

Chapter 7

Conclusions and Recommendations

7.1 Conclusions

Rice is the main staple for Bhutanese people and closely linked with culture and tradition. It also plays significant role in the economy of the country and the people. Demand for rice consumption is expected to increase faster than the production due to population growth and economic development. With 21% of the actual operated agriculture land under paddy cultivation, presently Bhutan is not able to meet its rice demand through domestic production. On an average, Bhutan imports about 60% of rice requirement. Pressure is further mounting as the horizontal expansion of rice area is not feasible, in fact it is decreasing due to conversion to other forms of land use and natural calamities. Therefore, increased production can only be met through increased rice productivity or land productivity.

It was found that the major resources that influence the rice production in the study area were labor, land, irrigation water and capital. In an average, 205 man days were required to cultivate one hectare of rice and 85% of the labor requirement was met through exchange or household contribution. Average land holding was 0.46 ha in Omtexha and 0.61 ha in Wangjokha. Share cropping was common and practiced by 55 to 67% of the farmers. Financial credit was considered important rice production which was mainly used to procure chemical fertilizers. Only 30% of the farmers in the area were able to meet the financial requirement for rice production and major income source were sale of agriculture and livestock products and off-farm activities. Irrigation water and labor shortage were reported as major constraints. It was also found that farmers rarely purchase improved rice seeds, own seeds were used over many years.

As a strategy to improve the productivity, Ministry of Agriculture has identified modern varieties and better chemical fertilizer management, especially nitrogen. However, analysis of the household survey indicated that farmers use suboptimal resources and management practices than recommended. Despite the major thrust for fertilizer as component of rice development program and continued support of the government to provide subsidies and fair price through out the country, the averaged fertilizer use in the studied area was found to be below the recommended rate. Recommended nitrogen rate for the modern varieties in the study area is 70 kg/ha but the average nitrogen used by the farmers was 50 kg/ha with a standard deviation up to 37 kg/ha. Chemical fertilizers, especially N, play an important role in rice production and productivity. Farmers in the studied area believe that use of chemical nitrogen increases rice yield and were the most commonly used chemical fertilizer.

Based on above background, yield gap analysis of three improved varieties commonly grown by the farmers in the studied area was conducted using the CERES-Rice model. The genetic coefficients of three varieties was adjusted based on the 2001 data set and validated using 2000 and 2002 data sets for its accuracy to predict phenological stages and yield of rice in mid altitude growing condition. First the potential yield was simulated using model and compared with actual farm yields to find out the gap. Analysis revealed that the gap between potential and farmers are as high as 50% and the gap between experimental farm and farmers' yield were around 35%. Considering the huge gap, different hypothetical trials using six planting date and eight nitrogen rates were conducted using model. Simulated results of this hypothetical experiments suggested that planting of these three varieties from 30th May to 30th June yield more with all rate of nitrogen application. It was also found that BajoKaap2 responded better to the high nitrogen application but at low nitrogen application all three varieties yielded comparatively close. Average yield of BajoKaap2 for planting dates between 30th May and 30th June at 150 N kg/ha was almost 13% and seven percent more than BajoMaap2 and IR-64 respectively. Analysis from the simulation result indicated that BajoMaap2 and BajoKaap2 are

more sensitive to date of planting than IR-64, it is more so with the increased nitrogen rate.

7.2 Recommendations

Considering the finding of this study, the following recommendations can be drawn:

- Conducive environment should be created to encourage farmers to use optimum fertilizer and new improved rice seed to improve yield. Use of quality seeding material is an effective way of realizing the yield potential of the recommended technology. High quality pure seed ensures correct germination, good crop stand and freedom from weed and seed born diseases. In general, it is recognized that the use of high quality seed ensures yields that are 10-15% higher than they would have been under the same crop management practices. Any attempts to narrow the yield gap should encourage farmers to use chemical nitrogenous fertilizer at the rate above 60 kg/ha. Therefore, it is of utmost important to create awareness about the usefulness of optimum fertilizer use and quality seed.
- Providing additional subsidies on temporary basis may be cost effective in attracting farmers to adopt and appropriately use fertilizer and other inputs together with new production technologies. However, such temporary subsidies should be phased out as adoption of recommended rate become popular. Further, role of extension and communication services are vital in this front, otherwise technologies generated will not find their own way out to the farmers.
- Considering the urgency and importance to narrow the rice yield gaps, accessibility and timely availability of necessary resources for farmers should be improved. System of input supply such fertilizer, seed, chemicals, agricultural machineries/tools may need to be decentralize to village market and quality assured. Optimum and timely use of inputs are equally important to realize the effectiveness and efficiency of its use. Studies found that farmers in the studied

area have poor and difficult accessibility to material inputs and financial resources.

- Timely and adequate intervention for the development of irrigation infrastructure is crucial. Water is an important resource for rice cultivation but it was reported that timely availability irrigation water was one of the major constraints faced by the farmers in the study area. Similarly, observation was also reported by the Department of Agriculture.
- Farmers can extend their transplanting time between 15th May and 15th July with relatively similar grain yields.
- For farmers using low nitrogen rate, 40 N kg/ha and below, can be advised to grow BajoMaap2 as it perform better with low nitrogen rate. On the other hand farmers who are capable of using high chemical nitrogen fertilizer should be recommended to grow BajoKaap2 as it has potential to yield almost 13% and seven percent more than BajoMaap2 and IR-64, respectively.
- Efficient, timely and site specific research need to be conducted regularly to narrow the gap and to increase production. Use of DSSAT will greatly help to carry out use research and identify gaps. Further, use of crop models like DSSAT will reduce resource and time required for research. Therefore, it would be appropriate and efficient to increase the use of crop simulation model as tool to conduct preliminary research before setting up promising and final set of research on station and on farm.
- During the study lack of experimental and meteorological data was experienced. Therefore, minimum data set required for crop simulation model like DSSAT should be generated and maintained. Climatic data has the maximum influence on the simulation result as such quality and availability data is very important for the accuracy and reliable results. So it is recommended to established proper meteorological stations at strategic locations.

- Lastly, success of narrowing rice yield gap largely depends on the goodwill and supportive rice development policy of the government. Government should address and find solution for socioeconomic problem before narrowing the agronomic gap between farmer's field and the research station. Government's role is also important to initiate a yield-gap narrowing program and to achieve effective coordination and intervention to provide appropriate solution to actual problems.

7.3 Further Research Issues

Yield gap analysis using the CERES–Rice model was carried out with weather data for 2002 and it is also known that weather has the highest influence on rice yields. Therefore, more analysis using a long-term weather data will help to fine tune the finding of this study. WGEN, a weather generating software can be used to generate long term weather for the area. This study has tried to examine the effect of planting dates and nitrogen rates only, but more studies on water management, age of the seedling, plant population are needed to improve the recommendation. Finding from this study have recommended higher rate of nitrogen fertilizer to increase the rice production, therefore, balanced study on yield gain and environment impact of using more nitrogenous fertilizer in Bhutanese situation need to be examined.