Effects of Organic Manures and Inoculation on Growth and Yield of Off Season Soybean Cultivars Grown on an Acid Soil

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Abstract

An off season soybean experiment was carried out during October-December, 1989 at Khon Kaen University to study the effect of organic manures and inoculation upon growth and seed yield of four soybean cultivars. The organic manures used were city garbage compost no. 2 and cattle manure. Each of these was applied at the rates of 0 and 3,750 kg/ha. Inoculation was carried out with the use of *Rhizobium japonicum*. The plants were grown on an acid Yasothon soil (Oxic Paleustult).

The results showed that shoot, leaf dry weights and leaf areas per plant were affected most by the shortday period. The plants produced only a small amount of shoot growth. Ther was no differences due to treatment found during the first four harvests but only at the final harvest, the effect due to treatment was found i.e. the plants received inoculation and organic manures gave significantly greater shoot, leaf dry weights and leaf areas than those without. Shoot growth was better with city garbage manure than that of the cattle manure. Seed yields were highly related to the total uptake of N in leaves, shoot dry weights, and leaf area duration. Suitable leaf area index was suggested.

Soybean *(Glycine max* L.*)* has been considered as one of the most important cash crops in the Thai economy for a number of years due to its numerous home and industrial uses. The amount of seeds produced each year can suply a large amount of protein, vitamins and oil for man and animal consumption. The oil contents in seeds can be exceeded 24% and the protein contents can be in a range of 26-40% (Davidescu et al., 1977). Each year Thailand produces a large amount of seeds, however, the amount requires by the national uses is relatively large and the production of seeds in each year can not presumably fulfill the requirements. In the past decades, soybean cultivation was made possible in the northern region and partly in the Central Plain areas. Nevertheless, recently the cultivation of the crop has been extended to Northeast due to modernized agriculture and the improved breeds of the crop. Therefore, further research works precisely focus on this particular cash crop should be of significant value especially to those growers of Northeast. There has been a number of publications concerning N-fixation both in and out of the country e.g. Vangnai and Niamsrichand (1979), Vangnai (1980), and henzell (1988). However, these published data concerned most on nodulation but less

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was concerned with the improvement of seed yields by organic manuring together with inoculated rhizobium particularly with the off season soybean cultivation. The use of organic manuring could possibly improve the physicochemical properties of the soil particularly with those light sandy acid soils. Furthermore, organic manuring can help in controlling the level of aluminum (Al) in the soil solution (Bloom et al., 1979) and organic N is not readily leached or denitrified (Kapland and Etes, 1985). Therefore, the objective of this work was to investigate how the growth and seed yield of the four soybean cultivars responded to the organic manuring and inoculation under an acid soil condition particularly during the off season period .

Materials and Methods

This off season soybean experiment was carried out by means of sprinkler irrigation at the Experimental Farm, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand during October-December 1989. The experiment was laid in a 5 × 4 factorial arranged in RCB with four replications. The organic materials used were cattle manure and city garbage compost no. 2. Each of these materials was used at the rates of 0 and 3,750 kg/ha with and without inoculation *(Rhizobium japonicum)* for both organic materials (Cf. Dept. of Agriculture). The soybean varieties used were : SJ 4, KKS 19-0-1, TGX 530-02D and KKS 23-1-6. The plants were grown on an acid soil (Yasothon Series, Oxic Paleustult). The initial soil property values for pH, organic matter, total N, available P, exchangeable K and Ca were 4.7, 0.6%, 0.03%, 4.5 ppm, 0.15 me/100g, 0.87 me/100g, respectively (the method of Jackson, 1973). The soil used was ploughed twice and followed by harrowing once and then raised to a pH value of approximately 5.5 with the use of $CaCo_3$ at the rate of one ton/ha. The plot size used was 3 × 5 metres and the distances used 50 cm between rows and 30 cm within the row. 4-5 seeds of each variety were sown directly into the soil at the depth of 4-5 cm. The application of herbicide (Lasso) was made once soon after the sowing of seeds to control the rapid germination of weed seeds. One week after emergence, seedlings were removed leaving two plants per hill, and at the same time a complete fertilizer (12-24-12), at the rate of 94 kg/ha and the organic materials were added to the soil accordingly. The irrigation water was given twice a week, each at approximately two hours (56.25 m^3/hour/ha). Weeding was carried out twice by hand and the application of insecticide (Azodrin) was made three times. The technique of growth analysis (Sestak et al., 1971) was used to measure the changes in growth of an aerial plant parts. The initial plant harvest was taken at day 21 after emergence and then followed by two-week intervals for the subsequent four harvests. At each harvest, fourteen plants were taken from each replicated plot except for the final seed yield, the number of plant samples used was forty plants. The plant materials were separated into stem plus petioles, leaves and pods. Leaf areas were measured using leaf area metre (Model no. AAC-400, Hayashi Denkon Co., Ltd. Tokyo, Japan). The plant parts were dried in a forced air oven at 80°C for 4 days and then weighed. The oven dried leaves were ground into meshes using a Wiley mill. The ground plant materials were analysed for the total nitrogen contents (Chapman and Pratt, 1961). The data obtained were statistically analysed.

Results and Discussion

Shoot, Leaf Dry Weights and Leaf Areas

With the four soybean cultivars, the results of shoot, leaf dry weights and leaf areas per plant due

to treatment were similar during the period from the initial harvest up to the fourth harvest. The results indicated that the soybean cultivars grown during the off season particularly cold season period did not respond to the organic materials and inoculated rhizobium added to the soil. Therefore, the data of the first three harvests are excluded, and only the data of the fourth and fifth harvests are included in this paper (Table 1). The soybean cultivars did not respond to the materials treated can be attributed to the short day photoperiod which was decreasing with time from October to December. Therefore the crop plants produced a similar amount of shoot growth. Short daylength induced premature flowering and gave less amount of growth was reported by a number of workers e.g. Hartwig (1954), Board and Hall (1984). Nevertheless, at the final harvest the effects due to

Table 1. Shoot dry weights per plant (gm) of soybean as influenced by organic manures and inoculation at day 63 (harvest 4) and day 77 (harvest 5) grown on an acid soil

Varieties	Treatments					
	0	City garbage compost		Cattle manure		Mean
		Uninoc.	Inoc.	Uninoc.	Inoc.	
			At day 63 after emergence			
SJ4	7.13	4.46	6.76	6.10	8.11	6.51
KKS23-1-6	4.52	7.28	6.45	5.56	5.95	5.95
KKS19-0-1	5.84	6.42	7.95	6.69	6.21	6.62
TGX536-02D	9.49	8.92	8.07	10.09	11.47	9.61
Mean	6.75	6.77	7.31	7.11	7.94	
LSD (0.05)	Variety = 2.39	Manure = 2.396			Variety × Manure = 4.793	
			At day 77 after emergence			
SJ4	7.61	4.19	9.31	8.26	14.82	8.84
KKS23-1-6	6.63	9.35	11.46	5.29	6.60	7.86
KKS19-0-1	7.34	7.57	15.36	10.81	10.98	10.41
TGX536-02D	9.76	9.04	13.60	13.55	13.53	11.90
Mean	7.84	7.54	12.43	9.48	11.48	
LSD (0.05)	Variety = 3.16	Manure = 3.16			Variety × Manure = 6.32	

treatment were found i.e. shoot and leaf dry weights and leaf areas per plant of the four cultivars were highest with rhizobium inoculated treatments. City garbage manure with inoculated rhizobium treatment gave the highest shoot growth followed by cattle manure with inoculated rhizobium treatment. The results suggested that rhizobium is required whenever soybean is to be sown. The results also indicated that this type of soil contents less amount of N necessary for growth. The differences in shoot growth between the city garbage manure plus inoculation and the cattle manure plus inoculation can be attributed to the differences in the amount of Ca composition in both organic materials which was greater for the city garbage manure than that of the cattle manure (on the dry weight basis, city garbage manure contents 15.46% Ca whilst cattle manure

contents only 1.84% Ca). The large amount of Ca with the city garbage manure could have promoted better activities of rhizobium than that of the cattle manure. The results confirmed the work reported by Lowther and Loneragan (1968). They have stated that nodulation, size and number of nodules are favoured by Ca. It is also possible that the value of soil pH was slightly raised up for better growth of the crop plants by the considerable amount of Ca added to the soil. The effect due to treatment was also found with the cultivars used i.e. the TGX 536-02D gave the highest shoot growth followed by the KKS 19-0-1 whilst the SJ4 and the KKS 23-1-6 were similar. The results suggested that the TGX 536-02D adapted well to this acid soil used and the KKS 19-0-1 ranked the second whilst the other two cultivars did less.

N Percentages, N Uptake, Pod Dry Weitht and Seed Yields.

The percentages of N in leaves of soybean cultivars, in most cases, were similar for all treated plants. However, N uptake was highest with the city garbage manure plus inoculation treatment. The results showed a similar trend to that of the shoot growth (Table 2). The results

Table 2. Leaf dry weights and leaf areas per plant of soybean as influenced by organic manures and inoculation at day 77 (harvest 5) grown on an acid soil

Varieties	Treatments					
	0	City garbage compost		Cattle manure		Mean
		Uninoc.	Inoc.	Uninoc.	Inoc.	
			Leaf dry weights (gm/plant)			
SJ4	0.42	0.30	1.00	0.83	1.14	0.74
KKS23-1-6	0.74	0.73	0.91	0.49	0.47	0.67
KKS19-0-1	0.92	0.84	3.35	1.64	1.70	1.69
TGX536-02D	1.54	1.45	2.43	1.62	1.58	1.72
Mean	0.91	0.83	1.92	1.15	1.22	
LSD (0.05)	Variety = 0.58		Manure = 0.58		Variety × Manure = 1.16	
			Leaf areas (cm^2/plant)			
SJ4	68	63	188	148	211	136
KKS23-1-6	154	167	186	76	114	139
KKS19-0-1	172	238	479	250	305	289
TGX536-02D	246	301	358	350	323	315
Mean	160	192	303	206	238	
LSD (0.05)	Variety = 116		Manure = 115		Variety × Manure = 231	

also indicated that the more the amount of N taken up by leaves of the plants the better the amount of shoot growth. The results agreed with the work reported by Watanabe et al. (1983) which they have stated that N accumulation by soybean plants (gm/plant) determined the amount of growth and seed yields, the larger the amount of N taken up by the crop plants the greater the amount of growth and seed yields (Table 3). Pod dry weights and seed yields/ha were also followed a similar trend to that of the shoot growth and total N in leaves. Seed yields were greater for the soybean plants treated with rhizobium inoculation than that of those without. The differences were large and statistically significant. Seed yields were 563, 629, 788 and 902 kg/ha for SJ4, KKS23-1-6, KKS19-0-1, and TGX536-02D, respectively (Table 4). From the regression calculations made, seed yields were correlated to (a) total N uptake in leaves ($y = 472.07 + 8.76X$, $r = 0.829^{**}$), (b) Shoot dry weights ($y = 292.99 + 43.86X$, $r = 0.703^{**}$), and (c) Leaf area duration ($y = 101.19 + 309.71X$, $r = 0.730^{**}$). These were highly significant. Therefore, to obtain high amount of seed yields, the soybean plants grown during the off season period must take up high amount of N to promote high amount of shoot growth, and to prolong life of leaves for longer duration of photosynthetic activities by retaining high value of leaf area duration throughout the life cycle of the plants. It is evidently found that seed yield/ha was rather low compared with those reported by Pookpakdi (1983) which was carried out in wet season. However, seed yields were much greater than those reported by the same reporter in dry season. The differences in seed yields during wet and dry seasons can be attributed to the small amount of growth in dry season resulted in a small value of maximum leaf area index (L). The highest values of L were 0.50 for SJ4, 0.73 for KKS cultivars and 0.8 for GTX 536-02 D.

Table 3 Percentages of N and N uptake in leaves of soybean as influenced by organic manures and inoculation at day 77 (harvest 5) grown on an acid soil

Varieties	Treatments					
	0	City garbage compost		Cattle manure		Mean
		Uninoc.	Inoc.	Uninoc.	Inoc.	
			Percentages of N			
SJ4	2.07	1.94	2.33	1.89	2.33	2.11
KKS23-1-6	2.28	2.05	2.50	2.55	2.38	2.35
KKS19-0-1	2.20	2.18	2.49	2.29	2.29	2.29
TGX536-02D	2.11	2.49	2.45	2.28	2.30	2.33
Mean	2.17	2.17	2.44	2.55	2.33	
LSD (0.05)	Variety = 0.24	Manure = 0.24			Variety × Manure = 0.47	
			Total N uptake (mg/plant)			
SJ4	17.99	6.40	23.51	7.58	28.44	16.78
KKS23-1-6	10.07	14.42	21.32	20.34	10.79	15.39
KKS19-0-1	35.97	18.47	84.69	20.85	39.50	39.90
TGX536-02D	33.44	36.86	40.92	59.43	36.44	41.42
Mean	24.37	19.04	42.61	27.05	28.79	
LSD (0.05)	Variety = 15.49	Manure = 15.49			Variety × Manure = 30.98	

Table 4 Pod dry weights at day 77 (harvest 5) after emergence and final seed yield of soybean at day 88 after emergence as influenced by organic manures and inoculation

Varieties	Treatments					
	0	City garbage	compost	Cattle	manure	Mean
		Uninoc.	Inoc.	Uninoc.	Inoc.	
			Pod dry weights (gm/plant)			
SJ4	5.90	3.09	6.74	5.84	11.15	6.54
KKS23-1-6	3.95	7.11	9.07	4.92	5.05	6.02
KKS19-0-1	7.33	5.47	9.27	5.15	7.44	6.93
TGX536-02D	6.74	5.97	9.83	8.77	9.82	8.22
Mean	5.98	5.41	8.73	6.17	8.36	
LSD (0.05)	Variety = 2.20		Manure = 2.20		Variety × Manure = 4.40	
			Seed vields (kg/ha)			
SJ4	453	383	614	581	785	563
KKS23-1-6	479	686	721	682	576	629
KKS19-0-1	625	521	1133	824	839	788
TGX536-02D	729	920	1028	933	900	902
Mean	572	628	874	755	755	
LSD (0.05)	Variety = 148		Manure = 166		Variety × Manure = 331	

The results indicated that the soybean cultivars failed to obtain a suitable value of L which should be in a range of 3-4. To increase the value of L the plant population/ha must be increased. Therefore, for this amount of growth the distances used between rows and within the row should be 30 × 10 cm, respectively. With these distances used the amount of seed yields/ha should reach 4,510 kg. An increase in the plant population density often increases seed yield due to high dry matter production was reported by Safo-Kantanka and Lawson (1980) and Siriprasert (1981).

Conclusions

Shortday photo-period during October-December affected shoot growth more than organic manures and inoculation. The four soybean cultivars produced a small amount of shoot, leaf dry weights and leaf areas particulary during the period from the initial harvest up to the fourth harvest. The effect due to treatment was found at the final harvest. Organic manures plus inoculation gave the highest amount of shoot, leaf dry weights and leaf areas, and the city garbage manure was the best followed by the cattle manure. City garbage manure contents much more Ca than that of the cattle manure, inoculation is most required whenever soybean in to be sown. The TGX 536-02D cultivar adapted well to the Yasothon acid soil and the KKS 19-0-1 ranked the second whilst the other two cultivars did less.

The percentages of N in leaves of the four cultivars were similar for all treated plants but the total N uptake was greater for those treated with manures and inoculation. The more the amount of N taken up by the plants the better the growth of shoot, pod and seed yield. Seed

yield was significantly related to total N uptake in leaves, shoot dry weights and leaf area duration.

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