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RESEARCH ARTICLE

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The Plant Defense Signal Salicylic Acid Activates the RpfB-Dependent Quorum Sensing Signal Turnover via Altering the Culture and Cytoplasmic pH in the Phytopathogen *Xanthomonas campestris*

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ABSTRACT [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible] *rpfB* [illegible] *rpfB* [illegible] *rpfF* [illegible] *rpfB*- [illegible] *In vitro* [illegible] 6 [illegible] *in vitro*. [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible]

IMPORTANCE [illegible] *Xanthomonas campestris* [illegible] *campestris* [illegible]

Editor Anne K. Vidaver, University of Nebraska-Lincoln

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The authors declare no conflict of interest.

Received 8 December 2021
Accepted 15 February 2022
Published 7 March 2022

KEYWORDS , Xanthomonas campestris

P (1–3). ( ) (4).
3 (5).
fl fi vir
Agrobacterium tumefaciens (6–). *repABC* ( ) *A. tumefaciens*,
fi *N*- *Pectobacterium carotovorum* *Pseudomonas syringae* . . *syringae*
(10–11). , *hrpA* *in vitro* *Erwinia amylovora* (12). *Xanthomonas oryzae* 12 (13).

Xanthomonas campestris . . *campestris* (14). *Xanthomonas campestris* . . *campestris* (15). , *Xanthomonas campestris* . . *campestris* (14, 16, 17). *Xanthomonas campestris* . . *campestris* (1 –20). *cis*-11- *Burkholderia cenocepacia* (*cis*-2-) *Xanthomonas* (21). (22–24). (25). (25, 26). *Xanthomonas campestris* . . *campestris*, *Xanthomonas* *Xanthomonas campestris* . . *campestris*, *β*- (27–2). *Xanthomonas* *Arabidopsis*, *Nicotiana benthamiana*, (30–32). *Xanthomonas campestris* . . *campestris*

, *Xanthomonas campestris* . . *campestris* fi fi

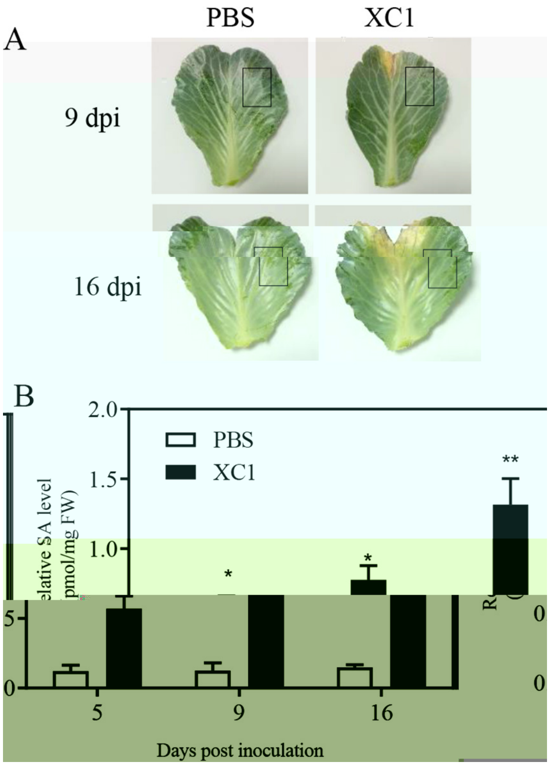

FIG 1 *Xanthomonas campestris* . . *campestris* 1 ( ) 1 *Brassica oleracea* . (1) 16 . ( ) 5, 16 1 (1×, 7.4), ( ). 5 (*, *P* ≤ 0.05 ,**, *P* ≤ 0.01).

Xanthomonas campestris . . *campestris* *Xanthomonas campestris* . . *campestris*.

RESULTS

***Xanthomonas campestris* pv. *campestris* infection promotes SA biosynthesis in cabbage.** 1 ( ) (. 1). ( ) (. 1). ( ) (. 1). 1 0.5 / ( ) 5 , 0.74 / 1.31 / 16 . 4.6- .3- 5, 16 (. 1).

Exogenous addition of SA induces DSF and BDSF turnover. *Xanthomonas campestris* . . *campestris* *Xanthomonas campestris* . . *campestris* *Xanthomonas campestris* . . *campestris* (21), *Xanthomonas campestris* . . *campestris*

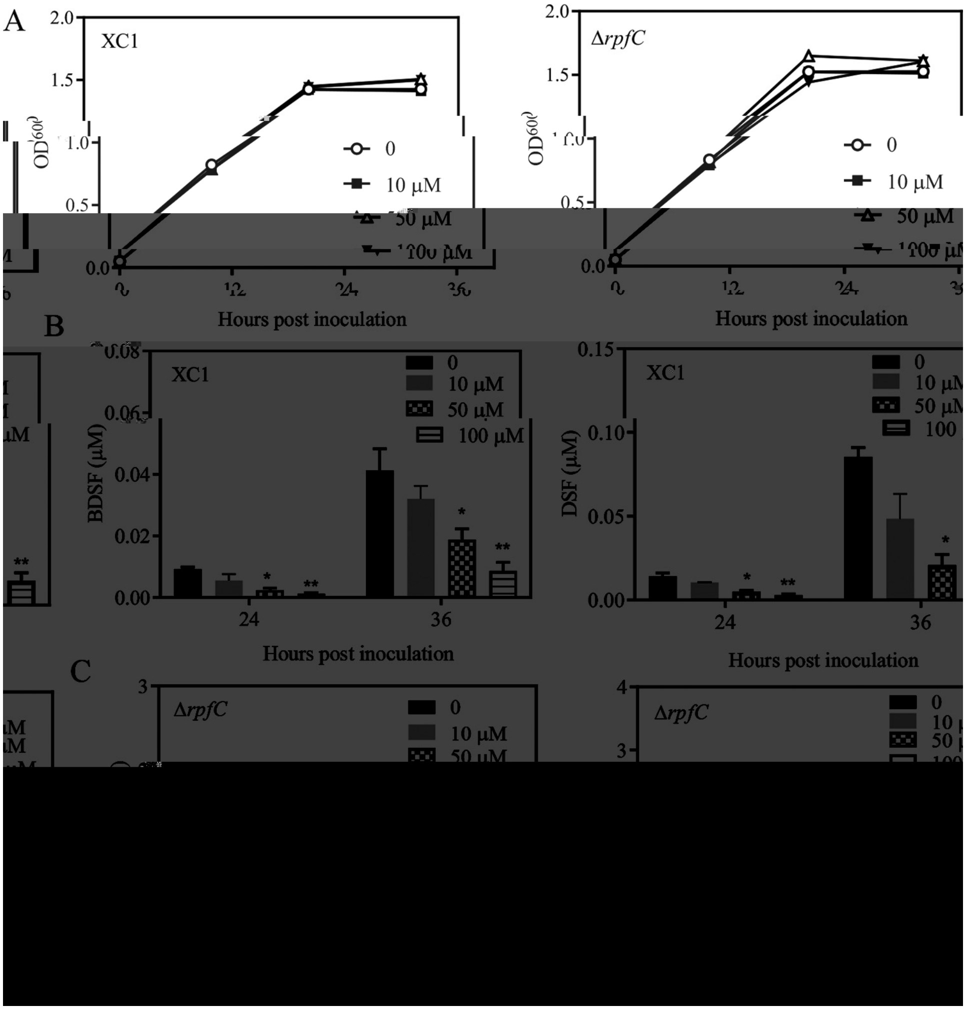

FIG 2 1 ΔrpfC. ( ) 1 ΔrpfC 10 100 μ . ( ) 1 10 100 μ . ( ) ΔrpfC 10 100 μ fi ff (*, $P \leq 0.05$, **, $P \leq 0.01$).

Xanthomonas campestris . . *campestris* , 3- (3-) 4- (33, 34), fi *Xanthomonas campestris* . . *campestris* *in vitro*. ff *Xanthomonas campestris* . . *campestris* (. 1). fi f 100 μ , f 1, ΔrpfC / ΔrpfB (. 2), f

Xanthomonas campestris . . *campestris* . fi f 10 μ , 50 μ , 100 μ , f 10 100 μ ff 1 (. 2). f 10 μ f 1 fi ff (. 2). f 50 100 μ f 1 fi 24 36 ( ) (. 2). 36 0.033, 0.020, 0.014 μ f 10, 50 μ , 100 μ , 3 . %, 23.5%, 16.4%, f

(0.0 5 µ) f (2). 12
1 ( ).
f
Δ*rpfC*. f
10 µ fi ff f Δ*rpfC*
(2) f 50 100 µ fi ff
f Δ*rpfC* 12 fi
24 36 (2).
Δ*rpfC* 50 100 µ 36
0.17 µ 0.05 µ 12.1% 3.5%
f (1.40 µ) Δ*rpfC* f (2).

Endogenous production of SA induces DSF and BDSF turnover. *Xanthomonas campestris* . . *campestris* 3- 4- (35, 36). f f ff f *Xanthomonas campestris* . . *campestris*, Δ*rpfC pchAB*, *pchAB* Δ*rpfC* (3). *pchAB* f f f *Pseudomonas aeruginosa* (37). Δ*rpfC* Δ*rpfC pchAB* Δ*rpfC pchAB* 55.1 µ 12 5.5 µ 24 124.6 µ 36 Δ*rpfC* (3). fi- ff 12 Δ*rpfC pchAB* 24 36 fi f Δ*rpfC* (3). f Δ*rpfC pchAB* 36 0.05 µ 1.4% f f 3.5 µ Δ*rpfC* (3). f Δ*rpfC pchAB* 36 0.04 µ 1. % f 2.2 µ Δ*rpfC* (3).

SA-induced DSF and BDSF turnover is dependent on rpfB. *rpfB* f f f *Xanthomonas campestris* . . *campestris* (2). *rpfB* f Δ*rpfB*, Δ*rpfB* f *rpfB* *att* 7 (Δ*rpfB rpfB*), *rpfB* *rpfC* (f Δ*rpfBC*), Δ*rpfBC* f *rpfB* *att* 7 (f Δ*rpfBC rpfB*). f Δ*rpfB* Δ*rpfB rpfB* f 100 µ f 100 µ f Δ*rpfB* fi Δ*rpfB rpfB* (4). f Δ*rpfB rpfB* f 0.002 0.02 µ 36 22.2% 25% f f (0.00 0.0 µ) (4). f Δ*rpfBC* Δ*rpfBC rpfB* f 100 µ f 100 µ f Δ*rpfBC* (4). f 100 µ fi Δ*rpfBC rpfB* (4). Δ*rpfBC rpfB* 0.23 0.15 µ 36 fi f (2.2 2.1 µ) (4).

SA does not affect the expression of *rpfB* and *rpfF*. f f *Xanthomonas campestris* . . *campestris* f f f ff f (10 100 µ) f *rpfB* *rpfF* 1 $_{rpfB}$-*gusA* 1 $_{rpfF}$-*gusA* fi . *rpfB* *rpfF* . . fi f-

f . *rpfB* . 1 *rpfB-gusA* -

1 *rpfB-gusA* (. . 3). , fi ff -

rpfF . 1 *rpfF-gusA* - 1

rpfF-gusA (. . 3).

. . f f f f

, - - . . f

f (2). fi ff f f .

1 Δ*rpfC* (. . 3), - . . . ff f

- . f . . -

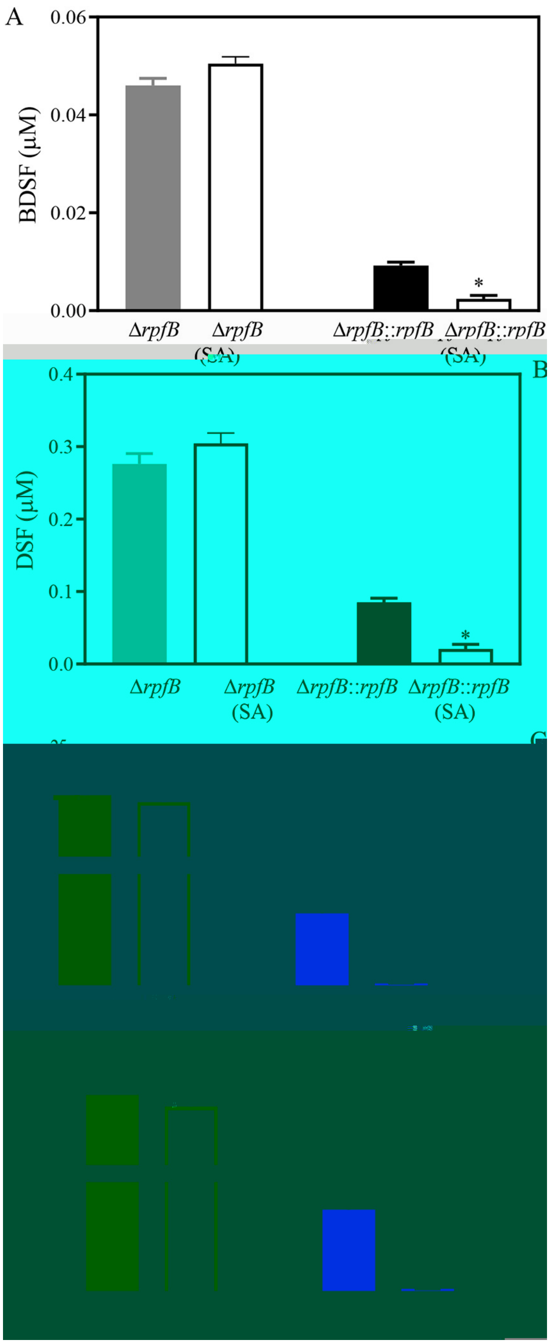

FIG 4 *rpfB* ... Δ*rpfB* ... Δ*rpfB rpfB* (Δ*rpfB* ... *rpfB* ...) ... 100 μ... 24 ... (...) ... *rpfC* ... *rpfB* ... Δ*rpfBC* ... Δ*rpfBC rpfB* (Δ*rpfBC* ... *rpfB* ...) ... 0 ... 50 μ... 24 ... (*, $P \leq 0.05$).

24 ... 4.4 ... 36 ... (... 5). ... Δ*rpfC* ... 1 (... 5). ... *Xanthomonas campestris* ... *campestris* ... *Xanthomonas campestris* ... *campestris* ... -2 ...

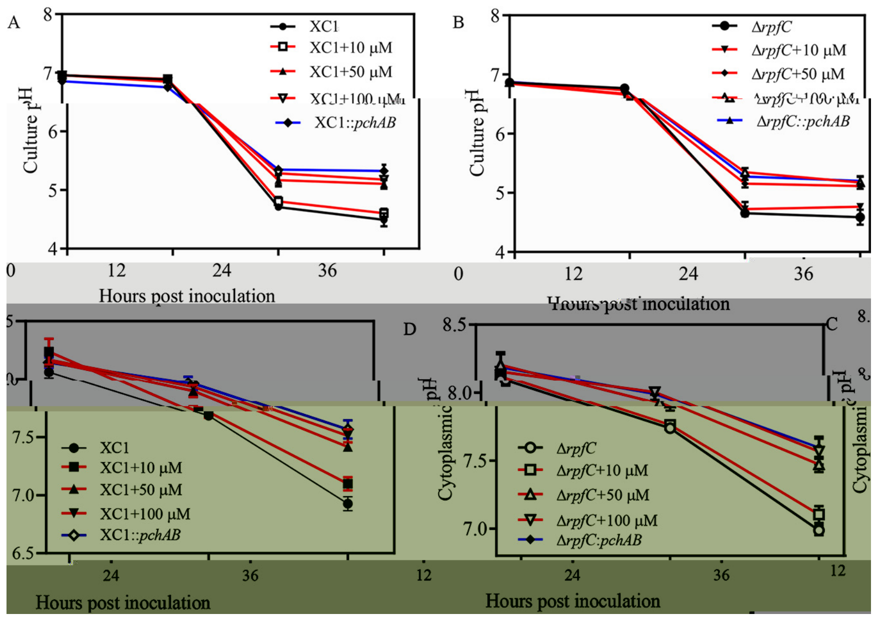

FIG 5 … 1 … *ΔrpfC*. ( ) … 1, 1 … 10 … 100 μ … 1 *pchAB*. ( ) … *ΔrpfC*, *ΔrpfC* … 10 … 100 μ … *ΔrpfC pchAB*. ( ) … 1, 1 … 10 … 100 μ … 1 *pchAB*. ( ) … *ΔrpfC*, *ΔrpfC* … 10 … 100 μ … *ΔrpfC pchAB*. …

(3) (… 4) … fl … (3.) … fl … fl … (3) … -2- … (… / …) … (… 4). … 1 … *ΔrpfC* … ~ .05 … .07 … 12 … ~6. 2 … 6. … 36 … (… 5 …).

Exogenous addition of SA or endogenous production of SA significantly prevents *Xanthomonas campestris* pv. *campestris* culture pH and cytoplasmic pH decrease. … 1 … *ΔrpfC* … 10, 50, … 100 μ … 10 μ … 1 … *ΔrpfC* (… 5). … 50 … 100 μ … 12 … 24 … 36 … (… 5). … 36 … 24 … (… 5).

… *ΔrpfC pchAB* … 1 *pchAB* … 12 … *ΔrpfC* … 1 (… 5). … *ΔrpfC pchAB* … 1 *pchAB* 24 … 36 … *ΔrpfC* … 1 (… 5).

… 7.0 (… -7.0) … 2 … 4 … 2 … 4 … *ΔrpfC* … -7.0 … 7.0 … (… 5 …). … 10 μ … 100 μ … *ΔrpfC* … *ΔrpfC* (… 5 …). …

Increasing the pH of XYS medium triggers BDSF and DSF turnover in an RpfB-dependent manner. …

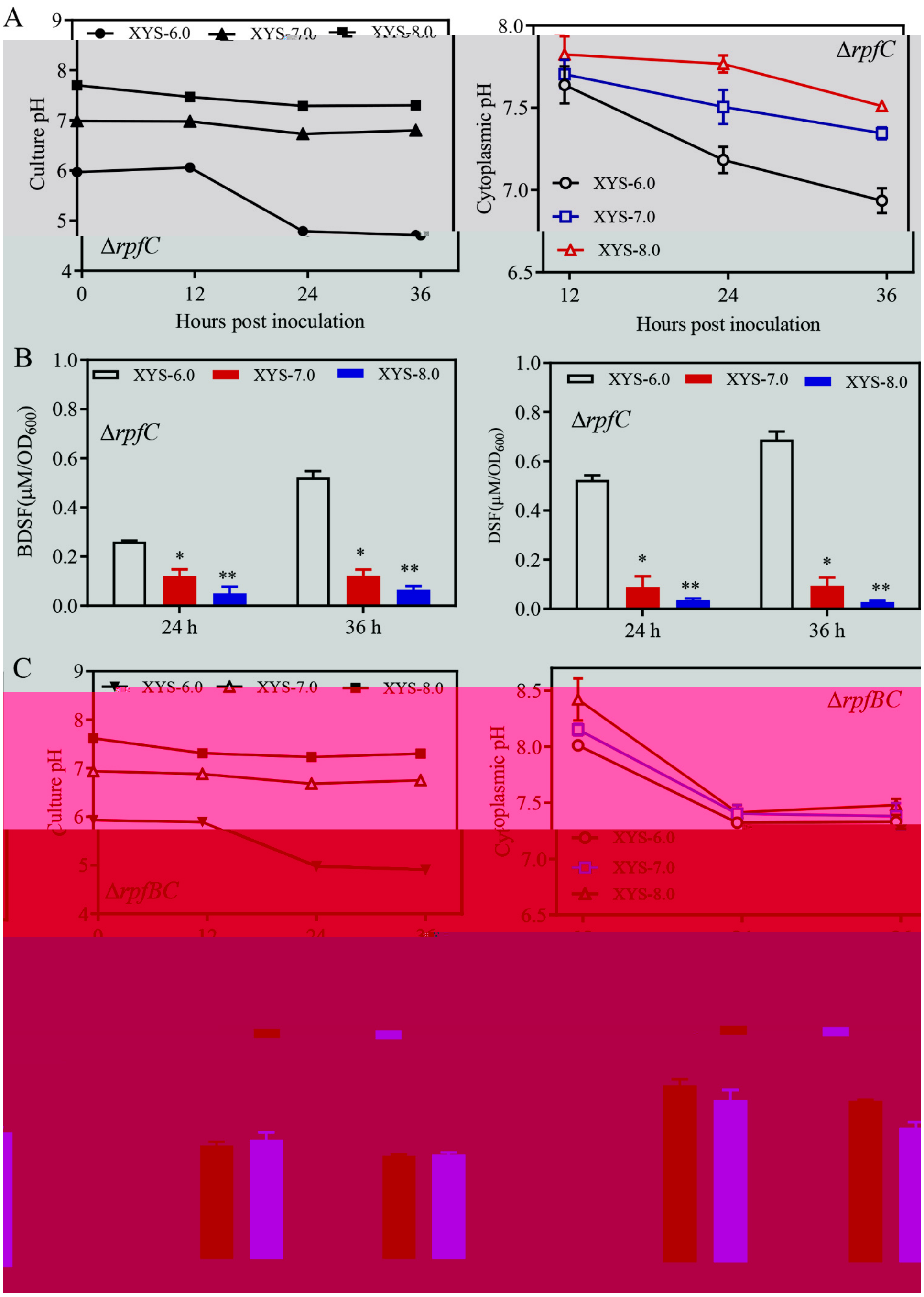

FIG 6 ... *Xanthomonas campestris* ... *campestris* ... ( ) ... Δ*rpfC* ... 6.0 ... .0, -6.0, -7.0, ... -.0. ( ) ... Δ*rpfC* ... 24 ... 36 ... ( ) ... *rpfC* ... *rpfB* ... Δ*rpfBC* ... -6.0, -7.0, ... -.0. ( ) ... Δ*rpfBC* ... 24 ... 36 ... fi ... ff ... (*, $P \leq 0.05$, **, $P \leq 0.01$).

... -6.0 (6.0), -7.0 (7.0), -.0 (.0), ... Δ*rpfC* ... Δ*rpfC* ... -7.0 ... -.0 ... 6.06 ... 12 ... 4.7 ... 24 ... -6.0, ... 4.71 ... 36 ... (. 6). ... Δ*rpfC* ... (. 6).

Δ*rpfC* ... 6.0 ... .0 (... 6).

... *rpfB* ... *rpfC* ... Δ*rpfBC* ... Δ*rpfBC* ... -7.0 ... .0, ... 5. ... 12 ... (4.) ... 24 ... 36 ... -6.0 (... 6). ... Δ*rpfBC* ... .1 ... .3 ... 12 ... (7.4) ... 24 ... 36 ... (... 6). ... Δ*rpfBC* ... (... 6).

Establishment of an *in vitro* RpfB-dependent DSF turnover system. ... (2). ... *in vitro* ... (27, 2). ... -2 ... ( ) ... 1 (250 ... , 50 ... 2 4, 300 ... , 1 ... 7.4) ... 2 250 ... , 25 ... , 100 ... 2, 100 ... , 100 ... (4)2 4, 7.2 (... 7). ... ( ) ... 1 ... (-), ... 71.2% ... 2 ... ( ) (... 7).

... *in vitro* ... 150 ... , 10 ... 2, 2 ... , 0.1% ... -100, 5 ... , 0.5 ... , 100 *μ* ... , 15 *μ* ... (7.2) (27, 2). ... (... 7). ... 150 ... 100 ... 2 4 ... 2 4 ... 60 ... (... 7). ...

***In vitro* RpfB-dependent DSF turnover activity increases with pH and is independent of SA.** ... 6.0, 7.0, ...0 ... (... 6, ... 7, ...). ... 250 ... , ... 37 ... 15, 30, ... 60 ... 6, ... 7, ... (... .). ... 10 *μ* ... (6), ... (7), ... ( ) (... .). ... (*K*$_m$) ... 12.3 *μ* ... (6), 6.5 *μ* ... (7), ... 3.6 *μ* ... ( ) (... .).

... 6, 7, ... 100 *μ* ... 37 ... 30 ... (... . 6), ... *in vitro* ...

SA-treated XC1 exhibits increased virulence in cabbage. *Xanthomonas campestris* ... *campestris* ... (40). ... 1 (1+ ...) ... (10 *μ* ... 100 *μ*) ... ( ) ... (... . 7).

... 1 ... 1+ ... 1 ... Δ*rpfC*, ...

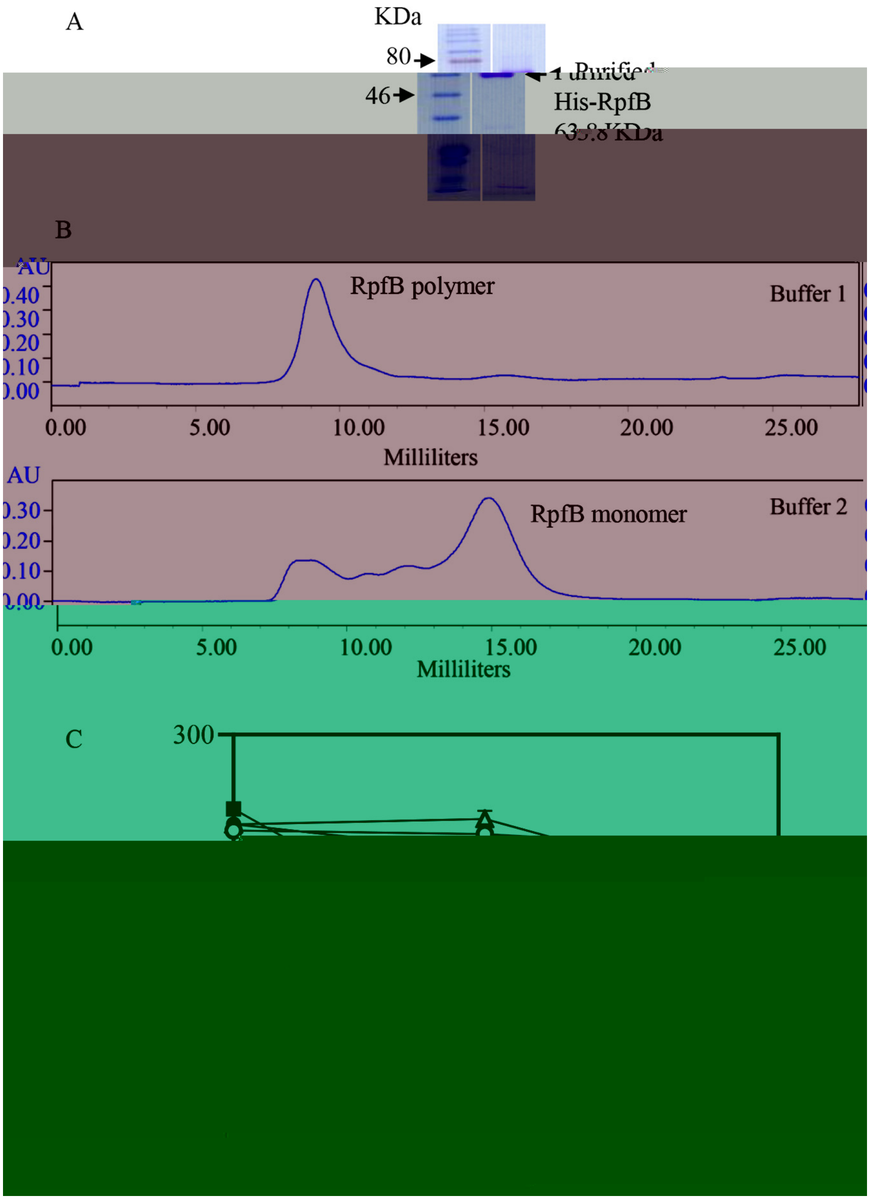

FIG 7 *In vitro* … 1 … 2. … 1 … 250 … 50 … 300 … 1 … (7.4), … 2 … 250 … 25 … 100 … 100 … 100 … (7.2). … *In vitro* …

… (-1) … ∆*rpfC*, … 2 … 1 … 1+ … 16% … 1 … *Xanthomonas campestris* … *campestris* …

DISCUSSION

… "…" …

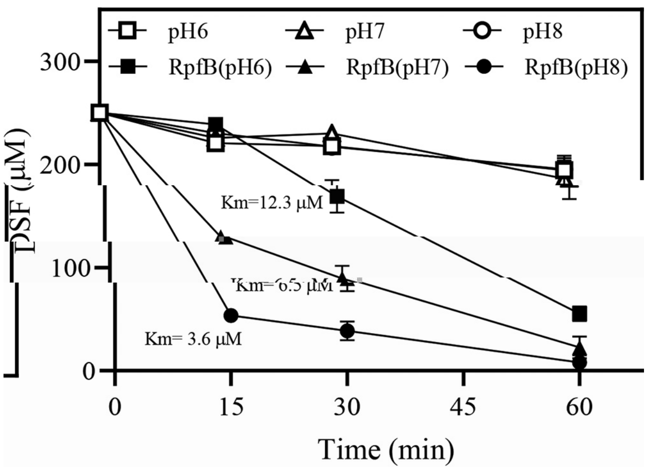

FIG 8 ... *in vitro* ... 6, 7, ... 6, 7, ... 10 μ ... 6, 7, ... (K_m) ...

(5, 41). ... (42, 43). ... (3, 5, 11). ... *Xanthomonas campestris* ... *campestris* ... (17, 1 , 20, 44). ... *Xanthomonas campestris* ... *campestris* ... *Xanthomonas campestris* ... *campestris* ...

N- ... *P. carotovorum* ... *Pectobacterium aroidearum.* ... *expI* ... *expR* ... *P. carotovorum* ... 1 ... 2.5- ... 10.0- ... 24 ... (11). *A. tumefaciens* 5 ... (6 μ ... 6) ... *attKLM* ... *N*-3- ... (3 ...) *A. tumefaciens* (6). ... 24 ... 36 ... (. 2 ... 3). ... 10- ... 100-μ ... *rpfF* ... *rpfB*, ... *Xanthomonas campestris* ... *campestris* (21, 2) (. 3). ... *Xanthomonas campestris* ... *campestris* ... *P. carotovorum*, *P. aroidearum*, ... *A. tumefaciens* (6, 11), ...

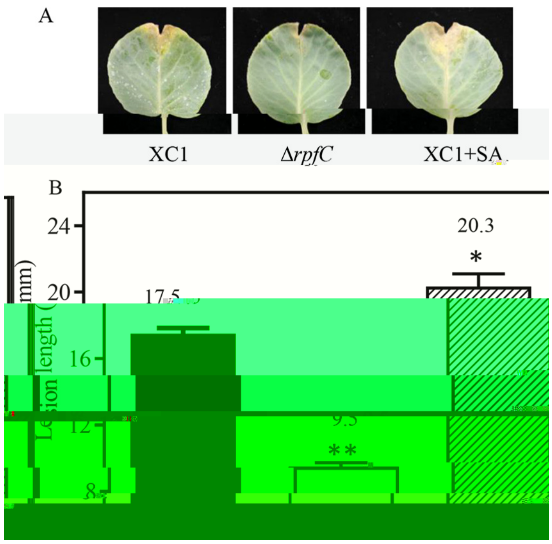

FIG 9 ... f *Xanthomonas campestris* ... *campestris* ... (... f ... -1). ( ) f ... 14 ... ( ) ... 1, Δ*rpfC*, ... 1 ... (1+) 14 ... (... f ... -1). f 15 ... fi ... ff ... (*, $P \leq 0.05$, **, $P \leq 0.01$).

... ffi ... f ... f ...

... f ... 24 ... 36 ... (... 2 ... 5) ... (...). ... 1 ... Δ*rpfC* ... 24 ... 36 ... (... 5). ... f ... 1 Δ*rpfC* ... (... 5). ... *attKLM* ... 3 ... *A. tumefaciens* ... f ... (6). ... f ... f ... f ... *Escherichia coli* (45). ... *Xanthomonas campestris* ... *campestris* ... f ... f ... ff ... f ... β- ... *Xanthomonas campestris* ... *campestris* ... ( ). ... f *rpfB* ... fi *Xanthomonas* ... (21, 2). ... *in vitro* ... (...) f ... f ... *in planta* ... *Xanthomonas campestris* ... *campestris* ... f ... f ... fi ..., *Xanthomonas campestris* ... *campestris* ... f ... f ... f ... (46). ... 5 ... $^{-1}$ ... 0.0625% ... *Xanthomonas campestris* ... *campestris* ... (21, 47). ... f ... (4 , 4). ... *Xanthomonas campestris* ... *campestris* ... (...). ... f ... f ... *Xanthomonas campestris* ... *campestris* ... f ...

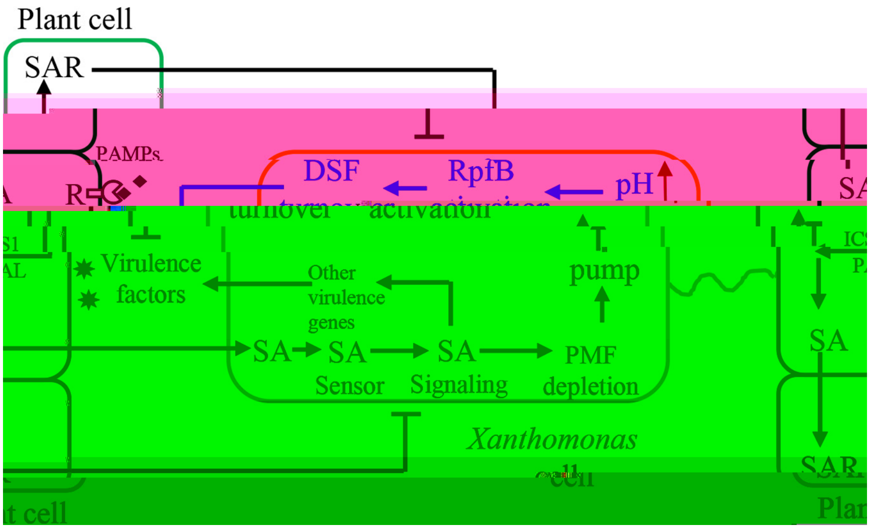

FIG 10 Xanthomonas Xanthomonas campestris . . campestris- ( ) ( ) 1 (1)- ( )- ( ) Xanthomonas campestris . . campestris Xanthomonas campestris . . campestris ( ) Xanthomonas campestris . . campestris, Xanthomonas .

24 36 (. 5). (. 6). in vitro (. 7). 6 in vitro (.). (. 6), (. 10). Xanthomonas campestris . . campestris Xanthomonas campestris . . campestris Salmonella enterica 25 50 (50). (51). Xanthomonas campestris . . campestris. Xanthomonas

campestris . . *campestris*

E. coli,

(45).

(4).

(4).

Xanthomonas campestris . . *campestris*

1 (52).

1 (7). 1

1 (. .).

1

1

Xanthomonas campestris . . *campestris*

Xanthomonas campestris . . *campestris.*

Xanthomonas

Stenotrophomonas maltophilia *Burkholderia*

Lysobacter, *Leptospirillum*, *Frateuria*, *Luteibacter*, *Rhodanobacter*, *Methylobacillus flagellates*, *Thiobacillus denitrificans*

MATERIALS AND METHODS

Bacterial strains and culture conditions. 1 . *Xanthomonas campestris* . . *campestris* 1 2 (0.7 $^{-1}$ $_2$ $_4$, 0.2 $^{-1}$ $_2$ $_4$, 1 $^{-1}$ ($_4$)$_2$ $_4$, 0.1 $^{-1}$ $_2$·6 $_2$, 0.01 $^{-1}$ $_4$·7 $_2$, 0.001 $^{-1}$ $_2$·4 $_2$, 5 $^{-1}$, 0.0625% 7.0), (5 $^{-1}$, 3 $^{-1}$, 20 $^{-1}$), ( ) (5 $^{-1}$, 10 $^{-1}$, 10 $^{-1}$), ( ) (5 $^{-1}$, 3 $^{-1}$, 10 $^{-1}$, 1 $^{-1}$ 7.0). (,). *E. coli* 5α . *E. coli* 37 25 μ $^{-1}$ ( ), 50 μ $^{-1}$ ( ), 20 μ $^{-1}$ ( ), 100 μ $^{-1}$ ( ). 600 ($_{600}$).

Gene deletion and functional complementation analysis in *Xanthomonas campestris* pv. *campestris*. (23). (~500) 1 . *Xanthomonas campestris* . . *campestris* 50 μ $^{-1}$ 5% (/ .)

Xanthomonas campestris campestris (53). 1.

Extraction and quantitative analyses of SA in *Xanthomonas campestris* pv. *campestris* cultures and in plant leaf tissues. 1 (33). (33). 0.5 1 4.0 1 0.1 5 μ 4.6 150 0.05% (25 75 1 −1.

-1) 25 75% 16 ,000 2 *Xanthomonas campestris* *campestris* 600 0.1 1× 7.4) 2 0% 16 (,000 (200 5 16 (54). 50 μ (34). 10 μ 1 (4.6 150 5 μ 0.1% (60/40 40 0.4 −1.

Extraction, purification, and quantitative analysis of BDSF and DSF using UPLC-TOF MS. *Xanthomonas campestris* *campestris* (55). 20 4.0 20 30 0.1 1 5 μ 4.6 150 0.1% 0/20 0.4 −1.

RpfB expression, purification, and *in vitro* DSF turnover activity assays. *E. coli* 21(3) 2 (2 0.1 -β- 1 16 1 2 25 100 100 2·6 2 100 4)2 4 10 7.2). 25 100 100 2·6 2 100 4)2 4 25 7.2). 25 100 100 2·6 2 100 4)2 4 250 7.2 200 25 100 100 2·6 2 100 4)2 4 7.2).

In vitro (2 100 2 4 2 4 10 2 2 0.1% -100, 5 0.5 0.3 10 μ 500 μ 2 15, 30, 45, 60 4.0 1 2-

Construction of *gusA*-dependent reporter strains to monitor *rpfF* and *rpfB* transcriptional activities and GUS assays. *gusA* *rpfF* *rpfB* (2 β- (34). 12 36 2 (1 ,000 17 10 1× 7.4). 1 20 μ 0.1% 40 μ

f f . ,000 f 5 , 100 μ f
250 μ (1 4- f β-
50 , 5 1 .0).
37 f 15 (200 μ) 00 μ f 0.2 $_2$ $_3$
6- fl
f 365 455

Western blotting. f
fl ( ) ( ). f 5% (/) f
1 5,000 f (2).
f ff (20 , 0.15
0.1% / 20). , 1 6,500 ( )-
(21001) f
f 610
( ).

Measurement of culture and cytoplasmic pH. f 3 f *Xanthomonas campestris* . . *campestris* f 5,000 f 5 4 f
f *Xanthomonas campestris* . . *campestris* f
f *Xanthomonas campestris* . . *campestris* f . (3).
fl 5332 6)
67 264) f
f ( )$_2$
f 1 -2
f *Xanthomonas campestris* . . *campestris*
1.
fl fl f
(, 4 510) (, 5 7
610). 12
f f
f *Xanthomonas campestris* . . *campestris* $_{600}$ f 0.6
6.0, 7.0, 7.5, .0 6 f
f 250 μ *m*- f
f f 20 f f fl

Virulence assay of *Xanthomonas campestris* pv. *campestris* strains in cabbage. f
Xanthomonas campestris . . *campestris* (f -1) f
(34). fl 1 Δ*rpfC*
f 12 ff fi $_{600}$ f 0.1. - 1 (1+
) 1 100
μ f 12 f 5,000 f 5 4
ff
ff fi $_{600}$ f 0.1.
$_{600}$ f 0.1. f f
fi 30 f 0%
f 10,000 2 f f 15
( )

Statistical analyses. f f
( ) f f f (
5.0). fi ff f *F* fi
f fi ff
P f <0.05.

SUPPLEMENTAL MATERIAL

FIG S1, fi , 1.2 .
FIG S2, fi , 0.4 .
FIG S3, fi , 1.6 .
FIG S4, fi , 1.1 .
FIG S5, fi , 0.6 .
FIG S6, fi , 0.3 .
FIG S7, fi , 1.4 .
TABLE S1, fi , 0.02 .

ACKNOWLEDGMENTS

fi (. 31 72231 32172355 .- .).

REFERENCES

1. . 2004. 42 1 5–20. /10.1146/ .42.040 03.140421.
2. . 2006. 444 323–32. /10.103 / 052 6.
3. . 201 . 11 1427–143. /10.1016/ .201 .10.002.
4. . 2020. 25 54 –565. /10.1016/ .2020.01.004.
5. . 2021. 72 761–7 1. /10.1146/ -0 1320-0 2 55.
6. . 2007. *Agrobacterium*. 104 117 0–117 5. /10.1073/ .0704 66104.
7. . 2014. *Agrobacterium* 5 730. /10.33 /f .2014.00730.

35. 2011. *Xanthomonas campestris* 3- 24 4 – 57. // /10.10 4 -02-11-0031.

36. 2015. 4- *Xanthomonas campestris* 5 1 456. // /10.103 / 1 456.

37. 201 . 3- 110 16–32. // /10.1111/ .14064.

3 . 201 . *E. coli* 3 6 . // /10.103 / 415 -01 -40560-3.

3 . 2000. 7 21 –220 . // /10.1016/ 0006-34 5(00)7646 - .

40. 2020. *Xanthomonas* 1 415–427. // /10.103 / 4157 -020-0361- .

41. 2011. 0156. // /10 .11 / .0156.

42. 200 . 47 177–206. // /10.1146/ .050 0 .135202.

43. 2020. 36 1–10. // /10.5423/ .12.201 .02 5.

44. 2017. 122 2–11. // /10.1111/ .13307.

45. 2021. *Escherichia coli* -12. 7 0072421. // /10.112 / .00724-21.

46. 2014. *Xanthomonas campestris* . . *campestris* 106712 43 6. // / 10.1371/ .00 43 6.

47. 2006. 11 17 –1 7. // /10 .1007/ 10265-005-0257- .

4 . 200 . (.) 176 4 7–504. // /10.1016/ .200 .01.002.

4 . 2017. 10 1371–13 6. // /10.1016/ .2017.0 .01 .

50. 2011. *Salmonella,* 2 6 2217 –221 5. // /10.1074/ 111.24525 .

51. 201 . / *Enterobacteriaceae.* 10 0000 -1 . // /10 .112 / .0000 -1 .

52. 2006. *Xanthomonas campestris* . . *campestris* 5 610–622. // /10.1111/ .1365-2 5 .2005.04 61. .

53. 200 . 7 . *Xanthomonas* 2 111–117. // /10.1111/ .1574-6 6 .200 .01707. .

54. 2010. 5 6– 2. // /10.103 / .2010.37.

55. 201 . / ( ) 1673 7–105. // /10.1007/ 7 -1-4 3 -730 -5 .