Demonstration and Extension of Biofertilizer on Vegetable Soybean Production in Southern Taiwan

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Abstract

Farmers apply more fertilizer than the recommanded level for the vegetable soybean. As a result,the fammer's investment on fertilizer increases cost of production of vegtable soybean. High rate of fertilizer application accelerates the acidification of soil, and excess chemical fertilizer which is not completely absorbed by the vegetable soybean pollutes ground water. Therefore, the objective of this demonstration and extension is to guide the farmers to use rhizobia inoculation instead of high rate of chernical fertilizer for cultivation of vegetable soybean, with reduced rate of nitrogen fertilizer application for the vegetable soybean fields.The results of this demonstration and extension were as follows : The effective nodule number and nodule ratio of vegetable soybean tended to increase with rhizobfa inoculation,but they also decreased with the increase in nitrogen application.Therefore,a judicious application of fertilizer with rhizobial inoculation is recommended.

The plant height was not increased by rhizobia inoculation and the rhizobia inoculation increased graded pod weight per plant.

In spring season of 1988, 1989 and 1990, rhizobia inoculation with 20 or 21 kg/ha nitrogen as basal application or top dressed at 20 DAS increased graded pod yield by 14.3%, 22.7% more than farmers' practice but fertilizer cost was reduced by US$225/ha US$140/ha and US$129/ha, as well as the profit increased by US$503/ha, US$524/ha and US$491/ha respectively. In autumn of 1988 and 1989, rhizobia inoculation and 20 kg/ha of nitrogen as basal dressing increased graded pod yield 18.2% and 15.2% more than farmers practice while the fertilizer cost was reduced by US$214/ha and US$140/ha, as well as the profit increased by US$504/ha and US$568/ha respectively.

Further analysis of variance for pod yield showed that the difference between with rhizibia inoculation and without rhizobia inoculation were significant.

Due to the effectiveness of rhizobia inoculation in the demonstration the extension of the technology was smooth and successful. Area inoculated with rhizobia increased from 900 ha in 1988 to 2,720 ha in 1990.

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Introduction

Vegetable soybeans are those which are harvested as green pods between R6 and before R7 growth stage.Its growth period varies with varieties and planting seasons.For the presently cultivated variety,growth period ranges from 70-80 days in spring season,and 65-70days in autumn season.Because the growth period of vegetable soybean is short,and the profit is more than that of other grain crops like adzuki bean,corn and peanut,the vegetable soybean area has rapidly increased from 5,012 ha in 1983 to 10,715 ha in 1988(3).In just five years,vegetable soybean has thus become one of the major economic crop in southern Taiwan.

In the past,the vegetable soybean commonly cultivated was selected from grain soybean variety which produces bigger seeds, and the management practices were also same as that for grain soybean. However, due to the development of new vegetable soybean cultivars in recent years, there is a need to conduct research on appropriate fertilizer management for vegetable soybean.

In recent years,vegetable soybean produced in Taiwan is frozen and then exported to Japan,and thus has gradually become an important processed vegetable (8). High quality is an essential requirement for Japanese market. Therefore, to eater to the needs of the market, all efforts need to be made to improve vegetable soybeans qualities, such as appearance, texture and flavor,all based on the criteria of Japanese companies. In appearance, the standard graded pods should contain two or more seeds with pod length of 4.5 cm and width of 1.3 cm, and be fresh green in color, and pod weight of 515 grams should be composed of less than 175 pods (2,4, and 8). In view of the fact that both quantity and quality of pods are important components to increase the profit of vegetable soybean, much attention is paid to improve the quality through cultural practices, such as, irrigation, harvest time, fertilizer management, planting time, etc. Generally, farmers who grow vegetable soybean are controlled by the merchants ; therefore, the amount of fertilizer applied is decided by the merchants. According to a survey of farmers fertilizer application amount in vegetable soybean production area in Southern Taiwan,the fertilizer application rate was found to be much higher than the recommended rate ($N\text{-}P_2O_5\text{-}K_2O$ = 60-60-60 kg/ha). For example, the increase was 1.8−3.7, 1.8−3.0 and 1.4−2.7 times for N, P_2O_5 and K_2O, respectively (4). Apparently, farmers investiment on fertilizer cost for the cultivation of vegetable soybean was considerable. Such high rate of fertilizer application accelerate the acidification of soil, and excess chemical fertilizers that can not be completely absorbed by crops will pollute ground water. Therefore, the objective of this demonstration and extension is to urgently guide farmers to use rhizobia inoculation instead of high rate of chemical fertilizer for cultivation of vegetable soybean, especially reduced rate of nitrogen fertilizer application for the vegetable soybean fields.

Materials and Methods

The observation trials were conducted in spring 1988 at two locations,in autumn 1988 at six locations in spring 1989 at six locations in autumn 1989 at six locations and in spring 1990 at six locations. The main plot consisted of cultivars,tzuzunoko (205)and Kaohsiung Selection No.1,whereas the subplot consists of N application rate with rhizobia inoculation (details as shown in Tables 1 and 2). The plot area of observation field for each treatment was 100 square meter. The demonstrations were carried out during the same seasons and same places as the observation fields but the area of demonstration plots was much larger than observation plots. There were 10 hectares for each demonstration field and 9.95 hectare inoculated with rhizobia with fertilizer application and 0.05 hectare without rhizobia inoculation with fertilizer as per farmers technique. The brady rhizobium japonicum was used for all the demonstration and extension which were

Table 1. The treatments of N fertilizer rate with Rhizobia Inoculation (Spring, 1988)

Main-plot:	2 cultivars			
	tzuzunoko 205(VI)			
	Kaohsiung Selection No. 1 (V2)			
Sub-plot:	Chemical fertilization and Rhizobia Inoculation			
	Chemical fertilizer			Rhizobia Inoculation
	N	P_2O_5	K_2O	
1	Commonly used by farmers*			Without
2	0	63	60	With
3	21	63	60	With

*Experiments were conducted at Chao-Cho 2 locations.
$N-P_2O_5-K_2O$ applied by the two farmers were 187-74-102, and 282-272-208 kg/ha, respectively.

Table 2. The treatments of N fertilizer rate with Rhizobia Inoculation (autumn 1988 & 1989 and spring 1989 & 1990).

Main-plot:	2 cultivars			
	tzuzunoko 205(VI)			
	Kaohsiung Selection No. 1 (V2)			
Sub-plot:	Chemical fertilization and Rhizobia Inoculation			
	Chemical fertilizer			Rhizobia Inoculation
	N	P_2O_5	K_2O	
1	Commonly used by farmers*			Without
2	60	60	60	Without
3	0	60	60	Without
4	0	60	60	With
5	** 20	60	60	With
6	*** 20	60	60	With

* Experiments were conducted at 6 locations in both seasons; N, P_2O_5 and K_2O applied by the six farmers ranged from 144-200, 148-180, and 72-226 kg/ha in autumn 1988 & 1989, and from 75-124, 42-321, and 96-208 kg/ha in spring 1989 & 1990, respetively.

** N applied as top-dressing.

*** N applied as basal.

Table 3. The effect of N application rate and Rhizobia Inoculation on nodule number (autumn 1988).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Nodule No. at 30 DAS			Nodule No. at 45 DAS		
	Total	Available	Ratio (%)	Total	Available	Ratio (%)
1.Farmer applied	14.9	6.1	40.7	14.5	3.5	24.2
2.60-60-60	14.3	6.1	42.7	16.1	3.8	23.7
3.0-60-60	22.1	10.0	45.3	20.3	6.7	32.8
4.0-60-60+R1	19.8	10.0	50.4	21.9	8.1	36.9
5.20T-60-60+R1	21.2	11.7	55.3	20.7	7.1	34.4
6.20B-60-60+R1	18.2	10.0	55.0	20.2	7.2	35.8

* RI: Rhizobia Inoculation DAS: days after sowing

** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 144-200, 145-180, and 72-226 kg/ha, respecitively.

supplied by Dr.Chiu-Chung Young,the professor of National Chung Hsin University. The reduction in fertilizer cost and the increase in profit were determined.

Results and Discussions

Effects of Rhizobia Inoculation and N Application on Nodule Number and Effective Nodule Ratio

Effective nodule number and nodule ratio of vegetable soybean tended to increase with rhizobia inoculation,but they also decreased with the increase in nitrogen application (Table 3).Survey of seven locations in 1988 autumn season at thirty days after sowing (DAS)indicated that the effective nodule ratio with rhizobia inoculation and 20 kg/ha of Ntop-dressing was highest,i.e.,55.3% ,which was 14.6% higher than farmers' common practice (treatment 1)and 12.6% higher than the check plot (N-P_2O_5-K_2O=60-60-60 kg/ha). However, effective nodule number at 45 DAS was highest in treatment with rhizobia inoculation plus P and K application only (N-P_2O_5-K_2O=0-60-60 kg/ha). Obviously, effective nodule number gradually decreased after additional N top-dressing. Kao (1984) pointed out that applying 20-50 kg/ha of nitrogen resulted in dark green leaf color,poor nodule number and low effective nodule ratio (7). Wang et al (1988) reported that rhizobia inoculation without nitrogen application had 30 times higher nodule number than that without inoculation.However,with 40 kg/ha of nitrogen application and rhizobia inoculatin nodule number increased by 14 times only,which is significantly less than inoculation without N application (9). Hung (1991) also showed that nodules in treatment with rhizobia inoculation and without N application were more in number,large sized and heavier,but with nitrogen application,nodules were smaller in number,size and lighter in weight,and the number decreased with increase in nitrogen application (5).

Effect of Rhizobia Inoculation and N Application on Plant Height and Numbers of Graded Pod per Plant

The plant height was not increased by rhizobia inoculation.The results showed that the treatment $N-P_2O_5-K_2O$=0-60-60, without rhizobia inoculation gave the highest plant height.In comparing treatment 3 with treatment 4 in the same fertilizer application rate but different in rhizobia inoculation and without rhizobia inoculation, the plant height of treatment 3 was higher than treatment 4 at spring season 1989 and spring season 1990 respectively (Table 4).Even with increased nitrogen application,the plant height did not increase. The rhizobia inoculation increased graded pod weight per plant.When applied with 20 kg/ha nitrogen applied as basal or top dressing with rhizobia inoculation the graded pod weight were 19% and 21% increased compared with farmers'practice respectively. When phosphorus and potassium alone were applied with rhizobia inoculation the graded pod weight increased by 17% compared with farmer's practice (Table 5).

Table 4. The effect of N application rate and Rhizobia Inoculation on plant height (soring 1989 and spring 1990).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Plant height (cm)										
	Spring 1989				Spring 1990						
	Yen-pu	Mei-long (1)	Mei-long (2)	Mean	Wan dan	Kating	Mei-long (1)	Mei-long (2)	Likan	Kao-Shu	Mean
1. Farmer applied	33.0	37.2	24.7	31.6	28.2	28.2	32.6	31.1	33.2	29.5	30.5
2. 60-60-60	32.6	36.7	33.0	34.1	29.5	30.2	31.7	28.9	30.4	32.2	30.5
3. 0-60-60	34.7	37.8	34.3	35.6	33.5	30.6	31.3	32.3	29.6	29.8	31.2
4. 0-60-60+RI	33.2	38.2	34.9	35.4	29.9	28.1	30.5	30.7	33.4	27.3	30.3
5. 20T-60-60+RI	31.8	36.5	32.8	33.7	27.7	30.0	33.4	25.9	31.7	28.0	29.3
6. 20B-60-60+RI	33.2	38.1	33.6	35.0	32.0	28.0	34.0	23.8	32.3	29.7	30.0

* RI: Rhizobia Inoculation T: Top-dressing B: Basal

** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 75-125, 42-321, and 96-208 kg/ha, respectively.

Table 5. The effect of N application rate and Rhizobia Inoculation on graded pod weight (spring 1989).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded pod weight (g/plant)				
	Yenpu	Meilong(1)	Meilong(2)	Mean	Index
1.Farmer applied	18.0	12.8	13.7	14.4	100
2.60-60-60	15.8	14.0	18.0	15.9	107
3.0-60-60	15.0	13.4	18.1	15.5	105
4.0-60-60+RI	18.6	14.8	18.5	17.3	117
5.20T-60-60+RI	18.5	15.0	19.3	17.6	119
6.20B-60-60+RI	18.1	16.5	19.0	17.9	121

* RI: Rhizobia Inoculation T: Top dressing B: Basal
** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 75-124, 42-321, and 96-208 kg/ha, respectively.

Investigation on Graded Pod Yield,Fertilizer Cost and Increase in Profit by Rhizobia Inoculation

According to the results of three trials in spring season 1988,rhizobia inoculation with 21 kg/ha nitrogen as basal application increased graded pod yield by 14.3% more than the two farmers' common practice. Rhizobia inoculation, the fertilizer cost is reduced by US$255/ha. The profit increased by US$503/ha (Table 6). In 1988 autumn,average graded pod yield of 7 locations, with rhizobia inoculation and 20 kg/ha of nitrogen as basal dressing increased 18.2% more than farmers' practice while the fertilizer cost is reduced by US$214/ha. The profit increased by US$504/ha (Table 7). However, rhizobia inoculation alone without nitrogen also increased profit by US$479/ha.

Table 6. Yield, fertilizer cost and profit increases with N application and rhizobia inoculation (spring 1988).

Location	Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded pod yield (t/ha)	Yield index (%)	Production price (A) (US$/ha)	Fertilizer cost(B) (US$/ha)	Return (A-B) (US$/ha)	Profit increases (US$/ha)
Chacho (1)	1.187-74-102	5.8	100	1,699	213	1,486	0
	2.0-63-60	6.0	103	1,752	61	1,684	198
	3.21-63-60	6.7	116	1,749	76	1,873	387
Chacho (2)	1.282-272-208	6.1	100	1,774	448	1,326	0
	2.0-63-60	7.2	118	2,096	61	2,035	709
	3.21-63-60	7.0	114	2,022	76	1,946	620
Average	1.Farmer applied	6.0	100	1,737	331	1,406	0
	2.0-63-60	6.6	111	1,921	61	1,860	453
	3.21-63-60	6.8	114	1,985	76	1,909	503

Table 7. Yield, fertilizer cost and profit increases with N application and rhizobia inoculation (autumn 1988).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded*** pod yield (t/ha)	Yield index (%)	Production price(A) (US$/ha)	Fertilizer cost(B) (US$/ha)	Return (A-B) (US$/ha)	Profit increases (US$/ha)
1.farmer applied	5.2	100	1595	287	1308	0
2.60-60-60	5.3	103	1647	101	1546	238
3.0-60-60	4.9	95	1518	59	1459	151
4.0-60-60+RI	6.0	116	1846	59	1787	479
5.20T-60-60+RI	5.7	110	1752	73	1679	371
6.20B-60-60+RI	6.1	118	1885	73	1812	504

* RI: Rhizobia Inoculation

** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 144-200, 145-180, and 72-226 kg/ha, respectively.

*** Average data of six locations.

Table 8. Yield, fertilizer cost and profit increases with N application and rhizobia inoculation (spring 1989).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded*** pod yield (t/ha)	Yield index (%)	Production price(A) (US$/ha)	Fertilizer cost(B) (US$/ha)	Return (A-B) (US$/ha)	Profit increases (US$/ha)
1.farmer applied	5.2	100	1696	213	1483	0
2.60-60-60	5.3	103	1748	101	1647	164
3.0-60-60	5.6	109	1846	59	1787	304
4.0-60-60+RI	6.0	116	1969	59	1910	427
5.20T-60-60+RI	6.4	123	2080	73	2007	524
6.20B-60-60+RI	6.2	119	2022	73	1949	466

* RI: Rhizobia Inoculation

** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 75-124, 42-321, and 96-208 kg/ha, respectively.

*** Average data of seven locations.

In 1989 spring season,rhizobia inoculation plus 20 kg/ha nitrogen top-dressed at 20 DAS increased graded pod yield by 22.7% more than farmers practice ; the fertilizer cost was reduced by US$140/ha. The profit increased by US$524/ha (Table 8). In 1989 autumn season, average graded pod yield of 6 locations with rhizobia inoculation and 20 kg/ha of nitrogen as basal dressing increased 15.2% more than farmers' practice. The fertilizer cost was reduced by US$159/ha. The profit increased by US$568/ha(Table 9). In 1990 spring season, rhizobia inoculation plus 20 kg/ha nitrogen top-dressed at 20 DAS increased graded pod yield by 22.7% more than farmers' practice. The fertilizer cost was reduced by US$129/ha. The profit increased by US$491/ha (Table 10).

It was obvious that rhizobia inoculation produced significantly higher yield and more benefit than farmers' method. Wang and others confirmed that rhizobia inoculation can better ensure the increase in soybean yield (1,6,10,11,12,13,14).

The demonstration fields were not replicated and therefore statistical analysis could not be done. Analyzing the coefficient of variations (C.V.)for the yield data from 7 locations in 1988 autumn season and 6 locations in 1989 spring season showed that the C.V.was 10.2% and 11.1% respectively.Further analysis of variance for pod yield showed that the differences between rhizobia inoculation and no rhizobia inoculation were significant (Table 11). Increased income is only one obvious benefit.There are a number of other hidden benefits from inoculation with rhizobia,for instance,the soil became acidic due to the application of excessive chemical fertilizer. This also affects the growth and yields of following crop and the residual fertilizer also possibly gets filtered into underground and pollutes ground water. The use of rhizobia and reduced N application will help avoid the above undersirable responese. The residue of vegetable soybean plants applied back to the field could also serve as green manure for improving soil fertility.

Table 9. Yield, fertilizer cost and profit increase with N application and rhizobia inoculation (autumn 1989).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded*** pod yield (t/ha)	Yield index (%)	Production price(A) (US$/ha)	Fertilizer cost(B) (US$/ha)	Return (A-B) (US$/ha)	Profit increases (US$/ha)
1.farmer applied	8.2	100	2,697	232	2,465	0
2.60-60-60	8.6	105	2,817	101	2,716	251
3.0-60-60	8.4	101	2,733	59	2,674	209
4.0-60-60+RI	9.1	110	2,969	59	2,910	445
5.20T-60-60+RI	9.3	113	3,047	73	2,974	509
6.20B-60-60+RI	9.5	115	3,106	73	3,033	568

* RI: Rhizobia Inoculation T: Top dressed B: Basal
** In treatment 1, the N, P_2O_5, K_2O applied by farmers averaged 147, 135, 120 kg/ha respectively.
*** Average data of six locations.

Table 10. Yield, fertilizer cost and profit increases with N application and rhizobia inoculation (spring 1990).

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Graded*** pod yield (t/ha)	Yield index (%)	Production price(A) (US$/ha)	Fertilizer cost(B) (US$/ha)	Return (A-B) (US$/ha)	Profit increases (US$/ha)
1.farmer applied	4.9	100	1,598	202	1,396	0
2.60-60-60	5.3	108	1,724	101	1,623	227
3.0-60-60	5.3	108	1,732	59	1,673	277
4.0-60-60+RI	5.4	111	1,779	59	1,720	324
5.20T-60-60+RI	6.0	123	1,960	73	1,887	491
6.20B-60-60+RI	5.8	119	1,902	73	1,829	433

* RI: Rhizobia Inoculation T: Top dressed B: Basal

** In treatment 1, the N, P_2O_5, K_2O applied by farmers averaged 105, 135, 120 kg/ha respectively.

*** Average data of six locations.

Table 11. The effect of N application rate and rhizobia inoculation on yield of vegetable soybean in 2 cultivations.

Treatment $N-P_2O_5-K_2O$ (kg/ha)	Autumn 1988, 7 locations		Spring 1989, 6 locations	
	graded pod yield (t/ha)**	Yield index (%)	graded pod yield (t/ha)***	Yield index (%)
1.Farmer applied	5.2cd***	103	5.2c	100
2.60-60-60	5.3bcd	103	5.3bc	103
3.0-60-60	4.9d	95	5.6abc	109
4.0-60-60+RI*	6.0ab	116	6.0ab	116
5.20T-60-60+RI	5.7abc	110	6.4a	123
6.20B-60-60+RI	6.1a	118	6.2a	119

* RI: Rhizobia Inoculation

** In treatment 1, the N, P_2O_5, K_2O applied by farmers ranged from 144-200, 145-180, and 72-226 kg/ha in autumn 1988, and from 75-124, 42-321 and 96-208 kg/ha in spring 1989, respectively.

*** Column means followed by the same letter do not differ significantly ($p=0.05$) according to Duncan's multiple-range tent

The Results of Biofertilizer Extension on The Vegetable Soybean Production and Its Potential in The Future.

Due to the efficiency of rhizobia inoculation the fertilizer cost is reduced,the graded pod yield increased and the profit increases was significant. There were 900 hectare in 1988,1880hectare in 1989 and 2720 hectare in 1990 (Fig. 1)respectively were planted with rhizobia inoculated seeds. The average profit increased around US$480/ha on rhizobia inoculation with N-P_2O_5-K_2O=20-60-60 kg/ha compared with farmer's method. The total vegetable soybean planted rhizobia inoculated seed was 5500 hectare from 1988 to 1990 and farmers made a profit of more than 2.64 million US dollars (Table 12).It is expected that about 5,000 hectare will be planted with rhizobia inoculated vegetable soybean seeds in 1992,and hope three years later the whole vegetable soybean area will be inoculated with rhizobia and the total area will be about ten thousand hectare each year in southern Taiwan.

Table 12. The profit increase on the extension field.

Year	Area of extension (ha) (I)	Profit increase on the extension area (II)	Total profit I× II
1988	900	459	413,100
1989	1,880	517	971,960
1990	2,720	462	1,256,640
Total	5,500		2,641,700

Conclusion

Rhizobia inoculation increased weight of nodules and the effective numbers of nodule. Rhizobia inoculation and 20 kg/ha of N applied as basal increased the graded pod yield by 14-22%. It also saved the fertilizer cost for around US$150/ha. The total profit increase due to rhizobia inoculation was US$480/ha.

Considering fertilizer application rate,cost,consumption of natural resources,possible pollution of ground water etc.,the appropriate fertilizer recommendation and management method for vegetable soybean cultivation should be rhizobia inoculation,which enables vegetable soytean to absorb and utilize nitrogen from the air through nitrogen fixation and judicious use of N fertilizer.

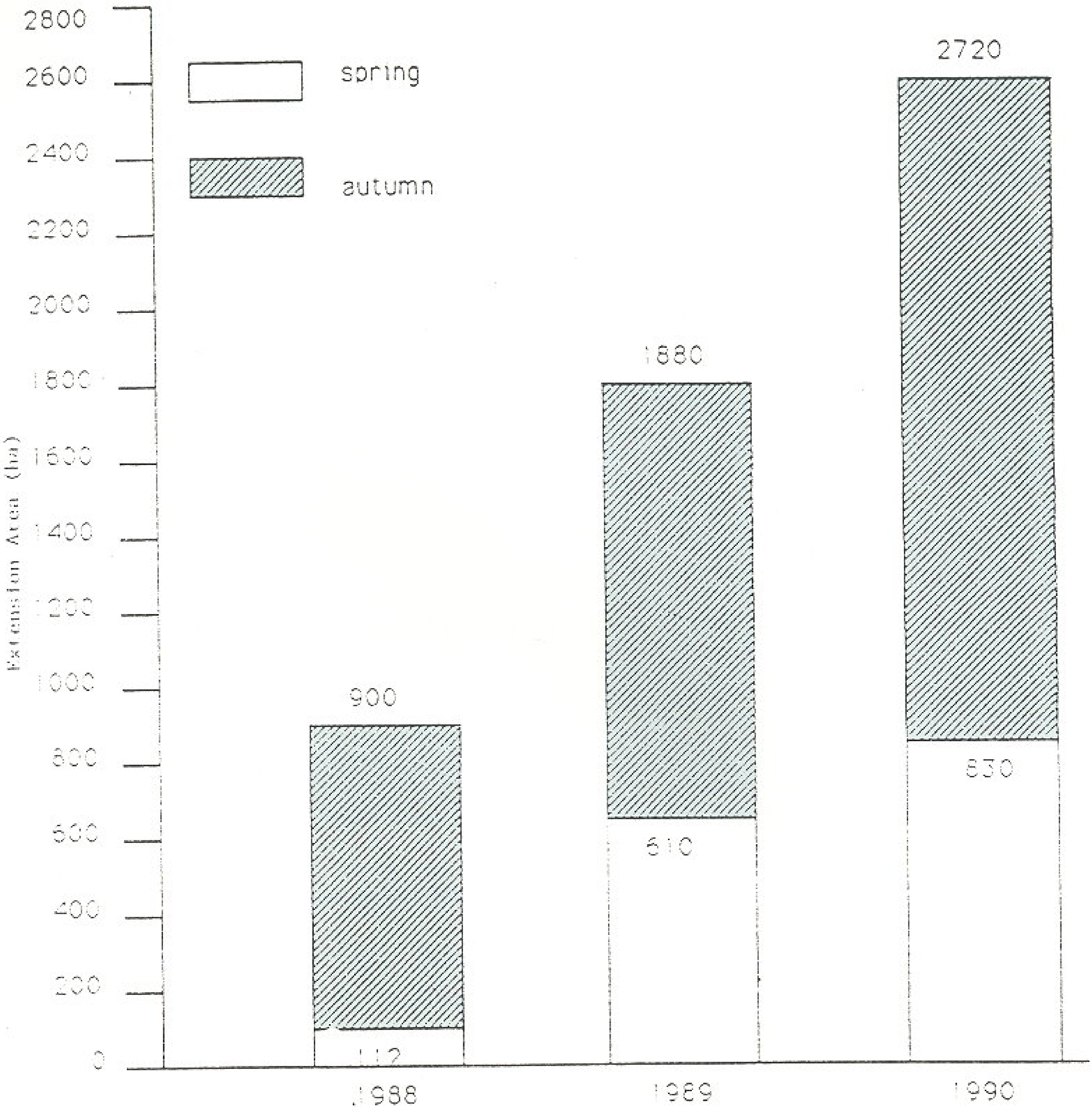

Fig. 1. The extension area during 1988-1990.

Referencess

1.Asian Vegetable Research and Development Center.1977. Soybean research highlights. Shanhua,Taiwan,Republic of China.

2.Cheng,J.H.1990.Study on the effects of organic ferilizers on the yield and quality of vegetable soybean.Soil and Fertilizer Experiment Report Published by Department of Agriculture and Forestry,Taiwan Provincial Govemment.p.208 -222.

3.Department of Agriculture and Forestry,Taiwan Provincial Government.1989. Crop production.6.Vegetables (15)Peppers,kidney beans,peas,vegetable soybean and other fruit vegetables.Taiwan Agricultural Yearbook.p.48-49.

4.Hung,A.T.,R.S.Lo,C.M.Hsu.1990.Demonstration and extension of biofertilizer on vegetable soybean production in Kaoping area.Proceeding of a symposium on soil and fertility management of legume crops published by Kalhsiung District Agricultural Improvement Station.p.234-251.

5.Hung,A.T.1991.Studies on the fertilization technique after inoculation the Rhizobia and V.A.Mycorrhiza of Soybean (no publication).

6.Kao,T.c.1984. Study on the effect of denitrifying Rhizobium Japonicam on Soybean-maize cropping system and soil fertility Bulletin of Taichung District Agriaultural Improvement Station 9:57-67.

7.Kao,T.c.and A.C.Lin.1984.Ecological studies on nitrogen fixation of soybean nodules in Kao-Ping area of the south Taiwan. Investigations on nodular development and distribution of soybeans.National Science Council Monthly Vol.XI, No.12-2, p.1409-1418.

8.Tsou,C.S.,M.H.Wu,T.L.Hong and J.s.Tsay.1990.Cultrual management on yield and quality of vegetable soybean.Proceedings of a symposium on soil and fertility management of legume crops published by Kaohsiung District Agricultural Improvement Station. p.135-146.

9.Wang,C.T.1988.Effects of rhizobia and glomus inoculation on soybean.Soil and Fertilizer Experiment Report,published by Department of Agriculture and Forestry,Taiwan Provincial Govermment,Republic of China. p.102-109.

10.Wu,M.H.1958.Studies on rhizobia inoculation of legumes in Taiwan.Journal of Agriculture & Forestry. Vol.7 .p.131-178.

11.Wu,M.H.1959. A selection of good strain of Rh. Japonicum by filed experiment, Jourmal of Agriculture & Forestry. Vol.8, p.83-87.

12.Wu,M.H.1964.A selection of a superior strain of Rhizobia Japonicum by field experiment. Vol.13, p.11-13.

13.Young,C.C.,M.H.Wu and T.C.Jaung.1982.The selection and use of Rhizobia in Taiwan.Food & Fertilizer Technology and Technical Bulletin No.66:1-9.

14.Young,C.C.,T.C.Juang and C.C.Cho.1983.Effect of Rhizobia and VA mycorrhiza inoculation on nodulation,symbiotic nitrogen fixation and yield of soybean in subtropical-tropical fields.Biology and Fertility of Soils (Germany) 6:165-169.

台灣南部毛豆施用微生物肥料（大豆根瘤菌）示範與推廣成果[1]

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摘　　要

由於農民栽培毛豆之肥料施量比推荐施量爲多，因此農民投入毛豆的生產成本也隨著增加，過量的施用生理性之化學肥料不但加速農田的酸性化，同時亦可能由於過量的肥料作物吸收不完滲入地下造成地下水的污染，因此本示範推廣之目的是教導農民種植毛豆時接種大豆根瘤菌以替代施用高量的化學肥料，本示範推廣的結果爲接種大豆根瘤菌有效根瘤率增加，但隨著氮素施量之增加而減少。接種大豆根瘤菌毛豆之植株高度沒有增高，單株合格莢重則增加。1988年春作接種根瘤菌後每公頃施氮素21公斤較農民慣行區合格莢重增加14.3%，肥料成本每公頃減少255美元接種區較農民慣行區每公頃收益增加503美元，1988年及1989年秋接種根瘤菌後每公頃基施20公斤氮素較農民慣行區合格莢重分別增產18.2%及15.2%肥料成本分別減少每公頃214美元及140美元收益每公頃分別增加504美元及568美元，1989年及1990年春接種根瘤菌每公頃於播種後20天追施20公斤氮素較農民慣行區合格莢重二年均增加22.7%，肥料成本每公頃減少分別爲140美元及129美元收益分別增加524美元及491美元，合格莢產量經變方分析結果接種根瘤菌較不接種根瘤菌間之差異達顯著平準。由於接種大豆根瘤菌對於毛豆合格莢重收益等之增加，肥料成本減少之效果顯著，接種大豆根瘤菌之種植面積已由1988年的900公頃增加至1990年的2720公頃。

關鍵字：毛豆、生物肥料、根瘤菌、接種、合格莢產量

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