

Underlying reasons for non-adoption, disadoption and continuing adoption of hybrid rice in Bangladesh

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Abstract. Among the various options available to increase rice yields, hybrid rice technology is perhaps the most promising one. Despite growing evidence of hybrid rice's profitability in Bangladesh, the adoption rate is still low. Understanding the reasons for non-adoption or disadoption is, therefore, critical to successful promotion. Hence this study investigates why non-adoption, disadoption and continuing adoption of hybrid rice occurs by examining hypothesized and farmers' stated reasons. The study was conducted in five regions of Bangladesh. A concurrent embedded design using a cross sectional survey was employed. 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 were collected through face-to-face interviews using a pre-tested and back translated questionnaire. Data confirmed that among the hypothesized reasons for non-adoption, the top three were higher production cost, excessive requirement for agrochemicals, and witnessing crop loss with hybrid rice in neighbours' fields. The key reasons farmers stated for non-adoption were the same as these hypothesized for disadoption, which were: hybrid rice was unsuitable for consumption, and receiving a lower market price. Severe infestations of insect pests, followed by lack of irrigation facilities were the main reasons farmers stated for disadoption. As the leading reasons to continue cultivating hybrid rice, growers asserted higher productivity and profitability, resistance to lodging, and shorter field duration of hybrid rice. It is crucial for the scientific community, both at national and international levels, to address problems of non-adoption and disadoption to ensure food for the growing population.

Keywords: Adoption, non-adoption, disadoption, continuing adoption, hybrid rice, Bangladesh

Introduction

Rice is the mainstay of Bangladesh's agriculture. It contributes more than 80% to the total food supply. More than 95% of the population consumes rice in Bangladesh (Awal and Siddique 2011). 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). There is a pressing need, therefore, to improve rice production further to meet the demands of the growing population, which increases at the rate of 1.32% per annum (BER 2010 as cited in Awal & Siddique 2011). Among the various options available to increase rice yields, hybrid rice technology is the most feasible and readily adoptable one, as has been demonstrated in China (Nirmala and Suhasini 2013; Nirmala et al. 2013).

Hybrid rice could play an important role in food security, especially in poor countries in the tropics, where population is increasing and agricultural areas shrinking (Santiaguel and Quipot 2012). Already hybrid varieties have shown 15-20% higher yield potential than inbred rice varieties and have demonstrated their ability to perform better under adverse conditions of drought and salinity (Singh et al. 2009). Hybrid varieties are more responsive to fertilizers and can adapt to varying environments (Chengappa et al. 2003). The 'father of hybrid rice', Professor Longping Yuan pointed out that Bangladesh could be self-sufficient by cultivating hybrid rice (2012).

In 1998-99 widespread floods led to shortfalls in domestic seed supply, causing the National Seed Board (NSB) to allow imports of two hybrid varieties: Aalok, a variety from China, and Sonar Bangla, a variety from India (Rashid et al. 2011). It was the private sector that took the lead in the introduction of hybrid rice in Bangladesh (Hossain et al. 2003). Despite growing evidence of hybrid rice's profitability in Bangladesh, the adoption rate of hybrids was still low (Azad et al. 2008). By the 2008-09 crop year, it was reported that only about 8% of the rice area was planted with different rice hybrids (Janaiah and Xie 2010). Recently, it was reported that the overall extent of adoption of hybrid varieties during the 2001-2011 *boro* season (i.e. the dry season between October and March) was relatively low in the sample areas (Shah et al. 2014).

The success of any technology depends entirely on its adoption by farming communities. Hybrid rice has a higher yield potential in farmers' fields but faces a mix of problems before it is likely to be adopted extensively (Husain et al. 2001). The promotion of hybrid rice is a challenging

and time-consuming task (Cidro & Radhakrishna 2006), which has been reflected in the adoption process over the last decade in Bangladesh. The field performance of this technology over this decade gives rise to a deep concern to practitioners for the future of this technology. Questions have remained unexplored as to why a massive proportion of farmers opt not to adopt and or discontinue, and why other farmers continue cultivating hybrid rice. Although some research on the adoption of hybrid rice has been conducted in Bangladesh, no study has dealt with pre and post-adoption actors, i.e. non-adopters, disadopters or continuing adopters. Therefore, the researchers conducted an in-depth study exploring the reasons for initial non-adoption, discontinuation after adoption and continuing adoption since the introduction of hybrid rice by comparing hypothesized reasons and farmers' self-stated reasons.

Methodology

Research Site

The land use pattern of Bangladesh is influenced by agro ecology, soil physiography and climatic factors (BBS 2011). Based on these factors, the land in the country has been classified into 9 regions of which at least five have been gazetted by the Government of Bangladesh for on-farm evaluation of each variety of hybrid rice to be registered (GoB 2003). Therefore, five regions were taken into account for this study in order to select the sample (Figure 1).

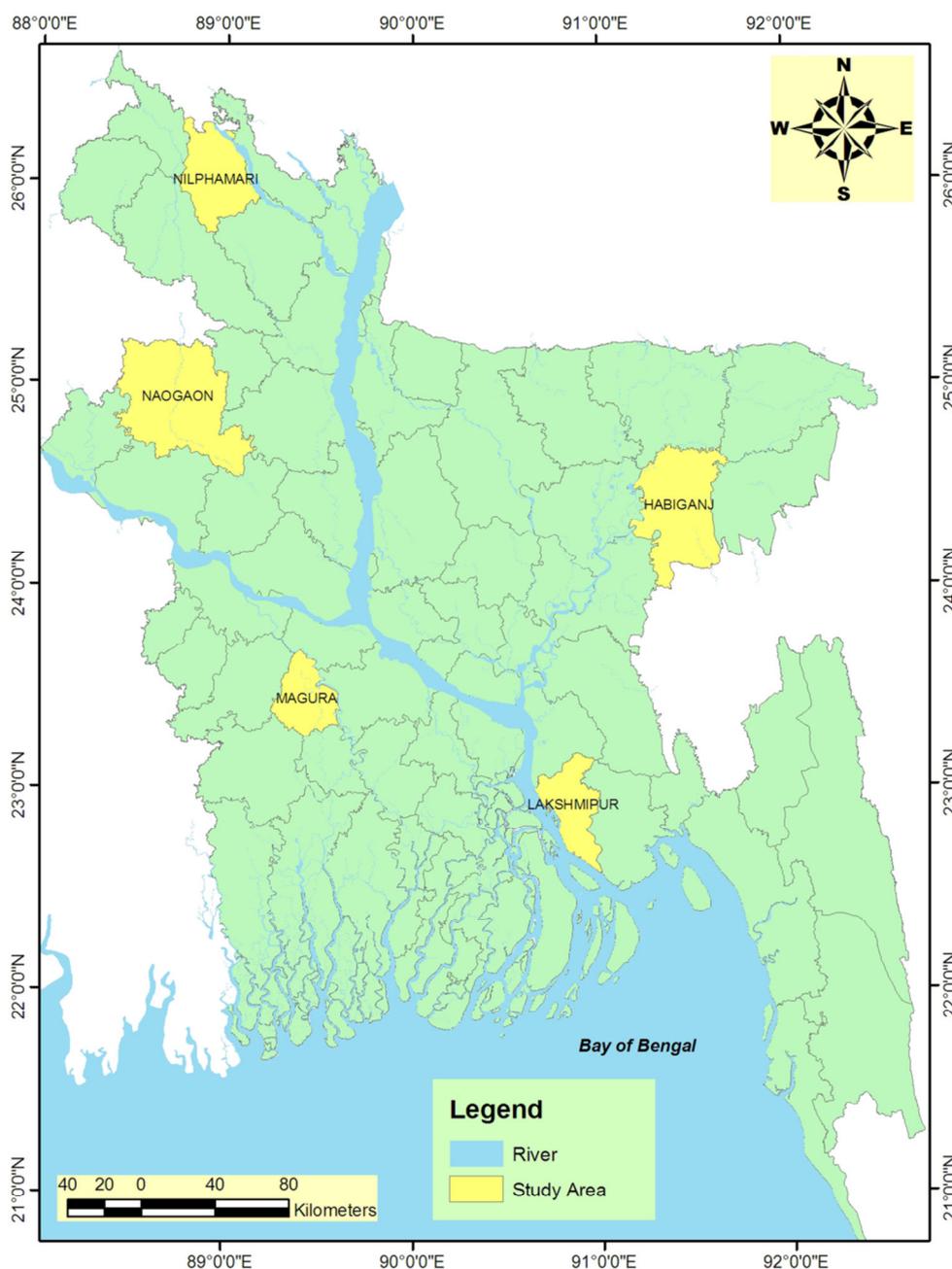
Sampling design

A concurrent embedded design using a cross sectional survey was employed (Creswell 2009). The population of this study consisted of rice growers in 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 (\pm) 5%, the level of confidence at 95% and the degree of variability at 50%, 425 farmers were selected following sample size recommendations as proposed by Corbetta (2003), Dillman (2007) and Israel (2009). Farmers in three adopter categories of hybrid rice were sampled: non-adopters (79), disadopters (122) and continuing adopters (224). Data were collected through face-to-face interviews with the sampled farmers using a pre-tested and back translated questionnaire. The questionnaire was formatted with both open and closed item questions to obtain both quantitative and qualitative data. The first author spent 120 working days in the study area between March 2 and June 30, 2012 to collect data.

Measurement of problem confrontational index (PCI) for hypothesized reasons for non-adoption and disadoption

From a review of the empirical literature on technology adoption (Feder et al. 1985; Supriadi & Chamala 1998; Cochran & Bonnell 2006; Gillespie et al. 2007; Fu et al. 2009; Paudel et al. 2011), 10 reasons for non-adoption were identified. Farmers who did not start cultivating hybrid rice were asked to rate the reasons against the scale as proposed by Agwu et al. (2008), viz. very serious constraints = 3; serious constraints = 2; and not serious constraints = 1. Then a problem confrontational index (PCI) as proposed by Jahan et al. (2010) was computed for each problem. To do so, the score for each point of the scale was calculated by multiplying its weighting by the number of responses. All weighted scores were then summed to calculate the PCI. The PCI of any problem for non-adoption could range from 79 to 237. If all 79 non-adopters rated a problem as not having serious constraints, the PCI of this problem would be 79 and if the same problem was rated as very serious problem by all non-adopters, then the PCI would be 237. In order to understand the severity of the problems, all ten problems were then ranked, based on computed PCI.

Based on the literature of Kremer et al. (2001), Janaiah (2002), Janaiah et al. (2002), Hossain et al. (2003), Janaiah & Hossain (2003), Sofranko et al. (2004), Oladele & Adekoya (2006), Miller & Mariola (2008) and Janaiah & Xie (2010), 13 reasons for disadoption were hypothesized. Disadopters were then asked to rate the reasons based on their perception of severity using the same scale as followed by non-adopters. The PCI of individual reasons for disadoption were also gauged. If all 122 disadopters rated a reason as not being a serious constraint to continuing adoption, the PCI of this reason would be 122 and if the same reason was rated as very serious problem by all disadopters, then the PCI would be 366. All thirteen reasons were arranged in order on the basis of PCI. The higher the PCI of a problem, the greater the magnitude of that problem.

Figure 1. Map of Bangladesh showing selected districts under study

Measurement of farmers' self-stated reasons for non-adoption, disadoption and continuing adoption

In addition to the hypothesized reasons, sampled farmers were asked to state any additional reasons that influenced them not to start and or discontinue cultivating hybrid rice. In order to identify the motivational factors, sampled farmers were asked for the reasons for continuing cultivation of hybrid rice. In either case, based on the response, frequency and percentage were computed.

Results and discussions

Hypothesized reasons for non-adoption of hybrid rice

Findings regarding hypothesized reasons for non-adoption are presented in Table 1. The problem that ranked highest was 'higher production cost', which suggests the production cost was higher than for conventional inbred rice. About 44% of the non-adopting farmers rated this problem as a 'very serious problem', while 22% of them rated it as a 'serious problem' and 34%

of respondents did not perceive this as serious. The PCI for 'higher production cost' was 166. One of the non-adopters noted: 'I could not afford cultivating hybrid rice mainly because of two reasons; one is higher production cost and another is lower market price'.

Table 1. Rank order of the hypothesized reasons for non-adoption

Reasons hypothesized	Extent of severity			PCI	Rank
	VSP	SP	NSP		
1. Higher production cost	35 (44)	17 (22)	27 (34)	166	1
2. Excessive requirement for agrochemicals	32 (41)	13 (17)	34 (43)	156	2
3. Seeing crop losses in neighbours' fields.	27 (34)	2 (3.0)	50 (63)	135	3
4. Higher seed price	11 (14)	23 (29)	45 (57)	124	4
5. Demand for intensive labour	16 (20)	8 (10)	55 (70)	119	5
6. Lack of irrigation facilities	2 (3.0)	20 (25)	57 (72)	103	6
7. Seed cannot be preserved at the farmers' level	3 (4.0)	13 (17)	63 (80)	98	7
8. Lack of demonstration plots	0 (0.0)	11 (14)	68 (86)	90	8
9. Lack of promotional campaigns	0 (0.0)	9 (11)	70 (87)	88	9
10. Discouragement by fellow farmers	2 (3.0)	2 (3.0)	75 (95)	85	10

VSP indicates 'very serious problem'; SP indicates 'serious problem' and NSP indicates 'not serious problem'. Numbers in brackets are percentages of the total.

$n = 79$

The second highest PCI was for the reason 'excessive requirement for agrochemicals (fertilizers, irrigation, pesticides)'. This was a problem for 57% of non-adopting farmers to the extent of being serious (17%) to very serious (41%), while 43% of non-adopting farmers did not consider this issue as a problem.

About 34% of non-adopting farmers recognized the problem 'seeing crop losses at a neighbours' field' as a 'very serious problem' while 3.0% rated it as a 'serious problem'. However, 63% of farmers didn't rate this issue problematic. The PCI for this problem was 135, which ranked third. One of the non-adopting farmers commented on this issue: 'I found one of my neighbours produced only 1400 kg rice from 0.4 ha (4000 kg from 0.4 ha is ideal), which is surprisingly shocking, and that constantly discouraged me not to go for it'.

The problem that ranked fourth was 'higher seed price'. Among the sampled farmers (especially those who are small and marginal), this problem also acts as a deciding factor. Forty-three percent of farmers identified this problem as a 'serious to very serious problem', while a majority of them (57%) did not worry about this issue, perhaps because they are financially stronger.

The fifth ranked problem was 'demand for intensive labour'. Less than one third of the farmers (30%) rated this as a 'serious to very serious problem', while the rest did not consider this issue as serious. The PCI calculated for this problem was 119. One of the farmer's statements about this issue was: 'I cannot make time to work myself in my crop field because of my profession, where I have to spend all time I have. If I cultivate hybrid rice by hiring labourers, I could not afford the cost. I observed that the expense my neighbours spend in their field surpass the yields they harvest'.

The next ranked problem was 'lack of irrigation facilities'. Although 28% of farmers marked this as a 'serious to very serious problem', 72% farmers did not rate this problem as serious. It is important to note that irrigation problems are not prevalent countrywide. Rather, it occurs in particular areas. The PCI of this problem was 103.

Reasons given by farmers for non-adoption of hybrid rice

Non-adopters were also asked to give additional reasons why they did not cultivate hybrid rice. Table 2 represents the findings from this enquiry. Decisions were often influenced by more than a single factor so multiple responses were permitted for this question.

Table 2. Reasons for non-adoption – numbers and percentages of farmers

Self-stated reasons	Distribution of respondents	
	Number	Percent
1. Unsuitable for consumption	52	66
2. Lower market price	30	38
3. Difficulties in selling	16	20
4. Severe infestation of insect pests	16	20
5. Longer field duration	10	13
6. Mismatch with transplanting time	6	8
7. Inconsistent yield performance	5	6
8. Outlandish cultivation procedure	5	6
9. Other reasons	10	13

$n = 79$

Sixty-six percent of non-adopting farmers were uncomfortable with consuming hybrid rice as they claimed hybrid rice was very coarse, becomes sticky after cooking and also becomes soft and soggy over time. With regard to consumption difficulties, some representative quotes as proposed by non-adopters are presented below:

As I am a subsistence farmer, whatever amount I produce, I consume that. I heard that hybrid rice is too coarse and not good for consumption, and it cannot be processed as watered rice as well. This is the one and only cause that largely discouraged me not to initiate cultivating hybrid rice.

As the boiled grains are so soft and soggy, it gets rapidly digested after being consumed, which is not good for working class people. The straw has less utility as fodder and cannot be used as thatching materials as it rots rapidly after getting drenched.

I had bought hybrid rice from the market and cooked it by myself and experienced the following difficulties; i. Did not find any taste, ii. Become sticky after cooking, iii. Released moisture from 2 hours onward and turned into soft and soggy.

The next reason, cited by 38% of non-adopting farmers, was 'lower market price'. Currently farmers are seriously struggling with this problem. Janaiah et al. (2002) reported that the price of hybrid rice in Bangladesh and Vietnam was 11% lower than that of high yielding varieties.

About 20% of farmers reported 'difficulties in selling' and 'severe infestation of insect pests'. One of the non-adopters of hybrid rice claimed, 'I was involved in rice trading. I was surprisingly disappointed with the market demand and its price as well. Once I bought some hybrid rice in the market for trading, I was not able to sell the total amount even at low cost. Some portion remained unsold. Market price is the key factor that motivates farmers not to adopt hybrid rice'. Another non-adopter commented on the issue, 'I could not sell even at a low price, no one steps forward to buy hybrid rice'. With regard to insect pests another non-adopter remarked, 'hybrid rice cultivation requires frequent application of pesticides with higher doses'. A problem mentioned by 13% farmers was 'longer field duration'. With regard to this problem, a couple of representative quotes from non-adopters are:

Hybrid rice goes through 10-15 days longer field duration as compared to BRRRI Dhan 28 that gives rise to a number of problems for the farmers to adopt. Firstly, it requires additional amounts of water. It is difficult to bring water into the crop field because of the interruption of rats' holes in the channel. At the end of the season channels are no longer under operation in the adjoining crop fields, which is why the rats nested inside the channels. Secondly, the crop field becomes vulnerable to insect pests, as there are no other crops standing around. In addition, the crop field becomes defenceless to the livestock grazing on harvested crop fields.

In the lower basin flash the flood comes in Chaitra (March) and causes a disaster for long duration crops. Even 10-12 days longer field duration may be a reason for being flooded in the lowest basin. Hence I used to cultivate local varieties, *tapi boro* and *khaia boro*, which are 15 days ahead of hybrid. As a result I can harvest them before the floods reach.

A minor proportion of farmers reported that 'mismatch with transplanting time', 'inconsistent yield performance' and 'outlandish cultivation procedure' were reasons for non-adoption of hybrid rice. Seven other reasons for Table 2 totalled about 13%.

Hypothesized reasons for disadoption of hybrid rice

A proportion of the farmers discontinued cultivating hybrid rice after previous adoption. Findings are presented in Table 3.

Table 3. Rank order of the hypothesized reasons for disadoption

Reasons hypothesized	Extent of severity			PCI	Rank
	VSP	SP	NSP		
1. Unsuitability for domestic use	87 (71)	25 (21)	10 (8.0)	321	1
2. Lower market price	66 (54)	34 (28)	22 (18)	288	2
3. Lower market demand	54 (44)	30 (25)	38 (31)	260	3
4. Higher input costs	52 (43)	19 (16)	51 (42)	245	4
5. Lack of seeds of good variety	36 (30)	35 (29)	51 (42)	229	5
6. Severe crop loss	35 (29)	13 (11)	74 (61)	205	6
7. Higher risk	10 (8.0)	34 (28)	78 (64)	176	7
8. Dissatisfaction with its yield	21 (17)	18 (15)	83 (68)	182	8
9. Higher seed cost	15 (12)	21 (17)	86 (71)	173	9
10. Requires intensive care	15 (12)	21 (17)	86 (71)	173	9
11. Seed cannot be produced	0 (0.0)	27 (22)	95 (78)	149	11
12. Lack of adequate land	0 (0.0)	11 (9.0)	111 (91)	133	12
13. Maintaining crop rotation	0 (0.0)	2 (1.6)	120 (98)	124	13

VSP indicates 'very serious problem'; SP indicates 'serious problem' and NSP indicates 'not serious problem'; Numbers in brackets are percentages of the total.

$n = 122$

The problem which ranked first was 'unsuitability for domestic use' cited by 71% of disadopters as 'very serious' and 21% as a 'serious problem'. About 8% of them did not consider this issue as a problem because they cultivate mainly for selling. Indeed, unsuitability of hybrid rice for domestic use is a key problem that leads farmers to switch over from hybrid to inbred varieties. This appears to apply in particular to those who are subsistence and semi-subsistence farmers. With regard to this problem a series of representative quotes of disadopters are presented:

Rice is coarse and sticky.

Need to be consumed immediately after cooking as it releases moisture after two hours of cooking. In rural Bangladesh, rice is cooked onetime and usually served twice, which is not possible for hybrid rice.

The straw cannot be used for thatching of houses as they rot within a very short period of time when it gets drenched with rainwater. Moreover, cattle are not comfortable with the straw because of the sharpness of leaf blades and coarseness of the leaf sheath.

'Lower market price' was the second highest ranking problem (PCI=288). About 54% of disadopters identified this issue as a 'very serious' and 28% as a 'serious' problem. Farmers reported that the market price of hybrid rice is lower than inbred varieties by 100-250 *Taka* (AUD 1.57-AUD 3.93, AUD I = 63.55 *Taka* as of December 17, 2014, Bangladesh Bank) for 37.5 kg depending on the grain size. Hybrid varieties which are slender (Laltirtia, Thej, Jhalak, Sl8h, Sampad, Ssankar and Dhani), are sold for 100 *Taka* (AUD 1.57) less but the hybrid varieties which are coarse (almost all, including Hira, ACI, Sonarbangla, Rajkumar) are sold for 250 *Taka* (AUD 3.93) less.

The next ranked problem was 'lower market demand'. About 69% of farmers rated this problem as 'serious to very serious'. Buyers did not want to purchase the husked rice (*chaul*) paying as much as 2-3 *Taka* (3-4 cents) less per kilogram (kg). However, it was not a serious problem for 31% of the farmers. For example, a disadopter stated, 'If a farmer is able to sell 100 *mound* (3,750 kg) or above at a time, he can easily do that. The buyers are only interested in purchasing a large amount, even coming to the seller's house, undertaking their own carrying cost'. This suggests that market demand is not a problem for big farmers. However, some representative quotes by disadopters regarding market demand are cited below:

The people who feed on bought rice still avoid hybrid rice because of poor intake quality (stickiness and sogginess). Instead they pay 2-3 *Taka* (3-4 cents) more/kg for buying inbred rice.

Although I put up my produce for sale in two markets, I could not sell. Simply I had to spend some money for *Gundi* (given 20 *Taka* (30 cents) to lessee as subscription) and *Thola* (given 10 kg rice to the sweeper), and also for carrying (300 *Taka*, AUD 4.72). This situation forced me to quit cultivating hybrid rice.

The problem that ranked fifth was 'lack of seeds of good variety'. Respondents were often confused about the meaning of this question. Hence this question was reworded as 'lack of pure

seeds'. About 58% farmers recognized this problem as a 'serious' to 'very serious' problem. Some comments from disadopters are given below:

Although the pure seed of hybrid rice was available when it came first in the market, it became unavailable in the next season.

Pure seeds are no longer available in the market. The seeds, which are not sold in the current year, have been unscrupulously preserved for selling in the following year. As a result germination percentage of those seeds drastically reduces. Buying those seeds, farmers are often deceived.

It was found that 39% of respondents perceived that 'crop loss' was a serious to very serious problem, but it is not a regular event. Rather, it occurs sporadically depending on a number of factors such as quality of seed, climatic condition, and outbreak of insect pest and diseases. Among these factors, the leading one is climatic variation. It is reported by BRRRI (2011) that fluctuation of temperature at the flowering stage leads to the formation of unfilled grains. If the temperature goes below 12-13°C at night and above 28-29°C during the day, it is considered critical to forming unfilled grains. Such a precarious situation occurring for 5-6 days turns into a catastrophe in the rice field. Whatever the cause, when a variety goes through a yield disaster farmers either stop cultivation of the variety or reduce the area of its cultivation. About 36% of disadopters believed that cultivation of hybrid rice was risky. For example, one of the disadopters said, 'there is a higher risk from natural calamities like hailstorm and flash flood when cultivating hybrid rice'. Thirty-two percent of the disadopters were dissatisfied with the yield they harvested, while 30% identified 'higher seed cost' and 'requires intensive care' as a 'serious' to 'very serious' problem. One of the disadopting farmers said, 'we should always keep a wary eye on the rice field about what to do'. About 22% of farmers added 'they could not produce seeds of hybrid rice' as a serious problem, while 9% of farmers have also identified 'inadequacy of land' as a serious problem.

Reasons given by farmers' for disadoption

Disadopters were also asked to give additional reasons as to why they had ceased the use of hybrid rice after having previously adopted it. Since such decisions often reflect more than a single factor, multiple responses were permitted on this question (Table 4). The most mentioned reason for discontinuing hybrid rice was 'severe infestation of insect pests'. Comments from the respondents regarding this issue included:

Insect infestation causing white head requires applying pesticide almost every week.

As the land remained occupied with other crops I could not transplant in due time. As a result the crop fields become severely infested with insects from surrounding crop fields.

Another factor that triggered discontinuance was 'lack of irrigation facilities'. Several respondents reported that: 'unfortunately we could not provide irrigation when it is necessary because of drying up the local rivers, namely, Jhingri and Kushier. It is one of the main reasons for ceasing the use of hybrid rice'.

Table 4. Reasons for disadoption – numbers and percentages of farmers

Self-stated reasons	Respondents	
	Number	Percent
1. Severe infestation of insect pests	37	30
2. Lack of irrigation facilities	15	12
3. Longer field duration	8	7
4. Difficulties in seedbed management	8	7
5. Labour crisis	6	5
6. Other reasons	6	5

$n = 122$

A third important factor that contributed to discontinuance was 'longer field duration'. Typical quotes were:

As hybrid is grown in the low lying areas and it lasts at least 15 days longer than br28, thus, sometimes it gets drowned in the flash flood.

Hybrid requires 15-20 days longer field duration than BRRRI Dhan 28 or local cultivar, Zira.

Another reason given for ceasing the use of hybrid rice was 'difficulties in seedbed management'. Disadopters made several comments on this issue:

For producing hybrid seedling, it is recommended to sow seeds thinly (1 kg/ 0.004 ha) which requires a larger area as compared to inbred. So, there remains enough space to grow weeds. Labourers often raise seedlings from the bed with weeds and transplant the same in the main bed. That creates further difficulties.

A single seedling should be uprooted very carefully so that its root-system remains intact. But farmers are not habituated to pluck individual seedling. It increases labour requirements.

Extremely hazy weather usually prevails during the time of sowing seed, which is injurious to seed germination and seedling health.

The next reason discouraging farmers not to continue cultivating hybrid rice was 'labour crisis'. Several disadopters reported, 'during the peak period of the *boro* season, we faced a severe labour shortage in the locality. We cannot hire labourers to cultivate even at a high price, as they migrate from north to southern Bangladesh for short times to make money'. Five other reasons for Table 4 account for about 5%.

Reasons given by farmers for continuing adoption of hybrid rice

Farmers who were continuing adopters (224) of hybrid rice were asked 'Will you continue cultivating hybrid rice for the next 2012 *boro* season?' Most of the continuing adopters (96%) would like to continue cultivating hybrid rice for the next session, while 3% are not going to continue and the rest had not decided. Although in the majority of cases the adopters perceived higher productivity of hybrids as the driving force for continuing cultivation of hybrid rice, there were other relevant factors that also persuaded them to continue. Some representative quotes are cited below.

As most of the people in my locality cultivate hybrid rice, I would like to cultivate the same no matter whether it is profitable or not.

I cultivate both inbred and hybrid, under the presumption that if hybrid will not perform well, inbred will do so or vice versa. Farmers do not know which variety is going to perform well or which not. Another point in favour of mixed cultivation is that inbred BRR I Dhan 29 is a long duration crop while hybrid is a short duration crop. So farmers can process harvesting of the crops one after another.

A farmer who remained undecided as to whether he would continue or not reported that 'as I am cultivating for the first time, I am still not sure whether I will continue or not. It depends on the productivity and suitability for household usage. If I am satisfied with production and comfortable with consumption, I will continue, otherwise not'. Farmers (96%) who decided to go for further cultivation of hybrid rice in the 2012 *boro* season were asked to give their reasons (Table 5). The most mentioned reason was getting a higher yield compared with conventional inbred varieties. Some representative quotes from continuing adopters are cited below.

As the production is higher, it satisfies my family requirement.

As compared to BRR I Dhan 28, it secures 4-7 *mound* (150-262.5 kg) higher for a 30 *decimal* (0.12 ha) land area.

Generally hybrid produces 37.5 kg/*decimal* (0.004 ha). As a whole it produces 5-6 *mound* (150-225 kg) higher than BRR I Dhan 28 for 30 *decimal* (0.12 ha) land.

Table 5. Reasons for continuing adoption – numbers and percentages of farmers

Self-stated reasons	Distribution of respondents	
	Number	Percent
1. More productive	209	93
2. More profitable	187	84
3. Resistant to lodging	159	71
4. Shorter field duration	83	37
5. Higher weight of rough rice	82	37
6. Less seed requirement	78	35
7. Spectacular and eye-catching views of rice field	67	30
8. Suitable for low-lying areas	61	27
9. Higher amount of husked rice	60	27
10. Used for consumption after being processed	54	24
11. Easy intercultural and post-harvest operation	51	23
12. Higher straw yield	48	21
13. Other reasons	34	15

n = 224

Another important reason (84%) was 'higher profitability'. For example:

Although the market price of hybrid rice is comparatively less, still it is more profitable because of the bumper production.

One *decimal* land (.004 ha) produces 40 kg of raw rough rice which is a lot more than inbreds. Although the market price is less and the production cost is higher, still it is profitable.

The third leading factor for continuation of hybrid rice was 'resistance to lodging'. This is one of the key advantages that motivate farmers to cultivate hybrid rice. Usually, inbred varieties like BRRI Dhan 28, lodge severely in the low-lying areas, causing a drastic reduction in yield, but hybrids do not. Thus, hybrid rice is suitable for cultivation in the lower basin. This finding is in agreement with the findings of Hossain et al. (2003), who found that hybrid rice is potentially more suitable for lowland areas, as shown by the negative relationship between land type and hybrid rice adoption. With reference to this issue, continuing adopters reported:

The individual plant of hybrid rice is dwarf, strong and stout, and the roots are profusely anchored in the ground. This prevents lodging even in gusty winds and hailstorms. These qualities of hybrid rice technology make it a boon in the lower basin.

If we grow br28 in the low land, it usually lodges due to higher fertility. Lodging helps to produce unfilled grains, rot and twist the straw and thus causing difficulties in harvesting. Instead, farmers prefer cultivating hybrid rice in those low lands because hybrid rice requires a higher fertility to be grown well. The higher the fertility, the better its productivity.

'Shorter field duration' was mentioned by 37%. One of the continuing adopters reported that hybrid rice could be harvested 10 to 15 days ahead of BRRI Dhan 29, which reduces the possibility of being affected by natural calamities, such as hailstorms and flash floods. Hailstorms happen all over the country but flash floods occur in the low-lying areas, in particular Habiganj and Naogaon. During this time farmers spend every single day in a state of anxiety, fearing a complete disaster to their crop standing in the field.

Hybrid rice has 'higher weight' as the grains are coarse. Cultivating hybrid rice involved 'less seed requirement'. The requirement is about 1.25 to 1.5 kg for 0.13 ha, as one seedling produces, up to 35 tillers.

Another stated reason, which gives farmers great pleasure to visit the field, was 'spectacular and eye-catching views of the rice field'. With regard to this point farmers stated, 'the rice field captures the attention of the growers, offering an enchanting beauty as the plants grow green uniformly to produce extra large and identical panicles. It creates a stunning view after ripening. There is a golden wave of large panicles playing in the field with the gesture of gentle breezes. When farmers came to visit the field, they are entertained with complete satisfaction'.

Hybrid rice produced 'higher amount of husked rice' compared with popular inbred such as BRRI Dhan 28 and BRRI Dhan 29, because of the thinner husk (outer covering of the panicle). Typical comments from continuing adopters are presented below.

Raw rough BRRI Dhan 28 produces 24-25kg husked rice/37.5 kg while hybrid produces 28kg but after getting dried, BRRI Dhan 28 produces 26-28kg while hybrid produces 30-32kg.

Hybrid can produce 29-32 kg husked rice from 37.5 kg rice while BRRI Dhan 29 is 26-28 kg from the same amount.

Some farmers (24%) reported hybrid rice can be 'used for consumption after being processed'. These farmers had developed special methods for increasing the suitability of consuming hybrid rice. They needed to consume their produce as many of them only had a single piece of land where they cultivate hybrid rice in the hopes of getting a higher yield. One of those farmers stated, 'as I am a tenant farmer. I have a single piece of land, which I have leased. So the amount I produced I had to be consumed. Although initially I faced difficulties, now I am comfortable, because, I believe, I have devised some ways to develop the suitability of cooked rice by practicing for four years'. However, whatever the amount farmers produced, they always sold some portion to meet their requirements and kept the remaining portion for household use.

About 23% of respondents reported that hybrid rice requires 'easy intercultural and post-harvest operation' including weeding, fertilizing, irrigation, harvesting and marketing. A few continuing adopters reported:

The intercultural operation is easy as the plants are grown in line, maintaining proper spacing, and the crop remained standing until the day of harvesting.

Because of the shorter life span of the hybrid, farmers gain some advantages over inbred, like managing labour at a comparatively low cost (as it is a dull season: 15-20 days earlier of peak period of *boro* season) and enjoying good weather for all the post-harvest operations like winnowing, drying, packing, marketing, etc. (as still it is 20 days ahead of monsoon), getting higher price for earlier availability in the market (because BRR1 Dhan29 is not yet available in the market).

The crop which becomes available in the market early in the season usually gets a higher price. More importantly, hybrid rice provides an opportunity to split the season into early and late. The money farmers earned from hybrid rice early in the season helps them afford the harvesting cost of other crops later in the *boro* season comfortably, one after another. The trait which was listed next is 'higher straw yield'. Representative comments were:

It can be used as good fodder if straw is preserved for two months in hive and then served after soaking in water.

If straw is served after soaking in water with mustard cake and molasses, it can be used as a good fodder.

Conclusions

Based on examination of hypothesized reasons and farmer reasons, the researchers can describe the major factors for non-adoption, disadoption and continuing adoption of hybrid rice. From the reasons, which were hypothesized for non-adoption of hybrid rice, higher production costs and excessive requirements for agrochemicals were rated by the majority of non-adopters as serious to very serious problems. Among the reasons given by the farmers for non-adoption, the two highest cited reasons were that hybrid rice is unsuitable for consumption and its lower market price. These two reasons were also rated by the majority of farmers as very serious problems for disadoption. The most cited problems for disadoption, however, were severe infestation of insect pests and lack of irrigation facilities. Growers continuing to cultivate hybrid rice identified higher productivity, more profitability, resistance to lodging, and shorter field duration as the leading factors influencing their decision to continue cultivation. In order to address the problems identified as reasons for non-adoption and disadoption, immediate action by the scientific community both at national and international levels is crucial.

Acknowledgements

We are grateful to Department of Agricultural Extension and the farmers who participated in this study. Also, thanks to the Department of Education, Employment and Workplace Relations (Australian Federal Government) for providing a doctoral scholarship and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for offering a research grant to conduct fieldwork to the first author of this paper.

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