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Actinomycetes improve seed nutritional quality and productivity of leguminous crops by boosting nitrogen availability and metabolism

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Table S1. Morphological characterization of the actinomycete strains isolated from the local legume fields. The sign + and – indicate presence or absence, respectively.

	Isolates	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
	Aerial mycelium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Pigmentation	+	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	+
Spore chain	**Spiral**	+	+	-	-	+	+	+	-	-	+	+	+	-	-	+	+	+
	Rectiflexibiles	-	-	+	+	-	-	-	+	+	-	-	-	+	+	-	-	-
	Verticillate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Substrate Mycelia	**White**	+	-	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-
	Brown	-	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-
	Yellow	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
	Orange	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Grey	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+
	Red	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
	Violet	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-

Table S2. Biochemical characterization of the actinomycete isolates. The sign + and – indicate presence or absence, respectively.

	Isolates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N source utilization	L-Cysteine	+	+	+	+	-	+	+	+	+	-	+	+	-	-	+	+	+
	L-Phenylalanine	+	+	+	+	-	+	+	+	+	+	+	-	+	+	+	-	-
	L-Histidine	-	-	+	-	+	+	-	-	+	-	+	+	+	-	+	+	+
	L-Lysine	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	-
	L-Asparagine	-	+	-	+	-	+	-	+	-	-	+	+	+	+	+	-	+
	L-Arginine	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+
	L-proline	+	-	+	+	+	-	+	+	-	+	-	+	+	-	+	-	-
	L-Valine	-	+	+	+	+	-	+	+	+	+	-	-	+	-	-	+	-
	Tyrosine	+	+	+	-	+	-	+	-	+	-	+	+	+	-	+	+	+
C source utilization	D-fructose	+	+	+	-	-	+	+	+	+	+	+	+	-	-	+	+	+
	D-glucose	-	+	+	+	+	+	-	-	+	-	+	+	+	+	+	-	-
	Sucrose	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+
	Maltose	+	+	-	+	-	-	-	+	-	+	-	-	-	-	-	+	+
	Raffinose	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+
	Lactose	-	+	+	-	-	+	-	+	-	-	+	+	+	-	+	+	-
	Galactose	+	+	+	+	-	-	+	+	+	-	-	+	+	-	+	+	-
	Meso-Inositol	-	-	-	-	+	+	-	+	+	-	+	+	-	-	-	+	-
	Cellulose	+	+	+	+	-	+	+	-	-	-	+	-	-	+	+	-	+
	Xylose	-	+	+	+	-	-	-	+	+	+	+	+	-	-	-	+	+
	Dextran	+	+	-	-	-	+	+	+	-	-	-	+	+	-	-	-	+
Enzymes activity	Catalase	+	-	+	-	-	+	+	+	+	-	+	-	-	+	-	-	-
	Peroxidase	-	+	+	-	+	-	-	+	-	-	-	+	+	-	+	+	+
	Starch hydrolysis	-	+	-	+	-	+	-	-	+	+	-	+	+	+	+	-	-
	Gelatin liquefication	-	+	-	+	+	+	-	+	+	-	-	+	-	+	+	-	+
	Casein hydrolysis	+	+	+	+	+	+	+	+	-	-	+	-	-	+	-	-	+
	Lipolysis	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	-	+
	Citrate utilization	-	-	+	+	-	+	-	-	+	-	-	+	+	+	-	+	+
	H_2S Production	-	+	-	+	-	+	-	+	-	-	-	+	-	-	+	+	+
	DNase	+	+	-	+	+	+	+	+	-	+	-	+	-	-	+	-	-
	Nitrate reduction	-	+	-	+	+	+	-	+	+	+	+	+	+	-	+	+	-
	Urease	-	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+	+
	L- asparaginase	-	+	+	+	-	+	-	+	+	-	-	+	+	+	+	+	+
	L-glutaminase	-	+	-	+	-	+	-	+	-	-	-	+	-	-	+	+	+

Table S3. Analysis of physical and chemical properties of soils of soybean, kidney bean, chickpea, lentil and pea under control (cont.) and after enrichment with biologically active actinomycete isolates. Values are the average of three individual replicates (means ± S.D). meq/L = milliequivalents of solute per liter of solution. Different letters represent significant differences between the treatments in each crop (Duncan test; $P < 0.05$; n=4).

	EC ds/ml	pH	HCO3 (meq/L)	Ca^{++} (meq/L)	P (ppm)	K^{+} (meq/L)	Mg^{++} (meq/L)	Zn (ppm)	Cu (ppm)	T. Phen	Organic matter
Soybean-Cont	3.4±0.5a	7.9±0.5a	10.1±1a	13.8±1.1a	33.6±2.3a	2.7±0.3a	7.3±0.7a	11.2±1.1a	9.7±0.9a	112±6.3a	2.6±0.4a
Kidney Bean-Cont	3.5±0.3a	7.2±0.8a	10.2±0.2a	14.1±0.9a	33.1±2.1a	2.8±0.3a	6.9±0.6a	11.7±1.0a	9.8±1.1a	112±6.3a	2.6±0.4a
chickpea-Cont	3.3±0.2a	7.5±0.4a	9.9±0.7a	14.1±1.5a	35.2±2.3a	2.8±0.4a	7.5±0.4a	12.1±0.9a	9.4±1.4a	112±6.3a	2.6±0.4a
Lentil-Cont	3.4±0.4a	7.7±0.7a	10.1±0.8a	14.0±1.2a	34.7±1.9a	2.7±0.2a	7.1±0.4a	12.1±0.9a	9.9±1.7a	112±6.3a	2.6±0.4a
Pea-Cont	3.6±0.5a	7.8±0.8a	9.9±0.9a	13.2±1.2a	35.6±2.1a	2.6±0.4a	7.2±0.8a	11.8±1.0a	9.6±0.4a	112±6.3a	2.6±0.4a
Soybean-I2	3.3±0.4a	7.4±0.3a	10.5±1.1a	25.5±0.5b	46.2±3.2b	3.4±0.1b	11.2±0.9b	14.6±1.1b	10.6±0.8a	132±6.8b	6.6±0.4b
Kidney Bean-I2	4.2±0.3a	8.1±0.3a	9.3±0.9a	19.8±0.5a	31.2±0.5a	2.9±0.5a	7.6±0.8a	13.2±1.1b	9.9±1.2a	110±4.1b	7.1±1.5b
chickpea-I2	3.9±0.4a	7.7±0.7a	9.9±0.3a	13.5±0.8a	31.2±3.8a	2.7±1.4a	8.1±1.1a	14.2±1.1b	11.6±1.8a	141±5.3b	6.6±1.8b
Lentil-I2	3.7±0.3a	7.5±09a	13.2±1b	16.1±3.2a	39.2±2.2a	5.7±0.7b	9.6±2.5a	21.8±0.8b	16.9±1.1b	151±5.1b	16.9±1b
Pea-I2	4.1±0.4a	7.2±0.2a	15.5±2b	21.5±1.2b	42.6±7.1b	3.9±1.4a	12.2±0.7b	14.2±1.1b	17.4±1.4b	161±2.5b	5.4±1.9b
Soybean-I8	3.5±0.6b	7.2±0.5a	9.6±1.1b	18.7±1.1b	49.5±2.8b	4.1±0.8b	12.5±0.7b	26.5±1.2b	11.3±1a	133±4.4b	7.3±1.4b
Kidney Bean-I8	4.3±0.2b	8.1±0.9a	11.2±0.7a	15.6±2.1a	31.3±1.1a	2.6±0.7a	7.6±0.9b	17.3±1.1b	13±2.1a	117±3.1b	8±4.1b
chickpea-I8	3.4±0.4a	7.1±0.5a	8.9±0.7a	13.6±3.1a	39.3±1.5b	2.8±0.4a	7.6±1.1b	15.3±0.9b	12.1±1.9a	111±8.4a	12.129b
Lentil-I8	3.5±0.6a	8.1±0.3a	11.7±1.4b	15.3±3.1a	45.3±3.1b	7.4±1.1b	15.2±1.5b	27±1.15b	9.2±0.6a	178±3.1b	3.2±0.6b
Pea-I8	4.2±0.1b	8.1±0.7a	12.5±0.8b	17.7±3.7b	42.3±1.7b	6.2±1.7b	17.1±1.1b	21.9±2.5b	9.8±0.7a	176±5b	5.8±0.7b
Soybean-I12	3.7±0.8a	7.6±0.4a	14.2±1.9b	19.6±2.9b	49.5±1.3b	2.6±2.4a	14.6±0.9b	15.3±0.9b	13±1.9b	113±7b	4±0.1b
Kidney Bean-I12	2.5±0.3a	8.1±0.7a	10.9±1.3a	12.7±4.5a	51.3±1.9a	3.1±1.2a	11.5±0.8b	10.6±1.1a	12.1±1a	100±11b	6.1±1b
chickpea-I12	3.1±0.5a	7.2±0.8a	11.3±2.1a	21.6±0.2b	49.3±1.5b	3.4±1.1a	10.2±0.2a	12.8±1.2a	9.6±1.2a	164±4.1a	9.6±1.2b
Lentil-I12	3.2±0.5a	8.2±0.8a	15.8±0.8b	18.6±5.6a	65.3±3.5b	6.7±0.8b	10.2±1.6a	14.9±2.1a	11.1±0.8a	139±9.4a	4.1±0.8b
Pea-I12	3.1±0.4a	7.6±0.5a	14.5±1.1a	23.5±0.8b	62.3±1.7b	7.4±0.7b	15.2±2.9b	18.2±1.7b	13.6±1.1b	100±7.5b	9.6±1.2b
Soybean-I15	3.3±0.2a	8.1±0.9a	14.5±0.7b	23.6±2.9b	46.6±0.2b	2.4±0.2a	8.1±0.2a	10.6±2.2a	10±2.4a	83±5.9a	10±2.4b
Kidney Bean-I15	2.3±0.5a	7.2±0.3a	11.9±0.7a	14.1±1.7a	35.4±2.7a	3.0±1.7a	12±1.9b	11.1±1.1b	11±2.6a	96±8b	6±0.6b
chickpea-I15	3.2±0.8a	7.6±0.1a	12.5±0.6a	15.6±1.7a	35.6±2.6a	2.7±0.6a	9.4±0.3a	23.5±1.1b	12.3±1a	172±5.4b	2.3±0.3a
Lentil-I15	4.4±0.5b	8.1±0.7a	17.2±1.1b	26.1±4.1b	51.5±6.4b	5.3±0.5b	11.5±1.7b	17.5±1.8b	19.3±1.2b	161±5b	9.3±.3b
Pea-I15	4.7±0.3b	7.4±0.5a	20.7±1.8b	23.9±2.1b	47.6±0.2b	6.4±0.9b	11.1±0.2a	23.6±1.4b	10.3±0.4a	123±3.1a	4.3±0.2b