RETURNS TO INVESTMENT ON RESEARCH AND DEVELOPMENT OF SOIL BORNE DISEASE MANAGEMENT STRATEGY FOR BRINJAL IN BANGLADESH

MAHMUDA AKTER1, M. A. MONAYEM MIAH2 AND M. I. HOSSAIN3

Abstract

The study estimated the economic returns to the past investment on the development of two IPM practices for controlling soil borne diseases in brinjal cultivation in Bangladesh. Economic surplus model with ex-post analysis was used to estimate returns to investment. The study showed that about 20.10% more brinjal production was made available due to adoption of IPM practices (i.e. use of poultry refuse and mustard oilcake) during 2002-2003. The yields of brinjal under IPM practices were 33% and 34% higher, respectively, over the non-IPM practices. Internal rate of return (IRR), net present value (NPV) and benefit cost ratio (BCR) of the past investments were estimated at 26%, Tk. 436.21 million and 3.0, respectively. Under various assumptions on cost and return, the IRR ranged from 20 to 32% and BCR ranged from 2 to 5. The investment in research and development of IPM practices for managing soil borne diseases in brinjal cultivation was found to be very efficient.

Key Words: Brinjal, soil borne disease, producer surplus, consumer surplus, ex-post analysis, returns to investment, internal rate of return, net present value

Introduction

Brinjal (Solanum melongenum L.) is the second most important and popular vegetable in Bangladesh. It is usually grown throughout the year, but extensively grown in the winter. The nutritive value of brinjal is quite high compared to tomato and other vegetables (Chowdury, 1976). The total area of brinjal is 60065 ha producing 358370 tons with an average yield of 5.97 ton/ha (BBS. 2004). In Bangladesh, brinjal farmers often fail to obtain the expected yield due to heavy damage caused by various insect-pests and diseases. Different species of fungal pathogens severely damage brinjal seedlings and plants as well. The diseases caused by these fungi are known as foot rot, damping off and stem rot. Initially, water-soaked blackened lesions appear at the base of the seedlings, then the affected portions become rotten and finally the plants wilt and die. High soil moisture and formation of crust on the soil surface enhance the attack of the pathogens and death of the brinjal plant (IPM-CRSP, 2004). Avoiding these

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diseases, farmers often use various kinds of materials and pesticides in attempts to control these diseases without success. As a result, farmers frequently face problems in raising brinjal seedlings and incur financial losses. The scientists of Bangladesh Agricultural Research Institute (BARI) under Integrated Pest Management Collaborative Research Support Programme (IPM-CRSP) have developed some IPM practices for controlling soil borne diseases (SBD) in brinjal cultivation. The IPM practices are the use of decomposed poultry refuse (PR) and mustard oil cake (MOC) in the soil of seedbed as well as crop field. The uses of decomposed PR and MOC are highly effective in controlling SBD and rising brinjal crops without pesticides. At present, many farmers in different parts of Bangladesh are benefitting by using these two IPM practices in brinjal cultivation. The present study thus look into consideration the benefits of past investment in developing two IPM practices beginning in 2000, the year when brinjal farmers adopted these practices. The present study can provide valuable information for the policy makers, donors, researchers, and extension personnel on the benefit of the past investments in soil borne disease management in brinjal cultivation. The specific objectives of the study were to: (I) know the adoption of IPM practices in brinjal cultivation; (i) estimate the yield advantage of brinjal cultivation under IPM practices over non-IPM practice, and (ii) assess the efficiency of IPM practices in brinjal production.

Materials and Method

An ex-post evaluation with the help of economic surplus model was adopted in this study to estimate the rate of returns to investment on research and development of IPM practices for brinjal cultivation. The analysis was done under closed economy situation.

(a) Data collection and sources

Two types of data are mainly needed for the analysis: i) market related data, and ii) research related data. The market related data of brinjal on annual prices and yearly production were collected from various issues of Bangladesh Bureau of 

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9 The decomposed PR and MOC release organic acid in the soil that kills soil-inhabiting pathogens and root knot nematodes. Additionally, the organic matter of MOC and PR improves the soil fertility. The using rates of PR and MOC are 3-5 t/ha and 300-500 kg/ha, respectively. Both these decomposed materials are properly mixed with the seedbed soil by spading.

10The closed-economy commodity market is defined as a commodity that is totally produced and consumed domestically.
Statistics (BBS). Iey and Norton (1993) estimated the price elasticities of demand and supply for brinjal as -0.20 and 0.13, respectively. Based on these estimates, a long-run price elasticity of supply of 0.13 and price elasticity of domestic demand ($\lambda<1$) of -0.20 were assumed throughout the present study. The brinjal prices ($P_0$) were converted to 2002-2003 constant prices using the Consumer Price Index (CPI) of middle-income group.

Research related data included rate of adoption of 1PM practices, annual area under 1PM practices, yield advantage of 1PM practices, input cost change (if any), and research & extension expenditures. Research related data were obtained from the office of the 1PM- CRSP, BARI, Gazipur. The yearly expenditure for research and extension of 1PM practices is also converted to 2002-2003 constant prices using the CPI of the middle-income group. The cost of brinjal production under 1PM practice was higher (Tk. 39,340/ha) than that of non-1PM practice (Tk. 38,131/ha) due to use more number of labour. Therefore, the input cost change was Tk 1209/ha and this was deducted from total social benefit.

(b) Analytical technique

Theoretical framework of the model: The concept of economic surplus has been used to measure economic welfare and the changes in economic welfare from policy and other interventions. (Alston et al., and Currie et al., 1971). The social benefits to the research and extension of 1PM technology for brinjal production in Bangladesh are measured in terms of producers’ and consumers’ surpluses resulting from a shift in the supply curve, caused by an increase in productivity. This outward shift in the supply function results from an upward shift in the aggregate production function resulting from the adoption of 1PM technology for brinjal production. This relation is shown in Fig. 1 in which $D_1$ and $S_0$ represent the actual market demand and pre-research supply curve, whereas $S$ represents the post-research supply curve that would have existed due to the adoption of 1PM practice.

Assuming market equilibrium and closed-economy commodity market, the shift in the supply curve from S to S would increase consumers’ surplus by Area $ABC+Area P_0PnBA$, the producers’ surplus by Area AOC-$Area P_0PnBA$, and the total social benefit or economic surplus by Area $ABC + Area AOC$ (Fig. 1). The shift in the supply curve has decreased the price that made consumers better off. The change in consumers’ surplus (benefits) can be measured as a monetary value. Besides, area AOC represents the benefits to the farmers from adopting the modern variety and can also be measured and quantified in monetary terms. Farmers will be benefited from the adoption of an intervention if Area AOC is
greater than Area $P_0P_nBA$. In the present case, the Area AOC is less than the Area $P_0P_nBA$. The site of the two areas depends on the elasticities of the supply and demand curves and the site of the supply curve shift. The total social benefit from the adoption of 1PM technology is the summation of the change in consumers’ surplus plus the change in producers’ surplus minus the input cost change for adopting the new 1PM technology.

**Figure 1. Closed-economy Economic Surplus Model**

Distribution of Economic Benefits:

Change in consumer surplus/benefit $\quad = \text{Area } ABC + \text{Area } P_0P_nBA$

Change in Producer surplus/benefit $\quad = \text{Area AOC - Area } P_0P_nBA$

Change in total economic surplus/benefit $\quad = \text{Area } ABC + \text{Area } P_0P_nBA$

**Empirical model**: The Akino and Hayarni (1975) approximation formula for calculating changes to producer and consumer economic surplus was used in this study. The approximation formula for calculating the change in economic surplus for a closed-economy situation (Fig. 1) is as follows:

1. Area $ABC = (1/2 \ P_nQ_n)((K(1+\lambda)^2/(\lambda+\eta)))$

2. Area $AOC = (kP_nQ_n)$

3. Area $P_0P_nBA = ((P_0Q_0k((1+\lambda))/(\lambda+\eta))\times((1-1/2k ((1+\lambda)\eta)/(\lambda+\eta))+ (1/2k (1+\lambda)))$

Where,

$P_0 = \text{Commodity price that would exist in absence of research}$
$Q_0 =$ Quantity produced that would exist in absence of research  
$P_n =$ Actual commodity price (existing market price)  
$Q_n =$ Actual quantity (existing production)  
$k =$ Horizontal supply shifter  
$\lambda =$ Price elasticity of commodity supply  
$\eta =$ Absolute price elasticity of the demand for the commodity.  
(For a closed-economy model, the estimated $\eta$ is used in the above formulae. For a small open-economy model where the $\eta$ is perfectly elastic, use a sufficiently large number for $\eta$.)

**The Supply Shifter ($k$):** The overall yield advantage of improved practices over the local practices weighted by the area sown to the new practices and is called the supply shifter ($k$). In estimating yield advantage, the yield of brinjal under IPM practices and non-IPM practice  

$$k_i = \sum_{i=1}^{n} [1 - \frac{Y_i}{Y_{it}}] \times A_{it}$$  

was collected from field survey at Jessore and Annual Report of IPM-CRSP (Anon, 2004). The supply shifter $k$ is calculated as follows:  

Where,  
$Y_{it}$ = Yield of brinjal under IPM practices in year $t$  
$Y_i$ = Yield of brinjal under non-JPM practices in year $t$  
$A_{it}$ = Proportion of the total area sown to brinjal under IPM practices in year $t$  
$n =$ Number of IPM practices.  

**Rate of return calculation:** The IRR is calculated relating the total social benefit (TSB) minus an input cost change, if any, in each year to the research expenditure ($C$) in each year and is the discount rate that results in a zero net present value of the benefits. The IRR is calculated as:  

$$o = \left[ \sum_{t=1}^{n} (TSB_t - C_t)(1 + IRR)^{-1} \right]$$  

(5)
Results and Discussion

Adoption of 1PM practices in brinjal cultivation

Two 1PM practices, namely PR and MOC were used to control soil borne diseases in brinjal cultivation. These technologies were released in 2000. The adoption of the selected IPM practices showed increasing trend and the share of brinjal cultivation adopting 1PM practices was 60% during 2003 (Table 1). Hence, the total area sown under 1PM technology was 44994 ha.

Table 1. Status of adoption of 1PM practices in brinjal cultivation.

<table>
<thead>
<tr>
<th>Item</th>
<th>Releasing year</th>
<th>% adoption in different years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td><strong>1PM practices to control SBD:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Use of mustard oilcake (MOC)</td>
<td>2000</td>
<td>5</td>
</tr>
<tr>
<td>(ii) Use of poultry refuse (PR)</td>
<td>2000</td>
<td>10</td>
</tr>
<tr>
<td>% Brinjal area under non-IPM practices</td>
<td>2000</td>
<td>85</td>
</tr>
<tr>
<td>% Brinjal area under IPM practices</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Area under brinjal production (ha)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Under to non-IPM practices</td>
<td></td>
<td>55298</td>
</tr>
<tr>
<td>(ii) Under IPM practice</td>
<td></td>
<td>9759</td>
</tr>
<tr>
<td>Total area (both practices)</td>
<td></td>
<td>65057</td>
</tr>
</tbody>
</table>

Source: IPM-CRSP, BARI, Gazipur.

Yield advantage of brinjal under 1PM practices

The 1PM practices in brinjal cultivation have replaced the non-IPM practice in the 1PM- CRSP areas starting in 2000. The potential yields of brinjal under the use of MOC and PR were recorded to be 7.45 and 7.65 t/ha, respectively. On the other hand, the productivity of brinjal under non-IPM practice was 5.02 t/ha. Thus the potential relative yields of brinjal under the use of MOC and PR over non-IPM practices were found to be 23% and 34%, respectively (Table 2).

Table 2. On-farm yields of brinjal by technology and yield advantage.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Yield (t/ha)</th>
<th>Yield advantage over non-IPM practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1PM practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of mustard oilcake</td>
<td>7.45</td>
<td>0.23</td>
</tr>
<tr>
<td>Use of poultry refuse</td>
<td>7.65</td>
<td>0.34</td>
</tr>
</tbody>
</table>
The supply shifter $k$ was calculated using the equation (4) and found that 20.10% more brinjal production was made available during 2002-03 because of farmers’ adoption of the 1PM practices (Table 3).

<table>
<thead>
<tr>
<th>Year</th>
<th>% brinjal area under</th>
<th>% brinjal area under PR</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-00</td>
<td>0.05</td>
<td>0.10</td>
<td>0.051</td>
</tr>
<tr>
<td>2000-01</td>
<td>0.15</td>
<td>0.15</td>
<td>0.100</td>
</tr>
<tr>
<td>2001-02</td>
<td>0.25</td>
<td>0.30</td>
<td>0.185</td>
</tr>
<tr>
<td>2002-03</td>
<td>0.30</td>
<td>0.30</td>
<td>0.201</td>
</tr>
</tbody>
</table>

Example: $k_{(2002/03)}= \{(1-\text{LP yield/MOC yield})\times \% \text{ Area MOC}\}+\{(1-\text{LP yield/PR yield})\times \% \text{ Area PR}\} = 0.201$

Rate of returns from investment

Equations (1) through (3) were used to estimate the economic returns to the past investment on the development of two 1PM practices for controlling soil borne diseases in brinjal cultivation in Bangladesh. The equations were embedded into a computer spreadsheet for ease of computation. First, the yearly total social benefits were estimated using the closed economy model (Fig. 1). Using various parameters mentioned earlier, the internal rate of return (IRR), net present value (NPV) and benefit cost ratio (BCR) were estimated to be 26%. Tk. 436.21 million, and 3.0, respectively (Table 4). The value of IRR indicates that each taka invested on the development of two 1PM practices for controlling soil borne diseases in brinjal cultivation, on an average, returns 26% annually from the date of the investment.

A sensitivity analyses was done on the economic returns to the past investment for the research and development of 1PM practices. When the yearly supply shifter $k$ was decreased by 25%, there was a decrease in the rate of return to 20%. When the supply shifter $k$ was increased by 25%, the IRR increased to 32% and BCR stands to 5.0. When the expenditures were decreased by 25%, the IRR and BCR remained the same. A simultaneous increase of 25% in the supply shifter and a 25% decrease in expenditures gave rise to a 32% IRR with BCR 5.0. Again, with the 50% increase and 50% decrease in the supply elasticity, there was no change in IRR (Table 5).
Table 4. Rate of returns to the investment on research and development of IPM practices for brinjal through ex-post analysis.

<table>
<thead>
<tr>
<th>Year</th>
<th>Supp. elasticity</th>
<th>Dem elasticity</th>
<th>Suppl Shifter (k)</th>
<th>Brinjal producton (ton) Q₀</th>
<th>Change in consumer surplus (CS)</th>
<th>Change in producer surplus (PS)</th>
<th>Change in total surplus (TS)</th>
<th>Research cost (C)</th>
<th>Research cost (C)</th>
<th>Extension cost</th>
<th>Total input cost change</th>
<th>Total cost</th>
<th>Net benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990-91</td>
<td>0.13</td>
<td>0.20</td>
<td>0</td>
<td>28251</td>
<td>185840</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>35027148</td>
<td>35027148</td>
<td>-35027148</td>
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<tr>
<td>1991-92</td>
<td>0.13</td>
<td>0.20</td>
<td>0</td>
<td>17045</td>
<td>185250</td>
<td>0</td>
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<tr>
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<td>0</td>
<td>8987</td>
<td>189245</td>
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<tr>
<td>1993-94</td>
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<td>0</td>
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<td>188220</td>
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<td>34946145</td>
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</tr>
<tr>
<td>1994-95</td>
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<td>0.20</td>
<td>0</td>
<td>7995</td>
<td>187705</td>
<td>0</td>
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<tr>
<td>1995-96</td>
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<td>0</td>
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<tr>
<td>1996-97</td>
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<td>0.20</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>6709</td>
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<td>0.051</td>
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<td>126440</td>
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<td>66728842</td>
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<td>-707790!</td>
</tr>
<tr>
<td>2000-01</td>
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<td>0.100</td>
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<td>370535147</td>
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<tr>
<td>2001-02</td>
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<td>0.20</td>
<td>0.185</td>
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<td>507404462</td>
<td>401195797</td>
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<td>2002-03</td>
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<td>0.20</td>
<td>0.201</td>
<td>7600</td>
<td>444540</td>
<td>354820146</td>
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<td>54397746</td>
<td>35611572</td>
<td>90661701</td>
<td>852431510</td>
</tr>
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</table>

Source: Dey and Norton (1993); BBS, 2004; IPM-CRSP.

**Results:** Internal rate of return 26%; Net present value =Tk. 436.21 million; Benefit cost ratio = 3.00
<table>
<thead>
<tr>
<th>Parameters</th>
<th>IRR (%)</th>
<th>NPV (million Tk.)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Base parameters</td>
<td>26</td>
<td>436.21</td>
<td>3</td>
</tr>
<tr>
<td>2. Supply shifter k decreased by 25%</td>
<td>20</td>
<td>208.50</td>
<td>2</td>
</tr>
<tr>
<td>3. Supply shifter k increased by 25%</td>
<td>32</td>
<td>686.82</td>
<td>5</td>
</tr>
<tr>
<td>4. Expenditure decreased by 25%</td>
<td>26</td>
<td>436.82</td>
<td>3</td>
</tr>
<tr>
<td>5. Expenditure decreased by 25% and supply shifter k increased by 25%</td>
<td>32</td>
<td>686.95</td>
<td>5</td>
</tr>
<tr>
<td>6. Supply elasticity increased by 50%</td>
<td>26</td>
<td>424.18</td>
<td>3</td>
</tr>
<tr>
<td>7. Supply elasticity decreased by 50%</td>
<td>26</td>
<td>455.65</td>
<td>4</td>
</tr>
</tbody>
</table>
Summary and Conclusion

The study estimates the economic returns to the past investment on the development of two IPM practices for controlling soil borne diseases in brinjal cultivation in Bangladesh. The productivity of brinjal under IPM practices was much higher than that of non-IPM practices. The investment made for the research programme was found to be very efficient in terms of higher JRR and NVP. Due to adoption of IPM practices, a large amount of brinjal was made available during 2002-2003. Sensitivity analysis revealed that the IRR of the programme ranged from 26% to 32% under various assumptions of the benefits and the research and extension expenditures. Simultaneous increase of supply shifter and decrease of expenditure gave higher IRR and BCR of brinjal cultivation implying that brinjal cultivation is profitable under IPM practice.

The study indicated that the research and extension of IPM practices for brinjal cultivation presents a lucrative public investment opportunity. Therefore, both government and donors should continue their financial support and technical efforts to develop more IPM technologies for brinjal cultivation. This also needs attention of researcher, extension personnel and policy makers.

References


