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ORIGINAL PAPER

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EFFECT OF *Tobacco etch virus* (TEV) ON YIELD AND QUALITY OF RED PEPPER IN TURKEY

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ABSTRACT

The most prevalently grown cultivars of red peppers in the Eastern Mediterranean region of Turkey are 'Sena' and 'Dila' in addition to local red pepper populations. Survey studies conducted on Kahramanmaras pepper growing areas in 2014 and 2015 indicated that *Tobacco etch virus* (TEV) was the most common virus in collected pepper samples. In this study, the effects of TEV on 'Sena' and 'Dila' were analyzed. The experiment was designed with 5 replicates and randomized plots in fully controlled greenhouses. The experiment consisted of TEV inoculated and control pepper plots. The pepper plants were mechanically inoculated with TEV at the 4–6 leaf stage and periodical observations were made. Virus transmission was confirmed using the double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) method. The total yield, red pepper flake production, average fruit weight, diameter, length and volume, average fruit wall thickness, fruit color and fresh and dry weights of all green parts of harvested red peppers were evaluated. The quoted data on % reduction in yield and different fruit quality criteria are averaged over two years. According to the results of the study, the highest loss of yield was recorded for 'Sena' (58.2%) while the highest red pepper flake loss ratio was in 'Dila'. In terms of fruit quality criteria, the most reductions in fruit weight (40.1%), fruit diameter (30.9%), fruit length (32.8%) and fruit volume (51.8%) were found in 'Dila', the highest losses in fruit wall thickness (27.2%) and average fresh and dry weights of green parts (49.9–43.1%) were in the 'Sena'. There was a significant effect of TEV inoculation. Overall, virus infected plants were had significantly lower yield and reduced quality compared to control plants.

Key words: quality, red pepper, 'Dila', 'Sena', *Tobacco etch virus*, yield

INTRODUCTION

Red pepper is an annual cultivated plant belonging to the genus *Capsicum* of the Solanaceae family, which is produced in many parts of the World. A total of 25 pepper species have been included in the genus *Capsicum* which originated on the American continents. Five of these species (*C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens*, *C. pubescens*) are cultivated. In the world, 34,497,462 tons of pepper are produced in an area of 1,938,788 ha. China is the most important pepper producer with 17,435,376 tons. Mexico and Turkey are the second and third most productive countries, with 2,737,028 and 2,457,822 tons, respectively [FAO 2016]. In Turkey, 2,608,172 tons of pepper were produced on 805,166 da in 2017 [TSI 2017]. Although Turkey ranks third in fresh pepper production in the World, it produces less than 1% of the World's red pepper flakes [Akbay et al. 2012]. Red pepper is grown more or less in every region of Turkey; how-

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ever, the province of Kahramanmaras and its environs are among the most important regions where red pepper is grown in the country. In Turkey, 16,139 tons of dry chilies and peppers were produced on 66,760 da [FAO 2016]. One of the most important varieties of red pepper in the Eastern Mediterranean region is the Kahramanmaras red pepper which is known by its own name in Turkey. This variety of pepper has very good color, perfect taste, aroma and bitterness and a good spice quality due to the ecological characteristics of Kahramanmaras such as its specific soil and microclimate. The red pepper producers in the region usually save seeds from the previous year's crop. In addition to using local pepper populations, farmers also prefer two cultivars of Kahramanmaras red pepper: 'Dila' and 'Sena'. 'Dila' and 'Sena' are the cultivars belonging Kahramanmaras red pepper type. Both cultivars were bred by the Eastern Mediterranean Transitional Zone Agricultural Research Institute Directorate and were used in this experiment to assess their reaction to virus infection.

There are many biotic and abiotic factors affecting the cultivation and yield of pepper. Virus diseases are the most important biotic factor, which reduces yield and fruit quality and cannot be chemically controlled [Çolak et al. 2018, 2019]. The symptoms of virus diseases in peppers include mottling, mosaic, vein banding and ring spots on the leaves. In addition, various necroses, color fading, deformities and stunting occur in the whole plant. Similar symptoms are also seen on pepper fruits. The disease also can affect roots and flowers [Pernezny et al. 2003]. *Tobacco etch virus* (TEV) is a member of the genus *Potyvirus*. This virus is transmitted in a non-persistent manner with aphids. The most important vector of TEV is *Myzus persicae*. TEV can be seen as a single infection or in combination with *Potato Y virus* (PVY) in peppers. At harvest time, there is a prevalence of about 100% [Padgett et al. 1987] and TEV-related yield losses can be as high as 70% [Koenning and McClure 1981]. TEV is one of the major viruses that cause infection in pepper plants grown especially in open areas [Fidan et al. 2013, Buzkan et al. 2012]. Wherever virus is seen, it causes great losses in yield and quality of pepper species [Pernezny et al. 2003]. Therefore, this study aimed at determining the effects of TEV infection on the yield and quality of two cultivars of Kahramanmaras red pepper.

MATERIALS AND METHODS

'Sena' and 'Dila' pepper seeds obtained from East Mediterranean Transitional Zone Agriculture Research Institute in Kahramanmaras were used in inoculation experiment. All results of the experiment were assessed with the JMP statistical software, (SAS Institute, Cary, North Carolina, USA) using the LSD test at 5% level of significance.

Pepper cultivation and inoculation experiment. The experiments were performed in the fully controlled greenhouses of Alata Horticultural Research Institute in 2015 and 2016. The seeds of the 'Sena' and 'Dila' pepper cultivars used in the experiment were germinated in the beginning of March, in seedling trays placed in a climate room. The leaves of plants emerging from germinated seeds were tested by means of DAS-ELISA method [Clark and Adams 1977] using polyclonal antiserum to determine if viruses (*Alfalfa mosaic virus*, *Cucumber mosaic virus*, *Tobacco mosaic virus*, *Tomato mosaic virus* and *Pepper mild mottle virus*) had been transmitted by the seeds. In consequence of the tests, only the virus-free seedlings were used in the experiments. The inoculation experiment was set up with 5 replicates according to a randomized block design forming one control for each cultivar with 25 plants used in each replicate. The experiment consisted of the TEV infected pepper plants to which virus was transmitted by mechanical inoculation and the uninoculated pepper plants (control plots). When the seedlings developed 3 or 4 leaves in the middle of April, they were planted in the fully controlled greenhouses and routine cultural processes such as irrigation, fertilization and pest control were done.

Mechanical inoculation of TEV. Pepper samples infected with TEV were ground in 0.02 M phosphate buffer (pH 7.0) (0.02 M KH_2PO_4, 0.02 M Na_2HPO_4) containing 0.1% beta-mercaptoethanol at the rate of 1:5 (w/v). The inoculum was filtered through two layers of cheesecloth. Carborumdum powder was dusted on the pepper leaves before inoculation. Leaves were then inoculated by rubbing their surface with the inoculum. After inoculation with in 1 or 2 min the plant leaves were rinsed [Çelik et al. 2010]. Inoculation was repeated one week later on newly emerged leaves.

After 10–15 days, the transmission of virus was determined by observation of disease symptoms on the leaves and confirmed by DAS-ELISA [Clark and Adams 1977] test using polyclonal antiserum. Virus symptoms were observed in almost all plants after the second inoculation. At the harvest stage, the mosaic disease symptoms caused by the TEV agent on the fruits and leaves were recorded (Fig. 1). The loss of yield and quality caused by TEV was determined by analyzing morphological and agronomic characteristics.

Yield assessments. Yield assessments were based on five harvests in each year (2015 and 2016) for the control plots. However, because fruit set was very low in the infected plots, only three harvests could be made in 2016. The total weights of the pepper fruits harvested from the control and infected plots were determined in each experiment. Moreover, the red pepper flake yield of the 'Sena' and 'Dila' red peppers were analyzed. Thus, each replicate of the healthy and infected plots of 'Sena' and 'Dila' were harvested and weighed separately and they were dried in paper bags in the drying oven at 50°C until the moisture reached 7–8%. Then, the peppers were weighed again and were ground.

Analysis of fruit quality. The analysis of fruit quality was performed for ripe pepper fruits picked in the second harvest of each year and several fruit quality properties were examined [IPGRI, AVRDC, CATIE 1995]. The 25 pepper fruits (Fig. 2) were chosen randomly from each of the healthy and infected plots, representing all cultivars and repetitions. Fruit weight (kg), fruit diameter (cm), fruit length (cm), fruit volume (ml), fruit wall thickness (mm), fruit color and the fruit total dry matter production (%) were recorded for the harvested fruits. The fruit diameters and lengths of the peppers representing the cultivars were measured with a ruler (Fig. 3). The fruit volume of the peppers was measured with a 5000 ml beaker. The fruit wall thicknesses of the peppers were measured with a Mitutoyo caliper. The fruit color of the peppers was evaluated with a Konica Minolta CR-400 colorimetric device. The pepper plants were uprooted after the last harvest and fresh weight measurements of the whole green parts were made. Then, after they were dried in an oven at 55–60°C to 10% moisture ratio, their dry weight data were recorded and statistical analyses were performed. The yield and quality losses caused by the TEV agent in the inoculation experiment were assessed as follows:

$$\text{\% effect of inoculation experiment} = \\ = (1\text{-application/control}) \times 100 \quad (1)$$

RESULTS AND DISCUSSION

Yield assessments

Analyses of the total yield of five harvests made in 2015 indicated that there were no statistically significant differences between the control group and the unhealthy individuals of the 'Sena' and 'Dila' cultivars at the 5% level (Tab. 1). However, TEV caused 36.3% yield loss in 'Sena' and 18.1% yield loss in 'Dila'. In 2016, the yield differences were statistically significant and the average yield losses in 'Sena' and 'Dila' were 80% and 80.7%, respectively. The differences occurred in the yield of the two years due to temperature differences and the conditions of the soil where the experiment was set. Therefore, yield reduction was observed both of the years.

Similar to the present study, Nutter et al. [1989] conducted field experiments to quantify the effect of TEV on yield of Yolo Wonder B bell pepper. They found that TEV caused yield losses from 15 to 50% during the 4 year period. In another study, the reactions of three pepper genotypes (Yolo Wonder B, Tembel 2 and Asgrow-XPH-5021) to TEV have been studied by Padgett et al. [1990]. TEV caused reductions of varying magnitudes in fruit yield and number of fruit on all pepper genotypes. Other viruses can also cause significant yield losses in solanaceous crops. Ramkat et al. [2006] conducted a study using mechanical inoculation to determine the reaction of TSWV on tomato cultivars 'Cal J', 'Marglobe', 'Moneymaker', 'Roma' and 'Rio Grande'. Tomato variety 'Cal J' was the most affected by TSWV with a 60% loss, this was followed 'Rio Grande' 55.3%, 'Moneymaker' 45.1%, 'Marglobe' 40.3% and 'Roma' 27%. On the other hand, Johnson et al. [1983] conducted field tests to quantify reductions in tobacco yield, quality and value among seven tobacco mosaic virus (TMV) resistant and three TMV-susceptible cultivars in 1980 and 1981. They noted some differences among the reactions of the TMV-susceptible cultivars to TMV infection. The leaf number and leaf area which are related with yield and

Fig. 1. Symptoms caused by TEV on the pepper fruits and leaves of the 'Sena' (a) and 'Dila' (b). Fruit deformity and diminution and severe mosaic on the leaves are observed (phot. P. Keles Ozturk)

Fig. 2. Pepper fruits of the 'Sena' (I) and 'Dila' (II) taken from the healthy (a) and the infected (b) plots (phot. P. Keles Ozturk)

quality of pepper are decreased by the TMV infection Pazarlar et al. [2013]. Sevik and Arlı Sokmen [2012] also reported that the yield of TSWV infected tomato plants decreased in comparison with uninfected plants. In that study, total weight of tomato fruits harvested from uninfected and infected from plots was 61.21 kg and 35.41 kg, respectively.

Red pepper flake production. In 2015, virus infection reduced total dry pepper flake production by 51.3% for 'Dila' (from 286.8 to 149.3 g), and only reduced by 31.7% in 'Sena' (from 263.8 to 172.2 g). In 2016, virus infection reduced flake production by 33.6% for 'Sena' (from 140.7 to 84.3 g), but only 23.6% for 'Dila' (from 139.4 to 97.8 g) (Tab. 1).

Assessment of fruit quality

Fruit weight. Fruit weight was significantly reduced by TEV inoculation in 'Dila' in 2015. The difference between control and infected plants was not significant in the 'Sena' cultivar (Tab. 2). The loss in average fruit weight was 51.3% in the 'Dila' (from 526.2 to 256.2 g), but only 31.7% for 'Sena' (from 615 to 419.8 g).

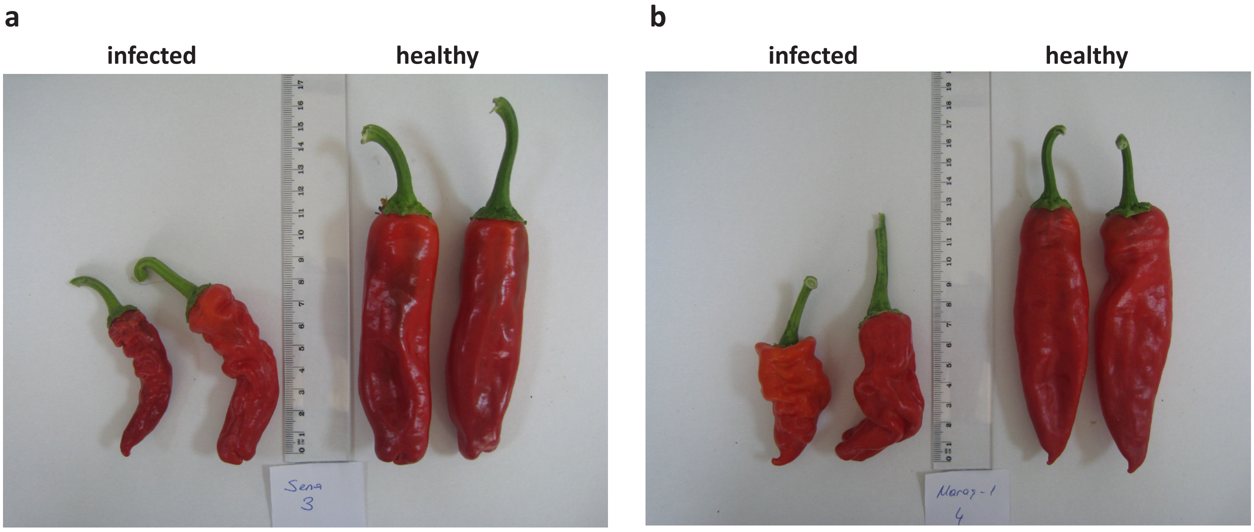

Fig. 3. Fruit length of the 'Sena' (a) and 'Dila' (b) taken from the infected and healthy plots (phot. P. Keles Ozturk)

In 2016, fruit weights in the 'Sena' and 'Dila' peppers with and without virus infection were found to be significantly different at the 5% level. Fruit weight was reduced by 28.9% for 'Dila' (from 603.46 to 429.44 g), but only 31.3% for 'Sena' (from 671.6 to 462.4 g). Ramkat et al. [2006] reported that TSWV inoculation on tomato cultivars caused reduction in total fruit weight when compared to uninoculated healthy controls. Murphy and Morawo [2017] evaluated the effects of TEV strains HAT, Mex21 and N on fruit yield of 'Calwonder' pepper. HAT infected plants had less of the standard bell pepper shape. Mex21 infected pepper plants produced only one marketable fruit and N-infected peppers did not produce any marketable fruit.

Fruit diameter. When the 2015 data of the experiment were analyzed, the most important loss in terms of fruit diameter in the cultivars was in the 'Dila' pepper with 32.1%. The average fruit diameter was 2.78 cm in the control group of 'Dila' and fell to 1.78 cm in the plants inoculated by TEV. The average fruit diameter was reduced by 15.4% for 'Sena'. In the applications made in 2016, the most important loss in the fruit diameter was 29.6% for 'Dila'. The average fruit diameter in the control group plants of 'Dila' cultivar was 2.7 cm and 1.88 cm in the plants inoculated by TEV. The average fruit diameter was reduced by 28% for 'Sena' (from 2.52 to 1.84 cm) (Tab. 2).

Fruit length. Fruit length differences between the 2015 and 2016 experiments were significant at the 5% level (Tab. 3). Fruit length was reduced by 26.6% for 'Sena' (from 10.9 to 7.97 cm) compared to the control group, but only 24.3% for 'Dila' (from 10.68 to 8 cm). According to the 2016 data, fruit length was reduced by 41.2% for 'Dila' (from 8.46 to 5 cm) compared to the control group, but only 37.9% for 'Sena' (from 9.50 to 5.95 cm).

Fruit volume. When the experiment applications were analyzed in terms of fruit volume in 2015 and 2016, the fruit volume differences between the control (healthy) and the infected plants were found to be statistically significant at the 5% level (Tab. 3). The fruit volume was reduced by 47.3% for 'Dila' (from 528 to 278 ml) while it was reduced by 42.8% for 'Sena' (from 808 to 382 ml) in 2015. In 2016, these values were determined as 50.2% and 56.3% for 'Sena' and 'Dila', respectively.

Fruit wall thickness. Only the 'Sena' had statistically significant differences in fruit wall thickness at the 5% level (Tab. 4). When compared to the control group, a 26.3% loss (from 2.09 to 1.54 mm) was determined in the average fruit wall thicknesses of the plants inoculated with TEV. When the 2016 data of the experiment were analyzed, the differences between the infected peppers and the control group of both of the cultivars were statistically insignificant at the 5% level. On the

Table 1. Average yield, red pepper flakes production values and % losses of the 'Sena' and 'Dila' peppers

Application	Yield (kg da^{-1})				Red pepper flakes yield (g)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	43.46a	12.75a	38.42ab	11.20a	263.8b	140.7a	286.8a	139.4a
Virus infected	27.66c	2.55b	31.46bc	2.16b	172.2c	84.3b	149.3d	97.8b
Average	35.56a	7.65a	34.94a	6.68a	218.0a	112.46a	218.1a	118.64a
Loss ratio (%)	36.3	80.0	18.1	80.7	31.7	33.6	51.3	23.6
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application	7.27		1.91		0.1		19.8	
cultivar	N.S.		N.S.		N.S		N.S.	
application × cultivar	10.28		2.7		0.2		28.0	

N.S. – nonsignificant

Table 2. Average fruit weight, fruit diameter values and % losses of the 'Sena' and 'Dila' peppers

Application	Fruit weight (g)				Fruit diameter (cm)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	615.0a	671.6a	526.2ab	603.46a	2.56a	2.52a	2.78a	2.70a
Virus infected	419.8b	462.4b	256.2c	429.44b	2.18b	1.84b	1.78c	1.88b
Average	517.4a	567.0a	391.2b	516.45a	2.37a	2.18a	2.28a	2.29a
Loss ratio (%)	31.7	31.3	51.3	28.9	15.4	28.0	32.1	29.6
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application	76.87		54.15		0.19		0.19	
cultivar	76.87		N.S.		N.S.		N.S.	
application × cultivar	108.7		76.58		0.27		0.26	

N.S – nonsignificant

Table 3. Average fruit length, fruit volume values and % losses of the 'Sena' and 'Dila' peppers

Application	Fruit length (cm)				Fruit volume (ml)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	10.92a	9.50a	10.68a	8.46b	808.0a	316.0b	528.0b	432.0a
Virus infected	7.97b	5.95c	8.06b	5.02d	382.0bc	138.0d	278.0c	215.0c
Average	9.44a	7.72a	9.37a	6.74b	595.0a	227.0b	403.0b	323.5a
Loss ratio (%)	26.6	37.9	24.3	41.2	42.8	50.2	47.3	56.3
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application: 0.43	0.43		0.45		165.49		50.10	
cultivar: N.S.	N.S.		0.45		165.49		50.10	
application × cultivar: 0.60	0.60		0.64		234		70.8	

N.S – nonsignificant

Table 4. Average fruit wall thickness, fruit color HUE values and % losses of the 'Sena' and 'Dila' peppers

Application	Fruit wall thickness (mm)				Fruit color (hue value)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	2.09a	1.85a	1.63b	1.64a	28.81a	44.59a	26.04b	43.45a
Virus infected	1.54b	1.33a	1.32b	1.41a	29.98a	34.67b	28.81a	39.21ab
Average	1.81a	1.59a	1.48b	1.52a	29.40a	39.63a	27.43b	41.33a
Loss ratio (%)	26.3	28.1	19.0	14.0	–	–	–	–
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application	0.22		0.36		1.33		3.93	
cultivar	0.22		N.S.		1.33		N.S.	
application × cultivar	0.31		N.S.		1.89		5.55	

N.S. – nonsignificant

Table 5. Average fruit color L, fruit color a-values of the 'Sena' and 'Dila' peppers

Application	Fruit color (L value)				Fruit color (a value)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	32.90b	43.81a	34.31b	42.23a	24.47b	30.50b	32.54a	35.15ab
Virus infected	33.66b	39.73b	36.64a	43.93a	25.87b	39.24a	33.68a	41.62a
Average	33.28b	41.77a	35.47a	43.08a	25.17b	34.87a	33.11a	38.39a
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application	1.48		N.S.		N.S.		4.9	
cultivar	1.48		N.S.		2.58		N.S.	
application × cultivar	2.10		1.99		3.65		6.94	

N.S. – nonsignificant

Table 6. Average whole green parts fresh weight, dry weight values and % losses of the 'Sena' and 'Dila' peppers

Application	Fresh weight of green parts (kg)				Dry weight of green parts (kg)			
	'Sena'		'Dila'		'Sena'		'Dila'	
	2015	2016	2015	2016	2015	2016	2015	2016
Healthy (control)	0.79a	0.73a	0.61a	0.83a	0.16a	0.22a	0.15a	0.25a
Virus infected	0.57	0.29b	0.65a	0.29b	0.16a	0.12b	0.19a	0.16b
Average	0.68a	0.51a	0.63a	0.56a	0.16a	0.17b	0.17a	0.20a
Loss ratio (%)	40.2	59.5	31.0	64.4	41.3	44.9	39.9	35.9
$LSD_{5\%}$ for:	2015 year		2016 year		2015 year		2016 year	
application	N.S.		0.15		N.S.		0.03	
cultivar	N.S.		N.S.		N.S.		0.03	
application × cultivar	N.S.		0.22		N.S.		0.05	

N.S. – nonsignificant

other hand, the most important loss was found in the 'Sena' with 28.1% reduction (from 1.85 to 1.33 mm).

Fruit color. For fruit color assessments, the hue value (fruit color tone), a-value (red-green) and L value (light-dark color) were measured and their statistical analyses were made. In terms of the hue level in 2015, while the difference between the healthy plot and infected plot for 'Dila' was found to be significant at the 5% level, it was insignificant in 2016 (Tab. 4). The difference in L value (light-dark color) between the healthy and the infected plots of 'Dila' and 'Sena' were found to be statistically insignificant (Tab. 5).

According to the 2015 data, in terms of a-value (red-green) the difference between the healthy and the infected plots of 'Dila' and 'Sena' were statistically insignificant at the 5% level but this difference was significant for 'Sena' in 2016 (Tab. 5). Therefore, the real color of fruits of 'Sena' was changed by TEV.

Fresh and dry weight of the whole green parts. The differences in fresh weight of green parts between the control group and the infected plants were significant at the 5% level in 2015 (Tab. 6). The loss in fresh weight was determined as 40.2% for 'Sena'. However, this difference was statistically insignificant for 'Dila' (31%). In 2016, higher loss in fresh weight of the green parts was determined for 'Dila' (64.4 %), while 'Sena' had 59.5% reduction. Fewer green parts in the plant causes a decrease in the photosynthesis rate. As a result, product yield is also significantly reduced.

In 2015, the difference in dry weight of the green parts between the control group and the infected plants for 'Sena' were significant at the 5% level but not significant for 'Dila'. The losses in the dry weight of the green parts were determined to be 41.3% and 39.9% for 'Sena' and 'Dila', respectively (Tab. 6). In 2016, the differences in dry weight of the green parts between the control and infected plots of both of the cultivars were significant at the 5% level. The dry weight losses of the green parts were determined as 44.9% and 35.9% for 'Sena' and 'Dila', respectively.

Al-Saleh et al. [2007] evaluated the response of eight peanut cultivars to TSWV using mechanical inoculation method under greenhouse condition. They determined some plant growth parameters such as root length and volume, plant height and fresh weight. Inoculation showed that fresh weight of 'Okrun' cultivar decreased by 17%.

CONCLUSIONS

In the inoculation studies, the yield and quality losses caused by TEV in the 'Sena' and 'Dila' cultivars of Kahramanmaras red pepper were examined by analyzing morphological and agronomical characteristics. In this study, how and how much the virus affected the yield and the quality of Kahramanmaraş red pepper were determined. Data were obtained for the measurable loss caused by TEV for 'Sena' and 'Dila' and it was determined that TEV affected yield most significantly by reducing the weight of the pepper fruit, fruit size and number. The quoted data on % reduction in yield and different fruit quality criteria are averaged over two years. The highest loss of yield was in 'Sena' (58.2%) while the highest loss of red pepper flake was in 'Dila' (37.5%). Moreover, the most of losses in fruit weight (40.1%), fruit diameter (30.9%), fruit length (32.8%) and fruit volume (51.8%) were determined in 'Dila', while the most losses in fruit wall thickness (27.2%) and average fresh and dry weights of green parts (49.9–43.1%) were in 'Sena'. In addition, the virus reduced the marketable value of the peppers. There is no chemical treatment that directly controls viral infection. A series of cultural practices and sanitary methods have been used to control TEV infection in pepper crops. The best way to reduce losses caused by TEV in red pepper production seems to be the use of resistance cultivars. Several sources of *Capsicum* (bell pepper, sweet yellow wax pepper and in hot jalapeno pepper) resistance have been reported. There are no reports of TEV-resistant tomato cultivars. Transgenic plants with resistance to TEV have been produced but have not yet been used commercially. In recent years, the use of resistant cultivars for plant viruses has become an economical and safe method. Therefore, the planting of resistant pepper cultivars is one of the best ways to control viruses.

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