	70	2.48
	Çine %25	30000	2583	8.61	21	6	64	9	100	3.87
	Çine %50	30000	2406	8.02	29	4	107	23	163	6.77
	Çine %100	30000	2252	7.51	58	12	94	31	195	8.65
	Menderes %25	30000	2520	8.40	19	4	69	1	93	4.13
	Menderes %50	30000	2328	7.76	26	2	78	14	120	5.15
	Menderes %100	30000	2126	7.09	47	5	93	11	156	7.33
	Koçarlı %25	30000	2487	8.29	20	3	72	0	95	3.81
	Koçarlı %50	30000	2202	7.34	22	4	69	12	107	4.85
	Koçarlı %100	30000	2016	6.72	51	5	87	9	152	7.53

Tcs: Total cells scored, Dcn: Dividing cells number, MI: mitotic index, Fr: fragments, Br: bridges, Pd: Polar deviation, St: stickiness, Tac: Total aberrant cells, %Ac: % Aberrant cells

Table 2. Comparison of mitotic index and chromosomal aberration between control and experimental groups.

	Groups	MI P (±SD)	CA P (±SD)
SEPTEMBER	Control - Çine %25	0.092 (±0.0247)	0.001*(±3.900)
	Control - Çine %50	0.001*(±0.0216)	0.000*(±6.683)
	Control - Çine %100	0.000*(±0.0276)	0.000*(±3.860)
	Control - Menderes %25	0.000*(±0.0123)	0.158 (±6.356)
	Control - Menderes %50	0.000*(±0.0218)	0.003*(±4.595)
	Control - Menderes %100	0.000*(±0.0232)	0.001*(±4.067)
	Control - Koçarlı %25	0.000*(±0.0230)	0.087 (±2.251)
	Control - Koçarlı %50	0.000*(±0.0230)	0.143 (±2.951)
	Control - Koçarlı %100	0.000*(±0.0173)	0.007*(±3.921)
MARCH	Control - Çine %25	0.069 (±0.0220)	0.083 (±3.162)
	Control - Çine %50	0.001*(±0.0191)	0.000*(±4.296)
	Control - Çine %100	0.000*(±0.0252)	0.000*(±3.923)
	Control - Menderes %25	0.013*(±0.0186)	0.092 (±3.653)
	Control - Menderes %50	0.000*(±0.0248)	0.002*(±3.771)
	Control - Menderes %100	0.000*(±0.0231)	0.000*(±3.534)
	Control - Koçarlı %25	0.002*(±0.0125)	0.096 (±2.273)
	Control - Koçarlı %50	0.000*(±0.0165)	0.058 (±3.335)
	Control - Koçarlı %100	0.000*(±0.0266)	0.000*(±3.853)

*p<0.05 MI: Mitotik index CA: Chromosomal aberrations

Table 3. Comparison of Mitotic Index and Chromosomal Aberration between Different Doses in Same Month.

	Groups	MI P (±SD)	CA P (±SD)
SEPTEMBER	Çine %25 - %50	0.284 (±0.0216)	0.055 (±6.683)
	Çine %25 - %100	0.017*(±0.0276)	0.002*(±3.860)
	Çine %50 - %100	0.112 (±0.0276)	0.602 (±3.860)
	Menderes %25 - %50	0.220 (±0.0218)	0.275 (±4.595)
	Menderes %25 - %100	0.001*(±0.0232)	0.275 (±4.067)
	Menderes %50 - %100	0.049*(±0.0232)	0.959 (±4.067)
	Koçarlı %25 - %50	0.090 (±0.0215)	0.250 (±2.951)
	Koçarlı %25 - %100	0.000*(±0.0173)	0.146 (±3.921)
	Koçarlı %50 - %100	0.031*(±0.0173)	0.163 (±3.921)
MARCH	Çine %25 - %50	0.120 (±0.0191)	0.002*(±4.296)
	Çine %25 - %100	0.012*(±0.0252)	0.000*(±3.923)
	Çine %50 - %100	0.212 (±0.0252)	0.099 (±3.923)
	Menderes %25 - %50	0.122 (±0.0248)	0.121 (±3.771)
	Menderes %25 - %100	0.001*(±0.0231)	0.001*(±3.534)
	Menderes %50 - %100	0.116 (±0.0232)	0.041*(±3.534)
	Koçarlı %25 - %50	0.001*(±0.0165)	0.361 (±3.335)
	Koçarlı %25 - %100	0.000*(±0.0266)	0.001*(±3.853)
	Koçarlı %50 - %100	0.117 (±0.0266)	0.012*(±3.853)

*p<0.05

The difference between Çine, September, 25% and Çine, March, 25% was determined to be statistically significant as a result of the analyses made for the same doses of the same regions between the months (September-March) (p<0.05). There were no significant differences between the other groups (Table 4).

Table 4. Comparison of mitotic index and chromosomal aberration of same doses of different months (September and March) of samples which obtained from same region.

Groups	MI P (±SD)	CA P (±SD)
Çine %25 Eylül - Mart	0.979 (±0.0220)	0.025*(±3.162)
Çine %50 Eylül - Mart	0.803 (±0.0191)	0.299 (±4.296)
Çine %100 Eylül - Mart	0.804 (±0.0252)	0.651 (±3.923)
Menderes %25 Eylül - Mart	0.393 (±0.0186)	0.426 (±3.653)
Menderes %50 Eylül - Mart	0.961 (±0.0248)	0.302 (±3.771)
Menderes %100 Eylül - Mart	0.729 (±0.0231)	0.332 (±3.354)
Koçarli %25 Eylül - Mart	0.274 (±0.0125)	0.498 (±2.273)
Koçarli %50 Eylül - Mart	0.703 (±0.0165)	0.531 (±3.335)
Koçarli %100 Eylül - Mart	0.502 (±0.0266)	0.125 (±3.853)

*p<0.05

When comparing the total chromosomal damage of the same doses of the sample taken from the different regions during the same month; the differences between September, Çine, 100% and Menderes 100%; Çine 25% and Koçarlı 25%; Çine 50% and Koçarlı 50%; Çine 100% and Koçarlı 100%; and, March Çine 50% and Menderes 50%; Çine 100% and Menderes 100%; Çine 50% and Koçarlı 50%, Çine 100% and Koçarlı 100% were found to be statistically significant (p<0.05), and the differences between the other groups were not (Table 5).

Table 5. Comparison of mitotic index and chromosomal aberration of same doses of samples which obtained from different region in same month.

	Groups	MI P (±SD)	CA P (±SD)
SEPTEMBER	Çine %25 - Menderes %25	0.255 (±0.0123)	0.267 (±6.356)
	Çine %50 - Menderes %50	0.366 (±0.0218)	0.069 (±4.595)
	Çine %100 - Menderes %100	0.333 (±0.0232)	0.002*(±4.067)
	Çine %25 - Koçarlı %25	0.144 (±0.0230)	0.021*(±2.051)
	Çine %50 - Koçarlı %50	0.025*(±0.0215)	0.007*(±2.951)
	Çine %100 - Koçarlı %100	0.026*(±0.0173)	0.000*(±3.921)
	Menderes %25 - Koçarlı %25	0.486 (±0.0230)	0.648 (±2.251)
	Menderes %50 - Koçarlı %50	0.182 (±0.0215)	0.184 (±2.951)
	Menderes %100 - Koçarlı %100	0.187 (±0.0173)	0.412 (±3.921)
MARCH	Çine %25 - Menderes %25	0.574 (±0.0186)	0.652 (±3.653)
	Çine %50 - Menderes %50	0.546 (±0.0248)	0.029*(±3.771)
	Çine %100 - Menderes %100	0.336 (±0.0231)	0.031*(±3.354)
	Çine %25 - Koçarlı %25	0.331 (±0.0125)	0.690 (±2.273)
	Çine %50 - Koçarlı %50	0.044*(±0.0165)	0.005*(±3.335)
	Çine %100 - Koçarlı %100	0.097 (±0.0266)	0.024*(±3.853)
	Menderes %25 - Koçarlı %25	0.706 (±0.0125)	0.885 (±2.273)
	Menderes %50 - Koçarlı %50	0.279 (±0.0165)	0.425 (±3.335)
	Menderes %100 - Koçarlı %100	0.422 (±0.0266)	0.812 (±3.853)

*p<0.05

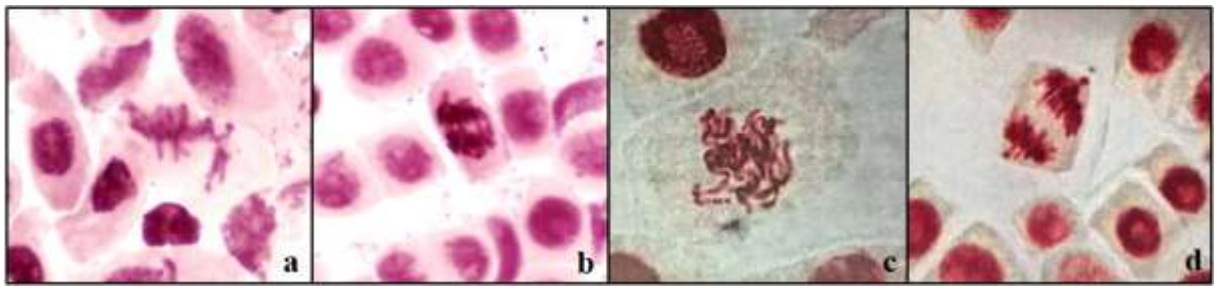

Figure 1. Chromosomal abberations in root tips of *A. cepa*. **a:** irregular distribution and stickness, **b:** anaphase bridge, **c:** fragmentations, **d:** polar deviation.

4. DISCUSSION

The *Allium* test is one of the tests that are used to determine the cytotoxic and genotoxic effects on organisms of the pollutants in the soil. The *Allium* test is a standard method for the rapid determination of environmental pollution. Mutagenic environmental influences can be analyzed with macroscopic parameters such as root shape and root growth, and cytological parameters such as the frequency of the chromosome aberrations and abnormal cell division. The results of these tests allow for the determining of the cytotoxicity, genotoxicity, and the mutagenicity of the pollutants with either direct or indirect effects on living organisms. In the *Allium* test; growth delay is generally described as cytotoxicity, and genotoxicity in certain chromosomal aberrations. However, chromosomal aberrations are associated with a specific growth inhibition. There are many factors that negatively affect the mitotic division and mitotic index. Heavy metals are one of them. Although some of the heavy metals in soil are required in terms of efficiency, and some are stimulant in the development, they all have toxic effects in high doses. Along with the toxic effects of heavy metals; they also have adverse effects on the mitotic division and chromosomes. As a result of the application of copper chloride to *Vicia hirsuta* at the doses of 10, 25, 50, and 100 mg/L at different lengths of time, the mitotic index was determined to decrease when compared to the control group [6]. In a study investigating the effects of the different concentrations of cadmium on *Allium sativum* [7], it was observed that the mitotic index decreased as cadmium concentration and the application time increased.

The effects of pesticides used to combat agricultural pests and to increase agricultural production on the mitotic index have been studied by various researchers. It was observed that the application of basudin (20 EM) to barley seeds increased the mitotic index [8], that the mitotic index did not change following the application of dursban to *Vicia faba* roots and seeds [9], and that the mitotic index decreased as a result of the application of paraquat to *V. faba* [10] flurochridone to *A. cepa* [11], Dichlorvos (DDVP) to *A. cepa* [12].

The researchers did not find a direct link between the overall pollution levels and toxicity. In order to determine the genotoxicity of the Ukrainian territory contaminated after the Chernobyl disaster, it was examined in a study by Kovalchuk et. al. using *A. cepa*, [13] that the mitotic index in the contaminated areas was lower than that of the control group. In the study conducted to determine the genotoxicity of the soils contaminated with heavy metals such as chromium and nickel using *V. faba*; they found that chromium and nickel reduced the cell division at concentrations between 2.5 and 5 mm [14]. A reduction in the mitotic activity shows the inhibition of DNA synthesis, or that the cell cycle preventing the cell from going into the mitosis was blocked in the G2 phase [15, 16]. In our study, we also found a statistically significant reduction in the mitotic index in all the doses and groups except for the 25% dose of Çine September and March periods (Table 2). The reduction in the mitotic index is in line with the increase in the concentration.

Our findings are in agreement with similar studies made by other investigators. The decrease in the mitotic index cannot be connected to a single cause. Although some chemicals do not have toxic effects alone, they can show them when combined. The contaminants in the soil samples may have shown genotoxic effects by inhibiting the DNA synthesis, which led to a decrease in the mitotic index.

Cytotoxicity is defined as a reduction in the mitotic index, and also an increase in the frequency of C-mitotic cells, multipolar anaphase, and sticky and vagrant chromosomes [13]. Such adverse effects of chemicals on chromosomes have been studied by various authors. Rieger and Michaelis [17] reported that certain areas of some chromosomes reacted in *V. faba* with chemicals first, and that they had the fracture zones. The heterochromatic regions are those that are primarily fractured in the fracture zones [18].

Several studies have shown that chemicals lead to the formation of anaphase bridges [11, 19-21]. The formation of bridges probably occurs as a result of the breakage and re-fusion of chromosomes and chromatids. Gömürgen [22] stated that chromosome bridges may arise from a failure in the chromosomal adhesion and anaphase separation, or an unequal translocation or inversion of the chromosome segments may contribute to this event. The fact that we observed bridge formations in our study shows that the pollutants in the soil samples lead to the breakage and re-fusion in the chromosomes and chromatids.

Stickiness is defined as the separation of the chromatids from each other in the metaphase by aggregating on the metaphase plane. Some researchers have suggested that the increase in the viscosity may be due to the influence of chemicals on the chromosomal proteins [23, 24]. Stickiness is considered as chromatid aberrations [23, 25], while bridges and fragments are considered as structural changes [26]. Fragments result from the fractures of chromosomes when affected by physical or chemical agents outside normal conditions. Many researchers have found that pesticides cause fractures [27, 28]. The existence of fractures in our study shows that there are pollutants in the soil samples we studied and that chromosomes caused the formation of the fragments by fracturing.

Various researchers have studied the genetic effects of heavy metals and pesticides that cause pollution by mixing soil and water pollution on the chromosomes of the organisms living in that environment. In a study on *Allium* root tip cells to determine the genotoxicity of sewage and industrial waste; the rate of abnormalities in anaphase was found to increase [29]. Rank and Nielsen [30], in their study to determine the effects of sewage sludge contaminated with industrial waste on *A. cepa*, observed that in pollution caused by heavy metals, the sludge increased bridges, fragments, and other chromosomal damage. They found that the damage occurred increased in direct proportion to the heavy metal concentration. Katnoria et al. [31] examined the genotoxic effects in the soils taken from two different industrial areas and contaminated with heavy metals using an *Allium* root anaphase aberration test. They observed that damage such as fractures; bridges, laggard, and vagrant were significantly more common in the onion roots treated with different concentrations of soil extracts than in those of the control group.

C-mitotic occurs as a result of the effects of chemicals on spindles, and consequently polyploidy and aneuploidy occur. While multipolar anaphases are formed by complete disintegration of the spindles, lagging chromosomes are formed by the inhibition of the spindle formation, and consequently the micronuclei take shape [32].

5. CONCLUSIONS

Damage such as stickiness, fragment, anaphase bridge, and polar deviation were observed in the soil samples taken from three different regions during September and March. These results indicate that there were genotoxic agents in the studied soil samples. It is not correct to connect these genotoxic effects to a single cause. The Büyük Menderes Basin has some of the most intensive agricultural activities. Agricultural activities in Aydın, our study area, are also very high. The pollution in the soils studied reduces the

yield and quality of the crops grown. The genetically disrupted seeds obtained from these products affect the products to be grown in later stages, and these pollutants also disrupt the genetic structure of the trees in these soils and cause a decrease in yield and even dry trees. It should not be overlooked that the same effects will be seen in the people and animals eating these plants directly and on the people consuming the products derived from the animals fed on these plants. Therefore, prevention of soil pollution in Aydın, one of the most important agricultural areas in Turkey, is of great importance for the health of humans, plants, and animals, and also for the national economy.

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