CHAPTER 5

RESULTS OF FIELD EXPERIMENT

5.1 Field experiment and climatic conditions

The research was conducted between August and December 2002 at the Irrigated Agricultural Research Station of the Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand.

The soil at the experimental site was classified as a sandy clay loam. The results of analysis of the main soil characteristics to a depth of 20 cm are summarized in Table 6. The soil at the site was moderately acid with a pH of about 5.8. Organic matter content was low at 1.02 %. Soil nitrogen content at 0.06 % was moderate.

Table 6. Soil characteristics at experimental site.

Indicator	Average	SD
pH	5.84	0.119
OM (%)	1.02	0.229
N (%)	0.06	0.014
P_2O_5 (ppm/100 g soil)	46.47	8.600
K_2O (ppm/100 g soil)	49.33	4.933

Source: MCC. Soil Analysis Laboratory, 2002.

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The climate of Chiang Mai is monsoonal with distinct wet, cool and hot seasons. During the five-months period of the field study, total rainfall at the experimental station was 932 mm, (covered by 55.5 % of total rainfall), with the month of heaviest rainfall being September (281 mm). The temperature during the same period was ranged between 21.9 °C. to 31.7 °C, with an average 26.8 °C. The

period critical weed control in maize and soybean corresponds with the month of heaviest rainfall at the mid of September (Figure 11).

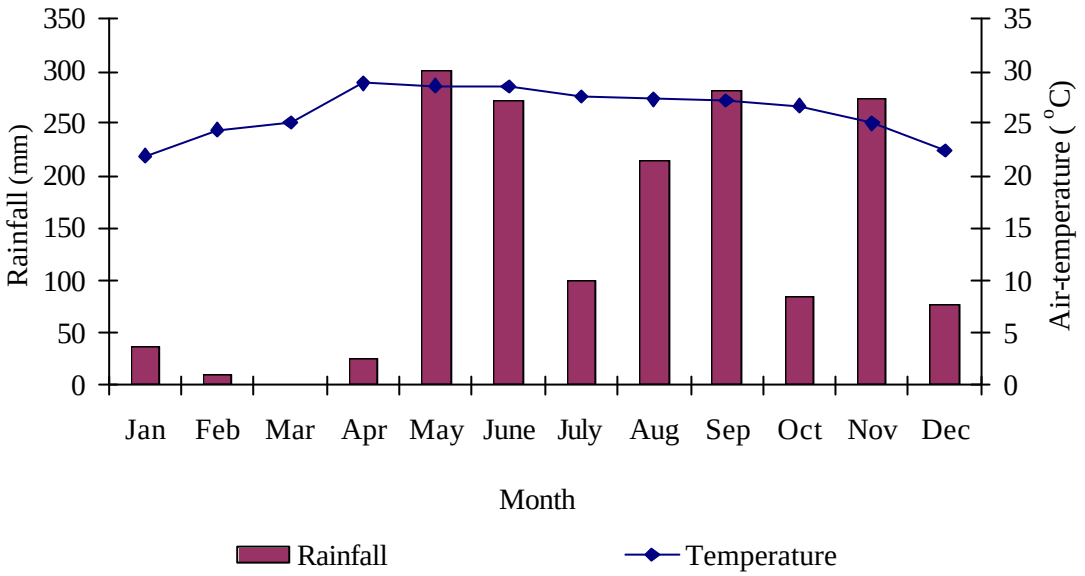

Figure 11. The mean of rainfall and air temperature.
Source: Irrigated Agriculture Research Station of MCC, 2002.

5.2 The response of weed control in maize and soybean intercrops

Table 7, summarizes the results of analysis of variance for weed population density, total dry matter weight of weeds, and labor use for weeding. There were statistically significant differences for weed population density (WPD), total dry matter of weed (TDMW) and labor days (Ld) ($p<0.01$) for each of main treatment effects time of weeding (B) and the maize/soybean intercrop treatments (C).

There was also all significant B*C interaction for weed density, weed dry matter and labor days ($p<0.01$). Labor input was significant for all treatments (but at the 0.05 level for the intercrop treatments) and for the interaction. Weed all of indicators were observed for time of weeding when the maize was a growth stages; V4, V8, and V12 of maize leaves.

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Table 7. Analysis of variance for overall weeds in experimental variables.

Source of variation	Level of significance (F test)		
	WPD	TDMW	Ld
Replication (A)	ns	ns	ns
Timing of weeding (B)	**	**	**
Maize/soybean intercrop (C)	**	**	*
Interaction (B*C)	**	**	**
CV (%)	14.8	31.6	9.3

WPD = weed population density; TDMW = total dry matter of weeds; Ld = labor days; ns = not significant; * significant at 0.05 probability level; ** significant at 0.01 probability level.

5.2.1 Weed population density

Weed population density was measured and calculated from two 50 x 50 cm quadrate samples in each treatment plot. The weed population density for each of the weeding treatments and their respective interactions is illustrated in Figure 12.

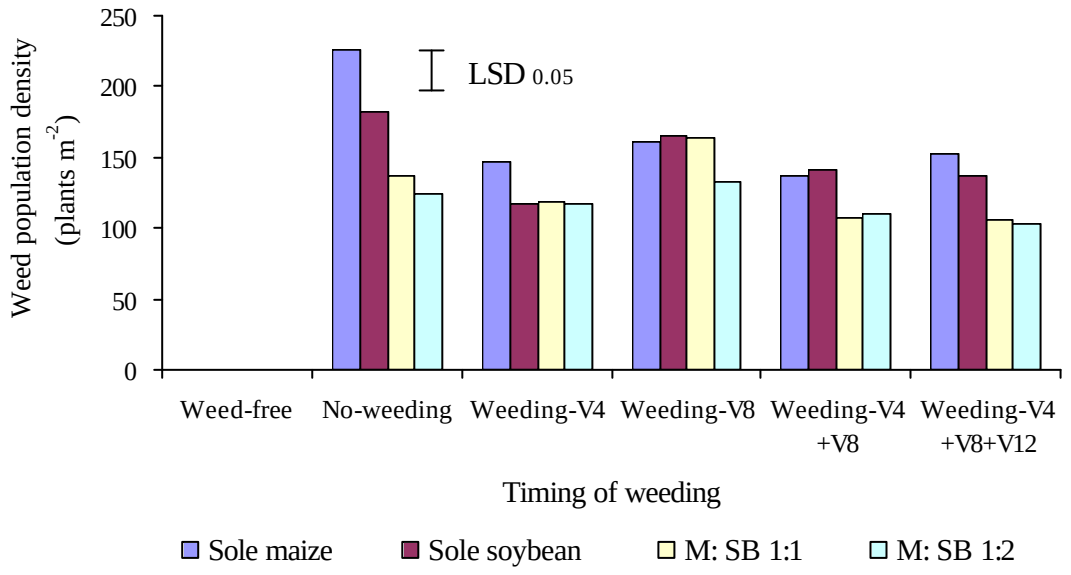

Figure 12. Weed population density in different weeding treatments.

Generally, the weed population was greatest in the single cropping treatments, with that for sole cropped of maize being significantly greater than for sole cropped soybean in the no-weeding treatments. Both the intercropping treatments (M: SB 1:1 and M: SB1: 2) had a very marked impact in suppressing weed growth even in the no-weeding treatment.

The weed population density in each of these two treatments were 39.2 % and 44.7 %, respectively, lower than the weed density in the sole maize crop, and 24.7 % and 31.5 % respectively, lower than weed density in the sole soybean crop. The sole soybean crop had a 19.2 % lower weed density than the sole corn crop in the no-weeding treatment.

Among the different weeding treatments, generally the intercrop treatments the weed density was significantly lower for the intercrop treatments, with there being relatively little difference between the two intercrop treatments. Further, there was little difference in weed density between the two weeding treatments V4+V8 and V4+V8+V12. Weed density in weeding treatment V8 was generally greater than for all other weeding treatments under all cropping regimes (i.e. in terms of weed density, V8 was the least effective in suppressing weed growth).

5.2.2 Weed species

Weed species were recorded in each treatment plot at the time of recording the weed density. A total of 26 different non-crop plants were recorded (including rice) in the different treatment plots.

Table 8 summarizes the different non-crop species recorded, together with the relative frequency that they were recorded. The five most common weed species recorded were *Eleusine indica* (L.) Gaertn, *Ageratum conyzoides* L, *Echinochloa glabrescens* Munro ex Hook .f. *Cynodon dactylon* (L.) Pers and *Oryza stiva* L.

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Table 8. Summed Dominance Ratio (SDR) of weed species in maize and soybean cropping combinations.

No.	Weed species	Relative density (%)	Relative frequency (%)	SDR (%)
1	*Eleusine indica* (L.) Gaertn.	21.63	11.67	16.65
2	*Ageratum conyzoides* L.	12.94	11.20	12.07
3	*Echinochloa glabrescens* Munro ex Hook. f.	14.37	9.40	11.88
4	*Cynodon dactylon* (L.) Pers.	8.08	7.28	7.68
5	*Oryza stiva* L.	6.26	7.99	7.13
6	*Elephantopus tomentosus* L.	6.35	7.13	6.74
7	*Cleome rutidosperma* DC.	4.89	6.42	5.66
8	*Scripus grossus* L. f.	4.58	5.56	5.07
9	*Eclipta prodstrata* (L.) L.	3.34	5.01	4.17
10	*Cyperus imbricatus* Retz.	3.13	4.93	4.03
11	*Paspalum conjugatum* Berg.	2.50	4.23	3.36
12	*Alternanthera sessilis* (L.) DC.	2.30	4.31	3.31
13	*Fimbristylis miliacea* (L.) Vahl.	2.58	3.37	2.98
14	*Phyllanthus amarus* Schum. & Thonn.	1.37	2.51	1.94
15	*Leptochloa chinensis* (L.) Nees.	1.12	2.11	1.62
16	*Cyperus rotundus* L.	0.81	1.64	1.23
17	*Mimosa pudica* L.	0.58	1.17	0.87
18	*Poa annua* L.	0.87	0.78	0.82
19	*Ludwigia octovalvis* (Jacq.) Raven.	0.43	0.78	0.60
20	*Panicum maximum* Jacq.	0.59	0.47	0.53
21	*Physalis angulata* L.	0.28	0.78	0.53
22.	*Pennisetum polystachyon* (L.) Schult.	0.51	0.39	0.45
23	*Staria geniculata* (Lmk.) P. Beauv.	0.28	0.55	0.41
24	*Pennisetum purpureum* Schumach.	0.12	0.16	0.14
25	*Sesbania sesban* (L.) Merr.	0.05	0.08	0.07
26	*Chloris barbata* Sw.	0.04	0.08	0.06
	TOTAL	100.00	100.00	100.00

Source: Field experiment, 2002.

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5.2.3 Total dry matter of weeds

Illustrated in Figure 13, showed that, the total dry matter of weeds harvested in the different cropping and weeding treatments (reflecting the statistically significant interaction between the main treatment). The importance of early weeding (V4) is clearly reflected in all treatments and cropping combinations, whether sole cropped maize or soybean, or the different intercrop treatments. It was also clear from the result that late weeding in maize (V8) was not very effective when compared with the unweeded treatments.

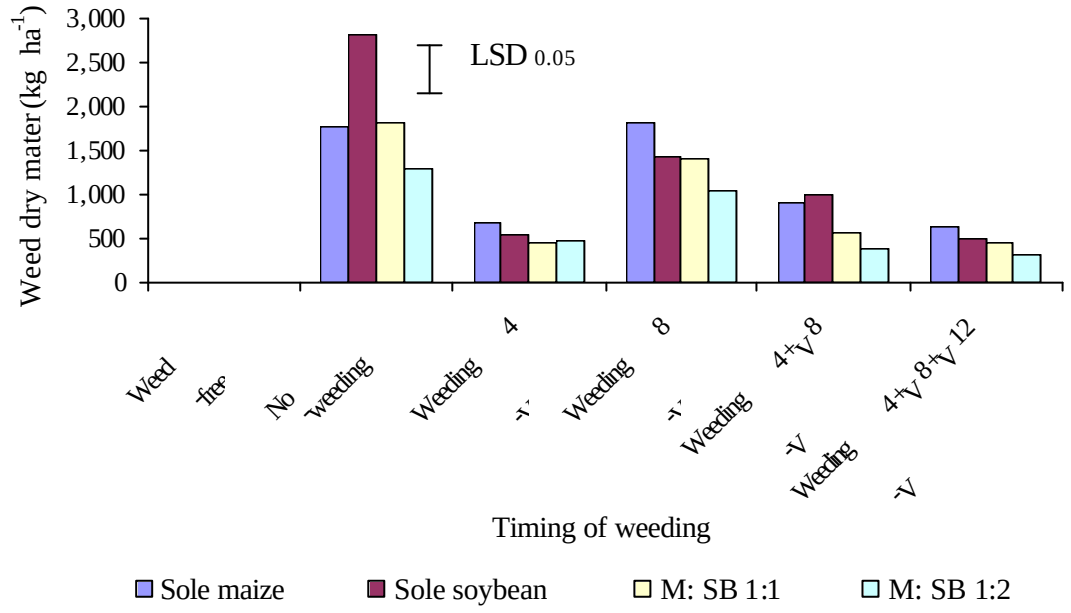

Figure 13. Total dry matter weight of weeds in different timing of weeding and cropping treatments.

The result illustrated in Figure 13, also indicate that sole cropping of soybean was 2826.4 kg ha^{-1} as much as more susceptible to weed ingress than sole cropping with maize. Generally the level of weed ingress (as reflected by the weed dry weight) in the intercropping combinations was less than in the sole crop situations for each weeding treatment. The lowest was 306.7 kg ha^{-1} for maize and soybean (M: SB 1: 2) treatment in the weeding-V4+V8+V12. However, with early and or frequent weeding (V4, V4+8, V4+8+12) the differences in the weed yield was not statistically significantly different from that in the sole crop treatments.

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5.2.4 Labor use for manual weed control

The differences in labor input for the different weeding treatments and cropping combinations is illustrated (Figure 14). nerally, speaking the labor input reflected the frequency of weeding, with treatments kept weed free having the higher labor input requirement requiring an average of 196 days of labor ha^{-1} input (six weedings were undertaken in this treatment). n contrast, the single early weeding treatment (V4) required only 42 labor days ha^{-1} of labor for weed control. In the weed free treatment, although the intercrop treatments had lower labor input requirements for weed control relative to the sole crop treatments, the labor input required for weed control remained high (185 labor-days ha^{-1} for M: SB 1:1, and 154 labor days ha^{-1} for M: SB 1:2) treatment.

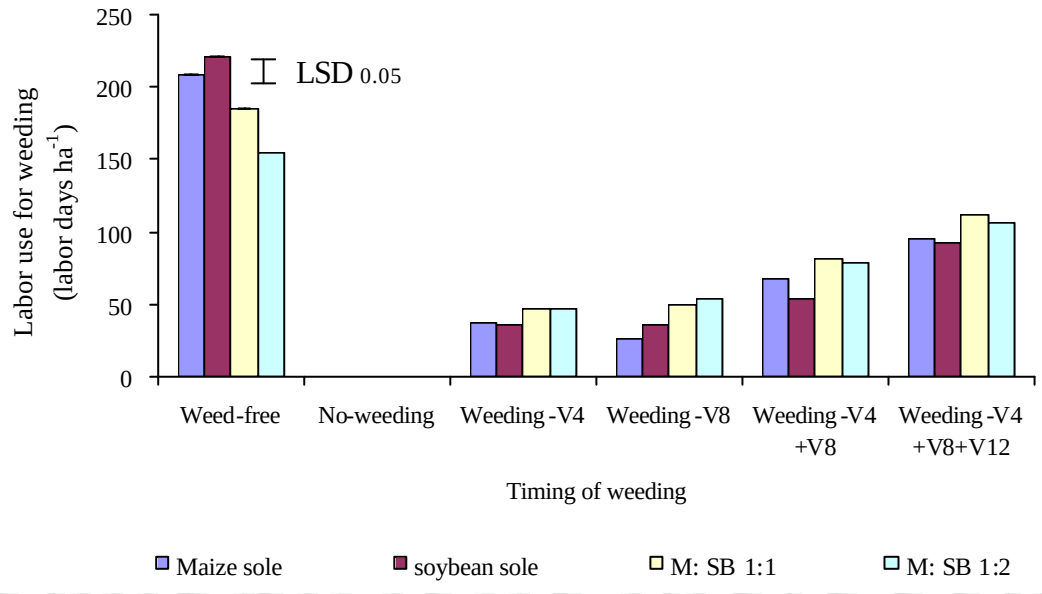

Figure 14. Labor use for weed control.

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Among of different weeding and cropping combination treatments, the labor used for weeding in the intercrop treatments was never less than the labor use for weeding in the sole crop treatments (although in most instances the differences were not statistically significantly different). The most important factor in reducing the labor input was early weeding (V4) whether in the sole crop treatments or intercrop treatments.

5.3 Crops growth stages and crop development

5.3.1 Plant growth and development

The maturity time for maize was 115 DAE (days-after-emergence), while for soybean it was 95-100 DAE (Table 9). Demonstrated that the maize in single cropping and/or intercropping systems was not affected to plant growth and development of maize crop. However, but soybean intercropping was greatest plant height and later for flowering and maturity than sole crop of soybean. The V4, V8, and V12 stages of leaf development for maize were 25, 35 and 45 DAE, respectively. The tassel stage (VT) was reached at 65 DAE. Generally the soybean crop reached equivalent stages of growth earlier than maize.

Table 9. Observations of maize and soybean growth stages.

Maize	Days after emergence (DAE)				
Growth stage	V4	V8	V12	VT	Harvest
Sole maize	25	35	45	65	115
M: SB 1: 1	25	35	45	65	115
M: SB 1: 2	25	35	45	65	115
Soybean	Days after emergence (DAE)				
Growth stage	V2	V4	R2	R5	Harvest
Sole soybean	15	35	40	60	95
M: SB 1: 1	15	35	45	65	100
M: SB 1: 2	15	35	45	65	100

V = vegetative stages; VT = vegetative tassel stage; R= reproductive stages. M: SB 1: 1 = one row of maize: one row of soybean; M: SB 1: 2 = one row of maize: two rows of soybean.

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5.3.2 Maize and soybean population density

The results in Table 10, show that maize and soybean population density per unit area (hectare) among critical timing for weed control in and maize and soybean cropping pattern. In this experiment found that the total population density for sole crop of maize treatment was a 52,632 plants ha^{-1} and 76,923 for sole crop of soybean treatment. For intercropping combination treatment between one row of maize and one row of soybean (M: SB 1: 1) treatment was 105,264 plants ha^{-1} and 163,743 plants ha^{-1} for one row of maize and two rows of soybean intercrop of (M: SB 1: 2) treatment.

The results of crops population density in the maize and soybean intercropping treatment was observed that the weed population in each timing of weed control treatment had affected to reduced weed population than both sole crops of maize and soybean treatment for all timing of weeding treatment included unweeded treatment. In the maize and soybean intercropping combination with plant population had also effected to grain yield higher than both maize and soybean sole cropping for all timing of weeding treatments.

Table 10. The total population of maize and soybean cropping pattern.

Treatment	Plant size (m)	Area (m^2)	Maize (plant ha^{-1})	Soybean (plant ha^{-1})	Total (plant ha^{-1})
Sole maize	0.75 x 0.25	0.19	52,632		52,632
Sole soybean	0.50 x 0.25	0.13		76,923	76,923
M: SB 1: 1	0.75 x 0.25	0.19	52,632		105,264
	0.75 x 0.25	0.19		52,632	
M: SB 1: 2	0.75 x 0.25	0.19	52,632		163,743
	0.375 x 0.25	0.09		111,111	

Sousrce: Field experiment, 2002.

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5.3.3 Plant height of maize and soybean

The results of analysis of variance for plant height of maize and soybean among the timing of weeding treatments and intercrop combinations are summarized in Table 11. There were significant differences at the 1 % level for interaction between timing and cropping treatments for maize and soybean plant height.

Table 11. Analysis of variance on plant height of maize and soybean at different timing of weeding and intercropping.

Source of variation	Significance level (F test)	
	Maize	Soybean
Replication (A)	ns	ns
Timing of weeding (B)	ns	*
Maize/soybean intercrop (C)	**	**
Interaction (B*C)	**	**
CV (%)	4.4	5.1

ns = not significant; * significant at 0.05 level; ** as significant at 0.01 level.

5.3.3.1 Plant height of maize

The relationship between plant heights of maize among timing of weeding and intercropping treatments illustrated in Figure 15. Plant height for maize intercropping was higher than sole crop of maize treatment. Generally plant height, its maximum (179 cm) for maize in intercrop in the no-weeding treatment. Minimum was found in sole maize crop (159 cm) at weeding-V4+V8 treatment. As indicated in the results of analysis of variance, there was no effect on plant height of the type of cropping practiced (whether a sole crop of intercropped with soybean).

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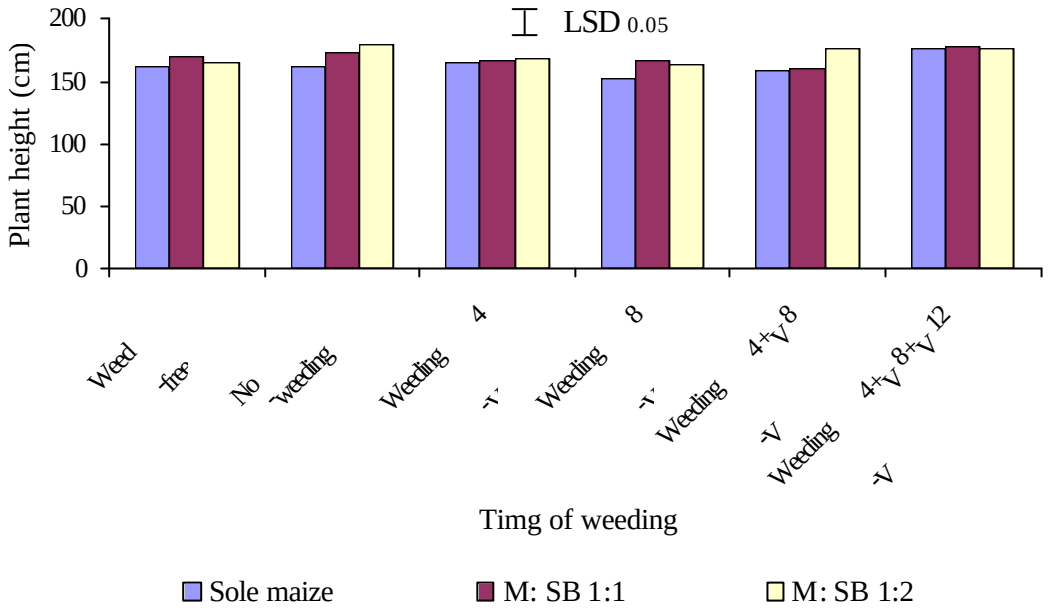

Figure 15. Plant height of maize at harvest in different timing of weeding.

5.3.3.2 Plant height of soybean

The results of analysis of variance for plant height for soybean among timing of weeding and intercropping treatments is summarized in Table 10. Unlike the situation with maize, there was an effect on soybean plant height of the cropping treatments, and soybean bean plant height at harvest, was effect of the interaction between weeding treatment and cropping treatment.

Generally the plant height of the soybean crop was greater in the intercrop treatments than when sole crop. Plant height was considered to the lowest for the sole soybean cropping treatment in all weeding treatments, and greater for the treatment when two soybean rows were intercropped with maize when compared with single row of maize and single row intercrop (M: SB 1: 1) treatment (Figure 16).

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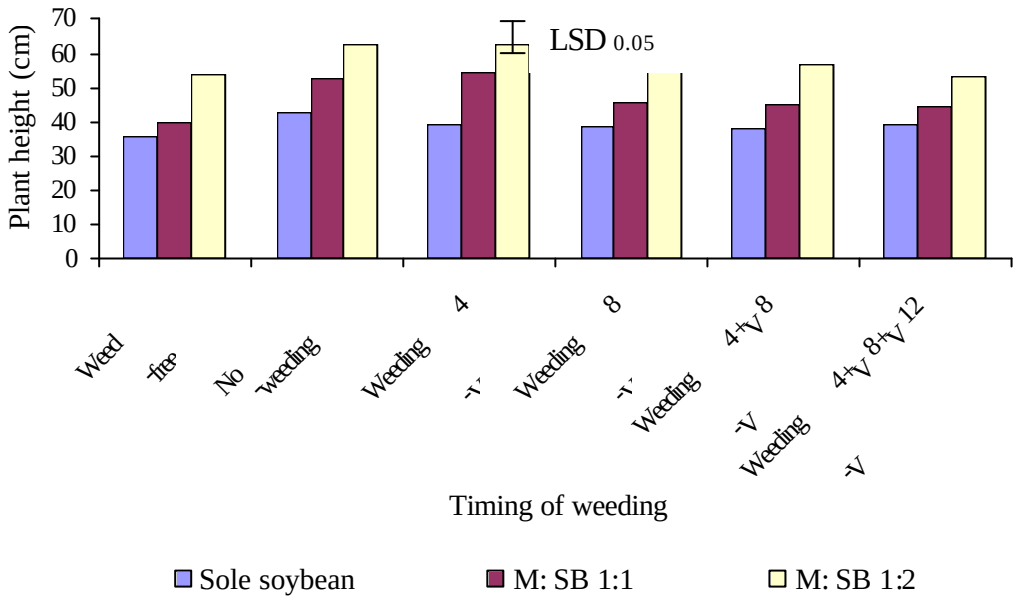

Figure 16. Plant height of soybean at harvest in different timing of weeding.

The maximum plant height achieved was 63 cm in the non-weeded and 62 cm for weeding-V4, treatment in the cropping sequence of 1 row of maize and 2 rows of soybean (M: SB 1: 2) treatment. The shortest soybean crop (36 cm) was in the weed-free treatment when soybean was sole cropped. It is apparent from these results that light competition with either weeds or the intercropped maize, helped determine the soybean crop height.

5.3.4 Number of soybean branches

The results of analysis of variance for number of soybean branches at harvest (Table 12), shows that there was significant different among the intercropping treatments and for the interaction between timing of weeding and intercropping treatments.

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Table 12. Analysis of variance for number of soybean branches at harvest.

Source of variation	Significance level (F test)
	Soybean branches at harvest
Replications (A)	ns
Timing of weeding (B)	ns
Maize/soybean intercrop (C)	**
Interaction (B*C)	*
CV (%)	16.5

ns = not significant, * = significant at 0.05 level; ** = significant at 0.01 level.

The result illustrated in Figure 17, showed that number of branching was higher in the different weeding treatments than the weed free treatment, although there was slightly difference between the weeding treatments.

The highest of soybean branches were indicated in the weeding-V4+V8 treatment (4.33 branches plant^{-1}), for sole soybean crops. Intercropping the soybean within maize rows was reduced the level of branching, with this reduction being greatest when two rows of soybean were intercropped to each row of maize (M: SB 1: 2) treatment. The lowest of soybean branches were found in the no-weeding and weeding-V4+V8 treatment (1.44 branches plant^{-1}), for single row of maize and double rows of soybean (M: SB 1: 2) treatment. Further the effect of the intercropping was greatest later in maturity.

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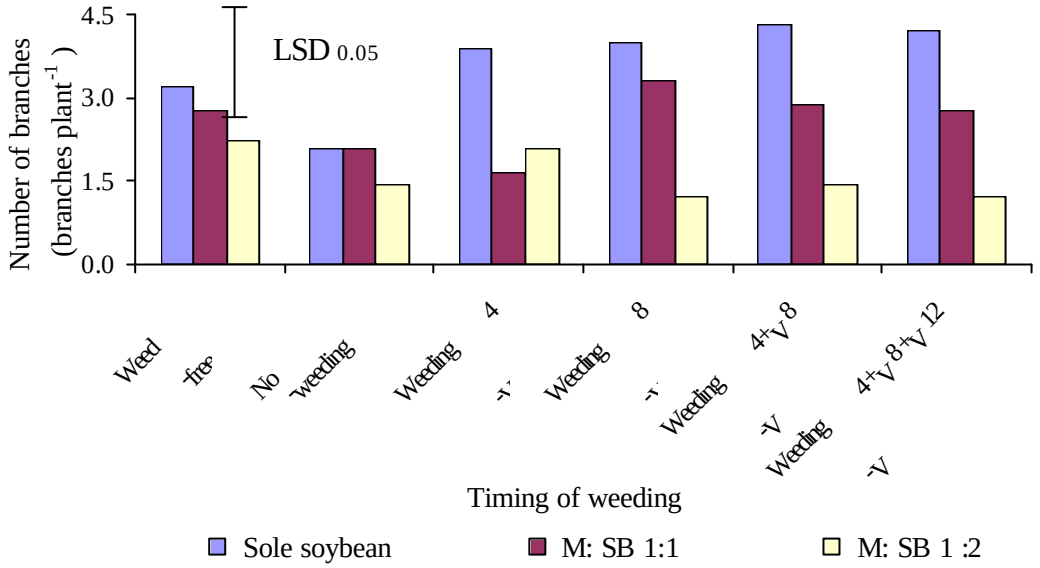

Figure 17. Number of soybean branches at harvest in different timing of weeding.

5.3.5 Leaf area index of maize and soybean

5.3.5.1 Leaf area index (LAI) of maize

The results of analysis of variance for leaf area index (Table 13) showed that there were significant differences among the timing of weeding treatments, among the intercrop treatments, and also in relation to the weeding x intercropping interaction.

Table 13. Analysis of variance for leaf area index of maize.

Source of variation	Significance level (F test)		
	V12	VT	Harvest
Replications (A)	ns	ns	ns
Timing of weeding (B)	**	**	**
Maize/soybean intercrops (C)	**	**	**
Interaction (B*C)	**	*	ns
CV (%)	9.25	11.3	13.5

ns = not significant; * significant at 0.05 level; ** significant at 0.01 level.

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Generally, leaf area index was greatest in sole crop of maize crop than maize intercropping, in the timing of weeding for all treatments. These relationships of LAI are illustrated in Figure 18 and 19 for V12 and VT stage of maize growth.

The maximum LAI at V12 stage of maize growth in Figure 18 was found in the sole maize crop in all weeding treatments, while between weeding treatments LAI for maize was at its maximum (2.63) in the weed-free treatment for the V12 stage of vegetative growth, and the V4+8 weeding treatment at the V12 stage of growth (2.54). In the no-weeding treatment for V12, the LAI dropped to 1.83 for maize in intercrop with single row of soybean (there being no significant difference between the cropping treatments).

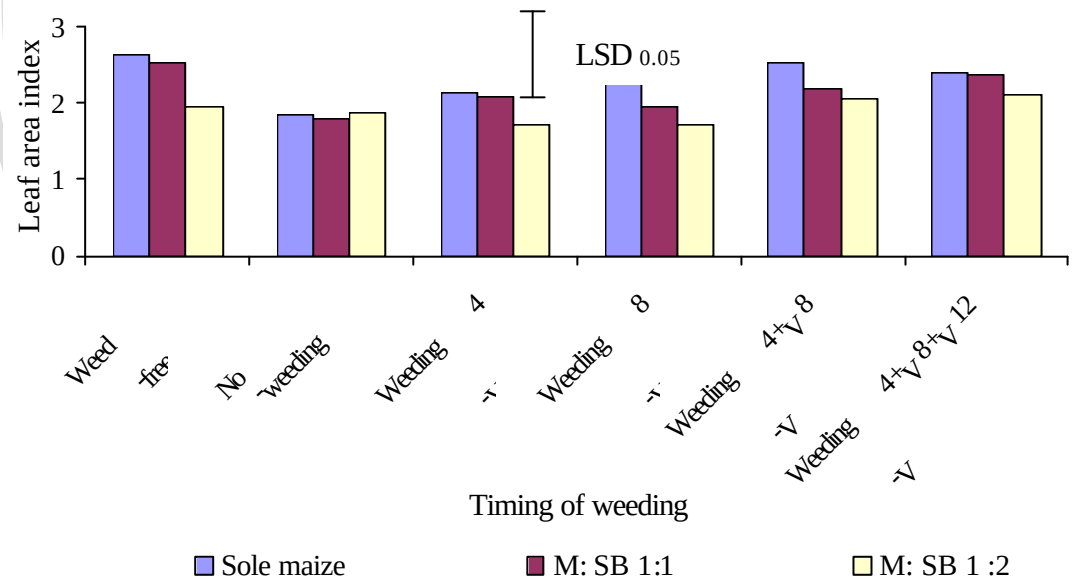

Figure 18. Leaf area index at V12 stage of maize growth.

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Leaf area index at VT stage of maize growth, illustrated in Figure 19. The biggest impact of LAI was recorded when weeding was undertaken at the weeding (V4+V8) of leaf stage, when combined with the soybean intercrop treatments. The LAI for the sole maize crop for this weeding treatment was 2.76 while for the single row of and single row of soybean (M: SB 1:1) and single row of maize and double row of soybean (M: SB 1.2) treatment the LAI had dropped to 2.31 and 2.01, respectively.

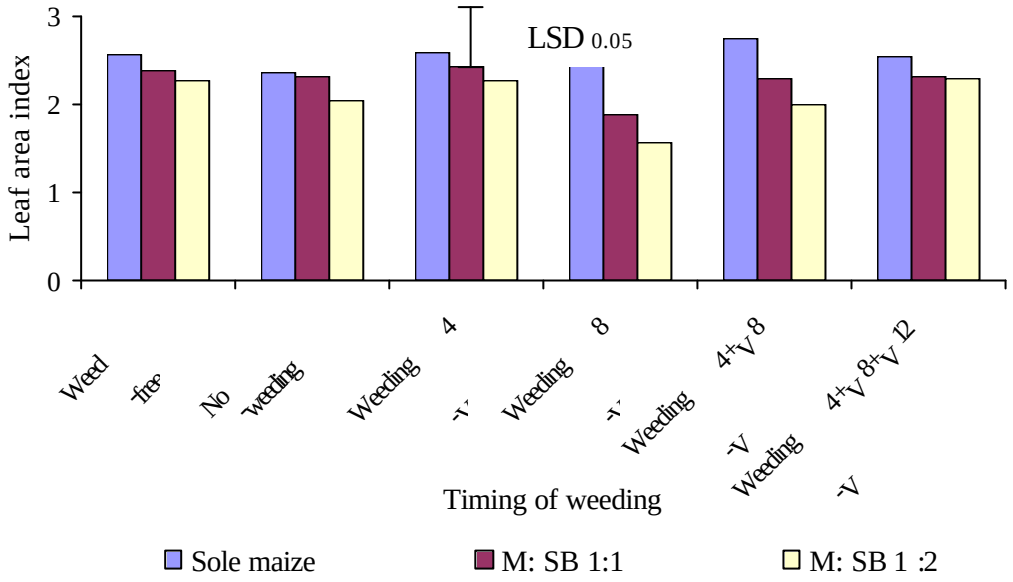

Figure 19. Leaf area index at VT stage of maize growth.

Leaf area index of maize at harvest for timing of weed control treatments and cropping treatments were demonstrated in Table 14 and 15. The highest of LAI among timing of weeding treatment was 2.10 found in the weed-free treatment, latter were found in the two, three times weeding include no-weeding treatment. However, there were not statistically significantly differences. The minimum of maize LAI was 1.48, demonstrated in the weeding-V8 treatment.

Table 14. Leaf area index of maize at harvest for timing of weeding treatments.

Treatment	Leaf area index
Weed-free	2.10
No-weeding	1.84
Weeding-V4	1.79
Weeding-V8	1.48
Weeding-V4+8	1.86
Weeding-V4+V8+V12	1.95

LSD $_{0.05}$ = 0.279

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In Table 15, demonstrated the maize LAI among intercropping treatments, the maximum LAI was found in the sole maize crop (2.05), which was significantly higher than maize intercrops (single row of maize and single row of soybean (M: SB 1: 1) and (single row of maize and single row of soybean (M: SB 1: 1) treatment, respectively. Minimum LAI was 1.71, obtained in the single row of maize and double rows of soybean treatment. However, in both maize intercropping treatments were related not statistical significantly differences.

Table 15. Leaf area index of maize at harvest for cropping treatments.

Treatment	Leaf area index
Sole maize	2.05
M: SB 1: 1	1.75
M: SB 1: 2	1.71

$LSD_{0.05} = 0.170$

5.3.5.2. Leaf area index (LAI) of soybean

Leaf area index was measured at the R2 and R5 stages of soybean growth. There were significant differences for LAI among timing of weed control treatment ($p<0.05$), and among the cropping systems treatments ($p<0.01$). The interaction between weeding treatments and cropping treatments was not significant (Table 16).

Table 16. Analysis of variance for leaf area index of soybean.

Source of variation	Significance level (F test)	
	R2	R5
Replications (A)	ns	ns
Timing of weeding (B)	*	*
Maize/soybean intercrop (C)	**	**
Interaction (B*C)	ns	ns
CV (%)	25.4	23.8

ns = not significant; * significant at 0.05 level; ** significant at 0.01 level.

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Generally, leaf area index of soybean, when sole cropped was higher than soybean intercropped treatment at differences timing of weeding and cropping all treatments. In table 17, showed the soybean LAI at R2, among timing of weeding treatments and among cropping treatments. The soybean LAI, between weeding at V4 and V4+V8 treatment were 0.64 and 0.66 respectively. There were related significantly higher than other timing of weeding treatments. The minimum LAI among timing of weeding treatments was 0.49 for no-weeding treatment.

Table 17. Leaf area index at R2 stage of soybean growth for timing of weeding treatments.

Treatment	Leaf area index
Weed-free	0.52
No-weeding	0.49
Weeding-V4	0.64
Weeding-V8	0.57
Weeding-V4+8	0.66
Weeding-V4+V8+V12	0.62

$LSD_{0.05}$ = 0.108

Leaf area index at R2 stage of soybean growth in Table 18, demonstrated in both sole crop of soybean and two rows soybean grown within each rows of maize intercrop (M: SB 1: 2) treatment. There were significantly related higher than single row of soybean grown within each rows of maize intercrop (M: SB 1: 1) treatment. The maximum LAI these there were 0.72 and 0.70 with respected to soybean sole cropped and two rows of soybean intercropped (M: SB 1: 2) treatment. Minimum LAI was 0.33 recorded in the single row of soybean intercrop (M: SB 1: 1) treatment.

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Table 18. Leaf area index at R2 stage of soybean grwoth for cropping treatments.

Treatment	Leaf area index
Sole soybean	0.72
M: SB 1: 1	0.33
M: SB 1: 2	0.70

$LSD_{0.05}$ = 0.100.

Leaf area index at R5 stage of soybean growth in Table 19, was also demonstrated the LAI among timing of weed control treatments. The maximum soybean LAI (0.32) was found in the three times of weeding for V4+V8+V12 treatment. However, LAI in the weeding-V8 treatment was slightly different between weed-free and statistically significant. Minimum LAI (0.24) was obtained for in the no-weeding and weeding-V4 treatment respectively.

Table 19. Leaf area index at R5 stage of soybean growth for timing of weeding treatments.

Treatment	Leaf area index
Weed-free	0.29
No-weeding	0.24
Weeding-V4	0.24
Weeding-V8	0.31
Weeding-V4+V8	0.26
Weeding-V4+V8+V12	0.33

$LSD_{0.05} = 0.051$.

The maximum LAI for cropping treatment was apparent to sole soybean crop of 0.36. However, when two rows of soybean were grown within each row of maize (M: SB 1: 2), although the LAI was always less than LAI for the sole crop, often this difference was slightly and statistically insignificant. Minimum LAI (0.16) was recorded for single row of maize and single row of soybean intercrop (M: SB 1: 1). It was the lowest and lower than double rows of soybean grown within maize rows and sole crop of soybean (Table 20).

Table 20. Leaf area index at R5 for cropping treatments.

Treatment	Leaf area index
Sole soybean	0.36
M: SB 1: 1	0.16
M: SB 1: 2	0.31

$LSD_{0.05} = 0.045$

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5.3.6 Light intensity and light interception of maize and soybean intercrop

5.3.6.1 Light intensity and interception of maize

The results of analysis of variance for light intensity and light interception (Table 21) demonstrated for maize growth stages at (V12 and VT), there were significant effects of maize/soybean intercropping treatments ($p<0.01$). It was only that the later stage of growth (tassel) that there was a significant interaction ($P<0.01$) between the timing of weeding and intercropping treatments.

Table 21. Analysis of variance for light intensity and light interception in maize cropping.

Source of variation	Significance level (F test)			
	Light intensity		Light interception	
	V12	VT	V12	VT
Replications (A)	ns	ns	ns	ns
Timing of weeding (B)	ns	**	ns	**
Maize/soybean intercrop (C)	**	**	**	**
Interaction (B*C)	ns	**	ns	**
CV (%)	8.1	8.6	9.8	8.6

ns = not significant; * significant at 0.05 level; ** significant at 0.01 level.

The light intensity and light interception for intercropping treatments at V12 in Table 22. Demonstrated the light intensity level in the maize intercropping was obtained higher than sole crop of maize treatment. The highest of light intensity level was 617.37 μ mol m^{-1} s^{-1}, found in the single row of maize and double rows of soybean intercrop (M: SB 1: 1) treatment. However, light intensity in maize intercrop (M: SB 1: 2) treatment was also higher sole crop of maize, but slightly different between maize intercrop (M: SB 1:1) treatment. The lowest light intensity was observed in the sole crop of maize treatment, in which was 563.82 μ mol m^{-1} s^{-1}. The relationship light interception at tassel stage of maize growth was also found in the maize intercropping higher than sole cropping. The highest light interception was 65.6% for maize intercrop (M: SB 1: 1) treatment and lowest light interception level

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was 58.4 % for sole crop of maize treatment. Although, light interception in the maize intercrop (M: SB 1: 2) treatment was also higher than sole crop but, often less than maize intercrop (M: SB 1: 1) treatment, slightly difference and not statistically significant.

Table 22. Light intensity at V12 stage of maize growth for cropping treatments.

Treatment	Light intensity (μ mol m^{-1} s^{-1})	Light interception (%)
Sole maize	563.83	58.4
M: SB 1: 1	617.37	65.6
M: SB 1: 2	601.26	61.4

$LSD_{0.05}$ = 32.886 (for light intensity)
$LSD_{0.05}$ = 4.081 (for light interception)

The light intensity and light interception for VT (tassel stage of maize growth), in Figure 20 and 21. Illustrated the differences of light intensity and light interception among timing of weeding and intercropping treatments. The highest of light intensity level was found in the no-weeding for sole maize crop, which was 759.13 μ mol m^{-1} s^{-1}. However, light intensity level in the early weeding (V4 treatment) for sole crop was also higher than other timing of weeding treatment, included weed-free treatment. Further, in the sole crop of maize was obtained light intensity lower than maize intercrop for all timing of weeding treatments. The lowest light intensity obtain level was 504.9 μ mol m^{-1} s^{-1}, recorded in the weeding-V4+V8+V12 for sole crop of maize treatment.

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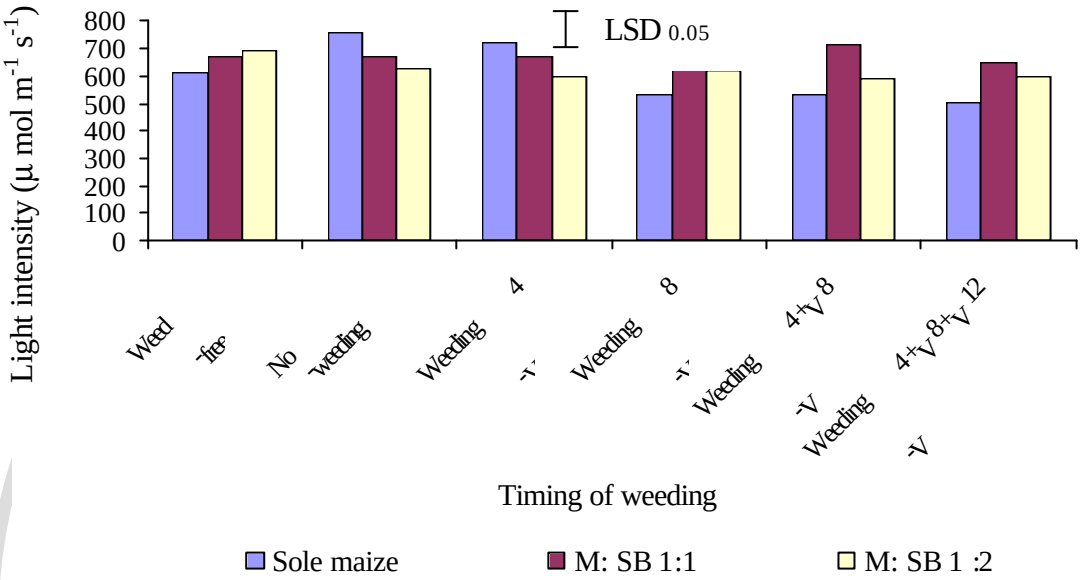

Figure 20. Light intensity at VT stage of maize growth.

Light interception at tassel stage of maize growth, among timing of weeding and intercropping treatments was showed in Figure 21. Demonstrated to the percents of light interception obtained level was calculated from light intensity on top of crop canopy and under canopy of maize. The statistical significant related to highest light interception obtain level was also found in the no-weeding, its was 61.4 %, for sole crop of maize treatment. Further, in the latter timing of weeding was observed in the weeding-V4 treatment for sole crop treatment also higher light interception than other timing of weeding treatments, included weed-free treatment. However, all timing of weeding treatment, included weed-free for sole crop of maize was related to lower than maize intercropping treatments. The lowest light interception was found in the sequences for weed control at (V4+V8+V12) treatment, in which was 40.9 %, for sole crop of maize treatment.

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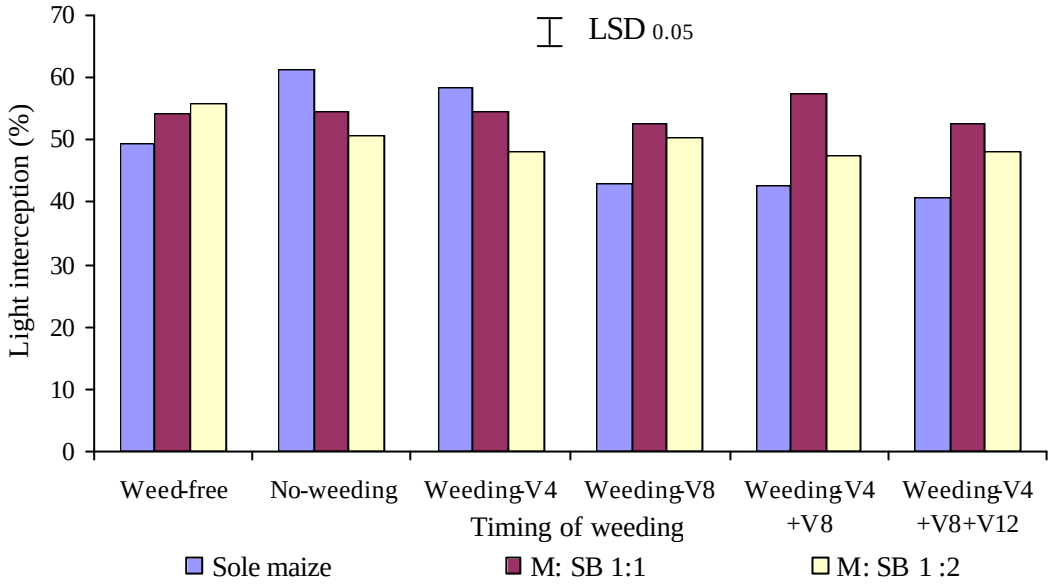

Figure 21. Light interception at VT stage of maize growth.

5.3.6.2 Light intensity and light interception of soybean

The results of analysis of variance for light intensity and light interception in Table 23, demonstrated that, there were significant differences of light intensity and interception of soybean in the timing of weeding and soybean cropping systems at R2 and R5 stage of soybean growth at ($p<0.01$).

Table 23. Analysis of variance for light intensity and light interception of soybean.

Source of variation	Significance level (F test)			
	Light intensity		Light interception	
	R2	R5	R2	R5
Replications (A)	ns	ns	ns	ns
Timing of weeding (B)	**	**	**	**
Maize/soybean intercrop(C)	**	**	**	**
Interaction (B*C)	ns	ns	ns	ns
CV (%)	19.5	16.5	26.3	16.6

ns = not significant, * significant at 0.05 level, and ** significant at 0.01 level.

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Light intensity and light interception at R2 in Table 24, showed that the highest of light intensity level at timing of weed control treatments was 198.44 μ mol m^{-1} s^{-1} found in the early weeding at V4 treatment. However, the related significant lowest was found in the weed-free treatment, which was 139.10 μ mol m^{-1} s^{-1}.

The highest of light interception level, among timing of weeding treatments at R2 for the soybean crop was 21.8 %, also appeared in the weeding-V4 treatment. The lowest was found in the frequency weed control (weed-free) treatment for weed-free, in which was 14.2 % of total light intensity from top of crops canopy and light intensity under crops canopy.

Table 24. Light intensity and light interception at R2 stage of soybean growth for timing of weeding.

Treatment	Light intensity (μ mol m^{-1} s^{-1})	Light interception (%)
Weed-free	139.10	14.2
No-weeding	156.38	16.4
Weeding-V4	198.44	21.8
Weeding-V8	162.49	16.4
Weeding-V4+V8	181.65	19.3
Weeding-V4+V8+V12	157.78	16.9

$LSD_{0.05}$ = 25.596 (for light intensity)
$LSD_{0.05}$ = 3.446 (for light interception)

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In table 25, demonstrated the light intensity and light intercrop obtained level at R2 stage of soybean growth. The high light intensity and light interception was occurred in the sole crop of soybean higher than soybean intercropping treatments. The highest of light intensity for sole crop of soybean was 245.62 μ mol m^{-1} s^{-1} and 23.5 % for light interception of total light intensity on the top of crops canopy and light intensity under crops canopy. However, the lowest of light intensity was recorded in the two rows of soybean intercrop within each row of maize, which was 122.44 μ mol m^{-1} s^{-1} and 14.0 % for light interception. Although, of this was lowest, for light intensity and light interception, but it was a slightly difference with single

row of soybean grown within each row of maize intercrop (M: SB 1: 1) treatment and not statistically significant.

Table 25. Light intensity and light interception at R2 stage of soybean growth cropping treatments.

Treatment	Light intensity (μ mol m^{-1} s^{-1})	Light interception (%)
Sole soybean	245.62	23.5
M: SB 1: 1	214.30	15.0
M: SB 1: 2	141.71	14.0

$LSD_{0.05}$ = 22.286 (for light intensity)
$LSD_{0.05}$ = 2.118 (for light interception)

Light intensity and light interception at R5 stage of soybean growth in Table 26 at difference timing of weeding treatments. Demonstrated that the highest of light intensity and light interception was found in the weeding-V8 treatment. There were 284.54 μ mol m^{-1} s^{-1} and 23.0 % for light interception of light intensity on the top of crops canopy and under crops canopy. The lowest of light intensity obtained was 198.40 μ mol m^{-1} s^{-1} and 16.1 % for light interception. However, light intensity and light interception for weeding-V4+V8, V4+V8+V12 and no-weeding treatment was lower than other timing of weeding treatments.

Table 26. Light intensity and light interception at R5 stage of soybean growth for timing of weeding treatments.

Treatment	Light intensity (μ mol m^{-1} s^{-1})	Light interception(%)
Weed-free	235.12	19.0
No-weeding	223.86	18.1
Weeding-V4	235.83	19.1
Weeding-V8	284.54	23.0
Weeding-V4+V8	204.32	16.5
Weeding-V4+V8+V12	198.40	16.1

$LSD_{0.05}$ = 35.126 (for light intensity)
$LSD_{0.05}$ = 2.851 (for light interception)

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Light intensity and light interception level at R5 among cropping treatments (Table 27), demonstrated, generally, sole soybean was obtained high light intensity and light interception level higher than soybean intercropping treatments.

The highest light intensity level was 335.03 μ mol m^{-1} s^{-1} and 27.1% for light interception level. The lowest was found in the two of soybean grown within each row of maize intercrop (M: SB 1: 2) treatment, which were 141.71 μ mol m^{-1} s^{-1} for light intensity and 11.5 % for light interception.

Table 27. Light intensity and light interception at R5 stage of soybean growth for cropping treatments.

Treatment	Light intensity (μ mol m^{-1} s^{-1})	Light interception (%)
Sole soybean	335.03	27.1
M: SB 1: 1	214.30	17.5
M: SB 1: 2	141.71	11.5

$LSD_{0.05}$ = 26.424 (for light intensity)
$LSD_{0.05}$ = 2.128 (for light interception)

5.3.7 Total dry matter of maize and soybean

5.3.7.1 Total dry matter of maize

The results of analysis of variance for total dry matter weight of maize (Table 28), demonstrated that there were significant differences for timing of weed control and maize/soybean intercrop at V12, VT and harvest for total dry matter weight of maize. However, all interaction was not effected for among timing of weeding and among intercropping al treatments.

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Table 28. Analysis of variance for total dry matter of maize.

Source of variation	Significant levels (F test)		
	V12	VT	Harvest
Replication (A)	ns	ns	ns
Timing of weeding (B)	*	**	*
Maize/soybean intercrop (C)	**	**	**
Interaction (B*C)	ns	ns	ns
CV (%)	11.8	18.0	6.4

ns = not significant; * significant at 0.05 level; ** significant at 0.01 level.

The total dry matter at V12 stage of maize growth (Table 29) demonstrated the TDM among timing of weed control treatments. When frequency of suppression of weed there had effected to total dry matter such as weed-free treatment as highest of total dry matter of maize per plant (130.12 g plant^{-1}). The lowest of TDM was recorded in the no-weeding, which was as 103.70 g plant^{-1}. However, all timing-of-weeding treatments, include no-weeding treatment were not statistically significantly differences, exception weeding-V4+V8+V12 treatment had slightly different, and statistical significantly.

Table 29. Total dry matter at V12 stage of maize growth for timing of weeding treatments.

Treatment	Total dry matter (g plant^{-1})
Weed-free	130.12
No-weeding	103.70
Weeding-V4	113.56
Weeding-V8	110.08
Weeding-V4+V8	114.09
Weeding-V4+V8+V12	117.48

LSD $_{0.05}$ = 15.081

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In Table 30, showed that the TDM of maize at V12, among cropping treatments. Generally, in both sole crop of maize and maize intercrop of single row of maize and double row of soybean (M: SB 1: 2) treatment was higher than maize TDM in the maize intercropping (M: SB 1: 1) treatment.

However, the highest of maize TDM was demonstrated in the sole cropped (120.38 g plant^{-1}) and the lowest of TDM of maize was recorded in the sign row of maize and single row of soybean intercrop (M: SB 1: 1) treatment (105.11 g plant^{-1}).

Table 30. Total dry matter at V12 stage of maize growth for cropping treatments.

Treatment	Total dry matter (g plant^{-1})
Sole maize	120.38
M: SB 1: 1	105.1
M: SB 1: 2	119.01

LSD $_{0.05}$ = 9.323

In Table 31 and 32, demonstrated the TDM of maize, among timing of weeding treatments and among of cropping treatments. Generally, the TDM of maize at VT was appeared in the timing of weeding at V8, V4+V8 and V4+V8+V12 of maize leaves treatment. There were 232.84, 233.63 and 227.83 g plant^{-1}, respectively, and these there were not statistically significantly differences.

However, when no-weeding and weeding early (weeding-V4) treatment, the TDM of maize was lower than on the timing-of-weeding treatments, included weed-free treatment. The lowest TDM of maize was 169.08 g plant^{-1}, found that in the no-weeding treatment.

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Table 31. Total dry matter at VT stage of maize growth for timing of weeding treatments.

Treatment	Total dry matter (g plant^{-1})
Weed-free	221.21
No-weeding	169.08
Weeding-V4	194.19b
Weeding-V8	232.84
Weeding-V4+V8	233.63
Weeding-V4+V8+V12	227.83

LSD $_{0.05}$ = 21.190

The highest TDM at VT stage of maize growth, among cropping treatments was demonstrated in the sole crop of maize (234.70 g plant^{-1}) and latter was found in the single row of maize and single row of soybean (216.71 g plant^{-1}). The lowest TDM was 187.9 g plant^{-1}, for maize intercrop (single row of maize and double rows of soybean intercrop treatment).

Table 32. Total dry matter at VT stage of maize growth for cropping treatments.

Treatment	Total dry matter (g plant^{-1})
Sole maize	234.70
M: SB 1: 1	216.71
M: SB 1: 2	187.97

LSD $_{0.05}$ = 26.419

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Total dry matter of maize at harvest in Table 33 and 34, demonstrated the maize TDM, among of timing of weeding and among of cropping treatments.

Generally, the maize TDM were apparent in the frequency and sequences for weed control (weed-free, weeding-V4+V8 and V4+V8+V12 treatment) higher than one time of weeding, included no-weeding treatment. The highest TDM for maize crop at harvest was found in the weed-free treatment (194.6 g plant^{-1}) and the lowest

was recorded in the weeding-V8 treatment of 167.4 g plant^{-1}. However, two and three times weeding (V4+V8 and V4+V8+V12 treatment) were also high TDM and slightly differently and statistically insignificant.

Table 33. Total dry matter of maize at harvest for timing of weeding treatments.

Treatment	Total dry matter (g plant^{-1})
Weed-free	194.59
No-weeding	168.77
Weeding-V4	172.15
Weeding-V8	167.36
Weeding-V4+V8	189.33
Weeding-V4+V8+V12	190.77

LSD $_{0.05}$ = 18.860

The highest TDM of maize in the cropping treatment was demonstrated in the sole crop of maize (194.5 g plant^{-1}). However, when maize was intercropped the TDM often lower than sole maize cropped treatment. The lowest TDM was 170.6 g plant^{-1} for maize intercrop of single row of maize and double rows of soybean intercrop (M: B 1: 2) treatment. Two of maize intercrop treatments were not statistically significant differences.

Table 34. Total dry matter of maize at harvest for cropping treatments.

Treatment	Total dry matter (g plant^{-1})
Sole maize	194.52
M: SB 1: 1	176.39
M: SB 1: 2	170.57

LSD $_{0.05}$ = 7.995

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5.3.7.2 Total dry matter of soybean

The results of analysis of variance for total dry matter (TDM) of soybean (Table 35) indicated that there were significant differences for TDM at all cropping treatment and interaction between timing of weed control and intercropping at R8 (maturity) of soybean.

Table 35. Analysis of variance for total dry matter of soybean.

Source of variation	Significant levels (F test)		
	R2	R5	Harvest
Replication (A)	ns	ns	ns
Timing of weeding (B)	ns	ns	*
Maize/soybean intercrop (C)	**	**	**
Interaction (B*C)	ns	ns	*
CV (%)	28.1	18.6	15.9

ns = not significant; * significant at 0.05 level; ** significant at 0.01 level.

In Table 36, revealed that the total dry matter at R2 stage of soybean growth, among cropping treatments. Generally, TDM for sole crop of soybean was higher than soybean intercropping treatments. The highest of soybean TDM was found in the sole soybean crop treatment of 14.98 g plant^{-1}. The lowest was 8.39 g plant^{-1} for two rows of soybean growth within each row of maize (M: SB 1: 2) treatment. However, in both of soybean intercropping treatments were related slightly difference for maize TDM per plant and also not statistically significantly different.

Table 36. Total dry matter at R2 stage of soybean growth for cropping treatments.

Treatment	Total dry matter (g plant^{-1})
Sole soybean	14.98
M: SB 1: 1	8.39
M: SB 1: 2	9.66

LSD $_{0.05}$ = 2.130

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The total dry matter at R5, in Table 37, showed that the TDM of sole crop of soybean was higher than two soybean intercrops (single row of maize and single row of soybean bean M: SB 1: 1 treatment; Single row of maize and double rows of soybean M; SB 1: 2). The highest of TDM was occurred in the sole crop of soybean treatment. The lowest of TDM was 13.09 g plant^{-1} for double rows of soybean were intercrop with sing row of maize (M: SB 1: 2) treatment.

Table 37. Total dry matter at R5 stage of soybean growth for cropping treatments.

Treatment	Total dry matter (g plant^{-1})
Sole soybean	21.61
M: SB 1: 1	13.72
M: SB 1: 2	13.09

LSD $_{0.05}$ = 2.066

The total dry matter of soybean at harvest (Figure 22) demonstrated the TDM of soybean between timing of weeding and cropping treatments. Generally, soybean TDM was greater for all sole soybean crops. However, the highest of TDM was found in the weeding-V4+V8+V12 treatment of 17.8 g plant^{-1} for sole soybean. While, dropped to 8.2 and 7.3 g plant^{-1} for soybean in intercropping (M: SB 1: 1 and M: SB 1: 2), respectively. The lowest was found in the timing of weeding at V4 treatment for single row of maize and double rows of soybean (M: SB 1: 2) treatment.

However, in the three of timing of weeding treatments were increased the of TDM accumulation, compare with weed-free and no-weeding treatment for sole crop of soybean treatment. There were 15.7, 14.8 and 17 g plant^{-1}, respective to weeding-V4, V8 and V4+V8 treatment for sole crop of soybean treatment.

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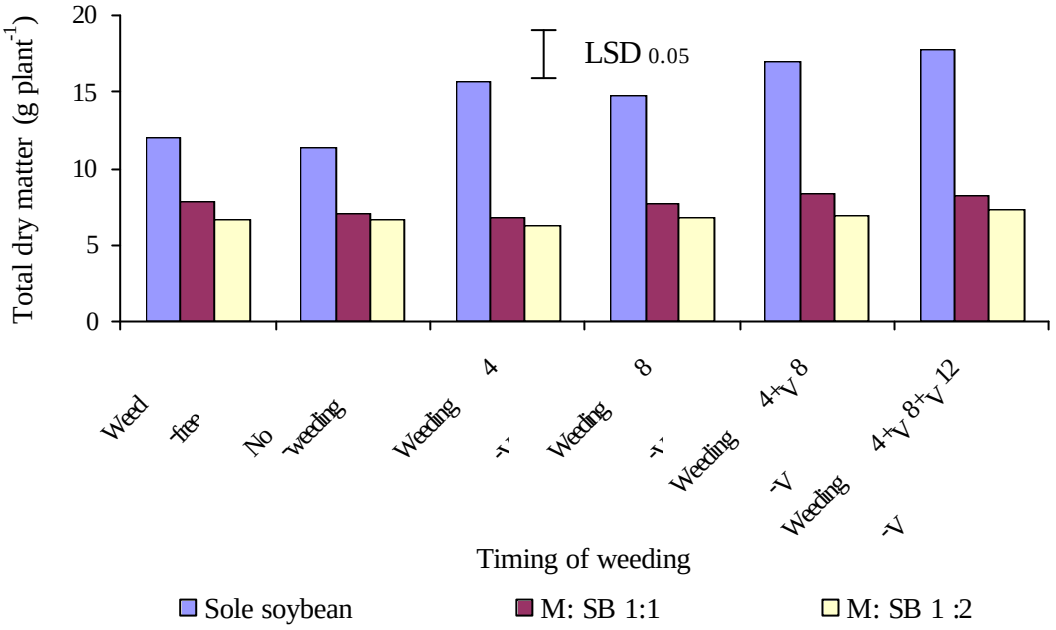

Figure 22. Total dry matter weight of soybean at harvest.

5.4 Yield components of maize and soybean

5.4.1 Maize yield components

The results of analysis of variance for maize yield components (Table 38) indicated that there were significant differences for several yield components but that the treatment effects sometimes differed with different components. Weeding treatments affected number of rows per ear, number of seeds per row, number of seeds per ear and harvest index (HI), while the intercropping treatments affected number of seeds per row, number of seeds per ear, 1000 seeds weight and HI. The interaction between weeding and intercropping treatments was significant only for numbers of rows per ear and seeds per row. The effects on individual yield components are summarized below.

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Table 38. Analysis of variance for maize yield components.

Source of variation	Significance level (F test)				
	No. Seed rows ear^{-1}	No. Seeds row^{-1}	No. Seeds ear^{-1}	1000 seed weight	HI
Replication (A)	ns	ns	ns	ns	ns
Timing of weeding (B)	**	*	*	ns	*
Maize/soybean intercrop (C)	ns	**	**	**	**
Interaction (B*C)	**	**	ns	ns	ns
CV (%)	5.7	7.3	5.2	6.1	6.9

ns = not significant; * = significant at 0.05 level; ** = significant at 0.01 level.

5.4.1.1 Number of seed row per ear

The maximum number of seed rows per ear among timing of weed control treatment was observed at the weed-free treatment. The highest number of rows per ear in sole maize crop (14.11 seed rows ear^{-1}), while decreased to 13.55 and 12.22 seed rows ear^{-1} for maize in intercrops (M: SB 1: 1) and (m: SB 1: 2), treatment, respectively.The lowest number of seed rows per ear was observed at the weeding-V8 treatment and there were not statistical significantly differences between sole maize crop and maize intercrops in this weeding treatment (Figure 23).

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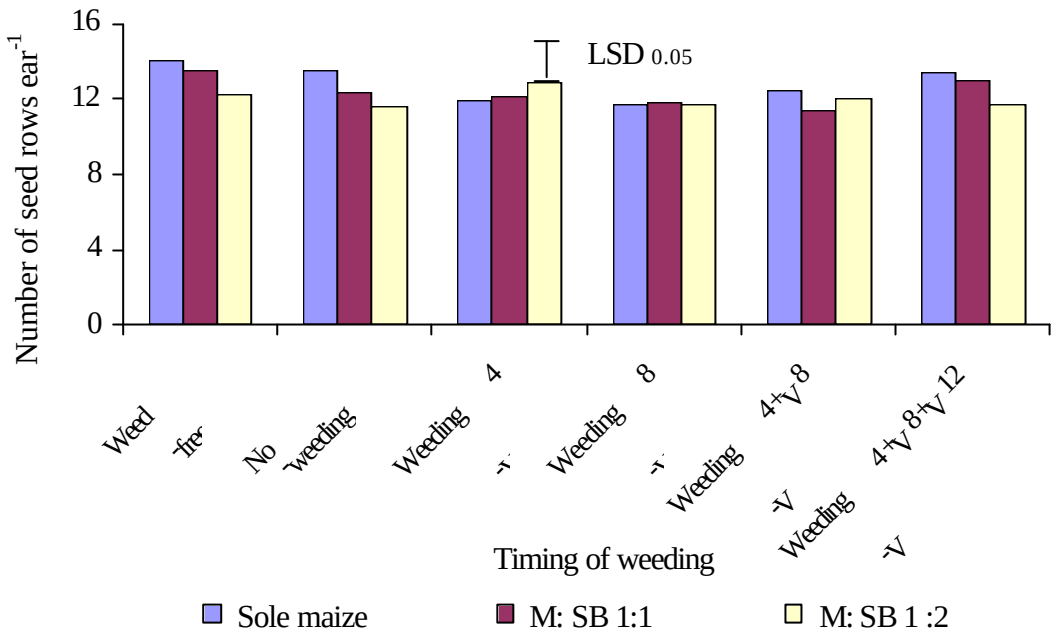

Figure 23. Number of seed row per ear.

5.4.1.2 Number of seeds per seed row

Number of seeds per seed row was differed among timing of weeding and cropping treatment (Figure 24), demonstrated the sole crop of maize was higher maize intercrops for the weed-free and weeding-V4+V8+V12 treatment. However, number of seeds per row at the weeding-V4, V8, and V4+V8 treatment was found that the maize intercrop (M: SB 1: 1) treatment higher than sole maize crop and (M: SB 1: 2)

treatment.

The highest of number seeds per seed row at the weeding-V4+V8+V12 treatment for sole crop of maize (29.66 seeds row^{-1}), while for both maize intercrops were decreased to 20.45 and 23.54 seeds row^{-1}, for (M: SB 1: 1) and (M: SB 1: 2) treatment, respectively. The lowest number of seeds per row was observed for maize intercrop for (M: SB 1: 2) treatment for all timing of weeding treatments, in which was 21.73 seeds row^{-1} for weeding-V8 treatment.

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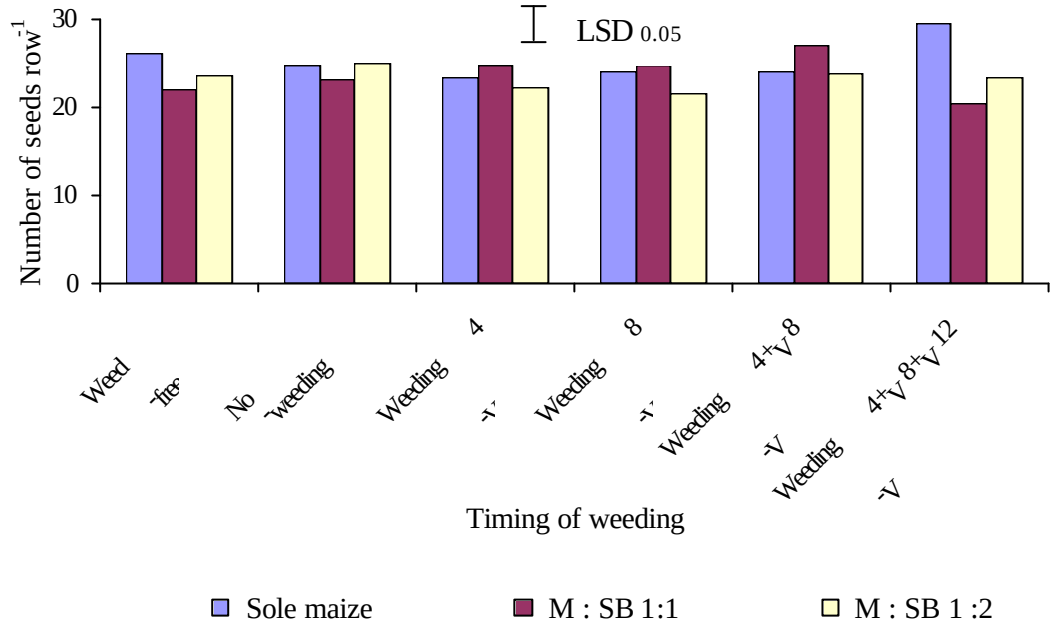

Figure 24. Number of seeds per seed row.

5.4.1.3 Number of seeds per ear

Number of seeds per ear in Table 39 and 40, demonstrated the differences number of seeds per ear in among timing of weed control treatments. The highest of seeds per ear was recorded in the weed-free treatment, which was 303.28 seeds ear^{-1}. The lowest seeds per ear were 273.19 seeds ear^{-1} for no-weeding treatment.

Table 39. Number seeds per ear of maize for timing of weeding treatments.

Treatment	No. Seeds per ear
Weed-free	303.28
No-weeding	273.19
Weeding-V4	283.74
Weeding-V8	280.33
Weeding-V4+V8	291.19
Weeding-V4+V8+V12	292.11

LSD $_{0.05}$ = 15.744

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Number seeds per ear in among of cropping treatment were found that, generally, sole maize crop treatment was higher than number seeds per ear in both maize intercrops of (M: SB 1: 1) and (M: SB 1: 1) treatment. The highest number of seeds per ear was 312.81 seeds ear^{-1} for sole crop of maize. The lowest was 271.89 seeds ear^{-1}, observed in the maize intercrop (single row of maize and double rows of soybean; M: SB 1: 2) treatment.

Table 40. Number seeds per ear of maize for cropping treatments.

Treatment	No. Seeds per ear
Sole maize	312.81
M: SB 1: 1	277.22
M: SB 1: 2	271.89

LSD $_{0.05}$ = 10.248

5.4.1.4 One thousand seeds weight

In table 41, demonstrated that one thousand of seeds weight for maize, it was cleared for differences between sole crop of maize and maize in intercrop treatments.

The weight of 1,000 seeds for sole crop of maize among timing of weed control treatment was higher than maize in intercropped treatments. However, the 1,000 seeds weight for maize intercrops was a slight difference between weeding treatment. The highest of average 1,000 seed weights was 279.11 g for sole crop of maize treatment. The lowest of average 1,000 seed weights was 256.81 g for single row of maize and double rows of soybean intercrop (M: SB 1: 2) treatment.

In difference, one thousand of seeds weight for maize, between sole maize and maize intercrop, there was only (19.45 g) difference between sole maize and maize in intercrop of sing row of maize and single row of soybean (M: SB 1: 1). And (22.3 g) for sole maize crop and maize intercrop of single row of maize and double rows of soybean (M: SB 1: 2) treatment.

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Table 41. One thousand seeds weight of maize for cropping treatments.

Treatment	One thousand seeds weight (g)
Sole maize	279.11
M: SB 1: 1	259.66
M: SB 1: 2	256.81

LSD $_{0.05}$ = 11.076

5.4.1.5 Harvest index (HI)

Among timing of weeding treatment, the relationship of harvest index was showed in table 42. The maximum was appeared in the weed-free treatment, which was 0.444 and latter were found in the sequences for weeding-V4+V8 and V4+V8+V12 treatment, there were 0.414 and 0.410 respectively. Minimum HI was not statistical significant differences in the weeding at V4, V8 and included no-weeding treatment. However, minimum HI was 0.387 found in the weeding-V4.

Table 42. The relationship of harvest index in maize crop for timing of weeding treatments.

Treatment	Harvest index (HI)
Weed-free	0.436
No-weeding	0.393
Weeding-V4	0.387
Weeding-V8	0.401
Weeding-V4+8	0.414
Weeding-V4+V8+V12	0.410

LSD $_{0.05}$ = 0.030

In Table 43, generally, the maximum of harvest index among cropping treatment was recorded in the sole crop of maize treatment (0.438). The minimum of

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HI were observed in the single row of maize and single row of soybean (M: SB 1: 1) and single row of maize and double rows of soybean (M: SB 1: 2) treatment. However, there were not statistically significantly differences. There were 0.398 and 0.392 respectively.

Table 43. The relationship of harvest index in maize for cropping treatments.

Treatment	Harvest index (HI)
Sole maize	0.431
M: SB 1: 1	0.398
M: SB 1: 2	0.392

$LSD_{0.05}$ = 0.019

5.4.2 Soybean yield components

The results of analysis of variance for the different yield components of soybean are summarized in Table 44. Time of weeding had a significant effect ($P<0.05$) on pod number per plant, number of filled pods per plant, and 100 seed weight. The greatest impact on soybean yield components was that of cropping treatment, which has a significant effect ($P<0.01$) on all yield components. It was not significant different for interaction between timing and cropping all treatments.

Table 44. Analysis of variance for soybean yield components.

Source of variation	Significance level (F test)				
	No. Pods plant^{-1}	No. Filled pods plant^{-1}	% unfilled pods plant^{-1}	100 seeds weight	HI
Replication (A)	ns	ns	ns	ns	ns
Timing of weeding (B)	*	*	ns	ns	*
Maize/soybean intercrop (C)	**	**	**	*	**
Interaction (B*C)	ns	ns	ns	ns	ns
CV (%)	20.1	20.6	25.5	4.9	7.0

ns = not significant; * = significant at 0.05 level; ** = significant at 0.01 level.

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5.4.2.1 Number of pods per plant

The relationship between the number of pods plant^{-1} with weeding treatments and cropping treatments were demonstrated in Table 45 and 46.

Number of pods per plant for soybean, among timing of weeding treatment was indicated that the one time weeding included weed-free and no-weeding did not affected to increased number of pods per plant. The highest of soybean pods per plant was found in the weeding-V4+V8 treatment (28.02 pods plant^{-1}) and lowest was recorded in the weed-free treatment of 22.28 pods plant^{-1}.

Table 45. The relationship of number pods per plant for timing of weeding treatments.

Treatment	No. Pods per plant
Weed-free	22.28
No-weeding	23.28
Weeding-V4	23.68
Weeding-V8	25.96
Weeding-V4+8	28.02
Weeding-V4+V8+V12	26.40

LSD $_{0.05}$ = 3.743

Generally, number of pods per plant of sole soybean cropped was higher than soybean were intercropped. The highest of number pods per plant among cropping treatments was found in the sole crop of soybean (32.56 pods plant^{-1}) and lowest was 18.96 pods plant^{-1} for two rows of soybean intercrop within each rows of maize crop.

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Table 46. The relationship of number pods per plant for cropping treatments.

Treatment	No. Pods per plant
Sole soybean	34.56
M: SB 1: 1	21.29
M: SB 1: 2	18.96

LSD $_{0.05}$ = 3.454

5.4.2.2 Number of filled pods per plant

Similarly, number filed pods per plant among timing of weeding treatments and cropping treatments, these relationships are demonstrated in Table 47 and 48.

The result for two times weed control was affected to increased number of filled pods per plant for soybean crop. However, the frequency of weed control was decreased number of filled pods per plant, included no-weeding treatment. The highest of number filled pods per plant was 26.58 pods plant^{-1}, observed in the weeding-V4+V8 treatment. The lowest of number filled pods per plant was 20.78 pods plant^{-1}, found in the wed-free treatment.

Table 47. Number of filled pods per plant for timing of weeding treatments.

Treatment	No. Filled pods per plant
Weed-free	20.78
No-weeding	22.16
Weeding-V4	22.68
Weeding-V8	24.59
Weeding-V4+V8	26.58
Weeding-V4+V8+V12	24.89

LSD $_{0.05}$ = 3.476

Number of pods per plant, among cropping treatments was demonstrated that the sole soybean cropped was higher than both soybean intercropped (M: SB 1: 1) and (M: SB 1: 2) treatment. The highest number of pods per plant was 32.83 pods plant^{-1}, for sole crop of soybean and lowest was 17.99 pods plant^{-1}, observed in the soybean intercrop of sing row of maize and double rows of soybean (M: SB 1: 2) treatment.

Table 48. Number of filled pods per plant for cropping treatments.

Treatment	No. Filled pods per plant
Sole soybean	32.83
M: SB 1: 1	20.02
M: SB 1: 2	17.99

LSD $_{0.05}$ = 3.340

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5.4.2.3 Percent of unfilled pods per plant

Percents of unfilled pods per plant, among cropping treatments was demonstrated in Table 49. The relationship between the percent of unfilled pods per plant had reflected to affeected between sole soybean cropping and two soybean intercroping treatments. The highest of percent of unfilled pods per plant was found that for soybean intercrop of single of maize and double rows of soybean (M: SB 1: 2) treatment (7.5%). The lowest was 5.5 %, recorded in sole crop of soybean treatment.

Table 49. The relationship of percent of unfilled pods per plant fro cropping treatments.

Treatment	Percent of unfilled pods per plant
Sole soybean	5.5
M: SB 1: 1	6.9
M: SB 1: 2	7.5

$LSD_{0.05} = 1.168$

5.4.2.4 One hundred seeds weight

The relationship of one hundred seeds weight (Table 50), showed that there was differed for 100 seeds weight, among cropping treatments. While for both sole soybean and soybean intercrop of (M: SB 1: 2) was higher than soybean intercrop of (M: SB 1: 1) treatment, but both of these not statistically significant. The highest for 100 seeds weight of soybean was recorded in the sole crop of soybean treatment, in which 13.40 g. The lowest of 100 seeds weight for soybean was observed in the soybean intercrop of single row of maize and single row of soybean (M: SB 1: 1) treatment, in which was 12.81g.

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Table 50. One hundred seeds weight for cropping treatments.

Treatment	One hundred seeds weight (g)
Sole soybean	13.40
M: SB 1: 1	12.81
M: SB 1: 2	13.12

LSD $_{0.05}$ = 0.438

5.4.2.5 Harvest index (HI)

The relationships of HI to the various treatments are indicated in Table 51 and 52. The HI ranged from a maximum of 0.543 for weed-free treatment and minimum of HI was 0.487 for weeding-V8 treatment. However, weed-free and no-weeding were not statistical significantly differences. The relationship between four times of weed control treatments were related lower than weed-free and no-weeding treatment, but all of these were not statistical significantly differences.

Table 51. Relationship for harvest index (HI) in the timing of weeding treatments.

Treatment	Harvest index (HI)
Weed-free	0.543
No-weeding	0.521
Weeding-V4	0.509
Weeding-V8	0.487
Weeding-V4+V8	0.509
Weeding-V4+V8+V12	0.493

LSD $_{0.05}$ = 0.031

The maximum of HI was observed in the soybean intercrop for sing row of maize and single row of soybean (M: SB 1: 1) treatment, which was 0.529. The lowest was 0.488, found in the soybean intercrop for single row of maize and double rows of soybean (M: SB 1: 2) treatment.

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However, it was usually the soybean intercrop for single row of maize and single row of soybean (M: SB 1:1) treatment that gave a slightly higher HI than the sole soybean crop or when two rows of soybean were intercropped to a single row of maize (M: SB 1:2); between these latter two treatments the sole soybean crop was usually associated with a slightly higher HI.

Table 52. Relationship for harvest index (HI) in the cropping treatments.

Treatment	Harvest index (HI)
Sole soybean	0.514
M: SB 1: 1	0.529
M: SB 1: 2	0.489

$LSD_{0.05} = 0.025$

5.5 Grain yield of maize and soybean intercropping

Analysis of variance was undertaken on grain yield for each of maize and soybean in the different treatments combinations, and also on total grain yield in the different cropping combinations. The results of these analyses are summarized in Table 53.

Table 53. Summary of analysis of variance for maize, soybean and intercrop yields.

Source of variance	Significance level (F test)	
	Maize grain yield	Soybean grain yield
Replications (A)	ns	ns
Timing of weeding (B)	**	*
Maize/soybean intercrop (C)	**	**
B*C	*	ns
CV %	7.5	22.3

ns = not significantly ; * significantly at 5% level; ** significant at 1% level.

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5.5.1 Grain yield of maize

Both the main effect treatments (weeding and cropping) had significant ($P<0.01$) effects on maize grain yield, as did the interaction between these treatments ($P<0.05$) (Table 53). The relationship between these treatments and maize yield is illustrated in Figure 25.

The highest grain yields for maize were achieved when maize was sole cropped in weed-free conditions or with frequent weeding treatments (weeding at V4+V8+V12). The yield in these two treatments was 5185.9and 4979.4 kg ha^{-1}, respectively. Weed competition in the sole crop of no-weeding treatment reduced the grain yield by 23.2 to 3984.8 kg ha^{-1}, (compare with weed-free treatment). Grain yield in the sole maize crop treatment for three of the four time-of-weeding treatments (V4, V8, V4+8) was little different from that of the sole maize in the no-weeding treatment, suggesting that overall, the impact of weed competition on yield was not very great. Among the intercropping treatments the relationship of maize grain yield did not show general consistency with the weeding treatments; for example, the single row maize: single row soybean (M: SB 1:1) gave a higher yield than single row maize: two rows soybean (M: SB 1:2) in two time-of-weeding treatments (V8 and V4+8) but showed no difference for two others (V4, V4+8+12). These differences could not be specifically associated with competition effects.

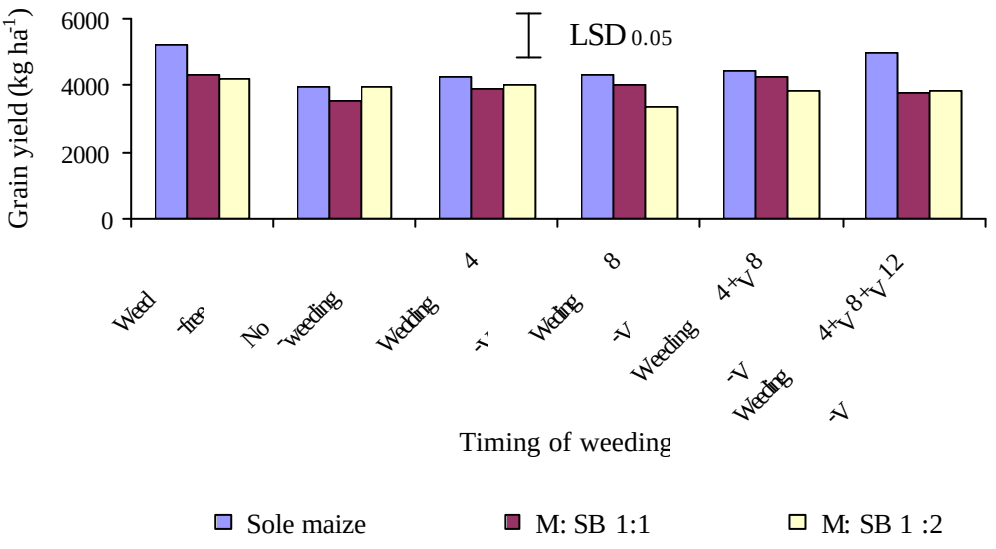

Figure 25. Relationship of maize grain yield to weeding and cropping treatments.

5.5.2 Grain yield of soybean

Soybean grain yield was determined by time-of-weeding ($P<0.05$) and intercropping treatments ($P<0.01$). The interaction between these variables was not statistically significant. The relationship between soybean grain yield and cropping treatment was generally consistent over all weeding treatments (Table 54 and 55). All weeding treatments (including the weed free and no weeding) highest soybean yields were associated with the weeding treatment V4+V8+V12 was 1323.1 kg ha^{-1}. The lowest soybean yields was associated with no-weeding treatment of 1177.4 kg ha^{-1}.

Table 54. The relationship for soybean grain yield in the among of timing of weed control treatments.

Treatment	Soybean grain yield (kg ha^{-1})
Weed-free	1323.1
No-weeding	1177.4
Weeding-V4	1203.7
Weeding-V8	1303.7
Weeding-V4+V8	1318.5
Weeding-V4+V8+V12	1410.6

$LSD_{0.05}$ = 147.98

Generally, sole crop of soybean was higher than soybean intercrop treatments, where the highest of sole soybean crop was 1973.2 kg ha^{-1}. The lowest of soybean yield was 678.4 kg ha^{-1}, for soybean intercrop of single row of maize and single row of soybean (M: SB 1: 1) treatment.

However, the soybean intercrop of single row of maize and double rows of soybean (M: SB 1: 2) treatment was on average 538.5 kg ha^{-1} (covered 44.3%) higher than soybean intercrop (M: SB 1: 1) treatment.

Table 55. The relationship for soybean grain yield in the among cropping treatments.

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Treatment	Soybean grain yield (kg ha^{-1})
Sole soybean	1973.2
M: SB 1: 1	678.4
M: SB 1: 2	1216.9

$LSD_{0.05}$ = 198.24

5.6 Land equivalent ratio (LER)

The results of analysis of variance for land equivalent ratio result (Table 56). Showed that there was significant different for LER in the timing of weeding ($p<0.05$) and maize/soybean intercropping systems all treatment ($p<0.01$).

Table 56. Analysis of variance for land equivalent ratio of maize and soybean intercropping.

Source of variation	Significant levels (F test)
	LER
Replication (A)	ns
Timing of weeding (B)	*
Maize/soybean intercrop (C)	**
Interaction (B*C)	*
CV %	9.1

ns = not significant; * = significant at 5 % level; ** as significant at 1 %level.

The land equivalent ratio (LER) of maize and soybean intercrop was illustrated (Figure 26). There was advantaged the grain yield of maize and soybean intercropping treatment, compared with maize and soybean sole cropped. The LER value, in intercrop was greater than 1.00 for all of timing of weed control and intercropping.

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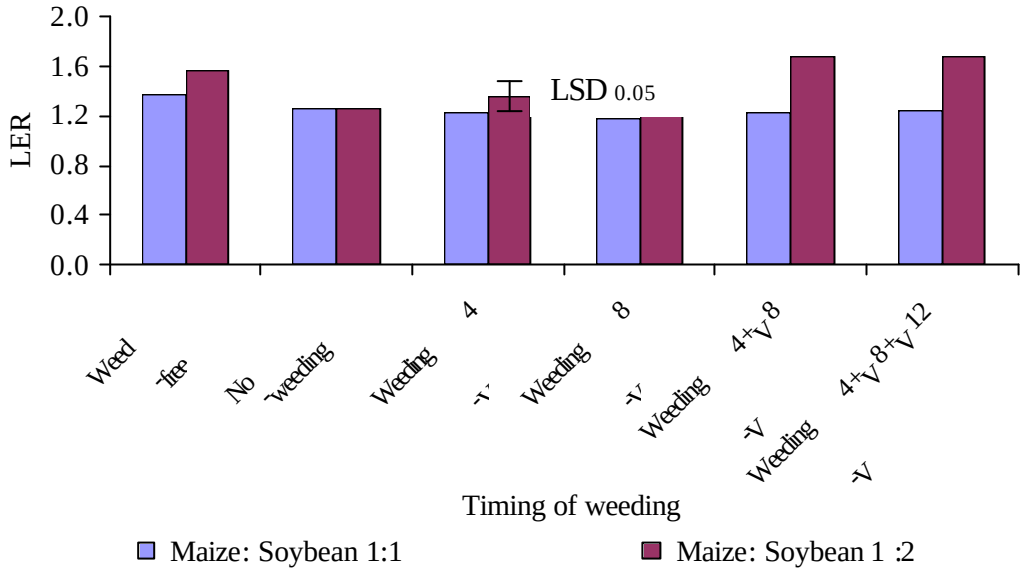

Figure 26. Land equivalent ratio of maize and soybean intercropping

Generally, all the LER values, for single row of maize and double rows of soybean intercrop, (M: SB 1: 2) treatment was higher than single row of maize and single row of soybean intercrop, (M: SB 1:1) treatment, for all timing of weeding treatment. The maximum of LER value for (M; SB 1: 2) was 1.69, recorded at the weeding-V4+V8 treatment and decreased to 1.26 was observed at no-weeding treatment. However, while the LER value, for (M: SB 1: 1) treatment was decreased to 1.38 for weed-free and 1.18 for weeding-V8 treatment was lowest of LER value. In difference, for average of LER value intercrops, for the (M: SB 1: 2) treatment was higher than (M: SB 1: 1) treatment 14.3 % of LER value.

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5.7 Economic consideration

The results of analysis of variance for economic indicators of all treatments in Table 57, demonstrated that there was significant different for total revenue in the timing of weeding and cropping all treatment ($p<0.01$). Three indicators of total variable costs, gross margin per unit area and gross margin per labor use for weeding. There were significant differences for interaction all economic indicators at 1% for total variable cost, 5% for gross margin and gross margin per labor use for weeding at

1%. The relationship of all economic indicators was showed in the summary in table as below.

Table 57. Economic return for maize and soybean intercropping systems.

Source of variation	Significant levels (F test)			
	Total Revenue	Total Variable Costs	Gross Margin	Gross Margin $Ld^{-1}Day^{-1}$
Replication (A)	ns	ns	ns	ns
Timing of weeding (B)	**	**	**	**
Maize/soybean intercrop (C)	**	**	**	**
Interaction (B*C)	ns	**	*	**
CV (%)	11.6	4.3	20.9	17.2

ns = not significant , * = significant at 0.05 level; ** = significant at 0.01 level.

Economic analysis was also performed to compare the economical advantages of intercropping over sole crop. Economic analysis was conducted based on the gross margin, total revenue and total variable costs at different timing of weeding and intercropping treatment.

It found that intercropping treatment increased the total revenue and gross margin. In fact, overall of intercropping gave higher total revenue as well as higher gross margin than sole crop of maize and sole crop of soybean.

The total revenue, results in Table 58 and 59, demonstrated the reflected of affects of frequencies in the timing of weeding and intercropping was higher of total revenue than other timing of weeding and sole cropping of maize and soybean treatment. The highest of total revenue was appeared in the weed-free treatment, which as 28,104 Baht ha^{-1} and latter was found in the weeding-V4+V8+V12 treatment, in which was 27,417 Baht ha^{-1}. However, in the timing of weeding at V4+V8 treatments was a not statistically significant difference between weed-free and weeding-V4+V8+V12 treatment. The lowest of total revenue was 24,425 and 24,874 Baht ha^{-1}, for no-weeding and weeding treatment at V4, respectively.

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Table 58. Total revenue per hectare (Baht ha^{-1}).

Treatment	Total revenue
Weed-free	28,104
No-weeding	24,425
Weeding-V4	24,874
Weeding-V8	591.17
Weeding-V4+V8	26,599
Weeding-V4+V8+V12	27,417

$LSD_{0.05}$ = 40.176

Note: 1. Price of maize seeds: 5 Baht kg^{-1} 2. Price of soybean seeds: 11.7 Baht kg^{-1}
3. Labor: 150 Baht day^{-1} 4. Fertilizer: (16-16-16): 11.10 Baht kg^{-1}
5. Fertilizer: (46-00-00): 7.00 Baht kg^{-1}
1 US $ = 43 Baht

Generally, the total revenue for maize and soybean intercropping was obtained greater than sole cropping of maize and soybean. The highest of total revenue was occurred in the single row of maize and two rows of soybean treatment, in which was 32,783 Baht ha^{-1}. The lowest were found in the sole crop of maize and soybean, but not statistically significant differences, there were 22,664 and 21,705 Baht ha^{-1}, for sole crop of maize and soybean treatment, respective.

Table 59. Total revenue per hectare (Baht ha^{-1}).

Treatment	Total revenue
Sole maize	22,664
Sole soybean	21,705
M: SB 1: 1	27,407
M: SB 1: 2	32,783

$LSD_{0.05}$ = 47.468

Total variable costs were included labor use for weed control, among timing of weeding treatments and maize and soybean intercropping treatments showed in

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Table 60. When, frequencies of weeding that, as a result to high cost of total variable costs for invest to timing of weeding in maize and soybean intercropping systems.

Thus, the highest of total variable costs were demonstrated in the weed-free treatment was 30,891 Baht ha^{-1} for sole soybean crop treatment. While dropped to 24,498 Baht ha^{-1} for single row of maize and double row of soybean intercrop (M: SB 1: 2) treatment. However, the lowest of total variable costs were found in the no-weeding for all cropping treatments, in which was 8,664 Baht ha^{-1} for sole crop of maize treatment.

Table 60. Total variable costs per hectare (Baht ha^{-1}).

Treatment	Weed-free	No-weeding	Weeding-V4	Weeding-V8	Weeding-V4+V8	Weeding-V4+V8+V12	Mean
Sole maize	29,498	8,664	12,484	11,327	15,377	18,271	15,937
Sole soybean	30,891	8,784	12,372	12,372	14,224	18,044	16,114
M: SB 1: 1	27,403	8,884	13,514	13,861	17,102	20,111	16,812
M: SB 1: 2	24,498	9,104	13,850	14,429	16,974	19,753	16,434
Mean	28,072	8859	13,055	12,997	15,919	19,045	16,325

$LSD_{0.05}$ = 26.802

Gross margin per unit area and gross margin per labor use for weed control was final necessary stage for assessment production output and investment efficiency in agricultural production. In this study economic analysis was also done to compare the advantages of intercropping greater than sole crop.

The economic analysis showed that all the intercropping treatments gave a positive gross margin per unit area and gross margin per labor use for weed control for all timing of weed control in maize and soybean intercropping systems. The relationship between gross margins per unit area showed that in Table 61.

Generally, the highest of gross margin per unit area was found in the no-weeding treatment for all cropping treatments. However, the highest of gross margin was appeared in the single row of maize and double rows of soybean treatment were

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24,242 Baht ha^{-1}, while reduced to 9484 Baht ha^{-1}, for sole crop of soybean treatment. The lowest was found in the frequencies of weeding as weed-free treatment for all cropping treatment. There were negatives for sole crop of maize and soybean treatment, which was (-3568 Baht ha^{-1}) and (-9247 Baht ha^{-1}), respectively.

Moreover, for four timing of weed control treatments were weeding treatment at V4, V8, V4+8 and weeding at V4+V8+V12. There were found that gross margin per unit area as higher than weed-free treatment for all croppping traetments. However, the highest of gross margin was demonstrated in the weeding treatment at V4, which was 24,242 Baht ha^{-1}, for single row of maize and double rows of soybean intercrop treatment (M: SB 1: 2). The lowest of gross margin was found in the weeding treatment (V4+V8+V12), which was 5,956 Baht ha^{-1}, for sole soybean cropping treatment.

Table 61. Gross margin per unit area (Baht ha^{-1}).

Treatment	Weed-free	No-weeding	Weeding-V4	Weeding-V8	Weeding-V4+V8	Weeding-V4+V8+V12	Mean
Sole maize	(-3568)	12628	7440	10409	6828	6626	6727
Sole soybean	(-9247)	9484	9043	8949	9360	5956	5591
M: SB 1: 1	2266	15,909	12,636	14,362	10,858	7540	10,595
M: SB 1: 2	10,676	24,242	18,156	15,975	15,672	13,369	16,348
Mean	32	15,566	11,819	12,424	10,680	8373	9815

$LSD_{0.05}$ = 116.86

Gross margin per labor-day use for weeding among timing of weeding and maize and soybean intercropping was showed in Table 62.

Gross margin per labor use for weed control was considered for labor requirement to using for weeding in each times. The highest of gross margin was obtained in the timing of weeding at V8 treatment for sole crop of maize treatment (394 Baht $Ld^{-1}Day^{-1}$). However, the lowest was found in the weed-free treatment for all maize and soybean intercropping treatments. In the both of sole crop of maize and

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soybean had also been negatives and dropped to (-16 Baht $Ld^{-1}Day^{-1}$) and (- 41 Baht $Ld^{-1}Day^{-1}$), respectively. Due to, weed-free treatments for all cropping treatments were peaked of labor requirement for weed control in maize and soybean cropping systems. While, in both of maize and soybean intercropping was higher than sole crop of soybean treatment. The highest of gross margin per labor use for weeding was observed in the weeding treatment at V4 for single row of maize and double rows of soybean intercropping (M: SB 1: 2), which was 380 Baht $Ld^{-1}Day^{-1}$. The lowest for maize and soybean intercropping treatment was found in the weed-free treatment (13 Baht $Ld^{-1}Day^{-1}$).

However, in the four timing treatments were weeding treatment at V4, V8, V4+V8 and V4+V8+V12, respectively. There were found that signle timing of weding such as weeding treatment at V4 and V8 had gross margin per labor use for weeding higher than weeding treatment at V4+V8 and V4+V8+V12, for all cropping treatments. While, maize and soybean intercropping was also higher than maize and soybean sole cropping treatment. The mean of gross margin per labor use for weeding treatments were 277 and 309 Baht Ld^{-1} Day^{-1}, for weeding treatment at V4 and V8, recpectively. The low and lower of gross margin per labor use for weeding, the mean was 156 Baht Ld^{-1} Day^{-1}, for weeding treatment at V4+V8 and 82 Baht Ld^{-1} Day^{-1}, for weeding treatment at V4+V8+V12, respectively.

Table 62. Gross margin per labor-day use for weeding (Baht Ld^{-1} Day^{-1}).

Treatment	Weed-free	No-weeding	Weeding-V4	Weeding-V8	Weeding-V4+V8	Weeding-V4+V8+V12	Mean
Sole maize	(-16)	0	201	394	102	70	125
Sole soybean	(-41)	0	254	249	186	65	119
M: SB 1: 1	13	0	273	287	132	67	129
M: SB 1: 2	69	0	380	308	203	126	181
Mean	6	0	277	309	156	82	138

$LSD_{0.05}$ = 1.985 (Ld = Labor day).

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
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