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Reduction of Chemical Application in Soybean at Farm Level : II Comparison between Wet and Dry Seasons Planting

Aphiphan Pookpakdi and Nukul On-nim

ABSTRACT

A comparison study was conducted for soybean production in the rainy season at Thongphaphoom district and in the dry season at Nongprue district of Kanchanaburi province in the year of 2001 to 2002. The objective of the study was to seek for the possibility of reducing chemical applications in soybean. Treatments were composed of the chemical and non-chemical control for weed, insect and soil fertility designed as non, less chemical and moderate chemical applications. The given treatments were compared with farmer practices in which various kinds of chemical at different amounts were used in soybean production.

This study was an on-farm research conducted in the farmer field where the treatments were subjected to the actual conditions of pest, weed and soil heterogeneity. Soybean cultivar "Chakkrabhandhu no.1" was grown in the upland soil on 20 July 2001 in the rainy season trial while the same variety was planted in the paddy field after rice in the dry season on 20 December 2001. Results of the experiments revealed that the yield of soybean crop grown in the wet season was lower than those of the dry season. The main factor reducing yield in both trials were weed infestation. Weed growth in the rainy season was mainly broadleaves while in the dry season the main weed infestation was volunteer rice. In both trials, insect infestation were mild, therefore, the use of neem extract seemed enough for controlling insect pests in soybean fields.

In both experiments, it was found that the application of triple super phosphate (TSP) at 62.5 kg/ha increased the yield of soybean to the highest level among other treatments. While the biophoska organic fertilizer raised the yield to the second highest level in both trials. It can be concluded in this study that for growing soybean successfully in the rainy season, post emergence herbicides such as Formezafen plus Fluazifop-p-butyl and the application of triple super phosphate were needed. However, to grow soybean successfully in the dry season, the triple super phosphate or biophoska alone was sufficient for increasing yield of soybean grown after rice.

Key words: reduction of chemical, on – farm trial, soybean

INTRODUCTION

In Kanchanaburi province, soybean can be planted in both rainy and dry seasons. In 1998, the planted areas of soybean in the rainy season was 1,664 hectares while the areas for dry season soybean cultivation was only 292 hectares (Pookpakdi *et al.*, 2000).

When soybean was planted in the rainy season, they were grown in the upland areas with no irrigation. Corn (*Zea mays* L.) was grown in the same field prior to soybean in Thongphaphoom

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

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district. Soybean was usually planted in the middle of the rainy season around the third week of every year.

In Nongprue district, approximately 62 km., north of Kanchanaburi city, soybean was planted after rice forming rice-soybean cropping system. In that particular area, the crop was planted in the paddy field immediately after the harvesting of rice. Soybean was grown in the former rice field using the method of rice stubble culture (Pookpakdi, 2002). Irrigation was given by surface irrigation scheme or shallow wells which was scattered in that particular areas.

Since Thongphaphoom and Nongprue districts were both located in Kanchanaburi province and the former district cultivated most of the soybean in the rainy season while the latter planted soybean in the dry season. The project on "An increase in soybean yield and farmer's income through on-farm testing" which operated by Kasetsart University and financially supported by Thailand Research Fund (Pookpakdi *et al.*, 2000) was interested in establishing the seed production program under the village level where the soybean cultivar "Chakkrabhandhu no.1" can be multiplied and produced as seeds of high quality in the rainy and dry seasons. Therefore, the project had expanded the research areas from Thongphaphoom into Nongprue districts in 2001.

The objective of this study was to investigate the possibility of reducing chemical in soybean production under the farmer field condition in both rainy and dry seasons planting at Kanchanaburi province. This research paper is the continuation of the finding formerly described by Pookpakdi and On-nim (2002) when the study was initiated in July 2000.

MATERIALS AND METHODS

1. Duration of crop growth

Soybean was planted in the farmer fields at Thongphaphoom district in the rainy season of 2001, and at Nongprue district in the dry season of 2001 – 2002. Planting dates for the rainy season trial was 20 July 2001 and for the dry season was on 20 December 2001. Harvesting dates for the rainy season and dry season soybean were 5 November 2001 and 4 April 2002 respectively.

2. Soil fertility

In the rainy season at Thongphaphoom, the site of the experiment was an upland with pH of 5.5 – 6.8. Soil texture was clay to clay loam. Organic matter of soil was between 3.3 – 4.4% which is considerably high. Among the essential elements, K, Ca and Mg were high to very high, the variation in nutrient element was P which ranged from 3 – 21 ppm.

At Nongprue district where soybeans were planted in the dry season, the site of the experiment was lowland paddy with pH of 5.6 – 6.8. Soil textures were clay loam to silt loam. Organic matter of the soil was between 2.3 – 3.4%. Among the essential elements, P was considered low to medium ranging from 9 – 15 ppm., K was between 92 – 123 ppm. which is considered medium to high, while Ca and Mg were high to very high.

3. Planting procedures

The experiments conducted at Thongphaphoom in the rainy season and in Nongprue in the dry season having a randomized complete block as the statistical design with three replications. Soybean cultivar "Chakkrabhandhu no.1" was used in both experiments. The seeding rate was 15 kg/rai (94 kg/ha) in both trials. In the rainy season planting, the field were ploughed twice and harrowed once before soybean were planted in rows with the distance between rows and between hills of 50 × 20 cm, 4 – 5 seeds were dropped in each hill and later thinned to single plant per hill immediately after emergence.

For dry season planting, soybean was sown in the paddy fields using the method of soybean planting in rice stubble as described by Pookpakdi

(2002). Planting was done 2 weeks after rice had been harvested. At planting the stubble of rice was cut with lawnmower to the ground level and seeds of soybean were planted underneath the stubble with hand digger making holes approximately 45° to the ground level. Seeds of soybean cultivar Chakkrabhandhu no.1 were dropped to the hole using 4 – 5 seeds per hill, they were also thinned to one plant per hill upon emergence. Since rice which grown prior to soybean was transplanted using the spacing of an equidistance of 25 cm, soybean plants were sown at the same spacing. The holes in which the soybean were planted were not covered, immediately after planting, rice straw was used to mulch the entire areas to conserve soil moisture and inhibit weed growth.

In the rainy season, the individual plot size was 1,600 sq m (1 rai) while in the dry season planting, individual plot size was according to each paddy size which was completely surrounded by the bun. Each paddy size range between 400 – 600 sq m and it was considered as individual plot size.

4. Treatments

Three treatments was assigned according to the combination of weed control, insect control and fertilizer application as no, less and moderats rates of chemical application. They were compared with the fourth treatment which was the farmer practice (Table 1).

5. Crop management and data gathering

Both experiments were very well taken care. At harvesting, the soybean plants were harvested for each individual plot, threshed and seeds were sun dried for 2 – 3 days to obtain 13 % seed moisture content.

During crop growth, weed and insect infestation were evaluated. After harvesting, the yield, yield components were collected, economic evaluation for the cost of input and net return were also obtained.

RESULTS AND DISCUSSION

1. Yield and yield components of soybean

Seeds yield, number of pods per plant, number of seeds per pod and seed size of soybean grown in the rainy season at Thongphaphoom district and also in the dry season of Nongprue district were shown in Table 2. The results of the experiments conducted revealed the following:

a) Yield

The yield of soybean in the dry season was higher than that grown in the wet season at Kanchanaburi province. Two obvious reasons were used to explain the difference in yield of the two trials. Firstly, very high amount of rainfall in the wet season often caused waterlogging conditions to the plot imposing the difficulty for drainage (Figure 1). Secondly, higher rainfall stimulated the growth and infestation of weed to be heavier than those of the dry season. When soybeans were grown in the dry season, the farmers irrigated the plots and drained the water afterward when necessary. On the other hand, slight amount of rainfall which occurred throughout the month of March 2002, when soybean reached the seed development and seed filling stages also stimulated good condition for seed filling and high yield was obtained (Figure 1). In the experiment conducted in the rainy season, the lowest yield was obtained from the treatment where none of the chemicals were applied. Likewise, in the dry season experiment at Nongprue, treatment 1 where none of the chemical was applied and treatment 4 of the farmer practices gave low yield as compared to treatments 2 and 3. Low yield in treatment 1 was due to weed infestation while in treatment 4 it was due to weed infestation and also the planting management done by farmers which resulted in ununiform stands in some paddy.

b) Yield components

In both trials conducted in the rainy and dry seasons, the number of pod per plant contributed most to the yield of soybean. Treatment 3 in which

the yield of soybean were highest in both trials, the number of pod per plant were also highest at that particular treatment. As it has been mentions that low yield was caused by weed infestation and poor crop management in treatments 1 and 4, the number of pods per plant at those treatments were also low and the difference was significant from other treatments ($P<0.05$).

Table 1 Combinations of weed control, insect control and fertilizer application composing as treatments in the experiment.

Treatment no.	Description	Weed control	Insect control	Fertilizer
1.	No chemical application	none	Spraying with the extract of neems *Azadirachta indica* A. having azadirachtin of 625 g ai/ha	Seed dressed with peat inoculum containing *R.japonicum* (200g per 10-15kg of soybean seeds.)
2.	Less chemical application	Fluazifop-p-butyl 15 g ai/ha + Formezafen 250 g ai/ha spray at 25 DAP	Triazophos40% 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 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 rate such as Paraquat as post-emergence herbicide and Alachlor as pre-emergence	Various chemical insecticide were used such as Monochrotophos 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
EC = Emusifiable concentrate
V1 = growth stage (Fehr and Carviness, 1977)
IPM = Integrated pest management

Weed infestation caused the reduction in number of seeds per pod and seed size in both experiments. The number of seeds per pod in treatment 1 was lower significantly than other treatments in the rainy season, while in the dry season, the number of seeds per pod were significantly lower in treatments 1 and 4 ($P<0.05$) than in treatments 2 and 3. Seed size of soybean in both trials followed the same trend as the number of seed per pod.

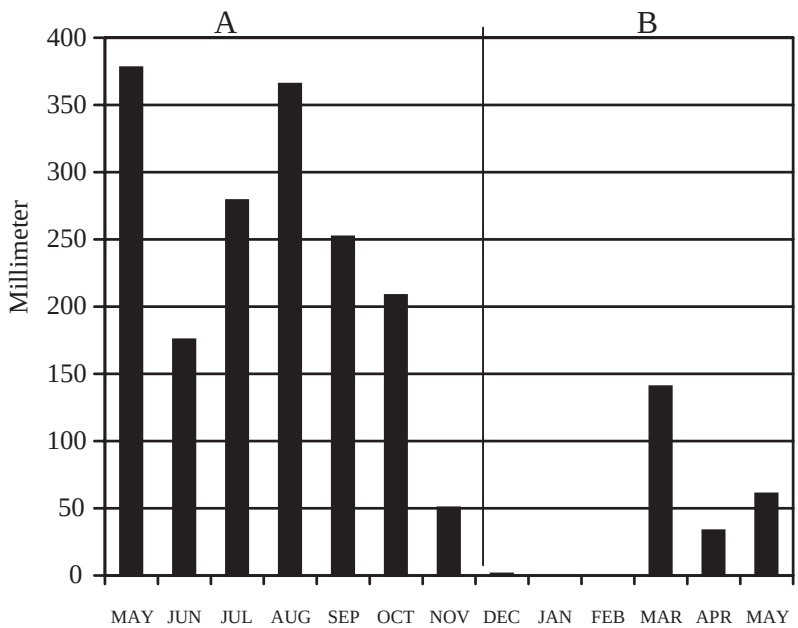

Figure 1 Amount and distribution of rainfall at Thongphaphoom district (A) and Nongprue district (B) during the experimentations.

Table 2 Yield and yield components of soybean grown in the rainy season, 2001 at Thongphaphoom district and in the dry season, 2001/02 at Nongprue in Kanchanaburi province.

Treatment no.	Yield (kg/ha)		No.pods per plant		No.seeds per pod		Seed size (g/100 seeds)	
	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
1	295.9 c	1645.8 c	21.6 c	48.0 abc	1.39 b	1.62 b	10.6 b	12.5 b
2	1650.4 b	2041.7 b	45.3 ab	53.9 ab	1.62 a	1.71 ab	13.2 a	13.3 ab
3	2124.7 a	2520.8 a	51.8 a	56.7 a	1.76 a	1.89 a	14.7 a	13.6 a
4	1467.4 b	1547.9 c	36.7 b	43.0 c	1.65 a	1.47 b	10.9 b	11.3 c
Mean	1384.6	1939.0	38.8	50.4	1.60	1.67	12.3	12.7
C.V.%	14.26	8.76	12.10	8.11	4.67	8.03	8.35	4.34
F-test	*	*	*	*	*	*	*	*
L.S.D.0.05	63.1	54.3	9.4	8.2	0.15	0.27	2.06	1.10

2. Weed infestation

Table 3 showed the dry weight of weeds infested in soybean field at V4, R2 and R8 growth stage (Fehr and Caviness, 1977) of the experiment grown in the rainy season 2001 at Thongphaphoom and dry season 2001/02 at Nongprue districts respectively. Table 4 also showed dry weight of weeds (g/sq m) as classified into different morphological groups of those particular experiments.

As reported earlier by Pookpakdi and Onnim (2002), it was found that weed infestation was strong in the rainy season of 2001 especially during the two months after planting (July and August 2001) (Figue 1). In the farmer practice plots, (treatment no.4) it has been a usual practice for farmers to hand weed soybean before flowering (36-40DAP) regardless of what kind of herbicide they had used. In the rainy season of 2001, heavy rainfall which occured in July and August prevented farmers to weed their soybean before blooming. On the contrary, hand weeding were not done in treatments 1, 2 and 3.

The dry weight of weeds infested in soybean field as reported in Table 3 also showed that weed infestation was high in the rainy season in treatment 1 due to no weed control measure was imposed, while in the treatment 4, it was due to unproper crop management. However, in treatments 2 and 3, post emergence herbicides such as Formezafen plus Fluazi fop-p-butyl and pre plus post emergence herbicides such as Alachlor followed by Formezafen plus Fluazifop-p-butyl could controlled weeds effectively and there were no significant different in weed dry weight in treatments 2 and 3. Weeds in the rainy season soybean field were mainly broadleaves (Table 4)

In dry season at Nongprue district, weed infestation was rather mild when compared with those planted in the rainy season of 2001 (Table 3). While, treatments 1 and 4 had heavier weed infestation particularly at R2 and R8 (Fehr and Caviness, 1977) than those of treatments 2 and 3. Most weed which infested heavily in treatments 1 and 4 were the volunteer rice seedlings (Table 4). Weed control management as they were imposed in Table 2 and 3 were considered very effective in soybean planting in dry season since very small amount of broadleaves, grasses and sedges were found in those fields in dry season soybean field.

Table 3 Dry weight of weeds infested in soybean fields at V_4, R_2 and R_8 growth stages when grown in the rainy season, 2001 at Thongphaphoom district and in the dry season, 2001/02 at Nongprue district of Kanchanaburi province.

Treatment no.	Dry weight of weeds (g/m^2)					
	Rainy season 2001			Dry season, 2001/02		
	V_4	R_2	R_8	V_4	R_2	R_8
1	115.60 a	150.10 a	427.00 a	17.05 a	131.19 a	192.99 a
2	12.84 b	9.38 c	6.38 b	7.06 b	14.21 c	27.47 b
3	10.50 b	6.50 c	2.08 b	19.87 a	6.38 c	13.04 b
4	17.19 b	57.74 b	73.57 b	20.90 a	88.10 b	220.89 a
Mean	30.03	55.93	127.26	16.22	59.97	113.60
C.V.%	19.02	35.23	34.49	20.10	26.95	18.19
F-test	*	*	*	*	*	*
LSD 0.05	14.83	39.36	87.71	6.51	32.29	41.27

Table 4 Dry weight of weeds (g/sq m) as classified into the different morphological characteristics taken at V_4, R_2 and R_8 growth stages in the experiment conducted in the rainy and dry seasons at Kanchanaburi province.

A. Rainy season, 2001 at Thongphaphoom district

Treatment	Broadleaf			Grass			Sedge		
No.	V_4	R_2	R_8	V_4	R_2	R_8	V_4	R_2	R_8
1	70.41	85.74	288.54	18.97	25.41	100.51	25.53	38.90	37.97
2	3.11	4.41	3.80	8.55	3.11	1.91	3.04	1.85	0.67
3	4.90	2.44	0.80	4.90	2.20	0.16	0.70	1.85	1.12
4	3.00	16.76	55.38	3.50	5.37	1.50	10.48	35.61	16.69
Mean	20.36	27.34	87.13	8.99	9.02	26.02	9.94	19.55	14.11

B. Dry season, 2001/02 at Nongprue district

Treatment	Broadleaf			Grass			Sedge		
No.	V_4	R_2	R_8	V_4	R_2	R_8	V_4	R_2	R_8
1	3.81	31.38	47.31	10.88	95.37	120.41	2.36	4.44	25.27
2	1.43	3.50	10.82	4.26	8.98	11.29	1.38	1.74	5.37
3	8.08	2.34	5.04	9.77	2.48	5.34	2.01	1.56	2.65
4	4.62	21.28	50.74	13.38	60.34	164.62	2.61	6.48	12.65
Mean	4.49	14.62	28.48	9.65	41.79	75.42	2.09	3.55	11.49

3. Insect infestation

Table 5 showed the score of insect infestation in soybean fields when grown at Kanchanaburi province. As it was shown in Table 5, insect infestation was mild in soybean fields when grown in the rainy and dry seasons. In the rainy season of 2001, the only insect problem in soybean at vegetative stage were aphids (*Aphis glycines* Matsumura) in which the spraying of neems extract from *Azadirachta indica* could not control them effectively. In the later growth stage insect infestation was considered very mild. Similarly, in the dry season planting, the insect infestation was also mild in treatments 1, 2 and 3. In the farmer practices, insect control was not effective and infestation was high in both vegetative and reproductive growth. During the vegetative growth (V1-V4) the infestation of beanflies and aphids were heavy, while soybean sting bugs were found numerously at R6-R8 (Fehr and Caviness, 1977) growth stages.

4. Soil fertility

Although the soil analysis of samples taken from the experiments conducted in the rainy and dry seasons had not been shown, it can be stated that the important components of soil analysis had not been changed very much during one crop growing season. However the yield data reflected the response of soybean crops to soil fertility treatments much clearer. In both trials, treatment 3 in which the triple super phosphate (TSP) was

Table 5 Insect infestation in soybean field (score 1-5)[1/] at V_4, R_2 and R_8 growth stages in the experiments conducted in the rainy and dry seasons at Kanchanaburi province in 2001.

Treatment no.	Rainy season, 2001 growth stage			Dry season, 2001/02 growth stage		
	V_4	R_2	R_8	V_4	R_2	R_8
1	4.3	2.6	3.0	2.5	1.0	1.6
2	1.1	1.0	1.0	1.4	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0
4	2.5	1.7	1.6	4.1	1.0	4.5
Mean	2.2	1.6	1.7	2.3	1.0	2.0

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

Key pest : V_4 bean flies : *Melanagromyza sojae* (Zehntner)
aphids : *Aphis glycines* Matsumura
R_2 white flies : *Trialeurodes vaporariorum* (Westwood)
leaf roller : *Adoxophyes privatana* (Walker)
R_8 soybean sting bug : *Riptortus lincaris* (L.)

applied to the soil, it could raised the yield up to 2,124 and 2520 kg/ha respectively. The difference in yield in treatment 3 was significantly different from those of other treatments ($P<0.05$). The application of Biophoska organic fertilizer increased the yield of soybean up to 77 and 80 percents of the highest yield in both trials in the rainy and dry seasons respectively (Table 2).

5. Cost of input and return

Table 6 showed the cost of input, gross and net income per hectare from soybean trials grown in the rainy season of 2001 at Thongphaphoom district and in the dry season 2001/02 at Nongprue district of Kanchanaburi province. It was shown in Table 6 that the cost of input in the rainy season soybean was slightly less than those of the dry season while the net return of the dry season planting was slightly higher than those of the rainy season soybean. The cost of input in the dry season planting which was considered higher than those of the wet season was due to the labour cost used in planting. However, since the yield of soybean in the dry season was higher than those of the rainy season, the net return from the dry season planting was higher than those of the wet season.

In Table 6, as it was shown that the net return of soybean grown in treatment 1 of the rainy season planting was –3043 baht/ha which was considered as loss. The loss in net return from that particular treatment was due to the poor yield resulted from weed infestation in the rainy season. There was no weed control measured in treatment 1. For the dry season planting, eventhough there was no weed control measured in treatment 1 the straw mulching gave a considerable protection of soybean crop from weeds. Therefore, in treatment1, even the trial did not receive any chemical control for weed, the yield of 1645.8 kg/ha was still obtained.

Table 6 Cost of input, gross and net income per hectare from soybean trials grown in the rainy season, 2001 at Thongphaphoom district and in the dry season, 2001/02 at Nongprue district of Kanchanaburi province.

Treatment	Rainy season, 2001			Dry season, 2001/02		
No.	Input cost	Gross income	Net return	Input cost	Gross income	Net return
1	6,343	3,300	-3,043	11,606	16,925	5,856
2	13,231	18,218	4,987	13,112	21,050	7,937
3	13,850	23,375	9,525	15,643	25,943	10,300
4	9,606	16,156	6,550	9,875	15,962	6,087
Mean	10,757	15,262	6,026	12,559	19,970	7,545

Note : The cost of soybean grain at 13% seed moisture content were 11.00 baht/kg in the rainy season of 2001 at Thongphaphoom and 10.50 baht/kg in the dry season of 2001/02 at Nongprue

In the dry season planting, the best and the second best treatments for the yield of soybean were treatment 3 and 2 respectively. Likewise, the best net return obtained in the dry season planting came from treatment 3 where TSP was given followed by treatment 2 where the organic fertilizer, Biophosha, was applied. In the wet season planting, treatment 3 and 2 were the best and the second in yield performance. Therefore the net return of the treatment 3 and 2 ranked highest and the second to the highest also. However, the yield of the crop in the rainy season was lower than those of the dry season, the net return from rainy season planting was also lower than those of the dry season.

CONCLUSION

A study was made to compare between the soybean planting in the rainy and dry seasons at Thongphaphoom district and Nongprue district of Kanchanaburi province in the year of 2001 towards 2002. The study was an on-farm research with the objective of studying for the reduction of chemical applications in soybeans. The trials were conducted in the actual conditions of pest, weed and soil heterogeneity.

The result of the study revealed that yield of soybean planted in the wet season was lower than that in the dry season. Yield reduction mainly came from weeds in which weed growth was more of the broadleaves in wet season and grasses which was mainly the volunteer rice in the dry season. The application of rhizobium inoculation plus TSP of 52.5 kg/ha gave the highest yield both in the rainy and dry seasons while the application of rhizobium inoculation plus Biophoska organic fertilizer gave the second highest yield of 1650 and 2041 kg/ha in the wet and dry seasons respectively.

In the trials conducted in both rainy season and dry season of year 2001-2002, insect infestation was considered mild and the use of neem extract from *Azadirachta indica* as an insect repellent was effective in controlling insects. In order to maintain the yield level of soybean, only combination of Formezafen + Fluazifop-p-butyl can be used as herbicides in the wet season plus the application of 10 kg/ha of triple super phosphate. For the dry season soybean planting, the only use of triple super phosphate is sufficient as the only chemical applied. There was no need to apply any herbicide or insecticide at all for the dry season soybean.

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