



Determination of the Effect of Tebuconazole Applications on Cucumber (*Cucumis sativus* L.) Seedling via Morphological and Molecular Methods

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ABSTRACT

Aim of this study was to determine the effect of tebuconazole applications on cucumber seedling via morphological and molecular methods. In order to determine the most appropriate dose of different concentrations (25, 50, 75, 100, 125 and 150 ppm) of tebuconazole affecting the seedling quality and preventing possible genotoxic effects, retrotransposon motility at all doses was determined. Polymorphism rates and changes in GTS values were also determined. At the applied doses, polymorphism values were found as 0%, 5.55%, 16.66%, 38.88%, 55.55% and 61.11%, respectively. The GTS value was decreased from 100% to approximately 38.89% based on the applied doses. Statistical evaluations indicated that different dose applications resulted significant changes in the seedling characteristics. The seedling and stem heights were suppressed by 57.5% and 55.9%, respectively compared to the controls. The stem diameter increased 9.95% following the application. Overall, 50, 75 and 150 ppm doses were determined to achieve an increase in the dry matter and leaf chlorophyll content. In this study, applications of Tebuconazole at different doses controled the seedling height in cucumber and affected specific quality characteristics of the seedlings.

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Tebuconazole Uygulamalarının Hıyar (*Cucumis sativus* L.) Fidelerindeki Etkisinin Morfolojik ve Moleküler Yöntemler ile Belirlenmesi

ÖZET

Çalışmada, Tebuconazole uygulamalarının hıyar (*Cucumis sativus* L.) fidelerindeki etkisinin morfolojik ve moleküler yöntemler ile belirlenmesi amaçlanmıştır. Yapraktan sprey şeklinde uygulanan Tebuconazole'ün 25, 50, 75, 100, 125 ve 150 ppm konsantrasyonları denenmiştir. Fide kalitesine olumlu etki eden en uygun dozun belirlenmesi ve muhtemel genotoksik etkilerin engellenmesi için tüm dozlardaki retrotranspozon hareketliliği tespit edilmiştir. Ayrıca oluşan polimorfizm oranları ve GTS değerlerindeki değişim belirlenmiştir. Uygulanan dozlarda sırasıyla %0, %5.55, %16.66, %38.88, %55.55 ve %61.11 oranında polimorfizm elde edilmiştir. GTS değerinin ise doza bağlı olarak %100 seviyesinden %38.89 seviyesine gerilediği görülmüştür. Yapılan istatistiksel değerlendirmelere göre, farklı doz uygulamalarının fide özelliklerinde önemli derecede değişiklik meydana getirdiği tespit edilmiştir. Elde edilen verilere göre, kontrol uygulaması ile karşılaştırıldığında, fide boyu ve gövde boyunda sırası ile %57,5 ve %55,9'luk bir azalma sağlanmıştır. Gövde çapında ise uygulama sonrası %9.95'lik bir artış olmuştur. 50, 75 ve 150 ppm'lik dozların gövde kuru madde oranında artış sağladığı belirlenmiştir. Ayrıca, doz uygulaması yaprak klorofil miktarında bir artış sağlamıştır. Bu çalışmada, farklı dozlarda Tebuconazole uygulamalarının, hıyarda fide boyunu kontrol altına aldığı ve bazı fide kalite özelliklerine olumlu yönde etki ettiği belirlenmiştir.

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INTRODUCTION

Cucumber is one of the major vegetables widely grown both in open field and greenhouses. As in many other vegetable species, the use of high-quality seeds are essential in successful cucumber production (Demir et al., 2010, Sönmez, 2017). Seedling quality has a direct effect on the growth and yield of the plant. A high-quality seedling should have a thick stem, dark green leaves, a vibrant and strong root structure. Low quality seedlings overgrow, the leaf area is reduced, the leaf chlorophyll content decreases and the colour of leaves gets lighter (Geboloğlu et al. 2016). Overgrowing seedlings can be taken under control with the proper control of environmental conditions or the use of chemicals with growth-hindering properties. To control the seedling height and improve seedling quality and appearance, mechanical stress factors (Johjima et al. 1992, Garner and Björkman 1996), various stress and ecological factors (Melton and Dufault 1991, Glowacka 2004, Mohsin et al., 2019) and various nutrients element have been experimented. However, these practices were not sufficient in increasing in the seedling quality. Therefore, plant growth-retarding chemicals were applied to control the seedling height and improve the quality, and when the desired outcome was obtained, the studies were conducted on promising chemicals. Numerous studies were conducted on chemicals with growth-slowing or retarding properties (such as Daminozid, Unicazol, Clormequatclorid and Paclobutrazol) that are effective in controlling seedling height in different vegetable species. However, such chemicals may cause problems such as chlorosis, leaf blight or a long delay in growth in seedlings. In addition, such substances can also alter the epigenetic construct affecting the activity of genomic elements. Retrotransposons are known to play key roles in host genome evolution by altering gene expression or inducing DNA rearrangement (Friedli and Trono, 2015). Studies conducted with IRAP analysis under different stress conditions to investigate the level of retroransposon mobility are available (Hamad-Mecbur et al., 2012; Temel & Gozukirmizi, 2013; Yigider et al., 2016). Against to environmental stresses, epigenetic mechanisms play a key role in responding to stress by regulating gene expression of the genome differently (Angers et al., 2010; Studer et al., 2011; Deng et al., 2017). Changing environmental conditions, stress factors or particular chemicals can modify the epigenetic structure, affecting the activity of these genomic elements (Wessler, 2009). Transposons can insert into several different regions of the genome as a result of their transposition. Especially when they settle in exons or regions near the gene, they cause various mutations

such as point mutation, frameshift mutation, deletion, duplication and insertion. As a result of these mutations, genes may cause a reading frame shift, formation of alternative gene products, and inability to synthesize the proteins of gene product (Bennetzen, 2000; Federoff, 2000; Wicker et al., 2007). This leads to differences in band profiles obtained in IRAP analysis. One of the most frequently used substances, Paclobutrazol allows controlling the seedling height and increasing in the quality of seedlings. It is widely used in commercial preparations where the active ingredient is Paclobutrazol. Paclobutrazol is belong to the Triazol group. Tebuconazole, another substance from the same group, is used in fungal diseases. Its chemical formula is (RS)-1-p-chlorophenyl-4,4-dimethyl-3-(1H-1,2,4-triazol-1-ylmethyl)-pent an-3-ol (Cadkova et al., 2013). There are not enough studies in literature examining the effects of this substance on vegetable quality by morphological and molecular methods.

Aim of the study was to investigate the effects of different doses of Tebuconazole on cucumber seedling height control and seedling quality, and to determine retrotransposon mobility creating within the plant and, to determine its genotoxic effects and the optimum dose(s) used in seedling production.

MATERIAL and METHOD

The study was conducted in March-May 2020 in the seedling greenhouse of Erzincan Horticultural Research Institute. Başak F1 variety of cucumber was used as plant material in the experiment. Seedlings were grown in 128-compartment viols, with 40 x 40 mm each. A mixture of peat:perlite (3:2) was used as seedling growing medium. As the source of Tebuconazole, a commercial preparation 'Folicur' containing 25% Tebuconazole (developed by Bayer) was used. In this randomized-block-design study, seven different application doses of Tebuconazole(0, 25, 50, 75, 100, 125 and 150 ppm, respectively) were applied to cotyledon leaf of plants. Seedlings with different Tebuconazole doses applied are given in Figure 1. Thu study was desighned as randomized block design, with 3 replicates wth 21 plants in each. Prepared different doses of Tebuconazole solutions were applied by spraying to the cotyledon leaves of the plants 20 days after sowing, with two applications at 14-day intervals, and after the final application, the seedlings were grown under the controlled greenhouse conditions (Figure 2). The necessary measurements, observation and analysis were performed in the seedling.

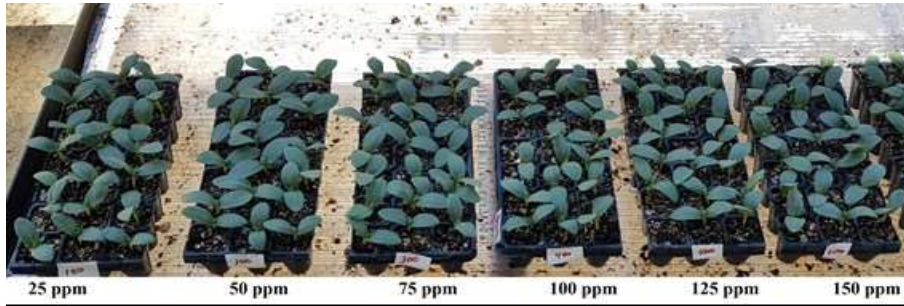


Figure 1. Cucurbit seedlings to which Tebuconazole will be applied
Şekil 1. Tebuconazole uygulaması yapılacak olan hıyar fideleri

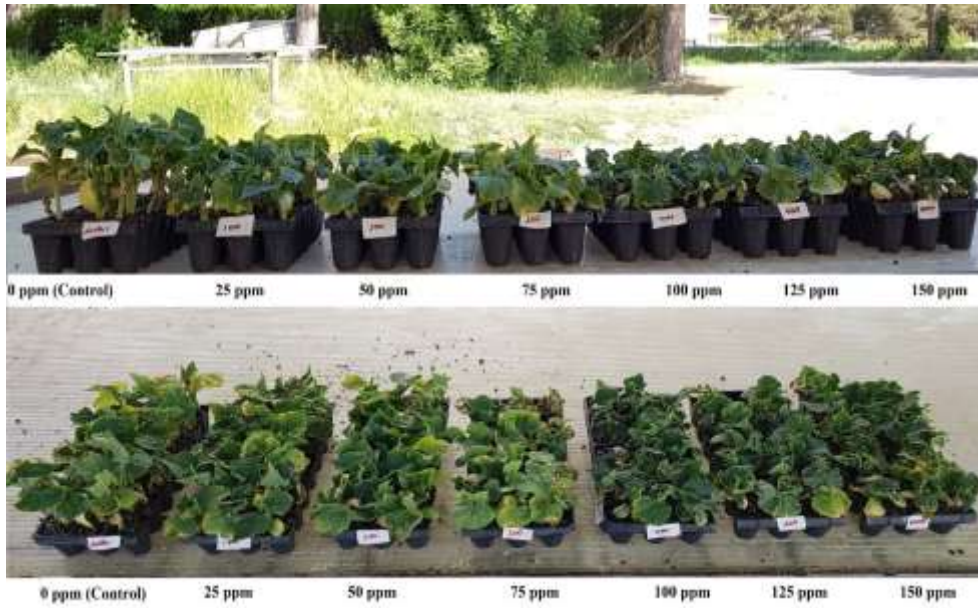


Figure 2. General view of cucumber seedlings 2 weeks after the last application
Şekil 2. Son uygulamadan 2 hafta sonra hıyar fidelerinin genel görünümü

Measurements and Weighings For Seedling Development

Seedling height (cm), stem height (cm), stem diameter (mm), number of leaf (number plant⁻¹), leaf dry matter content (%), stem dry matter content (%), root dry matter content (%) and leaf chlorophyll content (SPAD value) and overall seedling development were determined. Seedling height (cm) and stem height (cm) were measured with tape measure and stem diameter (mm) was measured with a digital caliper. Leaf chlorophyll content was measured using SPAD (Chlorophyll Meter SPAD-502Plus, Konica Minolta). The number of leaves per plant was determined manually. In order to determine the dry matter contents in seedlings, ten seedlings were taken randomly and leaves, stems and roots were dried in room temperature for one week after the wet weight was determined. They were then dried at 105 °C in an oven for 24 hours and weighed (A.O.A.C 1980). The wet and dry weights were determined using a scale with 0.01 g precision and dry matter content (%) was determined with the formula (Equality 1).

$$\text{Dry Matter Content (\%)} = \frac{\text{Dry Weight} \times 100}{\text{Wet Weight}} \text{ (Kılıç et al 1991).}$$

"SPSS 22.0" statistical program was used for statistical analysis of the data.

Molecular Analysis

DNA isolation

DNA was isolated from plant samples for IRAP (Inter Retrotransposon Amplified Polymorphism) analysis. DNA isolation was accomplished with minor changes in the method expressed by Saghai-Marouf et al. (1984). DNA concentrations were determined with ACTGene Spectrophotometer (ACTGene UVIS-99, NJ, USA) at A260 280-1 O.D. and the DNA of all samples was adjusted to 0.5 µg.

IRAP marker analysis

Six IRAP primers (Metabion International AG Lena-Christ-Strasse 44/I D82152 Martinsried, Deutschland) were used in the study. The name, sequence and melting temperatures of the primers are shown in Table 1.

Table 1. Details of primers used in IRAP-PCR analysis

Tablo 1. IRAP-PCR analizinde kullanılan primerlerin detayları

Primer name	Sequence 5'→3'	T.M. (°C)
SUKKULA	GATAGGGTCGCATCTTGGGCGTGAC	63.3
3LTR-5	TGTTTCCCATGCGACGTTCCCAACA	64.6
LTR 6150	CTGGTTCCGCCCATGTCTATGTATCCACACATGTA	64.4
NIKITA E2647-	ACCCCTCTAGGCGACATCC	58.7
5LTR1	TTGCCTCTAGGGCATATTTTCCAACA	58.4
LTR 6149 -5	CTCGCTCGCCCACTACATCAACCGGTTTATT	65.9

The components and quantities required for the IRAP-PCR procedure for the evaluation of retrotransposon mobility were prepared with the values given in Table 2.

Table 2. Components of IRAP-PCR analysis

Tablo 2. IRAP-PCR analiz bileşenleri

Component	Quantity (µl)
10 x PCR buffer	2
dNTPs (10 nM)	0.5
MgCl ₂ (25 mM)	1.25
IRAP primer (5 mM)	1
Taq DNA polymerase	1
Ultra pure water	13.25
Genomic DNA	1
Total volume	20

IRAP electrophoresis protocol

The PCR products obtained were loaded with a gel loading solution in agarose gel and were run at 90 volts

Table 3. IRAP-PCR protocol

Tablo 3. IRAP-PCR protokoli

Cycle name	Temperature	Time	Number of Cycles
Initial Denaturation	95 °C	2 min	1
Denaturation	95 °C	30 sec	2
Primer binding	* °C	1 min	1
Elongation	72 °C	2 min	1
Denaturation	95 °C	30 sec	41
Primer binding	35 °C	1 min	1
Elongation	72 °C	2 min	1
Last elongation	72 °C	5 min	1
Termination	4 °C	∞	1

* Adhesion temperature of the relevant IRAP primer given in Table 1

FINDINGS

Seedling height (cm)

The study revealed that the application of Tebuconazole at different doses had a statistically significant effect on seedling height of cucumber. The seedling height in the control application was 6.32 cm, and the lowest value (2.68 cm) was obtained from the application of 125 ppm. As a result of the application, a 57.6% decrease was determined in the seedling height compared to the control application (Table 4).

Stem height (cm) applications

Applications had a statistically significant effect on stem height in cucumber plants. The highest stem

for 100 minutes. The bands formed as a result of electrophoresis were examined under a UV device at 256-nm UV light.

IRAP analysis and calculation of genomic template stability (GTS)

Genomic mold stability (%) was calculated for each primer using the following formula of $100(100 - a/n)^{-1}$ by Ateizar (1999). 'A' in the formula refers to the IRAP polymorphic profiles determined for each sample, and 'n' refers to the total amount of DNA band obtained with the respective primary in the negative control group. The polymorphism observed in the IRAP profiles of the samples included the loss of a new band or the existing band that occurred compared to the negative control group. Total Lab TL120 was used to evaluate these bands.

The samples were subjected to the PCR protocol given in Table 3.

height was determined as 4.15 cm at 0 ppm (control) dose while the lowest stem height was determined as 1.83 cm at 150 ppm dose. In Tebuconazole application, a 55.9% suppression was detected in the stem height compared to the control application (Table 4).

Stem diameter (mm)

Significant differences were found among the applications in terms of stem diameter. The average stem diameter in the seedlings was 4.52 mm in the control application and the stem diameter showed an overall increase in compared to the control application as a result of the application of Tebuconazole. The highest stem diameter (4.97 mm) was detected in the

at 75 ppm. In the application of Tebuconazole at 75 ppm, a 9.96% increase in stem diameter was determined compared to the control application (Table 4).

Table 4. The effects of the application of Tebuconazole on seedling characteristics

Tablo 4. Tebuconazole uygulamalarının fide özelliklerine etkisi

Doses	Seedling Height (cm)	Stem Height (cm)	Stem Diameter (mm)	Number of Leaf (Number/Plant)	Leaf Dry Matter Ratio (%)	Stem Dry Matter Ratio (%)	Root Dry Matter Ratio (%)	Leaf Chlorophyll Quantiy (SPAD)
0 ppm	6.32±0.28 ^a	4.15±0.49 ^a	4.52±0.16 ^b	4.80±0.10 ^a	17.21±0.84 ^a	7.69±0.11 ^d	5.31±0.27 ^a	45.97±0.35 ^d
25 ppm	4.07±0.12 ^b	2.80±0.87 ^b	4.80±0.10 ^{ab}	4.40±0.17 ^b	15.52±0.58 ^b	6.83±.17 ^e	4.40±0.35 ^b	52.97±0.88 ^b
50 ppm	2.80±0.18 ^{cd}	1.87±0.12 ^c	4.90±0.50 ^a	4.80±0.17 ^a	15.07±0.17 ^{bc}	8.82±0.44 ^b	4.55±0.20 ^b	52.32±1.30 ^b
75 ppm	2.97±0.29 ^c	2.12±0.25 ^c	4.97±0.29 ^a	3.95±0.17 ^c	14.30±0.24 ^c	9.60±0.16 ^a	3.45±0.10 ^c	49.58±0.67 ^c
100 ppm	2.83±0.58 ^{cd}	1.95±0.13 ^c	4.85±0.25 ^a	4.15±0.17 ^{bc}	12.26±0.54 ^d	6.39±0.52 ^f	2.99±0.95 ^d	58.32±2.47 ^a
125 ppm	2.68±0.29 ^d	1.87±0.29 ^c	4.58±0.18 ^b	4.30±0.17 ^{bc}	12.45±0.27 ^d	6.76±0.79 ^e	3.12±0.10 ^{cd}	53.62±0.88 ^b
150 ppm	2.70±0.50 ^d	1.83±0.29 ^c	4.87±0.23 ^{ab}	4.48±0.17 ^{ab}	12.77±0.42 ^d	7.89±0.10 ^c	3.08±0.36 ^d	52.60±1.21 ^b
	***	***	*	*	***	***	***	***

*p<0.05 ***p=0.001 ns: not significant

Number of leaf (number plant⁻¹)

The effect of the application of Tebuconazole at different doses on the number of leaves of cucumber seedlings was significant at the 1% level. The mean number of leaves per plant in the control application was 4.8, and the number of leaves was observed to decrease in all applications, except for 50 ppm dose (Table 4).

Leaf dry matter content (%)

The application of Tebuconazole at different doses had a statistically significant effect on leaf dry matter content in seedlings. In the study, while the leaf dry matter content obtained by the control application was 17.21% as a result of the application of Tebuconazole, an overall decrease was observed in the leaf dry matter content at all doses compared with the control group. The highest dry matter content after the control group was obtained at doses of 25, 50 and 75 ppm, respectively (Table 4).

Stem dry matter content (%)

The applications of Tebuconazole were found to have a significant effect on cucumber seedlings at the 1% significance level on the stem dry matter content. In the study, the stem dry matter content obtained from the control group (0 ppm) was 7.69%. As a result of the application of Tebuconazole determined that the stem dry matter content increased in the doses of 50, 75 and 150 ppm, respectively, compared to the control dose of 0 ppm and decreased at the other doses. The highest rate (9.6%) was obtained from the dose of 75 ppm. (Table 4).

Root dry matter content (%)

According to the data obtained from the study, the application of Tebuconazole at different doses had a significant effect on root dry matter content in cucumber seedlings. The highest root dry matter

content with 5.31% ratio was determined in the control application at 0 ppm. As a result of the application of Tebuconazole, the root dry matter content decreased in all doses compared to the control application (Table 4).

Leaf Chlorophyll Content (SPAD Value)

Statistical analysis revealed that the applications of Tebuconazole had a substantial effect on the leaf chlorophyll amount (SPAD value). In the study, the mean SPAD value obtained in the control application was measured as 45.97 and this value increased in all other applications compared to the control group (0 ppm). The highest SPAD values were obtained from the doses of 100 (SPAD value = 58.32), 125 (SPAD value = 53.62) and 25 (SPAD value = 52.97) ppm, respectively (Table 4).

The correlation analysis between quality characteristics of seedlings

The analysis indicated that the seedling height had a significantly positive correlation with stem height, leaf and root dry matter content, and a significant negative correlation with stem diameter and the SPAD values. Leaf dry matter content was found to have a significant positive correlation with root dry matter content and a negative correlation with the SPAD values. On the other hand, the dose was found to have a statistically significant negative correlation with seedling and stem height, leaf and root dry matter contents, and a positive correlation with chlorophyll amount (Table 5).

IRAP Analysis

IRAP analysis was performed to determine retrotransposon mobility in the samples to which Tebuconazole was applied and compared with the control group. 114 bands were obtained from six IRAP primers used to determine the stress level caused by the fungicide of Tebuconazole at the molecular level.

The sizes of these bands ranged from 86 to 1,223 bp. The highest number of polymorphic bands was obtained from Nikita primer with 11 bands. 9 of these polymorphic bands were formed as new band formation and 2 of them as no band formation.

Polymorphic band was not formed in the sukkula primer and polymorphism did not taken place. Details of the data obtained from the IRAP analysis are given in Table 6.

Table 5. The correlation analysis between seedling characteristics

Tablo 5. Fide özellikleri arasındaki korelasyon analizi

	1	2	3	4	5	6	7	8	9
1 Seedling Height	1								
2 Stem Height	0.974**	1							
3 Stem Diameter	-0.493*	-0.451*	1						
4 Number of Leaf	0.416	0.366	-0.328	1					
5 Leaf Dry Matter Ratio	0.818**	0.816**	-0.266	0.459*	1				
6 Stem Dry Matter Ratio	-0.087	-0.092	0.371	-0.026	0.288	1			
7 Root Dry Matter Ratio	0.795**	0.768**	-0.301	0.612**	0.913**	0.184	1		
8 SPAD Value	-0.665**	-0.637**	0.221	-0.587**	-0.768**	-0.452*	-0.777**	1	
9 Doses	-0.779**	-0.768**	0.198	-0.399	-0.903**	-0.129	-0.906**	0.585**	1

** Significant at the 1% level

* Significant at the 5% level

Table 6. Data from IRAP analysis

Tablo 6. IRAP analizinden elde edilen veriler

Primer Name	Control	25 ppm	50 ppm	75 ppm	100 ppm	125 ppm	150 ppm
LTR 6150	4	....	....	...	-256	800 -442	749 -442
3LTR5	2	....	....	..	716	720	724 716
Nikita	5	....	768	700 -271	956 -271	984 800 271	1.000 838 271
Sukkula	1						
5LTR1	3	....	....	.....	782	793 -323	816 684
LTR6149-5	3	....	...	-263	-562 -263	-562 -263	-562 -263
Band Number	18	.....	1	3	7	10	11
Polymorphism rate		0	5.55	16.66	38.88	55.55	61.11
GTS value		100	94.45	83.34	61.12	44.45	38.89

Polymorphism was detected in all applications except for the 25 ppm dose. The resulting polymorphism varied between 0% and 61.11%. The lowest polymorphism was obtained from 0% in the samples to which Tebucozanole was applied at 25 ppm. Depending on the incremental dose, polymorphism value also increased in seedlings to which Tebucozanole was applied. The highest polymorphism was determined as 61.11% in seedlings to which Tebucozanole was applied at 150 ppm. .

The GTS (Genomic Template Stability) value, which represents the genomic stability, varied depending on the applied dose of Tebucozanole. The GTS value varied between 38.89% and 100%. The highest GTS value (100%) was found in seedlings to which Tebucozanole was applied at 25 ppm. The GTS value decreased to 38.89% depending on the increase in the

dose of Tebucozanole. Figure 3 shows the band image obtained from the Nikita primer.

The polymorphism rates and GTS values that vary depending on the dose of Tebucozanole applied are given in Figure 4.

DISCUSSION and CONCLUSION

Based on literature review, there is a very limited study regarding the effects of the application of Tebucozanol to cucumber and other vegetable on seedling quality and retrotransposon mobility. However, several studies investigating the effects of Paclobutrazol and similar substances, which are included in Triazol group similarly with Tebuconazole, on vegetable seedling quality are available (Brigard et al. 2006, Çopur and Sarı 2011). Geboloğlu et al. (2015) applied four different doses of Paclobutrazole (50, 100, 200 and 500 ppm, respectively) on eggplant seedlings

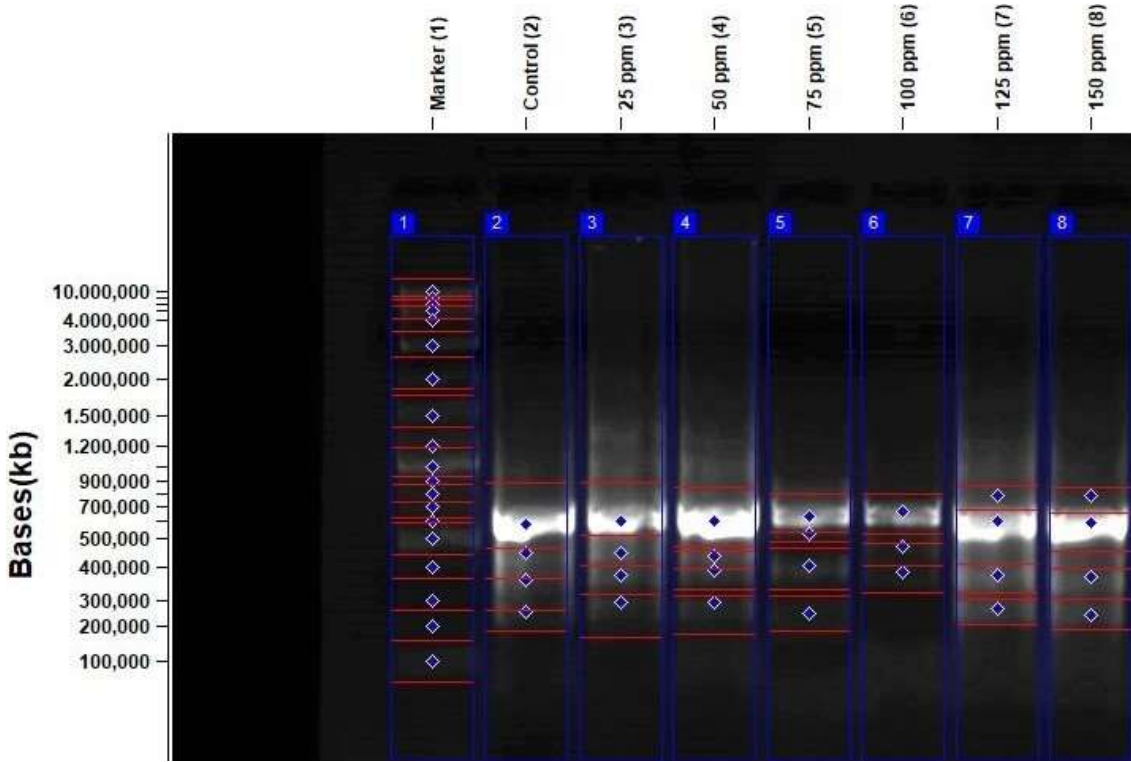


Figure 3. Band image from Nikita primer
Şekil 3. Nikata primerinin bant görüntüsü

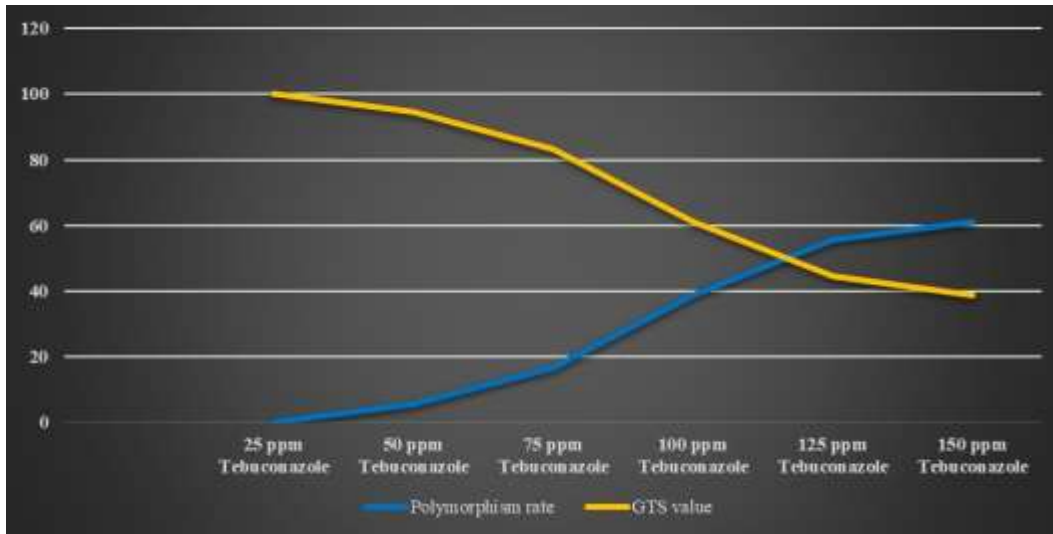


Figure 4. Polymorphism rate and the GTS value
Şekil 4. Polimorfizm oranı ve GTS değeri

in two different seedling development stages and found that seedling height and stem height were significantly suppressed. Another study found that stem elongation of eggplant inhibited by tebuconazole (Rogach, 2020). Similarly, the application of Tebuconazole significantly suppressed the seedling height. The results were similar to the results obtained from the researcher reports. These substances can inhibit Gibberelic Acid synthesis (Geboloğlu et al. 2015) and the decrease in height is thought to originate

from this fact. According to the control application, the dose of 150 ppm suppressed the stem height at the maximum level. The resulting data and measurements indicated that the applications increased in the stem diameter. The mean stem diameter in the control group was measured as 4.52 mm and the highest stem diameter (4.97 mm) was obtained from dosing of 75 ppm. Compared to the control application, 9.95% increase was determined in the stem diameter. Several studies reported an increase in plant stem diameter compared to the control application (Berova and Zlatev

2000; Zandstra et al. 2007; Teto et al. 2016). One of the key characteristics for seedling quality is the dry matter content. The results showed that the leaf, stem and root dry matter contents varied significantly among the applied doses. Compared to the control group, leaf and root dry matter contents decreased. In a similar study, the control applications showed decreases at 7% and 6% in dry weights of tomato seedlings (Berova and Zlatev, 2000). The stem dry matter content decreased at the doses of 25, 100 and 125 ppm, respectively but increased in all other doses, compared to the control group. Baninasab (2009) reported 6.11-16.45% increase in shoot dry weights of watermelon seedlings as a result from the application of Paclobutrazol. Alterations in plant dry matter contents are thought to be from the impact of Tebuconazole on the synthesis and transport of gibberalic acid resulting regression in growth. The SPAD value showed an increase in the seedlings to which the substance was applied compared to the control group. In similar studies, Paclobutrazole, which was applied as leaf spray to the tomato seedlings, increased in the leaf chlorophyll content (Berova and Zlatev 2000; Moraes et al. 2005) and similar results were obtained from watermelon (Baninasab 2009) and lettuce (Akdemir 2018).

In this study, it was determined that the stress caused depending on the applied dose of Tebuconazole increased in retrotransposon mobility and this mobility led to an increase in the polymorphism value. Also, in this study it was determined that this retrotransposon mobility caused a decrease in the GTS value, which represented the stability of the genome. The lowest polymorphism rates (0%) and the highest GTS (100%) values were obtained from doses of 25 ppm. The change in polymorphism and the GTS values was acceptable up to 75 ppm but higher doses resulted in significant changes in these values. The decrease in the GTS value is an indication that Tebuconazole stress affects the stability of the genome (Table 6).

Nearly all of the different doses of Tebuconazole prevented excessive and unnecessary elongation in seedling and stem heights during the growth of cucumber seedlings. As a result, although the seedlings in the control application came to sowing-maturity, the duration to the sowing-maturing was observed to extend in substance applied seedlings. However, such chemicals (plant growth regulator, fungicide, herbicide, etc.) may cause stress in plants depending on the dose used (Sunar and Bulut 2019). Yet, when the results of IRAP analysis and particular seed quality characteristics are evaluated together, the application of Tebuconazole doses at 25, 50 and 75 ppm applications indicated that it will be beneficial in obtaining the desired seedling quality. Numerous variations may be attempted in future studies by increasing in the number of doses ranging

from the dose that causes the lowest change in the polymorphism rate and GTS value to the highest dose that positively affects seedling characteristics or by reducing the number of applications to a single application.

In conclusion, Tebuconazole was determined to achieve height control in cucumber seedlings and had positive effects on seedling quality. Based on the data obtained in the study, we think that the recommended doses can be used in practice.

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Author's Contributions

The contribution of the authors is equal.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

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