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FACTORS OF ADOPTION AND FARMERS' PERCEPTIONS ON IMPROVED LENTIL VARIETY CULTIVATION IN BANGLADESH

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Abstract

For a sector to be successful in bringing innovation at the farm level, an understanding of potential adopters and the factors influencing their adoption decision is important. Hence, this study investigated the determinants of adoption and explored farmers' perceptions on improved lentil variety cultivation at the farm level in Bangladesh. The study analyzed 360 household's data collected from 240 improved lentil variety adopters and 120 non-adopters spread in the six lentil growing districts namely Faridpur, Magura, Kushtia, Jhenaidah, Manikgonj, and Sirajganj. Along with descriptive statistics, the study used probit regression model for analyzing the data. About 71% of households adopted improved lentil varieties, and 29% used local cultivars. BARI Masur-8 was the highest adopted variety in the highly-intensive growing areas, whereas BARI Masur-6 and BARI Masur-4 were popular in the medium-intensive and low-intensive growing areas. Pulse training, profitability of production, farmers' innovativeness, and farmer's extension contact were the major factors of improved variety adoption. Most farmers wanted to increase improved lentil cultivation in the next year considering the higher yield and net benefits. On the contrary, a good proportion of lentil farmers also wanted to decrease lentil cultivation due to lack of suitable land, biotic and abiotic stresses, and seeds of improved variety.

Keywords: Factors of adoption, farmer's perception, improved lentil variety, Probit regression model, Bangladesh.

1. Introduction

Pulses are important food crops of Bangladesh as it supplies nutrition for human diet (Das et al., 2016.), provides feed for the animal (Miah et al., 2009), increase soil nutrient status by adding nitrogen, carbon and organic matter (Senanayake et al., 1987; Zapata et al., 1987; Sarker and Kumar, 2011), and improves farmers' livelihood by enabling additional income. The favourable climatic condition exists in Bangladesh for growing pulses. Different types of pulses are grown all over the country. The local production of pulses almost remained static in the last five years, causing a rise in imports of pulses to meet the growing demand. The cost for importing lentils has been increasing with an annual growth rate of 13.4% during the period from 2010-11 to 2019-20 to meet the growing demand (BBS 2015, 2018,

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2020). The per capita consumption of pulse in our country is only 15.7 g/day (HIES, 2016) which is much lower than the desirable intake of 50 g/day (DDP, 2013).

Lentils (*Lens culinaris*) are important protein-rich legumes. Among the pulse crops in Bangladesh, lentils placed the first position according to area coverage (40% of total pulse area) and production (45% of total pulse production). It is cultivated in different parts of the country covering 146.03 thousand hectares of lands producing 185.50 thousand metric tonnes per year with a productivity of 1.27 t/ha (BBS, 2022). It is the most consumed pulse in the country and also ranks first among the pulses in terms of consumers' preferences (Miah and Rahman, 1991; Afzal et al., 1999). The area and production of lentils were found fluctuating in nature, but the yield registered an increasing trend over the years. Figure 1 shows that the area and production of lentils started decreasing from 2000-01 and continued up to 2008-09 that might be due to susceptible crop and less remunerative in production. To halt this steady decline trend, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have disseminated some improved lentil varieties and popularized them through different projects. Inclusion of these varieties in the cropping patterns replacing local by improved varieties might be increased the area, production, yield, and profitability of farmers. Hence the area, production, and yield of lentils further increased steadily from 2009-10 to 2019-20. However, the annual growth rates of the area decreased by 0.152%, while the growth rates of production (2.62%) and yield (2.77%) significantly increased during 2000/01-2019/20 due to the introduction of improved lentil varieties and technologies. However, various businesses and importers say that the country's yearly requirement for lentils is around 6-7 lakh MT (Daily Star, 2022). Therefore, the country has to import a huge amount of lentils every year to meet up the domestic demand.

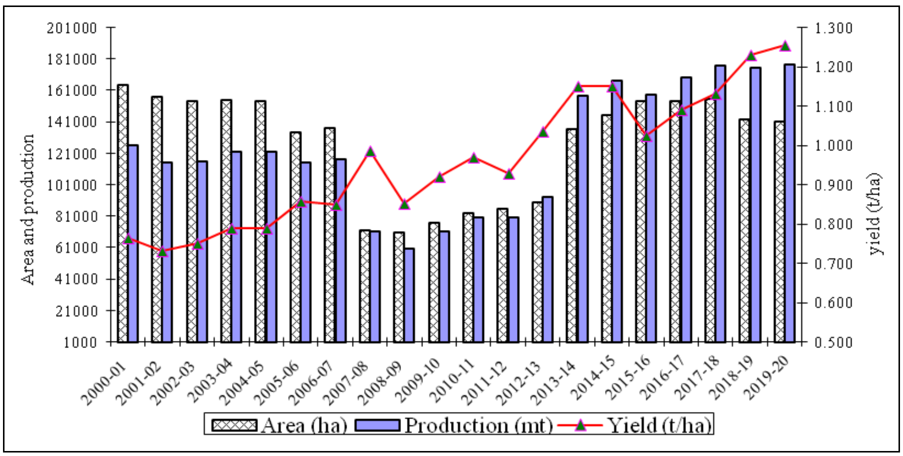

Figure 1: Trend of area, production, and yield of lentils in Bangladesh.

Source: Various issues of BBS (2021, 2016, 2011, 2006).

The scientists of BARI have been launching the pulse Research and Development program since 1991 and have developed nine improved lentil varieties along with their management technologies. BINA has also developed and disseminated seven improved lentil varieties since 2001. The lentil technologies so far developed have been disseminated in the farmers' fields through different agencies such as DAE, NGOs, and research institutes (*i.e.* BARI, BINA). The rate of adoption and sustainability of any crop depends largely on its profitability. The adoption decision involves a critical comparison of perceived benefits and costs associated with the technology (Uaiene, 2011). Economic viability is one of the important criteria for assessing the suitability of a new crop technology. Different studies conducted in the past (Miah et al., 2021a; Sarker et al., 2020; Matin et al., 2018; Tithi and Barmon, 2018; Hossain et al., 2016; Islam et al., 2015) revealed the suitability of improved lentil varieties adoption in terms of productivity and profitability for the adopting farmers.

The potential benefits of a new technology can only be realized when it is adopted and used properly. The variety-wise adoptions of any crop at the household level varied over time since their releasing periods are quite different. However, the current adoption status of BARI-developed improved lentil varieties are unknown to researchers and policymakers. Because a limited number of studies exist on the adoption of BARI improved lentil varieties (Miah et al., 2004; Miah et al., 2009; Rahman et al., 2012) in Bangladesh with varied conclusions. Most of these studies were conducted on a limited sample size covering a narrow geographical location. However, due to various unknown reasons, many farmers in the country are still reluctant to adopt these improved varieties that need to be explored. Again, an understanding of potential adopters and the factors influencing their adoption decision is important for a sector to be successful in bringing innovation at the farm level. However, the results of the present study will guide producers, research institutions, and policymakers in making prudent and informed decisions about allocating researches for technology development and the widespread cultivation of improved lentils in Bangladesh. With this view in mind, the study was undertaken to: (i) know the adoption status of improved lentil varieties at the farm level, (ii) explore the factors affecting the adoption of improved lentil varieties, and (iii) know the perception of farmers towards lentil cultivation.

2. Materials and Methods

2.1 Sampling design

A multi-stage sampling procedure was followed to select study areas and sample households. Based on the crop concentration index, the study was conducted in purposively selected six lentil growing districts of Bangladesh, taking Faridpur and Magura districts from highly-intensive growing areas, Kushtia and Jhenaidah districts from medium-intensive growing areas, and Manikgonj and Sirajganj districts from low-intensive growing areas. Again, in each district two *Upazilas* (administrative unit) and from each *Upazila* one/two Agricultural Blocks (ABs) were purposively selected for collecting data and information from the sample farmers. The *Upazilas* and ABs were chosen in consultation with Agricultural Extension Officer, Sub-assistant Agriculture Officer (SAAO), and the local scientists of Bangladesh Agricultural Research Institute (BARI). Finally, two lists of lentil growing farmers (adopter and non-adopter farmers) were prepared separately for each AB, and then a total of 30 farmers, taking 20 farmers from adopters and 10 from non-adopters were randomly selected from each *Upazila* for interview. The adopter farmers were those who cultivated improved varieties of lentils and non-adopting farmers cultivated only local varieties of lentils. Thus, the total numbers of adopting and non-adopting sample farmers were 240 and 120 respectively (Table 1).

Table 1. Distribution of sample lentil growing farmers in the study areas

Study area	District	Adopter	Non-adopter	All category
Highly-intensive growing area	Faridpur	40	20	60
(*CCI value = 5.54-11.31)	Magura	40	20	60
Medium-intensive growing area	Kushtia	40	20	60
(CCI value = 1.09-4.87)	Jhenaidah	40	20	60
Low-intensive growing area	Manikgonj	40	20	60
(CCI value = 0.02-0.83)	Sirajganj	40	20	60
All areas		240	120	360

* Crop concentration index (CCI) = (Total area under lentils ÷ Total cropped area) × 100 (Miah et al. 2021a) Source: Field survey (2021)

2.2 Data collection procedure

Data for the present study were collected by interviewing sample lentil growers with the aid of a pre-designed and pre-tested interview schedule during the period from March to April 2021. Both trained enumerator and researcher collected primary data. Concerning this study, secondary data on lentil area and production were collected and used to supplement the study.

2.3 Analytical techniques

In most cases, a tabular method of analysis supported with appropriate statistical parameters was used to present the study results. The following econometric model was used in this study.

Probit model: A Probit model has been used extensively by agricultural economists for analyzing farmers' adoption and diffusion of agricultural interventions. In many studies (Miah et al., 2004; Akter et al., 2010; Miah et al., 2015), this model was used to find out the factors of modern variety adoption or examine the role of intervention of development. The Probit model is based on a cumulative normal distribution function which is symmetric around zero with variance equal to 1. The maximum likelihood estimation method was followed to run the model using STATA software.

Within the area of econometrics, the commonly illustrated Probit model is in the following form (Sevier and Lee, 2004) shown in equation (1):

$$\Pr(y = 1|x) = \beta_0 + \beta_n X + \varepsilon \quad \text{………………………………………………} (1)$$

The following equation (2) represents the final Probit model used in this study.

$$\Pr(y = 1|x) = \beta_0+\beta_1 lnX_1+\beta_2 lnX_2+\beta_3 lnX_3+\beta_4 lnX_4+\beta_5 lnX_5+\beta_6 lnX_6+\beta_7 lnX_7+\beta_8 lnX_8 +\beta_9 lnX_9+\beta_{10} lnX_{10}+\varepsilon \text{--} (2)$$

Where,

$\Pr(y = 1|x)$ = Adoption of improved lentil varieties (If adopted= 1; Otherwise= 0)

β_0 = Intercept

β_i = Coefficients of the respective variables (i = 1, 2, 3 ----------10)

X_1 = Farm size (decimal)

X_2 = Farmer's age (year)

X_3 = Education (year of schooling)

X_4 = Training on pulse cultivation (No./life time)

X_5 = Active family member (No./HH)

X_6 = Household income (Tk./year)

X_7 = Net profit from lentil production (Tk./ha)

X_8 = Farmers' innovativeness (Score)

X_9= Farmers' extension contact (Score)

X_{10}= Suitable land for lentil (decimal)

ε = Error term

3. Results and Discussion

3.1 Adoption of improved lentil varieties

Since 1991, BARI has developed nine improved lentil varieties for farm-level cultivation. The Department of Agricultural Extension (DAE) has been involved in disseminating improved lentil varieties across the country. The responding households (*n=360*) were asked to tell the total number of farmers who cultivate the improved and local varieties of lentils in their areas. It was reported that 70.8% of the lentil growing households in the entire study areas cultivated different improved varieties of lentils, whereas the share of local variety was 29.2%. However, the rate of adoption of improved lentil varieties was much higher in the medium-intensive growing areas compared to high- and low-intensive growing areas might be due to the intensive demonstration of improved lentil varieties. The adoption of improved lentil varieties was found to be very low (41.5%) in the low-intensive growing areas might be due to the less demonstration of improved lentil varieties (Table 2). The overall adoption situation indicates the wider scope of disseminating improved lentil varieties in the study areas.

Table 2. Rate of adoption of improved lentil variety in the entire study areas

Type of variety cultivated	Highly-intensive growing area		Medium-growing area		Low-growing area		All growing area	
	HH*	%	HH*	%	HH*	%	HH*	%
Improved	672	73.3	374	84.7	119	41.5	1165	70.8
Local	245	26.7	67	15.3	168	58.5	480	29.2
All types	916	100	442	100	287	100	1646	100

Note: * indicates the total number of households cultivated lentils in the entire study areas

The variety-wise adoption of lentils at the farm level has been presented in Table 3. The study reveals that the most adopted lentil variety in the study areas is BARI Masur-6 (24.4%) which is followed by BARI Masur-8 (21.9%) and BARI Masur-4 (13.9%). The variety-wise adoption scenario varies from location to location. BARI Masur-8 is the most adopted variety in the highly-intensive growing areas due to its higher demonstration by the Pulses Research Centre of BARI which is located near to the study areas, whereas BARI Masur-6 and BARI Masur-4 are the most popular in the medium-intensive and low-intensive growing areas due to less demonstration. The variety adoption is likely to influence by different factors which are stated in section 3.2.2.

A limited number of studies exist on the adoption of improved varieties of lentils in Bangladesh with varied conclusions. The adoption of different lentil varieties varied from location to location over time since the releasing periods of the varieties and influencing factors are different. Miah et al. (2004) noted that 44% of the sampled farmers had adopted improved pulses and the highest adopted variety was BARI Masur-4 (97%) in six pulse growing areas, while Sarker (2011) noted that 100% of sampled farmers had adopted improved varieties of lentils. Again, Miah et al. (2009) stated that 32% of traditional lentils was replaced by different improved BARI and Binamasur varieties up to 2007. In 2011, Rahman et al. (2012) noted that 98% of total lentil areas were planted to BARI lentil varieties in Jhenaidah and Jashore districts, and the highest adopted varieties were BARI Masur-3 (49%) and BARI Masur-4 (47%). The adoption share was only 1% for BARI Masur-5 and -6. An expert elicitation revealed that the highest adopted variety in Bangladesh was BARI Masur-6 (30%) followed by BARI Masur-4, -3, and -5 (Rashid et al., 2018).

Table 3. Adoption of different lentil varieties by the respondent farmers

Variety/cultivar	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All area	
	N	%	N	%	N	%	N	%
BARI Masur-8	69	57.5	10	8.3	-	-	79	21.9
BARI Masur-7	-	-	10	8.3	13	10.8	23	6.4
BARI Masur-6	11	9.2	55	45.8	22	18.3	88	24.4
BARI Masur-4	-	-	5	4.2	45	37.5	50	13.9
Local cultivar	40	33.3	40	33.3	40	33.3	120	33.3
All	120	100	120	100	120	100	240	100

Source: Field survey, 2021

The total land devoted to lentil cultivation was 64,228 ha in the study areas in which 71.4% of areas were covered by BARI lentil varieties, 11.9% covered by BINA lentil varieties, and 15.4% by local cultivars. BARI Masur-7 and -8 planted to the highest area among different improved varieties (Table 4). Again, the highest proportion (79.8%) of lentil area was planted to BARI lentil varieties in the low-intensive growing areas followed by medium-intensive (77.4%), and highly intensive growing areas (70.2%). Some Indian lentil varieties were also covered 11.3% of medium-intensive growing areas (Jhenaidah and Kushtia district).

Table 4. The area devoted to cultivating different lentil varieties in the study areas, 2019-20

Variety	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All growing area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
BARI Masur-9	754	1.4	-	-	-	-	754	1.2
BARI Masur-8	17749	33.0	637	8.5	55	1.9	18442	28.7
BARI Masur-7	3742	6.9	1100	14.7	25	0.9	4867	7.6
BARI Masur-6	14078	26.1	3222	43	532	18.4	17832	27.8
BARI Masur-5	250	0.5	700	9.3	-	-	950	1.5
BARI Masur-4	-	-	94	1.3	953	33.0	1047	1.6
BARI Masur-3	1201	2.2	48	0.6	739	25.6	1988	3.1
BINA Masur-8	5188	9.6	127	1.7	-	-	5315	8.3
BINA Masur-6	2330	4.3	-	-	-	-	2330	3.6
Indian variety	-	-	843	11.3	-	-	843	1.3
Local cultivar	8557	15.9	719	9.6	585	20.2	9860	15.4
All variety	**53850**	**100**	**7489**	**100**	**2888**	**100**	**64228**	**100**

Source: Local DAE Office, 2021

Tasty and easily boilable (91%), higher demand and market price (85%), and the availability of seed (63%) were the major reasons for cultivating local varieties (Miah et al., 2021). The non-adopting farmers have been traditionally cultivating local varieties of lentils for a long time and they may not be conscious enough for cultivating improved lentil varieties. The area coverage scenario of local variety indicates the need for 3

2 Determinants of adoption of improved lentil varieties

The adoption of improved lentil varieties was likely to be influenced by different socio-economic factors. The results depicted in Table 18 show that the explanatory variables included in the model can explain about 70% of the variation in adopting improved lentil varieties. Among different variables, farm size, training on lentils, net profit, innovativeness, and contract with different extension sources had a positive and significant influence on the adoption of improved lentil varieties in the study areas (Table 5).

Farm size**:** The land is the most important asset for farm households because they mostly depend on the land. The average farm size of adopters and non-adopters was 1.15 ha and 1.07 ha respectively. Adopting households appear to have shared-out, mortgaged-in, and mortgaged-out land holdings slightly lower than non-adopting farmers, but their shared-in and leased-in land were much higher compared to non-adopter farmers (Miah et al., 2021b). Farm size had a positive and significant influence on the adoption of improved lentil varieties in the study areas. The marginal coefficient of farm size is positive and significant at 10% level implying that if farm size is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 17.61%.

Training on lentils: Farmer's training on crop production is important because it can improve their technical skills regarding crop production practices. About 75% of non-adopters had no training exposure on lentil cultivation in their life. The highest proportion of adopting (48.3%) and non-adopting farmers (22.5%) received 1-3 training on lentil cultivation. About 7% of adopters participated in 7-10 training in their life (Miah et al., 2021). The marginal coefficient of training is positive and significant at 1% level implying that if the number of training is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 31.26%. The result is supported by different studies conducted in the past (Islam et al., 2013; Akter et al., 2010).

Net profit: Net profit is one of the vital factors that influence the potential users of any technology at farm level. Sserunkuuma (2005) found that the profitability of improved maize variety significantly contributes to decision-making involving the use of land management technologies. However, net profit in this study had a positive and highly significant impact on the adoption of improved lentil varieties at farm level.

Innovativeness: Agricultural innovation is considered an important aspect of farming all over the world (Avermaete *et al.,* 2003). It is one of the best means of achieving competitive advantage and revenue growth in a rapidly changing environment (OECD, 2011; World Bank, 2006; Milestad *et al.*, 2012). Farmers' innovativeness is often claimed to be an important determinant of the adoption of new technology, increasing productivity and higher income for the farm families

(Eneji *et al.*, 2012). However, eight different innovative practices were considered in this study. All these practices were assigned different values (0 for no practice and 3 for regular practice) according to their importance. The total score was measured by adding all the values. The farmer with higher score value indicates more advanced towards different innovative practices. The marginal coefficient of innovativeness is positive and significant at 1% level implying that if the score of innovative practices is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 24.28%.

***Extension contract*:** Farmers with good extension linkage have more responsive to up-to-date information regarding modern agricultural technologies than non-linkage farmers. Therefore, extension linkage should have a positive effect on the adoption of improved lentil technologies at the farm level. Ten different extension Media were considered in this study. The possible total scores for extension contact were ranged from 0 to 40. The total score of extension contact was much higher for adopters compared to non-adopters implying that the adopters of improved lentil varieties were more advance in communicating with different extension Media compared to non-adopters (Miah et al., 2021). The marginal coefficient of extension contact is positive and significant at 10% level implying that if the score of extension contact is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 8.87%. The result is supported by different studies conducted in the past (Miah *et al.*, 2004; Miah *et al.*, 2015; Begum *et al.*, 2020).

Table 5. The marginal effect of the variables determining adoption of improved lentil varieties among respondent farmers

Explanatory variable	Coefficient	Marginal effect (dy/dx)	Standard Error	z-statistic	Probability (P>|z|)
Constant	-36.9606***	--	5.0389	-7.340	0.000
LnFarmSize (decimal)	0.5509	0.1761*	0.0935	1.880	0.060
LnAge (year)	0.2319	0.0741	0.1513	0.490	0.624
LnEducation (year)	-0.0850	-0.0272	0.0520	-0.520	0.601
LnTraining (Score)	0.9779	0.3126***	0.0816	3.830	0.000
LnActiveMember (No.)	0.0917	0.0293	0.0990	0.300	0.767
LnIncome (Tk/yr)	-0.0778	-0.0249	0.0661	-0.380	0.706
LnNetProfit (Tk/ha)	3.4079	1.0895***	0.1493	7.300	0.000
LnInnovativeness (Score)	0.7593	0.2428***	0.0777	3.120	0.002
LnExtContact (Score)	0.2774	0.0887*	0.0521	1.700	0.089
LnSuitableLand (decimal)	-0.4012	-0.1283*	0.0693	-1.850	0.064

Note: Number of observation = 360; LR chi-square (10) = 319.53; Log likelihood = -69.3825; Prob>chi^2 = 0.000; Pseudo R^2 = 0.6972. '***' and '*' represent significant at 1% and 10% level respectively. A higher score value represents the higher probability of improved variety adoption.

3.3 Farmers' decision towards future lentil cultivation

The respondent farmers were asked to mention the probability of expanding their cultivated area for lentil cultivation. In this regard, 72% of adopters and 58.3% of non-adopters showed their willingness to increase lentil cultivation in the next year. About 8% of adopting and 18% of non-adopting farmers wanted to decrease the lentil area in the next year. The proposed area increase for cultivating improved and local lentils will be 42 and 47 decimal respectively (Table 6). A good percentage (21-24%) of respondent farmers keep their lands unchanged for lentil cultivation. The farmers who wanted to decrease or unchanged their present lentil areas in future should be encouraged to expand their lands for improved lentil cultivation to increase their benefit and improve soil fertility.

Table 6. The willingness of farmers to increase lentil cultivation in the next year

Type of change	Adopter (*n=240*)			Non-adopter (*n=120*)		
	n	%	Proposed area (dec)	n	%	Proposed area (dec)
Increase	172	71.7	41.6	70	58.3	46.6
Decrease	18	7.5	27.7	21	17.5	33.8
Remain unchanged	50	20.8	--	29	24.2	--

Their justification and eagerness behind increasing lentil cultivation in the future were reasoned with anticipation of securing higher yields, preferable lentil prices, less infestation of disease and insects, and lower cultivation costs. The other reasons for increasing lentil cultivation are shown in Table 7.

Table 7. Reasons for increasing land for lentil cultivation in the next year

Causes of increasing	Adopter (*n=172*)			Non-Adopter (*n=70*)		
	n	%	Ranking	n	%	Ranking
1. More profitable than other crops	98	57	1	38	54	2
2. Higher yield	95	55	2	12	17	6
3. Less infestation of disease and insects	92	54	3	7	10	8
4. Need low input and less care	90	52	4	28	40	3
5. Higher demand or price	61	36	5	47	67	1
6. Short-duration crop	28	16	6	10	14	7
7. Meet up family demand	15	9	7	17	24	4
8. Availability of suitable land	7	4	8	5	7	10
9. Availability of seed in the market	5	3	9	15	21	5
10. Get boiled easily	--	--		7	10	9
11. Others	11	6	10	8	11	11

Note: Other causes included meet seed demand, cultivate as intercrop crop or chance crop, cultivate new lands, creates fertilizer, etc.

Some adopting and non-adopting lentil farmers mentioned various reasons for not expanding their lentil area in the next year. They opined that suitable/cultivable land was scarce and they need to grow other crops. The unavailability of good seed was the 3rd and 5th ranked problem of adopters and non-adopters respectively. The 4th ranked problem was the infection of diseases that discouraged them to expand lentil cultivation in the future. Seventy-two percent of non-adopters wanted to reduce the cultivation of local lentils only because of their low yield (Table 8).

Table 8. Reasons for decreasing lands for lentil cultivation in the next year

Causes of decreasing	Adopter (n=18)			Non-Adopter (n=21)		
	n	%	Ranking	n	%	Ranking
1. Scarcity of cultivable land	15	83	1	18	86	1
2. Other crops need to be grown	11	61	2	14	67	3
3. Unavailability of good seeds	8	45	3	4	19	5
4. Infection of diseases	3	17	4	10	48	4
5. Low yield	2	11	5	15	72	2
6. Others	7	39	6	6	29	6

Note: Other causes included lack of irrigation facility, labour shortage, lack of training, adverse weather, lack of good seeds, etc.

3.4 Facility demanded by farmers for increasing lentil cultivation

Many respondent farmers suggested that some facilities need to be created for them to expand their lentil area soon. All of their demanded needs are displayed in Table 9. High-yielding and disease-resistant varieties are pre-requisites for expanding lentil cultivation throughout the country. The highest proportion of adopters (17%) and non-adopters (31%) in the study areas mentioned the need for high-yielding and disease-resistant varieties. Training is an important tool that enhances the knowledge and skill of the farmers. It is noted that 13% of respondent farmers were approached to provide hands-on training regarding lentil production. As farmers require liquid money at the time of cultivation, institutional credit facilities should be made available at the proposed period to enable farmers to increase the volume of production. On average 8% of respondent farmers wanted easy access to institutional credit facilities consisting of feasible and soft terms and conditions in conjunction with the overwhelming high interest rates on non-institutional credit. The availability of cultivable land is a significant element for growing or expanding areas for lentils. About 7% of lentil farmers wanted to expand their cultivation for the next year if they could manage additional cultivable land on lease or mortgage with low cost. Irrigation is an important input for crop production as it helps increase crop productivity to some extent. Most of the study areas are facilitated with irrigation but, some improved lentil farmers (6%) are still distressed over the disparity of inadequate irrigation facilities. As a result, they demanded immediate support in the emphasized facilities in the study areas.

Table 9. Facilities demanded by the lentil farmers for increasing lentil cultivation

Causes of decreasing	Adopter (*n=240*)		Non-Adopter (*n=120*)		All category (*n=360*)	
	n	%	n	%	n	%
Need high yielding and disease-resistant variety	41	17	39	33?	80	22
Required training	31	13	17	14	48	13
Need hassle-free credit facility	16	7	12	10	28	8
Need low-cost lease land	18	8	7	6	25	7
Assurance of fair price of lentil	15	6	9	8	24	7
Adequate irrigation facility	14	6	--	--	14	4

4. Conclusion

This study was conducted to assess the adoption of improved lentil varieties, and the profitability and bottlenecks of its cultivation at the farm level. It revealed that improved lentil variety adoption is encouraging in the study areas except for low-intensive growing areas, but still, there are ample opportunities of spreading these varieties among pulse farmers. Training on pulse cultivation, the profitability of production, farmers' innovativeness, and the extension contact of farmers are the major factors of adoption in the study areas. The yield of improved variety is much higher than local cultivars. The highest yield was found in medium-intensive growing areas due to the use of better variety and higher levels of inputs. The cultivation of improved lentils is highly profitable from the financial point of view but moderately profitable from an economic perspective. Although the domestic production of improved lentils has a comparative advantage, the production of local cultivars has no comparative advantage due to lower production, higher production costs, and the lower import price of lentils. The overall production problems were not severe as opined by the lentil farmers of improved and local varieties. However, the infection of diseases and some abiotic stresses are the major bottlenecks of lentil cultivation. Farmers' perceptions reveal that most of the respondent farmers wanted to increase lentil cultivation in the next year considering the higher yield and net benefits of improved lentils. Oppositely, a good portion of lentil farmers also wanted to decrease lentil cultivation due to lack of suitable land, biotic and abiotic stresses, and seeds of improved variety.

It is vital to encourage farmers to cultivate and expand their lands for the cultivation of improved lentil varieties to improve soil fertility, increase the comparative advantage of production, raise the benefit of farmers, and achieve self-sufficiency in pulses in Bangladesh. For achieving these targets, Government ensure the adequate supply of high-yielding and disease-resistant seeds of improved lentil varieties at the farm level and provide hands-on training to the farmers on lentil cultivation and crop management practices. The Field Service

Wing of DAE should take initiatives through their related projects in this issue in association with national research institutes (*i.e.* BARI, BINA) and BADC. The agricultural extension services should be more strengthened for disseminating the improved lentil technologies among farmers. The appropriate measures for reducing the wage rate of labour and ensuring the irrigation facility may be the stimulus of expanding lentil cultivation in the study areas. Finally, the ongoing pulse research should be strengthened for evolving high-yielding new lentil varieties along with improved management technologies.

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