

MODERN RICE VARIETIES ADOPTION TO RAISE PRODUCTIVITY: A CASE STUDY OF TWO DISTRICTS IN BHUTAN

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ABSTRACT

Rice (*Oryza sativa* L.) is one of the main staple crops of Bhutan and is grown in all 20 districts of the country. Due to its key role in national food security, a number of development interventions like promotion of modern rice varieties is carried out. To assess the impact of such development interventions, this study investigated whether the farmers in two main rice growing districts, Punakha and Wangdue, have adopted the promoted rice varieties. Within a district, ten main rice growing geogs (administrative units) were chosen for the study. Representing the study area a questionnaire farming-household survey of 580 was carried out in 2014. The study found that the farming household level variety adoption rate was 68% and 62% in Wangdue and Punakha, respectively. The main modern varieties adopted by the surveyed farming households were IR-64, Khangma Maap, Bajo Maap, Bajo Kaap, No. 11 and IR-20913. In terms of area coverage, 54.50% of the area in Wangdue was covered by improved varieties and that in Punakha was 56.71%. Among the adopted varieties, the most widely grown variety in both the districts was IR-64 that accounts for about 55% adoption. However, the least adopted variety was IR-20913 which stood at just 0.2% in Wangdue and 2% in Punakha. Yield increase due to improved varieties over local ones, 80% of households in Wangdue and 91% of households in Punakha reported achieving 25% and 33% increases together. In Wangdue 80% of the households reported yield increase and in Punakha it was 91%, which corresponded to 25% and 33% increases, respectively. This surveyed finding can be validated by crop-cut yield data which was greater than or equal to 26% yield increase, on an average, by improved varieties over local ones. In terms of farmers' adoption rate of modern rice varieties and area covered by the modern varieties, the findings showed that there is a major impact of rice development interventions in Punakha-Wangdue valley to support food security of the farming households as well as for adding to the national food basket.

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Keywords: Modern rice varieties, adoption rate, comparative productivity, Bhutan

INTRODUCTION

Rice (*Oryza sativa* L.) is the number one staple crop in Bhutan. For Bhutanese populace, rice is the most preferred cereal food. Owing to the important role it plays, rice may be considered as synonymous to the national food security or the food self sufficiency state of the country. Over the years, Department of Agriculture, Ministry of Agriculture and Forests, has put in place strategic initiatives to enhance sustainable rice production. Currently the National Rice Commodity Program commands the largest annual budgetary share amongst the other cereal crops development programs in the country. It is grown in all the 20 districts of Bhutan in altitude range of about 150 m in the South to about 2600 m in the North. Rice is grown in approximately 23,000 ha area with production of little over 78,000 tons (DoA, 2012). This meets less than 50% of Bhutan's rice requirement and rest is imported from neighboring India. Thus, promotion of modern rice varieties was imperative as one key intervention to enhance rice production towards improving national food security. The green revolution in Asia was driven by revolution of technologies which included package of modern inputs such as improved seeds, irrigation, fertilizers and pesticides leading to dramatic yield increase (Pandey et al., 2012).

The trends in rice production and productivity over the years showed some gradual increases but Bhutan's rice industry has been beset by numerous challenges. The rice areas are under tremendous pressure from the forces of development and urbanization. Rice production in Bhutan is also being hit very hard by the effects of climate change and global warming. The irrigation water sources are seen to be drying out, precipitation is getting more and more erratic, and potential rice fields are getting fallowed or are converted to urban centres and other land uses. In the face of all such challenges, Department of Agriculture targets to enhance production and improve national rice self-sufficiency level using strategic interventions. In the past, there were several projects and initiatives which led to development and release of high yielding HYVs. All such interventions have contributed immensely to promotion and use of modern rice varieties. Most recent and one noteworthy initiative was the Accelerated Bhutan Socio-economic Development (ABSD) initiative for rice production which targeted to bring about 70% of the potential rice area under various forms of interventions (DoA, 2013; RNR RDC Bajo, 2012). The ABSD initiative targeted seven most potential rice-growing districts or the clusters viz. Wangdue-Punakha valley, Tsirang-Dagana, Sarpang, Samtse, Samdrup Jongkhar and others. Of these, Wangdue-Punakha valley was one of the most important clusters which constitutes about 25% of the total rice production and is an important lifeline for rice trade in the country. The two districts are famous for the highest rice productivity in the country along with Paro district.

As Bhutan moves away from subsistence level of production to commercial mode of production, modern farming technologies should be adopted. Thus, the use of input intensive modern varieties must be vigorously pursued along with other green revolution technologies. To increase rice productivity, interventions like vigorous promotion of modern varieties, providing increased access to irrigation water and farm mechanization, capacity development of farmers and extension staff, and so on are pursued. Despite all the efforts and initiatives, technology adoption is still quite low and use of modern rice varieties needed a thorough review to re-energize and launch intensified rice development program in the major rice growing areas. The need of the hour is to have higher yielding varieties with resilience to biotic and abiotic stresses. The national rice variety adoption rate is 42% (Ghimiray, 2012) and it is imperative to assess the impacts of technology promotion drives initiated and implemented over the years. Since the promotion of modern varieties was the cornerstone of the development agenda, this article investigates the rate of adoption of modern rice varieties, an important impact of the various initiatives. Specifically, the objectives of the current study were (1) to assess the impacts of rice development initiatives on the adoption of modern rice varieties by the farmers of Wangdue-Punakha valley, and (2) to assess and identify locations requiring immediate attention for enhancing rice production and productivity. To capture the situation in representative rice growing districts, Wangdue and Punakha districts were chosen because these two districts together accounts for 25% of rice production in the country (DoA, 2013) and sometimes referred to as a rice bowl of Bhutan.

MATERIALS AND METHODS

Site description

A questionnaire survey was conducted in ten major rice growing geogs (blocks) of Wangdue and Punakha districts in West-central region of the country (Figure 1). These two districts are also more often referred to as Wangdue-Punakha valley and the valley is one of the most important rice growing areas in Bhutan. The Wangdue-Punakha valley is the rice bowl of Bhutan and is well known for domestic rice trade constituting both improved and local varieties of rice. These areas fall in warm temperate to dry subtropical zone and constitute major mid-altitude rice growing area which stretches to the extremes of temperate climate. The research sites fall under the dry sub-tropical agro-ecological zone of broad national classification for Bhutan. That is, the Punakha-Wangdue valley generally has sub-tropical climate with dry winters and wet summers. Normally, the summers become hot with temperature reaching over 30 degree centigrade and the winters are dry and windy with frost in the morning. The maximum temperature is over 34°C in the month of May and the minimum is 0.5°C in the month of December. Similarly the maximum rainfall is about 125 mm in the month of August and the minimum rainfall can be as low as zero mm in the month of December.

Field survey

The rice variety assessment was done through a conduct of household sample survey. The actual survey was carried out by the respective extension staff of Wangdue and Punakha districts covering each of their 10 major rice growing geogs. Altogether, the survey captured 580 farming households and collected data on land use pattern, family income, crop production practices and use of higher yielding modern rice varieties. However, this paper focused on the study of modern variety use and spread in Wangdue-Punakha valley. Various studies have shown that adoption of modern varieties is the key to national food security (Hussain et al., 2005; Mercedita et al., 2014; Saka and Lowal, 2009; Wang and Pandey, 2012, Nakano and Kajisa, 2014). Shiferaw et al. (2014) also mentioned that adoption of HYV varieties of wheat were key to food security which would hold similarity even for rice.

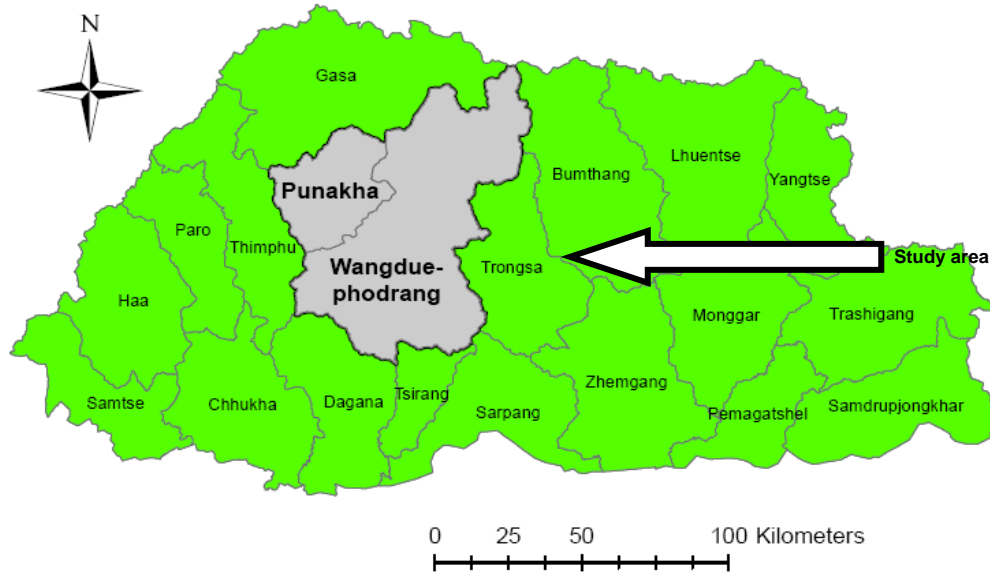


Figure 1. Map of Bhutan showing the study area, Punakha and Wangdue districts (within bold boundary) where variety adoption rate was assessed

Data analysis

The overall data collection works were coordinated by the Renewable Natural Resources Research and Development Centre- Bajo (RNR RDC-Bajo). The duly completed survey questionnaires from the field were received by the Dzongkhag Agriculture office and sent to RDC-Bajo where the data analysis was done. The data recording and compilation was completed in Microsoft Excel. Statistical analysis was done using IBM SPSS statistical software version 20 and Microsoft Excel.

RESULTS AND DISCUSSION

HH level variety adoption rate

The average modern rice variety adoption rates at household level in Wangdue and Punakha Dzongkhags were assessed to be 68% and 62%, respectively. This worked out to a healthy average of 65% for Wangdue-Punakha Valley. However, there were great variations in household variety adoption rate among the different rice growing geogs (Table 1). The household variety adoption rates among the geogs ranged from the low of 36% to high of 100% showing that there is a need to continue with crop varietal promotion works in a more strategic way so as to reduce the gap between the two. A couple of geogs like Thedtsho under Wangdue and Baap under Punakha Dzongkhag recorded HH variety adoption rate of 100%. On the other hand, few geogs like Kashi and Gase Tsho Gom under Wangdue, and Toewang and Toebasa under Punakha Dzongkhags had comparatively low HH variety adoption rates (below 50%). Such variations could be attributed to the difference in farmers' preference and social settings. Variety adoption rates are determined by many factors such as the nature of land endowment and farmers preference to a specific quality trait (Pandey et al., 2012). The variations could also be attributed to the department's variations in levels of support among the geogs and Dzongkhags. Under the rice commercialization program of the department, more focus was given to potential geogs with large rice areas. Nevertheless, the overall variety adoption rate was quite commendable and the credit goes to the Department's vigorous promotion of improved varieties in the last few years (DoA, 2012, RDC-Bajo, 2013, Chhogyel et al., 2014). The improved varieties adopted by the farmers included mid-altitude varieties like IR-64, Bajo Maap 1, Bajo Maap 2, Bajo Kaap 1, Bajo Kaap2, and a high altitude variety Khangma Maap. As the Department continues with rice commercialization program, the spread of improved varieties is going to increase in the near future increasing rice yield in the valley. One of the strategies of sustainable rice production for improving food security status is farmers' adoption of modern varieties (FAO, 2014).

Variety adoption rate in terms of area

Area under modern varieties, more or less followed the trends in variety adoption rate at household level. The average modern rice adoption rate in terms of acreage for Wangdue-Punakha valley was satisfactory, at 56%. The area under modern varieties in Wangdue was 54.5 % while it was 56.7% for Punakha Dzongkhag indicating that the variety adoption rates in the two dzongkhags were about similar. Ghimiray (2012) reported that the area under improved varieties in Bhutan was 42% which was almost 33% lower than what was recorded in the current study. It was also reported that the area under modern rice varieties in the mid-altitude zones of Bhutan which also includes Wangdue-Punakha valley was about 37.5% (Shrestha, 2004). This indicated that the Department's rice commercialization program which promoted 44.50 t seeds comprising of six different improved varieties

over three years was effective in spread of varieties across all the major rice growing geogs of the valley (Chhogyel et al., 2014). Over the years, the variety adoption rate has increased manifold portraying that the farmers are having increased surplus rice for sale in the market. One case in point which requires to be seriously viewed is to look at individual geogs and carry out need- based support programs. This is to raise the economic status of the backward geogs. According to Table 2, the geogs like Baap (Punakha) and Thedtsho (Wangdue) had 96% and 94% of the rice area under improved varieties, respectively. These geogs also recorded cent percent adoption rate in terms of households. There were also geogs, whose area under modern varieties registered as low as 36% (Toewang) under Punakha and 40% (Gasetsho Gom and Nahi) under Wangdue Dzongkhag. Thus, there is a need to bring all the geogs at same level through major shift in target areas and improved channeling of resources. Table 3 shows paddy production from the ten major rice growing geogs of Wangdue-Punakha valley as per the records maintained with the RNR RDC-Bajo.

Among the varietal coverage in terms of area, the most popular and widely spread variety was IR-64 followed by Khangma Maap and Bajo Maap (Figure 2). Earlier studies by Ghimirey (2012) and Shrestha (2004) have also reported that IR-64 was widely grown in the mid-altitude zone of Wangdue-Punakha valley. Records show that IR-64 rice variety in Bhutan was released in 1989 (Ghimiray, 2008). Since then, it has started to make inroad to other agro-ecological zones of the country, maximum being in the mid-altitude regions of Wangdue and Punakha valley. IR 64 is the most widely grown indica rice in South and Southeast Asian countries as it possesses many positive agronomic characteristics which include high yield potential, wider adaptability, tolerance to biotic stresses and good eating quality (Wu et al., 2005). Coverage of IR-64 in Wangdue and Punakha Dzongkhags was 54.7% and 57%, respectively registering average coverage of about 56% (Figure 2). The other popular top three improved varieties in the valley were Khangma Maap, Bajo Maap and Bajo Kaap. The variety IR20913 is also being grown on a small scale as short duration crop in chilly-rice and rice-rice cropping system. This variety has also been grown as a potential variety for second crop while the variety No. 11 is being grown as the first crop in rice-rice cropping system (double cropping) in Wangdue-Punakha valley (Chhogyel et al., 2014).

To provide wider varietal choices to the farmers, many varieties are at different stages of evaluation with few being already in the farmers' field (Chhogyel et al., 2013). Higher yielding varieties were promoted packaged with other supports such as need based training of farmers and staff on specific topics (seed selection, fertilizer application, nursery development, plant protection, etc.) including farm mechanization through hiring services (DoA, 2012; RNR RDC- Bajo, 2013).

Rice yield and production

Farmers grow both improved and local varieties. On an average, a farmer grows two kinds of rice, local and improved, or two local varieties annually. The

reason as to why the farmers grow more than one variety is to fulfill varied needs such as for self-consumption, sale, and use for rituals and ceremonies. Being an important part of their tradition and culture, the farmers have developed special attachment to their local varieties. It has also been reported that the sale value of the local varieties were higher and always considered as specialty rice for cash income and household traditional cultures as well as religious functions. However, in term of yield performance, the farmers unanimously rated superiority of improved varieties over their local ones. In both the Dzongkhags, the yields from the improved varieties were reported to be about 25% to 50% higher as compared to the local varieties. In Wangdue Dzongkhag, majority of the farmers in geogs like Thetsho, Ruepisa, and Athang reported yield increase of about 33% over their local varieties. In the same Dzongkhag, there were also farmers who reported yield increase of 50 % from the adoption of modern varieties. Likewise, some respondents also reported yield increase of about 25 % from adoption of improved varieties. Similarly, majority of the geogs under Punakha Dzongkhag reported yield increase of 25% to 33% from the adoption of improved varieties and close to about 1-2% of the farmers reported that the yield increases from the improved varieties were about 50%. Specifically, 3% to 17% of the farmers growing improved varieties in Punakha had reported yield increase of 50% (Table 4). On the other hand, there were also farmers in geogs like Chhubu, Dzome, and Toebsa which had less percent of farmers who reported increased levels of yield. In general, such information corroborated well with the crop cut based yield reports maintained at RDC-Bajo (Table 5). The yield reports from crop cuts conducted by the researchers and extension officials have showed that the yield gains from improved varieties were quite commendable at farmers' level of management practices.

As the DoA emphasizes on rice commercialization, variety adoption rate are targeted to be increased and more vigorous promotion will have to be continued targeting specific and needy geogs.

Though the improved varieties were seen to be gaining a strong foothold in all the geogs, the use of local varieties is going to continue for some time. However, going by the current level of crop promotion program and supply of seeds made to the farmers, the adoption rate for improved varieties is only going to increase. In the current project impact study, farmers' views on the improved varieties were sought and it was found that the reasons for adopting improved varieties were many. From the generalized perspective, the following were the major reasons provided by the farmers:

1. The local varieties are low yielding and they wanted to cultivate improved varieties in some areas,
2. The local varieties are highly susceptible to diseases and pests and interested to cultivate both local and improved varieties,

3. The seeds of the improved varieties were made more freely than the local varieties, and
4. Technical advice from the extension agents to grow more of improved varieties citing many advantages over the local ones.

The average yield of local and improved varieties on table 5 shows that improved varieties yield 31% and 26% higher in Wangdue and Punakha districts, respectively. For yield increase due to improved varieties over local ones, 80% households in Wangdue and 91% of households in Punakha reported achieving 25% and 33% increases together (Table 4). This surveyed finding can be validated by crop-cut yield data which was greater than or equal to 26% yield increase, on an average, by improved varieties over local ones. The least number of farmers reported 50% yield increase due to adoption of improved varieties.

CONCLUSION

The study concludes that the geog-wise average farming households adopting modern rice varieties was 68% in Wangdue and 62% in Punakha districts. The study found that at least five promoted modern varieties are adopted by farmers. About 55 % of the rice area in the two districts of Wangdue and Punakha are grown to modern rice varieties. The maximum number of households in both districts reported to have achieved yield increase of 33% by improved varieties compared with the local ones. In terms of farmers' adoption rate of modern rice varieties and area coverage, it is concluded that there is a major impact of rice development interventions in Punakha-Wangdue valley to support food security of the farming households as well as for adding to the national food basket. As the national rice program moves ahead, the identified locations (e.g. Kashi, Toeb) with low variety adoption rates be targeted strategically. These farming communities should receive top priority and need-based interventions such vigorous promotion of HYVs, mechanization, irrigation and other technical support. This is expected to contribute to adoption of improved technologies so as to enhance the livelihood of the farmers.

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Table 1. Household level rice variety adoption rate (%) in twenty geogs of Wangdue and Punakha Dzongkhags

Sl.No	Wangdue		Punakha	
	Geogs	% HH*	Geogs	% HH*
1	Athang	62	Baap	100
2	Bjena	63	Chhubu	50
3	Daga	67	Dzomi	59
4	GaseTsho Gom	44	Goenshari	57
5	Kashi	36	Guma	76
6	Nahi	60	Kabjisa	70
7	Nyisho	80	Limbukha	76
8	Phangyuel	85	Shengana	50
9	Ruepisa	78	Toebsa	49
10	Thedtsho	100	Toewang	38
Average % HH		68	62	
Std. Deviation		19.09	18.12	

N*=significant at 0.05% (Adoption rate between the geogs is significant)

Table 2. Area occupied by modern varieties in the ten geogs of Wangdue and Punakha Dzongkhags

Sl.No	Wangdue			Punakha		
	Geogs	Mean area (%)	Std. Error	Geogs	Mean area (%)	Std. Error
1	Bjena	48.00	3.980	Baap	96.00	1.212
2	Daga	55.00	4.308	shengana	47.05	3.577
3	Gasetsho Gom	40.00	3.820	Guma	70.00	5.410
4	Athang	43.00	3.747	Dzome	55.00	3.913
5	Thedtsho	94.00	1.568	limbukha	60.00	3.429
6	Nyisho	55.00	3.122	Kabjisa	62.00	3.826
7	Phangyuel	70.00	4.269	chhubu	48.00	3.826
8	Kashi	39.00	2.842	Toewang	36.00	3.737
9	Nahi	40.00	3.313	Toebsa	44.00	3.253
10	Ruepisa	61.00	3.348	Goenshari	49.00	3.705
	Average	54.50	1.590		56.71	1.617

Table 3. Rice area and production from the ten geogs of Wangdue-Punakha valley

Wangdue				Punakha		
Sl.No	Geog	Area (ac.)	Production (MT)	Geog	Area (ac.)	Production (MT)
1	Bjena	214	321.00	Baap	500	1250.00
2	Athang	220	308.00	Guma	1000	2200.00
3	Daga	322	527.44	Dzome	459	780.30
4	Gase Tshogom	544	864.96	Shengana	712	1480.96
5	Kazhi	222	288.60	Kabjisa	528	1045.44
6	Nahi	237	440.58	Toewang	744	1221.65
7	Nyisho	500	691.50	Chhubu	679	986.59
8	Phangyuel	596	827.25	Toebsa	358	638.67
9	Thetsho	200	344.60	Goenshari	250	431.75
10	Ruepisa	400	560.00	Limbukha	269	427.71

Table 4. Farmers' view on levels of yield increases from the cultivation of modern varieties in various geogs of Wangdue and Punakha Dzongkhags

Wangdue	Levels of yield increase			Punakha	Levels of yield increase		
	25%	33%	50%		25%	33%	50%
Athang	5	21	4	Baap	12	17	0
Bjena	3	5	0	Chhubu	8	3	3
Daga	5	7	8	Dzomi	2	5	0
Gasetshogom	0	7	3	Goenshari	9	6	0
Kashi	0	5	0	Guma	1	17	0
Nahi	12	4	0	Kabjisa	1	3	2
Nyisho	10	3	6	Limbukha	2	10	3
phangyuel	9	9	4	Shengana	4	2	4
Rubesa	8	10	1	Toebsa	4	7	0
Thetsho	0	20	9	Toewang	0	11	0
Total	52	91	35		43	81	12

Table 5. Crop-cut based average yield of local and improved rice varieties

Wangdue	Yield (t/ac.)		Punakha	Yield (t/ac.)	
	Local	Improved		Local	Improved
Athang	1.46	1.47	Dzomi	1.80	2.40
Bjena	1.45	2.00	Teob	2.00	2.10
Daga	1.46	1.79	Gonshari	1.80	1.90
Gasetshogom	1.68	2.52	Teowang	2.23	2.56
Kazhi	1.80	1.90	Chubu	2.32	3.00
Nahi	1.44	2.18	Guma	2.00	2.23
Nyisho	1.54	1.80	Shagana	1.90	2.31
Phangyul	1.83	2.10	Kabjee	1.18	2.30
Rupeisa	1.72	1.96	Barp	1.20	2.50
Thedtsho	1.67	2.56	Limbukha	1.67	2.33
Average	1.60	2.02	Average	1.80	2.36
Difference%		26%			31%

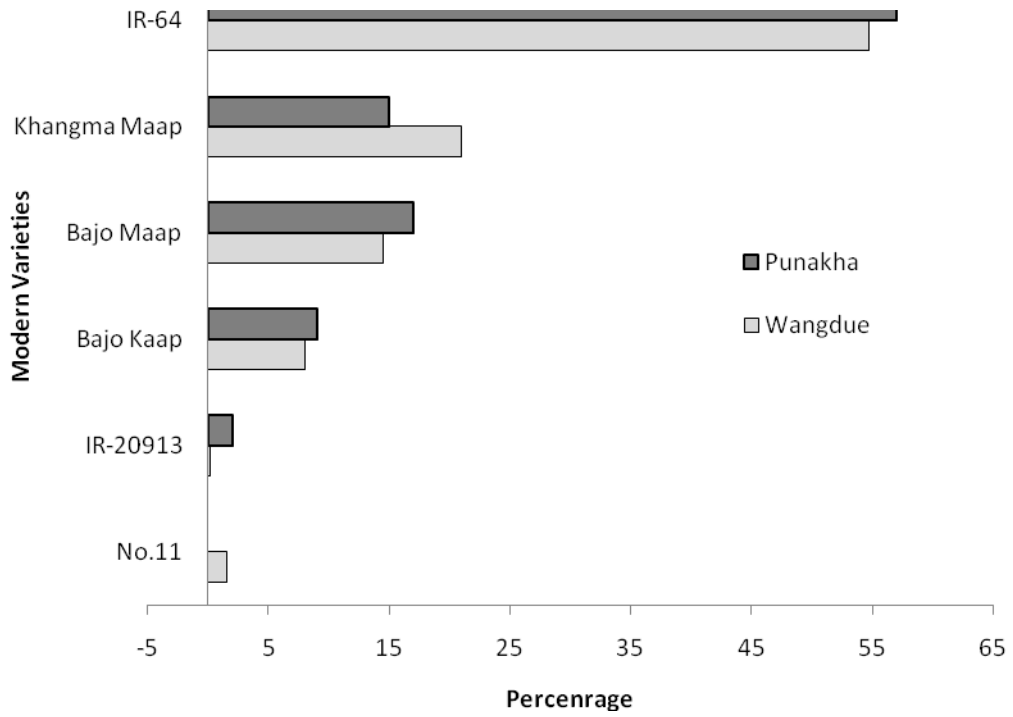


Figure 2. Specific rice varietal coverage in Wangdue-Punakha valley (A: area coverage in Wangdue Dzongkhag and B: area coverage in Punakha Dzongkhag)