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Data Article

Dataset on collecting volatile compounds produced by three bacteria and testing their efficacy against the pathogen *Peronophythora litchii*

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ABSTRACT

This data article provides supporting information to a related research article "Identification of volatile organic compounds for the biocontrol of postharvest litchi fruit pathogen *Peronophythora litchii*" (Zheng et al., 2019) [1]. The litchi downy blight (LDB) caused by *Peronophythora litchii* is a major postharvest disease that can severely damage litchi trees and harvested litchi fruit. This data article describes the analysis of volatile compounds (VOCs) in three bacterial biological control agents (BCAs) of LDB (*Bacillus amyloliquefaciens* PP19, *Bacillus pumilus* PI26, and *Exiguobacterium acetylicum* SI17) via gas chromatography/mass spectrometry (GC–MS). Volatile compounds produced by the three BCAs were captured at

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five culture time of 24, 36, 48, 60 and 72 h by a solid-phase micro extraction method. The chemical compositions were identified and their retention times as well as relative peak areas were analyzed. Compounds commonly produced at more than one time points were then subjected to *in vitro* (on petri dish) and *in vivo* (litchi fruit and leaves) evaluations for their antagonistic activities against the pathogen *Peronophythora litchii*.

Specifications Table

Subject area	Agricultural and Biological Sciences
More specific subject area	Plant disease
Type of data	Table and Figure
How data was acquired	Volatile compounds produced by three bacterial isolations (*Bacillus amyloliquefaciens* PP19, *Bacillus pumilus* PI26, and *Exiguobacterium acetylicum* SI17) were analyzed using gas chromatography coupled with mass spectrometry
Data format	Raw and analyzed
Experimental factors	Three bacteria (PP19, PI26, and SI17); five culture stages of each isolation (24, 36, 48, 60, and 72 h); two assays of the biocontrol activities against the pathogen *Peronophythora litchii* (*in vitro* on plate and *in vivo* on detached fruit and leaves)
Experimental features	Identification of bacterial volatile compounds using GC-MS; examination of identified volatile components for their *in vitro* antagonism and *in vivo* biocontrol efficacy.
Data source location	Guangzhou, Guangdong province, China
Data accessibility	The data are available with this article and accessible to the public.
Related research article	L. Zheng., J-J. Situ., Q-F, Zhu., P-G. Xi., Y. Zheng., H-X, Liu., X−F. Zhou., Z-D. Jiang. Identification of volatile organic compounds for the biocontrol of postharvest litchi fruit pathogen *Peronophythora litchii*. Postharvest biology and technology, 2019, 155: 37−46 [1].

Value of the data

- The data reveals distinct volatile profiles produced by different biological control agents (BCAs) of litchi downy blight which is valuable for researchers working on the disease.
- The data could be used by researchers to further investigate the mechanisms underlying the biocontrol activities of the bacterial volatile compounds reported in this study.
- The data allows to compare the reported compounds for their modes of action against *Peronophythora litchii in vitro* and/or *in vivo*.
- The data provides valuable information on the relationship between concentrations of compounds and their biocontrol efficacies.

1. Data

We collected data on different BCAs produced by GC-MS across different culture time, and against the pathogen *Peronophythora litchii* in *in vitro* and *in vivo* conditions. The six tables and two figures that are provided as data for this article contain the retention times, volatile compound names and the relative peak area (in percentage) of the three strains, antagonistic activity, efficacy to litchi downy blight at different concentrations.

2. Experimental design, materials and methods

2.1. Collection and identification of VOCs produced by strain PP19, SI17 and PI26

The three bacterial suspension was coated evenly on LB in sample vials. The bacterial VOCs were collected using advanced headspace solid phase microextraction (SPME) technique [2], and the

compounds were extracted using the protocol described by Raza et al. [3] with some modifications. The bacteria were incubated in water bath at 45 °C for 80 min, and VOCs were extracted by headspace solid phase microextraction (SPME) (Supelco Co., Bellefonte, PA, USA; 50/30 μm DVB/CAR/PDMS, gray) during the last 40 min. The SPME fiber was inserted in the injector of GC-MS system (SHIMADAZU GCMS-QP2010 Ultra), and desorbed at 250 °C (3 min) with an HP-5MS column (30 m, 0.25-mm inside diameter, 0.25 μm). The protocol used for over temperature was 50 °C (2 min), and 250 °C (6 °C/min). The volatile compounds were identified based on their diversity in the three isolation in gas chromatograph equipped with mass spectrometer. HP-5MS column was used for the separation. Gas carrier was helium 1 mL/min. The relative amounts of volatile compounds in each part from the bacteria were determined by comparing spectra of each compound with library NIST11S and by data analysis in a GC-MS workstation (Software Version SHIMADZU GCMS solution) (Tables 1–3, Fig. 1).

2.2. *Overview the levels of the volatile compounds from the three isolation at antagonistic activity against* P. litchii *and relative peak area*

The antagonistic activity against *P. litchii* and relative peak area across five time point to assess the volatile compounds level (Table 4, Fig. 2). The former was referred to Xing et al. [4] and the latter was analyzed from the GC-MS dataset.

2.3. *Measures taken against the* P. litchii in vivo *on litchi fruit and leaves*

The pathogen *P. litchi* was cultured on CA medium (carrot juice from 200 g carrot topped up to 1 L, 15 g/L agar) at 28 °C for 5 d, which was observed under an electronic microscope; its concentration was adjusted to 5×10^4 sporangia/mL followed the method of Jiang LQ et al. [5].

Six chemicals were evaluated at the concentrations of 1000, 500 and 200mg L^{-1}, while the corresponding solvent-only dilutions were used as control for each chemical and concentration tested. The healthy fruit of litchi cultivar “Huaizhi” (about 85% ripening degree, a private farm, Conghua district, Guangzhou City, Guangdong Province) or 5 branches (a private farm, Huadu district, Guangzhou City, Guangdong Province) with at least 10–20 leaves per replicate were collected and immediately transported to the laboratory for processing. Every 30 detached fruit were placed in a container (323 × 220×100 mm; Hualong Plastic Factory, Foshan, China) whose bottom was covered with two pieces of sterile filter paper (D = 18 cm), moistened with 15 mL sterile water. 300 mL was used for each treatment by spray. After 24 hours, fruit in each treatment were inoculated with the pathogen *P. litchii* at 5×10^4 sporangia/mL by spray. The relative humidity in the container was 85–90%, which was placed in a small greenhouse maintained at 25 °C and with 24 h light cycle and the relative humidity of 60%–75% (the parameters were monitored by TH6 automatic humidity and temperature data logge, Hangzhou Meacon Automation Technology Co., Ltd). Disease severity was monitored during 48–84 hours post inoculation (hpi) (Tables 5 and 6), and the levels of disease severity were determined using the method of Jiang YM et al. [6].

Disease severity was defined as follows: 0, 1, 3, 5, 7, and 9 represent 0, <5, 6 to 10, 11 to 25, 26 to 50, and >50% leaf area with symptoms, respectively. Disease index and biocontrol efficacy was calculated as follows: Disease index (%) = [Σ (Disease level × number of fruit in each level)/(the highest level × total number of fruit)] × 100; Biocontrol efficacy (%) = [(Disease index of control - Disease index of treatment)/Disease index of control] × 100.

2.4. *Data analysis*

Data on plate antagonism assay disease index, control efficacy were processed and analyzed in Microsoft Excel. Least significant difference test ($P < 0.05$) was performed using the statistical software data processing system (DPS version 7.05, Zhejiang University, Hangzhou, China). One-way ANOVA was used to compare the factors investigated.

Table 1
Volatile compounds identified from 24 h culture of PP19 (*Bacillus amyloliquefaciens*), PI26 (*B. pumilus*), and SI17 (*E. acetylicum*).

PP19-RT (min)	Relative peak area (%)	Volatile organic compounds	PI26-RT (min)	Relative peak area (%)	Volatile organic compounds	SI17-RT (min)	Relative peak area (%)	Volatile organic compounds
7.068	40.67	[a] **6-Methyl-2-heptanone**	7.088	13.95	**6-Methyl-2-heptanone**	7.113	2.92	2-Heptanone
7.3	32.35	5-Methyl-2-heptanone	7.327	21.81	5-Methyl-2-heptanone	7.351	1.42	2-Ethyl-1-butanol
8.933	7.21	**2-Ethylhexan-1-ol**	12.259	16.02	2-Decanone	7.515	3.33	1-Methyl-1,3-cyclopentadiene
9.587	6.15	**2-Nonanone**	12.335	1.72	2-Decanol	8.505	0.62	Tricyclo[2.2.1.02,6]heptan-3-ol
12.262	2.23	2-Decanone	12.513	4.02	2-Dodecanol	8.636	1.63	(1Z)-Cyclooctene
15.476	1.49	Pentadecane	14.985	28.81	2-Isobutyl-3-isopropylpyrazine	8.846	3.49	(3aR,6aR)-1,2,3,3a,4,6a-Hexahydropentalene
19.717	4.89	1-Iodohexadecane	16.82	10.62	2-Dodecanone	9.598	3.04	**2-Nonanone**
20.007	3.54	**(3E,6E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene**	20.011	3.04	**(3E,6E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene**	9.869	1.1	2-Nonanol
28.695	1.47	Ethyl palmitate				11.112	4.92	2-Phenylethanol
						12.121	21.75	2-Decanone
						12.324	10	2-Decanol
						12.5	2.82	2-Dodecanol
						14.287	0.26	Ethyl 2-phenylacetate
						14.528	7.4	**2-Undecanone**
						14.712	4.51	2-Tridecanol
						16.812	8.8	2-Dodecanone
						16.973	10.63	6,10,14-trimethylpentadecan-2-one
						17.129	3.82	2-Hexadecanol
						17.906	0.14	3-Undecanone
						18.879	0.21	6,10-dimethylundeca-5,9-dien-2-one
						18.985	2.84	2-Tridecanone
						19.119	0.58	2-Heptadecanol
						20.009	1.04	**(3E,6E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene**
						20.669	0.41	1-cyclododecylethanone
						21.031	1.2	2-Tetradecanone
						21.184	1.12	2-Nonadecanone

[a] Volatile organic compounds printed in bold type were selected for the *in vivo* antagonism assay.

Table 2
Relative peak area of the 17 main volatile compounds of three BCAs identified across 24 h−72 h.

Strain	Time point (h)	2,5-Dimethyl-pyrazine	Bicyclo [4.2.0] octa-1,3,5-triene	1-(2-Aminophenyl) ethanone	2-Unde-canone	Benzo-thiazole	Penta-decane	2-Ethylhexan-1-ol	2-Nonanone	(3E,6E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene	1-Tridecene	6-Methyl-2-heptanone	5-Methyl-2-heptanone	nonylcy-clopropane	6,10,14-trimethyl-pentadecan-2-one	2-Dodecanone	1-iodohex-adecane	5-Methyl-2-heptanone
PP19	24	0	0	0	0	0	1.49	7.21	6.15	3.54	0	40.67	0	0	0	0	4.89	32.35
	36	4.86	7.18	0.61	0.21	0.78	0.09	0.73	6.61	0.31	0.19	11.73	10.82	20.66	0.38	0.52	0.26	14.43
	48	0	0	0	0	0	0	0	1.21	0	0	24.66	41.47	0	0	1.9	0	0
	60	5.52	3.9	3.71	0.3	0.48	0	0	1.55	0	0.2	4.61	14.05	39.63	0.27	0.57	0	0
	72	0	0	0	0	0	0	0	4.07	0	0	7.64	4.16	0	0	0	0	0
PI26	24	0	0	0	0	0	0	0	0	3.04	0	13.95	0	0	0	10.62	0	21.81
	36	0	0	0	0	0	0	0	0	0.29	0	5	5.1	0	69.9	0	0	0
	48	0	0	0	0	0	0	0	7.76	0	0	39.84	0	0	0	0	0	0
	60	3.14	0	5.17	0	0.19	0	0	0	0	0.19	0	0	0	0	0	0	0.78
	72	0	0	0	0	0	0	0	6.26	0	0	23.46	0	0	0	4.78	0	0
SI17	24	0	0	0	7.4	0	0	0	3.04	1.04	0	0	0	0	10.63	8.8	0	0
	36	0	0	3.94	1.13	0	0	0	4.46	0	0.38	5.98	3.96	36.77	0	0	0	0
	48	0	0	0	12.03	0	0	0	1.62	0	0	0	0	0	0	0	0	0
	60	1.69	0	5.41	0	0	0	0	0	0.01	0.19	0	0	0.3	0	0	0	0.22
	72	0	0	0	5.6	0	0	0	1.97	0	0	3.62	0	0	1.01	18.7	0	0

Table 3
Numbers of bacterial VOCs compounds at 24, 36, 48, 60, 72 h.

Strain	24 h	36 h	48 h	60 h	72 h
PP19	9	33	14	28	17
SI17	26	22	13	16	21
PI26	8	13	11	16	22

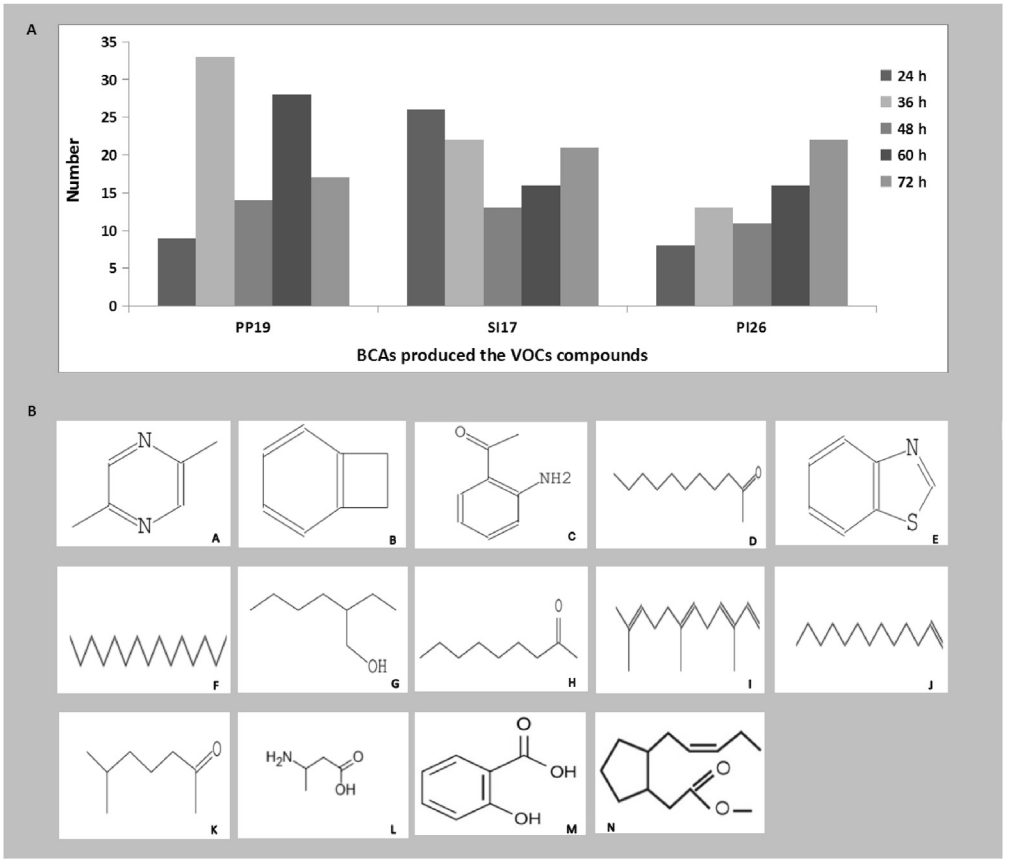

Fig. 1. Numbers of bacterial VOCs compounds at 24, 36, 48, 60, 72 h (**A**) and Chemical classes of volatiles (**B**), **A-K**, 2,5-Dimethylpyrazine ($C_6H_8N_2$); Bicyclo[4.2.0]octa-1,3,5-triene (C_8H_8); 1-(2-Aminophenyl)ethanone (C_8H_9NO); 2-Undecanone ($C_{11}H_{22}O$); Benzothiazole (C_7H_5NS); Pentadecane ($C_{15}H_{32}$); 2-ethylhexan-1-ol ($C_8H_{18}O$); 2-Nonanone ($C_9H_{18}O$); α-Farnesene ($C_{15}H_{24}$); 1-Tridecene ($C_{13}H_{26}$); 6-Methyl-2-heptanone ($C_8H_{16}O$), respectively released from PP19 (*B. amyloliquefaciens*), SI17 (*Exiguobacterium acetylicum*), PI26 (*B. pumilus*), and HS10 (*B. licheniformis*) and **L-N**, three positive compounds from the references of BABA (3-Aminobutanoic acid), SA (Salicylic acid), MeJA (Methyl jasmonate), respectively.

Table 4
Overview of the volatile compounds of three BCAs identified across 24 h−72 h.

Pure Compounds	Antagonistic activity	Relative peak area (%)		
		PP19	SI17	PI26
2,5-Dimethylpyrazine	+	10.38	1.69	3.14
Bicyclo[4.2.0]octa-1,3,5-triene	−	11.08	0	0
1-(2-Aminophenyl)ethanone	+	4.32	9.35	5.17
2-Undecanone	+	0.51	26.16	0
Benzothiazole	+	1.26	0	0.19
Pentadecane	−	1.58	0	0
2-Ethylhexan-1-ol	+	7.94	0	0
2-Nonanone	−	19.59	11.09	14.02
(3E,6E)-3,7,11-Trimethyl-1,3,6,10-dodecatetraene	−	3.85	1.05	3.33
1-Tridecene	−	0.39	0.57	0.19
6-Methyl-2-heptanone	−	89.31	9.6	82.25
5-Methyl-2-heptanone		70.5	3.96	5.1
Nonylcyclopropane		60.29	37.07	0
6,10,14-trimethylpentadecan-2-one		0.65	11.64	69.9
2-Dodecanone		2.99	27.5	15.4
1-Iodohexadecane		5.15	0	0
5-Methyl-2-heptanone		46.78	0.22	22.59

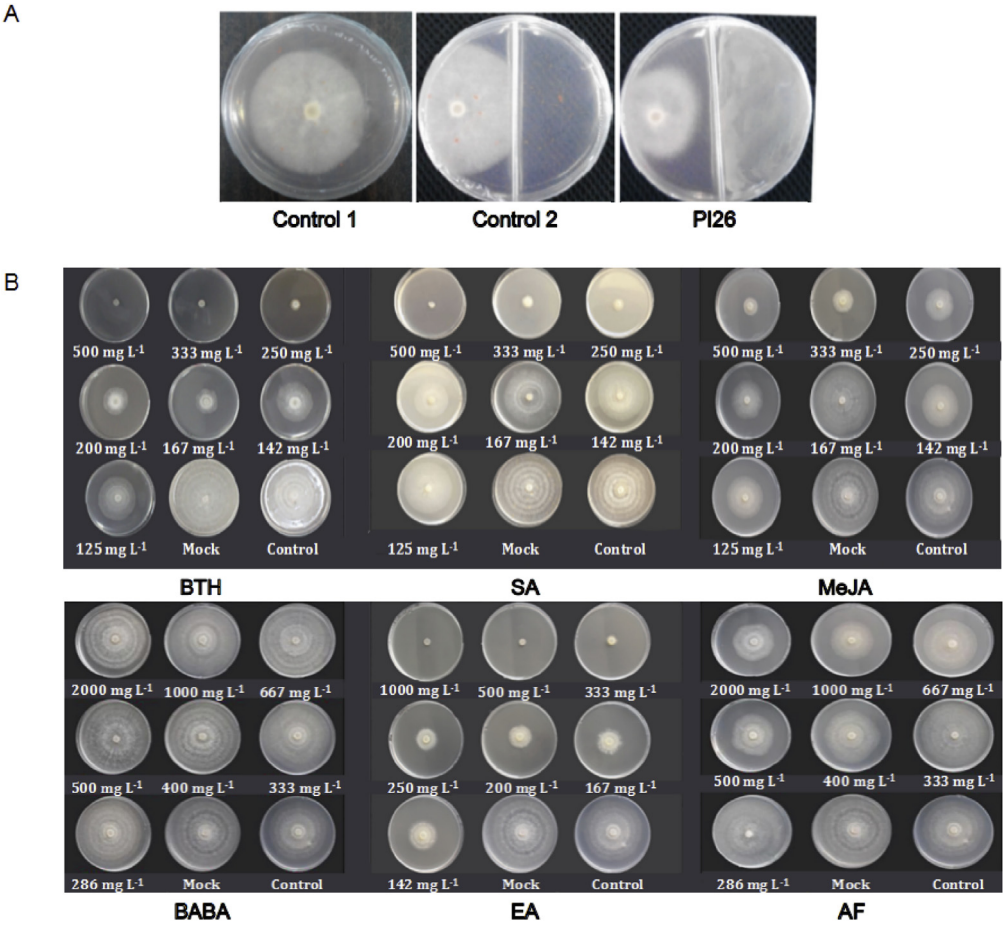

Fig. 2. The VOCs of PI26 (**A**) and compounds of BTH (Benzothiazole), EA (1-(2-Aminophenyl)ethanone), AF (α-Farnesene) and the positive control of SA (Salicylic acid), MeJA (Methyl jasmonate), BABA (3-Aminobutanoic acid) (**B**) against the pathogen *P. litchii* in the petri dish at 5 d.

Table 5
Efficacy against LDB of the VOCs blends of different concentration *in vivo* fruit or leaves "Huaizhi" (raw data).

Material	Treatment	Concentration (mg L^{-1})	48 hpi Disease index			60 hpi Disease index			72 hpi Disease index			84 hpi Disease index		
			Repeat I	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III
fruit	BABA	1000	5.19	10.74	10.37	9.26	11.85	14.44	11.48	23.33	19.26	17.78	35.19	29.26
	AF		17.78	28.89	36.30	25.93	37.04	38.15	35.19	42.59	64.44	54.81	57.04	81.11
	CK		12.96	12.59	2.22	18.52	12.96	5.56	22.96	28.52	15.93	38.52	36.30	26.30
	BABA	500	7.78	11.48	20.74	19.26	24.44	32.22	32.22	33.70	46.67	40.74	55.56	58.15
	AF		32.96	23.70	16.67	54.07	23.33	24.07	57.78	39.26	39.63	64.81	54.44	60.00
	EA		25.93	28.15	25.19	44.44	47.41	48.89	47.04	53.70	54.44	73.70	70.00	74.81
	BTH		36.30	38.15	26.67	47.04	45.93	45.19	52.59	61.85	57.78	79.63	82.22	78.52
	SA		27.78	21.48	20.00	37.78	37.78	35.56	66.67	72.22	72.22	81.11	81.11	77.04
	Me-JA		16.67	20.74	14.44	38.52	32.59	21.85	69.26	55.56	35.93	78.52	63.70	62.96
	CK		17.41	25.56	33.70	50.37	62.59	68.52	71.48	81.11	78.52	81.48	85.56	83.33
	EA	200	20.00	34.07	34.07	47.41	52.59	54.07	77.78	61.11	70.00	79.63	76.30	77.41
	BTH		20.74	27.04	20.00	35.56	46.67	32.59	54.07	81.85	61.48	65.93	83.33	71.11
	SA		7.78	24.07	19.26	13.33	38.52	25.19	33.70	45.19	51.85	53.33	71.11	75.56
	Me-JA		20.00	28.89	10.00	28.89	53.70	28.89	44.81	69.63	52.96	69.63	85.56	71.48
	CK		28.89	42.96	38.15	62.22	62.96	64.81	61.11	66.67	76.67	66.67	82.22	87.04
leaf	Treatment	Concentration (mg L^{-1})	62 hpi Disease index			72 hpi Disease index			84 hpi Disease index			96 hpi Disease index		
			RepeatI	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III	Repeat I	Repeat II	Repeat III
	BABA	1000	88.10	88.01	71.99	87.50	72.66	73.61	92.86	74.78	87.04	92.86	80.42	89.35
	AF		82.26	55.78	86.97	76.28	60.77	83.12	84.19	66.67	85.47	87.61	79.14	87.39
	CK		35.26	44.63	44.44	73.72	63.75	75.00	72.44	68.31	67.36	84.62	78.69	81.25
	BABA	500	14.94	5.29	6.72	20.50	22.75	25.06	53.26	80.95	63.31	59.96	77.25	61.24
	AF		29.31	20.86	34.57	80.27	41.04	56.58	85.44	51.25	85.60	92.34	61.00	86.63
	EA		9.95	3.86	14.32	37.50	9.66	31.20	44.91	17.87	83.12	62.04	21.98	79.70
	BTH		9.00	23.66	15.74	12.26	24.91	30.56	23.95	38.17	37.73	19.16	37.63	34.72
	SA		28.89	34.49	31.16	44.44	75.00	39.61	60.85	83.56	66.67	83.59	85.88	58.21
	Me-JA		23.61	32.26	51.91	21.76	46.15	61.46	65.74	63.68	80.73	67.13	75.00	79.34
	CK		22.22	13.22	30.24	25.99	17.05	40.98	84.23	72.80	76.32	84.05	31.23	75.77
	EA	200	24.27	37.04	12.59	24.27	37.04	12.59	57.89	38.89	48.70	60.82	65.28	66.85
	BTH		46.53	11.75	30.16	46.53	11.75	30.16	62.50	55.34	42.86	67.13	58.33	69.64
	SA		19.67	23.95	12.90	19.67	23.95	12.90	62.48	67.05	29.37	66.67	69.92	65.28
	Me-JA		6.19	20.30	16.91	6.19	20.30	16.91	12.57	41.24	75.85	17.12	45.73	39.61
	CK		11.46	11.73	33.10	11.46	11.73	33.10	27.78	38.58	69.44	26.74	43.83	52.08

Table 6
Efficacy against LDB of the VOCs blends of different concentration *in vivo* fruit or leaves "Huaizhi" (analyzed).

Material	Treatment[x]	Concentration (mg L^{-1})	48 hpi		60 hpi		72 hpi		84 hpi	
			Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)
fruit	BABA	1000	8.77±1.79b	5.33	11.85±1.50b	4	18.02±3.48b	19.78	27.41±5.11b	18.68
	AF		27.66±5.38a	−198.67	33.71±3.90a	−173	47.41±3.78a	−110.99	64.32±8.42a	−90.84
	Control		9.26±3.52b	0	12.35±3.76b	0	22.47±3.64b	0	33.71±3.76b	0
	P-value		0.0214		0.0048		0.0244		0.0109	
	BABA	500	13.33±3.85c	47.83	25.31±3.77c	58.16	37.53±4.59d	51.28	51.48±5.42e	38.31
	AF		24.44±4.72ab	4.35	33.82±10.13bc	44.08	45.56±6.11cd	40.87	59.75±3.00de	28.4
	EA		26.42±0.89ab	−3.38	46.91±1.31ab	22.45	51.73±2.35cd	32.85	72.84±1.45bc	12.72
	BTH		33.71±3.56a	−31.88	46.05±0.54ab	23.88	57.41±2.68bc	25.48	80.12±1.10ab	3.99
	SA		23.09±2.39bc	9.66	37.04±0.74bc	38.78	70.37±1.85ab	8.65	79.75±1.36ab	4.44
	MeJA		17.28±1.84bc	32.37	30.99±4.88c	48.78	53.58±9.67c	30.45	68.39±5.07cd	18.05
	Control		25.56±4.70ab	0	60.49±5.34a	0	77.04±2.88a	0	83.46±1.18a	0
	P-value		0.0203		0.0033		0.001		0.0001	
	EA	200	29.38±4.69ab	19.87	51.36±2.02ab	18.91	69.63±4.82a	−2.17	77.78±0.98a	1.1
	BTH		22.59±2.23b	38.38	38.27±4.28bc	39.57	65.80±8.31a	3.44	73.46±5.16a	6.59
	SA		17.04±4.83b	53.54	25.68±7.28c	59.45	43.58±5.30b	36.05	66.67±6.79a	15.23
	MeJA		19.63±5.46b	46.46	37.16±8.27bc	41.33	55.80±7.30ab	18.12	75.56±5.03a	3.92
	Control		36.67±4.13a	0	63.33±0.77a	0	68.15±4.55a	0	78.64±6.15a	0
	P-value		0.059		0.0052		0.0681		0.5325	
leaf	Treatment[x]	Concentration (mg L^{-1})	62 hpi		72 hpi		84 hpi		96 hpi	
			Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)	Disease index (%)	Efficacy (%)
	BABA	1000	82.70±5.36 a	−99.55	77.92±4.80 a	−10.03	84.89±5.33 a	−22.38	87.54±3.70 a	−7.39
	AF		75.00±9.71 a	−80.98	73.39±6.61 a	−3.63	78.78±6.06 a	−13.56	84.71±2.79 a	−3.92
	Control		41.44±3.09 b	0	70.82±3.56 a	0	69.37±1.56 a	0	81.52±1.72 a	0
	P-value		0.0101		0.6359		0.1448		0.3874	
	BABA	500	8.98±3.01 d	58.96	22.77±1.32 c	18.69	65.84±8.09 a	15.35	66.15±5.56 a	−3.87
	AF		28.25±3.99 abc	−29.02	59.30±11.41 a	−111.73	74.10±11.42 a	4.74	79.99±9.64 a	−25.6
	EA		9.38±3.03 d	57.16	26.12±8.43 c	6.74	48.63±18.93 ab	37.47	54.57±17.08 ab	14.31
	BTH		16.13±4.24 cd	26.31	22.58±5.41 c	19.39	33.28±4.67 b	57.21	30.50±5.73 b	52.1
	SA		31.51±1.63 ab	−43.94	53.02±11.08 ab	−89.31	70.36±6.81 a	9.54	75.89±8.87 a	−19.17
	MeJA		35.93±8.37 a	−64.11	43.12±11.56 abc	−53.98	70.05±5.37 a	9.94	73.82±3.57 a	−15.92
	Control		21.89±4.92 bcd	0	28.01±6.98 bc	0	77.78±3.38 a	0	63.68±16.40 a	0
	P-value		0.0046		0.0407		0.0579		0.0772	
	EA	200	24.63±7.06 a	−31.29	23.14±5.84 a	−1.55	48.49±5.49 a	−7.13	64.32±1.81 a	−57.32
	BTH		29.48±10.05 a	−57.12	42.05±4.18 a	−84.52	53.57±5.74 a	−18.33	65.03±3.43 a	−59.08
	SA		18.84±3.22 a	−0.4	28.58±4.88 a	−25.41	52.97±11.87 a	−17	67.29±1.37 a	−64.59
	MeJA		14.47±4.25 a	22.9	22.12±8.05 a	2.93	43.22±18.29 a	4.53	34.15±8.70 b	16.46
	Control		18.76±7.17 a	0	22.79±8.15 a	0	45.27±12.48 a	0	40.88±7.46 b	0
	P-value		0.5837		0.2238		0.9584		0.0034	

[x] Bacterial VOCs composition were sprayed to fruit (about 80% ripening degree) or leaves of branches in the lab of the fresh-box, and the suspension of *P. litchii* at at 5×10^4 sporangium mL^{-1} was sprayed onto the fruit or leaves at 24 hpt. Data are presented as means of four replicates ± standard errors; different letters indicate significant differences between treatments according to LSD test at $P < 0$.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] L. Zheng, J.J. Situ, Q.F. Zhu, P.G. Xi, Y. Zheng, H.X. Liu, X. Zhou, Z.D. Jiang, Identification of volatile organic compounds for the biocontrol of postharvest litchi fruit pathogen *Peronophythora litchii*, Postharvest Biol. Technol. 155 (2019) 37–46.
[2] M.A. Farag, Z. Huiming, R. Choong-Min, Dynamic chemical communication between plants and bacteria through airborne signals: induced resistance by bacterial volatiles, J. Chem. Ecol. 39 (2013) 1007–1018.
[3] W. Raza, L. Ning, L. Yang, Q. Huang, Q. Shen, Response of tomato wilt pathogen *Ralstonia solanacearum* to the volatile organic compounds produced by a biocontrol strain *Bacillus amyloliquefaciens* SQR-9, Sci. Rep. 6 (2016) 24856.
[4] L. Jiang, J. Situ, Y.Z. Deng, L. Wan, D. Xu, Y. Chen, P. Xi, Z. Jiang, PlMAPK10, a mitogen-activated protein kinase (MAPK) in *Peronophythora litchii*, is required for mycelial growth, sporulation, laccase activity, and plantinfection, Front. Microbiol. 9 (2018) 426.
[5] M. Xing, L. Zheng, Y. Deng, D. Xu, P. Xi, M. Li, G. Kong, Z. Jiang, Antifungal activity of natural volatile organic compounds against litchi downy blight pathogen *Peronophythora litchii*, Molecules 23 (2018) 358.
[6] Y.M. Jiang, X.R. Zhu, Y.B. Li, Postharvest control of litchi fruit rot by *Bacillus subtilis*, LWT-Food Sci. Technol. 34 (7) (2001) 430–436.