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## Prevalence of artichoke head rot (*Botrytis cinerea* Pers.) disease and determining its effect on production in the Western Mediterranean Region of Turkey

Batı Akdeniz Bölgesi'nde Enginar baş çürüklüğü (*Botrytis cinerea* Pers.) hastalığının yaygınlığı ve üretime etkisinin belirlenmesi

Mehmet AYDOĞDU<sup>a\*</sup>, İlker KURBETLİ<sup>a</sup>, Sirel CANPOLAT<sup>b</sup>

<sup>a</sup>Batı Akdeniz Agricultural Research Institute, Demircikara Mahallesi Paşa Kavakları Cad. No: 11 Pk:35 Muratpaşa, Antalya, Turkey.

<sup>b</sup>Directorate of Plant Protection Central Research Institute, Gayret Mah. Fatih Sultan Mehmet Bulv. 06172 Yenimahalle, Ankara, Turkey

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\* Corresponding author: Mehmet Aydoğdu

✉ [mehmet9498@yahoo.com](mailto:mehmet9498@yahoo.com)

### ABSTRACT

Globe artichoke (*Cynara scolymus* L.) is an herbaceous, edible plant and is cultivated for its immature head (bud) part. In 2016 and 2017, significant damages due to rots on the heads of globe artichoke plants were observed in the farmer fields in the Western Mediterranean Region of Turkey. To determine the cause of the rots, samples were taken from necrotic tissues. Fungal isolates were obtained by the agar-plate method and examined in detail. Based on the morphological and ITS region of the rDNA of the isolates, the causal agent of the disease was determined as *Botrytis cinerea* Pers. that was previously reported in the USA and Argentina. To our knowledge, this is the first publication that reports the occurrence and prevalence of *B. cinerea* that causes head rots and economic losses in globe artichoke production in the Western Mediterranean Region of Turkey. Although *B. cinerea* is a common plant pathogenic fungus with a wide range of hosts and little is known Botrytis rot of globe artichoke in Turkey. With this study, the causal agent of the disease was identified, and the status of the disease in globe artichoke growing areas and the influence of the disease on the production were investigated. Surveys were conducted in seven locations (Muratpaşa, Kepez, Aksu, Serik, Manavgat, Gazipaşa, and Kumluca) in the Western Mediterranean Region in 2016 and 2017. A simple random sampling method was used in the surveys and a total of 95 samples were selected from 79 fields in both years. Mean disease incidence and prevalence were 14.7 and 37.0% in 2016, and while they were 17.5 and 51.1% in 2017, respectively. This study revealed that *B. cinerea* has a significant impact on globe artichoke production by inducing head rots and accordingly 16.1% annual yield loss in pre-harvest period.

### INTRODUCTION

Globe artichoke (*C. scolymus* L.) belongs to Asteraceae family and contains bioactive phenolic compounds, inulin, fibre, minerals and cynarin. Thus, it is a functional food and

an important part of the Mediterranean cuisine (Lattanzio et al. 2009). Annual production of artichoke is 39477 tones in Turkey, which is the 11th producer in the world (FAO 2020).

Plant pathogenic fungi may cause rots on agricultural crops, one significant example of which is *Botrytis cinerea* Pers. The fungus, also known as gray mold or Botrytis rot, has the ability of thriving in different environments from tropical to cold regions and infects more than two hundred different plant species from 586 genera (Agrios 2005, Droby and Lichter 2007, Walker et al. 2016, Williamson et al. 2007, Valdés et al. 2016). The fungus negatively affects production of various crops (vegetables, fruits, field crops, ornamental plants etc.). To give some examples, Hao et al. (2017) reported that annual yield loss from *B. cinerea* was 30% in rose production. Uribe (2016) stated that economic losses from Botrytis rot reached up to 4.7 million USD in cut flower sector of Colombia. As for Esterio et al. (2013), they emphasized that post-harvest loss from Botrytis rot was over 20% in blueberry production in Chile. Likewise, Tanović et al. (2014) reported that Botrytis rot caused more than 50% yield losses in raspberry production particularly under wet and humid environmental conditions in pre-harvest in Serbia. The fungus also induced serious quantity and quality losses on susceptible varieties of grapevine (Elad and Stewart 2004). As regards field crops, Rashid et al. (2013) reported that yield loss from the disease was 64.35% in a susceptible chickpea genotype. It is also prevalent in the greenhouse-grown crops due to presence of suitable humid environment in the greenhouses. Yield losses from the disease range from 20 to 100% in tomato production in the greenhouses (Mor et al. 2016).

With regard to Botrytis rot on globe artichoke, although Link et al. (1924) stated that the disease occurred on globe artichoke plants in the field rather than during shipment or storage. There is no comprehensive field study. However, Moline and Upton (1987) underscored that Botrytis rot was the most common market disease of globe artichoke. Apart from these, Larran et al. (2004) reported it as a disease note in Argentina. Thus, little is known about *B. cinerea* in the globe artichoke production. The aims of the study were i) identifying casual agent of the rots on heads of globe artichoke plants, (ii) determining status of the disease in artichoke growing areas, and (iii) investigating influence of the disease on the production.

## MATERIALS AND METHODS

### Surveys

Surveys were conducted in globe artichoke growing locations (Muratpaşa, Kepez, Aksu, Serik, Manavgat, Gazipaşa and Kumluca) in the Western Mediterranean Region of Turkey in 2016 and 2017. In the surveys, simple random sampling method was used (Bora and Karaca 1970). Samplings were done according to size of the artichoke fields screened (Table 1).

**Table 1.** Size of the field and number of sampling

Field size	Sampling number
Up to 5 da	At least 5, from different points (fdp)
6 to 11 da	At least 10, fdp
11 to 50 da	At least 20, fdp
50 da >	At least 30, fdp

### Isolation

Entire plant heads and upper stem sections showing rotting symptoms were put into paper bags and taken to mycology laboratory of Batı Akdeniz Agricultural Research Institute. Newly decaying tissues including healthy parts were removed and washed under the running tap water. These plant tissues were cut into small pieces and exposed to NaOCl (2%) for two minutes and then rinsed with sterile distilled water. Later, they were left to dry for 30 minutes on sterile filter papers in a laminar flow cabinet. Afterwards, they were transferred to potato dextrose agar (PDA) containing streptomycin (50 mg/liter) and incubated at 25 °C. A few days later, growing fungal colony on the PDA was subcultured.

### Morphological identification

Three representative isolates from different geographical locations (Gazipaşa, Serik and Kumluca) were used for further comprehensive diagnosis. Fungal colonies of the three isolates on PDA had similar morphological traits. Initially, they were white but in time turned to gray with slightly fluffy aerial mycelium on PDA (Figure 1).



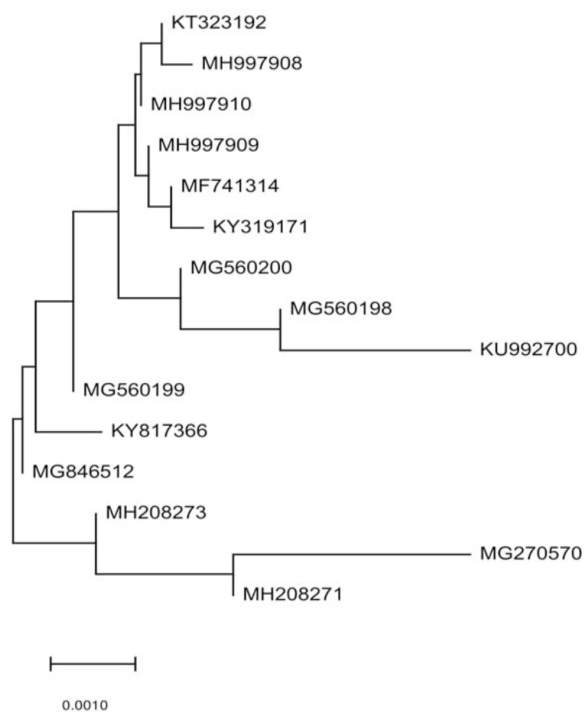
**Figure 1.** Colony of isolate SS on PDA

These isolates were designated as SG (Gazipaşa), SK (Kumluca) and SS (Serik). Isolates were examined using an Olympus BX43 microscope with SC100 digital color camera. Conidiophores were colourless or brown and sphere in shape. Conidia were one-celled, light colour, globose or ellipsoid. Measurements of the conidia (n= 50) of the isolate SG, SK and SS were 5.44 to 8.72 × 6.20 to 11.56 (average 7.34 × 9.18 µm), 5.26 to 9.90 × 6.94 to 12.62 µm (average

7.92 × 9.56 μm), and 5.52 to 8.86 × 6.10 to 11.28 (average 7.22 × 9.02 μm), respectively. Based on these morphological characteristics, the isolates were identified as *Botrytis cinerea* according to Ellis and Waller (1974). To confirm the findings, molecular diagnosis and further evaluations were performed.

#### Molecular identification

Newly-emerging mycelial parts from 5-day-old pure colonies were transferred into Eppendorf tubes. DNA extractions of the samples were performed using genomic DNA purification protocol of Promega (Promega Corporation, USA). Following DNA extraction, ribosomal DNA fragments were amplified with primer pairs ITS-1 (5' TCC GTA GGT GAA CCT GCGG 3') and ITS-4 (5' TCC TCC GCT TAT TGA TATGC 3') (White et al. 1990). Amplifications were performed using a SimpliAmp Thermocycler (Applied Biosystems, USA) and consisted of 1 cycle at 94 °C for 3 min, followed by 35 cycles at 94 °C for 30 s, annealing temperature at 58.5 °C for 1 min, 72 °C for 1 min, with a final extension at 72 °C for 7 min. PCR products were separated in 2% agarose gels, stained with safe DNA dye (Condalab, Madrid, Spain) and visualized under UV light. Sequence analysis was done by GENOKS (Çankaya-Ankara, Turkey). The ITS sequence sizes of the isolate SG, SK and SS were 466, 486 and 478 bp and they were deposited at GenBank with the accession numbers of MG560198, MG560199 and MG560200, respectively. To find the closest



**Figure 2.** Phylogenetic tree showing relatedness of our isolates (MG560198, MG560199 and MG560200) with the isolates in the Genbank

matches, the sequences were subjected to BLAST searches on GenBank (<http://www.ncbi.nlm.nih.gov>). They showed a 100% homology with other sequences (e.g. MH997910, KY817366, and MG270570) of *B. cinerea* isolates in the Genbank. Eventually, based on the morphological and molecular data, the isolates were identified as *B. cinerea*. In addition, to compare relatedness of our sequences with the other sequences displaying 100% homology, a phylogenetic tree (Figure 2) was constructed using neighbor-joining method in MEGA version 7.0 program.

#### Pathogenicity test

To fulfill Koch's postulates, eight healthy globe artichoke heads including upper stem parts were used for each isolate. Mycelial plugs, 5 mm in diameter, from one-week-old colonies were mount to the points of junction between upper stems and heads. Later, these parts were covered with parafilm and kept at 25 °C. Controls had only sterile agar plugs. Seven days later, necrotic and rotting areas appeared on the inoculated parts and then gray spore masses emerged. Length of the lesions on the stems ranged from 3.5 to 6.7 cm. No necrotic areas were seen on the controls (Figure 3). The fungus was reisolated from the necrotic plant tissues on the treatments.



**Figure 3.** Pathogenicity test, no symptoms on the left two heads (control), lesion and rots on upper stems next to the heads on the right (with red arrows)

#### Determination of disease incidence and prevalence in the field

Considering the data in Table 1 and Table 2, sampling was done by moving in the diagonal lines of the each field investigated. According to the formulas (1 and 2) below, disease incidence and prevalence were established (Bora and Karaca 1970).

Disease incidence (%) = Number of diseased plant ÷ total number of plants evaluated × 100 (1)

Prevalence (%) = Number of disease established fields ÷ total number of surveyed fields × 100 (2)

## RESULTS AND DISCUSSION

Conspicuous reddish-brown discoloration and rot symptoms and gray spore masses were usually observed on heads and rarely on upper stems next to the heads of plants. These symptoms were detected in the fields of Muratpaşa, Kepez, Aksu, Serik, Gazipaşa and Kumluca locations in the Western Mediterranean Region of Turkey. Rots on the heads were detected at any development stage of head formation. For example, mature head rot (Figure 4) and immature head rot (Figure 5) were established, which showed destructiveness of the fungus in the globe artichoke fields.



**Figure 4.** Beginning of *Botrytis cinerea* infection on the head of the globe artichoke (Gazipaşa, Antalya)



**Figure 5.** Early infection of *Botrytis cinerea* inducing rot on immature head of globe artichoke (Serik, Antalya)

Comparing surveyed areas in the both years, in 2016, surveyed area was 16.4% of the total artichoke growing areas in the region, while it was 22.3% in 2017. However,

mean disease incidence and prevalence of both years were 16.1 and 44.0%, respectively. Disease incidence varied from 20 to 27.5% in both years. Disease incidence values in Gazipaşa and Serik locations were higher than the other locations. However, incidence and prevalence of the disease in 2017 were higher than the ones in 2016 (Table 2). To our knowledge, these findings could be regarded as first perceptible data that shows prevalence of *B. cinerea* on globe artichoke and economic losses caused by the fungus in globe artichoke production in the world. The disease was reported in USA (Link et al. 1924) and Argentina (Larran et al. 2004) but this is the first report of *B. cinerea* causing head rot on globe artichoke in Turkey.

Among the globe artichoke growing locations, Serik can be regarded as a hub of the globe artichoke production in the region. Due to suitability of the Mediterranean climate (Tables 3 and 4), cultivation of various other agricultural crops may have restricted globe artichoke production to some extent in the region. In this context, field sizes usually varied from 5 to 60 decares, which also created difficulty in finding artichoke growing fields.

For example, although production areas in Döşemealtı and Korkuteli locations were present in the official records of the Turkish Statistical Institution (TÜİK 2018) in both years, we did not encounter any artichoke growing field in these locations.

Since growing well at 24 °C daytime and 13 °C nighttime temperature, globe artichoke has a narrow range of climatic requirements (Bratsch 2014), which restricts its cultivation to regions where these climatic conditions prevail. Surveyed locations stretching throughout the coastline of the Western Mediterranean region of Turkey have a suitable climate (mean yearly temperature: 18.7 °C; mean yearly lowest temperature: 13.6 °C) for globe artichoke cultivation (Anonymous 2018a). However, this climate may also constitute favorable conditions for fungi including *B. cinerea*. It is known that a plant disease occurs depending on causal agent, presence of susceptible host and favorable environmental conditions (Agrios 2005). In this regard, Ciliberti et al. (2015) reported that environmental conditions such as temperature, relative humidity and wetness duration were more significant than isolate of *B. cinerea* on mature grape berry infection. With regard to temperature, O'Neill et al. (1997) reported that stem rots caused by *B. cinerea* in tomato plants occurred at 5 to 26 °C but the infection was severe at 15 °C. On the other hand, Ahmed et al. (2014) emphasized that optimum temperature for conidia germination of *B. cinerea* in chickpea was at 20 °C. Similarly, Bulger et al. (1987) reported that optimum temperature for flower infection of strawberry was around

**Table 2.** The globe artichoke production areas (TÜİK 2018), number of fields screened and surveyed areas in 2016 and 2017

Locations	Cultivation area (da)		Surveyed area (da)		Number of field surveyed		Disease incidence (%)		Number of the diseased fields / Total number of surveyed fields		Disease prevalence (%)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Muratpaşa	10	05	10	05	2	2	-	10.0	-/2	1/2	-	50.0
Kepez	100	100	10	10	1	1	-	9.0	-/1	1/1	-	100.0
Döşemealtı	25	25	-	-	-	-	-	-	-	-	-	-
Aksu	255	255	10	10	2	1	20.0	21.0	1/2	1/1	50.0	100.0
Serik	600	600	100	150	15	18	22.5	24.0	6/15	8/18	40.0	44.4
Manavgat	60	62	-	25	-	5	-	10.0	-	2/5	-	40.0
Gazipaşa	380	345	65	75	12	12	26.0	27.5	4/12	7/12	33.3	58.3
Kumluca	50	50	50	50	4	4	20.0	21.0	1/4	2/4	25.0	50.0
Korkuteli	10	10	-	-	-	-	-	-	-	-	-	-
Total/Mean	1490	1452	245	325	36	43	14.7	17.5	12/36	22/43	37.0	51.1
General total	294.2		570		79		34/79		34/79		-	
Mean of the both year	1471		285		39.5		16.1		17/39.5		44.0	

**Table 3.** Meteorological data of Antalya province, mean of the years, 1929 to 2017 (Anonymous 2018a)

Months	Mean temperature	Mean highest temperature	Mean lowest temperature	Mean of total monthly rainfall
	°C	°C	°C	(mm)
January	10.0	14.9	5.9	235.2
February	10.7	15.5	6.3	154.5
March	12.8	17.9	8.0	97.0
April	16.3	21.3	11.1	52.4
May	20.5	25.5	15.1	32.2
June	25.3	30.7	19.5	9.3
July	28.4	34.0	22.6	2.4
August	28.3	34.0	22.6	2.7
September	25.1	31.0	19.3	14.4
October	20.4	26.5	15.1	71.9
November	15.4	21.2	10.7	131.1
December	11.6	16.6	7.5	259.3
Mean	18.7	24.1	13.6	1062.4

20 °C with 32-hour wetness. As for our study, although mean temperature of both growing seasons was nearly the same (around 17 °C) (Anonymous 2018b), in 2017 disease incidence (DI) and disease prevalence (DP) were higher than the ones in 2016. In other words, in 2017, DI and DP were 3.2 and 17.8% higher than the previous season, respectively. This may be interpreted as follows: even though difference in relative humidity (RH) between both seasons was little, that is, in 2017 RH was 0.6% higher than the one in 2016, which may have been an influence on the increase of the disease values in 2017. In addition, in 2017, mean total rainfall of the growing season was 29.3% higher than the one in 2016, indicating more wetness duration for Botrytis infection in 2017, which may have affected DI and DP in 2017. Likewise, Smith et al. (2008) reported that Botrytis rot was prevalent on globe artichoke during rainy years and temperate climates. In addition, Ciliberti et al. (2015) stated that 100% relative humidity with 36-hour of

wetness duration were favorable for *B. cinerea* infection on mature grape berry. Agrios (2005) also emphasized that humid weather conditions and temperatures ranging from 18 to 23°C were essential for the best growth of Botrytis infection.

In temperate and subtropical regions, *B. cinerea* can affect more than 200 plant species by inducing rots on all aerial plant parts and producing fertile gray conidia (Williamson et al. 2007). In our study, rots usually occurred on heads of plants and rarely on upper stem parts next to head with gray conidia masses (Figure 6). In addition, newly emerging secondary infections with slightly-brownish discoloration on heads and adjacent to heads were also observed (Figure 4). Considering these infections, during harvest, heads with conspicuous rots (Figure 5) can be discarded but aforementioned secondary infections on the heads may be overlooked, which means transferring of these infected

**Table 3.** Meteorological data of the locations surveyed in the both years (Anonymous 2018b) during the disease development

Location	Months	Mean temperature (°C)		Mean relative humidity (%)		Total rainfall (mm)	
		2016	2017	2016	2017	2016	2017
Muratpaşa	March	15.2	15.0	61.0	62.2	57.2	100.1
Kepez	March	15.2	15.0	61.0	62.2	57.2	100.1
Aksu	March	13.8	13.1	67.8	71.2	70.8	69.0
Serik	March	14.7	14.2	59.4	60.4	81.5	121.9
Manavgat	March	15.1	14.8	62.5	66.3	12.4	93.2
Gazipaşa	March	14.9	14.3	60.4	62.5	86.8	73.8
Kumluca	March	13.8	12.5	68.4	73.9	64.5	59.0
	Mean of March	14.6	14.1	62.9	65.5	61.4	88.1
Muratpaşa	April	19.1	17.7	68.1	62.3	14.4	46.8
Kepez	April	19.1	17.7	68.1	62.3	14.4	46.8
Aksu	April	18.2	16.4	68.7	69.3	10.4	28.8
Serik	April	19.3	17.0	59.6	61.0	12.0	69.0
Manavgat	April	19.3	17.2	65.1	66.3	0.0	75.7
Gazipaşa	April	18.5	16.9	62.6	61.0	12.8	48.2
Kumluca	April	17.6	15.7	69.1	70.2	31.3	27.0
	Mean of April	18.7	16.9	65.9	64.6	13.6	48.9
Muratpaşa	May	20.4	21.3	72.9	67.7	28.2	38.5
Kepez	May	20.4	21.3	72.9	67.7	28.2	38.5
Aksu	May	20.3	20.5	67.1	73.9	15.6	35.2
Serik	May	20.7	21.1	63.1	64.1	26.7	86.4
Manavgat	May	20.8	21.3	68.6	69.4	0.0	60.6
Gazipaşa	May	20.4	20.5	64.0	64.3	61.2	55.0
Kumluca	May	19.8	19.5	66.3	71.9	6.6	32.8
	Mean of May	20.4	20.7	67.8	68.4	23.7	49.5
	General Mean	17.9	17.2	65.5	66.1	32.9	62.2

heads to storage. These findings of our study indicate that rots on heads of globe artichoke plants may be associated with *Botrytis* infections in the field in pre-harvest and rots in storage may stem from the field infections of the fungus. Likewise, Link et al. (1924) stated that rots of heads of globe artichoke in the markets in USA were attributed to infections of *B. cinerea* in the field rather than during shipment or storage. However, Moline and Upton (1987) reported that *Botrytis* infections on heads were seen on any part of heads due to wounds from abraded surfaces or cut at the end of stems. The researchers also stated that infections in the field were prone to be problematic during long cool and wet weather conditions. As for Francois et al. (1991), they found that Ca-deficient inner bracts of the heads of globe artichoke were prone to *Botrytis* infection in Brawley (California, USA). Based on these findings, it can be inferred that physical injuries from various factors and abiotic stresses such as Ca-deficiency may enhance the *Botrytis* infection in the field. In addition, flower bracts damaged by insects, snails/slugs, frost, or other factors can be easily colonized by the fungus (Anonymous 2018c), which indicates pre-harvest association of the rots on the heads in our study.



**Figure 6.** Mummification and bending of the upper part of the plant from the *Botrytis* rot (Kumluca, Antalya)

Moline and Upton (1987) stated that losses from the disease could be handled by swiftly cooling heads to below 5 °C following harvest and by storing 0 to 3 °C during marketing. In addition, Smith et al. (2008) reported similar management

practices such as proper handling, discarding infected heads and suitable cooling during the storage and shipment. Since the disease initially occurs on heads in the field, plants should be observed regularly during cultivation. To prevent spore dispersal and reduce inoculum amount, heads showing the disease symptoms should be removed in pre-harvest. In addition, physical or any other injuries should be prevented throughout growing period of the crop. When necessary precautions are not taken properly, damages caused by the fungus can be serious. As reported by the researchers (Elad and Stewart 2004, Esterio et al. 2013, Hao et al. 2017, Mor et al. 2016, Rashid et al. 2013, Tanović et al. 2014, Uribe 2016) in the introduction part, due to thriving ability within a wide range of temperatures, the fungus can cause significant yield losses up to 100% in various agricultural crops. As regards globe artichoke, rots on heads of plants in the field may lead to considerable yield losses in globe artichoke production as well. Because, every infection on the heads means rotting of the heads and eventually causing direct losses both in the field in pre-harvest and in storage in post-harvest. Briefly, it can be concluded that percentage of *Botrytis* infection on the heads tantamount to percentage of the losses. In this regard, in our study, mean disease incidence of the both years, 16.1%, can be considered as remarkable economic loss in the globe artichoke production.

Globe artichoke is in great demand in agriculture owing to its nutraceutical food features. On the other hand, due to climatic requirements, its cultivation is restricted in certain areas of several countries such as Italy, Spain, France, Greece, Turkey, Egypt in the Mediterranean Basin and some other part of the world (South America, California, China, etc.), which creates low supply to the global market. Thus, insufficient quantity of the crop makes its economic value high in the market. In this context, any factor affecting production negatively is important not to reduce either quantity or quality of the crop. Herein, biotic factors, one of which is *Botrytis* rot, may play an important role. Because, affecting various crops in pre- and post-harvest with its extremely adaptive nature, *B. cinerea* has multiple negative influences on agriculture worldwide. One example of this is the head rot caused by *B. cinerea* in the globe artichoke plants. The present study revealed that the disease can cause serious economic losses in globe artichoke production. Because, it is highly likely that every infection on the heads is directly associated with the losses and should not be ignored.

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#### ÖZET

Enginar (*Cynara scolymus* L.) otsu, yenilebilir bir bitkidir ve olgunlaşmamış baş (tomurcuk) kısmı için yetiştirilmektedir. 2016 ve 2017 yıllarında Batı Akdeniz Bölgesi'nde üretici tarlalarında enginar bitkilerinin baş kısmındaki çürümeler nedeniyle önemli zararlar gözlenmiştir. Çürümelerin nedenini belirlemek amacıyla nekrotik dokulardan numuneler alınmıştır. Agar-plak metodu kullanılarak fungal izolatlar elde edilmiş ve detaylı olarak incelenmiştir. İzolatların morfolojik ve rDNA'larının ITS bölgelerine dayanarak, hastalığın etmeninin *Botrytis cinerea* Pers. olduğu belirlenmiştir. Hastalık daha önce ABD ve Arjantin'de rapor edilmiştir. Bilgilerimiz doğrultusunda bu yayın, Türkiye'nin önemli üretim potansiyeline sahip Batı Akdeniz Bölgesi'nde, enginarda baş çürüklüğüne neden olan, *B. cinerea*'nın ortaya çıkışı ve ekonomik zarar oluşturacak düzeyde yaygınlığına yönelik ilk kayıt niteliğindedir. *B. cinerea* geniş bir konukçu dizisine sahip yaygın bir bitki patojeni fungus olmasına rağmen, enginarda *Botrytis* çürüklüğü Türkiye'de çok az bilinmektedir. Bu çalışma ile hastalık etmeni tanılanmış, enginar üretim alanlarındaki durumu ve üretime olan etkisi araştırılmıştır. 2016 ve 2017'de Batı Akdeniz Bölgesi'nde yedi lokasyonda (Muratpaşa, Kepez, Aksu, Serik, Manavgat, Gazipaşa ve Kumluca) sürveyler yapılmıştır. Sürveylerde basit tesadüfi örnekleme yöntemi kullanılmış ve her iki yılda 79 tarladan toplam 95 numune alınmıştır. 2016'da, ortalama hastalık oranı ve yaygınlığı sırasıyla %14.7 ve %37.0 olurken, 2017'de ise hastalık oranı ve yaygınlığı sırasıyla %17.5 ve %51.1 olmuştur. Bu çalışma ile *B. cinerea*'nin hasat öncesi enginarda baş kısmında çürümelere ve sonuç olarak yıllık %16.1 verim kaybına neden olmasıyla enginar üretimi üzerinde önemli bir etkisinin olduğu ortaya konmuştur.

Anahtar kelimeler: enginar, *Cynara scolymus* L., *Botrytis cinerea*, verim kaybı

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