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RESEARCH ARTICLE

Antifungal Activities of Different Organic Solvent Extracts of Switchgrass (*Panicum virgatum* L.) Against Some Plant Pathogenic Fungi

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Keywords: Antifungal activities, Plant extract, Plant pathogens, *Panicum virgatum*, Lethal concentration

Abstract

This study was carried out to determine the antifungal activities of different organic solvent (acetone, ethyl acetate, chloroform and methanol) extracts of switchgrass (*Panicum virgatum* L.) against the plant pathogens *Sclerotinia sclerotiorum* (Ss), *Alternaria solani* (As), *Fusarium oxysporum* f. sp. *radicis-lycopersici* (Forl) and *Verticillium dahliae* (Vd). In the research, Trailblazer (PI 549094) variety of Nebraska origin and 70 SG 081 numbered line (PI 642267) of North Dakota origin of switchgrass were used as plant material. 100 g of *P. virgatum* plant samples were weighed and put into 1 liter glass jars. Extraction was carried out by adding organic solvents; acetone, ethyl acetate, chloroform and methanol in separate jars, enough to cover the plant parts. Antifungal activities of the extracts were determined by using food poisoning method. In addition, LC_{10}, LC_{50} and LC_{90} doses of the extracts of switchgrass PV1cultivar and PV2 line. In general, it was determined that Ss was the most sensitive pathogen to PV1 and PV2 extracts, followed by Vd, Forl and As. As a result of the dose-effect study, the lowest LC value for PV1 was 0.66 mg/mL against Vd with acetone extract. Among different organic extracts of PV2, the lowest LC_{50} value was determined against Ss as 0.48 mg/ml with methanol extract.

Dallı darının (*Panicum virgatum* L.) Farklı Organik Çözücü Ekstraktlarının Bazı Bitki Patojeni Funguslar Karşı Antifungal Aktiviteleri

Özet

Bu çalışma, dallı darının (*Panicum virgatum* L.) farklı organik çözücü (aseton, etil asetat, kloroform ve methanol) ekstraktlarının bitki patojeni *Sclerotinia sclerotiorum* (Ss), *Alternaria solani* (As), *Fusarium oxysporum* f. sp. *radicis-lycopersici* (Forl) ve *Verticilium dahliae* (Vd) üzerine antifungal aktivitelerini belirlemek amacıyla yürütülmüştür. Araştırmada dallı darının Nebraska orijinli Trailblazer (PI 549094) çeşidi ve Kuzey Dakota orijinli 70 SG 081 numaralı hattı (PI 642267) bitki materyali olarak kullanılmıştır. *P. virgatum* bitkilerinden 100'er g tartılarak, 1 litrelik cam kavanozlara konulmuştur. Bitki örneklerinin üzerini kapatacak kadar aseton, etil asetat, kloroform ve methanol organik çözücüleri ayrı ayrı kavanozlarda ilave edilerek ekstraksiyon yapılmıştır. Farklı organik çözücüler kullanılarak elde edilen ekstraktların antifungal aktiviteleri gıda zehirlenmesi metodu kullanılarak belirlenmiştir. Çalışmada ayrıca, PV1 çeşit ve PV2 hattan elde edilen ekstraktların doz-etki denemeleri ile LC_{10}, LC_{50} ve LC_{90} etkili dozları hesaplanmıştır. Genel olarak PV1 ve PV2 ekstraktlarına en hassas patojenin Ss olduğu, bunu Vd, Forl ve As'nin izlediği belirlenmiştir. Doz etki sonuçlarına göre PV1'de en düşük LC değeri Vd'ya karşı aseton ekstraktında 0.66 mg/mL olarak belirlenmiştir. PV2'nin farklı organik ekstraktları içerisinde ise en düşük LC_{50} değeri 0.48 mg/ml olarak methanol ekstraktı ile Ss'a karşı belirlenmiştir.

Introduction

Plant pathogenic fungi cause widespread damage in agricultural areas where vegetable cultivation is carried out worldwide. The causative agent of white mold disease on cucumbers worldwide is *Sclerotinia sclerotiorum* Lib.De Bary. This pathogen causes intense damage in the areas where cucumber production is made (Purdy, 1979). *Alternaria solani* is the causative agent of early blight disease on tomatoes. The pathogen causes significant yield losses in tomato production areas in Turkey (Yazıcı *et al.*, 2011). *Verticillium* wilt is a worldwide disease caused by the pathogen *Verticilum dahliae* Kleb (Bhat and Subbarao, 1999). *Fusarium oxysporum* f. sp. *radicis-lycopersici* is the causative agent of root rot disease of tomatoes (Lagopodi *et al*., 2002).

Switchgrass (*Panicum virgatum* L.) is a North American perennial C4 forage crop that responds well to fertilization, has a high biomass yield, wide adaptability, and can use marginal areas (Vogel *et al*., 1985; Monti *et al*., 2001; Parrish and Fike, 2005; Wright and Turhollow, 2010). In addition, it is a high-energy plant species used in cellulosic ethanol and biofuel production (Schmer *et al*., 2008).

Switchgrass has been used as a folk remedy, and is suggested to have a variety of biological functions derived from its phytochemical properties. Switchgrass extracts contain bioactive phenolic compounds of different classes vanillic acid, p-coumaric acid, ferulic acid, rutin, and quercitrin (Hu *et al.,* 2010; Ho *et al.,* 2022). Known to provide various health benefits, such as antioxidant, antibacterial, anti-inflammatory and anticancer activities (Tao *et al.,* 2019; Ho *et al.,* 2022).

Due to the harmful effects of pesticides used today, scientists are making great efforts to develop alternative control methods that are harmless to the environment and human health. Some of these methods are the use of plant extracts (Kordali *et al*., 2009), plant essential oils (Soylu *et al*., 2005), biological control agents (Onaran and Yanar, 2011) and entomopathogens against diseases and harmful organisms (Atay and Kepenekçi, 2016). Plant extracts, which have a broad effect, come first among these methods. It was determined in various studies that plant extracts had antifungal (Yanar *et al*., 2011), antibacterial (Yıldırım *et al*., 2003), insecticidal (Gökçe *et al*., 2007), nematicidal (Kepenekçi and Sağlam, 2015), and herbicidal effects (Yilar *et al*., 2020). However, each study provides a new source for science, since each plant contains different antifungal metabolites and compounds.

In this study, it was aimed to (1) determine the antifungal activity differences between switchgrass variety and line, (2) investigate the antifungal activity of extracts obtained in different organic solvents, and (3) determine the antifungal activity against different plant pathogens.

Materials and Methods

Fungi Culture

Plant pathogenic fungi used in the study were *Sclerotinia sclerotiorum, Alternaria solani, Fusarium oxysporum* f. sp. *radicis-lycopersici*, and *Verticilium dahliae*. They were isolated from cucumber and tomato plants in greenhouse cultivation areas in Antalya province. Plant pathogenic fungi (*Sclerotinia sclerotiorum, Alternaria solani, Fusarium oxysporum* f. sp. *radicis-lycopersici* and *Verticilium dahliae*) were obtained from stock cultures in Plant Pathology laboratory, Faculty of Agriculture, Department of Plant Protection, Ahi Evran University. Pathogens were grown in PDA (Potato dextrose agar) medium at 22±2°C for seven days.

Plant materials

In the study, Trailblazer (PI 549094) variety of switchgrass (*Panicum virgatum* L.) from Nebraska and 70 SG 081 line from North Dakota (PI 642267) were used as plant materials. The plant materials were washed with sterile distilled water and dried in the shade at room temperature. The dried plant materials were passed through a grinder (Waring Group, Model 8011 EB) and separated into small pieces.

Table 1. Plant materials used in the study.

Plant extracts no	USDA /ARS Registration Name	USDA /ARS PLANT ID	Origin
PV1	PI 549094	TRAILBLAZER (Variety)	ABD Nebraska
PV2	PI 642267	70 SG 081 (Line)	ABD North Dakota

Plant extracts

100 g of *Panicum virgatum* plants were weighed and put into 1 liter glass jars. Organic solvents; acetone, ethyl acetate, chloroform and methanol organic solvents were added in separate jars to cover the plant parts. Samples were shaken for 3 days at 120 rpm in an orbital shaker (Lab. Corporation Group, Model SI-300) for 72 hours (30 °C). Methanol was removed by evaporation at 40°C with a rotary evaporator (Heildolph Group, Model Hei-Vap-Presicion). Obtained dry extracts were dissolved in 5% dimethly sulfoxide (DMSO).

Determination of the antifungal activities of the extracts

The antifungal activities of the plant extracts (PV1 and PV2) were determined by agar plate method (Nwosu and Okafor, 1995). Extracts were added to PDA at 40°C to give the final concentration of positive control (Thiram 80%), 0, (negative control) 0.5, 1, and 2 mg/mL for each extract and then the PDA with extracts were poured (~10 ml plate^{-1}) each alone in petri plates (60 mm in diameter). Agar discs (5mm in diameter) from the seven-day-old cultures of the desired fungus were transferred into the petri plates. These fungus cultures were incubated at 22±2°C for 10 days. Fungus mycelial growth was recorded daily. Thiram 80% (w/v) (Commercial fungicide) was used as positive control. DMSO 5% (v/v) was used as negative control. Experiment was set up in 4 replications and repeated 2 times.

The percentage of mycelial growth inhibition was calculated according to the formula mentioned by (Pandey *et al*., 1982).

$$I=100\times(dc-dt)/dc$$

I: mycelial growth inhibition

dc: mycelial growth in control

dt: mycelial growth in treatment

Statistical analysis. All statistical data were performed by SPSS 15.0 software (SPSS, Chicago, IL). Comparison of means was analyzed by Tukey's multiple range test analyzed the comparison of means, and differences were considered significant when $P<0.05$.

Results and Discussion

As a result of the study, differences in antifungal activity were determined between switchgrass variety and line. The effects of different solvent extracts of *Panicum virgatum*, cultivar PV1 and line PV2 on mycelial growth of the test fungi are given in Figure 1, 2, 3, and Table 2, 3, 4.

It was observed that the effects of the acetone, ethyl acetate, chloroform and methanol extracts of *Panicum virgatum*, PV1 cultivar and PV2 line, on the plant pathogen Forl were different from each other. It is found that the 2 mg/ml dose of PV1 variety and PV2 line acetone extract inhibited the mycelial development of Forl by 73% and 100%, respectively. Ethyl acetate, chloroform, and methonal extracts were found to inhibit mycelial growth of the fungus at different rates.

2 mg/ml dose of acetone, ethyl acetate, chloroform, and methanol extracts obtained from PV1 cultivar and PV2 line showed different levels of inhibitory activity on the mycelial growth of *V. dahliae*. The highest inhibition on the mycelial growth of *V. dahliae* was observed in the acetone extract of the PV1 variety and 88% in the methanol extract of the PV2 line.

Different plant extracts from PV1 cultivar and PV2 line gave different responses to *A. solani* depending on the dose. At the highest dose used, it was determined that the most effective effect on mycelium growth of the fungus was in methanol extracts of PV2 and acetone extracts of PV1. Methanol of PV2 and acetone extracts of PV1 inhibited mycelium growth of the fungus by 73.73% and 73.15%, respectively.

It was determined that the extracts obtained from PV1 cultivar and PV2 line were the most affected fungus species *S. sclerotiorum*. Except for PV1 Ethyl acetate, methanol, and PV2 acetone, all other

extracts inhibited mycelium growth of the plant pathogen 100% (Table 2). Considering all the extracts, it was determined that the acetone extract obtained from the PV1 variety and the PV2 line were the most effective on plant pathogens.The pathogen most sensitive to extracts is *S. sclerotiorum*, while the most tolerant is *A. solani*. In addition, plant extracts with different solvents obtained from both plants showed high activity on different plant pathogens.

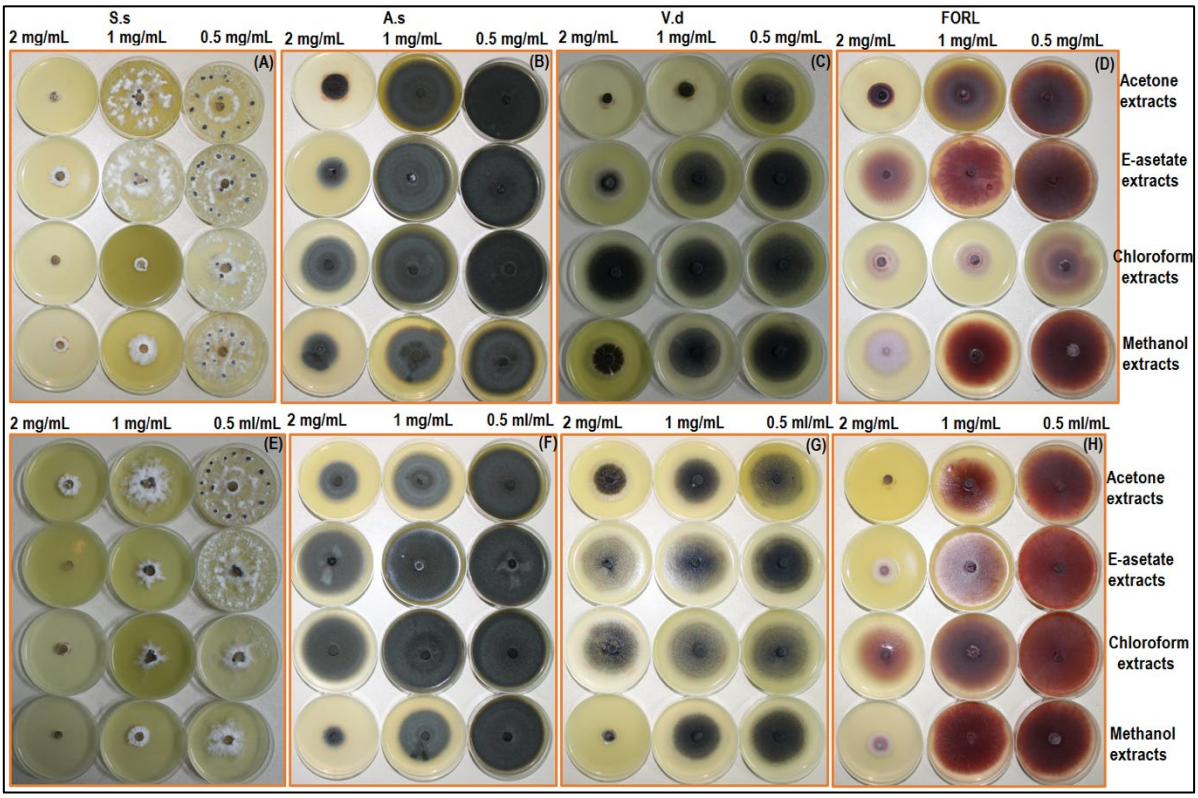

Figure: 1. *Panicum virgatum*'un Mycelium growth against test fungi of PV1 cultivar extracts (A,B,C,D), and PV2 line (E,F,G,H). S.s.=*S. sclerotiorum*, A.s.= *A. solani*, V.d= *V. dahliae*, Forl=*Fusarium oxysporum* f. sp. *radicis-lycopersici*. Photographs were taken at 10 days after inoculation.

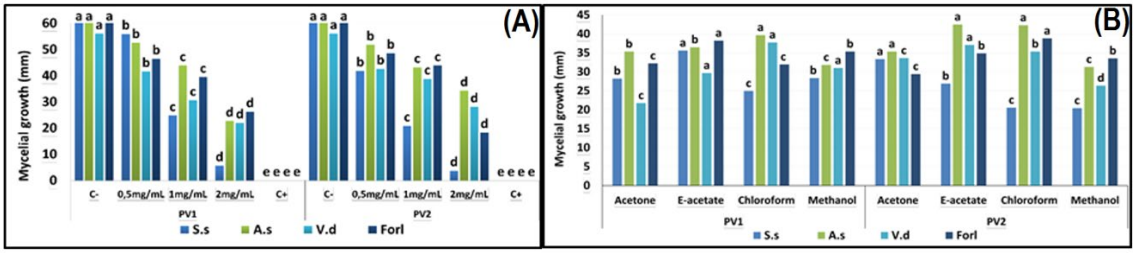

Figure 2: Evaluation of the doses of PV1 and PV2 against test fungi were shown in (A), and evaluation of organic solvents in (B)

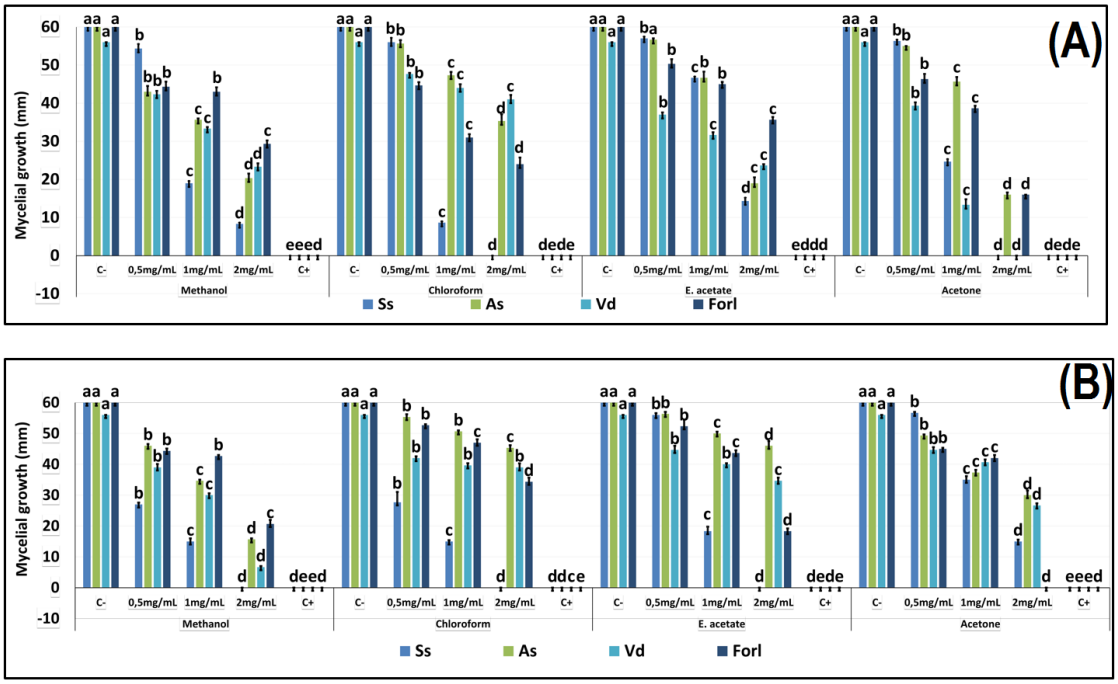

Figure 3. Mycelial growth means of PV1 (A) and PV2 (B) four different extracts (Acetone, E-acetate, Chloroform and Methanol) against test fungi

Table 2. Percent mycelium growth inhibition of PV1 and PV2 four different extracts (Acetone, E-acetate, Chloroform and Methanol) against test fungi

	Doses (mg/mL)	Methanol		Chloroform		Ethyl acetate		Acetone	
		PV1	PV2	PV1	PV2	PV1	PV2	PV1	PV2
Ss	C-	0.00±.00^{e}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{e}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{e}
	0.5	9.00±2.06^{d}	54.85±1.15^{c}	6.80±1.68^{c}	54.20±5.72^{c}	8.22±0.46^{d}	6.63±1.01^{c}	6.54±0.49^{c}	6.25±0.45^{d}
	1	68.80±0.72^{c}	75.25±1.47^{b}	85.20±0.59^{b}	74.62±0.19^{b}	22.60±0.83^{c}	69.08±2.52^{b}	58.89±1.30^{b}	42.14±1.77^{c}
	2	86.16±0.76^{b}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	75.84±1.53^{b}	100±0.00^{a}	100±0.00^{a}	75.18±1.00^{b}
	C+	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}
As	C-	0.00±.00^{e}	0.00±.00^{e}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{e}	0.00±.00^{e}	0.00±.00^{e}
	0.5	28.69±2.31^{d}	23.30±0.89^{d}	3.2±3.20^{d}	7.89±1.06^{cd}	2.32±2.32^{d}	6.74±0.94^{d}	7.73±0.18^{d}	17.50±0.33^{d}
	1	40.47±0.98^{c}	42.01±0.49^{c}	21.01±1.11^{c}	15.88±0.76^{bc}	22.75±4.34^{c}	16.66±0.77^{c}	23.91±1.74^{c}	37.96±1.26^{c}
	2	65.87±1.74^{b}	73.73±0.47^{b}	41.35±2.80^{b}	24.32±6.22^{b}	68.27±2.48^{b}	23.82±2.62^{b}	73.15±0.87^{b}	50.01±2.57^{b}
	C+	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}
Vd	C-	0.00±.00^{d}	0.00±.00^{e}	0.00±.00^{c}	0.00±.00^{c}	0.00±.00^{c}	0.00±.00^{d}	0.00±.00^{d}	0.00±.00^{e}
	0.5	29.26±0.99^{c}	35.01±3.77^{d}	20.98±5.47^{b}	30.44±0.87^{b}	38.38±1.06^{b}	24.95±2.33^{c}	34.59±1.25^{c}	25.31±1.61^{d}
	1	43.97±7.44^{c}	50.46±0.92^{c}	26.76±1.44^{b}	33.79±1.33^{b}	47.15±6.28^{b}	25.78±0.74^{c}	77.68±2.34^{b}	32.02±1.55^{c}
	2	61.44±1.61^{b}	88.57±0.51^{b}	31.43±1.61^{b}	35.29±3.89^{b}	60.2±12.29^{b}	33.67±1.43^{b}	100±0.00^{a}	55.06±1.18^{b}
	C+	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}
Forl	C-	0.00±0.00^{d}	0.00±0.00^{d}	0.00±0.00^{e}	0.00±0.00^{d}	0.00±0.00^{d}	0.00±.00^{e}	0.00±0.00^{d}	0.00±.00^{d}
	0.5	25.92±1.89^{c}	25.63±2.95^{c}	25.63±4.87^{d}	12.32±2.31^{c}	16.43±2.06^{c}	12.76±3.69^{d}	22.74±2.19^{d}	24.91±0.14^{c}
	1	28.21±1.55^{c}	29.01±0.26^{c}	48.06±0.29^{c}	21.89±3.57^{c}	25.34±1.07^{c}	26.94±1.21^{c}	35.55±1.07^{c}	30.47±1.92^{b}
	2	51.1±1.22^{b}	65.66±4.13^{b}	59.80±2.79^{b}	42.87±3.70^{b}	40.91±6.35^{b}	69.49±1.21^{b}	72.79±0.24^{b}	100.0±0.00^{a}
	C+	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	100.0±0.00^{a}

Tukey's multiple range test was used to compare means and differences were considered significant when P<0.05. C+= Positive control; C-= Negative control; Ss= *Sclerotinia sclerotiorum*, As=*Alternaria solani*, Vd=*Verticillium dahlia*, Forl= *Fusarium oxysporum* f. sp. *radicis-lycopersici*,

The study also performed dose-effect trials of different solvent extracts from PV1 cultivar and PV2 line. As a result of the dose-effect research, the effective doses of LC_{10}, LC_{50}, and LC_{90} were calculated and given in Tables 3 and 4. The LC_{50} values on Ss of the PV1 variety, ethyl acetate, methanol, acetone and chloroform extract are 1.38, 0.92, 0.90 and 0.75, respectively. The LC_{50}values of methanol, Acetone, Ethyl acetate and chloroform extracts on As were determined as 1.21, 1.41, 1.52 and 2.36 (mg/mL), respectively. The LC_{50} values of Acetone, Ethyl acetate, chloroform and methanol extracts on Vd were calculated as 0.66, 0.90, 1.37 and 1.57 (mg/mL). In the dose effect study of the PV1 variety on Forl, the LC_{50} values of Acetone, chloroform, methanol and ethyl acetate extracts were 1.21, 1.25, 1.40 and 2.41 (mg/mL), respectively (Table 3).

Table 3. LC_{10}, LC_{50} and LC_{90} values of 4 different extracts of PV1.

PV1	Effective Doses (mg/mL)	Ss			As			Vd			Forl		
		95% limits			95% limits			95% limits			95% limits		
		LC	Low.	Upr.	LC	Low.	Upr.	LC	Low.	Upr.	LC	Low.	Upr.
Methanol	LC_{10}	0.44	0.29	0.55	0.20	0.11	0.29	0.22	0.11	0.33	0.22	0.11	0.32
	LC_{50}	0.92	0.77	1.07	1.21	1.04	1.45	1.57	1.30	2.06	1.40	1.19	1.73
	LC_{90}	1.93	1.56	2.73	7.23	4.65	15.5	11.0	6.16	32.1	8.88	5.41	21.2
	LCP9	9.33	5.42	25.4	322.5	92.9	2841.6	679.8	145.9	12494.3	450.4	116.7	5034.8
	Slope	3.969+-0.287			1.648+-0.230			1.517+-0.239			1.594+-0.231		
	Het.	3.16			0.54			0.53			0.59		
	X^2	22.13			3.75			3.70			4.10		
Chloroform	LC_{10}	0.53	0.49	0.57	0.72	0.47	0.91	0.29	0.18	0.38	0.18	0.06	0.29
	LC_{50}	0.75	0.72	0.79	2.36	1.84	3.76	1.37	1.18	1.64	1.25	1.02	1.63
	LC_{90}	1.06	0.10	1.14	7.72	4.53	24.9	6.56	4.43	12.5	8.93	4.87	32.1
	LCP9	2.21	1.93	2.64	95.6	28.2	1478.2	182.8	63.8	1070.1	578.5	104.6	22964.3
	Slope	8.525+-0.606			2.487+-0.296			1.881+-0.244			1.501+-0.229		
	Het.	0.32			1.88			0.23			1.03		
	X^2	2.28			13.14			1.61			7.24		
Ethyl acetate	LC_{10}	0.62	0.49	0.73	0.75	0.59	0.88	0.18	0.01	0.26	0.37	0.23	0.50
	LC_{50}	1.38	1.23	1.59	1.53	1.3.6	1.78	0.90	0.77	1.04	2.41	1.90	3.57
	LC_{90}	3.09	2.50	4.27	3.13	2.53	4.43	4.51	3.22	7.85	15.5	8.22	49.9
	LCP9	17.6	10.2	38.6	14.3	8.55	34.03	137.8	49.6	772.7	805.6	172.3	14338.1
	Slope	3.667+-0.288			4.129+-0.335			1.831+-0.241			1.585+-0.245		
	Het.	1.54			1.88			0.56			0.19		
	X^2	10.80			13.16			3.90			1.36		
Acetone	LC_{10}	0.57	0.52	0.62	0.60	0.50	0.70	0.36	0.30	0.40	0.33	0.18	0.44
	LC_{50}	0.90	0.85	0.95	1.41	1.27	1.58	0.66	0.62	0.71	1.21	1.01	1.53
	LC_{90}	1.40	1.30	1.54	3.29	2.71	4.32	1.24	1.13	1.41	4.48	2.96	9.99
	LCP9	3.63	3.02	4.62	19.9	12.4	39.6	4.68	3.59	6.75	72.6	24.3	635.8
	Slope	6.584+-0.480			3.481+-0.283			4.723+-0.393			2.248+-0.266		
	Het.	0.58			1.01			0.79			1.32		
	X^2	4.04			7.10			5.53			7.92		

Ss= *Sclerotinia sclerotiorum*, As=*Alternaria solani*, Vd=*Verticillium dahlia*, Forl= *Fusarium oxysporum* f. sp. *radicis-lycopersici*, LC: Effective dose (Letal concentration) , Low.=Lower bound, Upr.=Upper bound, Het.= Heterogeneity, X^2= Chi-square

The LC_{50} values of PV2 variety, methanol, chloroform, ethyl acetate, and acetone extract on Ss were 0.48, 0.50, 0.83 and 1.24 (mg/mL), respectively. The LC_{50} values of methanol, acetone, chloroform and ethyl acetate extracts on As were determined as 1.10, 1.78, 4.53 and 5.04 (mg/mL), respectively. The LC_{50} values of methanol, chloroform, acetone, and ethyl acetate extracts on Vd were calculated as 0.87, 1.13, 1.90 and 2.06 (mg/mL). In the dose effect study of the PV2 variety on Forl, the LC_{50} values of Acetone, ethyl acetate, methanol and chloroform extracts were 0.86, 1.38, 1.40 and 2.18 (mg/mL), respectively (Table 4).

Table 4. LC_{10}, LC_{50} and LC_{90} values of 4 different extracts of PV2.

PV2	Effective Doses (mg/mL)	Ss			As			Vd			Forl		
		95% limits			95% limits			95% limits			95% limits		
		LC	Low.	Upr.	LC	Low.	Upr.	LC	Low.	Upr.	LC	Low.	Upr.
Methanol	LC_{10}	0.18	0.06	0.28	0.31	0.22	0.38	0.29	0.16	0.41	0.35	0.25	0.44
	LC_{50}	0.48	0.32	0.59	1.10	0.98	1.24	0.87	0.72	1.04	1.40	1.24	1.64
	LC_{90}	1.28	1.02	1.98	3.95	3.07	5.72	2.58	1.94	4.32	5.61	4.07	9.19
	LCP9	10.5	4.83	65.2	59.7	29.7	170.7	25.9	11.5	123.7	106.1	45.7	395.7
	Slope	2.975+-0.324			2.306+-0.240			2.717+-0.260			2.130+-0.241		
	Het.	2.51			0.31			1.99			0.94		
	X^2	17.59			2.14			13.95			6.61		
Chloroform	LC_{10}	0.20	0.08	0.30	0.64	0.42	0.81	0.23	0.14	0.32	0.55	0.41	0.66
	LC_{50}	0.50	0.35	0.62	4.53	3.04	10.1	1.13	0.98	1.32	2.18	1.84	2.80
	LC_{90}	1.28	1.03	1.96	32.3	13.2	212.8	5.52	3.84	10.0	8.66	5.76	16.7
	LCP9	9.29	4.46	50.5	207.3	28.4	1411.5	159.6	56.9	898.5	161.7	61.4	785.8
	Slope	3.160+-0.328			1.504+-0.276			1.861+-0.241			2.138+-0.264		
	Het.	2.67			0.21			0.10			0.18		
	X^2	18.71			1.45			0.70			1.29		
Ethyl acetate	LC_{10}	0.55	0.50	0.59	0.69	0.46	0.87	0.35	0.21	0.47	0.50	0.41	0.58
	LC_{50}	0.83	0.79	0.88	5.04	3.26	12.6	2.06	1.67	2.86	1.38	1.25	1.54
	LC_{90}	1.27	1.18	1.40	37.1	14.2	302.7	12.2	6.90	34.4	3.80	3.10	5.03
	LCP9	3.128	2.63	3.94	255.3	31.4	2654.9	533.2	128.8	7237.3	32.6	19.5	67.6
	Slope	6.967+-0.515			1.479+-0.284			1.658+-0.250			2.911+-0.262		
	Het.	0.37			0.26			0.24			0.43		
	X^2	2.62			1.80			1.71			3.04		
Acetone	LC_{10}	0.55	0.47	0.62	0.28	0.15	0.39	0.32	0.18	0.43	0.39	0.19	0.53
	LC_{50}	1.24	1.15	1.35	1.78	1.47	2.36	1.90	1.56	2.59	0.86	0.68	1.09
	LC_{90}	2.80	2.43	3.37	11.5	6.58	31.4	11.5	6.56	31.4	1.86	1.37	3.89
	LCP9	15.70	10.98	25.5	603.1	142.3	8421.5	515.9	125.7	6855.3	9.70	4.40	79.5
	Slope	3.632+-0.284			1.581+-0.236			1.644+-0.247			3.792+-0.323		
	Het.	0.65			0.25			0.13			4.86		
	X^2	4.52			1.74			0.88			29.13		

Ss= *Sclerotinia sclerotiorum*, As=*Alternaria solani*, Vd=*Verticillium dahlia*, FORL= *Fusarium oxysporum* f. sp. *radicis-lycopersici*, LC: Effective dose (Letal Concentration), Low.=Lower bound, Upr.=Upper bound, Het.= Heterogeneity, X^2= Chi-square

Many previous studies reported that plant extracts show antifungal activit (Xue-Na *et al*., 2012; Yilar *et al*., 2020; Hernández-Ceja *et al*., 2021). It has been reported that ethanol extracts obtained from the leaves and fruit parts of *Pyrus serikensis* show biofungicide activity against *Fusarium oxysporum* f.sp. *cucumerinum*, *Sclerotinia sclerotiorum*, *Rhizoctonia solani* and *Monillinia fructigena* (Yavuz *et al*., 2022).

Onaran and Başaran, (2018), *Muscari aucheri* (Boiss) Baker plant methanol extract (Flower + flower stalk) was found to be responsible for five different plant pathogens *Fusarium oxysporum* f.

sp. *cucumerinum*, *Alternaria solani*, *Verticillium dahliae*, *Rhizoctonia solani*, and *Botrytis cinerea* reported that it showed antifungal activity.

Ho *et al*., (2022) tested different biological activities of Switchgrass in a study they conducted. In addition to the anti-inflammatory properties, they have determined the potential biological activities of Switchgrass extracts anti-bacterial, anti-mycobacterial, anti-proliferative, anti-tyrosinase, and anti-elastase activity in vitro bioassays.

Six (plant age x field) ethanol extracts of a branched millet plant, collected from three different fields at two different ages [56 days (3 fields) and 112 days (3 fields)], against plant pathogenic bacteria (*Clavibacter michiganensis* subsp. *michiganensis, Xanthomonas perforans*, *Pseudomonas syringae* pv. *tomato* ve *Pseudomonas mediterranea*) investigated the antibacterial activities. According to these results, different antimicrobial effects were observed in the plants from all fields, and even plants of the same age had a dissimilar impact. The applied extract dose (50%) was more sensitive to *Xanthomonas perforans* (98%) than *Pseudomonas syringae* pv. *tomato* (100%). In addition, 99% percent bacterial growth was observed against *Clavibacter michiganensis* subsp. *michiganensis*, and 98.5% against *Pseudomonas mediterranea* (Vu, 2011). In a similar study, the effectiveness of branched millet plant extract against plant pathogenic fungi, plant pathogenic bacteria, and foodborne bacteria was determined (Bruce 2016).

Conclusion

As a result of the study, it was determined that there were differences in antifungal activity of different organic solvent extracts between the switchgrass variety and lines. It is thought that plant pathogenic fungi give different antifungal responses to different organic solvents of switchgrass, resulting from different chemicals dissolved in organic solvents. In addition, LC_{10}, LC_{50} and LC_{90} values of different solvent extracts of PV1 and PV2 were calculated in the study. The lowest LC_{50} value was observed in the methanol extract of PV2 with 0.48 mg/mL versus Ss. This study showed that different organic solvent extracts of switchgrass variety and line had antifungal activity on plant pathogens.

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Declarations

Conflict of interest the authors declare that they have no confict of interest.

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