APPENDIX

Appendix Table 1. List of farmers participant, on-farm research, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Farm number	Farmer name	Field number	Land Type
1	Charoen Chaisan	1	lower terrace
2	Dee Panrean	11	lower terrace
3	Tha Norkhum	90	lower terrace
4	Dee Manopan	91	lower terrace
5	Ton Pinta	94	lower terrace
6	Thong Pichainak	232	lower terrace
7	Boonyong Kampanprapankul	78	upper terrace
8	Chai chaisan	87	upper terrace
9	Suk Chaikewlae	118	upper terrace
10	Malee Sitthison	119	upper terrace
11	Rod Makaew	157	upper terrace
12	Tha Kampanprapankul	227	upper terrace

Appendix Table 2. List of the thirty households interviewed and monitored throughout the soybean growing season, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Household Number	Farmer Name	Field Number
1	Srinuan Guntawong	267
2	Ton Gonkeaun	266
3	Prapan Na Chiangmai	253
4	Suton Chanta	99
5	Peng Kaewpeng	135
6	Pan duangkaew	63
7	Dee Kaewpeng	212
8	Gumthorn Gunta	228
9	Sawang Montipan	281
10	Kaew Chaiauppala	9
11	Kamchad Taechesai	163
12	Thongsai Suksawasd	95
13	Suk Jaimakum	248
14	Kaew Wangsri	10
15	Unnrean Guntarak	74
16	Kaew Kamla	69
17	Kasem Pangun	146
18	Pan Boonma	262
19	Dee Tanoi	245
20	Hean Kumla	242
21	Suk Kodkaew	30
22	Udom Papankum	97
23	Sutin Moolkum	3
24	Kaew Upparee	239
25	Charean Jaisarn	25
26	Jan Mojomsin	154
27	Prasert Montipan	224
28	Rawat Norkum	35
29	Umnuay Tatan	234
30	Vichian Kaewjaiwong	300

Appendix Table 3. Rainfall data in 1989 comparing with the 25 years average rainfall (1959-1983) of Chom Thong district, Chiang Mai

month / date	J	F	M	A	M	J	J	A	S	O	N	D
1	-	-	-	-	-	-	0.2	-	-	0.3	-	-
2	-	-	-	-	-	-	1.1	-	-	1.1	-	-
3	-	-	-	-	-	-	-	-	0.4	29.4	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	0.1	-	-	12	-	-	-
6	-	-	-	-	2.1	-	-	-	27.1	40	-	-
7	-	-	-	-	-	-	-	-	-	15.2	-	-
8	-	-	-	-	-	-	-	-	-	34.1	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	0.2	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	0.2	0.2	-	-	-
13	-	-	-	-	-	-	0.4	1.1	-	-	-	-
14	-	-	-	-	-	-	-	4	-	52	-	-
15	-	-	-	-	5.1	-	-	2	-	74.1	-	-
16	-	-	-	-	21	-	-	-	-	70	-	-
17	-	-	-	-	52.2	-	0.1	-	-	-	-	-
18	-	-	-	-	40	-	-	-	-	-	-	-
19	-	-	-	-	-	7.2	-	-	0.2	-	-	-
20	-	-	-	-	-	5	-	-	1.1	28.2	-	-
21	-	-	-	-	-	-	-	-	17	-	-	-
22	-	-	-	-	-	-	0.4	0.1	-	12	-	-
23	-	-	-	-	-	-	0.2	-	-	-	-	-
24	-	-	-	-	0.3	-	1.1	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	32	-	-
26	-	-	-	-	-	-	-	-	0.3	18.4	-	-
27	-	-	-	0.2	0.2	0.3	-	-	-	-	-	-
28	-	-	-	-	27	1.2	-	-	0.1	-	-	-
29	-	-	-	-	45	-	-	-	2	23	-	-
30	-	-	-	-	-	0.2	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
total rainfall = 708.4 mm	0	0	0	0.2	192.9	14	3.5	7.4	60.4	430	0	0
raining day (53 days)	0	0	0	1	9	5	7	5	10	16	0	0
25 year-avg.rainfall = 966 mm	9	11	12	38	154	114	74	151	190	152	51	10
deviation of rainfall	-9	-11	-12	-37.8	38.9	-100	-70.5	-143	-129	278	-51	-10

Appendix Table 4. Daily minimum air temperature of the Chom Thong LRA in 1989

month / date	J	F	M	A	M	J	J	A	S	O	N	D
1	14	14	22	25	26	24	25	24	25	25	23	15
2	15	14	23	25	26	24	25	24	25	26	22	15
3	15	14	23	25	26	25	25	24	26	26	19	16
4	14	13	25	25	26	25	25	24	27	25	19	15
5	12	13	26	25	26	25	24	25	27	25	19	15
6	13	13	25	25	26	24	24	25	26	25	18	15
7	10	14	25	25	25	24	25	25	26	26	20	14
8	9	13	25	25	25	25	25	25	26	26	22	15
9	10	13	25	25	25	25	25	25	25	26	19	15
10	10	13	25	25	25	25	25	25	26	26	19	14
11	8	13	25	25	24	25	25	24	26	25	19	12
12	8	13	25	25	24	25	25	24	26	24	17	12
13	9	13	25	26	24	25	25	24	25	24	19	15
14	9	13	26	26	25	25	24	24	25	24	19	14
15	10	13	26	26	25	25	24	24	26	25	16	12
16	10	12	26	26	25	25	24	24	26	26	17	11
17	9	18	26	26	25	25	24	25	25	26	19	12
18	8	20	25	26	24	25	24	26	26	25	18	11
19	9	22	25	26	24	25	25	26	27	25	19	9
20	9	22	25	26	23	25	25	26	25	25	18	9
21	10	20	25	26	23	24	25	27	25	25	19	11
22	10	18	24	26	24	24	25	26	26	24	18	12
23	10	18	25	26	24	25	25	25	25	25	18	11
24	11	18	25	26	24	25	24	25	25	24	19	11
25	11	20	25	26	24	25	27	25	24	24	19	12
26	12	20	25	26	25	25	24	26	25	24	18	11
27	12	20	25	26	25	25	25	26	26	25	15	9
28	12	20	25	26	24	25	25	26	26	24	15	13
29	12		25	26	24	25	25	25	25	23	15	14
30	12		25	26	24	25	25	25	25	23	16	13
31	12		25		24		25	25		24		12
average	10.80	15.96	24.90	25.6	24.64	24.8	24.77	24.96	25.6	24.83	18.43	12.75

Appendix Table 5. Daily maximum air temperature of the Chom Thong LRA in 1989

month / date	J	F	M	A	M	J	J	A	S	O	N	D
1	25	26	34	35	35	32	34	32	34	34	32	23
2	25	26	34	35	35	32	34	32	32	34	32	23
3	26	27	34	35	34	32	34	32	34	33	31	24
4	25	26	35	36	35	32	32	32	35	32	31	24
5	25	26	35	36	34	32	32	32	36	34	31	22
6	25	26	35	35	33	32	32	33	36	35	31	23
7	26	26	35	36	32	32	32	33	37	35	29	22
8	26	26	34	36	32	34	33	32	36	35	31	29
9	26	28	34	36	32	34	32	32	34	35	30	30
10	26	30	34	36	32	34	34	32	34	34	31	29
11	25	31	35	36	32	35	34	32	33	34	31	30
12	25	31	34	36	32	34	32	34	34	32	30	29
13	25	32	34	36	32	34	32	34	32	32	32	22
14	25	32	35	37	33	34	32	32	32	32	32	25
15	25	35	35	37	33	33	32	32	34	34	32	25
16	25	35	35	38	33	32	32	32	33	34	32	27
17	25	36	34	38	33	32	32	34	32	34	32	27
18	25	36	35	40	32	32	32	34	32	33	32	29
19	25	36	35	40	32	32	32	33	36	32	32	25
20	25	37	34	40	32	32	32	36	36	34	32	25
21	25	35	34	39	32	32	32	36	35	33	31	26
22	25	34	34	39	32	32	32	35	34	34	29	28
23	26	32	35	39	33	32	32	35	32	32	29	28
24	25	32	35	37	32	33	32	34	31	32	29	28
25	26	32	35	37	32	32	32	32	32	32	28	29
26	26	33	35	38	32	32	32	34	33	33	29	29
27	26	32	35	37	32	32	32	36	34	33	28	28
28	25	33	35	37	32	32	33	36	32	33	27	31
29	26		35	36	32	32	33	36	31	32	25	29
30	26		35	36	32	32	32	36	32	32	25	28
31	26		35		32		34	34		32		29
average	25.38	31.10	34.61	36.96	32.61	32.56	32.48	33.51	33.6	33.22	30.2	26.64

Appendix Table 6. Grain yield of soybean in RCB design with six treatment combinations on 12 farms and two replications per farm, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Treatment Number (variety + fertilizer)	Grain yield, kg/rai		
	rep. 1	rep. 2	Average
	farm 1		
T1 (SJ 5 + 0-0-0)	118.60	138.37	128.49
T2 (SJ 5 + 1.5-4.5-3)	146.27	154.21	150.24
T3 (SJ 5 + 3-9-6)	179.75	158.37	169.06
T4 (CM 60 + 0-0-0)	123.15	160.13	141.64
T5 (CM 60 + 1.5-4.5-3)	182.10	153.74	167.92
T6 (CM 60 + 3-9-6)	144.87	204.56	174.71
	farm 2		
T1 (SJ 5 + 0-0-0)	89.16	136.10	112.63
T2 (SJ 5 + 1.5-4.5-3)	160.11	165.55	162.83
T3 (SJ 5 + 3-9-6)	176.20	174.23	175.22
T4 (CM 60 + 0-0-0)	126.60	200.18	163.39
T5 (CM 60 + 1.5-4.5-3)	211.85	153.82	182.83
T6 (CM 60 + 3-9-6)	186.79	171.66	179.22
	farm 3		
T1 (SJ 5 + 0-0-0)	85.84	48.11	66.98
T2 (SJ 5 + 1.5-4.5-3)	136.45	134.88	135.67
T3 (SJ 5 + 3-9-6)	82.97	140.34	111.66
T4 (CM 60 + 0-0-0)	120.86	139.59	130.23
T5 (CM 60 + 1.5-4.5-3)	176.22	169.10	172.66
T6 (CM 60 + 3-9-6)	210.22	169.90	190.06
	farm 4		
T1 (SJ 5 + 0-0-0)	170.10	172.90	171.50
T2 (SJ 5 + 1.5-4.5-3)	203.01	191.47	197.24
T3 (SJ 5 + 3-9-6)	121.89	207.18	164.53
T4 (CM 60 + 0-0-0)	225.78	211.57	218.67
T5 (CM 60 + 1.5-4.5-3)	175.72	249.16	212.44
T6 (CM 60 + 3-9-6)	199.13	210.47	204.80
	farm 5		
T1 (SJ 5 + 0-0-0)	186.28	134.93	160.60
T2 (SJ 5 + 1.5-4.5-3)	204.62	190.54	197.58
T3 (SJ 5 + 3-9-6)	220.82	176.47	198.64
T4 (CM 60 + 0-0-0)	210.26	132.97	171.62
T5 (CM 60 + 1.5-4.5-3)	203.99	202.01	203.00
T6 (CM 60 + 3-9-6)	220.51	194.35	207.43
	farm 6		
T1 (SJ 5 + 0-0-0)	102.92	125.49	114.20
T2 (SJ 5 + 1.5-4.5-3)	136.30	120.45	128.38
T3 (SJ 5 + 3-9-6)	207.24	151.85	179.55
T4 (CM 60 + 0-0-0)	177.16	133.04	155.10
T5 (CM 60 + 1.5-4.5-3)	275.15	273.60	274.37
T6 (CM 60 + 3-9-6)	155.64	232.94	194.29

Appendix Table 6. (continued)

Treatment Number (variety + fertilizer)	Grain yield, kg/rai		
	rep. 1	rep. 2	Average
		farm 7	
T1 (SJ 5 + 0-0-0)	93.05	122.62	107.84
T2 (SJ 5 + 1.5-4.5-3)	90.07	74.03	82.05
T3 (SJ 5 + 3-9-6)	125.05	109.84	117.45
T4 (CM 60 + 0-0-0)	128.52	110.68	119.60
T5 (CM 60 + 1.5-4.5-3)	130.47	151.85	141.16
T6 (CM 60 + 3-9-6)	125.25	150.12	137.69
		farm 8	
T1 (SJ 5 + 0-0-0)	135.37	149.23	142.30
T2 (SJ 5 + 1.5-4.5-3)	164.36	192.65	178.51
T3 (SJ 5 + 3-9-6)	143.30	145.10	144.20
T4 (CM 60 + 0-0-0)	153.46	143.89	148.67
T5 (CM 60 + 1.5-4.5-3)	169.48	122.62	146.05
T6 (CM 60 + 3-9-6)	154.81	232.40	193.61
		farm 9	
T1 (SJ 5 + 0-0-0)	148.62	161.02	154.82
T2 (SJ 5 + 1.5-4.5-3)	189.75	163.71	176.73
T3 (SJ 5 + 3-9-6)	262.62	261.68	262.15
T4 (CM 60 + 0-0-0)	186.67	231.37	209.02
T5 (CM 60 + 1.5-4.5-3)	286.97	183.83	235.40
T6 (CM 60 + 3-9-6)	283.51	285.62	284.56
		farm 10	
T1 (SJ 5 + 0-0-0)	127.50	189.84	158.67
T2 (SJ 5 + 1.5-4.5-3)	136.96	159.07	148.01
T3 (SJ 5 + 3-9-6)	137.33	217.25	177.29
T4 (CM 60 + 0-0-0)	104.45	145.42	124.94
T5 (CM 60 + 1.5-4.5-3)	152.58	195.35	173.96
T6 (CM 60 + 3-9-6)	237.44	218.04	227.74
		farm 11	
T1 (SJ 5 + 0-0-0)	79.96	148.48	114.22
T2 (SJ 5 + 1.5-4.5-3)	123.91	158.24	141.08
T3 (SJ 5 + 3-9-6)	154.13	219.62	186.88
T4 (CM 60 + 0-0-0)	206.81	119.74	163.28
T5 (CM 60 + 1.5-4.5-3)	137.62	230.59	184.11
T6 (CM 60 + 3-9-6)	158.74	144.18	151.46
		farm 12	
T1 (SJ 5 + 0-0-0)	162.00	192.51	177.26
T2 (SJ 5 + 1.5-4.5-3)	162.08	211.73	186.91
T3 (SJ 5 + 3-9-6)	174.46	292.85	233.66
T4 (CM 60 + 0-0-0)	159.93	145.45	152.69
T5 (CM 60 + 1.5-4.5-3)	199.07	213.69	206.38
T6 (CM 60 + 3-9-6)	327.26	215.04	271.15

Appendix Table 7. Partitioning combined analysis of variance for yield of soybean grown in a rainfed upland area

SOURCE OF VARIATION	DF	SS	MS	F	P
FARM (A)	11	1.1213E+05	1.0193E+04	8.54	0.0004
REP WITHIN FARMS (B)					
A * B	12	1.4316E+04	1193.0		
V (C)	1	2.7823E+04	2.7823E+04	25.77	0.0000
F (D)	2	4.5559E+04	2.2780E+04	21.10	0.0000
F_0vs (F_1F_2) of SJ 5	(1)	1.718E+04	1.718E+04	15.91**	
F_0vs (F_1F_2) of CM 60	(1)	2.348E+04	2.348E+04	21.74**	
C * D	2	831.48	415.74	0.39	0.6872
A * C	11	1.3472E+04	1224.7	1.13	0.3017
A * D	22	2.7912E+04	1268.7	1.18	0.3032
A * C * D	22	2.7124E+04	1232.9	1.14	0.3326
A * B * C * D	60	6.4781E+04	1079.7		
TOTAL	143	3.3395E+05			
GRAND AVERAGE	1	4.1551E+06			

Appendix 8. Analysis over sites

The procedure for combining data analysis over 12 farms are shown below for a trial involving two soybean varieties and three levels of fertilizer application tested in a factorial experiment in RCB design. The result of the individual analysis of variance at each farm is based on grain yield data. The procedure for combining data is as follows:

Apply the chi-square test for homogeneity of variance to the 12 error variances from the individual analysis of variance. If the test is significant, all farm whose coeficients of variation are extremely large (i.e., CV > 20%) can be excluded from the combined analysis.

Test for homogeneity of variance

This test is used to verify homogeneity of error variances in combining data from a series of experiments. In order to combine the data from the 12 farms, homogeneity of variance from the 12 individual RCB analysis of variance must be established. The data collected are grain yield in kg/rai, and the 12 error mean squares, each with 5 degrees of freedom are:

$$s_1^2 = 571.40$$

$$s_2^2 = 1,080.80$$

$$s_3^2 = 672.67$$

$$s_4^2 = 953.39$$

s_5^2 = 374.87

s_6^2 = 1,170.20

s_7^2 = 264.10

s_8^2 = 857.97

s_9^2 = 1,262.50

s_{10}^2 = 593.05

s_{11}^2 = 2,234.50

s_{12}^2 = 2,918.40

The step by step procedure to apply the chi-square test to test for homogeneity of variances with equal degree of freedom are:

STEP 1. For each variance estimate s^2, compute log s^2, where log refers to logarithm base 10. Then, compute the totals of all 12 values of s^2 and of log s^2.

The values of s^2, and log s^2, for each of the 12 error mean squared and their totals are shown below:

Farm	s^2	log s^2
1	571.40	2.7569
2	1,080.80	3.0337
3	672.67	2.8278
4	953.39	2.9793
5	374.87	2.5739
6	1,170.20	3.0683
7	264.10	2.4218

Farm	s^2	log s^2
8	857.97	2.9335
9	1,262.50	3.1012
10	593.05	2.7731
11	2,234.50	3.3492
12	2,918.40	3.4651
Total	12,953.85	35.2838

STEP 2. Compute the pooled estimate of variance as:

$$s_p^2 = \frac{\sum_{i=1}^{12} s_i^2}{12} \qquad 12{,}953.85/12 = 1{,}079.4875$$

STEP 3. Let f be the degree of freedom of each s_i, k be the number of variance with equal degree of freedom, compute the X^2 value as:

$$X^2 = \frac{(2.0326)\ (f)\ (k \log s_p^2 - \log s_i^2)}{1 + [(k + 1)/3kf]}$$

For the experiment, the X^2 value is computed as:

$$X^2 = \frac{(2.3026)(5)[(12)(\log 1079.4875) - 35.2838]}{1 + [(12 + 1)/(3)(12)(5)]}$$

$$= \frac{12.83}{1.07}$$

$$= 11.97$$

STEP 4. Compare the computed X^2 value with the tabular X^2 value with (k-1) d.f.; and reject the hypothesis of homogeious variance if the computed X^2 value exceeds the corresponding tabular X^2 value at the prescribed level of significance.

For the experiment, the compute X^2 value is smaller than the corresponding tabular X^2 value with (k-1) = 12-1 = 11 d.f. and at the 5% level of significance 19.67. Thus, the hypothesis that the 12 error variances are homogeneous can not be rejected.

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