Kasetsart J. (Nat. Sci.) 37 : 129 - 136 (2003)

Reduction of Chemical Application in Soybean at Farm Level I. Comparison between Two Wet Seasons Soybean Production

Aphiphan Pookpakdi and Nukul On-nim

ABSTRACT

The experiments were conducted in the farmer fields at Thongphaphoom district of Kanchanaburi province, Thailand in the year of 2000 and 2001. Soybean cultivar "Chakkrabhandhu no.1" were grown in the upland soil on 20 July 2000, and 20 July 2001 respectively. The harvesting dates for both experiments were in the first week of November.

Treatments composed of the combinations of chemical and non-chemical control for weed, insect and soil fertility designed as no chemical, less chemical and moderate chemical application. The given treatments were compared with farmer practices in which various kinds of chemical at different amounts were used in soybean production. Results of two experiments conducted revealed that yield of soybean in the year 2000 was higher than in 2001 due to less weed infestation. Biophoska organic fertilizer in less chemical treatment and triple super phosphate (TSP) in moderate chemical treatment were the main cause of high yield. To grow soybean successfully in the rainy season, herbicides were still needed. In both years of 2000 and 2001, insect infestation were mild, therefore the use of neem extract from *Azadirachta indica* A. as insect repellant seemed enough for controlling insects in soybean fields. This study indicated that in order to grow soybean in the rainy season, herbicides are still needed to suppress weed. Growth and yield of soybean can be enhanced by using organic fertilizer or TSP.

Key words: soybean production, reduction of chemical, on-farm trial

INTRODUCTION

An attempt to increase the production and yield of crops had resulted into the increasing amount of chemical application. Specifically, when crops are grown in monoculture system which may cause the accumulation of pests, diseases and reduction in soil fertility. Application of chemical pesticide and fertilizer may result in short term increase in crop yield. However, increasing the use of chemical in most crops cause the increase in production input, changing soil structure, increasing resistant to pest, disease and alter weed species in the field.

In soybean Jitsanguan *et al*. (2000) reported that the use of chemical application to control pests, diseases and weeds by farmers were tremendously high. The effects of increasing chemical pesticide not only increase the resistant ability of insect pest but also unnecessarily kill many natural enemy of insects. Therefore, the mechanism of natural control in crop pest could not be achieved.

Ratanarat (1999) mentioned in his report that soybean can be supplied with nitrogen through N_2 fixation, the most essential chemical for soybean is phosphorus which has been supplied through the soil. Therefore, the decreasing use of chemical

Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

Received date : 25/04/03 Accepted date : 30/06/03

fertilizer can be done through supplying only P_2O_5 to soybean as only chemical fertilizer.

The herbicide application may reduce weed infestation in soybean field tremendously. However species of weeds may be reduced after the heavy use of herbicide. Most of the left over species were difficult to control using chemical (Gazziero *et al.*, 1994). They suggested that combination of weed control should be used in order to achieve the effective control of weed and the reduction of chemical herbicide at the same time.

Production of soybean especially in the rainy season in Thailand requires heavy amount of chemical pesticide and fertilizer. Sooksathan and Pookpakdi (2000) reported heavy uses of herbicide, insecticide and urea fertilizer in soybean production by farmer at Kanchanaburi. Since research in the past had suggested the alternative ways of reducing chemical in crop plant, the objective of this study is to test for the possibility of reducing chemical in soybean production under the farmer field conditions.

MATERIALS AND METHODS

Soybean were planted in the farmer fields at Linthin Subdistrict of Thongphaphoom District in Kanchanaburi province which is located approximately 360 km. west of Bangkok. Soybean can be grown in the rainy and dry season. The total number of land grown for soybean was 12,225 rai (1,950 hectares) at Kanchanaburi as reported in 1998 (Pookpakdi *et al.*, 2000) The land cultivated for wet season soybean account for 85 percent of the total soybean growing areas in Kanchanaburi. At Thongphaphoom district, farmers grow soybean in the rainy season much more than those planted in the dry season. Rainy season soybean were grown in upland soil in mid July as the crop grown after sweet corn. Farmers used chemical fertilizer and pesticide tremendously. The yield obtained from rainy season soybean was 260 kg/rai (1,562 kg/ha).

The experiments were conducted in the farmer fields for two consecutive rainy seasons in the year 2000 and 2001. The site of the experiment was an upland with pH of 5.5 - 6.8. Soil textures were clay to clay loam. Organic matter of soil was between 3.3 - 4.4% , which is considerably high. Among the essential elements, potassium, calcium and magnesium were high to very high, the variation in nutrient element was phosphorus which range from 3-21 ppm. Soybean cultivar "Chakkra-bhandhu no.1" were planted in the randomized complete block experiment with three replications. Seeding rate when planting were 15 kg/rai (94 kg/ha) in both year. Each individual plot size were 1,600 sq.m. (1 rai) the experiment were treated as an on-farm trials therefore, each treatments were not necessarily located at the same farm. Four treatments were assigned as the different levels of weed control, insect control and fertilizer application classified as no, less, and moderate chemical applications (Table 1).

The experiments were planted on 20 July 2000 and 20 July 2001. The harvesting dates were November 3, 2000 and November 5, 2001 respectively. The crops were harvested totally for each individual plots, threshed and seeds were sun dried for 2-3 days. to obtain about 13 % seed moisture content. During crop growth, the evaluation of weed and insect infestation were conducted. After harvesting, the yield and yield components were collected, economic evaluation for the cost of input and net return were also evaluated.

RESULTS AND DISCUSSION

1. Growth and yield of soybean

Yield, number of pods per plant, number of seeds per pod and seed size of soybean grown in 2000 and 2001 were shown in Table 2. The results of the experiment conducted in the rainy season of both years revealed the following:

a. Yield

Yields of soybean in the year of 2000 was higher than in 2001. In both years, the lowest yield was obtained from treatment no.1 where non of the chemical was applied. However, in 2001 treatment 1 produced lowest yield due to weed infestation rather than insect attack (Tables 2 and 3, respectively) In year 2000, high yield were obtained in the treatments 2 and 3 in which the significant difference between them was not obtained

Table 1 Combination of chemical and non-chemical controls for weed, insect and soil fertility composing as treatments of different chemical reduction.

Treatment no.	Description	Weed control	Insect control	Fertilizer application
1.	No chemical application	None	Spraying with the extract of neems *Azadirachta indica* having azadirachtin of 625 g ai /ha	Seed dressed with peat inoculum containing *R. japonicum* (200g per 10-15 kg of soybean seeds.)
2.	Less chemical application	Fluazifop-p-butyl 15 g ai /ha + Formezafen 250 g ai /ha spray at 25 DAP	Triazophos 40% EC 1,000 g ai /ha spray at V1 growth stage	Inoculum containing with *R.japonicum* plus application of Biophoska organic fertilizer at 312.5 kg /ha
3.	Moderate chemical application	Alachlor 1875 g ai /ha as pre-emergence + Formezafen + Fluazifop-p-butyl at 25 DAP	Triazophos 40% EC 1,000 g ai /ha spray at V1 growth stage follow by IPM	Inoculum containing with *R. japonicum* plus application of triple super phosphate at 62.5 kg/ha
4.	Farmer practice	Different herbicides were used at irregular rates such as Paraquat as post-emergence herbicides and Alachlor as pre-emergence	Various chemical insecticide were used such as Monocrotophos 60 % EC 160 g ai /ha	Chemical fertilizer mostly 16-20-0 at 160 – 320 kg/ha or urea at 160 kg/ha

DAP = days after planting
V1 = growth stage (Fehr and Carvinass, 1977)
EC = Emusifiable concentrate
IPM = Integrated pest management

(P<0.05), while in the year 2001 the highest yield was obtained from treatment 3 where moderate amount of chemicals were used. In the farmer practice plots, yields of soybean were similar in both years of 2000 and 2001.

b. Yield component

Among the three yield components of soybean i.e. no. of pods per plant, no of seeds per pod and seed size, no of pods per plant contributed most to the yield of soybean. In the rainy season of 2000, the less chemical application treatment (treatment 2) which produced the highest yield per unit area had the highest no. of pods per plant (P<0.05) while in the rainy season of 2001, treatment no.3 where chemical were applied moderately produced the highest number of pods per plant and the highest yield. It can also be seen that the number of pods per plant in year 2001 were much less than those of year 2000 due to heavy weed infestation, especially at the early growth period due to heavy distribution of rainfall between July and August of 2001 (Figure 1).

There were no different in the number of

Table 2 Yield and yield components of soybean from the reduction of chemical experiments conducted in the rainy seasons of year 2000 and 2001.

Treatment no	Yield (kg/ha)		No. pods per plant		No. seed per pod		Seed size (g / 100 seeds)	
	2000	2001	2000	2001	2000	2001	2000	2001
1	1168.7	295.6	52.1	21.8	1.6	1.4	11.1	10.6
2	2450.0	1650.0	79.2	45.3	1.7	1.6	11.2	13.2
3	2350.0	2124.4	52.6	51.8	1.7	1.7	12.7	14.7
4	1525.0	1466.8	65.9	36.7	1.9	1.6	12.9	11.0
Mean	1873.4	1384.2	62.4	38.9	1.7	1.6	11.9	12.2
C.V. %	14.1	14.3	16.4	12.1	11.4	4.6	41	8.3
F – test	**	*	*	**	NS	NS	NS	**
LSD 0.05	529.3	394.3	20.4	9.4	-	-	-	2.1

Table 3 Dry weight of weed (g/sq m) as classified into the different morphological characteristics taken at R6 growth stage in the experiment conducted in 2000 and 2001.

Treatment no	Dry weight of weeds (g/sqm)							
	Broad leaf		Grass		Sedge		Total	
	2000	2001	2000	2001	2000	2001	2000	2001
1	39.3	63.8	20.0	22.5	19.0	31.4	78.3	122.7
2	10.7	64.5	4.3	1.2	-	11.7	15.0	77.4
3	8.7	9.1	-	75.7	-	16.0	8.7	100.2
4	-	28.7	-	5.02	-	21.6	-	100.5
Mean	14.6	41.5	6.0	37.4	4.7	20.2	25.5	100.2

*/ : In year 2000, farmers weeded their crops in the farmer practice plot (treatment no. 4) apart from using pre emergence and post emergence herbicides.

seed per pod in both years. The average number of seeds per pod were 1.7 and 1.6 respectively and there were no significant different among treatments in year 2000 and 2001. Seed size in soybean cultivar "Chakkrabhandhu no.1" was approximately 11.9-12.2 g/100 seeds as shown as the average seed size in Table 2. Seed size were similar in all treatments in both years. However, in year 2001 seed size were much less in treatments 1 and 4 where weed strongly suppressed the growth of soybean. Heavy infestation of weed caused the reduction in soybean growth particularly at the reproductive stage and this was the main reason for the reduction in seed size in treatments 1 and 4 in which chemical was not applied in the former treatment and the latter treatment was the farmer practice.

2. Weed infestation

As shown in Table 3 in which the dry weight of weed per sq m were taken in the experiments both years. Weed infestation was strong in year 2001 rather than the year 2000 especially during two months after planting (July and August) (Figure 1). In farmer practice plots, it has been a practice for farmers to hand weed soybean before flowering (36-40 DAP) regardless of what kind of herbicide they had used. In year 2001, heavy rainfall occurred few days after plantings prevented farmers to weed their soybeans before blooming. Therefore, hand weeding was not done in treatments 1, 2 and 3 of both years.

In Table 3, it appeared that weed still caused the problem in soybean grown in the rainy season of year 2001, no matter kind of herbicide used. Without the use of herbicide, tremendous amount of broadleaf, grass, and sedge predominantly took their spaces in soybean field and weed drastically reduced soybean growth and yield as seen in treatment 1. The use of Fluazifop-p-butyl+Formezafen and Alachlor plus Fluazifop-p-butyl+Formezafen controlled weed better in year 2000. However, where rainfall occurred heavily in year 2001 heavy rainfall and water logging

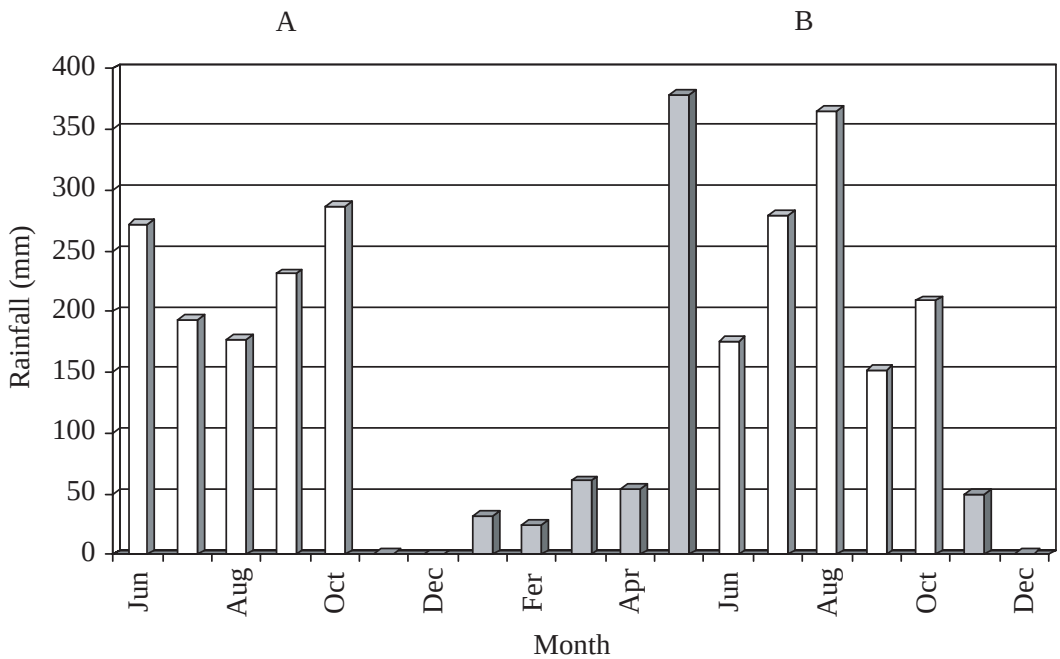

Figure 1 Amount and distribution of rainfall at Thongphaphoom District in the rainy season of 2000 (A), and in the rainy season of 2001 (B) during the growth period of soybean.

conditions reduced the effectiveness of weed control as seen in treatments 2 and 3 of the year 2001.

3. Insect infestation

As it can be seen in Table 4 that insect infestation was not the problem for soybean production at Thongphaphoom district of Kanchanaburi of both years where experiments were conducted. The use of spraying Triazophos only with the purpose of controlling bean flies (*Melanagromyza sojae* (Zehntner); *Ophiomyia phaseoli* (Tryon); *Ophiomyia centrosematis*) at V1 growth stage seemed sufficient in soybean production as it may be recommended as the less chemical reduction management for soybean growth at that locality. Only in treatment 1 of the trial grown in 2001 in which the score of insect attack was highest (4.35) neem extract was used as the mean of insect control. Since yield reduction did not obviously occured due to insect attack, it can be generally concluded that neem extract could be used as the organic insect control in the year where insect attack was not serious. However, close observation should be done in the near future into the fact that how much the organic repellant like neem extract can be used effectively in soybean production

White flies had been observed as one of the key pests of soybean at Thongphaphoom District. However in the year 2000 soybean virus disease had not been observed. While the virus disease had been found attacking soybean at R6 stage in year 2001. It may be possible that the causal vector for the disease might be white flies which had been found as one of the key soybean pest

4. Soil fertility

Although the soil analysis of samples taken from the experiments conducted in the year 2000 and 2001 had not been shown. It can be stated that the important components of soil analysis had not been changed very much during one growing season. For pH, there were 6.3 to 6.4 before and after cropping in year 2000 but reducing from 6.4 to 5.8 for the trial in 2001 respectively. The organic matter of soil before and after cropping were between 3.0-3.2 percents while phosphorus content (assessed by Bray II method) of the soils were between 18-27 ppm for the trials in both years. The treatments imposed in both experiments did not seemed to alter the values of pH, organic matter

Table 4 Insect infestation in soybean field (score 1-5) at R6 growth stage in the trial conducted in 2000 and 2001.

Treatment no.	Wet season 2000		Wet season 2001	
	Score 1/	Key pest 2/	Score	Key pest
1	1.50	white flies	4.35	soybean sting bug
2	2.66	white flies	0.85	soybean sting bug
3	1.00	soybean sting bug	0.65	soybean sting bug
4	1.00	white flies	1.65	soybean sting bug
Mean	1.54		3.17	

1/ Score of insect infestation 1 = non
2 = less
3 = moderate
4 = heavy
5 = heaviest

2/ White flies (*Trialeurodes vaporariorum* (Westwood)) soybean sting bug (*Riptortus linearis*(L.))

and phosphorus. Although the observation was made in treatment 3 where TSP at 62.5 kg/ha was given resulted in higher percentage of organic matter in the soil. This may be due to the stimulation of phosphate fertilizer to the crop biomass.

Even soil analysis failed to indicate the influence of Biophoska organic fertilizer and TSP as the factors contributing to the higher yield of soybean. It can not be fairly stated that those fertilizer did not influenced the growth and yield of this crop. Treatments 2 and 3 where the trial received Biophoska fertilizer and TSP applications gave the yield of 2,450 and 2,350 kg/ha in the experiment of the year 2000. In treatment no.3 of the year 2001 where the plot received 62.5 kg/ha of TSP, the highest yield of 2,124 kg/ha was obtained among the four treatments. Since the soil samples which had been taken for analysis was the composite samples of ten sub samples randomly collected per plot, the change in the components of soil analysis may not be detectable for a short period such as during one soybean growing season.

5. Cost of input and return

Table 5 showed the cost of input, gross and net income of soybean production under different chemical reduction treatments when grown in the year of 2000 and 2001. As it can be seen that the input cost in treatments 2,3 and 4 were similar in the year 2000 which were between 11,000-12,000 baht/ha. In the year 2001 the input cost in treatment 4 were slightly less than in treatment 2 and 3 due to the reducing amount of chemical fertilizer used. However, the input cost of treatment 1 in both years 2000 and 2001 were less due to the total reduction of chemical use in such treatment.

In year 2000, gross and net returns of soybean production in treatments 2 and 3 were highest due to the increase in soybean yield. Likewise, the gross and net returns of treatment 3 were highest in year 2001 due to the yield which was highest among all treatments. The yield in treatment 2 in year 2001 was not high due to weed infestation, therefore gross and net returns of soybean were not high also.

Gross income and net returns of soybean in treatment 1 were low in both years due to weed infestation. In treatment 4, farmer failed to obtain good soybean growth and net income due to their high cost of production and yield was also low.

CONCLUSION

On-farm experiments were conducted in the rainy season of years 2000 and 2001 with the objective of studying for the possibility of reducing chemical applications in soybean. The trials were conducted in the actual farm condition and the treatments given were subjected to the real conditions of pest, weed and soil heterogeneity.

Table 5 Cost of input, gross and net incomes per hectare basis of soybean when planted under chemical reduction trial in years 2000 and 2001. (unit : baht/ha.)

Treatment	Wet season 2000			Wet season 2001		
no.	Input cost	Gross income	Net return	Input cost	Gross income	Net return
1	9,937	12,275	2,338	6,343	3,300	-3,043
2	11,393	24,412	13,019	13,231	18,218	4,987
3	12,318	24,675	12,357	13,850	23,375	9,525
4	12,193	16,012	3,819	9,606	16,156	6,550
Mean	11,460	19,343	7,883	10,757	15,262	4,504

Note : the cost of soybean grain at 13% seed moisture content were 10.50 baht/kg in 2000 and 11.00 baht/kg in 2001.

The individual plot was as large as 1,600 sq m to practically calculate the economic input and return.

The yield of soybean in year 2000 were higher than in 2001 due to less weed infestation. The highest yield in both years was due to Biophoska organic fertilizer and TSP. To achieve a considerable yield of soybean in the rainy season, herbicide was still needed apart from fertilizer. In both years insect infestation were mild, therefore, the use of neem extract as insect repellant seemed ample for controlling insects.

Treatment received the highest yield also gave the highest net return. In the treatment of moderate chemical application (treatment 3) of year 2000, the net return was higher than those of the same treatment in year 2001 due to less weed infestation. The input cost of the treatments where Biophoska or TSP were applied, were similar in years 2000 and 2001. For farmer practice plot, the input cost was high because different kinds and amount of chemical that farmer had used.

The result of this study can be concluded that in order to grow soybean in the rainy season, chemical such as herbicides are needed to suppress weed. The growth and yield of soybean can be enhanced by using Biophoska organic fertilizer or TSP.

LITERATURE CITED

Fehr, W.R. and C.E. Caviness 1977. **Stages of soybean development**. Iowa State A.R.S Special Report 30.

Gazziero D.L.P., D. Karem and E. Voll. 1994. Weed control, pp 123-130 *In* **Tropical Soybean Improvement and Production**, Brazilliam Agricultural Research Enterprise, National Soybean Research Center (EMBRAPA-CNPS.) FAO, Rome, Italy.

Jitsanguan T., B. Masaeng, B. Sootsukhon, D. Sookkamnerd and W. Leesaenboonchai. 2000. **The Preliminary Study Report on Research and Development in Sustainable Agriculture**. Department of Agricultural Economic and Resources. Faculty of Economic. Kasetsart University, Bangkok, 368 p (in Thai)

Pookpakdi A., I. Sooksathan, T. Arayangkul, N. Potan, S. Suthipradit and T. Kewrum 2000. **Final Report of the Project on "An Increase in Soybean Yield and Farmer's Income through On-farm Testing**. Thailand Research Fund 31 December 2000. 206 p.

Ratanarat S. 1996. **Ways of soil improvement and fertilizer application in soybean and ground-nut**. Report of the technical seminar on "Upland soil management and fertilizer application based on soil analysis to increase the yield and production of field crops". Soil fertility and fertilizer of upland crop research group, Division of Soil Scrence, Department of Agriculture, Bangkok 232 p. (in Thai)

Sooksathan I. and A. Pookpakdi. 2000. The increase in yield and income of soybean farmers through an on-farm research. I Agro-ecoanalysis and production constraints of soybean production in central plain of Thailand, pp. 150-159. **Proceedings of The 38th Annual Technical Conference of Kasetsart University** 1-4 February 2000.