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Original article (Özgün makale)

Biocontrol potential of some entomopathogenic fungi against the Cotton Aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae)

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Entomopatojenik fungusların Pamuk Yaprakbiti, *Aphis gossypii* Glover (Hemiptera: Aphididae)'ye karşı biyolojik mücadele potansiyellerinin araştırılması

Öz: Bu çalışmada, Pamuk yaprakbiti *Aphis gossypii*'ye karşı Antalya ili'nin farklı ilçelerinden 2018-2020 yılları arasında alınan toprak ve enfekteli afid örneklerinden izole edilen entomopatojen fungus türlerinin etkinliği araştırılmıştır. Bu amaçla, 19 entomopatojen fungus izolatı $1x10^7$ spor/ml konsantrasyonda 9 cm çaplı Petri kaplarında *A. gossypii*'nin nimf ve erginlerine karşı test edilmiştir. Hedef zararlılara karşı test edilen fungus türleri arasında en patojenik tür, *Beauveria bassiana* olmuştur. Patojenisite testlerinde inkübasyondan 10 gün sonra *A. gossypii* erginlerine karşı *B. bassiana* izolatları için ölüm oranları %63.3-100 arasında değişirken, *Cunninghamella echinulata* izolatı %43.3, *Clonostachys rosea* izolatları %40 ve %70, *Isaria farinosa* izolatları %43.3 ve %63.3 ve *Purpureocillium lilacinum* izolatları ise %73.3 ve %83.3 oranında ölüme neden olmuştur. Biyolojik mücadelede kullanılan *Trichoderma atroviride* türüne ait TaAl-1 izolatı %33.3 ölüme neden olurken, *T. harzianum* türüne ait ThAk-1 izolatı %50.0 ölüme neden olmuştur. Yerli fungal izolatlarla mukayese amacıyla, 250 mL/1lt su dozunda test edilen 3 ticari fungal preparattan Nibortem (a.i.: *Verticillium lecanii*) uygulamadan 10 gün sonra nimf ve erginlerde sırasıyla %70 ve %56.7, Nostalgist (a.i.: *B. bassiana*) %56.7 ve %53.3, Priority (a.i.: *Paecilomyces fumosoroseus*) %50 ve %56.7 ölüme neden olmuştur.

Anahtar kelimeler: *Aphis gossypii, Beauveria bassiana*, Pamuk yaprakbiti, Entomopatojenik fungus, Mikrobiyal mücadele

Abstract: In this study, the effectiveness of entomopathogenic fungal (EPF) species isolated from soil and infected aphid samples taken from different districts of Antalya between 2018-2020 was investigated against the cotton aphid, *Aphis gossypii*. For this purpose, 19 entomopathogenic fungal isolates were tested against the nymphs and adults of *A. gossypii* in 9 cm diameter Petri dishes at a concentration of $1x10^7$ spores/mL. Among the fungal species tested, *Beauveria*

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bassiana was the most pathogenic species. In pathogenicity tests, 10 days after incubation, *B. bassiana* caused 63.3%-100%, *Cunninghamella echinulata* 43.3%, *Clonostachys rosea* 40-70%, *Isaria farinosa* 43.3%-63.3%, and *Purpureocillium lilacinum* 73.3%-83.3% mortality of *A. gossypii* adults. The TaAl-1 isolate of *Trichoderma atroviride* used in biological control caused a mortality of 33.3%, and the ThAk-1 isolate of *T. harzianum* caused 50.0% mortality. Of the 3 commercial fungal preparations tested at doses of 250 mL/1lt water for comparison with indigenous fungal isolates, Nibortem (a.i.: *Verticillium lecanii*) caused 70% and 56.7% mortalities in nymphs and adults, respectively, 10 days after treatment, while Nostalgist (a.i.: *B. bassiana*) and Priority (a.i.: *Paecilomyces fumosoroseus*) caused 56.7% and 50% nymphal mortality, and 53.3% and 56.7% adult mortality, respectively.

Keywords: *Aphis gossypii*, *Beauveria bassiana*, Cotton aphid, Entomopathogenic fungus, Microbial control.

Introduction

There are approximately 5000 known species of aphid belonging to 493 genera across the world (Remaudiere & Remaudiere 1997; Blackman & Eastop 2000). In Turkey, around 415 aphid species have been identified (Görür 2004). Aphids in the family Aphididae are harmful to a large number of host plants belonging to a total of 40 plant families, most of which are vegetables, ornamental plants or fruit trees. In addition, some aphids in this family serve as vectors in the spread of many plant viruses (Von Dohlen & Moran 2000). Aphids, which feed on the green parts of the plants by sucking the plant sap, expel the excess sugar they have absorbed as honeydew due to the low protein and high carbohydrate content of the plants they feed on, and all above-ground parts can be covered with this substance, except for the root. Secondary fungi develop on this secreted substance and a condition called fumagine or sooty mould occurs (Murphy et al. 2006).

The cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae), is one of the most important pests of cultivated plants in many parts of the world, including Turkiye (Cottier 1953; Görür 2004). The wide host range of the pest and the extent of the damage it causes to these plants increase the importance of controlling this pest. For this reason, different control methods are used to control *A. gossypii*. The use of synthetic insecticides in the control of this pest is a form of control measure that has been applied for a long time. However, biological control methods need to be investigated due to the emergence of the negative effects of chemical insecticides on the environment and human health and the development of resistance to the pesticides used. As an alternative method to the use of chemical pesticides, biological control is often considered to be the most environmentally friendly way to control many pests. In biological control, the use of entomopathogenic fungi is advantageous because the agent is usually easy to detect, infects insects easily, and their effectiveness can be seen quickly (Sáenz-de-Cabezón et al. 2003; Güneş & Gözel 2011; İzgi & Güven 2016).

For this purpose, the objective of this study was to determine the efficacy of some entomopathogenic fungal isolates and commercial products against *A. gossypii* as potential biocontrol agents.

Materials and Methods

Insect culture

Insects used in the experiments was taken from a laboratory colony of *A. gossypii* that originated with field-collected adults from cotton (*Gossypium hirsitum* L.) production areas in Manavgat (Antalya, Turkey) and maintained for 1 year at the Plant Protection Department of Akdeniz University. Rearing was done on the foliage of pepper (*Capsicum annuum* L.) plants in a climate room set to 25 ± 1°C, 60 ± 5 R.H. and 16 : 8 (L / D) hour photoperiod. Subsequent cultures were maintained to provide insect supply. Healthy nymphs and 4-5 days old wingless adult females from the cultured individuals were used in the pathogenicity assays.

Indigenous fungal isolates and commercial fungal preparations

Nineteen indigenous isolates belonging to 7 entomopathogenic fungal species, which had previously been isolated from soil samples collected from natural surroundings and agricultural habitats in Antalya Province, already being maintained in the EPF Collection of Plant Protection Department of Akdeniz University, were tested in this study. The species and code names, habitats, geographic coordinates and sampling sites of the isolates tested are presented in Table 1. Molecular diagnosis of the isolates used in the study was made with the PCR method of Baki (2021). The accession numbers of the isolates in GenBank are given in Table 1. For the purposes of comparison with the indigenous fungal isolates, three commercial fungal preparations, Nibortem (*Verticillium lecanii*, Agrobest Group, Türkiye), Priority (*Paecilomyces fumosoroseus*, Agrobest Group, Türkiye) and Nostalgist (*Bauveria bassiana*, Agrobest Grup, Türkiye), were used.

Bioassays

To determine the pathogenicity of entomopathogenic fungi and commercial preparations against *A. gossypii*, trials were conducted in the Entomology Laboratory of the Plant Protection Department of XYZ University in Antalya, Turkiye. The entomopathogenic fungal isolates used in the study were grown on SDA (Sabouraud Dextrose Agar) medium in an incubator set at 25±2°C for 10-14 days in a dark environment. Ten mL of sterile distilled water containing 0.1% Tween 80 was applied to the developing fungi and spores were obtained by scraping with a Dirigalski spatula (Hansoylu 2003). All spore solutions were filtered through four layers of sterile cheesecloth to remove agar and mycelial fragments and were then homogenized by vortexing for 2-3 minutes (Abebe 2002). The final concentration of each fungal isolate was adjusted to 1 x 10^7 spores/mL by using Thoma Lam (Fancelli et al. 2013; Gabarty et al. 2014).

Bioassay tests on *A. gossypii* were carried out in a climate room at a temperature of 25±1°C and a relative humidity of 60±5%. Firstly, three layers of blotting paper were placed on Petri dishes (9 cm in diameter), and then pepper plant leaves were placed with the bottom side up. For the spraying method, spore solutions were applied top the leaves with a hand spray device three times from a distance of 10-20 cm. After the leaves were air-dried, ten individual nymphs and adults of *A. gossypii* obtained from the culture were placed in each Petri dish with the help of a fine-tipped brush. Treatments were checked on a daily basis, with mortality counts made on the 3rd, 5th, 7th and 10th days after application, and the live and dead aphids were recorded separately. To confirm that the deaths were caused by the particular applied entomopathogenic fungal isolate, isolation was performed from the dead individuals and thus Koch's postulates were confirmed. As the control, water containing 0.1% Tween 80 was sprayed on the aphid-treated leaves. Additionally, three Commercial fungal preparations were used. The experiments were established according to a randomized plot design.

Table 1. List of the indigenous soil-borne entomopathogenic fungal isolates from Turkiye used in the bioassays against the cotton aphid, *Aphis gossypii*

Isolate code	Species	Origin	Vegetation	Latitude and longitude	Accession no.
BbKm-1	*Beauveria bassiana*	Kumluca	Olive	N 36°19'17.1" E 30°20'23.0"	MT441868
BbKr-1	*Beauveria bassiana*	Kemer	Forest	N 36°35'51.0" E 30°33'22.7"	MT441871
BbKs-1	*Beauveria bassiana*	Kaş	Olive	N 36°12'08.8" E 29°38'46.3"	MT441876
BbAk-1	*Beauveria bassiana*	Aksu	Grassland	N 36°56'03.3" E 30°52'35.1"	MT441881
BbSr-1	*Beauveria bassiana*	Serik	Orange	N 36°55'33.8" E 31°07'20.7"	MT441882
BbFn-4	*Beauveria bassiana*	Finike	Pomegranate	N 36°20'55.0'' E 30°07'36.0''	MW255006
BbKp-2	*Beauveria bassiana*	Kepez	Olive	N 36°54'59.8'' E 30°39'36.0''	MW255007
BbDs-3	*Beauveria bassiana*	Döşemaltı	Pomegranate	N 37°01'08.2'' E 30°36'06.2''	MW255008
BbMg-5	*Beauveria bassiana*	Manavgat	Cotton	N 36°56'30.7" E 30°54'57.9"	MW255014
BbGp-4	*Beauveria bassiana*	Gazipaşa	Oleander	N 36°16'00.7" E 32°18'56.7"	MW255016
CecKp-1	*Cunninghamella echinulata*	Kepez	Wheat	N 37°01'40.0" E 30°39'30.9"	MT441896
CrFn-1	*Clonostachys rosea*	Finike	Orange	N 36°19'11.2" E 30°09'12.1"	MT441897
CrMg-1	*Clonostachys rosea*	Manavgat	Wheat	N 36°57'49.2" E 31°16'51.9"	MT441900
IfGp-1	*Isaria farinosa*	Gazipaşa	Olive	N 36°14'50.3" E 32°21'19.2"	MT441902
IfKm-1	*Isaria farinosa*	Kumluca	Wheat	N 36°20'41.5" E 30°15'25.3"	MT441903
PlKa-1	*Purpureocillium lilacinum*	Konyaaltı	Apple	N 36°53'53.5'' E 30°37'51.8''	OM267784
PlMp-1	*Purpureocillium lilacinum*	Muratpaşa	Evergreen Spindle	N 36°53'42.6'' E 30°39'56.7''	OM267785
TaAl-1	*Trichoderma atroviride*	Alanya	Oleander	N 36°33'18.1" E 31°58'29.3"	MW255021
ThAk-1	*Trichoderma atroviride*	Aksu	Sweetcorn	N 36°56'46.8" E 30°51'38.4"	MW255024

Data analysis

In all cases, no control mortality was observed and, therefore, no correction was necessary for the mortality data. All values were subjected to arcsine transformation before analysis. Data were analyzed with one-way ANOVA using the general linear model of SPSS 23.0 Windows (IBM Corp. 2015, New York, USA). Differences between treatment means were compared at a significance level of $P < 0.01$ using Tukey's multiple comparison test.

Results and Discussion

Among the isolates of indigenous Turkish fungal species tested, *B. bassiana* was the most pathogenic. In the pathogenicity tests, 10 days after treatment, *B. bassiana* isolates caused mortalities ranging from 70% to 100% in both nymphs and adults of *A. gossypii* (Tables 2 and 3). *Purpureocillium lilacinum* wassecond most pathogenic, isolates of which caused mortalities between 73.3% and 83.3% in both nymphs and adults of the pest, followed by *Clonostachys rosea* (isolate, CrFn-1) with 80% and 70% mortalities in nymphs and adults, respectively. Of the four remaining species, *Isaria farinosa* (isolate, IfKm-1) caused a nymphal mortality of 70.0% and adult mortality of 63.3%. All other indigenous fungal species yielded mortalities below 60% in both nymphs and adults of the pest.

As for the commercial fungal preparations, Nibortem produced a nymphal mortality of 70% while it caused 56.7% mortality in adults. The other two preparations, Nostalgist and Priority yielded mortalities below 60% in both nymphs and adults of the pest (Tables 2 and 3).

Table 2. Effects of entomopathogenic fungal isolates from different districts of Antalya Province in Turkiye on *Aphis gossypii* nymphs stated below

Isolate name	Percent mortality (± SE)*			
	3rd day	5th day	7th day	10th day
BbKm-1	96.7±5.8^{Aa}	100.0±0.0^{Aa}	100.0±0.0^{Aa}	100.0±0.0^{Aa}
BbKr-1	43.3±5.8^{DEFGHb}	73.3±11.5^{ABCDEFa}	86.7±5.8^{ABCDa}	93.3±5.8^{ABa}
BbKs-1	60.0±10.0^{BCDEFb}	66.7±11.5^{BCDEFGb}	76.7±5.8^{ABCDEa}	86.7±11.5^{ABCDa}
BbAk-1	36.7±5.8^{FGHIJb}	56.7±15.3^{DEFGHab}	73.3±11.5^{BCDEa}	80.0±10.0^{ABCDEa}
BbSr-1	6.7±11.5^{LMb}	16.7±11.5^{KLMb}	53.3±11.5^{EFGa}	70.0±10.0^{CDEFGa}
BbFn-4	30.0±10.0^{GHIJKLc}	70.0±10.0^{BCDEFb}	96.7±5.8^{ABa}	100.0±0.0^{Aa}
BbKp-2	43.3±5.8^{DEFGHb}	73.3±11.5^{ABCDEFa}	76.7±5.8^{ABCDEa}	93.3±11.5^{ABa}
BbDs-3	60.0±10.0^{BCDEFc}	76.7±5.8^{ABCDEbc}	90.0±10.0^{ABCDab}	100.0±0.0^{Aa}
BbMg-5	50.0±0.0^{DEFGc}	63.3±5.8^{CDEFGHb}	93.3±5.8^{ABCa}	100.0±0.0^{Aa}
BbGp-4	60.0±10.0^{BCDEFb}	66.7±15.3^{BCDEFGab}	73.3±11.5^{BCDEa}	90.0±10.0^{ABCa}
PlKa-1	36.7±5.8^{FGHIJc}	40.0±0.0^{GHIJKbc}	53.3±11.5^{EFGb}	76.7±5.8^{BCDEFa}
PlMp-1	53.3±5.8^{CDEFGb}	56.7±15.3^{DEFGHab}	70.0±10.0^{CDEFab}	83.3±5.8^{ABCDa}
CecKp-1	6.7±5.8^{LMb}	23.3±15.3^{JKLMab}	33.3±5.8^{GHIab}	46.7±11.5^{HIa}
CrFn-1	46.7±5.8^{DEFGHc}	63.3±5.8^{CDEFGHab}	70.0±10.0^{CDEFab}	80.0±0.0^{ABCDEa}
CrMg-1	10.0±10.0^{KLMa}	20.0±10.0^{JKLMa}	26.7±5.8^{HIa}	36.7±5.8^{Ia}
IfGp-1	13.3±5.8^{JKLMc}	23.3±15.3^{JKLMbc}	36.7±11.5^{GHIab}	50.0±0.0^{GHIa}
IfKm-1	30.0±10.0^{GHIJKLc}	36.7±5.8^{HIJKLb}	53.3±5.8^{EFGab}	70.0±10.0^{CDEFGa}
TaAl-1	0.0±0.0^{Mc}	3.3±5.8^{Mc}	16.7±5.8^{IJb}	36.7±5.8^{Ia}
ThAk-1	0.0±0.0^{Mc}	20.0±10.0^{JKLMb}	26.7±5.8^{HIb}	56.7±5.8^{FGHIa}
Nibortem	30.0±10.0^{GHIJKLc}	46.7±5.8^{FGHIJc}	53.3±11.5^{EFGb}	70.0±10.0^{CDEFGa}
Nostalgist	13.3±5.8^{JKLMc}	36.7±5.8^{HIJKLb}	40±10.0^{GHIab}	56.7±5.8^{FGHIa}
Priority	10.0±10.0^{KLMc}	23.3±15.3^{JKLMbc}	36.7±11.5^{GHIab}	50.0±0.0^{GHIa}
Control	0.0±0.0^{Ma}	0.0±0.0^{Ma}	0.0±0.0^{Ja}	0.0±0.0^{Ja}

* All isolates were tested at a spore concentration of $1x10^7$ spores/mL.
Means in a column followed by a different capital letter differ significantly ($P < 0.01$; Tukey test).
Means in a row followed by thea different lowercase letter are significantly different ($P < 0.01$; Tukey test).

In parallel with the results obtained from this study, previous studies have shown that *B. bassiana* isolates are highly virulent against *A. gossypii* (Yeo et al. 2003; Vu et al. 2007; Down et al. 2009; Ibrahim et al. 2011; Jandricic et al. 2014; Lee et al. 2015; Mohammed & Hatcher 2017; Mohammed et al. 2018; Şahin & Karaca 2019) and can be used in the control of this pest. Herlinda et al. (2010) tested 10 *B. bassiana* and 15 *M. anisopliae* isolates obtained from infected insects against *A. gossypii* at a concentration of $1x10^6$ spores/mL. They reported that the most virulent *B. bassiana* and *M. anisopliae* isolates caused 100% mortality of *A. gossypii* in 2.54 days and2.81 days, respectively. They also suggested that entomopathogenic fungal isolates with high efficacy can be used in the control of *A. gossypii*. Castillo et al. (2014) tested *P. lilacinum* and *B. bassiana* isolates against *A. gossypii* on cotton plants under greenhouse and field conditions and reported that both isolates can be used in the control of pest.

Table 3. Effects of entomopathogenic fungal isolates from different districts of Antalya Province in Turkiye on *Aphis gossypii* adults

Isolate name	**Percent mortality (± SE)***			
	3rd day	**5th day**	**7th day**	**10th day**
BbKm-1	80.0 ± 10.0^{ABCb}	93.3 ± 5.8^{ABab}	100.0 ± 0.0^{Aa}	100.0 ± 0.0^{Aa}
BbKr-1	36.7 ± 11.5^{EFGHIb}	56.7 ± 5.8^{DEFab}	70.0 ± 10.0^{CDEFa}	80.0 ± 10.0^{ABCDEa}
BbKs-1	43.3 ± 11.5^{EFGHc}	56.7 ± 5.8^{DEFbc}	73.3 ± 5.8^{BCDEab}	83.3 ± 5.8^{ABCDa}
BbAk-1	26.7 ± 5.8^{GHIJKLb}	40.0 ± 0.0^{EFGHb}	60.0 ± 10.0^{DEFGa}	73.3 ± 5.8^{BCDEFa}
BbSr-1	10.0 ± 10.0^{JKLMc}	23.3 ± 11.5^{GHIJbc}	53.3 ± 15.3^{DEFGHab}	63.3 ± 15.3^{DEFGHa}
BbFn-4	26.7 ± 5.8^{GHIJKLd}	43.3 ± 5.8^{EFGc}	76.7 ± 5.8^{ABCDb}	93.3 ± 5.8^{ABCa}
BbKp-2	16.7 ± 11.5^{IJKLMc}	43.3 ± 5.8^{EFGb}	60.0 ± 10.0^{DEFGab}	73.3 ± 5.8^{BCDEFa}
BbDs-3	70.0 ± 0.0^{BCDc}	83.3 ± 5.8^{ABCb}	96.7 ± 5.8^{ABa}	100.0 ± 0.0^{Aa}
BbMg-5	53.3 ± 11.5^{DEFc}	76.7 ± 5.8^{ABCDb}	86.7 ± 5.8^{ABCab}	96.7 ± 5.8^{ABa}
BbGp-4	46.7 ± 5.8^{DEFGHd}	60.0 ± 0.0^{CDEc}	73.3 ± 5.8^{BCDEb}	86.7 ± 5.8^{ABCDa}
PlKa-1	26.7 ± 5.8^{GHIJKLc}	36.7 ± 5.8^{EFGHIbc}	50.0 ± 10.0^{EFGHIb}	73.3 ± 5.8^{BCDEFa}
PlMp-1	50.0 ± 10.0^{DEFGb}	56.7 ± 5.8^{DEFb}	70.0 ± 10.0^{CDEFab}	83.3 ± 5.8^{ABCDa}
CecKp-1	3.3 ± 5.8^{LMc}	13.3 ± 5.8^{IJc}	30.0 ± 0.0^{HIJKb}	43.3 ± 5.8^{GHIa}
CrFn-1	33.3 ± 11.5^{FGHIJb}	43.3 ± 15.3^{EFGab}	66.7 ± 5.8^{CDEFa}	70.0 ± 10.0^{CDEFa}
CrMg-1	6.7 ± 5.8^{KLMb}	16.7 ± 5.8^{HIJab}	23.3 ± 11.5^{JKLab}	40.0 ± 20.0^{HIa}
IfGp-1	0.0 ± 0.0^{Mc}	16.7 ± 5.8^{HIJb}	26.7 ± 5.8^{IJKb}	43.3 ± 5.8^{GHIa}
IfKm-1	6.7 ± 5.8^{KLMd}	20.0 ± 0.0^{GHIJc}	50.0 ± 0.0^{EFGHIb}	63.3 ± 5.8^{DEFGHa}
TaAl-1	0.0 ± 0.0^{Mc}	0.0 ± 0.0^{Jc}	13.3 ± 5.8^{KLb}	33.3 ± 5.8^{Ia}
ThAk-1	0.0 ± 0.0^{Mc}	6.7 ± 5.8^{Jbc}	23.3 ± 5.8^{JKLb}	50.0 ± 10.0^{FGHIa}
Nibortem	6.7 ± 5.8^{KLMb}	40.0 ± 10.0^{EFGHa}	46.7 ± 11.5^{FGHIJa}	56.7 ± 11.5^{EFGHIa}
Nostalgist	6.7 ± 5.8^{KLMc}	16.7 ± 5.8^{HIJbc}	30.0 ± 10.0^{HIJKb}	53.3 ± 5.8^{FGHIa}
Priority	6.7 ± 5.8^{KLMb}	16.7 ± 5.8^{HIJb}	40.0 ± 10.0^{GHIJa}	56.7 ± 5.8^{EFGHIa}
Control	0.0 ± 0.0^{Ma}	0.0 ± 0.0^{Ja}	0.0 ± 0.0^{La}	0.0 ± 0.0^{Ja}

* All isolates were tested at a spore concentration of $1x10^7$ spores/mL.

Means in a column followed by a different capital letter differ significantly ($P < 0.01$; Tukey test).

Means in a row followed by a different lowercase letter are significantly different ($P < 0.01$; Tukey test).

Mohammed et al. (2018) tested native Iraqi isolates of *L. lecanii*, *B. bassiana*, *I. fumosorosea*, *Chaetomium globosum* and *Metarhizium anisopliae* (Metschn.) Sorokin, 1883 (Hypocreales: Clavicipitaceae) against the aphids, *Myzus persicae* (Sulzer), *A. gossypii*, *A. fabae* Scopoli and *Macrosiphum euphorbiae* (Thomas) under greenhouse conditions. *Beauveria bassiana*, *M. anisopliae* and *L. lecanii* isolates caused 100% mortality of *M. persicae* and *A. gossypii* at a concentration of 10^8 spores/mL on day 7. Gurulingappa et al. (2011) investigated the causes and duration of the effects of *L. lecanii* and *B. bassiana* isolates on *A. gossypii*. They reported that methanolic fractions from *Beauveria bassiana* mycelium caused significant death of *A. gossypii*.

Current research has shown that *A. gossypii* is affected by contact with both conidia and fungal metabolites. This range of susceptibility of *A. gossypii* indicates that these entomopathogenic fungi may have an important role to play in controlling pest populations. All the results reported in the discussed studies are consistent with the findings obtained in this study.

In biological control, *B. bassiana* is widely used against insect pests due to its high efficacy compared toother entomopathogenic fungal species. In conclusion, native Turkish *B. bassiana* isolates, with the high efficacy rates demonstrated in this study, have the potential to be used in the control of *A. gossypii* and possibly other agricultural pests.

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