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Research Article

New Record in Summer Squash and Infestation of Branched Broomrape (*Phelipanche ramosa* (L.) Pomel) in Vegetable Areas in Van/Türkiye

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Abstract: The increasing vegetable production in Van/Türkiye province and its districts, where the study was carried out. The most significant of these issues is the parasitic and highly invasive broomrapes. A survey was conducted in August-October 2019 in order to determine the extent of the broomrape problem in the areas of vegetables. In this study, the type of broomrape found in vegetable areas was identified first, then the infestation rates and the average number of shoots in each plant were determined. The results concluded that the branched broomrape [*Phelipanche ramosa* (L.) Pomel] was found as a single species in all areas. It was also detected that branched broomrape was infested with tomato, eggplant, cucumber, and summer squash; with related densities of 4.2, 0.4, 0.26, and 0.78 %, on average, respectively. No infestation was encountered in pepper. As a result of the study, this infestation detected in summer squash is the first record in terms of the host series of branched broomrape. Although less infestation was seen in other areas, it is predicted that the branched broomrape could be spread rapidly to non-infested areas over time due to its character.

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1. Introduction

The broomrape genera (*Orobanche* and *Phelipanche*) in the Orobanchaceae family include more than 170 holoparasitic herbaceous plant species (Joel, 2009). Broomrapes cause yield losses as parasitic plants in many crops (Joel, 2007; Thorogood et al., 2009). Broomrapes whose native range is the Mediterranean regions, have nowadays invaded more than 73 million hectares of agricultural lands in many states of the USA, as well as in the Middle East, Southern and Eastern Europe, Türkiye and North Africa (Abang et al., 2007; Üstüner et al., 2020; Üstüner and Aksoy Orel, 2021). Despite intensive control measures, it is observed that there are new records and invasions in the world every day (Rubiales et al., 2011).

It was stated that the branched broomrape had a large host range as a holoparasite in Solanaceae (tomato, eggplant, pepper, potato, and tobacco), Brassicaceae (mustard and rapeseed), Cannabaceae (hemp), Fabaceae (chickpea, clover, peanut, broad bean, lentil, and pea), Apiaceae (carrot, celery, fennel, and parsnip) and Asteraceae (lettuce, sunflower and a few ornamental species) families (Parker, 2013).

It is understood from some studies that the broomrapes are also a problem in the members of the Cucurbitaceae family. *Orobanche crenata* and *Phelipanche aegyptiaca* were reported to cause damage to Cucurbitaceae members. Although *O. aegyptiaca* and *O. ramosa* show great similarity in terms of the host sequence they parasitize, it was reported that *O. aegyptiaca* had more problems than *O. ramosa* in members of the Cucurbitaceae family (Eizenberg et al., 2002).

In Türkiye, the broomrapes are common in all regions (Aksoy et al., 2011). Although there are more than 100 species in the world and 37 species in Türkiye (Gilli, 1982); only four species [*Phelipanche aegyptiaca* (Pers.) Pomel, *P. ramosa* L., *Orobanche crenata* Forsk*., O. cernua* Loefl., and *O. cumana* Wallr.] cause economic damage (Orel-Aksoy and Uygur, 2003; Bülbül and Uygur, 2009; Ekiz, 1970). According to Aksoy et al., (2009) among the broomrape species, *O. ramosa* L. and *O. aegyptiaca* Pers. prefer tomato, eggplant, and potato from Solanaceae, as well as cultivars such as lentils and broad beans from legumes; *O. crenata* Forsk. is seen in many legumes, especially in broad beans and lentils, and *O. cumana* in sunflowers (Üstüner et al., 2020).

Since broomrapes are parasitic weeds, their control is difficult, chemical control is limited, and it is an invasive plant for Türkiye (Nemli et al., 2010). With the increase in vegetable production in the region many plant protection problems have arisen. In the questionnaire conducted by Bingölbali (2019), it was stated that broomrapes were among the species that growers complained about the most. The aim of this study was to determine the problems of the growers in the region and to contribute to the literature, the species, densities, and infestation of broomrape were determined in the vegetable areas in Van province.

2. Material and Methods

This study was carried out in fields where vegetables (cucumber, tomato, pepper, eggplant, and summer squash) were grown in Van province between August and October 2019. The research was carried out in 6 of the 13 districts of Van province, where intensive vegetable cultivation is done. These six districts evaluated cover a total area of 95.6 hectares. Family lands, which are less than one decare and don't grow vegetables commercially, were excluded from the study. According to TURKSTAT (2018) data, it was understood that cucumber, tomato, pepper, eggplant, and summer squash were grown in a total of 1.2 thousand hectares area in Van province. The surveyed areas constituted approximately 8% of this area (Table 1).

Table 1. Surveyed districts and areas

Districts	Surveyed area (ha)
İpekyolu-Edremit	2.4
Gevaş	46.4
Erciş	14.8
Tuşba	28.0
Gürpınar	4.0
Total	95.6

Observations were made once in every three rows, as the cultivated plants in which the research was carried out were planted in rows. The species of broomrape found in vegetable areas were identified first, then the infestation rates (%) and the average number of shoots in each plant were determined during the surveys. In the areas where the infestation is seen, the root zone of each crop plant was opened and closely examined to determine whether or not the broomrapes hold onto the plant. In order to eliminate the influence of edge effects, the first and last two rows of the sampled area were not included during observation.

In calculating the number of infested vegetables in the field, first, the total number of plants was found by multiplying the number of vegetables in the row by number of rows in the field. Then, the number of infested plants in a row of every three rows was counted. The number of infested plants in the field was determined and the infestation rates were the contamination rates were calculated with the equation developed by us (Eq. 1) proportioning these values with the number of plants in the field. In

order to determine the average number of broomrapes per plant, the number of broomrape branches in each three infested plants was counted and the averages were calculated.

$$\text{Infestation rate (\%)} = (\text{Number of infested plants/Total number of plants}) \times 100 \quad (1)$$

The infestation rates were calculated for each district in general and specifically. The general infestation was calculated on the basis of all planting areas, and the special infestation was calculated based on only infested areas. These calculations were made separately for tomato, eggplant, pepper, summer squash, and cucumber.

3. Results and Discussion

The identification of broomrape species found in tomato, eggplant, pepper, cucumber, and summer squash growing areas in Van province was made according to Gilli (1982) and it was determined that branched broomrape [*Phelipanche ramosa* (L.) Pomel; *Syn: Orobanche ramosa* L.] was found in all vegetable areas. Parker (2012 and 2013) stated that *P. ramosa* was a host in Solanaceae (tomato, eggplant and tobacco as well as pepper and potato), Brassicaceae (rapeseed and mustard), Cannabaceae (hemp), Fabaceae (chickpeas, alfalfa, peanuts, broad beans, lentils, and peas), Apiaceae (carrot, celery, fennel, and parsnip) and Asteraceae (lettuce, sunflower and a few ornamental species) families. It was also found that this type of broomrape had been a host in wild species in Chenopodiaceae, Amaranthaceae, Malvaceae, Rosaceae, and many other families. Although it was reported to be a host in onions, it was stated that broomrape was not seen in other monocotyledonous plants. In another study carried out, it was determined that *Phelipanche ramosa* was the most significant pest of tomato in Iran (Minbashi Moeini, 2004). In studies conducted in Türkiye, *P. ramosa* was found to be most harmful among the hosts of tobacco (Ekiz, 1970; Uludağ and Nemli, 2009), tomato (Aksoy et al., 2001; Uludağ and Nemli, 2009), sunflower (Ekiz, 1970), lentil (Aksoy and Uygur, 2003), and eggplant (Demirkan, 1992).

Only table varieties are grown in tomato fields in Van. In these areas, surveys were carried out in 30 fields in total. The infestation was detected in 13 of the fields and no infestation was detected in İpekyolu, Edremit, and Gürpınar districts. The general and specific infestation rates were detected as 4.3% and 6.0%, respectively. The average number of broomrape shoots in tomatoes throughout the province was found to be 29.2 branches. This high number can be explained by the fact that the species in question gives a large number of tillering and has a number of shoots. It was determined that the general infestation rate in the Gevaş district, which has the highest tomato growing area, was 5.3%, and the infested fields were very close to this rate at 5.4%. The average number of broomrape shoots per plant was determined as 31.5 branches. It was determined that five of the 11 fields surveyed in Erciş were infested. The general infestation rate was found as 4.9%, and the rate in the infested fields is 7.3% (Table 2). Aksoy (2003), stated that *O. ramosa* caused 24.8% of product loss in tomato fields in Türkiye. According to Aksoy and Uygur (2003), Orobanche aegyptiaca and O.ramosa shoots were detected at a rate of 3.3% per m-2 in tomato fields. In a study conducted by Ruşen and Yazlık (2009) on tomato fields in the Marmara Region, they stated that they had never encountered *P. ramosa* in greenhouses; but detected it in 58%, 14%, and 50% in Bursa, Kocaeli, and Sakarya provinces, respectively. In the survey carried out in the tomato fields in Samsun province, it was determined that the density of *P. ramosa* was 22.3% and the number of shoots was 1.1 branches (Işık and Kaya 2009). In another study conducted by Özaslan and Kendal (2014) in tomato planting areas in Lice/Diyarbakır, it was determined that *P. ramosa* was among the species with the highest density with 3.7 plant m^{-2}. Bülbül et al., (2009) found that 27.7% of the greenhouses and 80% of the fields were infested with *Orobanche aegyptiaca* and *O.ramosa* in the Eastern Mediterranean region and that these species had an average shoot number of 0.4 branches per tomato root in greenhouses. Compared to other studies conducted in Türkiye, it was seen that branched broomrape infestation was higher in tomatoes in Van province.

There is limited cultivation land for eggplant and it is grown in the districts of Tuşba, Gürpınar, and Gevaş. Eggplant studies were conducted in seven districts and evidence of infection was found in three fields in the Gevaş district. Thus, infestations were found in three of the five fields, with general and specific infestations at 0.4% and 0.6%, respectively. These infestation rates also represent the Van province. Even though the infestation is limited to a particular district, Table 2 indicates that there are

an average of 11.6 broomrapes per plant. The eggplant is on the host list of *P. ramosa* (Musselman, 1987). According to reports, *O. aegyptiaca* reduces eggplant yields in India by 30–35% (Prasad et al., 2009; Singh et al., 2017). According to a study by Akhter and Khan (2020), *P. ramosa* densities in eggplant areas ranged from 15 to 35 percent.

Table 2. Survey values in districts of Van

Vegetables	Districts	Total number of fields	General infestation rate (%)	Total number of infested fields	Special infestation rate (%)	Average number of broomrape branches
Tomato	İpekyolu-Edremit	3	0	0	0	0
	Gevaş	9	5.30	7	5.42	31.57
	Erciş	11	4.94	5	7.37	25.75
	Tuşba	6	0.45	1	10.41	15
	Gürpınar	1	0	0	0	0
	Van	30	4.27	13	6.04	29.27
Eggplant	İpekyolu Edremit	No planting	No planting	No planting	No planting	No planting
	Gevaş	5	0.48	3	0.6	11.6
	Erciş	No planting	No planting	No planting	No planting	No planting
	Tuşba	1	0	0	0	0
	Gürpınar	1	0	0	0	0
	Van	7	0.43	3	0.6	11.6
Pepper	İpekyolu Edremit	1	0	0	0	0
	Gevaş	6	0	0	0	0
	Erciş	2	0	0	0	0
	Tuşba	2	0	0	0	0
	Gürpınar	1	0	0	0	0
	Van	12	0	0	0	0
Cucumber	İpekyolu Edremit	1	0	0	0	0
	Gevaş	6	0.26	2	0.35	10
	Erciş	No planting	No planting	No planting	No planting	No planting
	Tuşba	1	0	0	0	0
	Gürpınar	1	0	0	0	0
	Van	9	1.68	2	0.35	10
Summer squash	İpekyolu Edremit	No planting	No planting	No planting	No planting	No planting
	Gevaş	4	1.07	1	3.69	37
	Erciş	1	0	0	0	0
	Tuşba	1	0	0	0	0
	Gürpınar	1	0	0	0	0
	Van	6	0.78	1	3.69	0.52

Pepper is grown in all districts where surveys are carried out in Van province. The infestation was not detected in any field in the region where both pointed and bell pepper varieties are grown. Although *P. ramosa* was observed in pepper cultivation areas in Van province, when the root zone was examined in detail it was understood that the attachment was not in pepper plants but in different types of weeds in the field (Table 2). Qasem and Foy (2007), tested pepper as a trap plant in the greenhouse to determine the hosts of *O. ramosa*. Although it is not on the host list of broomrape, they reported that they had obtained moderate infestation (11–30 shoots/pot) in pepper. They explained this situation as exudates in the soil slightly increasing seed germination in pepper. Hershenhorn et al. (1996) also noted that pepper was parasitized by *O. aegyptiaca*. However, no record of pepper has been found in the references in Türkiye.

Similar to eggplant, cucumbers are only grown in a small portion of Van province. Infestation of branched broomrape in cucumber was found only in the Gevaş district. In the whole survey region, observations were made in nine fields, although only two of those areas had an infestation. The general and particular infection rates in this district were found to be 0.26% and 0.35%, respectively. Although the infestation rates are low, the average number of branched broomrape shoots in the plant was determined as 10 (Table 2).

The growing area of summer squash is limited, as is the case with cucumbers and peppers. The survey was carried out in nine fields, four of which were only in Gevaş. Although the general infestation rate is low, the specific infestation rate originating from a single district was determined as 3.6%. The average number of branched broomrape shoots in summer squash was found to be 37, and this value is seen as the highest average among all survey areas (Fig. 1, Table 2).

Figure 1. Branched broomrape infestation in summer squash.

It was stated that *P. aegyptiaca* species in the Cucurbitaceae family caused more parasitism than *P. ramosa* (Eizenberg et al., 2002). In addition, Musselman and Parker (1982) stated that the Cucurbitaceae family was also among the hosts of *O. crenata. Cucurbita moschata, Cucumis melo var. flexuosus,* and *Cucumis sativus* species were among the lowest infestation rates (≤ 10 shoots/pot), and *Cucurbita maxima* was among the species with moderate infestation rates, which were used as trap plants in a greenhouse study carried out by Qasem and Foy (2007) to determine the hosts of *O. ramosa* used. Labrada and Perez (1988) stated that beans, sorghum, corn, and cucumber can be used as trap plants for the germination of *O. ramosa* seeds. In the literature review, no record of *P. ramosa* infestation was found in summer squash (*Cucurbita pepo*) both in the world and in Türkiye; therefore, the results obtained from this study are considered to be the first record of summer squash.

4. Conclusion

According to the results obtained, it was determined that the branched broomrape [*Phelipanche ramosa* (L.) Pomel] was a problem in the tomato, eggplant, pepper, cucumber, and summer squash cultivation areas in Van province. The infestation was found to be high throughout Van province, and it was determined that this ratio was 4.2%, 0.4%, 0.26%, and 0.78% in tomato, eggplant, cucumber, and summer squash, respectively. No infestation was found in the pepper. The fact that no weed management method is applied and the same crops are grown in these areas every year without alternation has caused the density to increase. The infestation detected in summer squash in this study is the first record in terms of the host series of branched broomrape. The highest rate of infestation was determined in the district of Tuşba with 10% among the districts of Tuşba, İpekyolu, Edremit, Gevaş, Gürpınar, and Erciş, where the study was carried out. Although this situation may seem like a local infestation, the mentioned areas are the places where vegetable farming is done most intensively. It is anticipated that branched broomrape will spread rapidly to non-infested areas due to its invasive character in the following years.

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