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The Effect of Eucalyptus (*Eucalyptus camaldulensis* Dehnh) Essential Oil on the Germination and Plantlet Growth Parameters of Some Solanaceae Species

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Abstract: *In this study, the stimulative effect of different doses of essential oil from eucalyptus plant was investigated. In the study, the effects of Eucalyptus (Eucalyptus camaldulensis Dehnh) oil on the seed germination and vegetative development of tomato (Riogrande F_1, H-2274 cv.), pepper (Üç Burun cv., Demre Sivrisi cv.) and eggplant (Aydın Siyahı cv., Topan cv.) plantlets were investigated. For this purpose, four different concentrations (0, 0.1, 0.2, 0.3, 0.4 µl/petri) of oil were applied to seeds placed in petri dishes. After germination percentages and germination rates were determined, average plant weight (mm), shoot length (mm), root length (mm), shoot and root weights (g) of the plantlets obtained at the end of the study were measured. As a result of the statistical analysis of the obtained data, it was determined that the best germination percentage in tomato cultivars [Rio Grande F_1 (95%) H-2274 (100%)], pepper (Üç Burun cv. and Demre Sivrisi cv. 92%) and eggplant (Topan cv. 93%) were obtained from 0.2µl application. Considering the effect of applications on vegetative growth criteria, it was detected that the effect of 0.1µl dose was better than the other applications on the root and shoot length, root, shoot and plant fresh weight for both tomato cultivars. On the other hand, the effect of 0.2 µl eucalyptus oil application on the growth of plantlets has been found to be more advantageous in pepper (Üç Burun cv. and Demre Sivrisi cv.) and eggplant (Topan cv.) cultivars.*

Keywords: *Eggplant, Essential oil, Eucalyptus camaldulensis, Pepper, Tomato*

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I. Introduction

In parallel with the growing population, the increasing food demand made it necessary to increase the yield per unit area. Vegetables play an important role in human nutrition because of the vitamins, minerals, carbohydrates, fats and proteins they contain. The off-season production of summer vegetables such as tomatoes, peppers and eggplants are generally made in greenhouse. It is important to obtain healthy plantlets without the seed loss in tomato, pepper and eggplant production which are generally produced from the plantlets. Production with plantlets is also preferred for providing earliness and for eliminating problems caused by seed germination (Balkaya et al., 2015). Internal factors such as seed coat and small embryo and also external factors such as the lack of optimum conditions required for seed germination in natural environment, cause germination problems and consequently loss of plantlet (Kenanoğlu, 2016).

Only seedlings are used as material in the production of greenhouse vegetables (Yelboğa, 2014, Balkaya et al. 2015). Antalya province where establishment of the first modern seedling production company in Turkey (Demir et al., 2010) is an important region in terms of production of greenhouse vegetables. According to 2018 data (Anonymous, 2018), the number of firms producing vegetable seedlings in Antalya (64) province comprises nearly half the overall (135) Turkey. As can be seen from the data in Table 1, tomato, pepper and eggplant which are the members of *Solanaceae* family are among the most important vegetable crops and are grown extensively in the world and also in Turkey (Faostat, 2016).

Table1. Production values of tomato, pepper and eggplant in the world and Turkey

	Production quantity (tonnes)		
	Tomato	Pepper	Eggplant
World	177.042.359	38.415.621	51.288.169
Turkey	12.600.000	2.473.961	854.049

Seed properties and environmental conditions needed for germination vary according to the species and even cultivars of the plant and some pre-treatments can change the seed germination and plant growth positively (İşlek et al., 2010). Different chemicals and plant growth regulators are used for this purpose. Due to the increasing demand for organic agriculture in recent years, the use of materials of organic origin such as seaweed, plant extracts and essential oils are used (Kenanoğlu, 2016) has gained importance (Teksan&Kavak, 2016).

Eucalyptus is one of the most important and most widely planted species belongs to the family *Myrtaceae*. Several species of Eucalyptus are used in folk medicine as an antiseptic and against infections of the upper respiratory tract, such as cold, influenza and sinus congestion. The essential oil of Eucalyptus species showed a wide spectrum of antimicrobial, antifungal, anticandidal, antibacterial, expectorant and cough stimulant activity (Silva et al., 2003). Phytochemical analysis of *Eucalyptus* species, showed that the major components; aromadendrene, followed by α-phellandrene, 1,8-cineole, ledene and globulol (Pereira et al., 2005), α-pinene, β-pinene and β-caryophyllene (Sacchetti et al., 2005). It is important to determine the effectiveness (to speed up or promote germination with organic or inorganic treatments do positive effects to the seed or seedling) of these compounds in agricultural production.

Essential oils have widely application in chemical, pharmacology, food, cosmetic and agricultural sector (Çoban and Patır, 2010). Recently, the preparations which are eco-friendly, clean, inexpensive and most importantly of plant originated (seaweed extract, medical plant extract, vinegar priming, volatile oils and propolis), are used as an alternative to synthetic chemicals. Essential oil applications could be considered as an inhibitor to germination of viable seeds (Bakkali et al., 2008, Yanar et al., 2016, Paudel and Gupta 2008) but a few previously studies (Nasircilar et al., 2018) have revealed that it is one of the least discussed phenomena in the simulative effect on seed germination and plantlet growth parameters of these.

The aim of this study was to determine the effects of different doses of essential oils obtained from eucalyptus on growth development parameters in the early stages of plantlets and germination rate of the seeds of tomato, eggplant and pepper plants.

II. Material And Method

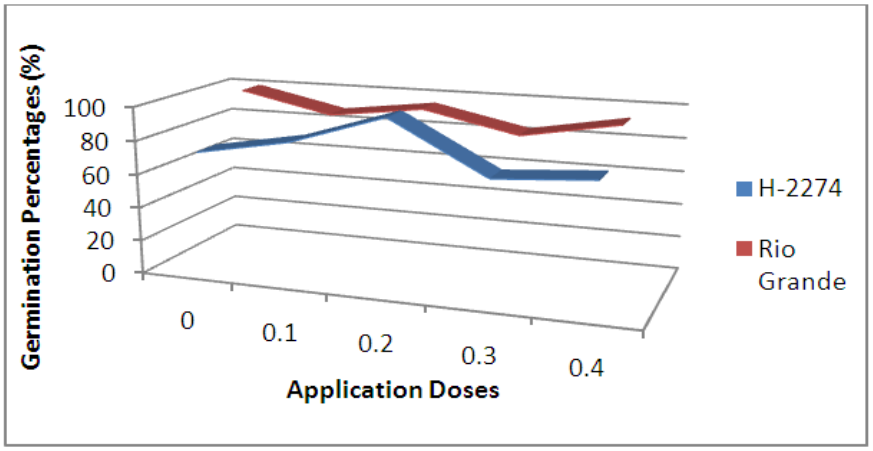
Three plant species (tomato, eggplant and pepper) and two cultivars of each species [tomato (*Solanum lycopersicum* L. cv. Rio Grande F_1 and cv. H-2274), eggplant (*Solanum melongena*L. cv. Topan and cv. Aydin Siyahı) and pepper (*Capsicum annuum* L. cv. Demre Sivrisi and cv. Üç Burun)] were used in the research. Hybrid vegetable seeds were purchased from commercial seed production concern. Eucalyptus oil have been extracted for 3 hours (v w-1%) by hydro-distillation method with Clevenger apparatus (Başer et al., 1998) was obtained from a commercial company and were preserved in +4 ºC until the analysis. 4 different concentrations of oil (0.1, 0.2, 0.3, 0.4 µl/petri) were applied to the seeds in the experiment.

The germination experiments were conducted in Akdeniz University, Vocational School of Technical Sciences, organic agriculture laboratory and climate room. Germination study was carried out in climate room with 24±1ºC in the dark until the first roots and the exit of the hypocotyls and then in 16/8 hours (light / dark) photoperiod. To prevent fungal and bacterial contamination, a sufficient number of seeds from each plant cultivar were sterilized in 10% commercial sodium hypochlorite solution for 10 minutes and rinsed 3 times with sterile distilled water. 100 seeds of each cultivar were divided into four replicates of 25 seeds and were put in the Petri dishes (9-cm glass) on two layer of filter paper that moistened with distilled water for control or test solution. Test solution of eucalyptus oil (0.1, 0.2, 0.3, 0.4 µl / petri) was added to the Petri dishes. Germinated seeds were recorded every day and the trial was terminated after 21 days. At the end of the experiment, plant, shoot and root length (mm) of the plantlets were measured by digital calliper and plant, shoot and root fresh weights (g) were determined with precision scales. Data were analysed by using SPSS statistical software program, Duncan test. Correlations were obtained by Pearson correlation coefficient in bivariate correlations.

III. Result And Discussion

As a result of the evaluation of the results, different doses of eucalyptus oil have been found to have different effects on seed germination and plantlet growth parameters of different cultivars of tomato, pepper and eggplant plants belonging to *Solanacea* family. When the effects of different dose applications of eucalyptus oil on the germination percentages of the seeds of two different tomato cultivars (Figure 1), the highest germination percentage in both cultivars [Rio Grande F_1 (95%) H-2274 (100%)] was determined in 0.2 µl application. Homogenous and rapid germination can be achieved by eliminating the germination of the seed (Tilki and Kambur, 2010). Pretreatment with many chemical or organic substances is known to be used to promote germination or seedling growth (Teksan and Kavak 2016). In this study, it was determined that different doses of essential oils, which are generally indicated to inhibit seed germination (Bakkali ve ark. 2008), promote germination.

Figure 1. Effect of eucalyptus oil on germination percentages of tomatoes cultivars.



The effect of eucalyptus oil on the vegetative growth of plantlets of tomato seeds was evaluated and the results are given in Table 2. According to these results, statistically significant differences were determined among all the applications. The highest values of RL (9,31 mm), SL (3,70 mm), RFW (0,0163 g), SFW (0,0267 g) and PW (0,0421 g) were obtained from 0,1 µl application. 0,1 ve 0,2 µl application results were the same statistical group in terms of SL (3,52 mm), RFW (0,0124 g) and SFW (0,0254 g) in Rio Grande F_1 cultivar and RL (7,22) and SL (3,81) values in H2274 cultivar. According to these results, it can be said that 0.1 µl eucalyptus oil application has the best effect on the growth of seedlings.

Table 2. Effects of eucalyptus oil applications on vegetative development of the tomato plantlets

Cultivar	Doses (µl)	RL (mm)	SL (mm)	RFW (g)	SFW (g)	PW (g)
Rio Grande F_1	**Control**	6,20 b	2,93 ab	0,0066 b	0,0160 bc	0,0244 c
	0,1	9,31 a	3,70 a	0,0163 a	0,0267 a	0,0421 a
	0,2	7,41 ab	3,52 a	0,0124 a	0,0254 a	0,0340 ab
	0,3	5,12 b	2,71 ab	0,0110 ab	0,0223 ab	0,0322 bc
	0,4	1,44 c	1,92 b	0,0059 b	0,0092 c	0,0120 d
H-2274						
	Control	5,01 b	3,42 ab	0,0085 bc	0,0282 b	0,0363 b
	0,1	6,82 a	4,00 a	0,0173 a	0,0373 a	0,0510 a
	0,2	7,22 a	3,81 a	0,0110 b	0,0277 b	0,0389 b
	0,3	3,26 c	2,94 b	0,0078 bc	0,0180 c	0,0216 c
	0,4	3,58 c	2,06 c	0,0043 c	0,0142 c	0,0231 c

Differences between groups with different letters in the same column are statistically significant (P <0.05).

The correlation between the mean values of growth and development criteria of tomato plantlets is given in Table 3. As expected, Table 3 shows positive correlations between the criteria (P<0,01). The highest correlation value was found between PW and SW (r=0,845, P<0,01) in Rio Grande F_1 cv., and H-2274 in RL and SL (r=0,766, P<0,01).

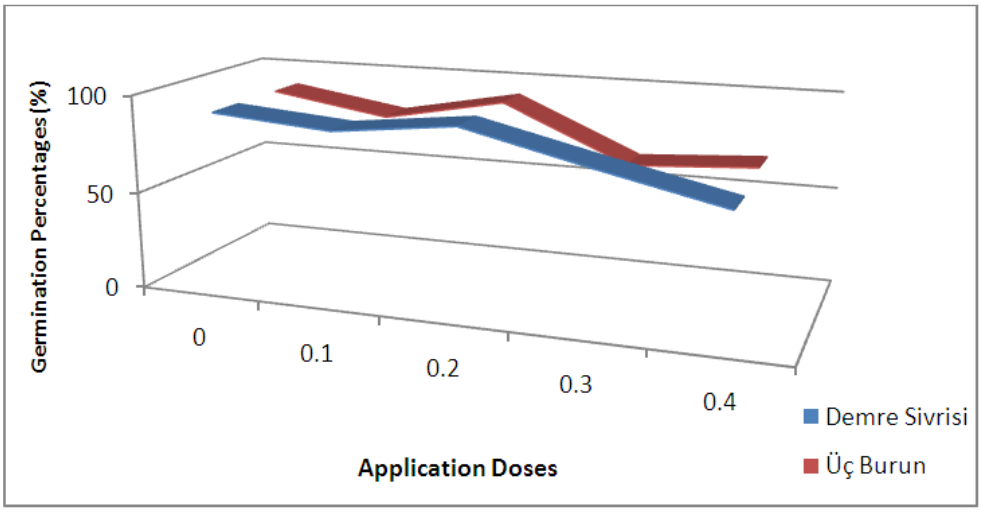
Table 3. Correlation of vegetative development criteria of H-2274 and Rio Grande F_1 cultivars applied with eucalyptus oil

H-2274	SW	RW	PW	RL	SL
SW	1	,559**	,736**	,613**	,602**
RW	,559**	1	,759**	,685**	,606**
PW	,736**	,759**	1	,707**	,640**
RL	,613**	,685**	,707**	1	,766**
SL	,602**	,606**	,640**	,766**	1
Rio Grande F_1	**SW**	**RW**	**PW**	**RL**	**SL**
SW	1	,606**	,845**	,756**	,630**
RW	,606**	1	,799**	,694**	,276
PW	,845**	,799**	1	,769**	,524**
RL	,756**	,694**	,769**	1	,605**
SL	,630**	,276	,524**	,605**	1

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed).

The effect of different doses of eucalyptus oil on the germination rate of two different pepper cultivars (Demre Sivrisi cv. and Üç Burun cv.) is shown in Figure 2. As a result of the evaluation, the highest germination rate (92%) was obtained from 0,2 µl application in both cultivars. It is seen that the application dose of eucalyptus oil decreases the germination rate over 0,2 µl. Application dose is important in the use of essential oils (Ashraf and Foolad, 2005). In some studies, it has been reported that low-dose essential oils have stimulating effects whereas inhibitory effect occurs due to dose increase.

Figure 2. Effect of eucalyptus oil on germination percentages of pepper cultivars



The effects of eucalyptus oil on the growth parameters of the pepper cultivars plantlets are given in Table 4. According to these results, it is possible to say that the effect of different doses of eucalyptus oil on the growth parameters of plantlets is statistically significant. In Üç Burun cv. the best results of RL (41.92 mm), RFW (0.0251 g) and PW (0.0379 g) were observed at 0,2 µl oil application. The highest mean values for SFW were obtained from 0,2 µl (0.0256 g) and 0,3 µl (0.0238 g) and these two applications were found in the same statistical group. In terms of SL (16.92 mm) value, the most prominent application was found to be 0,3 µl. When the response of Demre Sivrisi cv. to the application is examined, it is seen that the highest average values are (RL; 67,54 mm, SL; 21,23 mm, RFW; 0,0199 g, SFW; 0,0293 g, PW;0,0467 g) determined in 0,2 µl of oil application similar to the Üç Burun cv. (Table 4).

Table 4. Effects of eucalyptus applications on vegetative development of the pepper plantlets

Cultivar	Doses (µl)	RL (mm)	SL (mm)	RFW (g)	SFW (g)	PW (g)
Üç Burun	**Control**	17,11 c	9,84 bc	0,0088 c	0,0157 b	0,0287 ab
	0,1	27,72 b	6,86 c	0,0127 bc	0,0138 b	0,0267 ab
	0,2	41,92 a	11,91 b	0,0251 a	0,0256 a	0,0379 a
	0,3	33,11 b	16,92 a	0,0208 ab	0,0238 a	0,0332 ab
	0,4	25,12 bc	8,74 bc	0,0115 bc	0,0095 b	0,0187 b
Demre Sivrisi						
	Control	53,08 ab	13,92 c	0,0126 b	0,0220 bc	0,0383 b
	0,1	51,80 ab	16,12 bc	0,0145 b	0,0252 abc	0,0401 b
	0,2	67,54 a	21,23 a	0,0199 a	0,0293 a	0,0467 a
	0,3	54,08 ab	18,58 b	0,0157 ab	0,0260 ab	0,0435 ab
	0,4	43,01 b	17,88 b	0,0078 c	0,0212 c	0,0298 c

Differences between groups with different letters in the same column are statistically significant (P <0.05).

When the correlations between vegetative criteria measured in order to compare the growth and development of plantlets, it is observed that there is a positive correlation (P<0,01) between; RW and SW (r=0,689), PW and SW (r=0,639) for Demre Sivrisi cv. A positive correlation (P<0,01) was found between PW and SW (r=0,679), RL and SW (r=0,516), SL and SW (0,535) for Üç Burun cv.

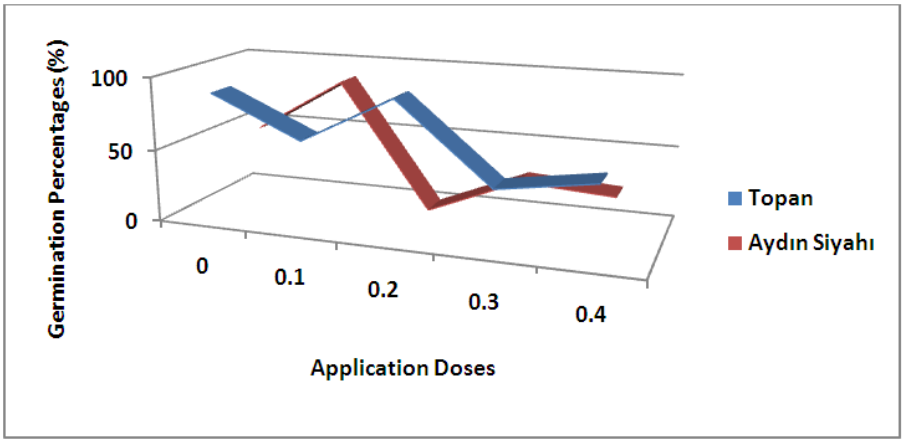
Table 5. Correlation of the vegetative development criteria of the Demre Sivrisi and Üç Burun cultivars applied with eucalyptus oil

Demre Sivrisi	**SW**	**RW**	**PW**	**RL**	**SL**
SW	1	,689**	,639**	,258	,449*
RW	,689**	1	,715**	,192	,399*
PW	,639**	,715**	1	,416*	,424*
RL	,258	,192	,416*	1	,214
SL	,449*	,399*	,424*	,214	1
Üç Burun	**SW**	**RW**	**PW**	**RL**	**SL**
SW	1	,361	,679**	,516**	,535**
RW	,361	1	,488*	,399*	,399*
PW	,679**	,488*	1	,350	,170
RL	,516**	,399*	,350	1	,268
SL	,535**	,399*	,170	,268	1

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed).

Figure 3 shows the germination rates of two different cultivars of eggplants (cv. Topan and cv. Aydin Black) in different doses of oil. When Figure 3 is examined, it is seen that the highest germination percentages are recorded with 93% in 0,2 µl application in Topan cv. The highest germination percentage (88%) was determined in 0,1 µl application in Aydın Siyahı cv., unlike the results of all other cultivars.

Figure 3. Effect of eucalyptus oil on germination percentages of eggplant cultivars



Different doses of eucalyptus oil applications on Topan cv. have a statistically significant effect on the growth parameters of plantlets (Table 6). As a result of the evaluation, it was determined that the highest average values (RL; 55.34 mm, SL; 39.22 mm, RFW; 0.0167 g, PW; 0.0347 g) were obtained from 0.2 µl application. In terms of SFW value, the highest values were determined in 0.2 µl (0.0212 g) and 0.3 µl (0.0212 g) application. While plantlets were obtained from control and 0.1 µl applications in Aydın Siyahı cv, enough plantlets could not be obtained for statistical analysis by increased doses of oil applications. Therefore, it can be said that the applications of eucalyptus oil over 0.1 µl have an inhibitory effect on Aydın Siyahı cv.

Table 6. Effects of eucalyptus oil applications on vegetative development of the eggplant plantlets

Cultivar	**Doses(µl)**	**RL**	**SL**	**RFW**	**SFW**	**PW**
Topan	**Control**	24,96 c	22,56 b	0,0076 b	0,0132 b	0,0208 c
	0,1	28,78 bc	25,04 b	0,0091 b	0,0148 b	0,0307 ab
	0,2	55,34 a	39,22 a	0,0167 a	0,0212 a	0,0347 a
	0,3	34,06 bc	25,37 b	0,0128 ab	0,0211 a	0,0310 ab
	0,4	46,08 ab	26,18 b	0,0105 b	0,0164 b	0,0267 bc
Aydın Siyahı	**Control**	2,22	1,51	0,0101	0,0140	0,0247
	0,1	1,62	1,42	0,0091	0,0126	0,0242
	0,2	-	-	-	-	-
	0,3	-	-	-	-	-
	0,4	-	-	-	-	-

Differences between groups with different letters in the same column are statistically significant (P <0.05).

Table 7 shows the correlation, between vegetative growth criteria's of Topan cv. When these results were evaluated, there was a positive correlation between RW and SW (r=0.431, P<0,05), PW and SW (r=0,597, P<0,01), SL and SW (r=0,444, P<0,05), RW and PW (r=0,602, P<0,01), RW and RL (r=0,480, P<0,05), RW and SL (r=0,476, P<0,05), PW and SL (r=0,468, P<0,05), RL and SL (r=0,464, P<0,05).

Table 7. Correlation of vegetative development criteria of Topan cv. applied with eucalyptus oil

	SW	RW	PW	RL	SL
SW	1	,431*	,597**	,080	,444*
RW	,431*	1	,602**	,480*	,476*
PW	,597**	,602**	1	,074	,468*
RL	,080	,480*	,074	1	,464*
SL	,444*	,476*	,468*	,464*	1

**Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed).

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