Chapter 4

Research Method

4.1 Research process

To achieve the objectives of the study, experimental data on Advanced Evaluation Trial (AET) for three improved rice varieties were collected from RNR-RC, Bajo. Data on soil and weather were also collected for the experimental site which was used as model input. These data were used to operate the model, estimate genetic coefficients of three Bhutanese rice varieties and validate the CERES-Rice model in Bhutanese rice farming system in mid altitude.

Along with data for model validation, information on resource endowment and uses and management practices for rice production in the study area Omteykha and Wangjokha, which represent the mid altitude rice farming of the country, were also collected through household questionnaire survey and interview. All the households were interview with structured questionnaires to find out the resource use and management practices for rice production. Further, document review was also done to gain more knowledge and information on study area and rice production system in the mid altitude of Bhutan.

After adjusting and validating, the model was used to simulate the potential yield and compare those with the actual farm yields to analyze the yield gap. Once the gap were identified, series of hypothetical experiments using different planting date and nitrogen rate were conducted using CERES-Rice model to come up suitable planting date and nitrogen rate to narrow the gaps.

4.2 Experimental data collection

Experimental data of Advanced Evaluation Trial (AET) for three improved varieties (IR-64, BajoMaap2 and BajoKaap2) were collected from RNR-RC, Bajo. The data for three consecutive years 2000, 2001 and 2002 with same management were collected. Varieties and planting were treated as different treatments. Each year trial were laid out in randomize complete block (RCB) design with three replications. Seedlings were transplanted in $10m^2$ plots at spacing of 20x20cm. Chemical fertilizer was applied at the rate of 70:40:20 NPK kg/ha with half the nitrogen as top dress at pannicle stage. No farm yard manure or compost was applied. To control the weed, Butachlore 5G was applied at the rate of 1.5 a.i kg/ha. Hand weeding was done whenever necessary. Irrigation was applied as and when necessary, normally after every seven days. Grain yield were estimated from a harvest area of $5.04m^2$ and the moisture content was standardized at 14%.

Since the experiments were conducted for varietal evaluation and not for model validation, there was lack of full information/data required for model validation. Leaf area index, biomass at different stages was not available. Similarly, for yield components only final grain yield was available. Data used for model validation were anthesis date, physiological maturity, and grain yield (Table 4.1). As a result, model adjustment and validation had to be performed with minimum available data. Dates of phenological events were recorded when 50% of the plants in each treatment had reached that stage of development.

Table 4.1: Observed phenological events and yield of different rice varieties planted at RNR-RC, Bajo.

Varieties	Sowing date	Transplanting date	Anthesis date	Physiological date	Grain yield
					Kg/ha
IR-64	5 May 2000 (125)	2 June (153)	27 August (238)	28 September (270)	6,900
	7 May 2001 (127)	2 June (153)	24 August (236)	25 September (268)	6,490
	30 April 2002 (120)	2 June (153)	26th August (238)	28 September (271)	7,000
BajoMaap2	5 May 2000 (125)	2 June (153)	17 August (228)	20 September (262)	6,000
	7 May 2001 (127)	2 June (153)	14 August (226)	20 September (263)	6,400
	30April2002 (120)	2 June (153)	21 August (233)	23 September (266)	6,450
BajoKaap2	5 May 2000 (125)	2 June (153)	2 September (244)	2 October (274)	6,400
	7 May 2001 (127)	2 June (153)	26 August (238)	27 October (270)	6,800
	30 April 2002 (120)	2 June (153)	27 August(239)	30 October (272)	7,250

(Source: RNR-RC, 2001, 2002a and 2003).

Note: Number in parenthesis is expressed in Julian date.

4.3 Weather data

Weather data for the research station was collected from meteorological Unit, CORRB, Thimphu. Data were recorded from the experimental site at RNR-RC-Bajo. Daily weather data for ten years, i.e., from 1993 to 2002 were gathered with information like maximum and minimum temperature, rainfall and solar radiation (Figures 4.1, 4.2, and 4.3).

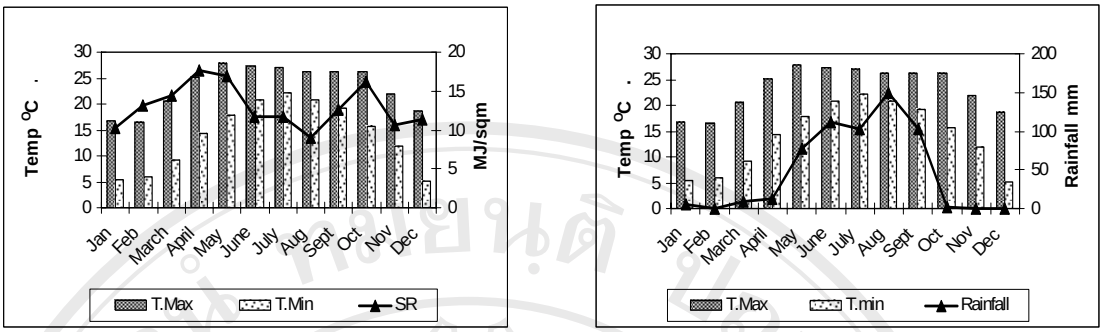

Figure 4.1: Average monthly temperature, rainfall and solar radiation, 2000 (Source: Meteorological Unit, Council of RNR Research of Bhutan, 2004)

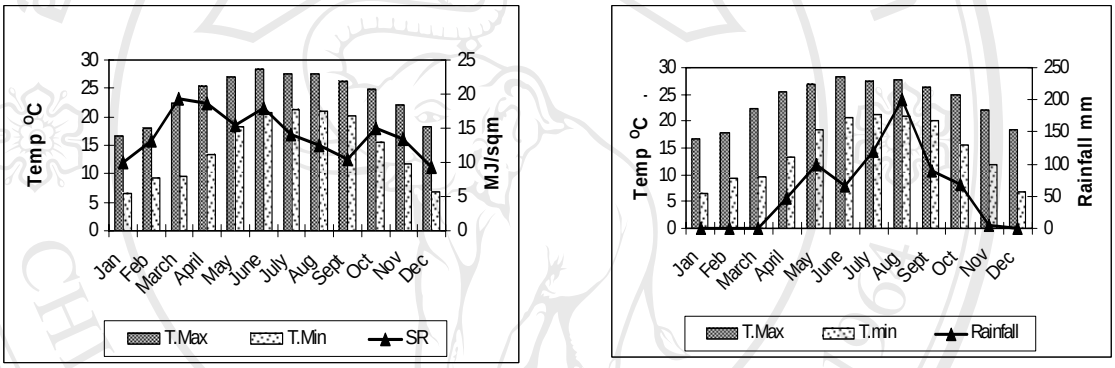

Figure 4.2: Average monthly temperature, rainfall and solar radiation, 2001 (Source: Meteorological Unit, Council of RNR Research of Bhutan, 2004)

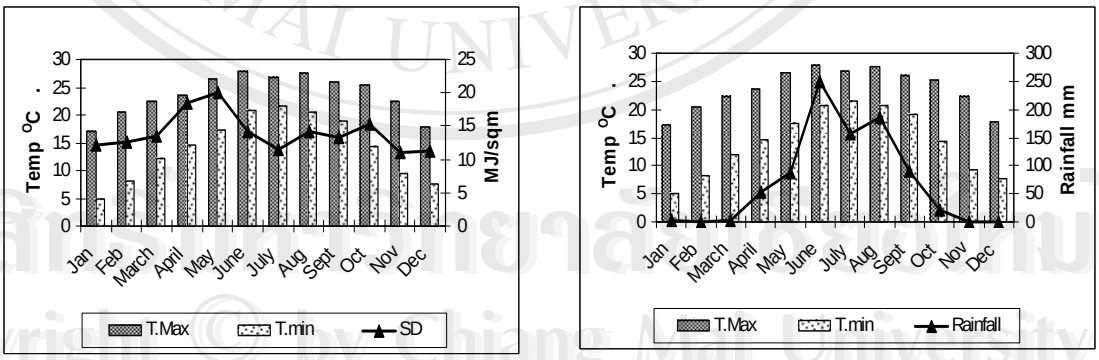

Figure 4.3: Average monthly temperature, rainfall and solar radiation, 2002. (Source: Meteorological Unit, Council of RNR Research of Bhutan 2004)

Since there was no meteorological station in the study area, the same weather data collected from RNR-RC, Bajo was use as input data during simulating management option for farmer's fields.

4.4 Soil data

There was lack of soil data for each experimental year to run the model, therefore, soil sample from the experimental fields were collected in March 2004. The soil samples were collected from different layers and analyzed at soil and plant analytical laboratory, NSSC, Semtokha. It was analyzed for pH, organic carbon, total nitrogen, bulk density, and texture (Table 4.2). Soil samples were also collected from the farmers' field in the study area and analyzed (Tables 4.3 and 4.4).

Table 4.2: Soil analysis report of experimental field, RNR-RC, Bajo.

Depth	pH		Organic	Total	C:N	Clay	Silt	Texture	Bulk
(cm)	Water	KCl	C %	N		%	%		Density
0-5	5.70	6.16	1.60	0.12	13.54	32.90	37.7	CL	1.21
5-15	6.20	4.25	1.30	0.10	12.50	36.60	31.00	CL	1.28
15-30	7.73	4.77	0.50	0.05	9.25	35.40	34.20	CL	1.65
30-45	7.96	6.58	0.30	0.04	8.18	ND	ND	ND	1.59

(Source: Lab analysis report, 2004).

Table 4.3: Soil analysis report of farmer's field, Omtekha

Depth	pH		Organic	Total	C:N	Clay	Silt	Texture	Bulk
(cm)	Water	KCl	C %	N		%	%		Density
0-5	5.28	3.94	1.10	0.08	14.44	25.40	29.80	L	1.35
5-15	5.51	4.17	1.00	0.08	11.84	28.10	28.70	CL	1.44
15-30	7.37	5.98	0.40	0.05	7.86	28.00	32.00	CL	1.55
30-45	7.88	6.43	0.40	0.04	11.22	28.60	26.20	SCL	1.45

(Source: Lab analysis report, 2004).

Table 4.4: Soil analysis report of farmer's field, Wangjokha.

Depth (cm)	pH		Organic C %	Total N	C:N	Clay %	Silt %	Texture	Bulk Density
	Water	KCl							
0-5	5.61	4.24	1.30	0.09	14.92	19.30	28.50	SL	1.35
5-15	5.48	4.18	1.30	0.10	13.20	20.30	28.80	L	1.33
15-30	6.12	4.50	1.00	0.07	13.89	23.70	26.20	SCL	1.41
30-45	6.83	5.02	0.50	0.05	10.49	20.70	34.70	L	1.57

(Source: Lab analysis report, 2004).

Note: L- Loam; CL- Clay Loam; SL- Silty Loam; SCL- Sandy Clay Loam; ND- Not Diagnose.

4.5 Field survey

Along with experimental, soil and weather data, information on resource use and management practices for rice production in the study area was also collected through household questionnaire survey and interview. Household survey was conducted using structured questionnaires to find out the resource use, management practices, marketing, and production of rice. Accessibility to resources and also potentials and constraints for rice production were collected during the survey. Since the study area had small population, all households were covered by structured questionnaires survey. Information on study area and rice production was also gathered by reviewing relevant documents.

4.6 Secondary data

Documents like, research reports and development plans of Renewal Natural Resource, Research Centre (RNR-RC), Bajo, National Soil Service Centre (NSSC), Planning and Policy Division (PPD) of Ministry of Agriculture, Department of Agriculture (DoA), Council of RNR Research of Bhutan (CoRRB), Dzongkhag Administration Punakha & Wangdue and Central Statistical Organization (CSO) were reviewed to find out more about the rice production system in mid altitude of Bhutan. Informal discussion with extension and research personnel and key informants were

also conducted to gain more knowledge about the rice production system in mid altitude zone and also to gather their personal and valuable experiences Annual rice crop cut data for the study area was also collected from the district agriculture office, Punakha and Wangdue.

4.7 Estimation of genetic coefficients

According to Hunt's approach (Hunt and Boote, 1989), the genetic coefficients for given variety are not known, so these have to be calculated using the field data set. This is accomplished by iteratively running the model with approximate coefficients, comparing model output to actual data; adjusting coefficients and repeating process until acceptable fit is obtained. Crop, weather, and soil data collected above were used as input for running model.

Using the default set of genetic coefficient of IR-64 available with CERES-Rice package initial run was made. After the initial run, genetic coefficients of three varieties IR-64, BajoMaap2 and BajoKaap2 for all treatments were adjusted till the close match was found between the observed and predicted from Advanced Evaluation Trial (AET) based on trail and error method.

4.8 Model validation

After adjusting the best genetic coefficient to find the close match between observed and simulated, model was validated using the best adjusted coefficient of three varieties for each treatment. Genetic coefficients of all three varieties generated from 2001 data set were use to validate with 2000 and 2002 data sets.

4.9 Data analysis

Information collected through households survey on resource use and rice production system in the research area were analyzed using descriptive statistic, such as mean, standard deviation and coefficient of variance. Accuracy of the model was tested by RMSE and d-stat value using analytical tool available with DSSAT v4 package. Further, simulated grain yields from different treatment were tested for statistical signigicants using one-way anova. Partial economic analysis was carried out to see the net return and production cost for different treatments.