

Endophytic *Bacillus vallismortis* and *Bacillus tequilensis* bacteria isolated from medicinal plants enhance phosphorus acquisition and fortify *Brassica napus* L. vegetative growth and metabolic content

Aziza Nagah¹, Mostafa M. El-Sheekh^{2*}, Omnia M. Arief¹, Mashaal Daghash Alqahtani³, Basmah M. Alharbi^{4,5}, Ghada E. Dawwam¹

¹Botany and Microbiology Department, Faculty of Science, Benha University, Benha,13518, Egypt.

²Botany Department, Faculty of Science, Tanta University, Tanta 31527, Egypt.

³Department of Biology, College of Sciences, Princess Nourah bint Abdulrahman University, P.O.BOX 84428, Riyadh 11671, Saudi Arabia.

⁴Biology Department, Faculty of Science, University of Tabuk, Tabuk 71491, Saudi Arabia.

⁵Biodiversity Genomics Unit, Faculty of Science, University of Tabuk, Tabuk, Saudi Arabia

***Correspondence:**

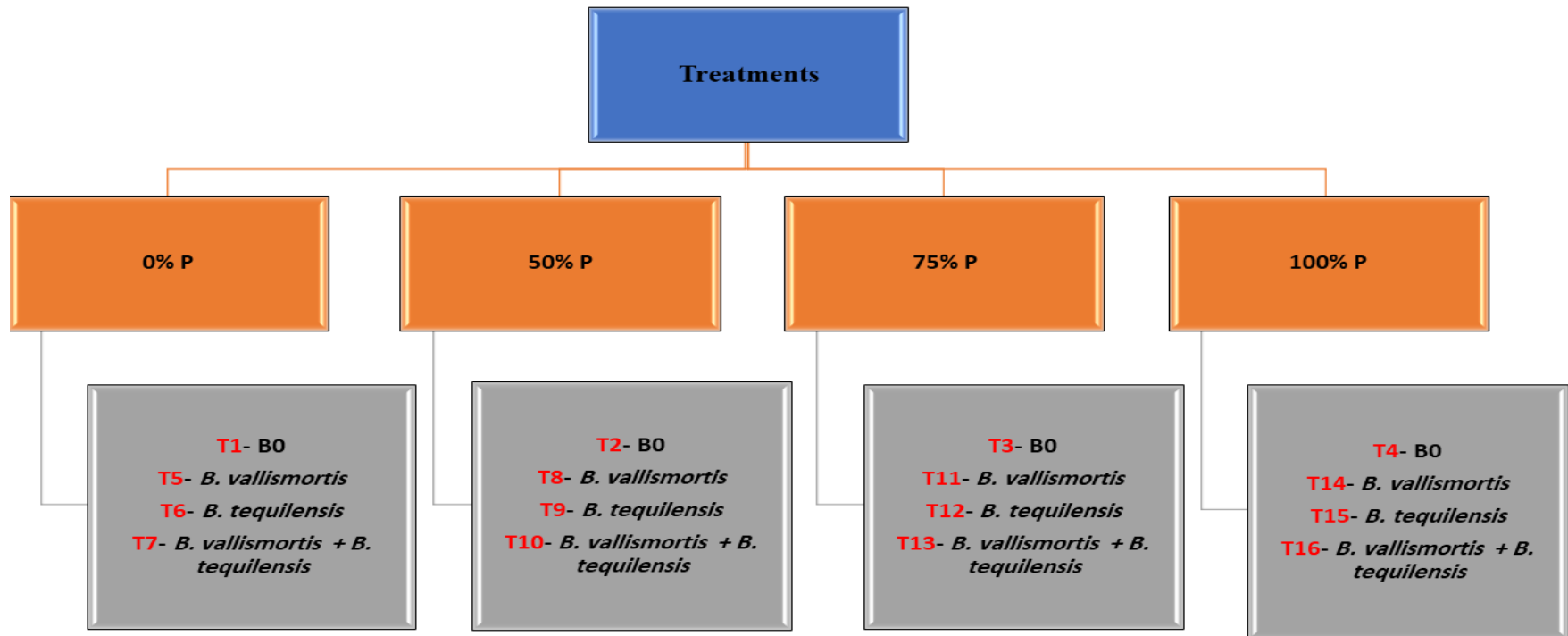
Mostafa M. El-Sheekh; E mail: mostafaelsheikh@science.tanta.edu.eg

Supplementary Table S1: Thirty-eight endophytic bacteria obtained from roots and leaves of nine medicinal plants gathered from different farms at Qalyubiya Governorate, Egypt.

Name of Medicinal plant	Plant part	Number of isolates	Isolate code
Marjoram (<i>Origanum majorana</i>)	Root	4	1P-4P
	Leaf	2	5p,6p
Lavender (<i>Lavandula</i>)	Root	3	7P-9P
	Leaf	2	10P,11P
Mint (<i>Mentha spicata</i>)	Root	3	12P-14P
	Leaf	1	15P
Stevia (<i>Stevia rebaudiana</i>)	Root	5	16P-20P
	Leaf	2	21P,22P
Rosemary (<i>Salvia Rosmarinus</i>)	Root	3	23P-25P
	Leaf	1	26P
Kalanchoe (<i>Kalanchoe blossfeldiana</i>)	Root	2	27P,28P
	Leaf	1	29P
Lemon (<i>Citrus limon</i>)	Root	2	30P,31P
	Leaf	1	32P
(Nerium) <i>Nerium oleander</i>	Root	2	33P,34P
	Leaf	1	35P
Roselle (<i>Hibiscus sabdariffa</i>)	Root	2	36P,37P
	Leaf	1	38P

Supplementary Table S2: The Effect of different concentrations of phosphorus (0, 50, 75, and 100%P) alone and/or in combination with *B. vallismortis*, *B. tequilensis* or both bacterial isolates. on the vegetative growth of canola (*Brassica napus L.*) plant

Treatment	Shoot height (cm)	Shoot FM (g)	ShootDM (g)	Leaf area (mm ²)	Root height (cm)	Root FM (g)	Root DM (g)	Root Mass ratio	Total DM (g)
Control	25.5 ^a ±4.96	12.04 ^a ±4.05	0.88 ^a ±0.4	98.73 ^a ± 12.05	6.50 ^a ±2.24	0.20 ^a ±0.088	0.04 ^a ±0.022	0.04 ^a ±0.0	0.92 ^a ±0.45
<i>B. vallismortis</i>	27.78 ^{0ab} ±4.43	13.99 ^{ab} ±3.13	1.17 ^{ab} ±0.3	149.30 ^{bcd} ±46.8	10.04 ^{abcd} ±2.4	0.30 ^{ab} ±0.21	0.05 ^{ab} ±0.02	0.05 ^a ±0.0	1.23 ^{ab} ±0.29
<i>B. tequilensis</i>	28.5 ^{ab} ±1.50	13.15 ^a ±2.42	1.15 ^{ab} ±0.2	167.25 ^{bcd} ±37.	10.20 ^{abcd} ±2.5	0.63 ^{bcd} ±0.2	0.13 ^{cde} ±0.05	0.01 ^{bcd} ±0.	1.28 ^{ab} ±0.23
(<i>B.vallismortis</i> + <i>B.tequilensis</i>)	30.8 ^{abc} ±1.30	17.76 ^{bc} ±2.32	1.49 ^{ab} ±0.2	216.34 ^{efg} ±45.4	10.20 ^{cd} ±1.79	0.61 ^{bcd} ±0.2	0.15 ^{cde} ±0.03	0.09 ^c ±0.01	1.64 ^{bc} ±0.25
50%P	27.75 ^{abc} ±5.64	14.77 ^{abc} ±5.31	1.25 ^{ab} ±0.4	119.21 ^{ab} ±23.4	10.56 ^{bcd} ±2.3	0.76 ^{abc} ±0.	0.30 ^{fg} ±0.17	0.20 ^{bcd} ±0.	1.55 ^{abc} ±0.47
50%P+ <i>B. vallismortis</i>	29.4 ^{abc} ±2.04	15.58 ^{abc} ±3.55	1.34 ^{ab} ±0.3	165.37 ^{bcd} ±72.	12.76 ^{bc} ±4.82	0.63 ^{bcd} ±0.2	0.10 ^{bcd} ±0.0	0.07 ^{abc} ±0.	1.44 ^{ab} ±0.33
50%P+ <i>B. vallismortis</i>	28.7 ^{abc} ±2.05	14.52 ^{abc} ±4.09	1.27 ^{ab} ±0.3	177.69 ^{cdef} ±30.5	10.75 ^{cd} ±0.18	0.85 ^{ef} ±0.14	0.18 ^{def} ±0.04	0.13 ^{cde} ±0.	1.46 ^{ab} ±0.30
50%P+(<i>B.vallismortis</i> + <i>B.tequilen</i>)	33.5 ^c ±4.12	23.46 ^c ±6.94	2.12 ^{abc} ±0.	296.99 ^g ±49.86	11.16 ^{bcd} ±2.9	0.99 ^{cdef} ±0.5	0.43 ^{gh} ±0.1	0.18 ^{ef} ±0.0	2.56 ^c ±0.81
75% P	26.3 ^{ab} ±4.47	12.48 ^a ±3.22	1.02 ^{ab} ±0.3	122.61 ^{abc} ±22.7	7.10 ^{ab} ±1.88	0.36 ^{abc} ±0.24	0.39 ^{gh} ±0.06	0.29 ^{fg} ±0.0	1.41 ^{ab} ±0.29
75%P+ <i>B. vallismortis</i>	27.8 ^{ab} ±1.89	13.06 ^a ±2.81	1.09 ^{ab} ±0.2	143.83 ^{abc} ±33.2	11.30 ^{cd} ±2.46	0.9 ^{cdef} ±0.38	0.53 ^h ±0.08	0.33 ^g ±0.0	1.63 ^{bc} ±0.32
75%P+ <i>B. tequilensis</i>	27.5 ^a ±3.28	13.90 ^{abc} ±4.67	1.14 ^{ab} ±0.4	158.61 ^{bcd} ±54.	14.30 ^d ±3.05	0.62 ^{bcd} ±0.2	0.09 ^{bc} ±0.04	0.07 ^{abc} ±0.	1.22 ^{ab} ±0.43
75%P+(<i>B.vallismortis</i> + <i>B.tequilen</i>)	32.32 ^{bc} ±2.35	19.71 ^{bc} ±4.79	1.72 ^{ab} ±0.4	267.66 ^{fg} ±61.60	13.26 ^d ±2.26	0.54 ^{bcd} ±0.1	0.12 ^{cde} ±0.08	0.07 ^{abc} ±0.	1.84 ^{bc} ±0.52
100 % P	29.50 ^{abc} ±3.43	16.19 ^{abc} ±4.61	1.33 ^{ab} ±0.3	173.51 ^{bcd} ±63.	9.70 ^{abcd} ±3.15	0.46 ^{bcd} ±0.1	0.22 ^{ef} ±0.16	0.15 ^{de} ±0.0	1.55 ^{bc} ±0.33
100%P+ <i>B. vallismortis</i>	29.1 ^{ab} ±3.94	16.27 ^{abc} ±5.57	1.36 ^{ab} ±0.4	146.68 ^{abc} ±23.3	9.70 ^{bc} ±1.52	0.52 ^{bcd} ±0.1	0.08 ^{bc} ±0.03	0.06 ^{ab} ±0.0	1.44 ^{ab} ±0.50
100%P+ <i>B. tequilensis</i>	29.8 ^{abc} ±2.93	16.69 ^{abc} ±5.38	1.42 ^{ab} ±0.5	143.23 ^{bc} ±8.45	14.40 ^{cd} ±4.32	1.09 ^f ±0.18	0.14 ^{cde} ±0.03	0.10 ^{abcde} ±	1.55 ^{abc} ±0.47
100%P+(<i>B.vallismortis</i> + <i>B.tequile</i>)	30 ^{abc} ±4.06	17.42 ^{abc} ±5.50	1.45 ^{ab} ±0.5	211.09 ^{defg} ±48.	9.70 ^{bc} ±1.30	0.59 ^{bcd} ±0.2	0.48 ^{gh} ±0.07	0.026 ^{fg} ±0.	1.93 ^{bc} ±0.53



Supplementary Figure 1: Description of the treatments tested for canola (*Brassica napus* L.) growth during the experiment course. *Note: the concentrations of P (as P₂O₅), were achieved by the following recipes: 100% P (0.39 g/2 Kg sand: clay soil mixture), 75% P (0.225 g/2 Kg sand: clay soil mixture), 50% P (0.195 g/2 Kg sand: clay soil mixture)