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Formal vs. Informal Seeds: Adoption and Productivity Differences

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While the literature on seeds is replete with the supply-side aspects of the market such as seed distribution, variety development, etc., there is hardly any rigorous study on the demand side of the seed market. This paper raises three important questions related to the development of the seed sector of Bangladesh. First, which crops are produced with more formal seeds? Second, who use formal seeds more? Is it the small farms or the large farms? Third, what is the output gain from using formal seeds? Based on a survey of 700 farming households from seven districts of Bangladesh, we have found that the spread of formal seeds is taking place predominantly from some non-rice crops such as vegetables, maize, wheat, etc. which are predominantly supplied by the private sector and the smaller farms are using more formal seeds. We have also found that there is an inverse relationship between farm-size and use of formal seeds for all crops but revenue and output per unit of land is higher for the larger farms. Finally, we have found that formal seed is more productive than the informal seeds – the productivity gain is about 10 per cent for rice but much higher for non-rice crops. Based on these findings we conclude that increasing use of formal seeds will increase output but the small farmers may gain less despite adopting more formal seeds.

Keywords: Formal Seeds, Informal Seeds, Adoption of Seeds, Agricultural Productivity

JEL Classification: Q12, Q16, Q18

I. INTRODUCTION

The issue of quality of seeds is based on the premise that formal seeds, i.e. the seeds formally approved of having an acceptable quality, are better than informal seeds, i.e. the seeds whose quality is not known or perhaps unacceptable. Formal seeds are better than informal seeds because they can produce more output. Thus the main thrust of the policy is to increase the supply of formal seeds because it cannot meet the existing demand for quality seeds. The state sector still plays a big role but the involvement of the private sector in the seed sector is also increasing and the seed markets are increasingly liberalised.

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However, the informal seeds still continue to hold a large part of the market and are not showing signs of total disappearance soon. This indicates that there is a market for informal seeds and for some farmers or for some crops the choice of informal seeds may not necessarily mean lack of availability of formal seeds in the market. Farmers may be more interested in short life cycle or better grain quality, or easy availability rather than higher yield of a seed. This raises the issue of the importance of the demand side of the market.

The existing literature on the quality of agricultural seeds is fraught with supply side analysis; it largely focuses on the policies, institutions, variety development, public distribution channels and the supply chain (Hossain *et al.* 2002, Huda and Smolders 2001, Jaim and Akhter 2012). There is hardly any full-blown study on the demand side of seeds, let alone on the quality issues. Therefore, we do not know much about the demand side of the market. The Ministry of Agriculture (MoA) conducted a study on agriculture governance in Bangladesh based on a survey of six thanas where seed was a small part of the study (Ministry of Agriculture 2006). The study found that a large majority of farmers used seed saved from previous harvest for the Aman and Boro crops. Another study by Islam et al. (2010) made some important observations about the use and quality of seeds. The study found that 80 per cent of the rice seeds were seeds saved by the farmers. On the other hand, Ali, Ahmed and Mannan (2014) find the use of formal seeds very high; for major cereal crops, 40-70 per cent of the farmers buy seed from the formal sources. This limited and dated information highlights our lack of knowledge about the demand side factors of the seed market.

We collected data on crops, seeds and their sources along with socioeconomic characteristics of 700 farming households from 7 districts - Thakurgaon, Pabna, Rajshahi, Chuadanga, Jhenaidah, Mymensingh and Netrokona. This regional dispersion provides us with enough variations in types of crops and seeds to study the adoption and productivity of formal seeds compared to informal ones.

Based on the primary data, this paper focuses exclusively on the demand side of the seed market and raises four important questions. First, which crops use more formal seeds? The subsequent questions are more pertinent to the smallholder nature of Bangladesh agriculture. We ask who use formal seeds more. Is it the small farms or the large farms? Third, how much crop production would increase from using formal seeds? We have used both descriptive statistics and regression analysis to address these questions. We have found that the spread of formal seeds is taking place predominantly from some non-rice crops such as vegetables, maize, wheat, etc. which are predominantly supplied by the private

sector. Our estimates reveal that the seed replacement ratio is about 47 per cent for all crops; among varieties of rice, it is 60 per cent for Boro. We have also found that the smaller farms are using more formal seeds and there is an inverse relationship between farm-size and use of formal seeds for all crops. This result is indicated by descriptive statistics and confirmed by regression results after controlling for all possible confounders. Finally, we have found that formal seeds are more productive than the informal seeds – the productivity gain is about 10 per cent for rice but much higher for non-rice crops. These results have significant bearing on the seed policy regarding the strategies for boosting the seed replacement ratio.

Section II discusses the main issues related to the literature on quality of seed and defines how quality of seed has been understood in this paper. Section III describes the background of the fieldwork done for collecting the data for the paper. Section IV presents the main findings of the paper. Finally, section V concludes the paper.

II. FORMAL AND INFORMAL SEEDS

Anyone can count the seeds in an apple, but only God can count the number of apples in a seed -- Robert H. Schuller

Quality of seed has several aspects: its genetic properties, i.e., the inherent genetic makeup of the variety, and the germination rate, seed health, and purity of the seed (Louwaars and Boef 2012:40). The seed standard of a country sets the requirement for seeds to be of good quality. In Bangladesh the National Seed Board publishes the seed standard for all the crops. In general, seeds produced from the formal sector and particularly those certified by certification agencies recognised by the government are considered to be of good quality. But the quality of seeds cannot be ensured in developing countries due to weak institutions.

The discourse on quality of seed refers to maximising the use of seed that goes through the formal channel. The seeds supplied through the informal system are not recognised as quality seeds because here seeds are not produced by following the steps of seed technology. The use of these poor quality seeds is the major factor for low productivity of crops (BADC 2012). Gradual replacement of informal seed by formal seed is believed to increase crop production by 15-20 per cent in Bangladesh (Jaim and Akhter 2012, Islam *et al.* 2010).

The issue of seed quality encompasses both the sphere of production and the sphere of distribution (Table I). The source of quality compromise can be

voluntary/deliberate or involuntary or accidental or unintended. The quality of seed can be affected at the level of production in a voluntary way. For example, TLS (Truthfully Labelled Seed) produced by either the private sector or the NGOs from foundation seeds may not go through rigorous quality testing (Hossain *et al.* 2002). Islam *et al.* (2010) have found TLS seeds to be less productive as compared to certified seeds. These seeds are normally produced by contracting farmers. Lack of supervision and contractual disincentives may result in these farmers producing seeds of inferior quality. Quality failure can be also involuntary. For example, a private sector agent may import seed of poor quality without knowing. On the other hand, proper sampling may not be carried out by the certification agencies for many reasons.

TABLE I

SOURCES OF COMPROMISES OF QUALITY OF SEED

	Voluntary/deliberate/ adulteration	Involuntary/accidental/unintended
Production/imports	**A.** Seeds not going through rigorous testing. Lack of supervision.	**B.** Improper sampling by certification agencies, private sector unknowingly importing seeds of poor quality.
Distribution (marketing)	**C.** Seed traders, retailers, MSVs (mobile seed vendors).	**D.** During transporting, packaging, etc. by traders

Likewise, the quality of seed can be compromised at the level of distribution, voluntarily or involuntarily. Seeds can lose quality through improper packaging or transportation by the traders or other agents. This is a case of involuntary quality failure at the level of circulation. Finally, a good seed can be deliberately adulterated. This is less likely to happen in the case of production of breeder or foundation seeds. The number of agents involved is finite or they have less incentive for adulterating the seed – for example the public sector breeders. Islam *et al.* (2010) have found foundation seeds to be more productive than other seeds. Seed adulteration is more likely to happen at the level of distribution in the seed chain.

In this study we have identified quality seeds by source and assume that formal seeds are generally of good quality and the quality of informal source is not known. Formal sources of seeds comprise the legal dealers including those of the Bangladesh Agricultural Development Corporation (BADC) and private seed companies, NGO and the informal source includes farmers' saved seeds, seeds purchased from neighbours, mobile seed vendors, etc.

III. STUDY AREA, SAMPLE SIZE AND SAMPLE DISTRIBUTION

The survey of farming households for the study was done along with another study titled "Extended Water Resources Management" which was also funded by the IFPRI. The study on water management took into account the variations in water resource management practices in the study areas and therefore gave us the opportunity to have enough regional variations in cropping pattern, use of seeds and their sources. This helped us to address the issues we intended to probe in this study.

Seven districts were selected: Thakurgaon, Pabna, Rajshahi, Chuadanga, Jhenaidah, Mymensingh and Netrokona. These districts are from six agro-ecological zones of Bangladesh which have distinct land texture, elevation and vegetation.[1] We selected one Upazila from each district and four unions from each Upazila. The criterion for choosing unions was that two unions would be closer to the Upazila Sadar while the other two would be far away. Two villages were chosen from each union; 24-26 households were randomly selected from two villages of each union. That is, 100 households were chosen from each district. The list of districts, upazilas, unions and villages and the corresponding number of households surveyed is given in Table II.

TABLE II
STUDY AREA AND SAMPLE DISTRIBUTION

District	Upazila	Union	Village 1	Village 2	No. of Households
Thakurgaon	Haripur	Haripur	Kholora	Jibonpur	24
		Bakua	Battala	Bokua Noyatuli	26
		Dangipara	Kanchal	Rahmatpur	25
		Bhaturia	Gobindopur	Dhakdah	25
District total					100
Pabna	Bera	Haturia Nakalia	Jagannathpur	Haturia	24
		Chakta	Paturia	Chakla	26
		Ruppur	Charpara	Boronowgaon	24
		Masumdia	Kazi Sharif Pur	Kazipara	26
District total					100
Rajshahi	Godagari	Godagari	Aihai	Saguan	24
		Rishikul	Chabbish Nagar	Vanpur	26
		Gogram	Gogram	Teropara	24
		Matikata	Ujanpara	Harisankarpur	26
District total					100

(Contd. Table II)

[1] http://www.bbs.gov.bd/userfiles/Image/ArgYearBook11/Chapter-1.pdf

District	Upazila	Union	Village 1	Village 2	No. of Households
Chuadanga	Damurhuda	Karpasdanga	Kutubpur	Hudapara	24
		Koralgachi	Sadabor	Buichatala	26
		Perkrishnopur	Monda	Sarabaria	24
		Hawli	PuratonHawli	Joyrampur	26
District total					100
Jhenaidah	Kaliganj	Niamatpur	Norendrapur	Niamatpur	24
		Roygram	Megurkhirda	Doyapur	26
		Rakhalgachhi	Mandarbaria	Hasanhati	24
		Kashtabhanga	Tetulbaria	Molladanga	26
District total					100
Mymensingh	Phulpur	Rupasi	Boroikandi	Pagla	24
		Balia	Moddhobaria	Daxinbalia	26
		Galagaon	Boherakanda	Mulbari	24
		Tarakanda	Koirakanda	Bakshimul	26
District total					100
Netrokona	Barhatta	Barhatta	Kashtola	Bikromsree	24
		Shahata	DH Shal	Machahala	26
		Baushi	Salipura	Kandapara	24
		Roypur	Roypur	Namapara	26
District total					100
Total sample size					700

IV. RESULTS

4.1 Which Crops are Produced with More Formal Seeds?

Since one of the objectives of this paper is to know who uses formal seeds more, we start with some descriptive statistics which highlights the extent of use of formal and informal seeds for a wide variety of crops. A farmer typically obtains seeds from a host of sources, apart from his own saved seeds. The source varies widely with the type of crops. In Bangladesh the BADC serves most of the rice seed market and the private sector and NGOs are more active in other non-rice crops such as maize, vegetables, etc. (Ali, Ahmed and Mannan 2014, Jaim and Akhter 2012).

The extent of use of informal seeds as opposed to formal seeds (retailers, BADC dealers, NGO dealers, private companies) is an issue of major concern for the policy makers as the productivity of former is found to be much lower than the latter in literature. In order to address this issue, we study the extent of use of formal and informal seeds in three different ways: (i) in terms of use of formal and informal seeds used in the crops, (ii) in terms of the proportion of farmers using formal and informal seeds, and (iii) in terms of land used under formal and

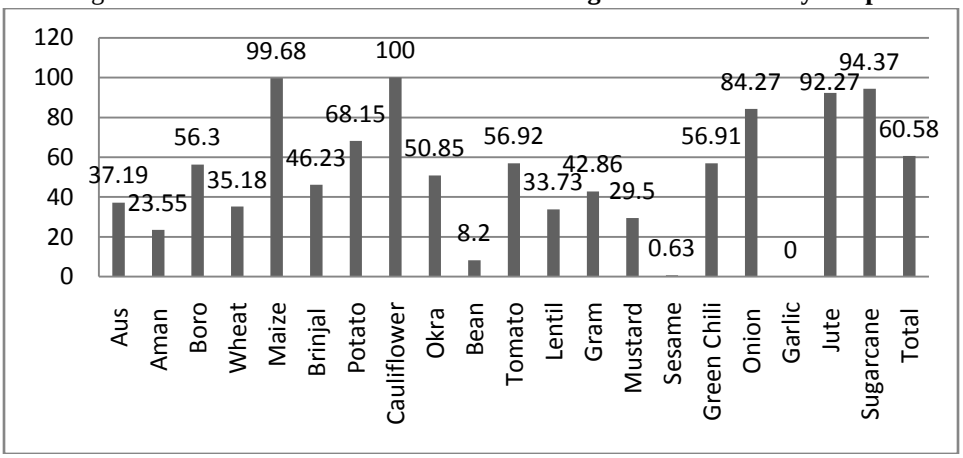
informal seeds. Note that our analysis is based on seeds only; seedlings have not been taken into account.

We also report 20 crops and the extent to which these crops are cultivated by the farmers (Table A1 in appendix). This will help place the next analysis on the extent of use of formal and informal seeds in context. The table shows that Boro and Aman are the most cultivated crops - out of 700 farmers (households), 656 and 615 farmers cultivated Boro and Aman respectively. Interestingly, in terms of land under cultivation, Aman was found to exceed Boro (127 decimals vs. 120 decimals). In our sample, 221 households cultivated wheat and 109 households cultivated maize. The amount of land under these two crops is also similar, approximately 70 decimals. Other notable crops in terms of the number of farmers and amount of land include mustard, jute and lentil.

4.1.1 Use of Quantity of Formal and Informal Seeds by Crops

We first focus on the share of formal seeds in terms of total seeds used by crops (Figure 1). We have found that about 61 per cent of total seeds used are formal seeds. Ali, Ahmed and Mannan (2014) have found that around 46 per cent of the seeds used by the farmers are bought from the market, mainly from the dealers.

Figure 1: **Share of Formal Seeds as a Percentage of Total Seeds by Crops**



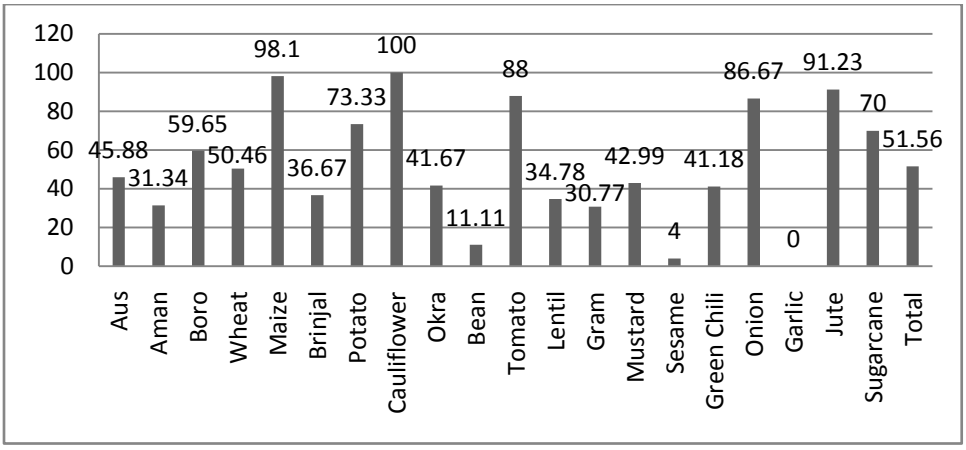
Amongst rice seeds, Boro has the highest formal seed component (56 per cent), followed by Aus (37 per cent) and Aman (24 per cent). Similar finding is reported by Ali, Ahmed and Mannan (2014) where the proportions of formal seeds are 74, 42 and 40 per cent for Boro, Aus, and Aman respectively although the extent of use of formal seeds is much higher than what we have found. In terms of proportion of seeds saved for next year, the same ranking is found by

Ali, Ahmed and Mannan (2014); the lowest for Boro (.85 per cent of total Boro crops produced), followed by Aus (1.93 per cent) and Aman (2.10 per cent). This study also found that the use of formal seeds is the highest for vegetables. MoA (2006) reports highest use of formal seed for Boro (46.2 per cent), followed by Aus (45.2 per cent) and Aman (21.8 per cent). MoA (2006) collected data for 2004 and 2005 and finds the use of formal seeds very low as compared to this study as well as to that of Ali, Ahmed and Mannan (2014). Therefore, it is quite clear that the use of formal seeds for rice production has increased substantially between 2004 and 2014. However, MoA (2006) reported the findings for two successive years (2004 and 2005) and found that the extent of use of formal seeds has been increasing for all crops and this happened when price of all seeds from all sources increased markedly during the short span of a year.

4.1.2 Use of Formal and Informal Seeds by the Farmers by Crops

In this case, we consider those farmers who use only formal seeds for a particular crop. We have not taken into account the mixed group separately who use both formal and informal seeds. The mixed group is lumped under the group of informal seeds. Figure 2 shows that 52 per cent of the farmers have used formal seeds in our sample. In the case of Aus, we found that about 46 per cent of the farmers have used formal seeds alone. These percentages are 31 per cent and 60 per cent for Aman and Boro respectively. Almost all the farmers who grow cauliflower and maize are found to use formal seeds only. Farmers are more likely to depend only on formal seeds in the case of jute (91 per cent), tomato (88 per cent), onion (87 per cent), potato (73 per cent), and sugarcane (70 per cent). This establishes the general view that formal seeds are more prevalent in the production of vegetable/maize and less in cereal.

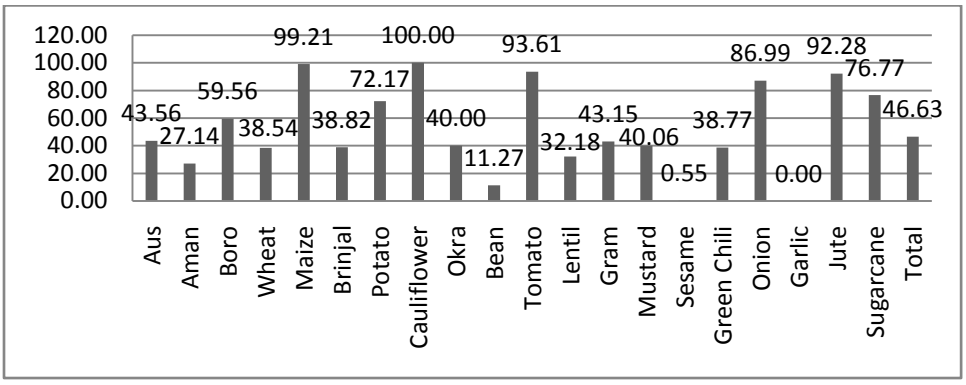
Figure 2: **Percentage of Farmers using Formal Seeds by Crops**



4.1.3 Use of Land under Formal and Informal Seeds by Crops

Seed Replacement Rate is the percentage of area sown out of total area of crop planted in the season by using certified/quality seeds other than the farm saved or other informal seed. Figure 3 shows the percentage of land cultivated by using formal seeds by the farmers in the sample. About 47 per cent of total land has been found under formal seeds for all crops. The seed replacement rate is significanlty high for cauliflower, maize, tomato, onion, jute and sugarcane. In the case of rice, the ratios are 44, 27 and 60 per cent for Aus, Aman and Boro respectively. These findings are in line with the information presented in Figures 1 and 2.

Figure 3: **Percentage of Land Used under Formal Seeds by Crops**



The formal sources of seed are as heterogeneous as informal sources. Table III documents the share of each source for a particular crop. In this case the share is defined in terms of percentage of farming households using particular source for a particular crop.

TABLE III
VARIOUS SOURCES OF SEEDS BY CROPS (%)

Crop	Source								Total
	Own	Neighbour	Retailer	BADC/ dealer	NGO/ dealer	Mobile vendor	Pvt. company	Others	
Aus	48.2	5.9	31.7	2.4	11.8				100.0
Aman	60.4	8.0	22.6	8.3	0.1	0.3		0.4	100.0
Boro	32.3	7.1	30.7	28.8	0.6	0.1	0.2	0.2	100.0
Wheat	45.3	2.7	34.8	15.4		1.8			100.0
Brinjal	41.2	20.6	35.3					2.9	100.0
Potato	13.3	13.3	66.7	6.7					100.0
Tomato	12.0		88.0						100.0
Mustard	50.9	5.6	34.3	9.3					100.0
Jute	2.9	0.6	67.3	9.4	5.3	4.7	9.9		100.0

Own saved seeds dominate other formal sources of seed in the case of Aman and Aus.[2] About 61 per cent of Aman seeds and 48 per cent of Aus seeds are own saved seeds. For these two crops, farmers purchase more from retailer than from BADC dealers. In the case of Boro, own saved seeds (32 per cent), retailers (31 per cent) and BADC/dealers (29 per cent) all have more or less equal shares, though own saved seeds slightly dominate. For rice, other sources such as NGOs, mobile seed vendors and private companies occupy a meagre share. However, for Aus, about 12 per cent of seeds are purchased from NGO dealer.

In the case of wheat also, own seeds dominate; 45 per cent of households use this source, followed by retailers (35 per cent) and BADC dealers (15 per cent). Farmers purchase most of their vegetable seeds from the retailers – 67 per cent of potato and 88 per cent of tomato seeds are purchased from the retailers. Interestingly, in the case of jute, private companies have about 10 per cent of share.

Table III shows that although there is a large number of sellers in the seed markets, some of them play a minor role. They are agents of the private companies, mobile seed vendors and NGO seed dealers. Informal seeds in the context of Bangladesh mainly constitute saved seeds and seeds exchanged with friends and neighbours. Besides own seeds, the retailers are the major source of seeds for the farmers. Although the extent varies, similar picture comes out from the study we have on the demand side of the seed market.

4.2 Who Use Formal Seeds More?

The factors responsible for the adoption of any new technology or input are of utmost importance to the policy makers. Insights into the factors that determine the uptake of formal seeds will help policy makers improve seed replacement rate and thus the overall agricultural productivity. The discussion carried out so far ignored the key players, the farmers, and assumed that land ownership has no role to play in the choice of formal seeds. In this section, we study how the shares of formal and informal seeds change with land ownership. First, this is studied with the help of some descriptive statistics and then we conduct some econometric analysis to study the determinants of adoption of formal seeds.

[2]It is found from field visits that those who grow seeds on their own follow a cycle: there is a cycle of using BADC seeds and home grown seeds. For example, in the first year, farmers use BADC seeds to grow rice. They store a small fraction of rice for the next year to use them as seeds. They use home grown seeds only for one or two years as their productivity falls after that.

4.2.1 Landholdings and Use of Formal Seeds

Since estimates of income of rural households are less reliable than the landholdings, we rely on the latter to study the role of landholdings in determining the extent of use of formal and informal seeds.

We report the results in terms of rice (Table IV) and non-rice crops (Table V) separately. We categorise the households into five landholding groups: marginal, small, medium, large and very large. We consider the share of formal and informal seeds from two aspects – in terms of percentage of households and in terms of share of land.

First consider rice (Table IV). Greater share of households and cultivable land of the small farmers (i.e. landholding group owning 50–100 decimals of land) is under formal seeds. For the next three landholding groups (medium, large and very large farmers), the shares of households using formal seeds are 49, 43 and 35 per cent respectively. These percentages are 51, 41 and 31 per cent respectively in terms of percentage of land cultivated by formal seeds. These declining shares indicate a pattern that as the size of land ownership increases, the shares of households and land using formal seeds decline, except for the marginal farmers who own less than 50 decimals of land. Note that among the farmers having land larger than 750 decimals, only about 35 per cent of the households use formal seeds of rice in 31 per cent of land. Note in particular that proportionately more marginal farmers (46 per cent) use formal seeds and commit proportionately more land (44 per cent) to formal seeds as compared to large and very large farmers.

TABLE IV
SHARE OF FORMAL AND INFORMAL SEEDS BY LANDHOLDING GROUPS (RICE)

	In terms of % of households		In terms of % of cropped lands	
Land ownership (decimal)	Informal (%)	Formal (%)	Informal (%)	Formal (%)
Marginal (<=50)	54.0	45.9	55.9	44.1
Small (>50 to <=100)	46.9	53.1	45.5	54.5
Medium (>100 to <=250)	50.9	49.1	48.9	51.1
Large (>250 to <=750)	57.5	42.5	59.2	40.8
Very large (>750)	64.5	35.5	68.6	31.4
Total	53.9	46.1	56.6	43.5

Table IV indicates that the farmers who do not save enough seeds use formal seeds more than the farmers who do. The cost of saving seed might be lower for large farmers – in terms of space-cost and labour cost for storing and monitoring.

Discussions with the stakeholders also reveal that the small farmers usually do not have good storage facilities (space and storing conditions) they require to store the seeds. This also forces them to rely more on the market.

Another argument is based on the precautionary motive of the farmers. Since large farmers need large amount of seed, they do not want to take the risk of not having enough seed available in the market when demanded. Small farmers requiring small amounts of seeds do not have that much risk.

MoA (2006) also found that despite their resource constraints, a larger proportion of small farmers compared to medium and large farmers used certified seed in all crop seasons. The reasons for this, as the study mentions, could be their lack of resource to set apart a portion of their produce as seed vis-à-vis the ability of large and medium farmers to do so easily.

Now consider other non-rice crops (Table V). As noted earlier, the use of formal seeds for non-rice crops is much higher than that of rice crops and this is true for all landholding groups. About 60 per cent of the households use formal seeds of non-rice crops and allocate 56 per cent of their land for formal seeds of non-rice crops. Similar to rice, the percentage of households using formal non-rice crop seeds and the proportion of land allocated for formal seeds declines with the size of landholdings. About 70 per cent of the marginal farmers use formal non-rice crop seeds and this percentage is higher than any other landholding group. For example, in contrast, 61 per cent of very large farmers use formal non-rice crop seeds. However, for the very large farmers this share is higher than the medium and large farmers, though it is much lower than the poorest group. We find similar pattern of the use of formal seeds in the case of non-rice crops in terms of percentage of cropped land under formal seeds. The marginal and small farmers use more land for cultivation of non-rice crops by formal seeds compared to medium, large and very large farmers.

TABLE V

SHARE OF FORMAL AND INFORMAL SEEDS BY LANDHOLDING GROUPS (NON-RICE CROPS)

Land ownership (decimal)	In terms of % of households		In terms of % of cropped lands	
	Informal (%)	Formal (%)	Informal (%)	Formal (%)
Marginal (<=50)	30.4	69.6	31.6	68.4
Small (>50 to <=100)	37.1	62.9	35.7	64.3
Medium (>100 to <=250)	41.2	58.9	45.9	54.1
Large (>250 to <=750)	52.3	47.7	52.9	47.1
Very large (>750)	39.2	60.8	43.1	56.9
Total	40.1	59.9	43.7	56.3

4.2.2Accounting for other Determinants of Uptake of Formal and Informal Seeds

The above paragraphs shed light on the role of land ownership in determining the uptake of formal and informal seeds. We have found that smaller farmers use more formal seeds and commit more of their land to formal seeds. We have also found that the choice of crops also determines the extent of use of formal seeds. However, this does not take into account other factors such as socioeconomic and geographical characteristics that may also influence the choice of seeds. In order to gain insight into the factors that determine the choice of formal seeds, we estimate two regression models: one for only rice and the other for all crops.

One can argue that characteristics of crops, households and regions influence the choice between formal and informal seeds. We use dummies for 6 types of crops – rice, non-rice cereal, vegetables, pulses, spices, and cash crops (jute and sugarcane). We also distinguish between local and HYV/hybrid crops by incorporating the variable HYV that takes the value 1 for HYV/hybrid crops and 0 otherwise. Household characteristics are captured by land ownership and education of household head. We use district dummies to control for district level observed and unobserved characteristics. We use a binary variable–choice of seeds - as the dependent variable which assumes 1 when the seed is formal and 0 otherwise. We estimate the following regression model for all crops where *i* denotes households and *c* denotes crops. Therefore, unit of observation is a household-crop pair.

$$\text{Choice of seeds}_{i,c} = \beta_0 + \beta_1 \text{type of crop}_{\text{i}} + \beta_2 \text{HYV} + \beta_3 \text{landholding}_{\text{i}} + \beta_4 \text{education of household head}_{\text{i}} + \text{u}_{\text{i,c}} \quad (1)$$

We estimate the following regression model for rice where *i* denotes households and *t* denotes types of rice (Aus, Aman and Boro).

$$\text{Choice of seeds}_{i,t} = \beta_0 + \beta_1 \text{type of rice}_{\text{r}} + \beta_2 \text{HYV} + \beta_3 \text{landholding}_{\text{i}} + \beta_4 \text{education of household head}_{\text{i}} + \text{u}_{\text{i,t}} \quad (2)$$

Regression Results

All Crops

Table VI reports the OLS results for regression model (1) specified above. The first column of the Table VI is the base result which includes only the crop related variables. The second column adds the variable HYV while the third column includes logarithm of land holding successively. Since the relationship between landholding and adoption of formal seeds is the mainstay of our analysis, our variable of interest in this regression table is the landholding variable. In the fourth column we add years of schooling of the household head

as a proxy for the socioeconomic characteristics of the household. The more educated the household head is, it is more likely that s/he would adopt the formal seeds. Inclusion of education variable also helps isolate the effect of formal seeds from the knowledge of the farmers. In column five we include district dummies to control for regional variations in cropping practices and uses of seeds.

TABLE VI

DETERMINANTS OF CHOOSING FORMAL SEEDS: DEPENDENT VARIABLE: BINARY VARIABLE: 1=FORMAL SEEDS, 0=INFORMAL SEEDS

	(1)	(2)	(3)	(4)	(5)
Non-rice cereal	0.200***	0.132***	0.106***	0.105***	0.197***
	(0.029)	(0.027)	(0.029)	(0.029)	(0.029)
Vegetable	0.153***	0.243***	0.219***	0.218***	0.239***
	(0.042)	(0.039)	(0.043)	(0.042)	(0.040)
Pulses	-0.180***	0.020	0.035	0.036	0.079*
	(0.046)	(0.043)	(0.046)	(0.046)	(0.044)
Spices	-0.003	0.205***	0.198***	0.192***	0.170***
	(0.032)	(0.031)	(0.034)	(0.033)	(0.033)
Cash crops	0.361***	0.290***	0.290***	0.287***	0.265***
	(0.033)	(0.031)	(0.033)	(0.033)	(0.032)
HYV		0.451***	0.449***	0.446***	0.438***
		(0.019)	(0.022)	(0.022)	(0.023)
log(Landholding)			-0.037***	-0.027***	-0.026***
			(0.008)	(0.009)	(0.008)
Years of schooling				-0.008***	-0.002
				(0.002)	(0.002)
Pabna					0.399***
					(0.032)
Rajshahi					0.205***
					(0.041)
Chuadanga					0.412***
					(0.031)
Jhinaidah					0.224***
					(0.036)
Mymensingh					0.547***
					(0.032)
Netrokona					0.345***
					(0.035)
Constant	0.461***	0.138***	0.315***	0.309***	-0.044
	(0.012)	(0.018)	(0.044)	(0.044)	(0.050)
Observations	2,792	2,792	2,455	2,455	2,455
R-squared	0.062	0.214	0.201	0.205	0.312

Note: Standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note that rice is the reference group of type of crops. With respect to rice, all types of crops except spices have positive and statistically significant coefficients. That is, the likelihood of using formal seeds is higher for non-rice cereals (wheat and maize), vegetables (cauliflower, green chilli, etc.), spices and cash crops (sugarcane and jute) than that of rice. The size of the coefficients is also very meaningful. It shows that, for example, the likelihood of using formal seeds for vegetables is about 24 per cent higher than that of rice (specification 5). This is very much consistent with the earlier finding that the use of formal seed is much higher for non-rice crops such as maize, sugarcane, potato, etc. as shown in Figures 1-3. It sheds light on the fact that increase in the formal seeds in Bangladesh is channelled mainly through non-rice crops. This has strong policy implications for the seed sector in Bangladesh. This shows that Bangladesh may have more scope to increase rice production through increasing the use of quality seeds, particularly through producing more varieties of the Aman rice crop.

If the seed is HYV or hybrid, the chances for adopting it by the farmers go up by about 44 per cent compared to local variety. Hybrid seed is the domain of the private sector. The private sector and the NGOs are also heavily involved in the multiplication of HYV seeds and they can promote the use of formal seeds in Bangladesh.

The result on landholding is also very interesting. In Tables IV and V, we found the inverse relationship between size of landholding and use of formal seeds. The regression results also corroborate this. It shows that a 1 per cent increase in landholding decreases the chance of using formal seeds by 0.03 per cent. Districts dummies are all positive and significant. It implies that district level heterogeneity captures significant variations of the adoption of formal seeds.

Rice

Table VII reports OLS results for regression model 2 for rice. In this case also variables are added staggeringly so that we can check the robustness of results across specifications. Note that Aus rice is the reference group of the types of rice. It shows that coefficients of Boro rice are not significant. It may be the case that the variable HYV has picked up the explanatory power of Boro as a large share of Boro rice is HYV. As in Table VI, the sign of landholdings is negative, implying that land-rich farmers are less likely to cultivate rice with formal seeds. In particular, a 1per cent increase in landholding leads to about 0.02 per cent decrease in the likelihood of adopting formal rice seeds.

TABLE VII

DETERMINANTS OF CHOOSING FORMAL SEEDS: DEPENDENT VARIABLE: SHARE OF LAND UNDER FORMAL SEEDS OF RICE

	(1)	(2)	(3)	(4)	(5)
Aman	-0.145***	-0.205***	-0.251***	-0.252***	-0.327***
	(0.055)	(0.049)	(0.062)	(0.062)	(0.057)
Boro	0.136**	-0.012	-0.048	-0.049	-0.085
	(0.055)	(0.050)	(0.062)	(0.062)	(0.057)
HYV		0.476***	0.471***	0.465***	0.405***
		(0.024)	(0.027)	(0.027)	(0.033)
Log (Landholding)			-0.025**	-0.016	-0.019*
			(0.011)	(0.011)	(0.010)
Years of schooling				-0.007**	-0.000
				(0.003)	(0.003)
Pabna					0.485***
					(0.040)
Rajshahi					0.173***
					(0.051)
Chuadanga					0.416***
					(0.038)
Jhinaidah					0.242***
					(0.047)
Mymensingh					0.618***
					(0.033)
Netrokona					0.415***
					(0.036)
Constant	0.459***	0.218***	0.386***	0.379***	0.094
	(0.052)	(0.048)	(0.079)	(0.079)	(0.084)
Observations	1,701	1,701	1,498	1,498	1,498
R-squared	0.076	0.251	0.240	0.243	0.410

Note: Standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.3 Productivity Difference between Formal and Informal Seeds

We are particularly interested to know the productivity differences between formal and informal seeds because the main rationale for promoting use of formal seed is that it is more productive than informal seeds. We use revenue per decimal of land and output per decimal of land as the dependent variable for all crops and rice respectively. For all crops, we cannot use the variable total physical product per decimal simply because of adding-up problem.

In this case, our variable of interest is the dummy variable of formal seeds. We also control for types of crops, household characteristics and district level heterogeneity. Since productivity of seeds varies significantly with types of crops, we include dummies to capture whether the crops are non-rice cereal, vegetables, pulse, spices and cash crops. The literature on farm-size and productivity sheds light on the fact that productivity of crops critically depends

on the size of farm-holding. Therefore, we use logarithm of landholding in our regression. Productivity of crops is also argued to be higher for the farmers who are knowledgeable about best practices and we use the education of the household head to control for it. Regional variations in weather, soil quality and topography are controlled by district dummies.

We estimate the following regression model for all crops where *i* denotes households and *c* denotes types of crops.

$$\text{Revenue per decimal}_{i,c} = \beta_0 + \beta_1 \text{d\_formal seeds}_{ic} + \beta_1 \text{d\_types of crops}_i + \beta_3 \text{landholding}_i + \beta_4 \text{education of household head}_i + u_{i,c} \quad (3)$$

We estimate the following regression model for rice where *i* denotes households and *t* denotes types of rice (Aus, Aman and Boro).

$$\text{Output per decimal}_{i,t} = \beta_0 + \beta_1 \text{d\_formal seeds}_{it} + \beta_1 \text{d\_types of rice}_i + \beta_2 \text{d\_HYV} + \beta_3 \text{landholding}_i + \beta_4 \text{education of household head}_i + u_{i,t} \quad (4)$$

Regression Results

All Crops

The choice of seeds between formal and informal crucially depends on the relative cost and benefit to the farmers. Hence, revenue per decimal is a good appropriate approximation of productivity of seeds. We also take logarithm of the dependent variable for a meaningful interpretation in terms of percentage. Table VIII reports the OLS results of regression model 3. As before, five sets of regression specifications have been used, from the most parsimonious one (column one) to the full-blown one (column five), allowing us to judge how robust the size and significance of the coefficients are, specifically our variable of interest – formal seed.

Note that the coefficients for formal seeds are positive and significant. That is, it shows that use of formal seeds increases revenue per decimal by 11per cent-15 per cent. Compared to rice, per decimal revenue for vegetables is more than 100 per cent higher. Larger farmers are found to have higher productivity; a 1 per cent increase in the size of landholding is associated with about 0.02-0.04 per cent increase in revenue per decimal. This is interesting because smaller farmers tend to use more formal seeds which are more productive than the informal seeds. On the other hand, revenue per decimal is higher for large farmers. It indicates that large farmers have higher factor productivity from some non-seed inputs such as irrigation, fertiliser, etc.

TABLE VIII

PRODUCTIVITY AND USE OF FORMAL SEEDS: DEPENDENT VARIABLE: LOG OF REVENUE PER DECIMAL OF LAND FOR ALL CROPS

	(1)	(2)	(3)	(4)	(5)
Formal seed	0.136***	0.114***	0.109***	0.107***	0.146***
	(0.026)	(0.025)	(0.027)	(0.027)	(0.029)
Non-rice cereal		-0.059	-0.055	-0.055	-0.123***
		(0.039)	(0.041)	(0.041)	(0.043)
Vegetable		1.133***	1.120***	1.120***	1.016***
		(0.057)	(0.063)	(0.063)	(0.064)
Pulses		-0.085	-0.062	-0.062	-0.165**
		(0.060)	(0.065)	(0.065)	(0.066)
Spices		-0.048	-0.014	-0.017	-0.008
		(0.042)	(0.046)	(0.046)	(0.049)
Cash crops		-0.039	-0.058	-0.058	-0.146***
		(0.047)	(0.050)	(0.050)	(0.051)
Log (Landholding)			0.021*	0.026**	0.035***
			(0.012)	(0.013)	(0.013)
Years of schooling				-0.004	-0.009***
				(0.003)	(0.003)
Pabna					-0.128***
					(0.047)
Rajshahi					-0.128**
					(0.058)
Chuadanga					0.134***
					(0.047)
Jhinaidah					0.204***
					(0.048)
Mymensingh					-0.098**
					(0.050)
Netrokona					-0.238***
					(0.054)
Constant	5.742***	5.717***	5.621***	5.619***	5.620***
	(0.019)	(0.019)	(0.062)	(0.062)	(0.069)
Observations	2,747	2,747	2,411	2,411	2,411
R-squared	0.010	0.141	0.130	0.130	0.170

Note: Standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Rice

Table IX reports OLS results for regression model 4 for rice specified above. We followed similar specification as in Table VIII. Note that in this case the dependent variable is quantity of various crops per decimal of land. Aus rice is

the reference group of the types of rice. It shows that productivity gain from using formal seeds varies widely with the extent of controls (7-21 per cent). However, since in specification 5 we controlled for all possible observed and unobserved heterogeneity, 10 per cent productivity gain is a more plausible estimate.

Productivity of Boro is about 41 per cent higher than that of Aus when formal seeds are used in both crops. The productivity of rice also increases with the size of landholding; larger farmers enjoy higher yields per decimal for rice than the smaller farmers, for a given level of quality of seeds.

Years of schooling of the household head is not significant. Some district fixed effects are also found very significant such as Pabna, Chuadanga and Netrokona.

TABLE IX

PRODUCTIVITY AND USE OF FORMAL SEEDS: DEPENDENT VARIABLE: LOG OF OUTPUT PER DECIMAL FOR RICE

	(1)	(2)	(3)	(4)	(5)
Formal Seed	0.209***	0.082***	0.069***	0.071***	0.100***
	(0.023)	(0.021)	(0.022)	(0.022)	(0.026)
Aman		-0.197***	-0.161***	-0.160***	-0.060
		(0.048)	(0.059)	(0.059)	(0.061)
Boro		0.278***	0.317***	0.318***	0.411***
		(0.047)	(0.058)	(0.058)	(0.060)
Log (Landholding)			0.027***	0.024**	0.034***
			(0.010)	(0.011)	(0.011)
Years of schooling				0.002	-0.001
				(0.003)	(0.003)
Pabna					-0.151***
					(0.042)
Rajshahi					-0.024
					(0.049)
Chuadanga					0.131***
					(0.041)
Jhinaidah					0.056
					(0.039)
Mymensingh					-0.045
					(0.037)
Netrokona					-0.147***
					(0.039)
Constant	-0.896***	-0.887***	-1.039***	-1.037***	-1.144***
	(0.016)	(0.046)	(0.075)	(0.075)	(0.083)
Observations	1,696	1,696	1,493	1,493	1,493
R-squared	0.046	0.259	0.267	0.267	0.300

Note: Standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1

V. DISCUSSIONS, POLICY OPTIONS AND CONCLUSIONS

The supply of formal seeds in Bangladesh is characterised by the government establishing firm control over variety development of 7 notified crops, particularly rice. The private sector is mostly involved in multiplication, producing certified or TLS seeds of rice. The major supplier is BADC, particularly in rice seeds supply. The private sector is heavily involved in the supply of vegetables and maize seeds. Private investment has taken place mainly in downstream seed supply initiated by the introduction of voluntary seed certification (Huda and Smolders 2002). The distribution channel is dominated by the private sector and comprises dealers, agents, mobile vendors, NGOs with overlapping in the sources of seed supply (semi-formal segment of the seed market).

Given this basic characteristics of the supply side of the seed market, this paper pays exclusive attention to the demand side of the issues related to the seed sector. It looked at the extent of use of formal seeds by the farmers by crops as well as by size of the farm. Given the structure of the supply side, we have found that formal seeds are adopted more for vegetables and maize while rice and wheat seeds have a higher informal content. These informal seeds come mainly from own saved seeds and purchases from other farmers. The role of other sources of informal seed such as mobile seed vendors is marginal.

We have then looked at adoption of seeds by land size and found that smaller farms are more dependent on formal seeds as compared to the large ones. In contrast to large farmers, proportionately more marginal and small farmers use formal seeds and they allocate proportionately more land to cultivation by using formal seeds, i.e. they have a larger seed replacement rate. There is no easy answer to this. We conjecture that the cost of holding seeds for the next season is higher for smaller farms. They either have less space for saving seeds or whatever space they have may not be safe or they have to meet immediate demand for food. The smaller farms may have larger social networks and buy or exchange seed with other small farmers. This finding has mirror image with other aspects of Bangladesh agriculture when experts were concerned whether small farms would be able to adopt Green Revolution technology as prices of inputs such as water and fertiliser could be prohibitively high for them.

We then looked into revenue earned by small and large farms and found that in general adoption of formal seeds is more profitable and brings in higher revenue per decimal of land. In the case of rice, use of formal seeds could raise production by around 10 per cent.

We have also found that the larger farms have higher revenue per decimal for all crops and higher land productivity for rice. This indicates that although the smaller farms are more inclined to use formal seeds, the larger farms get more revenue and more rice per decimal of land. This result is difficult to explain and requires different information and analysis beyond the scope of this paper. This possibly indicates that some non-seed inputs are more productively used by the large farmers. It may well be the case that the lands owned by the large farms are of better quality, have better access to irrigation or the larger farmers have improved access to credit and use of capital intensive techniques. While this paper cannot identify the factors that made large farmers more productive, it definitely points to the fact that the welfare of the small farmers cannot only be improved by supplying more formal seeds. Other factors of production such as credit, irrigation, etc. have to be taken into consideration if small farmers are to benefit more from using formal seeds. Whatever be the case, the government should try to increase the supply of formal seeds and ensure its smooth supply and quality. Effort should be made to raise awareness of the benefits of using formal seeds, especially the productivity gains.

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SCA (undated), Seed Standard and Field Standard of Notified and Non-Notified Crops, (Approved by NSB). Seed Certification Agency (SCA), Ministry of Agriculture, Gazipur-1701.

APPENDIX

TABLE A1

NUMBER OF FARMERS AND AREA OF LAND BY CROPS

Crop	Number of farmers cultivated this crop	Amount of land per farmer under this crop
Aus	83	72.1
Aman	615	127.0
Boro	656	119.6
Wheat	221	71.8
Maize	109	69.0
Brinjal	33	16.8
Potato	15	34.73
Cauliflower	1	33.0
Okra	1	33.0
Bean	22	18.5
Tomato	25	64.1
Lentil	47	50.8
Gram	13	82.5
Mustard	108	78.4
Sesame	51	88.1
Green Chili	21	14.3
Onion	80	63.5
Garlic	13	27.9
Jute	171	53.9
Sugarcane	19	142.8