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ADOPTION OF MUNGBEAN TECHNOLOGIES AND TECHNICAL EFFICIENCY OF MUNGBEAN (*Vigna radiata*) FARMERS IN SELECTED AREAS OF BANGLADESH

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Abstract

Mungbean is one of the most important pulse crops in Bangladesh. The demand of mungbean is very high due to its good taste. To date, different national institutes released 14 improve mungbean varieties with complete package of technologies and disseminated them to the farmers. But, the farm level adoption of mungbean varieties, their economics, and farmer's efficiencies are not well known to the researchers and policy planners. Therefore, the study assessed the farm level adoption of mungbean technologies, technical efficiency of mungbean growers, and find out constraints to its higher production. Data were collected from 283 randomly selected mungbean farmers from Jessore, Kushtia, and Barisal districts during March-April 2009. The highly adopted mungbean varieties were BARI Mung-3, 4 and 5. Technologies, such as ploughing, weeding, and seed rate occupied higher level of adoption. Sowing time and insect-pest control were medium level and irrigation was lower level adoption. In case of chemical fertilizer, urea secured higher level of adoption followed by TSP and MoP. The yield and net return of mungbean was 1196 kg and Tk. 15678 per hectare, respectively. The benefit cost ratio was 1.69 and 2.47 on full cost and cash cost basis, respectively. About 67% farmers achieved more than 90% technical efficiency level. Twenty eight percent farmers' technical efficiency level, between 81-90% and the rest 5% farmers' technical efficiency level was less than 80%. Diseases and pest infestation, lack of good quality seed, lack of knowledge about improved technologies were the major constraints to mungbean cultivation. Government should provide hand-on training and distribute quality seed to the farmers for increasing the area of mungbean cultivation.

Keywords: Mungbean, adoption, technical efficiency.

Introduction

Pulses are the most important protein in the diet of the majority of the people of Bangladesh. It contains about twice as much protein as cereals. It also contains amino acid lysine, which is generally deficit in food grains (Islam, 2007). Pulse bran is also used as quality feed for animals. Apart from these, the ability to fix

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nitrogen and addition of organic matter to the soil are important factors in maintaining soil fertility (Senanayake *et al.*, 1987; Zapata *et al.*, 1987). In the existing cropping systems, pulses fit well due to its short duration, low input, minimum care required and drought tolerant nature. Among the food legumes grown, lathyrus, lentil, chickpea, blackgram, and mungbean are the major and they contribute more than 95% to the total pulses production in the country (Rahman 1998). The present production of pulses can meet not more than 30% of the total national demand (Afzal and Bakar 2004). The rest 70% is being met up in every year by importing pulses using valuable foreign currencies.

Mungbean (*Vigna radiate L.*) is grown round the year (Three times) in Bangladesh. It provides grain for human consumption as it contains 19.5% to 28.5% protein (AVRDC, 1988). Mungbean supplies a substantial amount of nitrogen to the succeeding non-legume crops (i.e., rice) grown in rotation (Sharma and Prasad 1999). Currently, this crop is being cultivated after harvesting of Rabi crops (i.e., wheat, mustard, lentil, etc.). As a short duration crop, it can be fitted in as a cash crop between major cropping seasons. The present area under mungbean cultivation is 27.44 thousand ha with a total production of 19.45 thousand tons and an average yield of 0.708 t/ha (BBS, 2011). In spite of various positive sides, most of the mungbean areas are replaced by cereals (Abedin and Anwarul, 1991). The growth rates of production and yield are positive and highly significant but the growth rate of its area is less than half (0.32%) during 1982-2011. The area growth rates were even negative during 1992-01 and 2002-11 (Table 1).

Fourteen varieties of mungbean have been developed by different institutes like Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), and Bangabadhu Sheikh Muzibur Rahman Agricultural University (BSMRAU) and disseminated them with the complete package of management technologies to the farmers for cultivation. Mungbean cultivation is gaining popularity among the farmers day by day. But, the farm level adoption of mungbean technologies, their economics at farm level, and farmer’s technical efficiencies in cultivating the crop are not well known to the researchers and policy planners. Therefore, an attempt was made to study this important crop with the following objectives.

(i) to know the level of adoption of improved mungbean varieties and their management technologies at farm level;

(ii) to estimate the cost and return of mungbean cultivation;

(iii) to measure the technical efficiency of mungbean growers; and

(iv) to identify the constraints to mungbean cultivation and suggest remedial measures for its improvement.

Table 1. Mean, coefficient of variation and growth rates of area, production, and yield of mungbean in different periods.

Period	Mean	STD	CV (%)	Growth rate (%)
Area (ha)				
1982-91	36834	22805	162	20.54***
1992-01	54527	1005	5426	-0.00
2002-11	30129	10053	300	-7.58**
1982-11	40497	17397	233	0.32
Production (ton)				
1982-91	20271	12366	164	19.75***
1992-01	32731	1753	1867	1.43***
2002-11	23599	6681	353	-7.40***
1982-11	25534	9538	268	1.93**
Yield (t/ha)				
1982-91	0.556	0.032	1727	-0.73
1992-01	0.600	0.036	1661	1.44***
2002-11	0.804	0.165	486	0.18
1982-11	0.653	0.146	449	1.61***

Source: Using various issues of BBS

Materials and Method

Sampling technique: A multi-stage sampling technique was followed in this study to select study areas and sample farmers. In first stage of sampling, three mungbean growing districts, namely Jessore, Kushtia, and Barisal were selected purposively. In the second stage, one Upazila was selected from each district for sample survey. The names of the Upazilas were Jhekorgacha Upazila under Jessore district, Bharamara Upazila under Kushtia district and Uzirpur Upazila under Barisal district. In the third stage, a total of 283 mungbean farmers were selected by random sampling technique.

Method of data collection and period of study: Data for the present study were collected from sample mungbean farmers through face to face interview method using a pre-tested interview schedule. Field level primary data were collected by the researcher with the help of trained enumerators for the period of March-April, 2009.

Analytical techniques: Both fixed cost and variable cost were taken into account in calculating cost of mungbean cultivation. Land use cost was calculated on the basis of per year existing lease value of land. The profitability of mungbean cultivation was examined on the basis of gross margin, net return and benefit cost analysis. The mungbean cultivating farmers were classified into three categories for determining the adoption level of technologies in terms of variety, management technologies, and input use of mungbean. The categories were developed based on the mean index of the farmer with respect to each technology. A higher index indicates a higher level adoption, while a lower index indicates a lower level adoption of a technology. Adoption level was categorized for mean index > 100 as over use, (70-100) as high, (50-69) as medium, and < 50 as low. The stochastic Cobb-Douglas production frontier model was used for estimating technical efficiency of mungbean producer in the study areas

The empirical Cobb-Douglas stochastic frontier production function with double log form can be expressed as:

$$lnY_1 = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \beta_6 LnX_{6i} + \beta_7 LnX_{7i} + \eta_1 D_{1i} + \eta_2 D_{2i} + \eta_3 D_{3i} + \eta_4 D_{4i} + v_i - u_i \text{---} (1)$$

Where,

Ln = Natural logarithm,

Y_i = Yield of mungbean of the i^th^ farm (Kg/ha)

X_{1i} = Human labor used of the i^{th} farm (man-days/ha)

X_{2i} = Ploughing cost of the i^{th} farm (Tk/ha)

X_{3i} = Seed used by the i^{th} farm (kg /ha)

X_{4i} = Farm yard manure used by the i^{th} farm (kg /ha)

X_{5i} = Fertilizers used by the i^{th} farm (kg /ha)

X_{6i} = Pesticides cost of the i^{th} farms (Tk/ha)

X_{7i} = Irrigation cost of the i^{th} farms (Tk./ha)

D_{1i} = Dummy for land type of the $_i^{th}$ farm (1= Medium high land, 0 = otherwise),

D_{2i} = Dummy for soil type of the i^{th} farm (1= Sandy loam, 0 = otherwise),

D_{3i} = Dummy for sowing date of the i^{th} farm (1=Optimum sowing, o= 0therwise)

D_{4i} = Dummy for seed source of the i^{th} farm (1=Agriculture office, 0= otherwise)

β's and η*'s* are unknown parameters to be estimated

v_i-u_i = Error term

Technical inefficiency effect model

The u_i's in equation (2) are non-negative random variables, called technical inefficiency effects, assumed to be independently distributed such that the technical inefficiency effects for the i^th^ farmer, u_i, are obtained by truncation of normal distribution with mean zero and variance σ_u^2, such that

$$u_i = \delta_0 + \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 z_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + W_i \text{ .--------------- } (2)$$

Where,

z_{1i} = Age of the farm operator of the i^{th} farm (years)

z_{2i}= Education level of the farm operator of the i^{th} farm (year of schooling)

z_{3i}= Family size (persons/household)

z_{4i} = Family income (Tk/yr)

z_{5i} = Experience in mungbean farming (No. of years)

z_{6i} = Dummy for extension contact (1=having contact, 0 = otherwise)

z_{7i} = Dummy for mungbean training of the i^{th} farm (1= Trained, 0= Otherwise)

δ's are unknown parameters to be estimated and W_i s are unobservable random

variables or classical disturbance term, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2, such that u_i is non-negative.

The β, η and δ coefficients are unknown parameters to be estimated, together with the variance parameters, which are expressed in terms of γ is the ratio of variance of farm specific technical efficiency to the total variance of output and has a value between zero and one.

$\sigma^2 = \sigma^2_u + \sigma^2_v$ --- (3)

and $\gamma = \sigma^2_u / \sigma^2$ ---(4)

The estimates for all parameters of the stochastic frontier (1.0) and inefficiency model (2.0) were estimated in a single stage by using the maximum likelihood method. The econometric computer software package FRONTIER 4.1 (Coelli and Battese, 1996) was used to estimate the parameters of stochastic frontier models.

Results and Discussion

Adoption of mungbean varieties

Table 2 showed the adoption level of different mungbean varieties. On an average, 49% farmers adopted BARI Mungbean-5 followed by BARI Mungbean-4 (24%), BARI Mungbean-3 (11%), BARI Mungbean-2 (6%) and Binamoog-5 (6%), respectively. The adoption of mungbean varieties varied from location to location. The highest number of farmers in Jessore (52%) adopted BARI

Mungbean-5 followed by that of Kushtia (49%) and Barisal (47%). On the other hand, 24% farmers in Jessore adopted BARI Mungbean-4 followed by that of Kushtia (24%) and Barisal (23%). It was found that 7% farmers in Barisal adopted Binamongg-5, followed by Kushtia (5%) and Jessore (2%). A small number of farmers in Kushtia and Jessore adopted BU Mungbean- 2 and 3.

Table 2. Adoption of mungbean varieties in different study areas

Percent of farmers

Variety	Jessore	Kushtia	Barisal	All areas
BARI Mung-2	8	4	7	6
BARI Mung-3	12	11	9	11
BARI Mung-4	26	24	23	24
BARI Mung-5	52	49	47	49
Binamngg-2	-	3	2	2
Binamngg-5	2	5	7	6
BU Mung-2	-	2	3	1
BU Mung-3	-	2	2	1
All types	100	100	100	100

Adoption of management technology

The existing level of technology employed in terms of agronomic practices, time of operation, and input use are essential for achieving higher yield and return. The existing levels of technology employed in the production of mungbean are presented in Table 3. Three to four times ploughing and laddering are recommended for mungbean cultivation. On an average, 84% farmers ploughed their land 3 to 4 times and only 16% farmers ploughed their land 1 to 2 times for mungbean cultivation. Based on the adoption index, higher level adoption was occurred in ploughing and laddering. Line sowing was recommended for mungbean cultivation. Adoption of sowing seed was low in all the study areas. It was observed that 52% farmers performed weeding two times, which was recommended for mungbean cultivation and 42% farmers provided weeding one time. Based on the adoption index, the higher level of adoption was occurred in providing weeding to mungbean crop. About 65% farmers irrigated their land one time, whereas only 3% farmers irrigated their land two times. Based on the adoption index, the lower level adoption was found in the application of irrigation. In the study areas, 75% farmers used pesticides and 35% farmers did not use any pesticides in their crop. According to adoption index, medium level adoption occurred in applying pesticides to control insect-pest infestation.

Table 3. Crop management technologies for mungbean cultivation in different study areas.

Technology	Recommendation	Jessore	Kushtia	Barisal	All	Adoption level
1. No. of plowing (% responses)						
1-2		14	21	14	16	
3-4	Recommendation	84	79	86	84	
Adoption index		104	77	82	87	High
2. Sowing method (% responses)						
Broad casting		85	92	94	90	
Line	Recommendation	15	8	6	10	
Adoption index		15	8	6	10	Low
3. Sowing time (% responses)						
2nd Jan. -3rd Jan.	Late Rabi	-	-	49	16	
4th Jan.- 2nd Feb.	Recommendation	-	-	51	16	
2nd Feb.-3rd Feb.	Kharif -1	34	2	-	12	
4th Feb-2nd March	Recommendation	66	98	-	56	
Adoption index		66	98	51	72	Medium
5. No. of weeding(% responses)						
One time		29	44	54	42	
Two times	Recommendation	60	52	44	52	
Three times		11	4	2	6	
Adoption index		91	79	73	81	High
6. No. of irrigation(% responses)						
Not provided		39	36	32	35	
One time		57	62	66	62	
Two times	Recommendation	4	2	2	3	
Adoption index		33	33	34	33	Low
7. Pest control(% responses)						
Do not use pesticides		-	40	34	25	
Use pesticides	Recommendation	100	60	66	75	
Adoption index		100	60	66	75	Medium

Adoption of seed and fertilizer by the sampled farmers is presented in Table 4. The recommended seed rate of mungbean is 40 kg/ha. According to adoption index, it was found that the adoption level of seed was high. The farmers in the study area used lower quantity of urea and TSP and excess quantity of MoP than in recommended doses. Based on the adoption index, urea secured higher adoption level followed by TSP and MoP.

Table 4. Input use and adoption level of mungbean cultivation in different study areas. *(kg/ha)*

Inputs	Recomm-endation	Jessore	Kushtia	Barisal	All areas	Adoption level
Seed	40	35	40	43	39	
Adoption index		88	100	104	97	High
Urea	40-50	34	31	34	33	
Adoption index		86	82	78	82	High
TSP	80-85	62	62	55	60	
Adoption index		76	81	61	73	Medium
MP	30-35	33	35	30	32	
Adoption index		108	118	96	107	Low

Profitability of mungbean cultivation

The cost of mungbean cultivation included all variable cost items like human labour, power tiller, seed, manures, fertilizer, irrigation, insecticide, etc. (Table 5). In case of family supplied inputs, opportunity cost was considered for the study. The cost of land use was calculated on the basis of lease value of land. The costs of mungbean cultivation were Tk. 22689 and Tk. 15564 per hectare on full cost and cash cost basis, respectively. The highest cost was incurred for human labour (55%) followed by seed (10%), power tiller (9%). and fertilizer cost (8%). The cost of mungbean cultivation was found highest in Kushtia (Tk. 24418/ha) followed by that in Jessore (Tk 22021/ha) and Barisal (Tk 21638/ha) due to higher cost of fertilizers and land use.

The average yield of mungbean was found to be 1196 kg per hectare (Table 6). The yield was highest at Jessore (1211kg /ha) followed by Kushtia (1189 kg /ha) and Barisal (1187 kg /ha). The gross margin was found Tk 18173 on variable cost basis. Gross margin was highest in Jessore followed by Kushtia and Barisal area. The net return per hectare was Tk 15678. The net return was highest in Jessore (Tk 18016/ha) followed by Barisal (Tk 14554/ha) and Kushtia (Tk 14091/ha) due to higher gross return. Benefit cost ratio was 1.69 and 2.47 on full cost and cash cost basis.

Table 5. Cost of mungbean cultivation in different study areas.

Items	Cost of production (Tk/ha)			
	Jessore	Kushtia	Barisal	All areas
Human labour:	12060(55)	13205 (54)	11928 (55)	12397(55)
Family	2970	3325	3024	3106
Hired	9090	9880	8904	9291
Power tiller :	2063 (9)	2006 (8)	2054 (10)	2041(9)
Owned	813	401	308	507
Hired	1250	1605	1746	1534
Seed :	2221 (10)	2420 (10)	2495 (12)	2378 (10)
Owned	440	488	522	483
Purchased	1781	1932	1973	1895
Manures (Owned)	29	80	143	84
Fertilizers :	1704 (8)	1860 (8)	1585 (7)	1716 (8)
Irrigation :	469 (2)	850(4)	620 (3)	646 (3)
Owned	94	220	103	139
Hired	375	630	517	507
Insecticides	685 (3)	543 (2)	635 (3)	621(3)
Interest on operating capital	299 (1)	329 (1)	307 (1)	311 (1)
Fixed cost (FC)*	2491(12)	3125 (13)	1871(8)	2495 (11)
Total cash cost (TCC)	14979 (68)	16450 (67)	15360 (66)	15564 (68)
Total variable cost (TVC)	19530(89)	21293 (87)	19767 (91)	20194 (89)
Total Cost (VC+FC)	22021(100)	24418(100)	21638 (100)	22689 (100)

Note: Bracketed figures indicate the percentage of total cost.
* Fixed cost included cost of land use.
Land use cost was calculated on the basis of rental value of land.

Factors of mungbean production

The maximum likelihood estimates for parameters of the Cobb-Douglas stochastic production frontier for mungbean was presented in Table 7. The empirical results indicated that the coefficients of human labour, seed, fertilizer, power tiller, and irrigation cost were found positive and significant at 1, 1, 1, 5, and 5% level, respectively. This implies that the aforesaid variables had a significant and positive impact on mungbean yield. Moreover, the coefficients of dummy variables, such as soil type, sowing date, and seed source were also positive and significant at 10, 1, and 1%, respectively. The dummy for sowing date had the largest positive coefficient (0.964) followed by source of seed (0.739) and soil type (0.269).

Table 6. Profitability of mungbean cultivation in different study areas.

Items	Study areas			
	Jessore	Kushtia	Barisal	All areas
Grain yield (kg/ha)	1211	1189	1187	1196
Price (Tk./kg)	32.67	32.00	30.00	31.56
Gross return (Tk./ha)	40037	38509	36192	38367
Grain	39563	38058	35610	37865
By -product	474	451	582	502
Total cash cost (Tk./ha)	14979	16450	15360	15564
Total variable cost (Tk./ha)	19530	21293	19767	20194
Total cost (Tk./ha)	22021	24418	21638	22689
Gross margin (Tk./ha)	20507	17216	16425	18173
Net return (Tk./ha)	18016	14091	14554	15678
Benefit cost ratio:				
Full cost basis	1.82	1.58	1.67	1.69
Cash cost basis	2.67	2.34	2.36	2.47

Technical efficiency of mungbean farmers

The estimated coefficient of technical in-efficiency model showed that the coefficient of farmers education, income, and farming experience were negative but significant at 1% level which implies that technical inefficiency in mungbean production decreases with the increases in farmers education, income, and farming experiences. The coefficient of training on pulse was positive but not significant and on the other hand, the coefficient of extension linkage was negative but not significant (Table 7).

On an average, 67% farmers of mungbean achieved technical efficiency level of more than 90%. Twenty eight percent farmers' technical efficiency level between 81 and 90% and the rest 5% farmers' technical efficiency level less than 80% (Table 8). In considering locations, farmers in Jessore achieved highest technical efficiency level (94%) followed by that of Kushtia (73%) and Barisal (31%).

Constraints to mungbean cultivation

Although mungbean is opined to be a profitable crop in the study areas, there are several constraints to its higher production. The constraints have been presented in Table 9. About 81% farmers opined disease and pest infestation as a top ranked problem of mungbean cultivation. Other constraints were lack of good quality seed (60%), lack of knowledge of improved technology (50%), and excess rainfall after flowering (20%).

Table 7. Maximum likelihood estimates of the stochastic Cobb- Douglas frontier production function and technical inefficiency model for mungbean in the study areas.

Independent variables	Para-meters	Co-efficient	Standard error	T- ratio
Stochastic Frontier model				
Constant	β_0	0.407***	0.411	9.90
Human labor (Man-days/ha)	β_1	0.306***	0.731	4.18
Power tiller cost (Tk./ha)	β_2	0.497**	0.244	2.03
Seed (kg/ha)	β_3	0.263***	0.458	5.74
Fertilizer (kg/ha)	β_4	0.118***	0.350	3.37
Farm yard manure (kg/ha)	β_5	0.222	0.196	1.13
Irrigation cost (Tk./ha)	β_6	0.395**	0.190	2.07
Insecticides cost (Tk./ha)	β_7	-0.200	0.217	-9.18
Dummy for land type (1=MHL, 0= otherwise)	η_1	-0.169	0.141	-1.19
Dummy for soil type (1= Sandy loam, 0= otherwise)	η_2	0.269*	0.140	1.91
Dummy for sowing date (1= Optimum, 0= otherwise)	η_3	0.964***	0.168	5.72
Dummy for seed source (1= Agricultural office /BARI, 0= otherwise	η_4	0.739***	0.148	4.96
Technical Inefficiency Model				
Constant	δ_0	0.117***	0.380	3.08
Farmers age (Years)	δ_1	-0.645	0.131	-0.49
Farmers education (year of schooling)	δ_2	-0.591***	0.346	-2.47
Family size (person/ hh)	δ_3	-0.150	0.104	-1.44
Farmers income	δ_4	-0.101***	0.363	-2.77
Pulse farming experience (years)	δ_5	-0.514***	0.241	-2.13
Dummy for extension linkage (1= yes, 0= otherwise)	δ_6	-0.284	0.397	-0.71
Dummy for pulse training (1= yes, 0= otherwise)	δ_7	0.351	0.277	1.26
Variance Parameters				
Sigma- squared	σ^2	0.111***	0.274	4.05
Gamma	Γ	0713***	0.152	4.67
Log likelihood function		-	312.33	

Note: ***, ** and * indicate significance at 1, 5 and 10% level of probability, respectively.

Table 8. Distribution of sample farmers by level of technical efficiency.

Technical efficiency level (%)	Jessore		Kushtia		Barisal		Total	
	No. of farmers	%	No. of farmers	%	No. of farmers	%	No. of farmers	%
71-80	-	-	-	-	14	16	14	5
81-90	6	6	26	27	48	53	80	28
91-100	92	94	69	73	28	31	189	67
All level	98	100	95	100		100	283	100

Table 9. Constraints of mungbean cultivation.

(% of farmers)

Constraints	Jessore	Kushtia	Barisal	All	Rank
1. Lack of good quality seed	51	64	64	60	2
2. Disease and pest infestation	97	75	72	81	1
3. Excess rainfall after flowering	20	36	22	26	4
4. Lack of knowledge of improved technology	43	50	56	50	3

Conclusions and Recommendations

It may be concluded from the above discussion that the level of adoption of mungbean technologies are very much encouraging. The adopted promising mungbean varieties are BARI Mungbean-5 and BARI Mungbean-4. The level of adoptions of the crop management technologies, such as weeding, use of urea, and seed rate are also very high. Economic analysis of mungbean production reveals that it is a profitable crop to most of the farmers. They could increase mungbean yield by spending more on tillage operations, crop management (Human labour), seed, fertilizers, and irrigation since these inputs had significant and positive impact on yield. About 67% mungbean farmers could achieve 90% technical efficiency implying that they could increase mungbean productivity through increasing their technical efficiencies in many issues, such as education, income, and farming experience. Although mungbean is a profitable crop, its growers faced different constraints, such as disease and pest infestation, lack of good quality seed, and lack of knowledge of improved technology.

The following recommendations are given based on the findings of the present study.

- Improved variety of mungbean seed should be made locally available to the farmers at proper time. For this reason, government should encourage BADC and private seed companies for producing improved mungbean seed and supply them at reasonable price to the farmers.

- Regular training on mungbean cultivation should be organized by the Department of Agricultural Extension (DAE) in association with BARI for mungbean farmers to develop their technical knowledge about improved cultivation practices of mungbean.
- Motivational campaign through distributing booklets and other supporting materials to the farmers and extension personnel about the improved technologies of mungbean.
- More intensive research should be undertaken by the scientists of BARI and BINA to develop disease and insect-pest resistant mungbean varieties in future.

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