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EFFECT OF BRADYRHIZOBIA AND PHOSPHATE SOLUBILIZING BACTERIA APPLICATION ON SOYBEAN IN ROTATIONAL SYSTEM IN THE MEKONG DELTA

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ABSTRACT:

To study the effect of Bradyrhizobia (Bradyrhizobium japonicum) and phosphate solubilizing bacteria (Pseudomonas spp.) application on soybean in rotational system (soybean-rice-rice), the experiments were carried out at three different provinces of Mekong delta viz., An Giang, Can Tho and Dong Thap. The treatments composed of different combination level of inorganic nitrogen fertilizer levels (namely 20, 40, 60 kg N/ha) and biofertilizer (Bradyrhizobium japonicum+ Pseudomonas spp.) as compared to conventional farmers' fertilizer level (80 N - 60 P_2O_5 – 30 K_2O kg/ha). The results showed that application of Bradyrhizobia (Bradyrhizobium japonicum) and phosphate solubilizing bacteria (Pseudomonas spp.) can enhance the number of nodules, dry weight of nodules, yield components, grain yield, soil nutrient availability and uptake of soybean crop. Moreover, the economic efficiency could be increased in term of reducing the production cost for soybean from 785,000 to 1,000,000 VND/ha.

Key-word: *Bradyrhizobium japonicum,* grain yield, *Pseudomonas* spp.,soil nutrient, soybean

INTRODUCTION

Nitrogenous chemicals account for as much as 30% of the total fertilizer needed for agricultural crops, with the increasing cost of chemical fertilizers and concern about environmental pollution. The role of biological nitrogen fixation (BNF) in supplying plants with needed N, which can make agriculture more productive and sustainable without harming the environment, has to be harnessed efficiently. Studies indicate that rhizosphere, roots, stems and leaves of even healthy plants harbour diverse microbial communities that include N_2 fixing bacteria as rhizobia and free living bacteria (*Azotobater, Azospirillum, Herbaspirillum*…) or *Gluconacetobacter diazotrophicus*, a promising diazotrophic endophyte (Muthukumarasamy *et al.* 2002).The long term field experiment on soybean conducted at Can tho province showed that the quality nutrient contents and uptake of soybean with reference to N, P and K and soil available P and K were significantly improved by application of composted paddy straw and inoculants viz. *Sinorhizobium fredii* and *Bradyrhizobium japonicum* (Tran Thi Ngoc Son *et al.*, 2003). After N, phosphorus (P) is the major plant growth-limiting nutrient despite being abundant in soils in both inorganic and organic forms. However, many soils throughout the world are P-deficient because the free phosphorus concentration (the form available to plants) even in fertile soil is generally not higher than 10 µM even at pH 6.5 where it is most soluble (Gyneshwar *et al.* 2002). To circumvent the problem of P deficiency, chemical fertilizers are added to the soils but cost of chemical phosphatic fertilizers is high (Goldstein *et al*. 1993) and low efficiency (<0.1%) (Scheffer and Schachtschabel, 1992). Phosphorus biofertilizers in the form of micro-organisms, especially phosphate-solubilizing bacteria in rhizosphere, can help in increasing the availability of accumulated phosphates for plant growth by solubilization (Richarson, 1994; Nautiyal *et al.* 2000). In addition, the micro-organisms involved in P solubilization as well as better scavenging of soluble P (P biofertilizer) can enhance plant growth by increasing the efficiency of BNF, enhancing the availability of other trace

elements such as Fe, zinc (Zn), etc. and by production of plant growth promoting substances (Kucey *et al*. 1989) and these bacteria also produced indole-3-acetic acid, a phytohormone is known to be involved in root initiation, cell division and cell enlargement, very commonly (Barazani and Friedman 1999). These beneficial micro-organisms, especially PGPR (Plant Growth Promoting Rhizobacteria), are grown in the simple, cheap media and they are mixed with the appropriate carriers to produce biofertilizers. However the most optimum inorganic and bio-fertilizer combination doses as well as their effectiveness for upland crops rotation with rice have not been studied in details so far. In this regard an attempt has been made to study on" Effect of Bradyrhizobia (*Bradyrhizobium japonicum*) and phosphate solubilizing bacteria (*Pseudomonas spp*) application on soybean in the rotational system (soybean-rice-rice) in the Mekong Delta.

OBJECTIVES:

- To address Bradyrhizobia and Pseudomonads'effects on soybean nodulation, yield components and grain yield of soybean.
- To study the effect of two kinds of bacteria on soil fertility, soybean production cost in order to reduce environmental pollution as well as increase farmers' income and sustainable agriculture.

MATERIAL AND METHODS

Bradyrhizobial inoculant

Bradyrhizobium japonicum (USDA 110 strain) for soybean was grown in the G6 medium (Singleton *et al*, 2002), in 4 days on rotary shaker and population reaches $>10^9$ cells/ml, bradyrhizobial liquid was mixed with sterile peat at 50% moisture and rhizobial inoculant ($>10^9$ cells/g) contained in plastic bags and stored at room temperature.

Phosphate solubilizing bacteria fertilizer (PSB fertilizer)

Pseudomonas spp. (P18 strain) was isolated from soybean rhizosphere soil and was determined high soluble phosphate and IAA (Cao Ngoc Diep and Nguyen Hoang Uy Phong 2006, unpublished data). It was grown in sucrose apatite medium (Whitelaw et al. 1999) in 7 – 10 days and population reached $>10^9$ cells/ml, pseudomonad liquid was mixed with the combination of sterile peat and bagasse at 50% moisture and the inoculant ($>10^9$ cells/g) was put in plastic bags and stored at room temperature.

The experiments were carried out at three sites: An Khuong hamlet, Hoi An village, Cho Moi district, An Giang province (site 1), Experimental Station of Cuu Long Delta Rice Research Institute, Thoi Thanh village, Co Do district, Can Tho city (site 2), Binh Hiep A hamlet, Binh Thanh Trung village, Lap Vo district, Dong Thap province (site 3)

Timing of study: in Spring- Summer 2005 cropping season. Physical and chemical characteristics of experimental soils were presented in Table 1. The soils had been intensively cropped with high-yielding rice at least twice a year and they were classified as alluvial soil group.

Table 1. Physical and chemical characteristics of experimental soil at An Giang (site 1), Can Tho (site 2) and Dong Thap (site 3)

Characteristic	Site 1	Site 2	Site 3
pH	5.14	5.25	5.07
Available N (ppm)	47.4	36.8	48.8
Available P (ppm)	6.64	3.98	4.15
Available K (ppm)	51.2	79.5	35.2
Organic matter (%)	1.18	1.13	0.545

Source: from Soil Science Department, CLRRI

There were eight treatments (Table 2) with three replications in a randomized completely block design, with a plot size of 50 m^2 (5m x 10 m) / treatment.

Table 2: List of eight treatments

Treatments	Fertilizer (kg/ha)
T1	0 N – 0 P_2O_5 -30 K_2O
T2	20 N + Bradyrhizobial inoculant (10 kg/ha) + 60 P_2O_5 - 30 K_2O
T3	40 N + Bradyrhizobial inoculant (10 kg/ha) + 60 P_2O_5 - 30 K_2O
T4	60N + Bradyrhizobial inoculant (10 kg/ha) + 60 P_2O_5 - 30 K_2O
T5	20N + Bradyrhizobial inoculant (10 kg/ha) + PSB fertilizer (100 kg/ha) + 30 K_2O
T6	40N + Bradyrhizobial inoculant (10 kg/ha)+ PSB fertilizer (100 kg/ha) + 30 K_2O
T7	60 N + Bradyrhizobial inoculant (10 kg/ha) + PSB fertilizer (100 kg/ha) + 30 K_2O
T8	80 N - 60 P_2O_5 - 30 K_2O

Before soybean planting in all experiments, rice straw was cut at the soil surface and it was used for mulching to prevent from water evaporation with zero land preparation. Holes of about 2.5 cm in diameter and 2.5-3.0 cm deep were made by pointed poles and spaced 15 cm apart with the rows. Three soybean seeds were dropped into each hole and the hole was filled with either mixture of ash-bradyrhizobial inoculant or ash of bradyrhizobial and pseudomonad inoculants and control (T1 and T8 covered by ash alone); plot size was 5x10 m with the spaced at 40 cm and interrows spaced at 15 cm, the final population of soybean plants was 500,000 plants/ha. After sowing seeds, phosphorus (as super phosphate 15% P_2O_5) and potassium (KCl 60% K_2O) fertilizers were band dressed to seed rows, where applicable (Table 2); nitrogen was applied in increasing rates 0, 20, 40, 60 and 80 kg N/ha as urea (46% N) at 10 days after sowing (DAS) depending on treatments in Table 2. Soybean plants were watered twice a day with skinler-can, weed control by hand and plants were protected with liquid insecticides when necessary.

All plant samples in all experiments were taken by randomized digging of five plants in central portion within guard rows and 0.5 m from each end of each plot. The first sampling was done when 80% of the plants had flowers for nodulation (nodule number and dry weight (DW) of nodule) and the second sampling when 80% of the plants had reached ripening stage for yield component and grain yield. After harvesting, soil samples were collected for evaluating initial analysis: soil samples were air-dried and sieved out of 2-mm sieve to analyze nitrogen (micro-Kjeldahl method) and phosphorus content; plant samples were also dried at 70^oC in 24 hours, ground and analyze nitrogen and phosphorus content.

An analysis of variance was done on data obtained from each parameter of three experiments. Treatment means were processed by Duncan test.

RESULTS AND DISCUSSIONS:

1. Nodulation of soybean

The number of nodules/plant ranged from 26.9 to 40.8, 17.2 to 45.8 and 27.8 to 34.60 in An Giang, Can Tho and Dong Thap province, respectively. At all of sites, bradyrhizobia and pseudomonads increased the number of nodules/plant (treatment T6 and T7) and the lowest nodule number/plant in treatment T8 (the highest inorganic nitrogen fertilizer), this led to the same dry weight (DW) of nodule (Table 3).

Table 3. Effect of bradyrhizobia and pseudomonads on nodule number/plant and DW of nodule/plant of soybean cultivated on various alluvial soils of Mekong Delta

Treatment	Nodule number/plant			DW of nodule/plant (g)		
	Site 1 (An Giang)	Site 2 (Can Tho)	Site 3 (Dong Thap)	Site 1 (An Giang)	Site 2 (Can Tho)	Site 3 (Dong Thap)
T1	30.3 c *	45.8 a	30.9 ab	0.307 b	0.27 a	0.175 d
T2	36.7 b	30.2 e	31.9 ab	0.346 a	0.17 e	0.204 c
T3	36.7 b	43.0 b	30.9 ab	0.363 a	0.24 abc	0.250 ab
T4	37.4 b	42.9 b	29.4 ab	0.336 ab	0.21 cd	0.250 ab
T5	37.6 b	38.6 c	34.6 a	0.346 a	0.22 bcd	0.268 a
T6	40.8 a	37.9 c	34.5 a	0.361 a	0.25 ab	0.265 a
T7	39.6 ab	33.1 d	32.3 ab	0.351 a	0.19 de	0.231 bc
T8	26.9 d	17.2 f	27.8 b	0.258 c	0.10 f	0.117 e
F test	*	***	***	***	***	***
C.V (%)	**4,6**	**3,8**	**10,6**	**6.0**	**8.9**	**7.1**

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

2. Yield components of soybean (table 4, 5 and 6)

- Total number of pods/plant ranged from 29.23 to 35.80, 62.83 to 74.83 and 24.73 to 30.97 in An Giang, Can Tho and Dong Thap, respectively. In An Giang and Dong thap, we obtained the higher total number of pods/plant under treated by bradyrhizobia and pseudomonads. Pod number / plant was significantly different from conventional fertilizer dose (80 N - 60 P_2O_5 - 30 K_2O) at 1%0 level. In Can Tho, mean of treatments are not significantly different to each other

- The number of pods bearing 1 seed/plant ranged from 2.4 to 5.74, 4.93 to 9.83 and 1.97 to 2.87 for An Giang, Can Tho and Dong Thap, respectively. The highest value obtained in T1 (5.74) and the lowest one obtained in T4 (2.40).

- The number of pods bearing 2 seeds /plant ranged from 15.23 to 19.50, 24.33 to 37.67 and 13.67 to 17.80 for An Giang, Can Tho and Dong Thap, respectively. There were significant differences among treatments. The effect of bradyrhizobia and pseudomonads application treatments showed a clear cut at Dong Thap and An Giang.

- The number of pods bearing 3 seeds /plant ranged from 6.73 to 12.03, 12.33 to 20.50 and 8.20 to 10.87 for An Giang, Can Tho and Dong Thap, respectively. At An Giang province the highest value was recorded by treatments *viz*., T2, T3, T4, T6 and T7 and different significantly with T5, T1 and T8 treatment. Among the treatments, the lowest number of pods bearing 3 seeds obtained under control treatment (T1) and uninoculated treatment (T8 - 80 N - 60 P_2O_5 - 30 K_2O). At Can tho province, the mean value of pods bearing 3 seeds offered the highest in case of treatment T7 (60 N + Bradyrhizobial inoculant (10 kg/ha) + PSB fertilizer (100 kg/ha) + 30 K_2O). At Dong Thap province, the highest of mean value of pods bearing 3 seeds of soybean were recorded in T2 then T4, T5, T6 and T7. The lowest value was obtained in T1. There were significantly different among treatments at 1%o level. At all of sites, bradyrhizobia and pseudomonads increased the number of pods bearing 3 seeds. This could be one of the reasons, which had contributed to the higher grain yield of soybean

- The unfilled pods percentage (%) ranged from 3.33 to 8.09, 13.45 to 31.51 and 6.91 to 11.98 at An Giang, Can Tho and Dong Thap provinces, respectively. The unfilled pods were the highest under application of high dose of inorganic fertilizer (T8) or unfertilizer. Among three experimental sites, the highest unfilled pods percentage was recorded at site 2 (Can Tho), this led to lower grain yield of soybean as compared to two other sites.

- The 100-grain weight (g) varied from 15.93 to 17.27, 18.70 to 20.53 and 16.79 to 17.37 at An Giang, Can Tho and Dong Thap, respectively. Among the treatments, grain weight was not significantly different in site 1 (An Giang). At Can Tho, the highest value was obtained in T8 then T5, T6 and T7 treatments and they were significantly different at 5% level. At Dong Thap, the highest value was noticed in T5 (17.37g) and the lowest in T1 (16.83g), T8 (16.79g), they were very significantly different at level of 0.001.

Table 4: Effect of bradyrhizobia and pseudomonads on yield components of soybean cultivated at An Giang province in Mekong Delta

Treatment	Total no. of pods/plant	No. of pods bearing 1 seed/plant	No. of pods bearing 2 seeds/plant	No. of pods bearing 3 seeds/plant	Unfilled pods (%)	100-grain weight (g)
T1	29.93 b*	5.74 a	15.40 c	6.73 d	7.63 ab	15.93 b
T2	34.73 a	3.53 bc	18.00 b	12.03 a	3.33 c	16.29 b
T3	35.73 a	3.90 b	17.93 b	11.97 ab	5.48 bc	16.60 ab
T4	34.50 a	2.40 c	19.50 a	11.27 ab	3.85 c	17.27 a
T5	34.33 a	2.80 bc	19.17 ab	10.63 b	4.92 c	16.48 ab
T6	35.80 a	3.37 bc	19.47 a	11.50 ab	4.11 c	16.42 ab
T7	35.40 a	2.77 bc	18.93 ab	11.93 ab	5.00 c	16.23 b
T8	29.23 b	2.57 bc	15.23 c	9.07 c	8.09 a	16.13 b
F	***	**	***	***	**	ns
CV(%)	3.6	24.9	4.1	7.3	23.9	3

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

Table 5: Effect of bradyrhizobia and pseudomonads on yield components of soybean cultivated at Can Tho province in Mekong Delta

Treatment	Total of pods/plant	No. of pods bearing 1 seed/plant	No. of pods bearing 2 seed/plant	No. of pods bearing 3 seeds/plant	Unfilled pods (%)	100-grain weight (g)
T1	62.83 b*	6.50 c	24.33 b	12.33 c	31.51 a	18.70 c
T2	69.57 ab	7.90 b	24.33 b	19.33 ab	25.91 b	18.93 bc
T3	71.77 ab	5.77 cd	33.67 a	18.67 ab	19.01 c	19.17 bc
T4	70.97 ab	6.13 cd	33.33 a	19.50 ab	16.86 cd	18.83 bc
T5	73.47 a	6.53 c	36.00 a	19.93 ab	14.96 cd	19.97 ab
T6	69.10 ab	4.93 d	31.33 ab	19.50 ab	19.29 c	20.40 a
T7	66.07 ab	5.57 cd	31.00 ab	20.50 a	13.73 d	19.77 abc
T8	74.83 a	9.83 a	37.67 a	17.33 b	13.45 d	20.53 a
F	ns	***	**	***	***	*
CV(%)	7.5	11.4	12.4	8.4	12.5	3.3

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

Table 6: Effect of bradyrhizobia and pseudomonads on yield components of soybean cultivated at Dong Thap province in Mekong Delta

Treatment	Total of pods/plant	No. of pods bearing 1 seed/plant	No. of pods bearing 2 seeds/plant	No. of pods bearing 3 seeds/plant	Unfilled pods (%)	100-grain weight (g)
T1	24.73 c*	2.83 a	13.67 b	8.20 d	11.98 a	16.83 d
T2	30.60 a	2.50 a	17.23 a	10.87 a	6.91 c	17.13 c
T3	30.40 a	2.67 a	17.80 a	9.93 b	7.32 bc	17.17 c
T4	30.97 a	2.63 a	17.80 a	10.53 a	6.92 c	17.28 b
T5	30.77 a	2.27 a	17.67 a	10.83 a	7.43 bc	17.37 a
T6	29.93 a	1.97 a	17.43 a	10.53 a	7.80 bc	17.17 c
T7	29.60 a	2.60 a	17.00 a	10.00 b	8.41 b	17.13 c
T8	26.60 b	2.87 a	14.47 b	9.27 c	11.64 a	16.79 d
F	***	ns	***	***	***	***
CV(%)	3.6	20.6	5.8	2.6	9	0.3

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

3. Grain yield of soybean

- At An Giang, grain yield of treatments T2, T3, T5 and T6 did not differ from farmers' fertilizer level (treatment T8). However, application of biofertlizer as bradyrhizobial inoculant or both bradyrhizobial inoculant and BSP fertilizer increased, grain yield increased 3.30; 6.65; 8.30 and 11.65 % in T2 (2,067 kg/ha), T3 (2,133 kg/ha), T5 (2,167 kg/ha) and T6 (2,233 kg/ha), respectively, as compared to T8. Among the treatments, the treatment T4 and T7 obtained the highest grain yield (2267 kg/ha) and it differed significantly from treatment T8 (2,000 kg/ha) (Fig. 1)

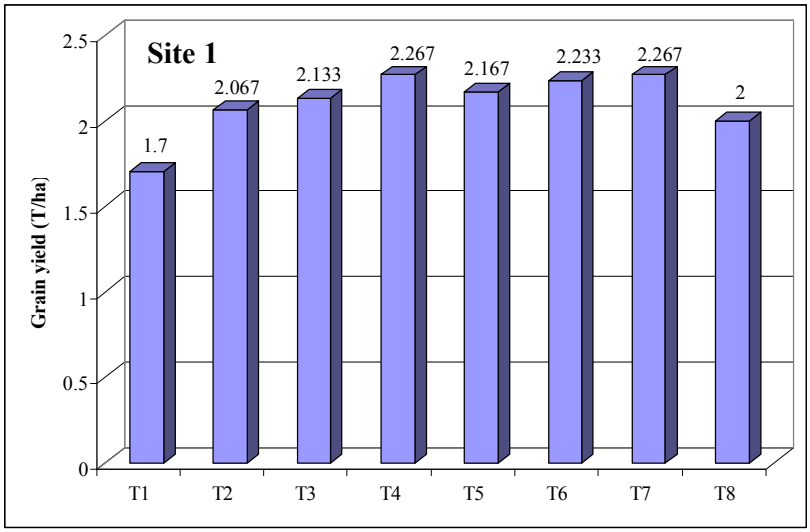

Fig 1. Effect of bio-fertilizer and chemical fertilizer on grain yield of soybean cultivated on alluvial soil of An Giang province (site 1)

- At Can Tho, there was no difference grain yield among the treatmentsas compared to farmers' fertilizer level. This result indicated that under alluvial soil condition, the amount of 40 -60 kg N and 60 kg P_2O_5/ha could affect to biofertlizer for soybean production in the Mekong Delta (Fig. 2)

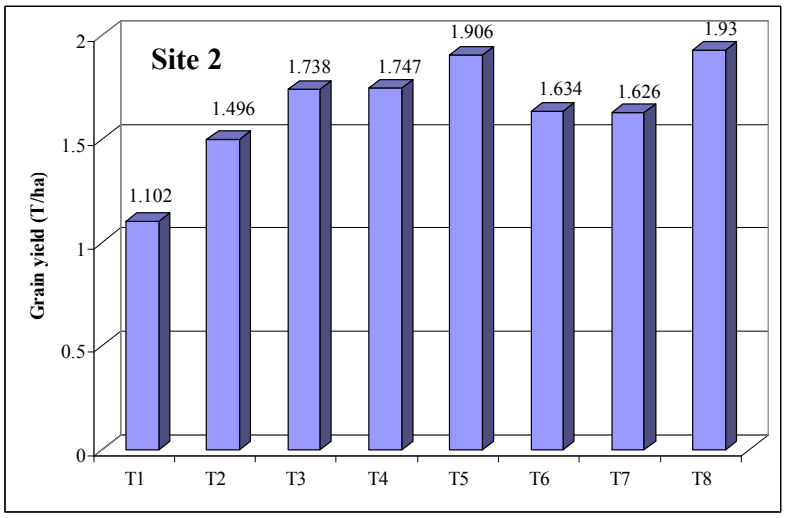

Fig 2. Effect of bio-fertilizer and chemical fertilizer on grain yield of soybean cultivated on alluvial soil of Can Tho city (site 2)

At Dong Thap, grain yield varied from 1,700 - 2,333 kg/ha, the highest grain yield was obtained in treatment T6 (2,333 kg /ha). Application of biofertlizer (bradyrhizobial inoculant and BSP fertilizer), soybean grain yield was higher than control. T2 obtained 2,203 kg /ha, T3: 2,200 kg/ha, T4: 2,167 kg/ha, T5: 2,233 kg /ha, T7: 2,200 kg/ha as compared to treatment T1: 1,833 kg /ha. Biofertlizer soybean increased grain yield from 13.66% to 27.32 % as compared to treatment T8 (Fig 3).

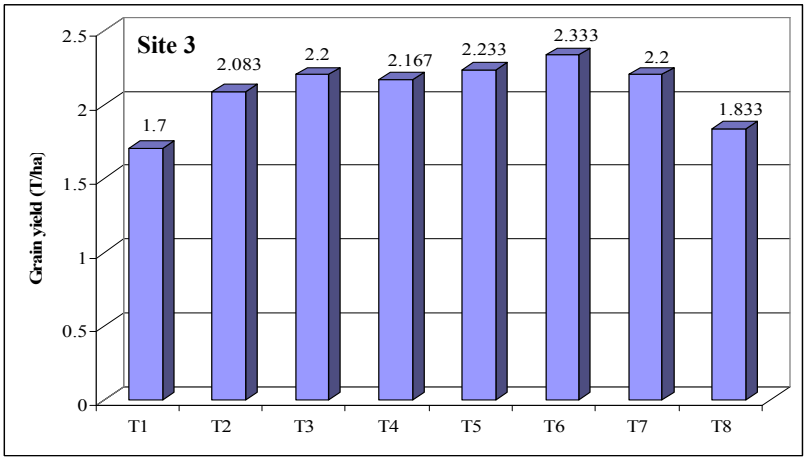

Fig 3. Effect of bio-fertilizer and chemical fertilizer on grain yield of soybean cultivated on alluvial soil of Dong Thap province (site 3)

4. Soil available nutrients

At harvesting time of soybean, available N and P has been increased significantly under application of biofertlizer whether only bradyrhizobial inoculant or both bradyrhizobial inoculant and PSB fertilizer as compared to farmers' fertilizer level.

At An Giang, soil available nitrogen increased from 3.17 % to 28.35 % except treatment T4. At Can Tho, it increased from 12.36 % to 26. 76 %, except treatment T2. At Dong Thap, it increased from 2. 92% to 24.77%.

Soil available phosphate increased from 14.58 % to 59.72 %, from 5.15 % to 32.16%, and from 4.42 % to 36.18% at An Giang, Can Tho, and Dong thap, respectively (Table 7)

Table 7. Effect of treatments on soil available nutrients (ppm) of grown soybean at harvest stage (Spring–Summer, 2005)

Treatment	An Giang (site 1)		Can Tho (site 2)		Dong thap (site 3)	
	N	P	N	P	N	P
T1	54,3 c *	5,45 d	52,7 d	4,34 c	55,5 c	5,45 e
T2	71,7 b	6,60 cd	58,7 cd	5,10 bc	68,0 abc	6,61de
T3	66,9 bc	8,38 ab	73,6 abc	5,19 bc	77,3 ab	6,88 cde
T4	76,4 ab	7,70 bc	75,3 ab	6,18 ab	67,9 bc	7,06 bcd
T5	81,8 ab	7,16 bc	73,9 abc	6,41 a	66,9 bc	8,44 ab
T6	89,2 a	9,20 a	81,0 a	6,15 ab	75,4 ab	8,62 a
T7	77,3 ab	8,08 ab	71,8 abc	6,24 ab	81,1 a	8,29 abc
T8	69,5 b	5,76 d	63,9 bcd	4,85 c	65,0 bc	6,33 de
F test	**	***	*	*	*	**
CV (%)	11,4	10,3	13,3	12,2	11,5	12,2

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

5. Nutrient uptake by soybean grain

In An Giang experimental result showed that N and P uptake by soybean grain increased from 13.64% to 37.27% and from 17.77 to 41.12%, respectively (Table 8).

In Can Tho, N and P uptake by soybean grain increased from 3.25 to 21.14 % and from 0.96 to 27.88%, respectively.

In Dong Thap, nitrogen uptake increased from 13.64 to 30.00 % and phosphorus increased from 17.17 to 41.12 % under application of bio-fertilizer (bradyrhizobial inoculant and PSB fertilizer) as compared to farmers' fertilizer level (uninoculation)

Table 8. Effect of treatments on nutrient uptake (kg/ha) of grown soybean at harvest stage (Spring-Summer, 2005)

Treatment	An Giang		Can Tho		Dong thap	
	N	P	N	P	N	P
T1	96.8 d *	8.57 c	65.9 b	5.16 c	95.5 d	8.65 c
T2	127.0 bc	10.50 bc	96.4 a	8.04 b	125.0 bc	11.60 b
T3	131.0 bc	11.40 ab	117.0 a	9.50 ab	136.0 ab	12.20 b
T4	138.0 abc	12.30 ab	118.0 a	9.59 ab	132.0 ab	13.00 ab
T5	140.0 ab	12.40 ab	125.0 a	11.04 a	136.0 ab	12.80 ab
T6	150.0 a	13.30 a	110.0 a	9.91 ab	151.0 a	13.90 a
T7	141.0 ab	12.40 ab	104.0 a	9.59 ab	143.0 ab	13.10 ab
T8	123.0 c	10.40 bc	127.0 a	10.58 ab	110.0 cd	9.85 c
F	***	*	**	*	***	***
CV (%)	**7,5**	**12,4**	**14,6**	**16,3**	**8,8**	**7,1**

* Means followed by the same letter(s) are not significantly different at 5% level based on DMRT

6. Economic performance

Application of bradyrhizobial inoculant for soybean production at the rate of 10kg/ha can save from 40–60 kg N/ha equal to 87–130 kg Urea/ha (as compared to farmers' nitrogen level as 135kg Urea/ha). So we can reduce 185,000–400,000 VND/ha in terms of nitrogen supply with 5000VND/kg Urea, 25.000VND/kg Rhizobial inoculant, recommended dose as 10 kg /ha. Application of PSB fertilizer for soybean production at the rate of 100 kg/ha can save 60 kg P_2O_5 /ha equal to 375 kg SSP /ha by farmers' fertilizer level equally to reduce 600,000 VND/ha in terms of phosphorus supply with 1,600VND/kg SSP, 25.000VND/kg PSB fertilizer, recommended dose as 100 kg /ha.

CONCLUSION

The optimal fertilizer dose for soybean production can be suggested with 40 N-rhizobial inoculant + PSB fertilizer - 30 K_20. The results showed that application of bradyrhizobia (*Bradyrhizobium japonicum*) and phosphate solubilizing bacteria (*Pseudomonas* spp.) can enhance the number of nodules, dry weight of nodules, yield components, grain yield, soil nutrient availability and uptake of soybean crop. Moreover, the economic efficiency can be increased in term of reducing the production cost for soybean from 785,000 to 1,000,000 VND/ha

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Hiệu quả chủng vi khuẩn nốt rễ và vi khuẩn hòa tan lân trên đậu nành trong hệ thống luân canh đậu - lúa ở đồng bằng sông Cửu Long

Ba thí nghiệm ngoài đồng được thực hiện trên đất phù sa tại 3 tỉnh ở đồng bằng sông Cửu Long là An Giang, Cần Thơ và Đồng Tháp để khảo sát hiệu quả chủng vi khuẩn nốt rễ và vi khuẩn hoà tan lân cùng với phân hoá học trên đậu nành luân canh với lúa cao sản trên năng suất, độ phì và hấp thu dinh dưỡng cho cây đậu nành. Kết qủa thí nghiệm cho thấy hai nhóm vi khuẩn có ích này gia tăng số nốt rễ, thành phần năng suất, năng suất hột đậu và đóng góp vào độ phì của đất, giảm được khoảng 40 - 60 kg N/ha và 60 kg P_2O_5/ha và năng suất đậu nành có chủng vi sinh vật có ích không khác biệt với đậu nành chỉ bón phân hoá học theo công thức của nông dân (80 N - 60 P_2O_5 – 30 K_2O kg/ha). Hàm lượng đạm và hấp thu N, P của cây trồng và N, P hữu dụng trong đất được nâng lên một cách có ý nghĩa do chủng những vi sinh vật có ích (*Bradyrhizobium japonicum, Pseudomonas* spp). Ngoài những lợi ích trên, nông dân còn tiết kiệm được chi phí canh tác đậu nành từ 785.000 đến 1.000.000 đồng/ha