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

Hüseyin BULUT1, Halil Ibrahim ÖZTÜRK2*, Atilla DURSUN3,4

1,2Erzincan Binali Yıldırım University, Vocational School of Health Services, 24100, Erzincan/Turkey, 3Faculty of Agriculture, Department of Horticulture and Agronomy, Kyrgyz-Turkish Manas University, Bishkek/Kyrgyzstan, 4Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240, Erzurum / Turkey

DOI:10.18016/ksutarimdoga.vi.754689

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 dose. 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 controlled the seedling height in cucumber and affected specific quality characteristics of the seedlings.

**Keywords**

Seedling
Genotoxic effect
Cucumber
IRAP
Tebuconazole

---

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 dozlarla 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 değerlendirilmelere 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 sırasıyla %57.5, %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 yaparak klorofil miktarında bir artış sağlamıştır. Bu çalışmada, farklı dozlarada Tebuconazole uygulamalarının, hıyarda fide boyunu kontrol altında aldığını ve bazı fide kalite özelliklerine olumlu yönde etki ettiği belirlenmiştir.
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 (Gebololu 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, Głowačka 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 retrotransposon mobility are available (Hamad-Mecbur et al., 2012; Temel & Gözkirmizi, 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. The study was designed as randomized block design, with 3 replicates with 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.
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 a 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 (AOAC 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).

\[ \text{Dry Matter Content (\%)} = \frac{\text{Dry Weight}}{\text{Wet Weight}} \times 100 \]

"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-Maroof 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

| Primer name   | Sequence 5’→3’         | T.M. (°C) |
|---------------|------------------------|-----------|
| SUKKULA       | GATAGGGTCGCGATCTTGGGCGTGAC | 63.3      |
| 3LTR-5        | TGTTTCCCATGCGACGTCTCCCAACA | 64.6      |
| LTR 6150      | CTGGTTCGGCCCATGTCTATGTATCCACACATGTA | 64.4      |
| NIKITA E2647  | ACCCTCTTAGGCGACATCC      | 58.7      |
| 5LTR1         | TTGCCTCTAGGGCATATTTTCCAACA | 58.4      |
| LTR 6149 -5   | CTCGCTCGCCACTACATCAACCGGCTTTATT | 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

| Component             | Quantity (µl) |
|-----------------------|---------------|
| 10 x PCR buffer       | 2             |
| dNTPs (10 nM)         | 0.5           |
| MgCl2 (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 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 Ateinzar (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.

Table 3. IRAP-PCR protocol

| 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 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

| Doses  | Seeding Height (cm) | Stem Height (cm) | Stem Diameter (mm) | Number of Leaf (Number/Plant) | Leaf Dry Matter Ratio (%) | Dry Matter Ratio (%) | Root Dry Matter Ratio (%) | Leaf Chlorophyll Quantity (SPAD) |
|--------|---------------------|------------------|-------------------|-----------------------------|--------------------------|---------------------|---------------------------|-------------------------------|
| 0 ppm  | 6.32±0.28a          | 4.15±0.49a       | 4.52±0.16b        | 4.80±0.10c                  | 17.21±0.84d              | 7.69±0.11d          | 5.31±0.27a                | 45.97±0.35d                   |
| 25 ppm | 4.07±0.12b          | 2.80±0.87b       | 4.80±0.10ab       | 4.40±0.17b                  | 15.52±0.58b              | 6.83±1.7e           | 4.40±0.35b                | 52.97±0.88b                   |
| 50 ppm | 2.80±0.18cd         | 1.87±0.12c       | 4.90±0.50a        | 4.80±0.17a                  | 15.07±0.17bc             | 8.82±0.44b          | 4.55±0.20b                | 52.32±1.30b                   |
| 75 ppm | 2.97±0.29c          | 2.12±0.25c       | 4.97±0.29a        | 3.95±0.17c                  | 14.30±0.24c              | 9.60±0.16c          | 3.45±0.10c                | 49.58±0.67c                   |
| 100 ppm| 2.83±0.58cd         | 1.95±0.13c       | 4.85±0.25a        | 4.15±0.17bc                 | 12.26±0.54d              | 6.39±0.52f          | 2.99±0.95d                | 58.32±2.47a                   |
| 125 ppm| 2.68±0.29d          | 1.87±0.29c       | 4.58±0.18b        | 4.30±0.17bc                 | 12.45±0.27d              | 6.76±0.79e          | 3.12±0.10d                | 53.62±0.88b                   |
| 150 ppm| 2.70±0.50d          | 1.83±0.29c       | 4.87±0.23ab       | 4.48±0.17bc                 | 12.77±0.42d              | 7.89±0.10e          | 3.08±0.36d                | 52.60±1.21b                   |

*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 take place. Details of the data obtained from the IRAP analysis are given in Table 6.

Table 5. The correlation analysis between seedling characteristics

| Table 5. Fide özellikleri arasındaki korelasyon analizi |
|-----------------------------------------------|
| 1   | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |
| Seedling Height | 1       |         |         |         |         |         |         |         |
| Stem Height     | 0.974** 1  |
| Stem Diameter   | -0.493* -0.451** 1 |
| Number of Leaf  | 0.416 0.366 -0.328 1 |
| Leaf Dry Matter Ratio | 0.818** 0.816** -0.266 0.459 1 |
| Stem Dry Matter Ratio | -0.087 -0.092 0.371 -0.026 0.288 1 |
| Root Dry Matter Ratio | 0.795** 0.768** -0.301 0.612** 0.913** 0.184 1 |
| SPAD Value      | -0.665** -0.637** 0.221 -0.587** -0.768** -0.452** -0.777** 1 |
| 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

| Table 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 | 800 749 |        |        |        |
| 3LTR5       | 2 ... ... 716 | 720 724 |        |        |        |
| Nikkula     | 5 ... 768 700 | 956 984 | 1.000  |
| Sukkula     | 1 ... ... 782 | 793 816 |        |        |        |
| 5LTR1       | 3 ... ... 443 | 562 562 |        |        |        |
| LTR6149-5   | 3 ... -263 | 562 -562 |        |        |        |
| Band Number  | 18 ... 800 | 16.66 38.88 | 55.55 61.11 |
| 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 |

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 retrotranspozon 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
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 Tebucozanele 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
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.

ACKNOWLEDGMENT
Thank you for the contributions of the Erzincan Horticultural Research Institute.

Author’s Contributions
The contribution of the authors is equal.

Statement of Conflict of Interest
Authors have declared no conflict of interest.

REFERENCES
Akdemir S 2018. Marul (Lactuca sativa L.) fide kalitesi ve bitki gelişimi üzerine paclobutrazol ve prohexadione-calcium uygulamalarının etkileri., Kırşehir Ahi Evran Üniversitesi, Fen Bilimleri Enstitüsü, Tarımsal Biyoteknoloji Anabilim Dalı, Yüksek Lisans Tezi, 103 Sy, Kırşehir.
Baninasab B 2009. Amelioration of chilling stress by paclobutrazol in watermelon seedlings. Scientia Horticulturae, 121(2): 144-148.
Bennetzen JL 2000. Transposable elements contributions to plant gene and genome evolution. Plant Molecular Biology, 42: 251-269. https://doi.org/10.1023/A:1006344508454
Berova M, Zlatev Z 2000. Physiological response and yield of paclobutrazol treated tomato plants (Lycopersicon esculentum Mill.). Plant Growth Regulation, 30(2): 117-123.
Brigard JP, Harkess RL, Baldwin BS 2006. Tomato early seedling height control using a paclobutrazol seed soak. Horticultural Science, 41(3): 768-772.
Cakiroglu M, Bozkurt B, Kayacan S, Eren S, Caner S, Balikova, M 2013. Tebuconazole sorption in cucumber seed soak. Horticultural Science, 41(3): 1125-1130.
Demir İ, Balkaya A, Yılmaz K, Onus AN, Uyanık M, Kayacan M, Bozkurt B 2010. Sebzelerde tohumluk ve fide üretimi. TMMOB Ziraat Mühendisleri Odası, VII. Türkiye Ziraat Mühendisliği Teknik Kongresi, 11-15 Ocak 2010, Ankara.
Federoff N 2000. Transposons and Genome Evolutions in Plants. Proceedings of the National Academy of Sciences, 97 (13): 7002-7007.

Garner LC, Björkman T 1996. Mechanical conditioning for controlling excessive elongation in tomato transplants: sensitivity to dose, frequency, and timing of brushing. Journal of the American Society for Horticultural Science, 121(5): 894-900.

Geboloğlu N, Durukan A, Sağlam N, Doksöz S, Şahin S, Yilmaz E 2015. Pathcanda Fide Gelişimi ve Fide Kalitesi ile Paclobutrazol Uygulamaları Arasındaki İlişkiler. International Journal of Agricultural and Natural Sciences (IJANS) E-ISSN: 2651-3617, 8(1): 62-66.

Geboloğlu N, Kum AD, Şahin S, Boncukçu SD, Sağlam N 2016. Paklobutrazolun Marulda Fide Boyu ve Kalite Özelliklerine Etkisi. International Journal of Agricultural and Natural Sciences (IJANS) E-ISSN: 2651-3617, 9(2): 26-29.

Glowacka B 2004. The effect of blue light on the height and habit of the tomato Lycopersicon esculentum Mill.) transplant. Folia Horticulturae, 16(2): 384-388.

Kılıç O, Çopur U, Göktay S (1991) Meyve ve Sebze İşleme Teknolojisi Uygulama Kilavuzu. Uludağ Üniversitesi Ziraat Fakültesi Ders Notları: 7, s: 143.

Temel A, Gözükirmizi N 2013. Analysis of retrotransposition and DNA methylation in barley callus culture. Acta Biologica Hungarica, 64 (1): 86-95.

Teto AA, Laubscher CP, Ndakidemi PA, Matimati I 2016. Paclobutrazol retards vegetative growth in hydroponically-cultured Leonotis leonurus (L.) R. Br. Lamiaceae for a multipurpose flowering potted plant. South African Journal of Botany, 106: 67-70.

Wessler SR 2009. Eukaryotic transposable elements: teaching old genomes new tricks", http://www.plantbio.uga.edu/wesslerlab/The_Implicit_Genome.pdf, Son Erişim Tarihi: 10.03.2017.

Wicker T, Sabot F, Hua-Van A, Bennetzen J, Capy P, Chalhoub B, Flavell A, Leroy P, Michele M, Olivier P, E Paux, Phillip S, Alan HS 2007. A Unified Classification System for Eukaryotic Transposable Elements. Nature Genetics, 8: 973-982.

Yigider E, Taspınar MS, Sigmaz B, Aydin M, Agar G 2016. Humic acids protective activity against manganese induced LTR (long terminal repeat) retrotransposon polymorphism and genomic instability effects in Zea mays. Plant Gene, 6: 13-17.

Zandstra JW, Squire RC, Watt GJ 2007. Managing transplant size and advancing field maturity of fresh tomatoes and peppers. In: Ontario vegetable crop research: University of Guelph Ridgetown Campus, pp. 1-16.