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Seasonal Variations of HYV Paddy Adoption Patterns and Complimentary Inputs: Field Level Observations from Assam

Dr. Phanindra Goyari,
Assistant Professor, School of Economics, University of Hyderabad, Gachibowli, Hyderabad-500046
Ph: 8106862730, Email: phanin12@yahoo.com

Abstract
Empirical evidences all over the world have established the fact that adoption of High Yielding Varieties (HYV) of seeds with appropriate complementary inputs can increase the yield per unit of land compared to the traditional varieties. Adoption patterns of farmers do change over the years or even across seasons during a particular year. Understanding the seasonal variation of adoption patterns is important for policy formulations.The analysis of present paper is based on farm household level primary field survey data collected from Assam state of India. Specific objectives are (i) to examine the seasonal variation in adoption patterns of HYV paddy and its complementary inputs such as irrigation, fertilizer, pesticide etc. of sample farmers across three seasons (winter, autumn and summer) covering one complete agricultural year, (ii) to identify the factors influencing the adoption patterns of sample farmers and (iii) to draw policy options for successful adoption by examining linkages between adoption patterns and influencing factors. The study showed that the adoption of HYV paddy seed technology was wide spread but still not cent percent in the sample region due to some farmer's preferences on traditional varieties. Although winter is still the most dominant, paddy cultivation in summer season is a new emerging phenomenon and facilitated by new HYV technology combined with irrigation. Any agricultural policy regarding the successful spread of new crop variety needs to consider available complementary inputs and flood control measures.

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Broad Theme: (4) Environment and Development in the North-East India

1. Introduction

Empirical evidences all over the world have established the fact that through the adoption of High Yielding Varieties (HYV) of seeds with appropriate complementary inputs (like fertilizer, irrigation etc.), it is possible to increase the yield as well as the return per unit of land to a significant extent compared to the traditional methods of cultivation (Saha, 2004, p.1). HYV paddy seeds are adopted by farmers because of some positive advantages like higher yield, shorter maturity duration, higher output price, all season cultivable etc. However, inspite of many positive advantages, adoption of improved paddy seed varieties and related inputs has often met with partial success in many agriculturally backward regions. Persistence of incomplete adoption of modern agricultural technology in backward agriculture has invited alternative theoretical explanations. Limited access to working capital, incomplete learning, farmer's attitude towards risk and other attributes, preference towards traditional crop etc. have been identified as factors inhibiting the process of diffusion at the farm level (ibid).

Adoption decisions change over time in any region or country. But even during a particular year, adoption patterns of farmers change across seasons due to various reasons. For example, Parthasarathy and Prasad (1971) found from their study in Andhra Pradesh that the progress of HYVs of rice was much slower in the wet kharif season than in the dry rabi season. They gave explanations in terms of economic factors of costs and productivity. The HYVs, which require greater cost per hectare than local varieties, do not fare very well in the wet kharif season compared to the established local varieties. In the rabi season, however, the relatively higher productivity of HYVs makes them more attractive to the farmers than the local varieties. Parthasarathy (1975), in the west Gadavari district of Andhra Pradesh and Rajagopalan (1975) in North Arcot district of Tamil Nadu found the improved varieties of rice to have fared better in the wet-season than the local varieties. Some studies (Lacsna and Barker, 1978) found that absence of suitable conditions needed for modern varieties during the wet season is responsible for not being able to attract HYV farmers. Understanding this seasonal variation of HYV adoption patterns of paddy is important for various reasons, particularly for the economy of Assam.

Farmers in Assam cultivate paddy in three seasons – winter (sali), autumn (ashu) and summer (boro) in an agricultural year[1]. The period from May to October is very crucial for almost all farmers in the state. Because this is during this period when ‘ahu’ rice (autumn rice) is harvested and ‘sali’ rice (winter rice), the main kharif crop, is cultivated. But during this important period only, Assam receives heavy rainfall and due to excess rainwater, floods of several intensities occur almost every year. Floods destroy properties worth of several crores of rupees besides crop area and standing crops (Goyari, 2005). Moreover, out of three varieties of seasonal rice, winter rice is the most popular among farmers due to easy availability of rainwater. But excess rainwater disturbs farmers in the form of floods. In a normal year, floods occur during three-month period from June to August, when the monsoon rains are the heaviest in the state. However, early floods in May and late floods in September and even in October do occur in occasional years. Floods in early parts of the season mainly damage the ‘ahu’ rice crop. But the floods occurring late in the season are the most devastating as they damage the standing ‘sali’ rice, the main ‘kharif’ crop of the state.

Summer season is relatively flood free season of the year. The arrival of short maturity duration new rice varieties has helped some farmers in adjusting crop seasons (before and after floods) in the flood affected areas of the state so as to reduce the risk of crop damage by floods to some extent. It has been tried to make the non-flood prone season as the major cropping season. The sources of water in Assam are many, such as two mighty river systems (viz., the Brahmaputra and Barak along with their tributaries and streams), rich underground water aquifer, various ponds and lakes. The heavy rainfall further adds to the vastness of water resource. Unfortunately, only a small fraction of the vast inland water resources has been utilized for gainful economic activity (Saikia 1999; Basu 1979; Goswami 1993). Despite abundant water resources, the ratio of gross irrigated area (GIA) to gross cropped area (GCA) was only 12% per year on an average during 1980-81 to 2004-05, compared to 36% at the all India level, 93% in Punjab, 40% in Andhra and 29% in West Bengal during the same period (Goyari, 2008a). Hence, Assam exhibits the paradox of water scarcity inspite of water abundance (Goyari, 2008b). Academicians and policy makers have also been advocating for making summer and autumn season as important crop seasons for paddy farmers. Since the answer to

[1] Crops are named by autumn, winter and summer during which these are usually harvested, and not by cultivation period. Autumn (ashu) rice is sown in February-March and harvested in July-August. Winter (sali) rice is cultivated in July-August and harvested in November-December. Summer (boro) rice is generally grown in low-lying marshy lands during dry season from December to May.

such a question requires an understanding on the land use pattern of farmers at the farm household level, a study using the field survey data assumes importance.

With the above motivation in mind, the present paper attempts to examine the seasonal variations in adoption patterns of HYV paddy in Assam. Specific objectives are (i) to examine the seasonal variation in adoption patterns of HYV paddy and its complementary inputs such as irrigation, fertilizer, pesticide etc. of sample farmers across three seasons (winter, autumn and summer) covering one complete agricultural year, (ii) to identify the factors influencing the adoption patterns of sample farmers and (iii) to draw policy options for successful adoption by examining linkages between adoption patterns and influencing factors.

2. Sample Data and Study Locations for Field Surveys[2]

Primary data were collected through field surveys at farm household level in seven villages spread in two distinct locations of Udalguri district in Assam. Total sample included 300 farm households the distributions of which across sample villages and regions are shown in Table 1. Udalguri town is about 160 kms towards the northern side of Guwahati, the biggest city in the north-eastern region of India. The two sample regions were selected on the basis of differential conditions in irrigation facility and soil quality. The first region, basically is having clayey-sandy type of soil (locally known as *hasrao ha or bala sahia ha*, the clayey proportion being larger than that of sand). This region 1 is better irrigated in the sense that it gets water more from naturally flowing sources. This region covers four villages closely lined up with each other and located towards the north-eastern side of Udalguri town. The second region, having more alluvial or loamy or muddy and sticky type of soils, (locally known as *hama ha*) depends more on rainwater for cultivation. This region is less irrigated in the sense that it has less naturally flowing water ways and depends more on rainwater. The water retention capacity of *hama ha* in this region is high. Surveys were conducted in two phases using a systematic questionnaire schedule. The first survey conducted during December-2004 to June-2005 covered data on crops of *sali* and *boro* seasons. Data on *ashu* season were collected in the second survey, during September-October 2005. Data for the three seasons formed one complete cycle of agricultural year.

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[2] The primary survey for data correction was a part of author's doctoral thesis, Goyari (2008a).

3. Field Results and Discussion

3.1 Profiles of sample farmers, land and cropping pattern

The study region as a whole is agrarian in nature, nearly 91% of the total workers being agricultural workers. Occupational diversification is very limited. The whole sample had 130% of cropping intensity. Almost all non-rice crops are cultivated only once during one cycle of the agricultural year. So the extent of overall cropping intensity is totally dependent on rice acreage. The ownership-land holdings in the study villages were dominated by marginal farmers (owning below 1 hectare) in terms of number of holders. However, in terms of land shares, small farmers (between 1 to 3 ha) dominated other holders. In the case of the number of land operators, marginal farmers with 42.7% of households topped and small farmers dominated in terms of operated land area (with 42% of operational land) among the four farm-size groups found in the combined sample. The average sizes of ownership and operational land holding per household were 1.46 and 1.53 hectares respectively for the combined sample. The latter figure was higher than the average figure for Assam (1.20 ha) and India (1.32 ha) in 2000-01.

Table 2 shows the season-wise crops, areas and proportions of crop areas in the sample regions. About 65% of GCA in the combined sample was allocated for kharif (winter) season crops. The main kharif crop in the sample is *sali* rice. Maximum number of crops is cultivated during rabi (summer) season. But, land allocation in rabi season is the lowest (5%) among the three seasons. Majority of rabi crops are vegetables like cabbage, cauliflower, arhar, grams, potato etc. The perennial crops together occupy about 8% of GCA. Both sample regions allocated almost similar seasonal proportions of cropped areas inspite of differences in irrigation conditions and soil quality. Cropping patterns in both sample regions are dominated by rice. The total area under rice in the sample region 1 was 300.5 hectares, which accounted for 87% of GCA. This acreage share of rice in this region is much higher than the figure of 66.19% of GCA observed for Assam as a whole during the quinquennium period 2000-01 to 2004-05 (Goyari, 2008a).

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3.2 Period of first adoption and sources of inspiration to adopt

The adoption of HYV paddy seeds in Assam started picking up only in the middle of 1970s, compared to its first arrival during 1960s in the Indian agricultural fields (Bezbaruah 1994). However, the information provided by sample farmers shows that adoption of HYV paddy seeds in sample locations is comparatively a recent phenomenon. Sample farmers started adopting new varieties of paddy only in the early 1990s, about three decades after these new varieties had appeared on the Indian agricultural scene. This is not surprising in view of the remoteness of the sample regions, both from cities and research stations. Thus, sample farmers are *late adopters* compared to *early adopters* in other parts of the state or India. While none in the sample region 1 was adopting prior to 1990, only four farmers were found responding to adoption of HYV paddy prior to that year. More than half of the total farmers in the combined sample adopted new varieties during 1996-2000. Farmers in region 2 were adopting HYV paddy earlier than the farmers in region 1.

Farmers derive inspiration to adopt HYV seeds at the first time from various sources of information. Many adoption studies (*e.g*., Chauhan 1980, Srinivasas and Mukunda 1980) found contacts with officers in the agricultural extension services as the major source of adoption. But in the sample villages showed a completely different picture. Farmers told that the extension visit was not an important factor. Only 3% of sample farmers got inspiration to adopt from the contacts with extension service people. Majority of farmers, i.e., about 80%, adopted HYV paddy seeds after observing friends, relatives or other farmers growing new varieties successfully. This source has more advantage than the extension service personnel. The main reason is that farmers in the same village can discuss cultivation matters more conveniently, at any time than with extension officers. Other sources had only negligible contributions towards adoption motivation.

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3.3 Paddy cultivation

Out of the total sample of 300 households, only 189 were paddy cultivators. Of the total paddy area, 88.4% was allocated to HYV paddy cultivation. Only HYV paddy was cultivated during summer (Table 3). In the sample region, almost all paddy farmers are cultivating HYV seeds in the whole sample. Only two farmers were found cultivating traditional varieties (TV) of paddy. However, in each sample village, many farmers (40%) were found cultivating TV of paddy along with the modern varieties. Of the total paddy output in the combined sample during the survey period, about 91% was contributed by HYV paddy.

3.4 New paddy varieties (HYV) within each season

Even in an agricultural year, seasonal variations have been found in adoption patterns of new rice varieties in terms of number of adopters and area allocations. The patterns of adoption of new varieties during the wet 'sali' (i.e., the main kharif or winter rice) season by sample farmers have been observed different from the pattern of adoption of these varieties in other two seasons, i.e., the pre-kharif 'ashu' or autumn season and summer or 'boro' season. Later two seasons are relatively dry compared to the first season. [Data on variety wise season wise number of sample farmers cultivating HYV rice and area allocations in the sample areas during the survey period could not presented here due to space problem]. Based on the sample data and sample farmers' opinions, following important points on the adoption patterns of HYV seeds were drawn:

(1) The highest number of adopters of HYVs in the combined sample was found during the sali season (i.e., 94%), followed by the ashu (autumn rice) season. Excluding summer season, less number of farmers cultivated TV paddy compared to HYV paddy in sali and ashu seasons. In the combined sample, 34% of farmers during sali season and 15% of farmers during ashu season were cultivating traditional paddy. Like in the number of adopters, the absolute area allocation in new varieties of rice was the highest during sali season, followed by ashu and summer season in that order. About 338 hectares were allocated to sali HYV paddy. Ashu HYV paddy was cultivated in 106 ha and summer paddy in 10 ha during the survey periods. However, in terms of shares, all paddy area (100%) was allocated to new paddy varieties during summer season.

(2) Among all new rice varieties cultivated in the sample areas, Mahsuri has been the most popular among sample farmers in all the three seasons, both in terms of the number of adopters as well as area allocation. Among three seasons, sali season had the largest number of cultivators of this new variety, i.e., 84.2% of HYV paddy farmers in that season. As per the responses of sample farmers, there are some important factors responsible for the immense popularity of this new variety of rice (Mahsuri). First, this variety is taller than many other new rice varieties. The relatively taller Mahsuri plants are preferred to dwarf plants of other new varieties during sali season so that they can stand high even during excess rainwater filled flooded paddy fields. Second, this variety suits to almost all types of land- sandy, sandy-muddy, alluvial etc. Farmers can cultivate this variety with or without using chemical fertilizers. Farmers can expect some assured yields irrespective of soil types. Other two popular semi-dwarf varieties, which also have gained fairly wide acceptance among sample farmers, are Ranjit and Aijong. These varieties were cultivated during both sali and ashu seasons by sample farmers in both regions. These two varieties are comparatively of little longer duration of maturity than Mahsuri. Plants and stems are also stronger than those of Mahsuri.

(3) Since many years, Assam has a history of cultivation of varieties of fragrance rice, having nice aroma, locally known as *jwosa* or *joha* rice (Dhar, 2002). Traditional jwosa is popularly known as jwosa gwoswom. Nowadays, new varieties of such rice have been made available. Gerempul jwosa and Jaojali jwosa belong to this type of varieties. These varieties were cultivated only during sali season by sample farmers. Allocating about 4% of land, 12% of sali farmers were found cultivating jwosa varieties during the survey period in the combined sample. Output prices of these varieties are the highest in the market among all rice varieties. However, unlike Mahsuri, these jwosa varieties, according to sample farmers, are selective in soil qualities, land types and irrigation facilities or water conditions. So, sample farmers preferred cultivating this rice only during sali season when there was plenty of rain water. Their yield per hectare, in general, is also lower than that of other new varieties even in the best cultivation conditions.

(4) A recent new variety of paddy is Chinari. As per farmers' responses, this variety is very suitable for cultivation during comparatively dry period (like summer and ashu seasons) and on high lands compared to low-lying marshy lands. Chinari cannot tolerate heavy rainfall, but it requires plenty of water supplies. Because of suitable land conditions, this variety has been gaining popularity among farmers in the region 2 and is being cultivated during dry periods. Largest number of farmers in the region 2 was cultivating this variety during summer and ashu seasons. This variety is very responsive to chemical fertilizers and irrigation facilities. The soil types in region 1 are not suitable for Chinari.

Discussion above shows that adoption pattern of HYV paddy varied from wet season (sali season) to comparatively little dry ashu season and very dry summer season even in a single agricultural year. The number of adopters and area allocations in HYV paddy increased as we move from dry summer season to wet sali season. Even among different varieties of HYV paddy, farmers' preferences differed depending on the maturity period, height of plant, quality of grain and responsiveness to soil types or other inputs.

3.5 Adoption of complementary inputs

This section examines the adoption of complementary inputs and facilities to HYV paddy seeds. Among these complementary inputs and facilities, we examine only irrigation, mechanization in ploughing and irrigation, use of chemical fertilizers and pesticides.

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3.5.1 Irrigation water sources for cultivation: All crops

The sources of water for crop cultivation in both the sample regions can be broadly classified into three: (i) rainwater, (ii) the natural flow of river, streams, springs and water of small lakes and low-lying areas and (iii) groundwater. Thus, both sample regions do not have any systematic irrigation system. Canal irrigation is nil. Table 4 shows the source wise irrigated areas under all crops in sample regions. In the combined sample, the largest crop area (about 53%) is served by small dams lifted water. Farmers depend on rainwater for as high as 36% of the crop areas. Borewells and pumpsets irrigation water constitutes 11% of the total irrigated crop areas.

Groundwater is harnessed through privately owned shallow tubewells, dugwells, borewells and pumpsets. Field surveys revealed that the groundwater level is high in both sample regions compared to some other parts of Assam and the rest of the country[3]. Due to less naturally flowing water ways, the groundwater level is deeper in the region 2 than in the region 1 (by about 2 to 3 meters). Generally, for dugwell, it is easy to get groundwater by digging 2 to 4 meters deeper. For borewell and tubewell operations, it is necessary to put water pipe 10 to 13 meters inside the ground. But, for effective discharge of water, some farmers, who are using borewells, put water pipes to even 30 meters inside the ground. River or stream water is harnessed by means of community or collectively-owned lift irrigation system. Water is lifted usually by constructing small dams on

[3] In an article on tubewell drilling in Punjab, Agnihotri (2004) wrote 'The water level was 12 metres in Jattpur village, Balachaur Block, in 1996. It is 20 metres now. Similarly, the level was 14 metres in Takhatgarh village of the same block in 1992. It is 18 metres at present. Hassanpur village, Derabassi block, has a current static water level of 60 metres. It was 36 metres 10 years ago.' ….He quotes of one driller, 'To ensure good water discharge, we have to dig 300 to 375 metres in Derabassi block. Earlier, 120 metres of drilling used to be sufficient.' Likewise, in Rayalaseema and Telengana regions of Andhra Pradesh, a majority of the wells are of 10 to 20 metres depth in 1999-2000 (Reddy, 2003).

naturally flowing water ways. Under this system, water is diverted to cultivation fields through narrow canals or distributor channels. The bounds of canals are made up of soils and, therefore, not pucca. Since water channels may be long, head reach (near dam) farmers get more water than tail end (far from dam) farmers. Water can be lifted to the fields both during the kharif and rabi seasons depending on the availability of water flow. The waterways can have continuous water flow mostly if there is rainfall. But, whenever there is heavy rainfall during kharif season, there may be excess water in the area.

The use of shallow tubewells, borewells and pumpsets or other artificial irrigation methods are also not economical in the sample region 1 because of more sandy soil. Water can stay on the surface only about two or three hours. Some plots can retain water for about one day. So, watering should be done repeatedly, especially for rice cultivation. However, the sample region 2 has soil types most of which are sticky, muddy and yellowish. These soils are naturally more fertile than those in region 1. These sticky soils have a high water retention capacity. Since region 2 has less streams or naturally flowing water ways, many land plots are rainfed. Once irrigated, water stays for three to four days, in some plots up to ten days. So, people are using borewells and pumpsets for irrigation purposes. They are drawing water either from the nearby low lying areas or from underground through borewells. If there is rainfall, farmers have to use less irrigation from artificial methods.

3.5.2 Irrigation water for paddy

Paddy is the dominant crop in both sample regions. For paddy cultivation, farmers in region 1 get water only from rain and small dams. Artificial means of irrigation through borewells and pumpsets are in use only among farmers in region 2. Data in Table 5 show some interesting features about paddy cultivation under different irrigation sources. First, water from small dams provided the highest portion of water needs in paddy cultivation in the whole sample It accounts for 56% of HYV paddy and 78% of TV paddy. Second, artificial irrigation by borewells and pumpsets provided water to 14% of HYV paddy areas. Compared to this figure, sample farmers used very small portion of borewells and pumpsets irrigation (less than 2%) in the cultivation of TV paddy. Third, as high as 29% of the total area under paddy cultivation in the total sample region is still fully rainfed. Variety-wise, HYV paddy was cultivated more under rainfed condition than TV paddy, both in terms of absolute area and relative share. Fourth, region-wise, farmers in region 2 are highly dependent on rainfall for paddy cultivation (in 61% of paddy area) than their counterparts in region 1. In region 1, 93% of HYV paddy area was irrigated, all of it through small dams and 7% area was completely rainfed during the survey period. It must be mentioned that most waterways in sample regions get continuous water flows if there is rainfall. Thus, small dams irrigation also depends on rainfall.

3.5.3 Season-wise irrigation for paddy

Season-wise and variety-wise irrigated areas under both varieties of paddy, HYV and TV, are also shown in Table 5. Rainwater was not available for summer rice during the survey period. The proportion of both varieties of paddy areas getting water from small dams was higher during sali season than during ashu season in region 1. Compared to this, the proportion of both varieties of paddy areas under rainfed condition was more during sali season than during ashu season in region 2. Season-wise, farmers in region 2 had to depend only on borewells and pumpsets to irrigate paddy lands in summer. Farmers in region 2 got the largest proportion of irrigation water from rain during sali season for both HYV and TV. However, irrigation by borewells and pumpsets provided the largest share of irrigation water (74.1%) to farmers in region 2 during ashu season for the cultivation of HYV paddy followed by rainwater.

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Thus, as we move from sali to ashu and summer seasons, the proportion of the use of irrigation water from borewells and pumpsets went up among HYV paddy farmers in region 2 (i.e., from about 15% in sali to 74% in ashu and cent per cent in summer season). On the contrary, the proportion of the rainfed irrigation among paddy farmers increased as we move from summer to ashu and sali seasons in both sample regions. In terms of area allocation, sali season is still the dominant season for paddy growers among three seasons due to available rainwater.

Comparing the seasonal adoption patterns of HYV data with the irrigation data, it can be seen that the presence of systematic irrigation is not a crucial input for the adoption and cultivation of new varieties of paddy in the sample regions. Sample farmers were cultivating modern varieties of paddy even under rainfed condition in about one-third of the paddy area. Systematic canal irrigation facilities are yet not available in the sample regions. But, as we shall see in a section later that the yields of paddy cultivated under unsystematic irrigated conditions of sample regions are lower than yields obtained under systematic irrigated conditions elsewhere in the state and other parts of the country. Seasonal irrigation variations and paddy yield differences can also be found in Goyari (2013).

3.5.4 Mechanization in ploughing and irrigation

In many agricultural states in India and other countries of the world, mechanization of various farm operations (such as ploughing, harvesting, threshing, irrigation, processing etc.) has been considered as one of the important modern strategies for present day agricultural development. In this study also, the field surveys collected data on mechanized farming among sample farmers to know the emergence of mechanization even in remote villages. In the field survey data, some instances of mechanization were found only in (a) ploughing by tractors and power tillers and (b) irrigation equipments such as pumpsets and borewells or tubewells.

It was observed that there was only one big tractor in the whole study area, owned by a farmer in Dhalkata village. Besides using it in ploughing, it was used for various other purposes also such as threshing. There were three power tillers in the whole sample area, two in the sample region 1 and one in the sample region 2. These power tillers were mainly used for ploughing. Tractors and power tillers were also used in other farm operations like carrying crops from the fields to home, threshing etc. Majority of farmers use only the wooden ploughs for tilling their lands. A small fraction of farmers were found using steel ploughs also. There were 42 steel ploughs compared to 275 wooden ploughs in the whole sample area.

Although the ploughing machines like tractors and power tillers owned by sample farmers are few in number within the sample villages, there exist hired services of machine ploughing. For paddy plantation, a plot of land is to be tilled, on average, five times. In the first two times, ploughing is to break the hard soil. Ploughing with bullock-drawn wooden ploughs is in such cases a difficult task. So farmers would like tilling first and second times with tractors or power tillers. Subsequent ploughings can be done with bullocks using wooden or steel ploughs. For this reason, some farmers, who can afford, hire machine-ploughing services. Another reason for adoption of hired machine ploughing is dependence on rainwater. As soon as the rainfall starts during cultivation period, farmers want to till their lands immediately and complete the plantation of paddy as quickly as possible. This happens mainly during kharif season. Ploughing by bullocks and buffaloes is more time consuming, whereas huge plots of land can be tilled with tractors and power tillers in a few days. The information showed that about 10% of total paddy farmers adopted mechanized ploughing in 4.8% of the total acreage under rice cultivation during the study period. Mechanized ploughing is a costly service. So, only rich farmers can adopt it. Thus, majority of farmers rely on bullocks and wooden ploughs, the age old traditional tools of tilling lands.

The field surveys also found the presence of modern irrigation equipments like pumpsets and borewells in the sample villages. There were 29 pumpsets and 13 borewells used for irrigation purposes in paddy cultivation in the combined sample region. Altogether 28 households owned pumpsets and 11 households owned borewells. Thus, only 15% and 6% of paddy cultivators had pumpsets and borewells respectively in the total sample. All the borewells were in the sample region 2. Although 3 pumpsets were there in the sample region 1, no farmer used these for irrigating paddy area during our survey period. Generally dugwells and tubewells were used for drinking water and other domestic purposes and not for rice/other crops cultivation.

Like mechanized ploughing, irrigation through pumpsets and borewells is also a costly service; hence only middle (21 farmers) and high income group farmers (19 farmers) were adopting these services. It may be noted that there also existed the market for hired pumpset irrigation services in the study villages, mainly in villages of region 2. However, like mechanized ploughing, supply of hired services of pumpset and borewell irrigation was not adequate in the study area. Almost all users of pumpsets and borewells were using these equipments for irrigation only during rabi season when there was less rainfall.

3.5.5 Use of chemical fertilizers in paddy

Chemical fertilizers have nowadays been considered as one of the important complementary inputs in the cultivation of HYV paddy seeds. It was observed that 62% of the total paddy cultivators in the combined sample are using chemical fertilizers in paddy cultivation. Comparatively higher proportion (77%) of rice farmers in the region 2 is using chemical fertilizers, compared to 48% in region 1. Across three seasons, summer rice has the lowest number of chemical fertilizer users. The main reason behind this is due to less number of farmers cultivating paddy during summer season. In the combined sample, the highest number of farmers using chemical fertilizers is in the autumn rice followed by winter rice. Region wise, the highest number of fertilizer users is found in winter rice in region 2 and in autumn rice in region 1. Thus, comparison of HYV paddy seed adopters and users of chemical fertilizers shows that the adoption of HYV seeds is more wide spread than the use of chemical fertilizers among the sample farmers.

Intensity of fertilizer use: Table 6 shows that the consumption per hectare of chemical fertilizers in paddy is low (8.4 kg) in the whole sample region taken together. The use of chemical fertilizer was more intensive and wide-spread among farmers in the region 2 than in the region 1. Farmers in region 2 consumed, on average, 18.5 kg/ha. However, the intensity of use in the region 1 was as low as about one kilogram only. Among seasons, significantly higher dose of chemical fertilizer was applied in the summer rice (39.4 kg/ha) in the whole sample followed by the autumn rice. In the region 2 also, per hectare consumption was the highest in summer rice period followed by the autumn rice. However, the absolute quantity of consumption was the lowest during the summer rice period in the whole sample as well as in the two regions.

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The region 1 witnessed very low chemical fertilizer consumption per hectare in all three seasons. It was the lowest in the winter rice (0.9 kg) and the highest (1.9 kg) in the autumn rice. The main reason behind low fertilizer consumption in the winter rice was already mentioned. Cultivation of winter rice starts in June-July. During this period, the rainfall was the highest during 2004-2005 like in any other years. Paddy fields, most of which are low-lying areas, are flooded with excess water. Excess water washes away chemical fertilizers from one plot to other plots. So many farmers do not apply fertilizer in the winter rice even if some farmers can afford to apply it. Most of those who are using, are applying it in their paddy-seedling-plots to grow paddy seedlings taller quickly so that these can be transplanted early and comfortably. Added to excess rainwater problem, most of the lands in the region 1 are sandy to sandy-clayey. From their long years' experience, farmers know that such soils are not suitable for chemical fertilizers. In fact, some farmers reported that their sandy-muddy soils became very hard after applying chemical fertilizers, making them unsuitable for rice cultivation for some years. Although excessive rain water is not so much a problem for cultivation of autumn and summer paddy in the region 1, farmers do not want to apply chemical fertilizers even in the autumn and summer paddy mainly due to sandy type of soils.

Contrary to that, farmers in the region 2 are using more chemical fertilizers in all three seasons. The main motivating factor for using more chemical fertilizers by farmers in the sample region 2 is the good water retention capacity of soil and not much disturbance of excess rainwater during the kharif season. Since the soil quality of this region 2 has good water retention capacity, the use of pumpsets and borewells for irrigation is more economical here compared to the region 1. While farmers get rain water during the cultivation of winter rice, many farmers are using pumpset and borewell irrigation water during summer and autumn rice as rainfall is scanty or almost zero. So farmers can use chemical fertilizers during rabi as well as kharif season.

Thus, while the excess rain water and sandy soil discourage sample farmers from using chemical fertilizers in region 1, controlled irrigation by pumpset and borewell combined with loamy type of soil encourage farmers to use this input in region 2. While there is a fear of fertilizers being washed away to other plots by excess rain water, there is no such fear in case pumpset and borewell irrigation.

Use of fertilizers in HYV and traditional paddy: The field survey data showed the differential use pattern of chemical fertilizers between paddy varieties among sample farmers. In the combined sample, number of paddy farmers using chemical fertilizers was higher (i.e., 63%) than non-users. Moreover, number of farmers using chemical fertilizers in HYV paddy cultivation (62%) was higher than in TV paddy. Variety wise consumption of chemical fertilizers in sample regions is shown in Table 5.24. It is seen that of the total quantity consumed, substantial portion was used in the high yielding varieties of paddy in both sample regions. The absolute quantity of chemical fertilizers consumed in HYV paddy in region 2 was 3894 kg, which was about 98% of the total chemical fertilizer consumption in paddy in that region. In region 1, with 301 kg consumption of chemical fertilizers in HYV paddy, the proportion was about 88%. So, in the combined sample, 97% of the total chemical fertilizers were applied in the high yielding varieties. In absolute quantity, the consumption of chemical fertilizers in both paddy varieties was higher in region 2 than in region 1. In percentage terms, farmers in region 1 used higher proportion of fertilizer in traditional paddy than in region 2.

Due to larger portion consumption in HYV varieties, per hectare consumption in HYV is also found to be higher in both sample regions (see Table 7). Per hectare consumptions in the sample region 2 were higher than that of region 1 in both HYV and traditional varieties by about 18 kg and 4 kg respectively. In the combined sample, all sample farmers together used about 9 kg/ha in HYV and 2 kg/ha in traditional varieties of paddy during the survey period. The intensity of fertilizer use was higher in HYV paddy than in local variety when only actual users were considered, i.e., 20 kg in HYV compared to 8 kg/ha in traditional paddy in the combined sample. The intensity of use was significantly higher in new variety than in local varieties among paired observations (users both in HYV and traditional). Thus, in both types of measurement, the intensity of fertilizer use in paddy by sample farmers was lower than the overall fertilizer intensity of Assam (49.3 kg/ha in all crops) in 2005-06.

[redacted]

It was reported by sample farmers that the yields of new varieties of seeds are more responding to chemical fertilizers than traditional seeds. Inspite of knowing the benefits of use of chemical fertilizers, there are still farmers who cultivate paddy without using chemical fertilizers for several reasons. Important constraints restricting the use of chemical fertilizers reported by sample farmers were lack of credit, unsuitable land, excess rain water and the belief that use of chemical fertilizers destroys the natural fertility of soil.

A particular rice variety requires some soil nutrients while other varieties do not require. During the field surveys, sample farmers were not found to be aware of the need of soil testing for deciding suitability of a particular rice variety or application of chemical fertilizers. Added to this problem, many farmers were unaware about the exact proportions in which different chemical fertilizers are to be applied. Most farmers were using only nitrogen or urea. However, many farmers reported of changing varieties on the same plot every year to regain natural soil fertility.

3.5.6 Use of pesticides/insecticides

The use of pesticides and insecticides among sample farmers was negligible. A farmer usually uses pesticides/insecticides only when his crops have been affected by pests or insects. So long a crop is free from any pest or insect disturbance, he may not use it. Majority of paddy farmers (73%) reported that they were not interested to apply pesticide in paddy. Sample farmers used pesticides more often in rabi crops like potato, tomato and other vegetables. Paddy witnessed the lowest per hectare pesticide consumption among individual crops in the study area. The intensity of use of pesticide was the highest in tomato, followed by potato. It may be mentioned here that farmers applied pesticides in potato and tomato only in HYV varieties. For other crops, farmers applied on both HYV and traditional varieties. The intensities of solid and liquid forms of pesticide use in paddy were respectively 0.606 kg per hectare and 0.267 kilolitres per hectare in the combined sample (data for actual users only).

*HYV versus traditional***:** In Table 8, it was observed that higher percentage (73%) of pesticide users in paddy were in new varieties in the combined sample. This is true in both sample regions.

[redacted]

However, the intensity of pesticide use was comparatively higher in HYV paddy than in TV paddy in the sample location during our field survey (see Table 8). This is true for both liquid and powder forms of pesticide. These differences were statistically significant at 5% level only for liquid form of pesticide. In the combined sample, paddy farmers taken together used 0.77 kg/ha of powder pesticide in HYV paddy, which was higher than that used in TV by about 0.263 kg/ha. Similarly, in case of liquid pesticide use, HYV paddy farmers used 0.27 kilolitres/ha, which was higher marginally higher than that used in the TV paddy in the combined sample.

Thus, field survey data on pesticide use in paddy support many sample farmers' opinions that (a) new paddy varieties are more prone to pests and insects compared to traditional varieties and (b) hence, higher dose of pesticide has to be applied in HYV paddy varieties to protect from pests and insects. The probable reasons behind the use of higher intensity of pesticides in HYV are the following: First, net returns to new varieties are higher than those of traditional varieties. So, farmers give more attention to new these varieties by applying pesticides, fertilizers etc. Secondly, while HYV seeds give higher yields, they are more prone to pests. Being relatively new and non-acclimatized strains, new varieties are more prone to local pests and diseases than well established indigenous varieties. Therefore, farmers need to protect them by applying pesticides.

Thus, although the pesticide use in paddy was negligible in the study area, the intensity was higher in HYV compared to that in local varieties.

Simultaneous use of fertilizer and pesticide: Use of pesticides in paddy was less wide spread compared to chemical fertilizers in the sample regions. While 63% of the paddy farmers were using chemical fertilizers, only 13% of the paddy farmers were using pesticides and insecticides in the whole sample region. The number of sample farmers using simultaneously both fertilizers and pesticide in paddy also very few. Except for one farmer, there is no relation between the use of fertilizer and pesticide in paddy among sample farmers in region 1. That is, those farmers using fertilizers were different from farmers using pesticides in paddy. However, at least some farmers were applying both fertilizers and pesticides in the same plots of land in two villages in region 2. In Dhalkata and Hokradoba, all farmers using pesticide also applied fertilizers. Out of 17 simultaneous users in region 2, only 2 farmers were local paddy cultivators. In the combined sample, thus, only 10% of paddy farmers were simultaneous users of fertilizers and pesticides during our surveys.

3.6 General factors influencing adoption of HYV paddy

This section examines some general factors which affect adoption pattern of all farmers in a region. Some of these factors are duration, yield, irrigation conditions, climatic conditions, price levels, suitability of land etc. Data provided in Table 9 give us summary information on farmers' responses on what motivated them, in terms of general factors, to cultivate HYV paddy in larger areas compared to traditional varieties. We describe below in some detail.

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3.6.1 Short duration: The most attractive feature of HYV seed varieties of paddy is its short period of maturity. Majority of sample farmers (about 98%) found shorter duration of HYV paddy an attractive feature in their decision to plant them. Similar to our finding, in a study of rice farming in Asian villages, Castillo (1975) also found that 'they (new varieties) were adopted because of their shorter growing period and non-photoperiodism'. He writes 'although high yielding capacity is the characteristic most associated with the new varieties, their yields did not exceed those of local varieties in many villages where adoption has taken place'.

Table 10 shows the comparative picture of minimum time duration required for harvesting various new and local traditional varieties of paddy in the sample region. A new variety can be harvested after a minimum of 100 days of planting. However, a traditional variety of paddy, on average, requires about minimum 160 days to become ready for harvesting, taking about two months more than a new variety. Even the longest duration new variety, (say Aijong or Ranjit) matures about one month earlier than the shortest duration traditional variety like Ashu gwoja or Kaowajuri.

Aijong, Ranjit and Mahsuri varieties, which require minimum of about 115 to 125 days time, are of little longer duration among new varieties. The shortest duration varieties among new varieties are Chinari, Maniram, Jumbra, Raj, Sonkos and Vijaya Mahsuri. These varieties can be harvested, on average, minimum of about 100 days after seedling/planting. Rest of the new varieties is of moderate duration. Sandan jwosa variety was not cultivated by any of the sample farmers at the time of field survey.

Among local traditional varieties of paddy, *Baoa* is of the longest duration. It takes minimum of 9 months time to get ready for harvesting. This variety has tall and strong plants. It is generally grown in low-lying and marshy areas which can stand tall even during flood and water logging. It is generally cultivated in *Fagun* month (during February-March) and harvested in *Aghan* month (during

November-December), the time during which winter rice is harvested. Number of farmers cultivating this variety has been declining over the years. Nobody was found cultivating *Baoa* paddy during our field survey time.

Haldharam variety is one of the most standard traditional varieties, which has been in use among farmers since many years. This variety has good quality grain. The most important characteristic of this variety is that pests and insects cannot destroy its harvested fruits easily. Even after harvesting, this paddy can be kept for many years. Some sample farmers reported that they stored Haldharam paddy in their house for as long as 40 years. A limitation of this variety is that it is suitable only for sali season, to be cultivated in low-lying areas and has long maturity period. In recent years, many farmers have stopped cultivating this because it takes a long time to mature. Only two sample farmers were found cultivating this variety during our surveys. Tengrai and Tiamikri also have been in use among sample farmers since many years.

Reported and claimed by sample farmers, one notable feature of traditional paddy varieties is that they are *season-specific*, compared to *all-season cultivable* character of HYVs. Traditional varieties used for sali season are Haldharam, Tiamikri, Tengrai, Losmon, Maibra, Maisali maima, Pulpakri and Sobmoni. These varieties are not suitable for ashu season. This is one of the reasons for which farmers prefer more of new varieties. Famous varieties for ashu season are ashu gwoja, korma guput and korma pakri. These are comparatively shorter duration varieties among traditional varieties. These are preferred during ashu season as the land should be free immediately for sali rice cultivation. Any new variety, e.g., Mahsuri, can be cultivated in any season of the year.

Arrival of new varieties with short duration of maturity has brought many advantages to sample farmers. It became convenient to divide their lands between new varieties (shorter duration) and traditional varieties (longer duration) instead of planting only one variety. Since many new varieties of paddy become ready for harvest about a month ahead of usual local varieties, it gives an early relief to many small and poor farmers for meeting their food requirements. Division of land between new and local varieties has benefits for many big size and rich farmers too. It enables to space the harvesting works to a considerable extent, harvest new varieties first and then later local varieties. Added to it, comparatively early harvesting time releases land in time for cultivating other crops in the next season. In our field survey, it was also reported that farmers used to cultivate paddy only in two seasons – sali (winter) rice and ashu (autumn) rice during one agricultural year. With the arrival of short duration new paddy varieties, summer season has also emerged as one of the crop seasons. It is now possible to cultivate paddy three times in one agricultural year in Assam. Similar evidence was observed in other eastern states like West Bengal (Rawal and Swaminathan 1998; Saha and Swaminathan 1994). Three major rice seasons in West Bengal are aus (May to September), aman (kharif, from June to November) and boro (summer, from March to June). Like in Assam, 'the cultivation of paddy in the summer season is a relatively new phenomenon' (Rawal 1999, p.93). Rawal and Swaminathan (1998) state 'the boro or summer crop was introduced in the 1960s and area cultivated with boro increased rapidly thereafter'. Arrival of new varieties of seeds enabled many farmers in North-Western states of India to have rotation of rice and wheat in a single agricultural year (Castillo 1975, Chand and Haque 1998, Kumar *et al*. 1998, Singh *et al*. 2004). Castillo (1975) writes 'In Uttar Pradesh, it was possible to have a rotation of modern varieties of rice and wheat. The practice of keeping land fallow in the kharif season to grow wheat in the rabi (season) has declined' due to arrival of short duration new seeds and increase in irrigation facilities. Short maturity modern rice varieties sown in kharif season releases quickly land for wheat to be sown on time. Rice-wheat rotation system is still not possible in many plots in Assam. Many rice growing plots in the state are not suitable for wheat.

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3.6.2 Higher yield of HYV paddy per unit of land[4]: Across seasons

With 2821 kg/ha, the overall yield in the summer rice was the highest among three varieties of rice in the combined sample (see Table 6). On the contrary, the yield per hectare of autumn rice was the lowest in the combined sample during our survey period. The overall paddy yield in the combined sample during our survey period 2004-05 was 2509 kg/ha, which was higher than 1467 kg/ha observed for Assam as a whole in 2005-06. In HYV category also, yield was the highest in summer.

Although the yield of summer paddy was the highest, the area allocations and number of plots were the lowest among all the three seasons because many farmers are not cultivating summer paddy due to scarcity of irrigation water. Only two categories of sample farmers were cultivating summer

[4] Several studies exist which show that the yield (kg/ha) of new varieties of paddy is higher than traditional paddy. Some references can be found in Goyari (2008a, p.168).

rice – (i) farmers whose land plots have access to naturally flowing water and (ii) farmers who are having (or who can afford) artificial means of irrigation through borewells and pumpsets. Moreover, only HYV paddy was cultivated during summer.

HYV yield compared to traditional yield: As stated above, many farmers are adopting and allocating larger areas in new varieties of paddy due to significantly higher yields of these varieties. The physical productivity of HYV paddy in the total sample was 2597 kg/ha compared to 1851 kg/ha of traditional variety. Thus, the yield gap between the new and traditional varieties was coming to be as high as 746 kg/ha in the combined sample. The yield gap is observed in both autumn and winter rice also. This yield gap was higher in autumn rice than in winter rice. The yield gap could not be known in summer rice as traditional variety was not cultivated during this season. The yield level varied across seasons in new paddy also. The HYV yield in physical terms of winter rice was higher than that of autumn rice by 49 kg/ha.

Yields of HYV varieties and traditional varieties: Among new varieties, Chinari variety had the highest yield level in physical unit (3396 kg/ha) during the survey period. Next to Chinari variety, Pankaj recorded a very high yield followed by Sonkos, Ranjit, Mahsuri and Aijong. All other varieties had physical yields lower than the overall yield of HYV paddy, i.e., 2597 kg/ha. Jaojali jwosa was at the lowest strata, having lowest physical yield level (1241 kg/ha) among the varieties of HYV paddy in the sample. Looking across seasons, we find that only three varieties (Chinari, Mahsuri and Jumbra) were cultivated during summer season. Yield levels of these three varieties were higher than those of autumn and winter paddy. In both summer and autumn seasons, the yield level of Chinari was the highest among the new varieties. However, Pankaj witnessed the highest yield in winter season. Only two new varieties (Chinari and Mahsuri) were cultivated in all three seasons of a year.

Among traditional varieties, the yield of Maisali maima was the highest in physical unit (2198 kg per hectare) during the survey period. Maibra variety was at the lowest strata, having the lowest yield among traditional varieties. This variety witnessed the physical yield of 1570 kg per hectare, which was 29% lower than the highest yield of Maisali maima. No local variety was cultivated during summer season. One variety was cultivated either in autumn or in winter season, not in both seasons.

Comparing the yield levels of HYV and local varieties of paddy, it was seen that yield variations among traditional varieties are less wide than found among modern varieties. The coefficient of variation (CV) of yields among traditional varieties was only 9.9% compared to 27.1% of yields among modern varieties. Variations in yields among new varieties were more prominent if yields are examined under different irrigation conditions and with/without chemical fertilizers. We examine these below.

Yield of HYV paddy with chemical fertilizers: Yield differences were observed within the new varieties between use and no-use of chemical fertilizers (Table 7). The HYV paddy yield was 2792 kg/ha when chemical fertilizer was applied, compared to 2433 kg/ha without using that input. Between regions, the fertilizer effect on yield was observed to be substantial in HYV paddy yield in region 2. The fertilizer effect on paddy yield in region 1 seems to be very marginal as the yield difference with fertilizer and without fertilizer was not substantial and is not statistically significant. The reasons are as follows. The intensity of overall use of chemical fertilizers was much higher in region 2 than in region 1. Most of the rice farmers in region 1 were using this input in rice seed-beds only to grow rice seedlings quickly. This might be the reason behind less yield difference in region 1.

Yield of paddy under different irrigation conditions: Yields of paddy, for both varieties, in the sample were observed to vary by irrigation conditions (Table 8). The yields of both varieties of paddy were observed to be the highest under irrigation condition of borewells and pumpsets, i.e., 3305 kg/ha for HYV and 2112 kg/ha for TV paddy[5]. However, the yield of HYV paddy was significantly higher than the yield of TV paddy in all three irrigation conditions. The yield of total paddy under rainfed condition (2218 kg/ha) was the lowest among three irrigation conditions. The yield of total paddy under small dams irrigation was lower than the yield under borewells and pumpsets by 488 kg/ha but higher by 580 kg/ha under rainfed condition. This is expected as the water from equipments like borewells and pumpsets is under better human control than the other two conditions. Rainwater depends totally on the vagaries of nature and hence the yield per unit of land can be low.

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'HYV seeds-fertilizers-irrigation' combinations: Studies on the combined input-use technology, like the adoption of HYV paddy seeds along with the application of chemical fertilizers and use of systematic irrigation water, have been attracting the attention of many scholars, more particularly since 1960s when green revolution technology made its appearance in India[5]. Many new varieties of paddy seeds are able to give higher yields than the traditional varieties, especially if the supply of soil nutrients can be increased. So, soils are to be supplied with additional nutrients through application of chemical fertilizers to get better results from HYV seeds. Since chemical fertilizers contain nutrients in concentrated form, they, in turn, have to be applied with adequate supply of water to enable plants to absorb the nutrients without causing damage to them. The use of chemical fertilizers with HYV seeds, thus, necessitates the use of controlled supply of water. Full utilization of potentialities of the new technology requires adequate application of the complementary inputs of fertilizers and irrigation with the HYV seeds (Bezbaruah 1994, p.17).

Substantial yield differences of HYV paddy were observed under different irrigation and fertilizer use conditions in the study areas (Table 9). As already discussed above, yields of HYV paddy with chemical fertilizers were significantly higher than those without chemical fertilizers. Similarly, taken individually, paddy yields under controlled irrigation conditions, say, borewells and

[5] The yield (in kg/ha) of total paddy of this sample (3286) under the borewells and pumpsets irrigation condition was higher than that of all Assam average (1468) and some states like Andhra Pradesh (2939), Haryana (3051 for kharif paddy), West Bengal (2509) and even all India (2103) in 2005-06. However, it was lower than that of Punjab (3858 kg/ha for kharif) in that year.

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pumpsets, were much higher than those under natural water conditions like rainfall. In addition to this finding, data in Table 9 also reveal some interesting results. The yield of HYV paddy under borewells and pumpsets irrigation with chemical fertilizer (3347 kg/ha) was significantly much higher than the yield (2955 kg/ha) when it was not applied. Similar trends were also observed in case of yields of paddy under rainfed and dam water conditions. However, the yield difference (between chemical fertilizer applied and not applied) under borewells and pumpsets was much higher than those under rainfed and dam water conditions. The absolute yield difference was 392 kg/ha under borewells and pumpsets. Compared to this quantity, the yield difference with and without chemical fertilizers was about 213 kg/ha under dam water condition. The yield difference of HYV paddy was only 79 kg/ha under rainfed condition. So, as we move from rainfed to dam water condition and controlled water by borewells and pumpsets, HYV paddy yield increased significantly with the application of fertilizers.

The above results indicate that new varieties of paddy can be cultivated without fertilizers (as many sample farmers were doing), but yields can be enhanced by applying this input. Secondly, new varieties of paddy can be cultivated without any assured irrigation facility. But, yields can be much higher under controlled irrigation condition. Farmers are willing to use artificial means of irrigation but due to high cost, every farmer cannot use it.

Borewells and pumpsets irrigation has not yet been used by sample farmers in region 1. So, irrigation cost was found to be zero in that region. In region 2, irrigation cost was Rs. 127/ha in HYV paddy and Rs. 34/ha in TV paddy. The total irrigation cost accounted for about 4% of the total cultivation cost of paddy in that region. Farmers need not pay any out-of-pocket expenses for utilizing small dam water since it is managed by private individuals or/ and village communities themselves. Whatever costs they incur are in the form of constructing small dams and maintenance of distributor channels. It forms only very negligible part of total cultivation cost.

3.6.3 Higher output prices of HYV: About 73% of the total sample farmers responded saying that they have been cultivating new varieties of paddy because of higher output prices than TV varieties. Output prices of most of the high yielding varieties of paddy have been comparatively higher since their arrival in the market, partly because many consumers like consuming fine grains. A comparative picture of output prices of new varieties and local traditional varieties have been shown in Figure1. These were prices were prevailing during the survey period in the Nalbari local village market centre within the sample region 1. Since prices in both regions do not vary much, prices were collected only from one place.

Data in the Figure 1 show that except for Jwosa gwoswom variety, output prices (per quintal) of all other traditional varieties were lower than those of high yielding varieties of paddy. The output price of Jwosa gwoswom was Rs. 650/quintal, the highest output price among traditional varieties. Next to that, the prevailing output prices of Pulpakri, Baoa and Korma pakri varieties were equal at

Rs. 495/quintal. Ashu gwoja had the lowest output price of Rs. 472.5/quintal among traditional varieties.

Among new varieties of paddy, gerempul jwosa had the highest output price of Rs. 762.50/ quintal, followed by Rs. 750/quintal of Jaojali jwosa. With Rs. 510/quintal, Jumbra variety recorded the lowest output price among new varieties during the survey periods.

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Excluding Gerempul jwosa and Jaojali jwosa, the average output price (calculated) of total HYV paddy was Rs. 523/quintal. Excluding Jwosa gwoswom, the average output price of total traditional paddy was Rs 485/quintal. Thus, on average, output price of traditional paddy was lower than HYV paddy by about Rs. 38/quintal during the survey period in the sample region.

It may be mentioned here that most of the small and marginal poor farmers cultivate paddy for their home consumption. So, higher output prices are not so important for them. Inspite of this, many small and subsistence farmers would like to cultivate as it brings prestige and honour to them that they are cultivating high-priced paddy variety in their lands. Large size farmers and rich farmers are concerned with higher output prices; they cultivate paddy more for commercial purpose after satisfying their family food requirements.

4.Concluding Remarks

This paper examined the seasonal variation of adoption patterns of HYV paddy and complementary inputs in Assam. The main analysis was carried out using the primary field survey data which were collected from seven villages in Udalguri district of north Assam. The study found that paddy cultivation in summer season is a new emerging phenomenon (though still at a low scale), actually facilitated by new HYV technology combined with irrigation. Moreover, the paddy yield obtained under the combination of "HYV seed-chemical fertilizer-borewells and pumpsets irrigation" package was the highest among all water conditions. These findings have important implications for policy actions mainly with respect to irrigation development. The state is still not having adequate irrigation facilities to make the summer season as the main cropping season. All farmers who are willing to cultivate summer paddy are not able to cultivate paddy in their plots. Only those sample farmers were found to be cultivating summer paddy whose land plots have access to naturally flowing water ways and who can afford irrigation by borewells and pumpsets.

Growing importance of summer rice is good for Assam's economy to avoid crop damages by excess rainwater or floods during kharif season. Emphasis on summer paddy cultivation demands development of suitable agricultural infrastructural facilities in the state. The first component of infrastructure which requires attention is the development of irrigation facilities. Inspite of abundant water sources, canal and other types of systematic irrigation facilities are very low in the state. Even though the irrigation potential created in the state has been increasing over the years, the irrigation potential utilization has been declining over the years for various reasons, some of them being the flood problems and lack of efficient water management system. Still many farmers depend on rainwater and naturally flowing water ways.

Thus, for widespread summer paddy cultivation, irrigation development policies in the state should give attention to some of the following points. First, in general, Assam is still having vast potential of developing irrigation facilities based on groundwater through installation of shallow tubewells and borewells. Development of more irrigation facilities based on groundwater will really help farmers, especially to cultivate summer paddy on a larger extent. Given the hydrological conditions of Assam, groundwater-based well irrigation systems are both cheap and within the easy reach of an average farmer. Many studies (like ADR 2002, p.163) also emphasized the development of irrigation in the state through the utilization of the abundant groundwater by installation of shallow tubewells. It is true that large scale development of groundwater-based irrigation systems may lead to new problems like depletion/lowering of water table. Many studies conducted in others parts of India and abroad have revealed this problem. Assam, as a whole, is too early to reach such problem. Added to it, the state, as a whole, generally receives heavy rainfall during kharif season, which acts as a replenishment of the natural water resources of the state. Second, because of the presence of available naturally flowing water ways, small streams and rivers, ponds, lakes, etc., Assam has tremendous potentials of developing small and medium irrigation systems in the form of surface flow irrigation and lift irrigation through construction of small dams and distributor channels. Due to large initial investment and long gestation period involved, large scale irrigation systems based on big dams and large canals have several limitations. Moreover, due to heavy rainfall and frequent floods every year, the possibility of large scale irrigation systems being destroyed and great loss is obvious. Third, the state receives heavy rainfall during kharif season. But, rainwater is wasted due to lack of rainwater harvesting facilities. Therefore, government should make provisions for rainwater storage during wet season, which can be used during dry season. Fourth**,** more emphasis should be given on the fuller utilization of already created irrigation facilities rather than creating new and new additional irrigation potentials. Along with the irrigation development, successful summer paddy cultivation also requires available and accessible complementary inputs like short-duration improved seeds, fertilizers, pesticides, credit etc. Since kharif paddy is still the dominant season for crop cultivation, complete seasonal shifting in favour of summer rice is not possible. Thus, adoption of short and long-term flood control measures is also very much important for agricultural development and environmental protection in the state of Assam.

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