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ADOPTION STATUS AND PROFITABILITY ANALYSIS OF MANGO VARIETIES BARI AAM-3 AND BARI AAM-4 IN RAJSHAHI REGION

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Abstract

The study was conducted in three mango growing districts namely Naogaon, Natore, and Chapainawabganj during 2023 to assess the adoption status of mango var. BARI Aam-3 and BARIAam-4 varieties, thier farm level profitability, and constraints to cultivation at the farm level. A total of 60 farmers taking 20 from each district were randomly selected for interviews. The study revealed that BARI Aam-3 is highly adopted in Naogaon district which covered 61% of the total mango production in that area. Besides, 32% of the mango orchards are occupied by BARI Aam-3 variety in Natore district. Whereas, BARI Aam-4 is highly adopted in Naogaon district which shared 7.5% of the total mango production in that area. The highest fruit yield of BARI Aam-3 was found at 12.56 ton ha^{-1} from a more than 8 years old orchard. Gross return and net return was Tk. 7,26,474 ha^{-1} and Tk. 5,58,474 ha^{-1}, respectively from 8 years above old mango orchard. Regular bearings, higher yield, higher profit, sweetness, and less insect-pest infestation were the prime reasons for choosing BARI Aam-3 and BARI Aam-4 at the farmers' level. Farmers observed very low bearing after 15 years, scarcity of quality saplings, unattractive color, and short shelf life were the major constraints to BARI Aam-3 cultivation. Market controlled by a business syndicate, lack of credit facilities, lack of knowledge about modern cultivation, and lack of storage facilities were common problems opined by the sample farmers.

Keyword: Mango, Cultivation, Adoption, Production, Market, Yield, Profitability.

Introduction

Bangladesh is a predominantly agro-based developing country in the world and its fertility status of soil and weather are very expedient for harvesting different varieties of agricultural products, especially mango. In addition, mango is the most important source of nutrients and energy (Mukherjee et al., 2009) because it is rich in amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins, and

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vitamins, mainly vitamins A and C (Moore, 2004). In Bangladesh, mango is called the king of all fruits but it is native to the Indian sub- continent. The largest amounts of mangos are produced in India, China, Thailand, Indonesia, Bangladesh, Pakistan, Mexico, and Brazil. Nowadays, its worldwide trading is increasing, especially in the USA and European markets for better quality and higher standards.

In Bangladesh, a variety of mangoes including Fajli, Langra, Gopal-bhogh, Misribhogh, Arshini, Laksmanbhogh, Mohonbhogh, Raj-bhogh, Himsagar, Chokanan, Khirshapat, Shurjapuri, Chosha, Hari Bhanga, Shatapora, Kachamitha, and Mollika are produced (Azad et al., 2017). These varieties are mostly grown in Rajshahi, Dinajpur, and Nawabganj where the Rajshahi region alone produces over 270 varieties of mangoes. This area's mango has huge demand in the market both domestically and commercially but there is no large industry in the northwestern region. Most of the people are employed in different jobs like nursing, giving areas of production in Rajshahi, Chapainawabganj, Dinajpur, Rangpur, Kushtia, and Natore is ranged from 35,000 ha to 50,000 ha per year and 50,000 people involved in mango production (BBS 2018). Now a day, Khagrachori and Bandarban are also producing huge quantities of mangos. Bangladesh Agricultural Research Institute (BARI) developed 18 mango varieties. For domestic consumption and international export, BARI developed BARI Aam-3 and BARI Aam-4 mango varieties. gainning popularity . However, the adoption status of those varieties throughout the country is still unknown. Therefore, it is important to know the adoption status of different BARI-released varieties, and cultivation practices, and identify region-based problems. The specific objectives of this study were as follows.

- To know the adoption status of BARI Aam-3 and BARI Aam-4 at the farmers' level;
- To estimate the profitability of BARI Aam-3 and BARI Aam-4;
- To identify social, economic, and biological constraints to BARI Aam-3 and BARI Aam-4 cultivation; and
- To recommend short-term and long-term plans of action for policymakers, researchers, and extension personnel to enhance BARI Aam-3 and BARI Aam-4 production.

Materials and Methods

Sampling Technique and Sample Size

Multi-stage and purposive random sampling techniques were used to select the study areas and sample respondents. In the first stage of sampling, three mango

growing districts namely Naogaon, Natore, and Chapainawabganj were selected purposively based on the area coverage and production of mango. A total of 60 samples taking 20 farmers from each district were randomly selected for this study. Data were collected by experienced field investigators under direct supervision of the researchers using a pre-tested interview schedule.

Analytical Techniques

Data were categorized according to the age of mango orchard like 1st year, 2nd year, 3rd year, 4-8th year and above 8 years. Tabular methods of analysis using descriptive statistics were used in presenting the results of the study. The following equations were used to calculate the profitability of mango cultivation (Gittinger et al., 1984).

Gross return = GRij = YijPij

Net return = GRij – TCij

Gross margin = GRij – TVCij

Where,

GRij = Gross return of j^{th} orchard fori^{th} farmer (Tk./ha)

Pij = Price (Tk./ha) of j^{th} crop received by i^{th} farmer

Yij = Yield of mango of j^{th} orchard for i^{th} farmer(kg/ha)

TC_{ij}= Total cost of j^{th}orchard for i^{th} farmer (Tk/ha)

TVC_{ij}= Total variable cost of j^{th}orchard for i^{th} farmer (Tk/ha)

Analysis of returns to investment

The following techniques were used to estimate the returns to investment of establishing a mango orchard at the farmers' level.

Benefit cost ratio (BCR): BCR analysis is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity. BCR can be used to evaluate the economic merit of a project.

$$Benefit\ \cos t\ ratio\ (BCR) = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+t)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

Net present value (**NPV):** NPV is the current value of all project net benefits. Net benefits are simply the sum of benefits minus costs. The sum is discounted at the discount rate. The following formula is used to calculate NPV:

$$Net\ present\ value\ (NPV) = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Internal rate of return (**IRR)**: IRR is the discount rate for which the present of total benefits equal to the present value of total cost. Generally, the IRR should be greater than the discount rate for a project to be accepted.

$$Internal\ rate\ of\ return\ (IRR) = \sum_{t=1}^{t=n} \frac{B_t - C}{(1+i)^t}$$

$$IRR = Lower\ discount\ rate + Difference\ between\ t(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

Where,

B_t= Total benefit (Tk./ha) in thetth year

C_t = Total cost (Tk./ha) in thetth year

t = Number of year

i = Interest (discount) rate

Results and Discussion

Adoption of BARI Aam-3 and BARI Aam-4 Mango Variety

Table 1 enumerates the extent of adoption of BARI Aam-3 and BARI Aam-4 in the study areas. Among the three survey areas, BARI Aam-3 is highly adopted in Naogaon district which covered 61% of the total mango production in that area. Besides, 23.32% of the mango orchards are occupied by this variety in Natore district. The lowest adopted area was Rajshahi which covered only 6.49% of the total mango production. The adoption of BARI Aam-4 is highly adopted in Naogaon district which occupied 7.5% of the total mango production in that area. Besides, 2% of the mango orchards are occupied by this variety in Chapainawabganj. The lowest adopted area was Rajshahi and Natore which covered only 1% of the total mango production.

Table 1. Percentage of area coverage at farm level in different district

Variety	Naogaon	Natore	Chapainawabganj	Rajshahi
BARI Aam-3	61.0	23.32	7.0	6.49
BARI Aam-4	7.5	1.0	2.0	1.0

Table 2. Varity-wise area coverage (ha) in different Upazila at Chapainawabganj

Sl No.	Name of the Varieties	Study areas						% of total
		Sadar	Shibgonj	Gomustapur	Nachol	Vulahat	Total	
1.	Fazli	750	4600	985	737	923	7995	21
2.	Arshini	585	5790	1230	833	889	9327	25
3.	Langra	320	1850	395	319	229	3113	8
4.	Gopalbhog	250	540	220	97	84	1191	3
5.	Khirshapat	1088	2250	255	310	305	4205	11
6.	Bombe	585	525	15	28	10	1163	3
7.	Laksmanbhog	140	940	195	20	607	1902	5
8.	BARI Aam-3	450	515	297	1307	51	2620	7
9.	Mollika	35	2	5	0	05	47	0
10.	Mohonbhog	5	0	5	0	0	10	0
11.	Kishanbhog	2	0	0	0	0	2	0
12.	Nagfazli	0	0	0	0	1	1	0
13.	BARI Aam-11	55	2	85	105	5	252	1
14.	BARI Aam-4	270	20	140	350	6	786	2
15.	Ranipochondo	2	1	0	0	15	18	0
16.	Kumrajali	1	2	0	0	0	3	0
17.	Haribhog	7	2	5	1	0	15	0
18.	Kachamitha	1	0	1	0	0	2	0
19.	Dudhsor	10	0	2	0	0	12	1
20.	Gourmoti	65	10	50	0	3	128	0
21.	Katimon	105	80	90	110	12	397	5
22.	Mohanonda	30	0	2	0	0	32	1
23.	Boishak	1	0	0	0	0	1	
24.	Localguti	36	2283	13	30	185	2547	2
25.	Othersguti	375	848	240	24	332	1819	3
	Total	5165	20260	4230	4271	3662	37588	100

Table 3.Varity-wise area (ha)and production (MT) in Naogaon district

SL No.	Variety Name	Area (ha)	Production (MT)	Yield (MT/ha)	% of area
1	Nag fazli	940.75	13170	14	3.14
2	Langra	1559	20270	13	5.20
3	Fazli	1420	21300	15	4.73
4	BARI Aam-3	18313.50	255660	13.9	61.05
5	Gupalbhog	646	8400	13	2.15
6	Khirshapat	1388	17350	12.5	4.63
7	BARI Aam-4	2262.50	27150	12	7.54
8	BARI Aam-11	35	490	14	0.12
9	Mollika	44	530	12	0.15
10	Katimon	138.25	1225	8.9	0.46
11	Gourmoti	141.25	1840	13	0.47
12	Haribhanga	34.50	435	12.5	0.12
13	Banana mango	113.25	1235	11	0.38
14	Arshini	2326	3140	13.5	7.75
15	Kumrajali	13	180	14	0.04
16	GutiAam/ local	625	5625	9	2.08
	Total	30000	378000		100

Table 4. Area and production of different mango varieties in Rajshahi district

SL No.	Variety Name	Area (ha)	No. of mango tree	Production (MT)	Yield (MT/ha)	% of total area
1	Laksmanbhog	6535	981605	84952.89	13.00	33.38
2	Gupalbhog	883	151789	11488.99	13.01	4.51
3	Khirshapat	2770	422970	36189.70	13.06	14.15
4	Langra	1650	263926	21460.75	13.01	8.43
5	Fazli	2433	345846	36033.85	14.81	12.43
6	Arshini	1816	333752	27273.25	15.02	9.28
7	BARI Aam-3	1271	501447	15814.20	12.44	6.49
8	Guti/others	1917	290419	21897.87	11.42	9.79
9	BARI Aam-11	9	1350	87.90	9.77	0.05
10	BARI-4	169	52665	2199.50	13.01	0.86
11	Ranipochondo	49	5632	594.43	12.13	0.25
12	Katimon	71.5	10305	434.45	6.08	0.37
13	Banana mango	0.8	365	3.5	4.67	0.004
14	Gourmoti	4	1800	24.40	6.10	0.02
15	Miajaki	0.3	115	0.00	0.00	0.00
	Total	19578.8	3363986		13.201	100

Table 5.Varity-wise area (ha) coverage in different Upazilas of Natore district

SL No.	Variety Name	Sodor	Noldanga	Singra	Guru-daspur	Borai-gram	Lalpur	Bagati-para	Distric t total	% of total
1	Gupalbhog	110	35	30	25	22	110	30	362	6.30
2	Langra	100	45	10	30	50	100	25	360	6.26
3	Khirshapat	150	65	20	30	80	100	95	540	9.40
4	Laksmanbhog	190	85	0	10	110	690	475	1560	27.14
5	Fazli	80	50	52	90	80	120	45	517	9
6	BARI Aam-3	220	85	200	60	100	335	340	1340	23.32
7	Mollika	55	5	10	22	0	10	12	114	1.98
8	Arshini	75	20	0	10	10	240	85	440	7.66
9	Ranipochondo	25	3	0	0	17	0	7	35	0.61
10	Mohonbhog	0	2	3	0	2	0	0	22	0.38
11	BARI Aam-4	14	1	15	0	11	7	20	59	1.03
12	Haribhanga	15	2	10	10	0	1	10	59	1.03
13	Kachamita	0	0	0	0	0	0	5	5	0.09
14	Dudhsor	0	0	0	0	7	0	7	7	0.12
15	krishanbhog	0	0	0	0	6	0	6	13	0.23
16	Gourmoti	10	2	0	0	0	3	3	24	0.42
17	Katimon	1	0	0	0	0	1	1	3	0.05
18	Mohanonda	0	0	0	0	0	0	1	1	0.02
19	Beishaki	0	0	0	0	0	2	3	5	0.09
20	Guti	90	15	20	5	500	91	55	281	4.89
	Total	1135	415	370	292	100	1810	1225	5747	100

Reasons for choosing BARI Aam-3 variety: Table 6 shows that 85% of the respondents cultivated the variety as it is free from alternate bearing. At the same time, 77% of farmers told that BARI Aam-3 cultivation makes them financially profitable, and 73% of farmers mentioned that they obtained a good yield. Besides, several reasons were responsible for adopting this variety such as sweetness and taste (76%) and can plant a lot of saplings on a small piece of land (62%).

Table 6. Percent of responses on the reasons for choosing BARI Aam-3 variety for cultivation

Reasons	Natore	Naogaon	Chapainawabganj	All area
1. No alternate bearing	80	90	85	85
2. Higher profitability	79	75	77	77
3. Higher demand	60	60	62	60
4. Higher yield	75	71	75	73
5. Sweet and tasty	75	78	75	76
6. Needs smaller space to grow	65	60	62	62
7. Higher consumer preference	40	30	35	35
8. Availability of saplings	30	40	32	34

Source: Field survey 2023

Reasons for choosing BARI Aam-4 variety: Table 7 shows that 85% of the respondents cultivated BARI Aam-4 as it is high yielding hybrid variety. At the same time, 77% of farmers also told that BARI Aam-4 cultivation makes them financially profitable because the market price is higher for late harvest and 60% of farmers mentioned that the variety has good potential for export. Besides, several other reasons such as vibrant merun colour at the ripening stage (47%), large size (622%), and low disease and pest attack (35%) were responsible for adopting this variety.

Table 7. Percent of responses on the reasons for choosing BARI Aam-4 variety for cultivation

Reasons	Natore	Naogaon	Chapainawabganj	All area
1. Hybrid variety	80	90	85	85
2. Vibrant merun colour at the ripening stage	50	47	44	47
3.Getting higher price for late harvest	79	75	77	77
4. Export potentialities	60	60	62	60
5. Higher yield	75	71	75	73
6. Large size	65	60	62	62
7. Less disease and pest attack	40	30	35	35

Level of extension contact: Extension agents play a vital role in technology dissemination. DAE is the key agent of the Bangladesh government in the

dissemination of crop-related agricultural technologies from research organizations to farmer's levels. Table 8 reveals that the adopters of BARI Aam-3 and BARI Aam-4 had frequent contact with the extension personnel and neighboring farmers and their level of contacts were more than non-adopters in the study areas. It was opined that about 49% of farmers contacted extension personnel regarding BARI Aam-3 and BARI Aam-4 cultivation which was much higher than that of non-adopters. Contact with mass media (i.e. radio, television, newspaper) was also higher than non-adopters in the study areas.

Table 8: Level of extension contact of mango farmers with different extension Medias

Extension medias	Farmer's responses (%)			
	Frequently	Often	Rarely	Never
A. Adopter				
Extension personnel	27	49	18	6
Neighbor farmer	23	58	17	2
Demonstration plot	3	7	14	76
Participating agricultural fair	-	3	13	84
Television	-	2	4	94
Attend in the field day		8	18	74
Research organization visit	-	4	10	86
Radio	-	6	8	86
Read Newspaper	-	-	4	96
Agriculture booklet/leaflet	-	-	1	99
B.Non-adopter				
Extension personnel	18	34	23	25
Neighbor farmer	17	44	7	32
Demonstration plot	6	29	18	47
Participating agricultural fair	2	3	11	84
Television	2	4	17	77
Attend in the field day	-	-	6	94
Research organization visit	--	12	17	71
Radio	-	-	-	100
Read Newspaper	-	-	-8	92
Agriculture booklet/leaflet	-	-	-	100

Influencing persons in variety adoption:

At the beginning stage of the adoption of the BARI Aam-3 and BARI Aam-4 varieties, most farmers were influenced by different persons at different levels. Table 9 shows that the overall influence of SAAO in adopting BARI Aam-3 and BARI Aam-4 was higher than the influence of others. Neighboring farmers and Agriculture Officer also influenced farmers in adopting BARI Aam-3 and BARI Aam-4 varieties in the study areas.

Table 9. Percent distribution of BARI Aam-3 BARI Aam-4 adopters by influencing persons

Persons	Level of influence (%)				
	Very high	High	Medium	Low	No influence
1.Family member	-	-	8	16	76
2.Neighboring farmer	15	41	27	5	12
3.SAAO	82	6	-	4	8
4.Agriculture Officer	13	18	13	42	16
5.IPM/ICM club			14	13	73
6.Scientists of OFRD	-	-	-	7	93

Profitability of BARI Aam-3 and BARI Aam-4 Variety Mango Farming

Profit is a basic criterion for selecting an enterprise. The study was found that farmers planted 120-140 trees per acre (100 decimal) of land in the sense that after 8 years they cut one of every three of the line to clear it for air and light. Farmers have the option to do intercrop with BARI Aam-3 and BARI Aam-4 mango orchards up to 3-4 years of age. Generally, after 4 years of mango tree, farmers did not cultivate any kind of intercrop. The study also found that only 18% of the respondents cultivated intercrop in one or two years in their orchard with different crops. Due to the complexity of accounting costs and return of intercropping, the present study does not cover costs and return of intercropping in determining the profitability of BARI Aam-3 and BARI Aam-4 mango farming.

It is evident from Table 10 that hired labor ranked the highest variable cost item of BARI Aam-3 mango orchard. The lowest-used variable input was manures followed by gypsum among the chemical fertilizers. The per hectare total cost of BARI Aam-3 mango orchard from the establishment year was estimated to be Tk. 210000 ha^{-1} where the cost of saplings was the major cost item. Fixed cost does not depend on the level of production. Only three items were considered as a fixed cost for the mango orchard viz., family labour, interest on operating capital (IOC), and the rental value of land in the study areas as indicated in Table 10. Considering all variable and fixed costs, total cost and net return were determined in the study areas.

The average return of BARI Aam-3 mango orchards in the study areas are depicted in Table 11. Farmers obtained fruits just after one year of plantation and this is unique only for BARI Aam-3 variety. So, the gross margin was negative in the first year of plant age as total cost was high enough at that time. The net return increased substantially over the years. Respondent farmer opined that the fruit yield of BARI Aam-3 started decreasing drastically after 15 years of plant age. The highest yield was found 12560 kg/ha and gross return and net return was Tk. 6,90,800/ha and Tk. 5,58,474/ha, respectively from 8 years above to 8 years of mango orchard.

Table 10. Cost of BARI Aam-3 cultivation in the study areas

Items	1st year	2nd year	3rd year	4-8th year	8th year & above	All years
Sample number	n=6	n=6	n=6	n=6	n=6	n=30
A. Variable Cost	95759	84000	78000	75550	78000	82262
Hired labour	13916	9876	13452	17678	31456	17276
Land preparation	4901	0	0	0	0	980
Saplings	30000	0	0	0	0	6000
Manures	9691	0	4689	4325	0	3741
Fertilizers						
Urea	1575	1649	1275	1326	1513	1468
TSP	3500	4080	3146	2834	2262	3164
MoP	2800	1072	1216	944	1152	1437
Gypsum	1235	150	0	165	115	333
Insecticides	5700	6750	7546	8787	17769	9310
Irrigation	7103	7103	7103	7103	7103	7103
Bamboo stick	8245	0	0	0	0	1649
Intercrop	-	15586	19258	18936	15326	17277
Interest on operating capital	7093	2454	3074	3453	4910	4197
B. Fixed cost	54282	50514	55641	56079	61630	55629
Family labour	11628	7860	12987	13425	18976	12975
Land use cost	90000	90000	90000	90000	90000	90000
C. Total Cost (A+B)	210000	174000	168000	165550	168000	177110

Table 11. Profitability of BARI Aam-3 cultivation in the study areas

Items	1st year	2nd year	3rd year	4-8th year	8th year & above	All years
Sample number	n=6	n=6	n=6	n=6	n=6	n=30
A. Total cost (Tk/ha)	210000	174000	168000	165550	168000	166094
Variable cost	120000	84000	78000	75550	78000	76094
Fixed cost	90000	90000	90000	90000	90000	90000
B. Yield of mango (kg/ha)	0	3000	5400	9600	12560	6112
C. Selling Price (Tk/kg)		55	55	55	55	55
D. Gross return frommango (Tk/ha)	0	165000	297000	528000	690800	336160
E. Gross return from intercrop (Tk/ha)	0	31546	35980	31546	35674	29267
F. Total gross return (Tk/ha)	0	196546	332980	559546	726474	365427
G. Gross margin (Tk/ha)	-120000	112546	254980	483996	648474	289333
H. Net return (Tk/ha)	-210000	22546	164980	393996	558474	199333
I. Per unit production cost (Tk/kg)	-	58	31	17	13	27
		BCR				2.05
		NPV				830354
		IRR				72%

The average per hectare return of BARI Aam-4 mango orchards in the study areas is depicted in Table 13. Respondent farmers opined that they got fruits just after one year of plantation and this is unique only for BARI Aam-4 variety. So, the gross margin was negative in the first year of plant age as the total cost was high enough at that time. The net return increased substantially over the years. The fruit yield of BARI Aam-4started decreasing drastically after 15 years of plant age. The per hectare highest fruit yield was found at 13,460 kg and gross return and net return was Tk. 7,26,474 and Tk. 6,24,474, respectively from above to 8 years of mango orchard.

Table 12: Cost of BARI Aam-4 cultivation in the study areas

Items	1st year	2nd year	3rd year	4-8th year	8thyear & above	All years
Sample number	n=6	n=6	n=6	n=6	n=6	n=30
A.Variable cost	140000	80500	95300	115300	12000	88620
Hired labour	13916	9876	13452	17678	31456	17276
Land preparation	4901	0	0	0	0	980.2
Saplings	30000	0	0	0	0	6000
Manures	9691	0	4689	4325	0	3741
Fertilizers						
Urea	1575	1649	1275	1326	1513	1468
TSP	3500	4080	3146	2834	2262	3164
MoP	2800	1072	1216	944	1152	1437
Gypsum	1235	150	0	165	115	333
Insecticides	5700	6750	7546	8787	17769	9310
Irrigation	7103	7103	7103	7103	7103	7103
Bamboo stick	8245	0	0	0	0	1649
Intercrop	-	15586	19258	18936	15326	17277
Interest on operating capital	7093	2454	3074	3453	4910	4197
B. Fixed cost	54282	50514	55641	56079	61630	55629
Family labour	11628	7860	12987	13425	18976	12975
Land use cost	90000	90000	90000	90000	90000	90000
A. Total cost (A+B)	230000	170500	185300	205300	102000	178620

Table 13. Profitability of BARI Aam-4 cultivation in the study areas

Items	1st year	2nd year	3rd year	4-8th year	8thyear & above	All years
Sample number	n=6	n=6	n=6	n=6	n=6	n=30
A. Total cost (Tk/ha)	230000	170500	185300	205300	102000	178620
Variable cost	140000	80500	95300	115300	12000	88620
Fixed cost	90000	90000	90000	90000	90000	90000
B. Yield of mango (kg/ha)	0	1830	4580	14560	13460	6886
C. Price (Tk/kg)		90	90	90	90	90
F. Total gross return (Tk/ha)	0	196546	332980	559546	726474	365427
G. Gross margin (Tk/ha)	0	112546	254980	483996	648474	289333
H. Net return (Tk/ha)	-230000	26046	147680	354246	624474	186807
I. Per unit production cost (Tk/kg)	-	93.17	40.46	14.10	7.58	25.94
		BCR				2.63
		NPV				1005630
		IRR				84%

Returns to investment on BARI Aam-3 and BARI Aam-4 cultivation: To calculate the benefit-cost ratio (BCR), net present value (NPV), and internal rate of return (IRR), the cost and returns were discounted at a 12% rate of interest. The calculated BCR was found to be 2.05 at a 12% discount rate which is greater than unity and acceptable. The estimated NPV of the BARI Aam-3 orchard was Tk.830354 per hectare which indicates that BARI Aam-3 cultivation was highly profitable in the study areas. The IRR was found to be 72% which is highly acceptable because it is much higher than the opportunity cost of capital.

The estimated BCR was found to be 2.63 at a 12% discount rate which is greater than unity and acceptable. The estimated NPV of the BARI Aam-4 orchard was Tk.1005630 per hectare which indicates that BARI Aam-4 cultivation was highly profitable in the study areas. The IRR was found to be 84% which is highly acceptable because it is much higher than the opportunity cost of capital.

Problems and Constraints of BARI Aam-3 and BARI Aam-4 Cultivation

Although mango farming is a profitable enterprise, respondent farmers encountered several problems and constraints regarding mango farming (Table 13). About 93% of the respondents mentioned that very low bearing after 15 years of the trees (82%) are the main hindrance to this mango variety adoption followed by unequal size (87%). Besides, colour is not attractive (42%), short shelf life (73%), and susceptibility to diseases (56%) are some of the constraints towards

disseminating this variety. The higher price of saplings (35%) and lack of quality saplings (63%) were found to be the main problem in BARI Aam-4 to dissemination at farmers' fields. Some common problems were found in the study areas such as adulteration of pesticides (55%), market controlled by a business syndicate (71%), no credit facilities for mango cultivation (79%), and lack of knowledge about modern cultivation (60%) etc.

Table 13. Problems and constraints of BARI Aam-3cultivation in the study areas

Problems and constraints	Farmer's responses (%)			
	Natore	Naogaon	Chapainawabganj	All area
A. BARI Aam-3				
Colour not attractive	42	40	45	42
Very low bearing after 15 years	80	82	84	82
Unequal size	90	86	87	87
Short shelf life	75	74	72	73
Susceptibility to disease	56	60	52	56
B. BARI Aam-4				
Higher price of sapling	50	30	25	35
Lack of quality saplings	60	64	67	63
C. Common problems				
Adulterate of pesticide	56	64	45	55
Market controlled by a business syndicate	50	86	78	71
No credit facilities of mango cultivation	75	80	82	79
High prices of inputs	45	65	62	57
Lack of knowledge about modern cultivation	80	50	50	60
Lack of storage facilities	90	95	92	92
Lack of irrigation facilities	30	57	64	50

Conclusions

This study examines the adoption status, profitability and bottlenecks of mango var. BARI Amm-3 and BARI Amm-4 cultivation at Rajshahi region. Above fifty percent farmers in Naogoan district adopt BARI Amm-3 in their gardens. Overall, adoption status of BARI Amm-3 has been increasing in Rajshahi region. Farmers shifted their garden through BARI Amm-3 because it's much more profitable than other varieties. Although adoption rate of BARI Amm-4 was found very low in Rajshahi region, but the establishment of orchard is showing increasing trend. But only a few farmers are informed that those varieties were released by BARI, especially BARI Aam-3. Gradually BARI Aam-3 and BARI Amm-4 occupy the rice and vegetable field as a best alternative in the survey areas. More than fifty

percent respondents practiced intercropping different crop up to 4-5 years along with BARI Aam-3 and BARI Amm-4 mango orchard. The cultivation of BARI Aam-3 and BARI Aam-4 mango is profitable because it gives substantially higher gross return and net return. Human labor, cost of saplings, and insecticides were the major cost items for mango production in the study areas. The rate of returns (i.e. BCR, NPV, and IRR) indicated that BARI Aam-3 ad BARI Aam-4 cultivation in the study areas is profitable for the farmers. After adopting these varieties, all categories of farmers could change their livelihood. It signifies that BARI Aam-3 ad BARI Aam-4 mango production has good potential in Bangladesh.

Recommendations

- The saplings of BARI Amm-3 and BARI Amm_4 variety should be made available at farmers level. Government should encourage DAE, BADC and nursery owners to produce more BARI Amm-3 and BARI Amm-4 saplings and supply to the interested farmers at reasonable price.
- Regular training program should be arranged for the farmers to develop their knowledge about improved cultivation practices of BARI Amm-3 and BARI Amm-4 cultivation.
- A proper initiative should be taken to record the information on cost and return and to disseminate this information throughout the different stakeholders.
- At the same time, government, research institution and agriculture extension should work together to make a sustainable market environment for the growers so that they can get fair price of mango.

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