CHAPTER 6

RESULTS OF SIMULATION

The CANEGRO-DSSAT sugarcane simulation model has been a useful tool in understanding the response of sugarcane to varying weather conditions (rainfall, temperature, solar radiation and day length) and certain agronomic management options (planting, harvest times and irrigation scheduling). In addition, some of sugarcane varieties response to day length inducing flowering event or maturity, therefore it had well modified and validated in simulation and modeling through DSSAT v3.5 by incorporation of ScFM model (Promit and Jintrawet 2001). Sugarcane growth and response are also affected by nitrogen nutrition. The response to applied nitrogen is particularly sensitive to a range of factors including soil type, fertilizer type and the available soil water status, resulting in a variable and usually lower level of response in dry land regions (O'leary *et.al.,* 2000). In this study, the DSSAT -CANEGRO (v3.5) incorporated with a N sub-model had tested against with the observed field data. The N sub-model had developed based on dynamism of nitrogen in both soil and plant system. This model simulation is a part of the study had attempted in order to know, whether the model could able to predict closely to the response of sugarcane to applied nitrogen together with irrigation water supply, or not.

6.1. Minimum data sets for the model simulation

The CANEGRO-DSSAT (v3.5) incorporated with a nitrogen sub-model had tested against to data form the field experiment. In the simulation, the minimum data set for weather recorded from data logger which was set at MCC farm station, Chiang Mai, Thailand, had entered into the model. The soil parameters of Hong Dong soil series, current existing in the soil database, had used. The genetic parameter of variety of U-Thong 2 had used in the simulation. Simulation of above ground dry weight had tested against the observed field experiment data in order to compare carbon accumulation dynamism within plant system. Moreover, overall nitrogen

concentrations in plant parts of leaves and roots were used in testing against with the experiment data, as comparison of nitrogen dynamic in plant system.

6.2. Model performance

Simulated crop dried biomass at main development stages was presented in Table 24. Model simulates the soil water balance and nitrogen status in soil and plant systems. Generally, the biomass of the two water management systems was quite different. Simulated results showed that the highest dry matter had resulted in irrigation system. The simulated biomass yield obtained from nitrogen application under irrigation system was higher than rainfed system. However, due to simulated results, there was no prominent biomass yield increase due to increasing nitrogen application rate in both water management systems. The predicted biomass yields had already reached plateau at 100 kg N ha^{-1} in both water management systems.

Table 24: Simulated biomass yields (CWAD) at nitrogen application under different water management systems (tonnes ha^{-1}).

Date	Day after Sowing (DAS)	Irrigation				Rainfed			
		N 0	N 1	N 2	N3	N 0	N 1	N 2	N3
28 FEB	40	0.05	0.05	0.05	0.05	0.024	0.05	0.05	0.05
15 MAR	55	0.176	0.412	0.412	0.412	0.089	0.303	0.303	0.303
30 MAR	70	0.406	1.669	1.669	1.669	0.198	0.486	0.487	0.487
14 APR	85	0.851	4.462	4.462	4.462	0.316	0.624	0.625	0.625
29 APR	100	1.496	8.751	8.751	8.751	0.472	0.820	0.822	0.822

Moreover, the reports of simulation revealed that relative high water stress had occurred in rainfed when crop had been getting age coupling with drought during the experiment period (Table 25). The model could simulate the dynamism of nitrogen in soil-plant system due to the effect of nitrogen applications under different water management systems. Simulated biomass yield had increased with nitrogen application comparing to none application. The simulated nitrogen status in soil system showed that the nitrogen stress had occurred at none N application in both

water management systems (Table 26). The simulated nitrogen concentration in leaf and root, presented in Table 27 and 28 indicated that the dynamism of nitrogen concentration under different water management systems in both leaf and root had changed by the effect of nitrogen application. Moreover, the simulated nitrogen concentration in leaf and root was also different due to different water management system.

Table 25: Simulated water stress (WSGD) status on crop growth at nitrogen application under different water management systems.

Date	Day after Sowing DAS	Irrigation				Rainfed			
		N 0	N 1	N 2	N3	N 0	N 1	N 2	N3
28 FEB	40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 MAR	55	0.48	0.39	0.39	0.39	0.76	0.73	0.73	0.73
30 MAR	70	0.00	0.00	0.00	0.00	0.90	0.89	0.89	0.89
14 APR	85	0.22	0.00	0.00	0.00	0.94	0.93	0.93	0.93
29 APR	100	0.50	0.00	0.03	0.03	0.91	0.91	0.91	0.91

Table 26: Simulated nitrogen stress status (NSTD) on crop growth at nitrogen application under different water management systems

Date	Day after Sowing DAS	Irrigation				Rainfed			
		N 0	N 1	N 2	N3	N 0	N 1	N 2	N3
28 FEB	40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 MAR	55	0.79	0.00	0.00	0.00	0.55	0.00	0.00	0.00
30 MAR	70	0.79	0.00	0.00	0.00	0.79	0.38	0.00	0.00
14 APR	85	0.79	0.00	0.00	0.00	0.79	0.54	0.00	0.00
29 APR	100	0.79	0.00	0.00	0.00	0.79	0.45	0.00	0.00

Table 27: Simulated nitrogen concentration in root (RN%D) at nitrogen application under different water management systems.

Date	Day after Sowing (DAS)	Irrigation				Rainfed			
		N 0	N 1	N 2	N3	N 0	N 1	N 2	N3
28 FEB	40	0.56	1.06	1.06	1.06	0.57	1.06	1.06	1.06
15 MAR	55	0.48	0.84	0.92	0.94	0.40	0.56	0.66	0.71
30 MAR	70	0.51	0.85	0.84	1.04	0.80	0.50	0.59	0.64
14 APR	85	0.49	0.87	1.06	1.06	0.25	0.46	0.55	0.59
29 APR	100	0.51	0.86	1.04	1.05	0.28	0.65	0.76	0.76

Table 28: Simulated nitrogen concentration in leaf (LN%D) at nitrogen application under different water management systems.

Date	Day after Sowing (DAS)	Irrigation				Rainfed			
		N 0	N 1	N 2	N3	N 0	N 1	N 2	N3
28 FEB	40	0.47	0.88	0.88	0.88	0.38	0.88	0.88	0.88
15 MAR	55	0.29	0.62	0.67	0.69	0.23	0.4	0.49	0.52
30 MAR	70	0.23	0.54	0.66	0.67	0.13	0.3	0.38	0.42
14 APR	85	0.17	0.43	0.63	0.63	0.09	0.25	0.32	0.35
29 APR	100	0.13	0.35	0.58	0.59	0.08	0.25	0.33	0.36

6.3. Model evaluation

6.3.1. Biomass accumulation

The trends of model yields in irrigation systems at different nitrogen applications are similar as yields in rainfed system. However there were differed between predicted and observed yields. Although predicted yields were closed with observed yields at beginning, later, the model predicted with over-estimations. The comparison between predicted biomass accumulation (SWAD), model yields and observed yields were shown in Figures 16 and 17. At the final observation stage, it was found that the predicted yield slightly lower than observed yield at none application under irrigation system, whilst the others at all nitrogen applications had

over estimations. Moreover, the predicted yields had more closed to observed yield at that stage rather than other stages, excepted the yields at 400 kg N ha^{-1}. One the contrary, the model had under estimation at 100 kg N ha^{-1} under rainfed system, but slightly. In generally, the model showed responding to soil water status and effect of nitrogen application. At 40 DAS, the model had under estimation, but, later, had over estimation during the period (Figures 16 and 17). In order to evaluate model accuracy and tendency, the statistical analysis had calculated (Table 29).

Table 29: The results of statistical analysis for the comparison between the simulated biomass yield and observed biomass yields (tonnes ha^{-1}).

Treatment	MSD	SB	MSV	SDSD	LCS	r
Irrigation 0 Kg N ha^{-1}	0.3809	0.0866	0.2942	0.2494	0.0447	0.9585
Irrigation 100 Kg N ha^{-1}	2.0013	1.0932	0.9080	0.7109	0.1921	0.9875
Irrigation 200 Kg N ha^{-1}	1.6304	0.9327	0.6976	0.7162	0.1066	0.9931
Irrigation 400 Kg N ha^{-1}	5.8517	1.6419	4.2097	3.8319	0.0740	0.9910
Rainfed 0 Kg N ha^{-1}	0.0030	0.0000	0.0029	0.0019	0.0010	0.9725
Rainfed 100 Kg N ha^{-1}	0.0231	0.0103	0.0128	0.0002	0.0125	0.9154
Rainfed 200 Kg N ha^{-1}	0.0378	0.0275	0.0103	0.0016	0.0086	0.9273
Rainfed 400 Kg N ha^{-1}	0.0837	0.0669	0.0168	0.0077	0.0090	0.9037

According to the results of statistical analysis, the simulated biomass yields obtained at all sampling of the period, had more closer at none application in both water systems. It was indicated by the values of Mean Square Deviation (MSD) where 0.3809 in irrigation, 0.0030 in rainfed at none application were less than the values at nitrogen application in both water systems. Generally, the values of MSD under rainfed were relatively lower than irrigation system. Moreover, the highest MSD (5.8517) was found at 400 kg N ha^{-1} nitrogen application under irrigation. Similarly, the results of the Standard Bias (SB), errors were increased with the increasing nitrogen application, especially in irrigation system. Among the nitrogen application treatments, the highest SB (1.6419) occurred at 400 kg N ha^{-1} under irrigation and the lowers at 100 kg N ha^{-1} under rainfed. Mean of Standard Variation (MSV) were also relative highs. It was indicating that the model was failed to simulate the variability of the measurement around the mean of the simulated yields, and observed yields.

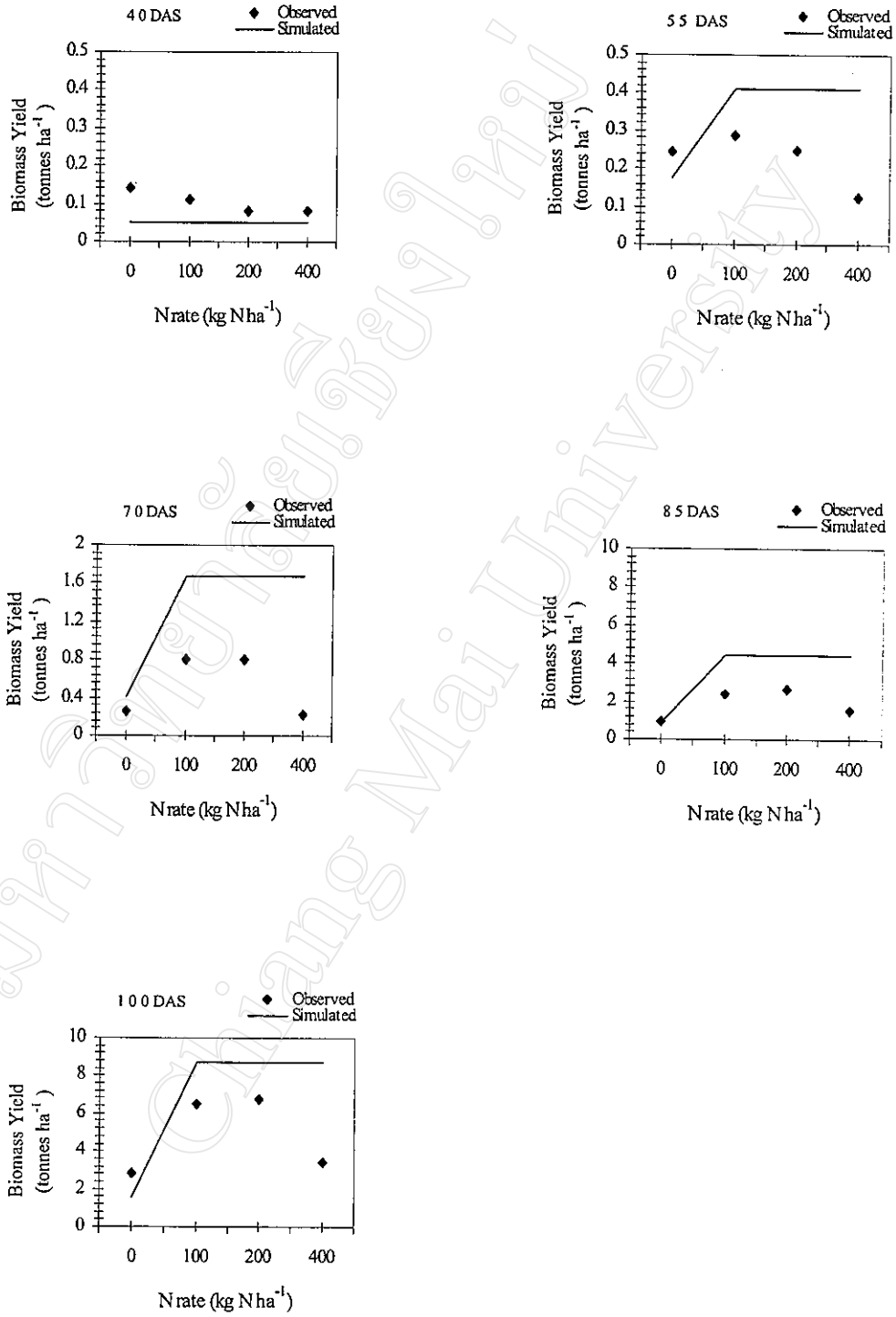

Figure 16: Comparison of simulated and observed biomass yields (tonnes ha^{-1}) responding to nitrogen applications under irrigation system at different stage.

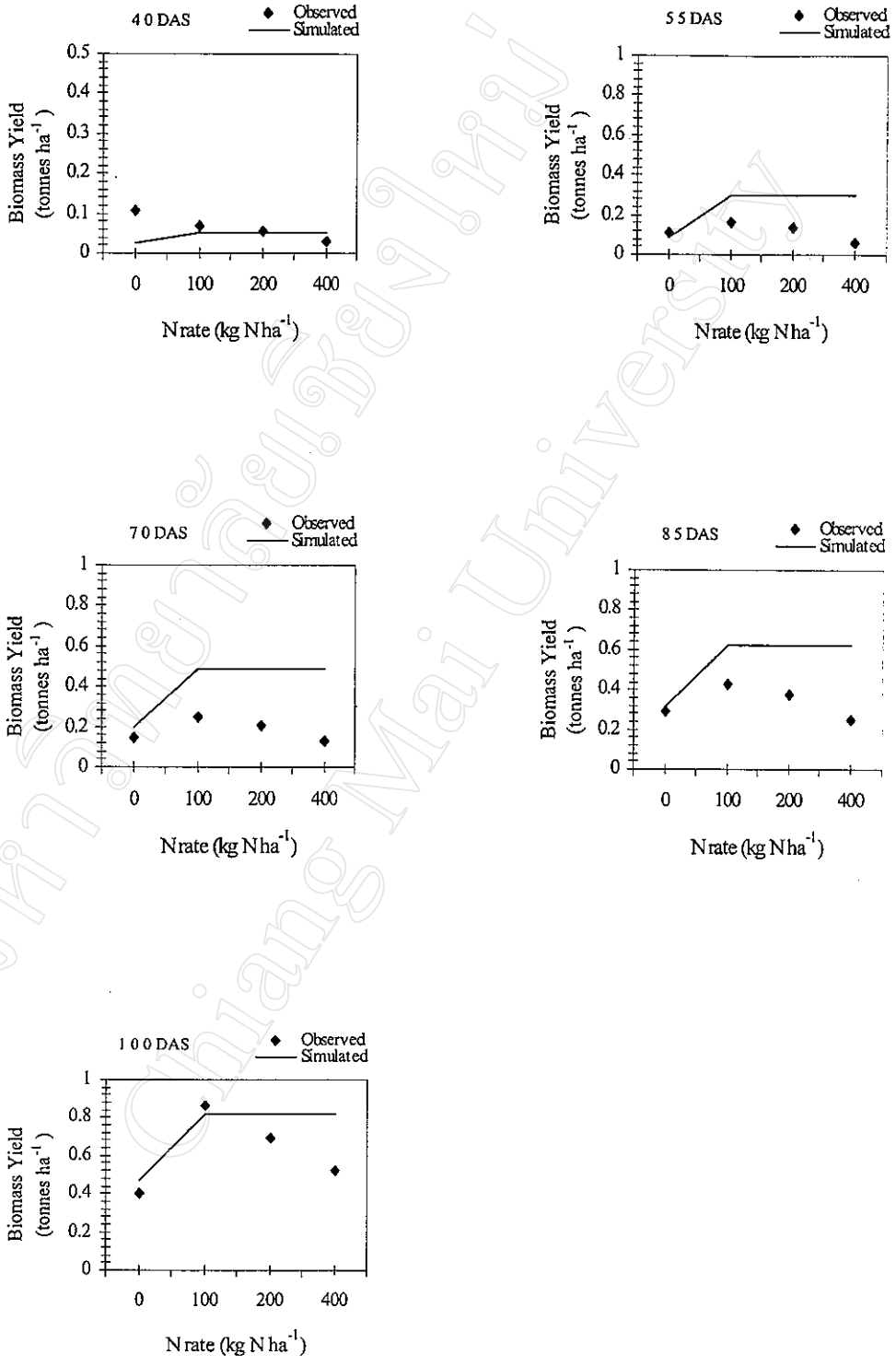

Figure 17: Comparison of simulated and observed biomass yields responding to nitrogen applications under rainfed system at different stage.

Due to the values of Square difference between Standard Deviation (SDSD), the model could simulate more closely to observed-data in rainfed system than irrigation system. Moreover, the Lack of Correlation weighted by Standard Deviation (LCS) values indicated that model fairly simulated the pattern of the fluctuations across the period in irrigation system (Tables 24 and 29). However, the high positive correlation (r> 0.9) between model yields and observed indicated that biomass yields.

6.3.2. Nitrogen concentration in root

Figures 18 and 19 showed the comparison of simulated and observed nitrogen concentration in root (RN%D) and the results of the statistical analysis was presented in Table 30.

Table 30: The results of statistical analysis for the comparison between the simulated and observed nitrogen concentration in root (RN%D).

Treatment	MSD	SB	MSV	SDSD	LCS	r
Irrigation 0 Kg N ha^{-1}	0.0456	0.0184	0.0271	0.0942	0.0212	-0.1539
Irrigation 100 Kg N ha^{-1}	0.0432	0.0163	0.0268	0.0067	0.0201	0.26210
Irrigation 200 Kg N ha^{-1}	0.0771	0.0129	0.0641	0.0106	0.0534	-0.5672
Irrigation 400 Kg N ha^{-1}	0.1534	0.0084	0.1450	0.0878	0.0571	-0.8308
Rainfed 0 Kg N ha^{-1}	0.0742	0.0519	0.0222	0.0002	0.0219	0.1194
Rainfed 100 Kg N ha^{-1}	0.2324	0.1324	0.0999	0.0046	0.0952	-0.4812
Rainfed 200 Kg N ha^{-1}	0.4143	0.3069	0.1074	0.0042	0.1032	-0.1438
Rainfed 400 Kg N ha^{-1}	0.6579	0.4651	0.1928	0.0313	0.1614	-0.4348

According to results of analysis, MSD values for RN%D were contrasty from CWAD, the values for rainfed were higher than irrigation. The model made under estimations in rainfed systems. The model predicted more closer to observed data at beginning, until 70 DAS in the irrigation system, however high difference was found in rainfed system with under estimations (Figures 18 and 19). It was also indicated by the statistical analysis whilst the relative higher value of MSD in rainfed system had

resulted (Table 30). In the irrigation system, the highest MSD was recorded at 400 kg N ha^{-1}, however, the lowest bias of the simulation (SB) was found.

Due to the results of MSV, the model could simulate the variability of the measurement around the mean of simulated and observed values, excepted 400 kg N ha^{-1} that had 0.145 MSV value, in irrigation system. At none nitrogen application under irrigation, although MSD had not much different from the others, the model could weakly simulate the dynamism of RN%D comparing to its dynamism in real system. It was indicated by relative higher value (SDSD = 0.0942), which was similar as 400 kg N ha^{-1} (SDSD= 0.0878). On the contrary, the model could simulate on dynamism of RN%D more better in rainfed rather than irrigation indicated by SDSD values and values of LCS (Table 30). As overall, model simulated dynamism of RN%D at all treatments under both water systems (Table 27) indicating with reliable low SDSD (Table 30). However, the correlation between simulated and observed RN%D had ranged between (– 0.8308) at 400 kg N ha^{-1} under irrigation to (0.2621) at 100 kg N ha^{-1} under irrigation. Mostly, the yields had weak negative correlation.

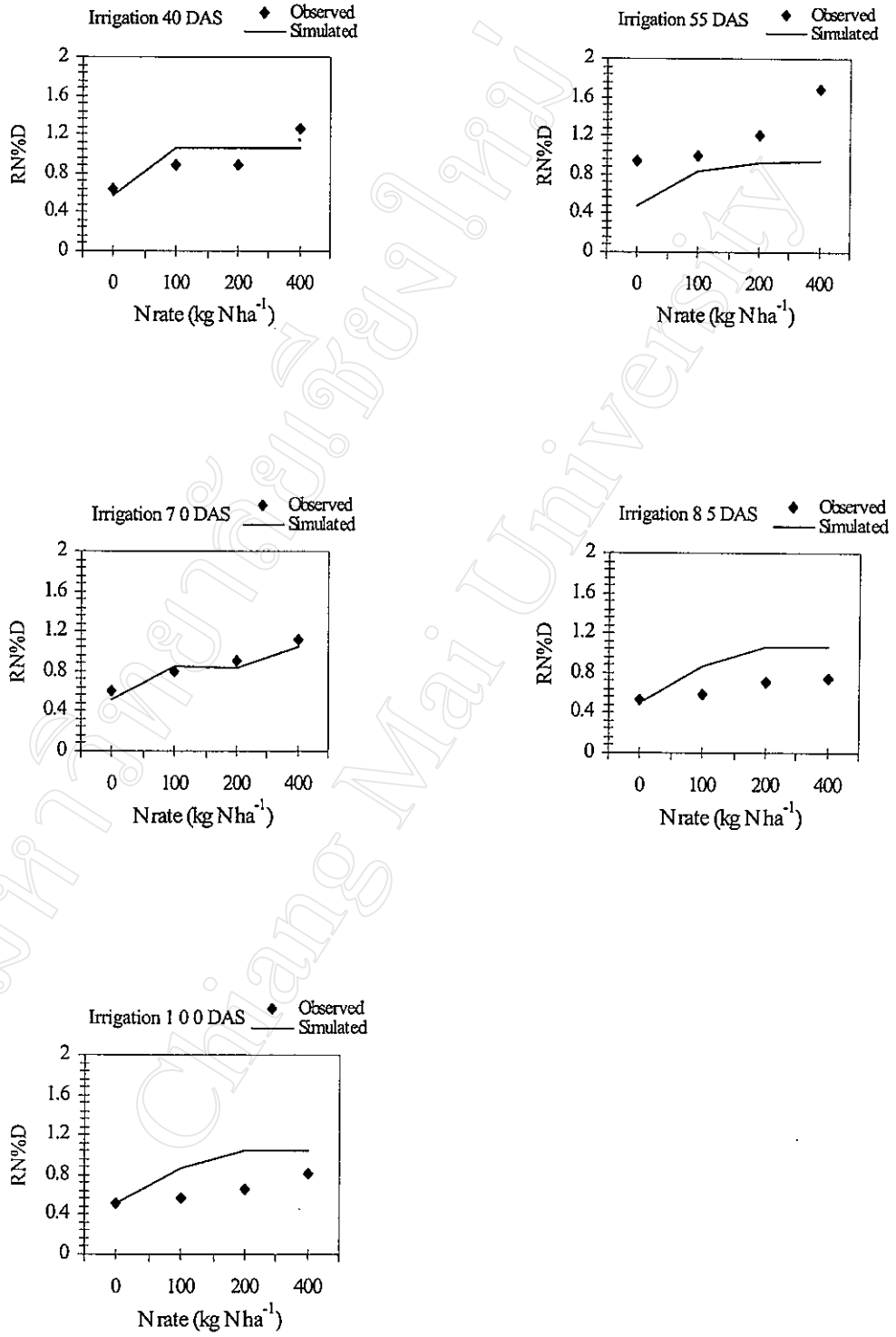

Figure 18: Comparison of simulated and observed nitrogen concentration (percentage) in root responding to nitrogen applications under irrigation system at different stages.

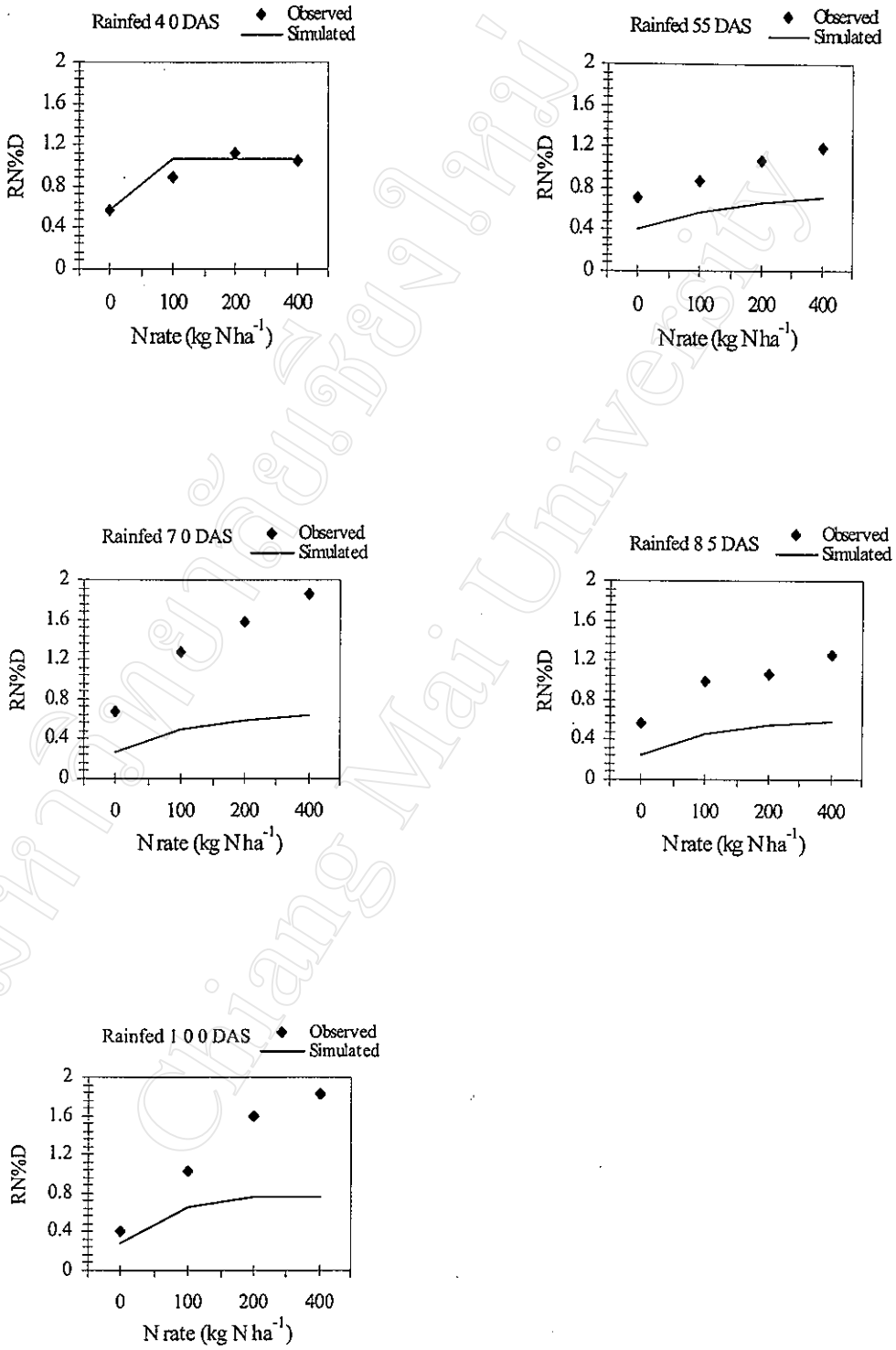

Figure 19: Comparison of simulated and observed nitrogen concentration in root responding to nitrogen applications under rainfed system at different stages.

6.3.2. Nitrogen concentration in leaf

According to the comparison of nitrogen concentration in leaf (LN%D), it was found that there were high difference between model predictions and observed data. The model had under estimations at all stages for all treatment in both water management systems (Figures 20 and 21).

Table 31: The results of statistical analysis for the comparison between the simulated and observed nitrogen concentration in leaf (LN%D).

Treatment	MSD	SB	MSV	SDSD	LCS	r
Irrigation 0 Kg N ha^{-1}	1.3500	1.2859	0.0641	0.0039	0.0599	-0.3830
Irrigation 100 Kg N ha^{-1}	1.8008	1.6078	0.1930	0.0252	0.1673	-0.3478
Irrigation 200 Kg N ha^{-1}	1.7426	1.5926	0.1500	0.0479	0.1012	-0.5468
Irrigation 400 Kg N ha^{-1}	1.7880	1.5725	0.2155	0.0882	0.1272	-0.6028
Rainfed 0 Kg N ha^{-1}	1.2797	1.2276	0.0520	0.0043	0.0475	-0.1916
Rainfed 100 Kg N ha^{-1}	1.4112	1.3689	0.0423	0.0161	0.0258	0.5111
Rainfed 200 Kg N ha^{-1}	1.4289	1.3409	0.0879	0.0044	0.0829	-0.4139
Rainfed 400 Kg N ha^{-1}	1.8743	1.7956	0.0787	0.0108	0.0676	-0.8771

The results of statistical analysis indicated there were high MSD at all treatments under both water management systems. This means that the model could not predict closely to observed values (Table 31). Moreover, the relative high SB indicated that high errors had occurred at all treatments in both water systems. Nevertheless, due to the desirable results, relative low values of SDSD and LCS indicated (Table 31) that model could fairly simulate to the dynamism of LN%D across the period (Table 28).

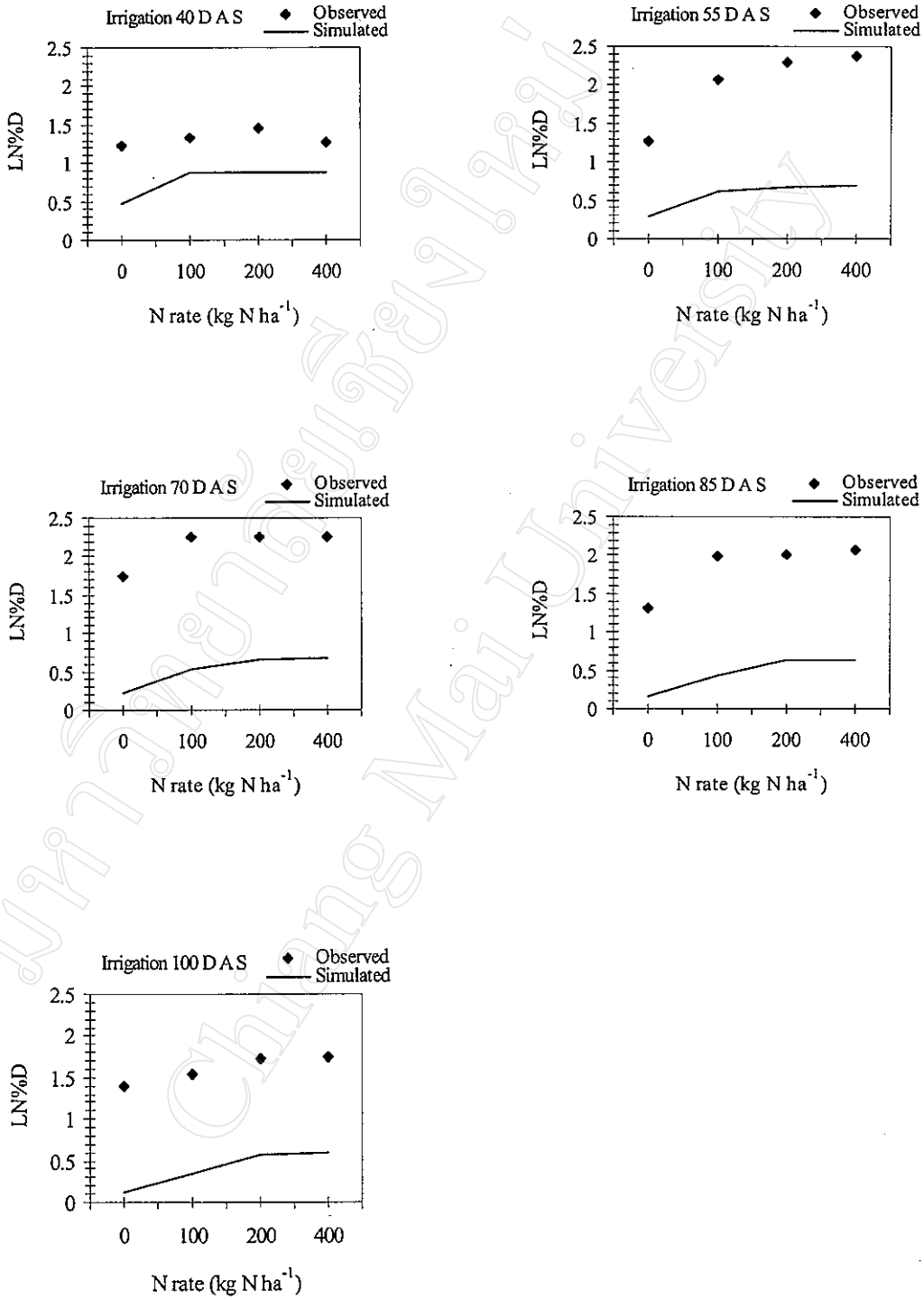

Figure 20: Comparison of simulated and observed nitrogen concentration in leaf (percentage) responding to nitrogen applications under irrigation system at different stages.

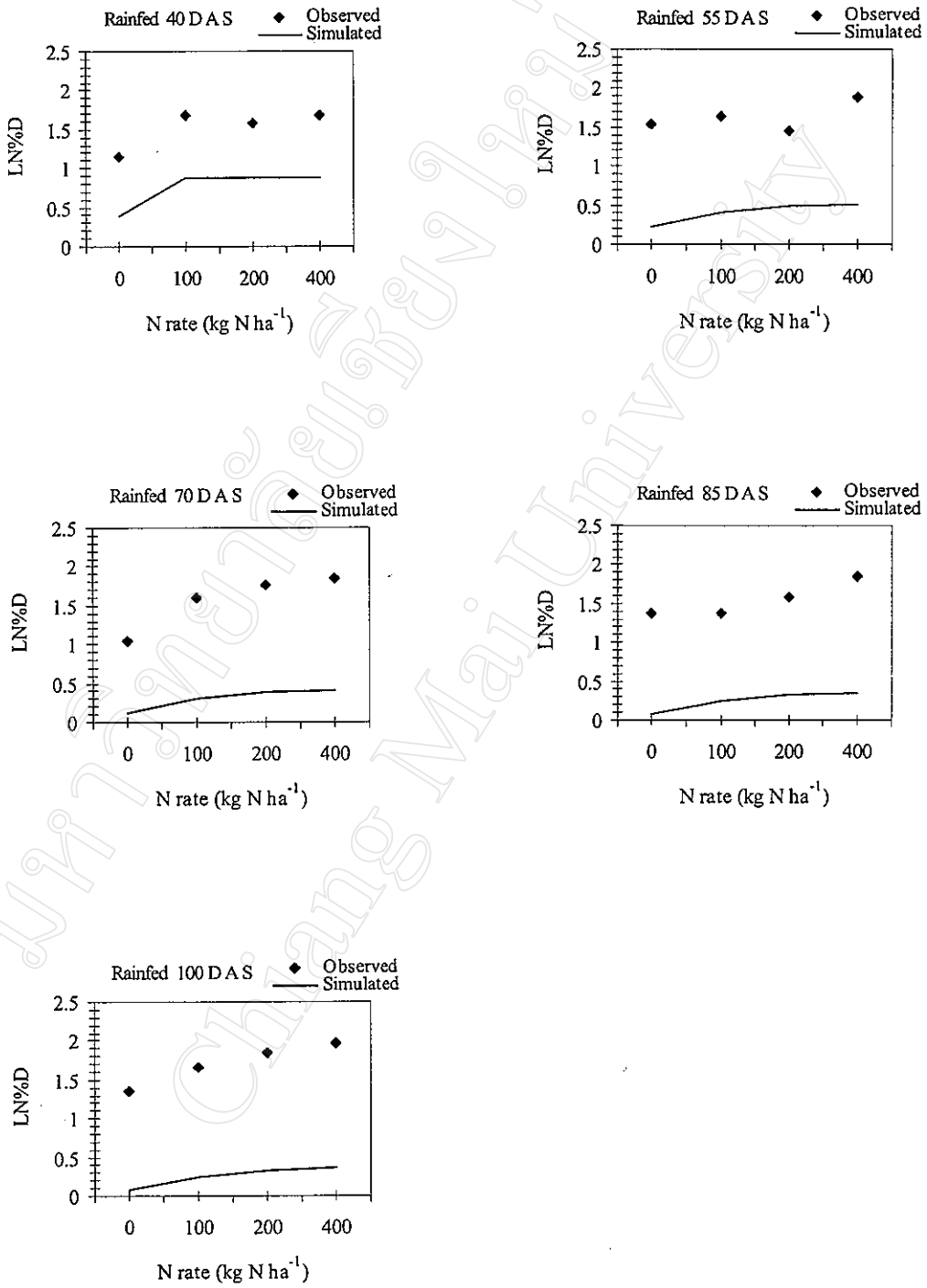

Figure 21: Comparison of simulated and observed nitrogen concentration (percentage) in leaf responding to nitrogen applications under rainfed system at different stages.