CHAPTER 5

CROP SIMULATION

Risk and uncertainty in rice production were divided in production risk and marketing risk. In this study, crop model was a tool to simulate rice grain yield. The fluctuation of simulated yield was then analyzed in production risk analysis. The simulated yield outcomes were combined with varying cost of inputs and prices of rice as sources of marketing risk for simulation of net margin. Hence, net margin encompassed of both production risk and marketing risk. Analysis of risk from these simulated series of net margin is considered as economic risk analysis.

5.1 Input Data

Input data of CERES-Rice crop model in the study consisted of weather condition, genetic coefficient, soil series and farm management strategies. These input data was transformed to database file of CERES-Rice crop model in DSSAT v3.5. Preparations of these data file are described in the following topics.

5.1.1 Weather Condition

Weather data, preferably daily, must be available for the duration of the growing season, beginning with the day of planting and ending at crop maturity. The weather file should contain data of several days before planting to after maturity. This would allow a simulation to be started before planting, thus providing an estimate of soil conditions at planting time. Additional weather data would also allow for the selection of alternate planting dates and for simulation based on weather and soil condition at planting, and for the simulation of longer duration crop cultivars for model sensitivity analysis. The first lines in each weather data file, regardless of its length, contain some details of the site (institution and site code (INSI), latitude (LAT), longitude (LONG), elevation (ELEV), temperature average for whole year (TAV), air temperature amplitude (AMP), Reference height for weather measurements (REFHT) and Reference height for wind speed measurements (WNDHT)). On all subsequent lines, there are data for different weather aspects at daily intervals. Generally, the file contain data on date (DATE), solar radiation (SRAD), maximum temperature (TMAX), minimum temperature (TMIN), precipitation (RAIN), but more variables could be included as long as abbreviations for all variables are included in the header line and crop model.

Weather data of San Sai district was used in the study. The daily weather data was collected for the period of 1972 -2001 that consists of solar radiation, maximum air temperature, minimum air temperature and precipitation. These weather data was input in the weather data file of DSSAT v3.5. Figure 5.1 shows the example weather data file of the study.

```
*WEATHER  DATA :Mae Jo
@ INSI       LAT      LONG  ELEV   TAV   AMP REFHT WNDHT
  CM71    18.917    99.000 317.0 -99.0 -99.0 -99.0 -99.0
@DATE  SRAD  TMAX  TMIN  RAIN
01001  13.6  25.8  14.7   0.0
01002  13.2  26.3  16.7   0.0
01003  13.5  25.9  13.0   0.0
01004  15.3  27.7  13.8   0.0
01005  15.5  28.4  13.5   0.0
01006  15.1  28.4  15.7   0.0
01007  14.8  28.7  15.2   0.0
01008  14.8  28.0  14.2   0.0
01009  15.2  27.8  13.4   0.0
01010  15.5  27.7  12.8   0.0
```

Note: see file naming convention in Figure 1 of Appendix A

Figure 5.1 Example weather data file of the study (file name = cmmj0101.wth)

5.1.2 Genetic Coefficient

The content and organization of files that contain the genotype specific inputs required for simulation currently vary greatly among crop models and crops. The cultivar file begins each line with 6 characters for a cultivar identification code (the first two items should be a code for the Institute or Person that assigned the code), a blank, 16 characters for the cultivar name, a blank, 6 characters for a type identifier, and then data in a (P1, P2R, ...) format (i.e., 1 blank, followed by 5 number for a real variable with the required number of decimals).

The genetic coefficient of CERES-Rice consists of development coefficients (P1, P2R, P5 and P2O) and growth coefficients (G1, G2, G3 and G4). The definition of coefficients values were demonstrated as follow (Ekasingh *et al.*, 2000):

P1 is time period (expressed as growing degree days [GDD] in °C above a base temperature of 9 °C) from seedling emergence during which the rice plant is not responsive to changes in photoperiod. This period is also referred to as the basic vegetative phase of the plant

P2R is extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in °C) for each hour increase in photoperiod above P2O

P5 is time period in GDD (°C) from beginning of grain filling (3 to 4 days after flowering) to physiological maturity with a base temperature of 9 °C

P2O is critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P2O developmental rate is slowed, hence there is delay due to longer day lengths.

G1 is potential spikelet number coefficient as estimated from the number of spikeltet per gram of main culm dry weight (less lead blades and sheaths plus spikes) at anthesis. A typical value is 55.

G2 is single grain weight (g) under ideal growing conditions, i.e. nonlimiting light, water, nutrients, and absence of pests and diseases.

G3 is tillering coefficient (scaler value) relative to IR64 cultivar under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.0.

G4 is temperature tolerance coefficient. Usually G4 is 1.0 for a variety grows in normal environments. G4 for japonica type growing in a warmer environment would be 1.0 or greater. Likewise, the G4 value for indica type in very cool environments or season would be less than 1.0.

The genetic coefficient of the study had been calibrated and validated for the major Thai rice cultivars by Decision Support System for Crop Production Project (Ekasingh *et al*., 2000). The project collected data from the experiment field of each rice variety in different condition. Then, the genetic coefficients used in CERES-Rice were modified by using GENCAL3.5 in DSSATv3.5 according to the outcomes from the field experiment. The genetic coefficient of RD6, NSPT, SPT1 and KDML105 were defined by the project (Table 5.1) were then transformed into data file named RICER980.CUL of DSSAT v3.5[1].

1 see Figure 2 in Appendix A

Table 5.1 Genetic coefficient of rice varieties in the study

Rice Variety	P1	P2R	P5	P2O	G1	G2	G3	G4
KDML105	502.1	1233.0	385.0	12.7	45.7	0.0263	0.35	0.85
NSPT	495.0	1283.0	364.5	12.7	40.7	0.0275	0.30	0.80
RD6	502.1	1233.0	385.0	12.7	45.7	0.0263	0.35	0.85
SPT1	540.0	154.7	497.0	11.9	77.7	0.0280	0.28	1.00

Source: The Decision Support System for Crop Production Project, 2000

5.1.3 Soil Data

The soil file contains data on the surface and profile characteristics. These data used in the soil water, nitrogen, and root growth sections of the crop models. In the file, the first line of data contains the soil identifiers (ID_SOIL), source (SLSOURCE), soil texture (SLTX), depth (SLDP). The second line contains geographic data together with taxonomic information presented according to the USDA-SCS soil taxonomy (1975) system such as site name (SITE), country name (COUNTRY), latitude (LAT), longitude (LONG) and Family in SCS system (SCSFAMILY). The third line contains information on soil surface properties and on measurement techniques that consist of color (SCOM), albedo (SALB), evaporation limit (SLU1), drainage rate (SLDR), runoff curve number (SLRO), mineralization factor (SLNF), photosynthesis factor (SLNF), pH in buffer determination method (SMHB), phosphorus (SMPX) and potassium determination method (SMKE). The fourth and subsequent lines contain data for each layer in the profile that the file contain data on depth (SLB), master horizon (SLMH), lower limit (SLLL), upper limit drained (SDUL), upper limit saturated (SSAT), root growth factor (SRGF), sat. hydraulic conduction conductivity (SSKS), bulk density (SBDM), organic carbon (SLOC), clay (SLCL), silt (SLSI), coarse fraction (SLCF), total nitrogen (SLNI), pH in water (SLHW), pH in buffer (SLHB) and cation exchange capacity (SCEC). The percentage of sand is assumed to be 100 minus the percentages of clay and silt, and thus is not included as an input. Properties for several soils may be included by appending data from several soils, each with its own 'soils' code number. The file may thus contain properties for several soils of the same classification.

Table 5.2 demonstrates the soil characteristic of Hang Dong, San Sai and San Pa Thong soil series. The detail of soil series were transformed to SOIL.SOL of DSSAT v3.5 by Decision Support System for Crop Production Project[2] (Ekasingh *et al.*, 2000). This soil data file was read for use in this study. Moreover, the file SOIL.SOL could provide soil data for other soil series covering the whole country of Thailand.

Table 5.2 Data on soil characteristic of Hang Dong, San Sai and San Pa Thong soil series used in the study

Description	Soil series														
	Hang Dong soil series					San Sai soil series					San Pa Thong soil series				
Albedo (fraction)	0.11					0.13					0.13				
Evaporation limit (cm)	7.8					23.8					8.4				
Drainage rate (day)	0.18					0					0.4				
Runoff curve number	76					76					76				
Depth (cm)	7	24	29	74	120	17	33	48	90	110	11	30	75	120	150
Lower limit (cm3 cm^{-3})	0.276	0.211	0.271	0.299	0.34	0.043	0.056	0.072	0.065	0.098	0.062	0.081	0.076	0.085	0.092
Upper limit, drained (cm3 cm^{-3})	0.406	0.346	0.399	0.425	0.462	0.168	0.178	0.193	0.188	0.22	0.199	0.198	0.193	0.2	0.207
Upper limit, saturated (cm3 cm^{-3})	0.421	0.393	0.41	0.44	0.477	0.322	0.318	0.327	0.327	0.339	0.305	0.317	0.315	0.317	0.32
Root growth factor (0.0 to 1.0)	1	0.2	0.2	0.2	0.14	0.5	0.2	0.2	0.25	0.14	0.5	0.2	0.2	1	0.05
Bulk density, moist (g cm^{-3})	1.44	1.42	1.42	1.43	1.44	1.65	1.63	1.63	1.63	1.59	1.7	1.66	1.67	1.66	1.65
Organic carbon (%)	1.79	1.3	0.54	0.36	0.26	0.6	0.09	0.09	0.39	0.08	2.8	0.86	0.51	0.35	0.25
Clay (<0.002 mm.) (%)	54	39.4	52.9	59.3	68.4	1.5	4.5	8	6.5	14	5.1	10.1	9	11	12.5
Silt (0.05 to 0.002 mm) (%)	43.7	54.1	40.6	35.9	27.8	33.5	27.5	27.5	29.5	27	19.8	17.2	18.3	15	14.3
Coarse fraction (> 2 mm) (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pH in water	5.4	5.4	6.5	7.5	7.9	6.7	7.3	7	6.8	5.5	4.8	4.9	4.6	4.8	4.7
pH in buffer	4.3	4.3	5.5	6.4	6.5	6.4	6.8	5.9	5.9	3.8	4	3.9	3.9	3.9	3.7
Cation exchange capacity (cmol kg^{-1})	14.3	13.8	14.1	17.4	15.5	4.8	0.6	1.5	1.3	3.6	5.6	4.2	3.1	2.5	2.9

Source: The Decision Support System for Crop Production Project, 2000

2 see Figure 3.1 – 3.3 in Appendix A

5.1.4 Farm Management

The farm management details file documents model inputs for each strategy to be simulated. The file heading contains the experiment code and name, and file sections contain information on the treatment combinations, and details of the farm management strategies (cultivars (CU), field characteristics (FL), soil analysis data (SA), initial soil water and inorganic nitrogen conditions (IC), seedbed preparation and planting geometries (MP), irrigation and water management (MI), fertilizer management (MF), organic residue applications (MR), chemical applications (MC), environmental modifications (ME), harvest management (MH), and simulation control (SM). Detailed information on these variables for each farm management strategy are shown in Figure 4.1 – 4.3 of Appendix A.

The structure of the file has been designed with the goal of maximizing the flexibility of input configurations while preserving the concept of entering only a minimum of inputs to run a simulation. This has been accomplished by defining an farm management strategies in terms of constituent factors that deal separately with information on planting, fertilization, irrigation, cultivars, fields, and etc.

Rice farm management strategies under condition of selected season (rainy and dry season) on given soil series (Hang Dong, San Sai and San Pa Thong soil series) in this study are shown in Table 5.3 consists of choice rice varieties (KDML105, NSPT, RD6 and SPT1) and fertilizer management levels (Low, High and Intensive rate). The detailed farm management strategies of the study were transformed to FILEX in CMMJ0101.SNX[3]. This file was used to run the model that simulated the outcomes of each farm management strategy in the study.

[3] see Figure 4.1 – 4.3 in Appendix A

Table 5.3 Farm management strategies in the study

FMS	Condition		Management	
	season	**Soil series**	**Rice variety**	**Fertilizer rate**
1	Rainy season	HD	KDML105	Low
2	Rainy season	HD	KDML105	High
3	Rainy season	HD	KDML105	Intensive
4	Rainy season	HD	NSPT	Low
5	Rainy season	HD	NSPT	High
6	Rainy season	HD	NSPT	Intensive
7	Rainy season	HD	RD6	Low
8	Rainy season	HD	RD6	High
9	Rainy season	HD	RD6	Intensive
10	Rainy season	SS	KDML105	Low
11	Rainy season	SS	KDML105	High
12	Rainy season	SS	KDML105	Intensive
13	Rainy season	SS	NSPT	Low
14	Rainy season	SS	NSPT	High
15	Rainy season	SS	NSPT	Intensive
16	Rainy season	SS	RD6	Low
17	Rainy season	SS	RD6	High
18	Rainy season	SS	RD6	Intensive
19	Rainy season	SPT	KDML105	Low
20	Rainy season	SPT	KDML105	High
21	Rainy season	SPT	KDML105	Intensive
22	Rainy season	SPT	NSPT	Low
23	Rainy season	SPT	NSPT	High
24	Rainy season	SPT	NSPT	Intensive
25	Rainy season	SPT	RD6	Low
26	Rainy season	SPT	RD6	High
27	Rainy season	SPT	RD6	Intensive
28	Dry season	HD	SPT1	Low
29	Dry season	HD	SPT1	High
30	Dry season	HD	SPT1	Intensive
31	Dry season	SS	SPT1	Low
32	Dry season	SS	SPT1	High
33	Dry season	SS	SPT1	Intensive
34	Dry season	SPT	SPT1	Low
35	Dry season	SPT	SPT1	High
36	Dry season	SPT	SPT1	Intensive

5.1.5 Prices of Output

The prices of output were the average price of rice yield in year 1998 – 2002. It divided in to 2 group, glutinous rice and non-glutinous rice. Table 5.4 demonstrates the average price of rice yield during 1998 – 2002. The average price in Table 5.2 that each average price (P_j) was used to multiply with simulated yields (Y_i)[4] that generated the simulated total revenue.

Table 5.4 The average price of rice yield in year 1998-2002

Year	Non-glutinous rice (KDML105)	Glutinous rice (RD6, NSPT and SPT1)
1998	6.62	5.18
1999	7.07	4.43
2000	6.12	5.14
2001	5.14	4.93
2002	6.29	5.38

Source: http://www.oae.go.th

5.1.6 Cost of Inputs

Cost of inputs were collected from field surveys but did not include fertilizer cost (fertilizer application and labor for fertilizer application). Cost of inputs from field surveys was added to the average fertilizer application cost of each farm management strategies to generate the total cost. Table 5.5 presented the four value of total cost that select by using percentile technique (Percentile = 20, 40, 60 and 80). Each total cost (TC_k) were used to subtract each of simulated total revenue ((P_j x Y_i) - TC_k) to obtain profit (π_m).

4 Refer the Rice Yield Simulation in Chapter 2

Table 5.5 Total cost in each farm management strategies, San Sai district, Chiang Mai province, 2001/02

Rice Variety	Fertilizer Management Level	Percentile			
		20	40	60	80
KDML105	Low	1,140.86	1,405.00	1,713.93	2,011.13
	High	1,225.36	1,489.50	1,798.43	2,095.63
	Intensive	1,290.36	1,554.50	1,863.43	2,160.63
NSPT	Low	1,582.97	1,615.95	1,750.80	2,258.58
	High	1,667.47	1,700.45	1,835.30	2,343.08
	Intensive	1,732.47	1,765.45	1,900.30	2,408.08
RD6	Low	1,306.72	1,523.17	1,739.53	2,424.22
	High	1,391.22	1,607.67	1,824.03	2,508.72
	Intensive	1,456.22	1,672.67	1,889.03	2,573.72
SPT1	Low	1,453.50	1,904.10	2,194.91	2,358.47
	High	1,570.50	2,021.10	2,311.91	2,475.47
	Intensive	1,642.00	2,092.60	2,383.41	2,546.97

5.2 Simulated Yield

5.2.1 Rice Yield in Rainy Season

The rice yields in rainy season were simulated for each soil series and farm management strategy. The rice farm management strategies were discussed following steps.

For Hang Dong soil series, the high level of fertilizer management produced the highest rice grain yield in each rice variety. The simulated yields were ranging about 1,000 - 1,100 kg./rai with the standard deviation of 142 – 188 kg./rai. Low level of fertilizer management produced approximately 710 - 740 kg./rai with the standard deviation of 88 – 113 kg./rai. The intensive rate of fertilizer application yielded nearly 830 – 875 kg./rai with the standard deviation of 204 – 267 kg./rai (Table 5.6). The average yield of high fertilizer management level was larger while the standard deviation is smaller than the intensive level. However, the rice yield using intensive fertilizer application was higher than the low level of fertilizer application and the standard deviation was also larger thus demonstrated more risk. In high level of fertilizer management, RD6 yield was the highest with average grain yield approximately 1,098 kg./rai while NSPT and KDML105 produced about 1,075 and 1,034 kg./rai, respectively. However, the NSPT was the smallest standard deviation with nearly 142kg./rai while that of KDML105 and RD6 were approximately 147 and 188 kg./rai. For low level of fertilizer management, NSPT yield the highest average grain yield approximately 736 kg./rai. KDML 105 produced the highest average yield of intensive fertilizer management level with about 874 kg./rai.

Table 5.6 Mean and standard deviation (S.D.) of simulated rice yield classified by farm management strategy and condition in rainy season, San Sai district, Chiang Mai province, 2001/2002

Farm Management Strategy		**Condition (Soil series)**		
Variety	**Fertilizer Application**	**Hang Dong**	**San Sai**	**San Pa Thong**
KDML 105	**Low**	731.86	673.87	526.94
		(113.42)	*(197.49)*	*(172.33)*
	High	1,034.41	894.23	730.55
		(188.26)	*(269.22)*	*(351.13)*
	Intensive	874.48	1,067.14	895.74
		(241.07)	*(210.42)*	*(200.63)*
	Average	**880.25**	**880.88**	**890.02**
NSPT	**Low**	736.14	715.55	429.93
		(88.40)	*(199.31)*	*(215.46)*
	High	1,074.84	1,008.09	852.82
		(142.47)	*(236.94)*	*(313.86)*
	Intensive	831.65	1,054.46	844.95
		(267.28)	*(175.81)*	*(219.47)*
	Average	**878.41**	**926.03**	**962.96**
RD6	**Low**	711.93	694.47	418.41
		(113.61)	*(193.91)*	*(214.95)*
	High	1,098.03	1,054.88	658.23
		(147.26)	*(192.22)*	*(327.88)*
	Intensive	860.09	1,139.53	851.01
		(204.73)	*(148.61)*	*(186.80)*
	Average	**717.74**	**709.23**	**642.55**

Note: Figures in parentheses are S.D.

On San Sai soil series, intensive level of fertilizer management yield the highest simulated yield with approximately 1,050 – 1,150 kg./rai. Low level of fertilizer application yielded about 670 - 715 kg./rai while the intensive fertilizer management level produced nearly 900 - 1,050 kg./rai (Table 5.6). By examining the standard deviation, it demonstrated that the intensive level of fertilizer management produced rice yield with the standard deviation ranging from 148 – 210 kg./rai that was smaller than other fertilizer management levels. For intensive fertilizer management level, RD6 produced the highest average grain yield with about 1,140 kg./rai and was also the smallest standard deviation with approximately 149 kg./rai. While KDML105 produced the average yield nearly 1,067 kg./rai and with standard deviation of 210 kg./rai. RD6 was also the highest average grain yield for high level fertilizer management (yielded about 1,055 kg./rai and with standard deviation of 192 kg./rai). NSPT produced the highest average grain yield in the low level of fertilizer management (approximately 716 kg./rai and with the standard deviation of 199 kg./rai).

On San Pa Thong soil series, intensive fertilizer management produced also the highest simulated rice yield with nearly 850 - 900 kg./rai. The low level of fertilizer management produced approximately 420 - 520 kg./rai and high level of fertilizer management yielded 650-850 kg./rai (Table 5.6). The standard deviation of simulated rice yield raged from 172 – 351 kg./rai in this soil series. KDML105 produced the highest average grain yield for the intensive fertilizer management level with approximately 896 kg./rai while NSPT yielded the highest average grain yield of high fertilizer management level with nearly 853 kg./rai. For RD6 with intensive fertilizer management level, the average grain yield was about 851 kg./rai but standard deviation was the smallest with approximately 187 kg./rai implying less risk in the production.

5.2.2 Rice Yield in Dry Season

In dry season, only SPT1 was simulated in the study. The presentation of primary results were also classified by soil series as follows:

On Hang Dong soil series, the high level of fertilizer management produced approximately 965 kg./rai that was the highest yield while the low and intensive yielded 648 kg./rai and 805 kg./rai, respectively (Table 5.7). The standard deviation of low level was 341 kg./rai while the high level was 499 kg./rai. The high level of fertilizer management was more risk although the mean yield was larger.

On San Sai soil series, the intensive level of fertilizer management produced 1,177 kg./rai that was higher than that of the low level by nearly 500 kg./rai (Table 5.7). The high level of fertilizer management also produced higher rice yield than that of the low level by approximately 200 kg./rai. The standard deviation increased from 250 kg./rai in the low level to 454 kg./rai in the intensive level of fertilizer management. This showed that the higher levels of fertilizer management increased more risk in rice production of San Sai farmers who produced rice on San Sai soil series.

On San Pa Thong soil series, the rice yield was lower than another soil series. The low level of fertilizer management produced 458 kg./rai while the high level and intensive level yielded 508 kg./rai and 653 kg./rai, sequentially. Hence, producing rice on San Pa Thong soil series using intensive level of fertilizer management was more risky, although the mean yield was highest but the standard deviation was highest as well (Table 5.7).

Table 5.7 Mean and standard deviation (S.D.) of simulated rice yield classified by biophysical conditions and rice farm management in dry season

Farm Management Strategy		Condition (Soil series)		
Variety	**Fertilizer Application**	**Hang Dong**	**San Sai**	**San Pa Thong**
SPT1	**Low**	647.97 *(341.36)*	677.23 *(249.55)*	458.20 *(284.60)*
	High	964.76 *(498.50)*	872.09 *(359.90)*	508.07 *(306.18)*
	Intensive	805.01 *(369.27)*	1,177.45 *(454.18)*	653.11 *(357.55)*
	Average	**805.92**	**908.92**	**539.80**

Note: Figures in parentheses are S.D.

5.3 Simulated Net Margin

5.3.1 Net Margin of Rice Production in Rainy Season

On Hang Dong soil series, the average net margin from rice production using high fertilizer management level gained approximately 3,500 – 4,800 baht/rai while using intensive level obtained about 2,200 – 3,750 baht/rai. It showed that producing rice using high level of fertilizer management got the better net margin than intensive level fertilizer management (Table 5.8). For low level fertilizer management, it was the smallest standard deviation in each variety (567 – 906 baht/rai) while the intensive level was the larger of standard deviation (ranged from 1,130 – 1,626 baht/rai). According to rice varieties, KDML105 using high level of fertilizer management produced the highest net margin of about 4,810 baht/rai. Moreover, KDML105 yielded highest simulated net margin compared to other rice varieties in every fertilizer management level. While producing RD6 and NSPT using high level fertilizer management gained approximately 3,670 baht/rai and 3,500 baht/rai, respectively.

Table 5.8 Mean and standard deviation (S.D.) of simulated net margin classified by farm management strategy and condition in dry season, San Sai district, Chiang Mai province, 2001/2002

Farm Management Strategy		Condition (Soil series)		
Variety	**Fertilizer Application**	**Hang Dong**	**San Sai**	**San Pa Thong**
KDML 105	**Low**	3,004.65	2,642.32	1,724.37
		(905.83)	*(1,336.05)*	*(1,164.64)*
	High	4,810.36	3,934.59	2,911.95
		(1,380.07)	*(1,790.82)*	*(2,244.43)*
	Intensive	3,746.17	4,949.84	3,878.99
		(1,626.04)	*(1,506.87)*	*(1,406.17)*
	Average	**3,853.73**	**3,842.25**	**2,838.34**
NSPT	**Low**	1,887.04	1,783.82	352.45
		(567.22)	*(1,047.78)*	*(1,107.59)*
	High	3,499.86	3,165.34	2,387.25
		(831.57)	*(1,245.80)*	*(1,598.78)*
	Intensive	2,216.15	3,332.74	2,282.80
		(1,375.24)	*(972.65)*	*(1,151.22)*
	Average	**2,534.35**	**2,760.63**	**1,674.17**
RD6	**Low**	1,819.33	1,731.85	348.39
		(738.09)	*(1,070.15)*	*(1,150.10)*
	High	3,669.77	3,453.52	1,465.74
		(912.76)	*(1,093.61)*	*(1,687.34)*
	Intensive	2,412.35	3,812.73	2,366.86
		(1,130.41)	*(923.43)*	*(1,051.04)*
	Average	**2,633.82**	**2,999.37**	**1,393.66**

Note: Figures in parentheses are S.D.

On San Sai soil series, producing rice using intensive level of fertilizer management yielded the highest average net margin with approximately 3,330 – 4,950 baht/rai while intensive and low level of fertilizer management produced about 1,730 – 3,935 baht/rai. KDML105 with intensive fertilizer management level created the highest average net margin of nearly 4,950 baht/rai with standard deviation of 1,507 baht/rai.

On San Pa Thong soil series, the intensive level of fertilizer management produced also highest of average net margin. The intensive level fertilizer management produced approximately 2,300 – 2,900 baht/rai of net margin while the high level earned 1,400 – 2,900 baht/rai (Table 5.8). KDML105 yielded the topmost of the average net margin in each level of fertilizer management (approximately 1,724 – 3,879 baht/rai) and also topmost of standard deviation with raged from 1,165 – 2,244 baht/rai.

5.3.2 Net Margin of Rice Production in Dry Season

Producing SPT1 using high fertilizer management level in Hang Dong soil series yielded the highest average net margin of approximately 2,740 baht/rai with the standard deviation of 2,507 baht/rai (Table 5.9). The other level of fertilizer management produced lower net margin.

On San Sai soil series, the rice farmers could earn on the average of 3,734 baht/rai with standard deviation of approximately 2,303 baht/rai by using the intensive level of fertilizer management. If they applied the high level of fertilizer management they would obtained only 2,276 baht/rai of net margin with standard deviation of nearly 1,834 baht/rai.

The San Pa Thong soil series yielded the lowest average net margin. As rice farmers using the intensive level, the highest average net margin nearly 1,107 baht/rai with the standard deviation of 1,813 baht/rai. if they applied the high level fertilizer management they got only 451 baht/rai with the standard deviation of about 1,560 baht/rai (Table 5.9).

Table 5.9 Mean and standard deviation (S.D.) of simulated net margin classified by farm management strategy and condition in dry season, San Sai district, Chiang Mai province, 2001/2002

Farm Management Strategy		**Condition (Soil series)**		
Variety	**Fertilizer Application**	**Hang Dong**	**San Sai**	**San Pa Thong**
SPT1	**Low**	1,269.51	1,416.11	318.49
		(1,734.47)	*(1,299.08)*	*(1,455.51)*
	High	2,740.07	2,275.65	451.42
		(2,507.04)	*(1,833.53)*	*(1,560.41)*
	Intensive	1,868.00	3,734.41	1,106.77
		(1,875.29)	*(2,302.69)*	*(1,812.55)*
	Average	**1,959.19**	**2,475.39**	**625.56**

Note: Figures in parentheses are S.D.

Based on the above finding, different rice farm management strategies produced different mean and standard deviation of net margin. The high average net margins accompany with link risk. For risk-averse farmers, the high outcomes with lowest risk were preferred. Therefore, it was difficult to decide the farm management strategies at this stage by using only mean and standard deviation.

The simulated outcomes were close to the actual ones. The actual average grain yield range from 700 – 785 kg./rai while simulated rice grain yield ranged from 643 – 963 kg./rai. These findings were not much different from the yield experiment. This study demonstrated potential of the CRERS-Rice model to generate outcomes in each farm management. Since, the crop model represented abstractions of reality. Not all real world factors can be built into a model. If such simplified reality could predict outcomes as close as to the actual ones, the model is justified. In this study, the rice production environment was simplified and schematized into CERES-Rice that works fairly well.

The mean of simulated rice grain yield was approximate to the mean of surveyed rice grain yield for low fertilizer management. The simulated rice grain yields were mostly larger than the actual yields represented. The possible yield limiting factor such as nutrients and pests and diseases that might operate in the area and were not considered by the model. On the other hand, the substantially lower average yield on farmer's fields could be due mainly to harvest and post-harvest processes (Ekasingh, 2000).

Increasing of fertilizer management level in crop model tended to increase the rice yield outcomes. The finding conforms with Decision Support System for Crop Production Project that simulated the rice yield in different nitrogen fertilizer rate. The project presented the effects of nitrogen fertilizer rates that expend the phonological development of different varieties of rice in various treatments.