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Farmer innovativeness and hybrid rice diffusion in Bangladesh

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ABSTRACT

Hybrid rice technology was introduced in Bangladesh to meet the seed crisis caused by a devastating flood in the 1998–1999 cropping season. The rate of acceptance of hybrid rice amongst potential growers demonstrated, however, that getting a new idea adopted, even when it has obvious advantages, is challenging. The rate of adoption continues to be limited. In order to have an insight into the diffusion scenario of hybrid rice technology, we conducted the present research to: (i) identify the channel used for the diffusion of hybrid rice; (ii) determine the diffusion pattern of hybrid rice in Bangladesh and characterize rice farmers by their stage of adoption, following Rogers' model; and to (iii) explore the influence of selected characteristics of the rice growers in influencing farmers' innovativeness. A concurrent embedded design using a cross sectional survey was employed. The study was conducted in five regions of Bangladesh. The population of this study consisted of rice growers of the boro season. A multistage stratified random sampling design was employed in selecting the sample of 425 farmers. Data was collected through face–to–face interviews with the sampled farmers using a pre-tested and back translated questionnaire. Data confirm that the most frequently used channel from which farmers first became informed about hybrid rice was TV, followed by dealer, neighboring farmers and Agricultural Extension Office. The diffusion pattern of hybrid rice approaches a normal distribution or S- shaped cumulative distribution as proposed by Rogers. Adopter categories made in this study differ significantly, confirming to diffusion theory and empirical literature. Regression results show that farm size, availability of the promotional efforts, perception of risk in cultivating hybrid rice, and attitude towards hybrid rice was significant predictors of the farmers' innovativeness. The findings of the study might help planners and extension workers to consider refining their working procedure and policy guidelines for accelerating the rate of the adoption of hybrid rice in Bangladesh and beyond.

1. Introduction

Bangladesh is primarily an agrarian economy with high population density where food security remains a major concern. Agriculture plays a great role in the creation of rural employment and generation of income and is therefore considered a lifeline of the Bangladeshi economy. The agricultural sector contributes 22% of Gross Domestic Product (GDP) (BER, 2008 as cited in Ahmed Khan et al., 2013). Rice contributes a significant proportion to the total food grain production and is the mainstay of Bangladesh's agriculture. In the agriculture sector, the crop sub-sector dominates with 14.3% in GDP of which rice itself contributes about 53%. Rice contributes more than 80% to the total food supply. More than 95% of the population consumes rice and it alone provides 76% of calorie and 66% of total protein requirements of daily food intake (Salam et al., 2009 as cited in Awal and Siddique, 2011). As rice is essential for producers and consumers alike, the government of Bangladesh is working to promote rice research and development. They are especially focused on improving rice yields that will allow the country to remain self-sufficient despite the nation's population growth rate of 1.5% per annum (Julfiquar, 2002) by making the sector commercially profitable, technically feasible and environmentally sound (Ahmed Khan et al., 2013).

Even though Bangladesh has achieved significant progress in agriculture, especially with respect to rice production and yields, the demand for rice still outstrips domestic production, and the country remains a net importer of rice (FPMU, 2008 as cited in Ganesh-Kumar et al., 2012). Recent projections indicate that the annual increase in per capita rice demand is in the range of 0.85 to 1.2 kg (Ganesh-Kumar et al., 2012). Alongside population growth at the rate of 1.32% per annum (BER, 2010, as cited in Awal and Siddique, 2011), declines in rice yield growth rates and land pressures from urbanization have left Bangladesh searching for ways of improving rice yields. Among the various options available, hybrid rice technology is the most feasible and readily adoptable, following ample demonstration in China (Nirmala and Suhasini, 2013; Nirmala et al., 2013) and a wide range of studies noting the benefits of the technology including yield increases over conventional open pollinated varieties (OPV), increases in farm incomes, and stabilized grain prices for both urban and rural consumers

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(Spielman et al., 2012). It is also asserted that hybrid rice could play an important role in food security, especially in poor countries in the tropics, where population is soaring and agricultural areas shrinking (Santiaguel and Quipot, 2012). The 'father of hybrid rice', Professor Longping Yuan, has argued that Bangladesh can be self sufficient through the cultivation of hybrid rice (Yuan, 2012). But in practice, only 6% of total agricultural land has been used to cultivate hybrid rice during 2009–10 cropping season (Rashid et al., 2011).

In order to feed the growing population, hybrid rice research and development began in the 1993 at the Bangladesh Rice Research Institute (BRRI), although concerted efforts were not undertaken until 1996 with additional technical support from the International Rice Research Institute (IRRI) and financial support from Bangladesh Agricultural Research Council (BARC) (Julfiquar, 2002; Rashid et al., 2011). It did not receive high priority on the public research agenda until after 2000. In 2001, the government of Bangladesh released their first governmentally developed national hybrid, a variety called BRRI hybrid dhan-1 (Julfiquar, 2002). In 1998–99 widespread floods led to shortfalls in domestic seed supply, leading the National Seed Board (NSB) to allow imports of two hybrid varieties: Alok-6201, a variety from India and Sonar Bangla, a variety from China. It was the private sector that took the lead in the introduction of hybrid rice in Bangladesh without a clear deployment strategy (Hossain et al., 2003).

Getting a new idea adopted, even when it has obvious advantages, is difficult (Rogers, 2003). It is a common experience that the adoption of an apparently useful agricultural technology is slower than predicted, or desired, by extension agents (Röling, 1988). Masangano and Miles (2004) pointed out "when an agricultural program introduces a new agricultural technology, the program must be able to evaluate whether the technology has been adopted. Of equal importance is the need to identify the factors that influence adoption." Hybrid rice is no exception. The success of any technology depends on its dissemination among the potential users, which ultimately is measured by the level of adoption of the technology.

After the release of hybrid varieties in the year of 1999, due to the lack of information flow, and experience with the new varieties, farmers' perception and adoption were limited and slow. In order to prepare programs and courses of action for wider adoption of hybrid rice, it is necessary to have a clear understanding of the diffusion scenario of hybrid rice. To our knowledge, no research has been conducted to understand this situation until now. Hence we conducted the study presented here with the following objectives; (i) to identify the channels used for the diffusion of hybrid rice (ii) to determine the diffusion pattern of hybrid rice in Bangladesh and characterize rice farmers by their stage of adoption, following Rogers' model (2003) and (iii) to explore the influence of selected characteristics of the rice growers in influencing farmers' innovativeness.

1.1. Conceptual framework

Recent studies have attempted to reveal when farmers start using an innovation and what factors influence the adoption lag (D'Emden et al., 2006; Dadi et al., 2004). Diffusion, on the other hand, depicts the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003), or can be interpreted as aggregate adoption such as a percentage of the farming population that adopts new innovations (Poolsawas and Napasintuwong, 2013). Understanding the diffusion of technology and the process of innovation is useful in understanding the dynamics of technological change and how it influences the economy (Feder and O'Mara, 1981; Grilichs, 1957; Zhang et al., 2002). The diffusion of an innovation depends on the rate of adoption, i.e., the speed at which an innovation is adopted by potential users. An S-shaped rate of adoption implies that the diffusion of the innovation follows a normal, bell-shaped frequency curve or an S-shaped cumulative curve when plotted over time. The study of hybrid seed corn diffusion by Grilichs (1957) was perhaps the first evidence of an S-shaped diffusion pattern in agricultural technology (Poolsawas and Napasintuwong, 2013). Based on their innovativeness, adopters may be categorized by the rate of individual adoption, i.e., whether to adopt and when to adopt. Rogers (2003) divided adopters based on the adoption lag determined by their innovativeness into five categories: innovators, early adopters, early majority, late majority, and laggards. Innovators are the first to adopt an innovation. Their interest in new innovations leads them to play an important role in the diffusion process by launching a new technology into the system. Innovators are expected to cope with a high level of risks and be willing to accept occasional setbacks when a new technology proves unsuccessful. Early adopters have the highest degree of opinion leadership. They help trigger the critical mass when adopting an innovation. By being respected by their peers and representing the embodiment of the successful use of innovations, they decrease uncertainties and demonstrate approval of the innovation by adopting it. Early majority represents those who adopt new innovations before the average member. Their innovation decision period takes longer than the previous two groups, and they generally follow consciously but rarely lead. The late majority adopts new ideas after the average member of a social system. Adoption for them could be both an economic necessity and the result of increasing peer pressure. Their relatively scarce resources make them feel safe when adopting after most uncertainties have been removed. The laggards are those whose decisions are frequently made in terms of what has been done in the past. Their resistance to innovations is justified by having limited resources, such that adoption will not take place unless they are certain that the innovation will not fail. Presuming a normal distribution of the adoption rate, two statistics, the mean ($\bar{x}$) and standard deviation (sd), are used to divide adopters based on their innovativeness (year of adoption) into five categories (Rogers, 2003). From Fig. 1, about one-third of adopters are the early majority and another one-third is the late majority, while less than 3% are innovators. It is worth noting that this system of classification typically requires complete adoption, which is not the case of hybrid rice in Bangladesh. The fivefold classification scheme for this study is therefore not exhaustive.

2. Research methods

2.1. Research site

The land use pattern of Bangladesh is influenced by agro ecology, soil physiographic and climatic factors (BBS, 2011). Considering the variations of all these factors the total land area of Bangladesh has been classified into 9 regions of which at least five have been approved through the gazette notification of the Bangladesh Government for evaluation and registration of every single variety of hybrid rice (GoB, 2003). Therefore five regions were taken into account for this study in order to select the sample (Fig. 2).

2.2. Sampling design

A concurrent embedded design using a cross sectional survey was employed (Creswell, 2009). The population of this study consisted of rice growers of the boro season who were responsible for farming decisions. A multistage stratified random sampling design as proposed by Babbie (1990) was employed in selecting the sample. In order to maintain the level of precision (sampling error) at (± 5) percent, the level of confidence at 95% and the degree of variability at 50%, 425 farmers were selected following sample size recommendations as proposed by Israel (2009); Dillman (2007) and Corbetta (2003). Farmers in two categories were sampled: namely, non-adopters (79) and adopters (346) of hybrid rice. In this paper, non-adopters are not discussed.

Data were collected through face–to–face interviews with the sampled farmers using a pre-tested and back translated questionnaire. Through prior consultation, we designed an eight-page questionnaire comprising 183 items in a series of 21 questions sequencing from

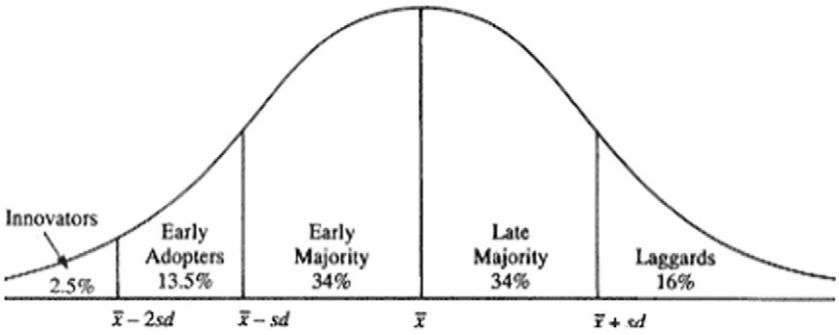

Fig. 1. Adopter categorization on the basis of innovativeness From Diffusion of Innovations (5th Ed.) (p. 281), by E.M. Rogers, 2003, New York: Free Press. Attributes of Innovation and Farmer's Innovativeness.

general to specific. The questionnaire was formatted with both open and closed question items to obtain both quantitative and qualitative data. For data collection the primary investigator spent 120 working days traveling to different places of the selected research sites between March 2 and June 30, 2012.

2.3. Measurement of innovativeness and adopter categorization

Innovativeness was measured following the procedure proposed by Muneer and Mohamed (2003), measuring the time (in years) that the farmer took to adopt the innovation (initiated cultivating hybrid rice). Each farmer was given a score according to the time he or she had taken to adopt since 2001; the first year of cultivating hybrid rice. The adoption period considered for this study was 2001–2011, where 2011 *boro* season is the year of data collection. Therefore, a scale of 11 was used. The farmers who adopted in 2001 were given a score of 11 (the most innovative) while those adopted in 2011 were given a score of 1 (the least innovative). It ranges from 1 to 11.

The hybrid rice adopters were classified into five categories using the mean ($\bar{X}$) and standard deviation (SD) of the initial year of adoption of the growers as the diffusion pattern approaches a normal distribution (S-shaped cumulative distribution) shown in Fig. 5. Based on the frequency distribution of the adopters it was gauged that the mean year of adoption was 2007 and standard deviation was 1.76. Using this it was found that the area lying to the left of the mean time of adoption minus two standard deviations ($\bar{X}$-2SD) covers the year 2001–2004 for innovators. The following group of individuals fell into the area between the mean minus one standard deviation ($\bar{X}$-SD) and the mean minus two standard deviations ($\bar{X}$-2SD) were called early adopters who adopted hybrid rice during 2005–2006. The next group of the adopters, the early majority, adopted hybrid rice in 2007 and are included in the area between the mean time of adoption ($\bar{X}$) and the mean minus one standard deviation ($\bar{X}$-SD). Between the area of mean ($\bar{X}$) and the mean plus one standard deviation ($\bar{X}$-SD) the late majority, who adopted hybrid rice between 2008 and 2009. The last group to the right of the mean plus one standard deviation ($\bar{X}+$SD) are laggards, having adopted hybrid rice during 2010–2011.

2.4. Statistical analysis

We reviewed each survey instrument for missing information (name of block, upazila and district), ineligible writing, and incomplete sentences and responses. Based on the outputs of the questionnaire survey, various statistical analyses were performed, including analyses of frequencies, percentage, range of scores, means, and standard deviations of the variables. In order to compare the groups of adopters, ANOVA was conducted. In order to find the significant impact of predictors on the innovativeness, a regression analysis was also performed. Five percent (0.05) and 10% (0.10) level of probability with an accompanying 95% confidence level was used as a basis for rejecting the null hypotheses.

3. Research findings

3.1. Communication channels used for the diffusion of hybrid rice

The essence of the diffusion process is the information exchange through which one individual communicates a new idea to one or several others. At its most elementary form, Rogers (2003) explained the process identifying the elements as (i) an innovation — in this study it is hybrid rice, (ii) an individual or other unit of adoption that has knowledge of, or has experience using the innovation — practicing farmers, (iii) another individual or other unit that does not yet have knowledge of, or experience with the innovation — potential farmers and (iv) a communication channel connecting the two units. It is therefore important to recognize the channels and intensify their use for prompting the diffusion of hybrid rice technology. Realizing this fact, the researchers identified and plotted the channels from which farmers first became informed about hybrid rice in Fig. 3.

Farmers learn about hybrid rice from a wide variety of sources and channels. The highest number of respondents (31%) first learned about hybrid rice and became interested in it through television (TV). Television is one of the most popular mass mediums in Bangladesh, especially for the poor and illiterate farmers. Even in rural Bangladesh farmers who do not have a TV of their own still often have access in neighbors' premises. In order to motivate farmers, respective seed companies organized telecasting advertisements showing the relative advantage of hybrid rice over the conventional inbreeds. Watching TV farmers became aware of hybrid rice. In addition, some specific channels televise agricultural programs on a routine basis. For instance, Bangladesh TV (BTV) telecasted three agricultural program everyday, "*Krishi Samachar*", at 6:25 am "*Sonali Fashal*" at 6:05 pm and "*Desh Amar and Mati Amar*" at 7:05.

At the non-government level, Channel 'I' also aired the program "*Ritheya mati and manush*" on every Thursday at 11.05 am and every Saturday on 9:35 pm. In addition, Channel 'I' also broadcast agricultural news (*Krishi sangbad*) every day at 5:15 pm. In addition to news items, occasionally field based live programs on hybrid rice are shown through those programs.

Dealers are the second highest category of diffusion sources regarding hybrid rice. About 24% of farmers first learned about hybrid rice through face-to-face interaction with dealers. Primarily dealers are the agents of seed companies assigned to selling seeds. While selling seeds and or other agricultural inputs viz., fertilizers, pesticides, they often interact with individual farmers in an effort to motivate them about a specific variety of hybrid rice to be brought under cultivation. In addition, they often assert the superiority of respective hybrid varieties in the populous places (e.g. markets) for building awareness.

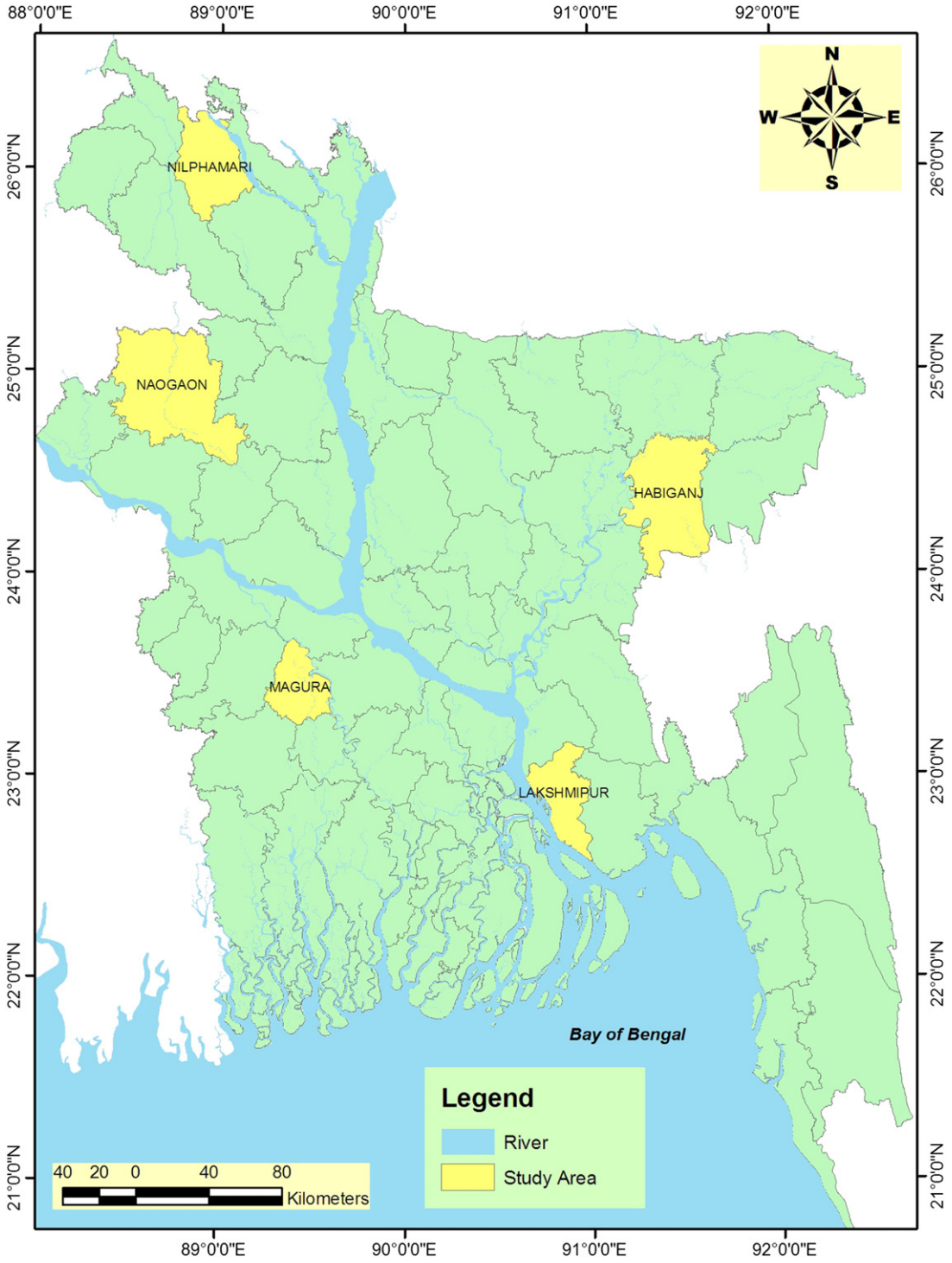

Fig. 2. Map of Bangladesh showing selected districts under study.

Farmers in the neighborhood form the third most important source in the diffusion of hybrid rice. About one sixth of the farmers (16.7%) first learned about hybrid rice from the neighboring farmers through day-to-day interaction at their leisurely gathering places or at household premises (Fig. 3). In addition they share information at their work places, the dealer's shop, and tea stalls. The neighboring farmers are mostly from the same village but a few may be from neighboring villages and even from neighboring districts. In order to accept a new idea, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from individuals like themselves who have already adopted the innovation (Rogers, 2003).

Farmers (7.3%) also learned first about hybrid rice directly from the Upazila (sub district) Agricultural Extension Office (Fig. 3). The department of Agricultural Extension often organizes training for the farmers at the upazila level in an attempt to develop their farm operation skills. Farmers learned about hybrid rice through discussion with the Department of Agricultural Extension (DAE) office staff (Upazila Agriculture Officer, Additional Agriculture Officer, Agriculture Extension Officer and Sub-Assistant Agriculture Officer) by participating in training programs. In addition, progressive farmers go to the upazila agricultural office to meet their extension needs.

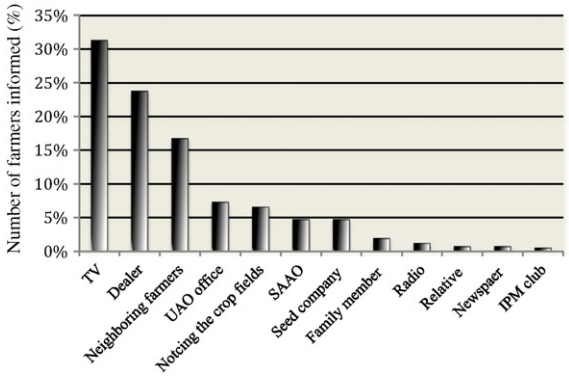

Fig. 3. Sources and channels by which respondents first learn about hybrid rice.

A small group of farmers (6.6%) first learned about hybrid rice directly by noticing the crop field. Indeed, the spectacular view of hybrid rice attracts passers-by and provokes their curiosity to know more about it. They question the owner and get acquainted with the crop variety. Sighting the crop field and being encouraged to learn about hybrid rice is not only the case of intra-village inhabitants, it also happens to the residents of other villages and other upazilas and even other districts. Nevertheless the most common occurrence is within the same territory.

Some farmers (4.7%) got to know first about hybrid rice directly from the seed company. Although every company distributes dealerships to sell their seeds, the company itself occasionally organizes training for hybrid rice growers at the grassroots level. In addition, they frequently put up posters in populous places to build awareness among the farmers. At the same time, 4.7% of farmers became conversant with hybrid rice by coming in direct contact with the Sub-Assistant Agriculture Officer (SAAO). The SAAO is a grassroots level worker of the DAE designated as sub assistant agricultural officer who is responsible for identifying farmers' problems and needs using a farmers' information needs assessment (DAE, 1999). Although Agricultural Extension Offices and SAAOs are directly used by a minority of farmers, they play a passive influence in the diffusion process. The larger farmers with more financial resources that seek their advice may be used as a primary sources for less progressive neighboring farmers. As they are reliable, messages from them may have much more acceptance among the potential users. Despite the insignificant visible impact, these channels may be more important for innovation diffusion than at first appears.

A negligible proportion of the farmers first became informed about hybrid rice from other family members (1.9%), radio (1.2%), relatives (0.7%), newspaper (0.7%) and from Integrated Pest Management (IPM) club (0.5%).

3.2. Diffusion of hybrid rice

Farmers were not aware of the performance of hybrid rice till 1999 boro season (spanning 1999–2000), the year of introduction (Hossain et al., 2003). Until 2002 its adoption was sporadic and covered only 0.2% all area under rice cultivation (Spielman et al., 2012). However, for this study the year of initiation of cultivating hybrid rice has been considered 2001 *boro* season. Using the frequency of adopters and their respective year of adoption, the diffusion curve and cumulative diffusion are presented in Figs. 4 and 5, respectively. (See Fig. 6.)

Fig. 4 clearly indicates that early in the diffusion process – up to 2004 – only a few individuals (6 individuals out of 346 in this study) adopted hybrid rice because of the limitation of actual information flow on rice hybrid technology to the farmers and constraints in the supply seed availability (Harun-Ar-Rashid, 2004). At the same time, negative positions by some public sector extensionists, researchers and to some extent policy markers initially hampered the diffusion processes of hybrid rice (Harun-Ar-Rashid et al., 2011). Gradually, however, the rate of adoption sped up in 2005 with adoption by 16 individuals and escalated in 2009 boro season with adoption by 295 individuals probably due to the introduction of effective extension approaches and appropriate uptake pathways offering massive campaigns using television, and mike in populous places by private seed companies and NGOs. The rate of new adopters started decreasing in 2010 (with adoption by 43 individuals) and reached at the bottom in 2011 with adoption of 8 individuals as the numbers of potential adopters were found reducing over time by the impediment of higher production cost, excessive requirement for agrochemicals, witnessing crop loss with hybrid rice in neighbors' fields, unsuitable for consumption, and lower market price (Shah et al., 2014).

The active participation of the private sector and NGOs in the hybrid rice seed sector and Government's liberal policy on seed imports from other countries were key factors in the increased diffusion of hybrid rice in Bangladesh (Hossain et al., 2003). Fig. 5 shows the cumulative number of adopters of hybrid rice approaching a S-shaped curve over time with a slight variation from normality. Rogers (2003) postulated that the S- shaped adopter distribution rises slowly at first, then accelerates smoothly to a maximum when it reaches a critical mass point, known as the 'take-off' period and then increases at a slower rate until the saturation point (the maximum level of adoption) is reached. In this study 'take-off' period is found between 2005 and 2006 boro seasons. In the early days hybrid rice technology seemed excessively complicated and expensive to the farmers. Farmers moved slowly from non-hybrids to hybrids in Bangladesh over this four-year period. It gained momentum in 2005 boro season. The yield performance of hybrid rice has been stabilized over the years and exceeded farmers' expectation due to the availability of quality seed and the experiences farmers' gained over the years. In addition to yield some other key

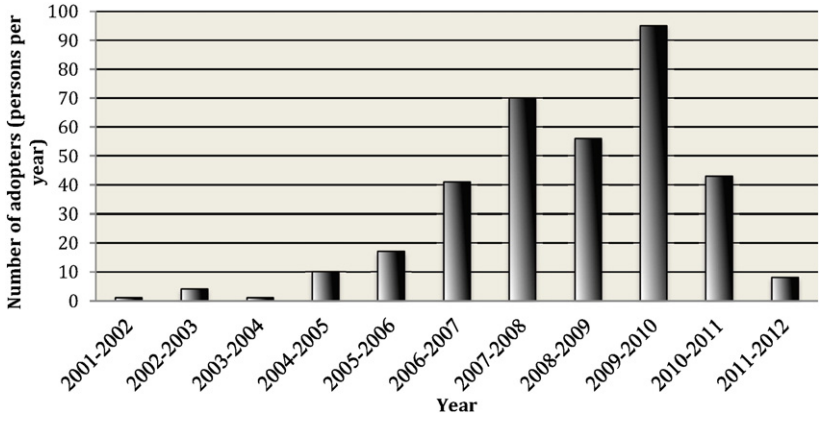

Fig. 4. Diffusion of hybrid rice over time.

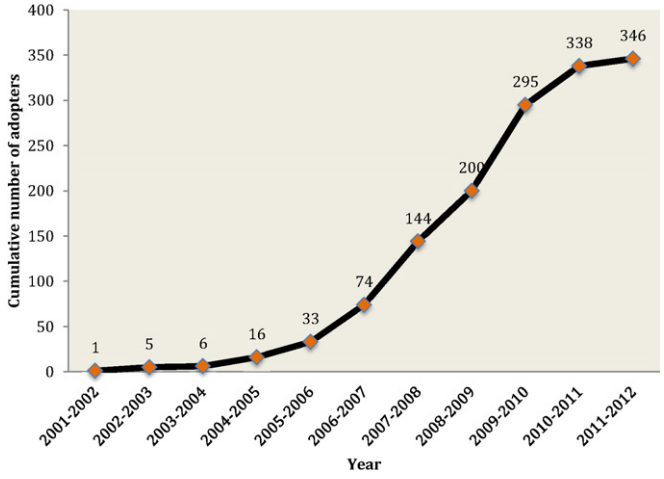

Fig. 5. Cumulative distribution of hybrid rice adoption.

factors that triggering accelerating adoption rate were resistance to lodging and field duration of hybrid rice as compared with conventional inbred (Shah et al., 2014).

However the diffusion curve obtained in this study represented Rogers' model with a couple of variations. Firstly, it makes a deviation from a gradual increment by reducing 14 (20%) new adopters in 2008 boro season as compared to the previous season 2007 (Fig. 4). Secondly, it decreases from the highest point of adoption by 95 individuals (28% of the adopters) in 2009 to 43 (12% of the adopters) individuals in 2010 and then 8 individuals (2% of the adopters) in 2011, an abrupt rather than gradual decrease. The difference from the standard S-shape diffusion curve might be explained by uncertainty about the technical efficiency of an innovation (Sneddon et al., 2011). Field performances of hybrid rice technology dependents on climatic condition and therefore vary from season to season. In some seasons it has shown outstanding field performance; in others disaster (A. Auwal, N. Amin, Abdur Rab, DAE, Pers. Comm.). Such variability in the field performances makes its profitability uncertain and put farmers at risk. The adoption status of hybrid rice therefore remains unstable especially among the subsistent and semi-subsistent farmers.

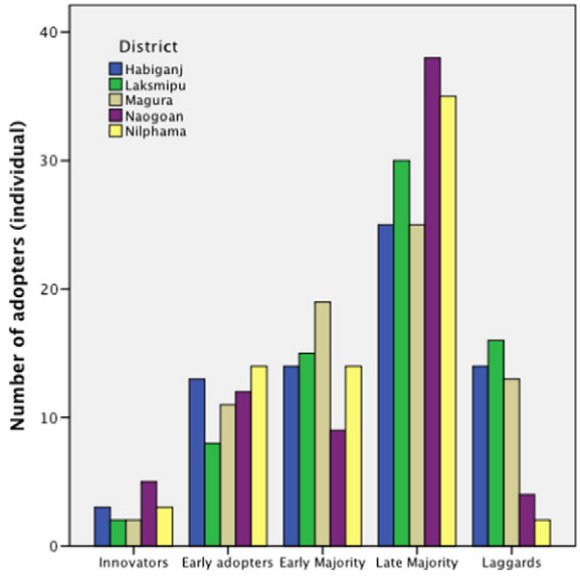

Fig. 6. Adopter categorization on the basis of innovativeness regarding hybrid rice.

3.3. Innovativeness and adopter categorization of hybrid rice

All individuals in a social system do not adopt an innovation at the same time. Rather they adopt in an order time sequence, and they may be classified into adopter categories on the basis of when they first began using a new idea (Ray, 1999). In case of adopting hybrid rice, the farmers of Bangladesh are no exception. The adopters are herein categorized based on the innovativeness as put forwarded in Rogers' model (2003). He reported innovativeness as the bottom line behavior in the diffusion process. It is referred to the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system (Rogers, 2003). In order to categorize farmers, innovativeness has been measured as the year in which each farmer first adopted hybrid rice (Parra-Lopez et al., 2007; Rogers, 2004; Sarker et al., 2005; Ahmed Khan et al., 2013; Poolsawas and Napasintuwong, 2013).

Data presented in Table 1 show the number and percentage of farmers who adopted hybrid rice by category. Table 2 and Fig. 6 show district wise categorization of of farmers with regard to hybrid rice. From the Tables 1 and 2 it can be seen that in the first four years after hybrid rice became available, the innovators comprised about 4.3% of all eventual adopters, which is greater than normal diffusion (2.5%) but this is similar to the findings of Ahmed Khan et al. (2013). They obtained 5% in this category for the adoption of *Binasail* rice in Bangladesh. Within the category of this study, the diffusion rate is much higher (7.4%) in Naogoan district while the same is close to the ideal type (2.5%) in Laksmipur and Magura district.

Early adopters accounted for about 16.8% as a whole, which is greater than normal diffusion (13.5%) in this category. This implies that the diffusion of hybrid rice is relatively faster than typical technology. After observing the tremendous performance of hybrid rice with innovators, neighboring farmers from all five districts were largely motivated and adopted hybrid rice. This finding supports the findings of Poolsawas and Napasintuwong (2013) in case of hybrid maize in Thailand and Sarker et al. (2005) in the case of organic farming in Bangladesh. It is also found that the much higher rate of adoption is evident in Nilphamari district (20.6%), while the lower rate is found in Laksmipur (11.3%).

The early majority account for 20.5% of all adopters, which is much lower than the category of ideal type (34%) in this category. This implies that the rate of adoption sharply declined. Two primary factors are responsible for such a fall: much damage through severe insect infestation that resulted in formation of unfilled grain and unprofitability because of lower market price. Higher number of farmers belonged to this category is found in Magura (27.1%) in contrast to 13.2% found in Naogoan district.

The number of farmers belonging to the late majority (44.2%) was quite high and surpassed the amount of ideal type category (34%). They begun cultivating hybrid rice in 2008 and continued up to 2009. By the year 2008, 53 (2 by public sector and 51 by the private sector) hybrid varieties were released (Janaiah and Xie, 2010), which offered farmers a better opportunity to cultivate the right variety or at least they attempt to trial the varietal performance for future decision making. Such a massive involvement accelerates the rate of adopters. Also in this category, the highest number of farmers is found in Naogoan

Table 1
Categorization of hybrid rice adopters.

Adopter Category	Year	Number of farmers	Percentage of farmers
Innovators	2001–2004	15	4.3
Early adopters	2005–2006	58	16.8
Early majority	2007	71	20.5
Late majority	2008–2009	153	44.2
Laggards	2010–2011	49	14.2

Table 2
District wise categorization of hybrid rice adopters.

Category	Selected district					Total
	Habiganj	Laksmipur	Magura	Naogoan	Nilphamari	
Innovators	3	2	2	5	3	15
(2001–2004)	(4.3)	(2.8)	(2.9)	(7.4)	(4.4)	(4.3)
Early adopters	13	8	11	12	14	58
(2005–2006)	(18.8)	(11.3)	(15.7)	(17.6)	(20.6)	(16.8)
Early majority	14	15	19	9	14	71
(2007)	(20.3)	(21.1)	(27.1)	(13.2)	(20.6)	(20.5)
Late majority	25	30	25	38	35	153
(2008–2009)	(36.2)	(42.3)	(35.7)	(55.9)	(51.5)	(44.2)
Laggards	14	16	13	4	2	49
(2010–2011)	(20.3)	(22.5)	(18.6)	(5.9)	(2.9)	(14.2)
Total	69	71	70	68	68	346
	(100)	(100)	(100)	(100)	(100)	(100)

Figures in parentheses indicate percentage of the respondents.

district (55.9%) while the lowest number is found in Magura district (35.7%).

The laggards who had initiated cultivating hybrid rice from 2010 onward were found to 14.2% in total, which is slightly lower than normal diffusion (16%) in this category. This finding is consistent with the findings of Ahmed Khan et al. (2013); Sarker et al. (2005). Although the greater number is found in Laksmipur district (22.5%), the same has sharply reduced in Naogoan (5.9%) and Nilphamari (2.9%).

Adopter classification based on the mean and standard deviation typically requires complete adoption of a particular technology. However, because hybrids rice diffusion remains an ongoing process, the farmers identified as laggards here in this study might be considered in a future study as late majority or even early adopters.

3.4. Socioeconomic status of hybrid rice adopters

In order to differentiate the categories of farmers with respect to the selective independent variables, analysis of variance (ANOVA) was conducted. In regard to this findings are presented in Table 3.

Table 3 shows the mean (M) and standard deviation (SD) of socioeconomic, personality and variables by category. ANOVA-tests revealed that adopter categories differed significantly by education, farm size, total annual income, training received, membership in social organization, communication exposure, availability of promotional efforts, risk perception and attitude towards hybrid rice. Although hybrid rice cultivation does not require greater skill, nor is it a complex technology, its production technology is partially different from conventional inbreed. This is why it is worthwhile to go through leaflets or any other printed materials to be acquainted with production technology as provided by the respective seed company within the seed pack. Hence the farmers who are educated are probably advanced in adopting hybrid rice. Farm size is another important socioeconomic factor affecting the adoption of new agricultural technologies.

As hypothesized, it is possible that smaller farmers have fewer financial assets and less leverage; thus, the higher price of hybrid rice seeds compared with seeds of conventional rice is slowing them from hybrid technology adoption. In addition, small farmers may be more attached to traditional cultures and local varieties, and are less willing to adopt new technology (Poolsawas and Napasintuwong, 2013). There is also

Table 3
Socioeconomic status of hybrid rice adopters, by category.

Variables (units)	Type of variable		Adopters' category					Total sample	F statistics
			Innovators	Early adopters	Early majority	Late majority	Laggards		
Age	Continuous	$\bar{X}$	45.2	46.02	45.08	45.87	42.71	45.26	.735 ^{NS}
(number of years)		SD	9.21	12.80	10.69	11.88	12.52	11.79	
Education	Continuous	$\bar{X}$	9.73	7.6	7.87	6.76	6.9	7.28	2.184*
(years of schooling)		SD	3.82	4.06	4.28	4.56	4.58	4.43	
Family size	Continuous	$\bar{X}$	5.67	6.41	6.55	6.03	6.69	6.28	.764 ^{NS}
(number of persons)		SD	2.637	3.05	3.84	2.58	3.80	3.13	
Farm size	Continuous	$\bar{X}$	6.98	5.14	5.10	3.35	2.87	4.10	3.95**
(Ha)		SD	6.81	4.60	8.28	3.65	2.60	5.22	
Total annual income	Continuous	$\bar{X}$	6.63	5.30	5.13	4.49	4.24	4.82	2.088*
('000 USD)		SD	2.95	3.65	3.82	3.45	3.06	3.52	
Training received (0/1, 0 for no, 1 for yes)	Dummy	$\bar{X}$	0.87	0.59	0.56	0.56	0.39	0.55	2.976**
		SD	0.35	0.50	0.50	0.50	0.49	0.50	
Membership in social organization (0/1, 0 for no, 1 for yes)	Dummy	$\bar{X}$	1.00	0.81	0.73	0.66	0.63	0.71	3.177**
		SD	0.00	0.40	0.45	0.48	0.49	0.45	
Communication exposure (composite scale score)	Continuous	$\bar{X}$	36.13	33.36	31.92	31.09	29.98	31.7	2.011*
		SD	8.87	8.60	8.65	9.34	9.32	9.11	
Availability of promotional effort (composite scale score)	Continuous	$\bar{X}$	27.13	27.16	26.38	26.18	25.88	26.38	3.707*
		SD	1.407	1.881	1.967	2.065	2.412	2.078	
Risk perception	Continuous	$\bar{X}$	21.33	21.62	20.82	20.86	19.78	20.84	1.993*
(composite scale score)		SD	2.63	3.33	3.27	3.29	4.39	3.47	
Attitude towards hybrid rice	Continuous	$\bar{X}$	48.2	49.83	50.41	47.92	47.96	48.77	2.093*
(composite scale score)		SD	8.32	6.38	7.06	6.85	7.20	6.98	

Note: ^{NS} = indicates non significant ($p > 0.1$).
* Significant at the 10% level ($0.05 < p < 0.1$).
** Significant at the 5% level ($0.01 < p < 0.05$),

a significant difference among the adopters in regards to annual income. Likewise the farm size, farmers with higher annual income may adopt hybrid rice varieties earlier than those with smaller income. Being involved in training, social organization and contact with communication sources and channels, farmers become more informed and updated about hybrid rice technology and its cultivation procedure. The extent of their participation and contact thus influences farmers' adoption behavior. Farmers availing themselves of promotional efforts such as posters, educational materials (leaflets), demonstration plots, or subsidies on inputs become prompted to cultivate hybrid rice. Risks in cultivating hybrid rice seriously influence the speed of adoption. Farmers move forward to adopt hybrid rice based on their farm size and income (Shah, 2015). All farmers naturally do not have the same predisposition about hybrid rice: possessing favorable attitudes accelerate the rate of adoption while unfavorable attitudes tend to linger.

3.5. Determinants of farmers' innovativeness adopting hybrid rice

The effect of the social system's characteristics on the hybrid rice's adoption becomes clear when the factors affecting the household's innovativeness regarding its adoption were examined. A multiple linear regression analysis was therefore conducted to predict farmers' innovativeness for 346 respondents using age, education of the respondent, family size, farm size (ha), total annual income (USD), membership in social organization, training experience, communication exposure, assessment of current promotional effort, risk perception, and attitude towards hybrid rice as predictors. The model is statistically significant ($F(12,333) = 4.446$, $P < 0.001$). The output analysis of the model is outlined in Table 4. The Table indicates that farm size (ha), assessment of current promotional activities, risk perception in cultivating hybrid rice and attitude towards hybrid rice significantly affect farmers' innovativeness in adopting hybrid rice. The model also tests multicollinearity maintaining the threshold of 0.5 and confirms that multicollinearity is missing among variables as the model shows high tolerance and low Variance Inflation Factor (shown in Table 5 in Appendix A).

One of the factors that influenced farmers' innovativeness is farm size. It has a significant effect at 0.05 level. Farmers with larger farms are more innovative than those with smaller farms. This finding reflects the real condition of the potential adopters in the study area. Hybrid rice is not only an expensive technology but it also is at risk of crop loss due to its vulnerability to biotic stresses such as insect attacks and disease infestations, and abiotic stresses, mainly hail storms and flash floods. This situation discourages marginal and small farmers from rapid adoption of hybrid rice. Itharat (1980) (cited in Guerin and Guerin, 1994) proposed that farmers who have a larger amount of land used for agricultural production are more innovative. Availability of current promotional activities is also found to have significant positive impact (at 0.05 level) on farmer's innovativeness regarding the adoption of hybrid rice. Farmers having higher access to promotional efforts are more innovative. The most important factor that influenced farmer's innovativeness is the perception of risk in cultivating hybrid rice. It is the only factor that has a significant effect at 0.01 level. Agriculture nearly always involves a considerable degree of risk, and this may assume major dimensions when a new practice is being contemplated (Hawkins et al. 1982 as cited in Guerin and Guerin, 1994). Ongaro (1988) cited in Guerin and Guerin (1994) also confirmed that a perception of risk leading to a farmer's uncertainty is an important factor in the prompt adoption of new technology. Finally it is also found that attitude of the farmers towards hybrid rice has significant impact (at 0.05% level) on the innovativeness of farmers regarding quick adoption of hybrid rice. A farmer's attitude to change is one of the main catalysts for the adoption of an innovation (Chamala, 1987). He further clarified negative attitudes isolate the individual from information that is considered inconsistent with beliefs, values, and needs. Conversely, positive attitudes prompt an individual to seek new ideas and information. The coefficient of determination was 0.13, which means that the regression model used is capable of explaining 13% of variation in the farmers' innovativeness regarding adoption of hybrid rice. The similar coefficient (R square = 12.3) was also reported by Napier and Bridges (2003) in explaining the impact of gross farm income in the conservation adoption index. As the coefficient is only 0.3, there are some other factors, which accounted for the influence of farmers' innovativeness.

4. Conclusions and implications

The analysis of survey data in five districts of Bangladesh reveals that all the sources and channels do not seem equally effective for conveying the message of hybrid rice. The first ranked channel was TV (31%) followed by dealer (24%), neighboring farmers (17%), Agricultural Extension Office (7.3%), noticing the crop field (6.6%), seed companies (4.7%), and radio (1.2%). The use of TV would be more efficient for rapid and wider circulation of new varieties. Dealers might also be a good platform for spreading information about new technology. Seed companies and other varietal sources like BRRI take advantages of this platform by developing their communication skill through organizing training program with the cooperation of Upazila DAE Office.

The diffusion pattern of hybrid rice approaches a normal distribution or S- shaped cumulative distribution. Based on the mean and standard deviation, adopters were categorized into five categories: innovators, early adopters, early majority, late majority, and laggards. Significant difference is found among the categories in terms of education, farm size, total annual income, training received, membership in social organization, communication exposure, availability of promotional efforts, risk perception and attitude towards hybrid rice. These characteristics of adopter categories should be considered to target farmers for

Table 4
Effect of independent variables on the growers' innovativeness regarding hybrid rice.

Dependent variable	Independent variable	Regression Coefficient (b)	t-ratio
Farmers' innovativeness	Age	0.066	1.199
	Educational qualification	0.130	0.208
	Family size (persons)	−0.088	−1.591
	Farm size (ha)	0.146*	2.388
	Annual family income ('000 USD)	0.096	1.477
	Training experience	0.008	0.156
	Membership in social organization	0.041	0.724
	Communication exposure	0.014	0.209
	Availability of current promotional activities	0.139*	2.313
	Perception of risk in cultivating hybrid rice	0.192**	3.141
	Attitude towards hybrid rice	0.153*	2.545
	Constant	−3.558*	−2.202

Note: $R^2 = 0.13$.
** Significant at the 0.01 level ($0.001 < p < 0.01$) (2-tailed).
* Significant at the 0.05 level (($0.01 < p < 0.05$)(2-tailed).

promoting the speed of adoption of agricultural technology. Multiple linear regression results showed that farm size, availability of the promotional efforts, perception of risk in cultivating hybrid rice, and attitude towards hybrid rice made significant contributions to the farmers' innovativeness. Farmers with a larger farm tended to adopt more rapidly than the others, likely because of the availability and suitability of land resources. Providing subsidies on seed & agrochemicals and visiting crop field by the experts (e.g. SAAO) to guide famer on a regular basis might help avoid risk and form favorable attitude.

An understanding of the adopter categories and the impact of farmers' attributes on this innovativeness might help planners and extension workers to refine their working procedure and policy guidelines in the areas of delivery and development to further accelerate the adoption of hybrid rice and also speed up the adoption of new crop varieties in Bangladesh and beyond.

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Appendix A. Table 5

Multicollinearity of the predictor variables.

	Collinearity statistics	
Predictor variables	Tolerance	VIF
Age	0.860	1.162
Educational qualification	0.687	1.455
Family size (persons)	0.855	1.170
Farm size (ha)	0.699	1.430
Annual family income (‘000 USD)	0.614	1.629
Training experience	0.893	1.120
Membership in social organization	0.817	1.225
Communication exposure	0.549	1.822
Availability of current promotional activities	0.718	1.392
Perception of risk in cultivating hybrid rice	0.695	1.439
Attitude towards hybrid rice	0.717	1.395

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