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An Ex-Post Analysis of Ginger (*Zingiber officinalis)* Research and Extension Investment in Bangladesh

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Abstract

The study estimated the benefit and rate of returns to investment on ginger research and extension in Bangladesh. The Economic Surplus Model with ex-post analysis was used to determine the returns to investment and their distribution between production and consumption. Several discounting techniques were also used to assess the efficiency of ginger research. The adoption rate was found increasing over the period. The yield of modern varieties of ginger developed by Bangladesh Agricultural Research Institute (BARI) was 78 per cent higher than that of the local varieties. Society got net benefit of Tk. 432.31 million by investing in ginger research and extension. The net present value (NPV) and present value of research cost (PVRC) were estimated to beTk. 135.01 and 81.15 million, respectively. The internal rate of return (IRR) and benefit cost ratio (BCR) were estimated to be 32 per cent and 3.75, respectively indicating that investment on ginger research and development was profitable. Ginger seed production programme should be taken largely to increase production by increasing improved variety adoption area.

Keywords: Ginger, investment, returns, adoption, yield advantage, benefit and rate of return

1. Introduction

Ginger (*Zingiber officinalis)* is one of the most common and popular spices which is widely used in manufacturing a number of food products like; ginger bread, confectionary, ginger ale, curry powder, certain curried meats, table sauces, in pickling and in the manufacture of certain soft drinks like; cordials, ginger cocktail, carbonated drinks etc. It has medicinal values as well. Ginger is also used for the preparation of ginger oil, oleoresin, essences and tinctures. A number of alcoholic beverages are prepared from ginger in different countries of the world, such as; ginger brandy, ginger wine, ginger beer etc. (Bose, *et al*., 1999). It is a principal ingredient of curry paste in the Bangladeshi kitchen.

In 2001/02, just before development and introduction of improved varieties of ginger in Bangladesh, national yield per hectare was only 5.69 tonnes per hectare which was much lower than the production at research station. It was because of lack of sufficient improved varieties and practice of traditional cultural method followed by the farmers. The productivity trend has been increasing since 2003-04 (Figure 1) and in 2007/08, productivity reached to 7.65 tonnes per hectare, due to develop and dissemination of improved varieties of ginger (BBS, 2012).

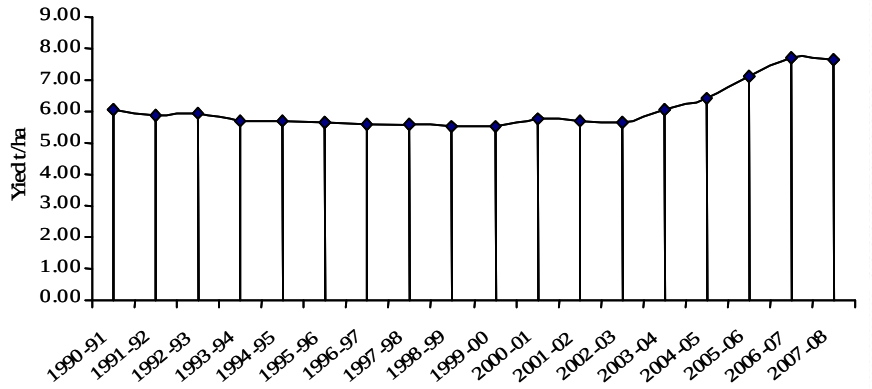

Figure 1. Yield trend of ginger

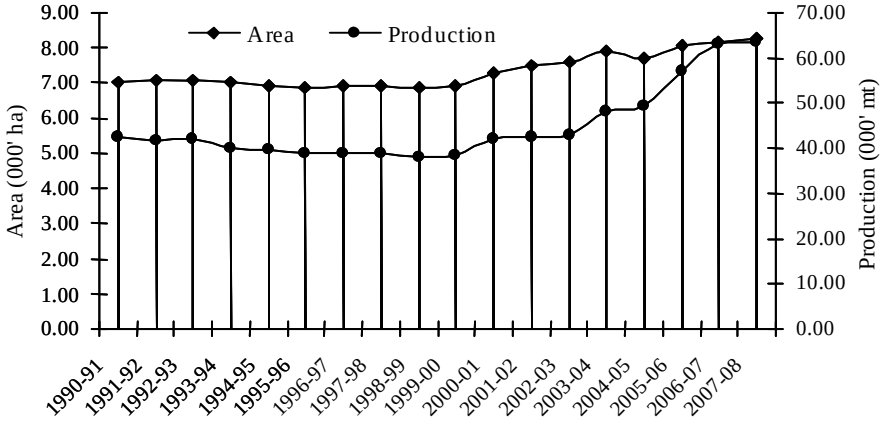

Figure 2. Area and production trend of ginger

National productivity will be further increased with the increased adoption of improved variety of ginger in farmers' field and more area coverage which will results getting higher income of the farmer (Figure 2). Growing area of ginger increased from 7500 hectares of land in 2001-02 to 8280 hectares in 2007-08. On the other hand, production increased from 4266 metric tonnes in 2001-02 to 6339 metric tonnes in 2007-08 (BBS, 2003, 2009).

Due to increasing population, demand for cereal crops increased significantly. To meet up this demand, ginger crops land is being diverted to cereal food crop cultivation, which results in a big gap between production and demand. To meet up this extra demand, the country has to spend a huge amount of foreign currency for importing ginger every year.

Realizing the importance of ginger, ginger research has been strengthened through the Spices Research Centre of BARI since 1996-97. BARI has already released one improved ginger variety named BARI Ginger- 1.

The variety is cultivated in the farmers' fields since it was released. BARI in association with

BARC (Bangladesh Agricultural Research Council) and DAE (Department of Agricultural Extension), has strengthened the research and extension works to improve ginger production.

The study was taken to examine the adoption of improved variety of ginger and its yield advantages over local varieties; to measures the social benefits derived from ginger research and extension activities and finally to estimate the rate of return of ginger research and extension in Bangladesh. However, this study provided information for the policy makers, donors, researchers, extension people and the public on the contribution and the rate of return to investment in ginger research in Bangladesh.

2. Methodology

2.1. Sources of data

For the present study, the data were collected from different published and unpublished reports, and informal scientists' interview. The area, production and yield of BARI Developed Modern Variety (BDMV) of ginger were collected from Spices Research Centre; adoption rates were collected through informal scientists' interview; and harvest price and consumer price index (CPI) were collected from various issues of Statistical Yearbooks (1996-2008) published by the Bangladesh Bureau of Statistics. The supply elasticity was taken from the study conducted by Day and Norton (1993). Since Spices Research Centre (SRC) of BARI is the main organization for ginger research, the data on research cost included mainly from SRC of BARI. The extension and promotion activities were done by DAE and the data on related costs were collected from this organization. BARC mainly provided the data on administrative costs. The on-farm yield data of BDMV ginger variety were collected from the SRC, Bogra. Data on the input cost change was calculated by the researcher through analyzing increased production, higher labour costs for harvesting and transporting, higher cost of modern seeds, and slightly more fertilizers application for improved variety than for traditional varieties.

2.2. Analytical procedure

The collected data were analyzed using graphical, tabular and statistical methods.

2.2.1. Estimation of returns to investment

The Economic Surplus Model (ESM) with Ex-Post analysis was used to estimate the rate of returns to investment in ginger research and extension. The analysis was done under small open-economy market situation. The theoretical concept of ESM has been illustrated below.

Theoretical concept of economic surplus model (ESM): The concept of economic surplus was used to measure economic welfare and the changes in economic welfare from policy and other interventions (Alston *et al.*, 1995; Currie *et al.*, 1971). Usually, the economic surplus concept is adopted to estimate the benefits from the adoption of improved varieties. The components of economic surplus are consumer surplus and producer surplus. Given the initial condition (i.e., pre-research supply curve S_1 and demand curve D_1), consumer surplus is depicted as Area P_oP_nb in Figure 3. This is the surplus or benefit to consumers because of a functioning market. Consumer surplus is that area beneath the demand curve less the cost of consumption. The cost of consumption is the area below the price line P_n.

Producer surplus is defined by the area P_nbO in Figure 3. Area P_nbO in the surplus left to the farmers after they have paid for the total costs of production, area ObQ_n (Alston *et al.*, 1995). The adoption of an intervention by farmers, such as an improved variety usually means one of two things: (i) a farmer can supply more of the commodity using the same level of resources (i.e. same land area and other inputs), or (ii) a farmer can supply the same level of commodity output but does it with fewer resources. In either case, this is depicted by a shift to the right of the supply curve as shown in Figure 3 (the shift is from S_1 to S_2). The shift is the supply curve from the adoption of an intervention changes the initial equilibrium price and quantity of the commodity. This new price quantity equilibrium

increases economic surplus. The change in economic surplus (economic benefits) is measured by comparing the difference in economic surplus between the pre-adoption period and the post-adoption period.

Given a shift in the supply curve S_1 to S_2, the change in consumer surplus is depicted in Figure 3 as Area abc + Area P_nbaP_0. The shift in the supply curve (due to the adoption of an intervention) has decreased the price consumers now have to pay for the commodity.

Given a shift in the supply curve S_1 to S_2, the change in producer surplus is depicted in Figure 3 as Area Oac-Area P_nbaP_0. Area Oac represents the decrease in the cost of production the same unit of the commodity that farmers now enjoy because they are using the intervention. This represents the benefits to the farmers from adopting the intervention and can be measured and quantified in monetary terms. The adoption of the intervention, however, has increased the quantity produced thereby decreasing the price of the commodity (P_n to P_0 in Figure 3) and is a loss to farmers income. Farmers can recover some of this loss since they can sell more quantity (Q_n to Q_0 in Figure 3) of the commodity.

The total social benefits to society from the adoption of an intervention is the summation of the change in consumer surplus plus the change in producer surplus (Area abc + Area Oac) minus the input cost change from adopting the new interventions.

For a closed economy model, the estimated price elasticity of demand is used in the above formulas. For small open-economy model where the elasticity of demand is perfectly elastic, use a sufficiently large number of η (Nagy *et al.*, 2000). A small open economy market is one where the amount of exports or imports is small relative to total world trade in the commodity. Thus, there is little or no effect on the world price of the commodity (the small country assumption). In this case, the price of commodity does not change with the shift in the supply curve. For this study, the Bangladesh ginger market is modelled as a small open economy market.

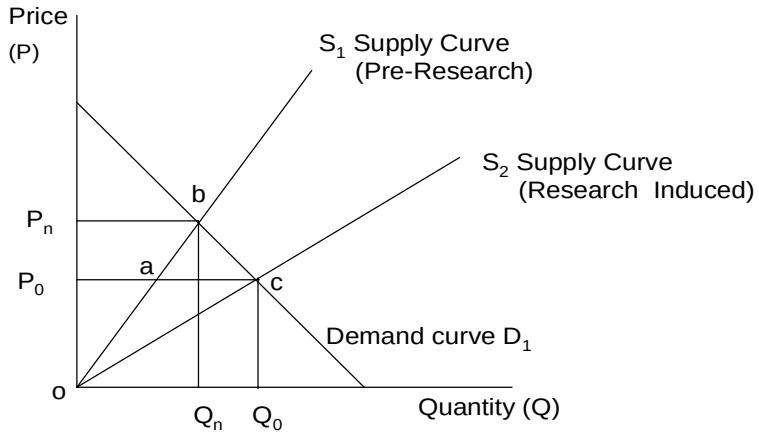

Figure 3. Economic surplus model (closed economy)

Change in Consumer Surplus	=	Area abc + Area P_nbaP_o
Change in Producer Surplus	=	Area Oac-Area P_nbaP_o

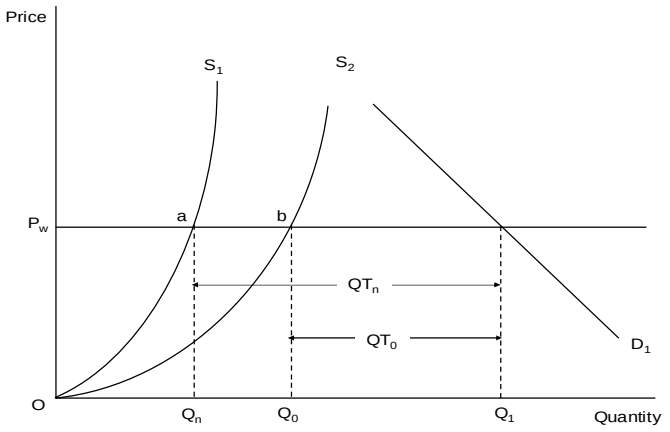

Figure 4. Small open-economy importer economic surplus model

The change in economic surplus for a small open-economy that is domestically produced but allows imports to cover shortfall (i.e., the Bangladesh ginger market) is depicted Figure 4. The world price P_w and quantity demanded by Bangladeshi consumers Q_1 defines the initial equilibrium. At price P_w, producers supply Q_n amount of ginger when faced by the pre-research supply curve S_1. Ginger imports are equal to QT_n. When faced by the research induced supply curve S_2 (the supply curve that exist because farmers have adopted new high yielding varieties). Ginger producers increased production to quantity Q_n and increase Q_nQ_0. Ginger imports are decreased by the same amount as the increase in production Q_nQ_0 and are now at QT_0. Since P_w does not change (small economy assumption), there is no change in consumer surplus- consumers are neither better off nor worse off. The enter change in economic surplus from the adoption of new ginger varieties is thus a change in producer surplus only and is identified by area oab in Figure 4 (corresponds to area oac in Figure 3). The amount of foreign exchange saved by the adoption of improved varieties is equal to P_w x (Q_nQ_0).

Empirical approach: The Akino and Hayami (1975) approximation formulas for calculating changes to producer and consumer economic surplus are described below and these are used in this study. The Akino and Hayami (1975) approximation formulas for calculating the change in economic surplus for a closed economy analysis (Figure 3) is as follows:

$$\text{Area A (abc)} = 0.5\, P_oQ_o\, ((k(1+\gamma))^2/(\gamma+\eta)) \quad (1)$$

$$\text{Area B (Oac)} = kP_oQ_o \quad (2)$$

$$\text{Area C } (P_nbaP_o) = ((P_oQ_ok\,(1+\gamma))/(\gamma+\eta)) \text{ x } (1-((0.5k(1+\gamma)\eta)/(\gamma+\eta))-0.5k\,(1+\gamma)) \quad (3)$$

Where,

P_o = Price of ginger (Tk/ton) (Existing market price)
Q_o = Production of BDMV ginger (ton) (Existing production)
P_n = Quantity price that would exist in absence of research
Q_n = Quantity of the ginger produced that would exist in absence of research
k = Horizontal supply shifter
γ = Price elasticity of ginger supply
η = Absolute price elasticity of the demand for the commodity.

The supply shifter (k): The supply shifter 'k' is the overall yield advantage of improved varieties of ginger over the local variety weighed by the area sown to the improved variety of ginger. In the case of the Akino and Hayami (1975) approximation formulas, k is the horizontal shift from the equilibrium price P_n given S_1 to the equilibrium price P_o given S_2 which corresponds to a distance equal to Q_nQ_o in Figure 3 (Gardener *et al*., 1986; Nagy and Furtan, 1978). The supply shifter k is calculated as follows:

$$k_t = \sum_{i=1}^{n} [1 - \frac{Y_t}{Y_{it}})] \times A_{it}$$

Where,

Yit = Yield of the improve varieties of ginger in year t

Yt= The yield of a base (or average yield of local variety ginger) that has been gown in the past and that would still be grown if no new varieties had been developed

Ait=The proportion of the total area sown to improved variety of ginger in year t

N = The number of improved ginger variety

Estimation of net present value (NPV)

The amount of total funds returned from the investment in research is called NPV. The NPV of the benefits was calculated by using the following formula:

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

Where,

C_t=The cost of research and extension investment in year t

r = The discount rate

n = The time horizon over which the benefits of the research investments are realized

Internal rate of return (IRR):

The IRR was calculated relating to 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:

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

The IRR can be defined as the rate of interest that makes the accumulated present value of the flow of costs equal to the discounted present value of the flow of returns, at a given point in time (Peterson, 1971).

3. Results and Discussion

3.1 Adoption status and yield advantages of BARI developed modern ginger variety

Foster and Rosenzweig (2010) pointed out that "adoption and input use are the outcomes of optimizing by heterogeneous agents". The adoption of improved variety is very important factor by which the volume of change in economic surplus is determined. The more the adoption of improved variety over traditional one, the higher is the changes in surplus. Apart from this, it gives us feedback as to why and how well a technology is being accepted by the farmers. So far, there is no ginger varietal adoption survey report in Bangladesh. The existing variety survey information along with the considerable field experience of the ginger scientists is used to sketch out the percentage area sown by variety grouping which are presented in Table 1. Rusike *et al*. (2010) used PSM (propensity score matching) alongside DD (double difference) in investigating adoption rates of new varieties.

Modern ginger variety named BARI Ginger-1 was released in 2009. Before releasing this variety, the Accession No. of this variety was G-001. To increase the production of ginger, Bangladesh Government had taken programme named Action Plan from 2002-03 through the Ministry of Agriculture. Dissemination of the variety was started at that time through DAE. Spices Research Centre of BARI supplied the seed (rhizome) to DAE named G-001. The area covered by of BARI Ginger-1 was 1 per cent in 2002-03, which has gradually increased to 15 per cent in 2007-08 (Table 1). The annual rate of adoption of BARI Ginger-1 was 2.50 per cent (Table 2).

Supply shifter k

The supply shifter k identifies the amount of production that can be attributed to the varietals improvement research in each year (i.e., the shift in the supply curve). The more the value of supply shifter the more is the shift in the supply curve, resulting higher benefit to the society. The supply shifter is the outcome of the simultaneous force of adoption percentage and yield advantage. It was calculated using the formula discussed in methodology. Table 3 shows each year adoption percentage and supply shifter of ginger. It was observed that the rate of shift has gradually increased. The shifter accounted for the yield advantage of BARI developed ginger variety over the traditional variety. The supply shifter of ginger was found to be 0.117 for the year 2007/08; meaning that 12% more ginger production was made available during 2007/08 because of farmers' adoption of BARI developed ginger variety.

Yield advantages

This is very important factor to determine the economic surplus. The higher yield advantage always ensures higher level of economic surplus. Two types of data exist in most of the less developed countries for good estimation of yield advantage (YA) as well as the aggregate production function shifter. They are on-station yield trial data and on-farm yield data. The on-station yield data is readily available and most often the only reliable source. One of the arguments against using on-station yield trial data is that superior management practices and techniques are used and therefore, the results may not reflect on the on-farm situation. Another argument placed by different author (Hertford *et al.,* 1971 & 1977; Ayer *et al.,* 1972; Akino *et al*. 1975; Scobie *et al.,* 1977 and Nagy *et al.,* 1978) and showed that the yield advantage estimation from the on-station yield trial data would be biased upward because the estimation might also include the contribution made by inputs such as fertilizer and water. To account for this problem, the estimated yield advantage of new varieties by estimating production functions of yield as a function of new varieties and other inputs. This process requires a substantial data which is not readily available in Bangladesh.

Table 1. Area of traditional variety replaced by BDMVs of ginger

Year	Total ginger area		Area of LVs of ginger		Area covered by BARI Ginger-1(G-001)	
	Hectare	%	Hectare	%	Hectare	%
1996-97	6899	100	6899	100.00	0	0.00
1997-98	6913	100	6913	100.00	0	0.00
1998-99	6877	100	6877	100.00	0	0.00
1999-00	6909	100	6909	100.00	0	0.00
2000-01	7296	100	7296	100.00	0	0.00
2001-02	7498	100	7498	100.00	0	0.00
2002-03	7573	100	7497	99.00	75.73	1.00
2003-04	7917	100	7759	98.00	158.34	2.00
2004-05	7715	100	7406	96.00	308.58	4.00
2005-06	8045	100	7482	93.00	563.12	7.00
2006-07	8148	100	7252	89.00	896.26	11.00
2007-08	8283	100	7041	85.00	1242.45	15.00

Note: BDMV- BARI Developed Modern Variety, LVs- Local Varieties and shaded area indicates no improved varieties were released.

Table 2. Adoption rate of BARI Developed Modern Varieties of Ginger

Name of crop	Varietals Name	Adoption rate (%)
Ginger	BARI Ginger-1 (G-001) (2000-01 to 2007-08)	2.50

Table 3. Calculation of the supply shifter (K) of BARI Ginger over traditional variety

Year	% Area of BARI Ginger-1 replacing LVs	Supply Shifter K
1996-97	0	0.0000
1997-98	0	0.0000
1998-99	0	0.0000
1999-00	0	0.0000
2000-01	0	0.0000
2001-02	0	0.0000
2002-03	1	0.0078
2003-04	2	0.0157
2004-05	4	0.0313
2005-06	7	0.0548
2006-07	11	0.0861
2007-08	15	0.1174

Table 4. Yield advantages of improved varieties of ginger over traditional varieties

Name of ginger crop	Average (weighted) yield of Improved variety (t/ha)	Average yield of traditional variety (t/ha)	Yield difference (t/ha)	Yield advantage
BARI Ginger-1	28.380	6.16	22.22	0.783

For the present study, on-farm yield trial data were considered as a more reliable source for the calculation of yield advantage rather than the on-station yield data in Bangladesh. The yield advantages for this study have been calculated following Gardiner *et al*. (1986), Nagy *et al.* (1978) and Nagy (1991).

Spices Research Centre (SRC) of BARI developed variety: BARI Ginger-1 that has replaced the traditional varieties since 2002-03.

The weighted yields were calculated by taking the average of the irrigated optimum, late irrigated and non irrigated yield multiplied by the mean of irrigated, late irrigated and non irrigated area of ginger. Per hectare average yield of improved variety of ginger i.e. BARI Ginger-1 was found to be 28.38 tonnes. In case of traditional variety it was only 6.16 tonnes. Therefore, the yield advantage of BARI Ginger-1 over traditional variety was found to be 78 % (Table 4).

3.2. Estimating benefits from ginger research and extension

This section deals with the estimation of returns to investment in ginger research and extension using the economic surplus approach. This approach estimates the benefits to agricultural research by measuring the change in consumers' surplus (CS) and producers' surplus (PS) from a rightward shift in the supply curve that is brought about through technological change. It should be mentioned here that aggregate consumers' surplus, producers' surplus and total surplus were calculated by summing up corresponding surpluses of all ginger rather

than summing up from the areas of the model. In order to calculate the net benefits (NB), research and extension expenditures are subtracted from total surplus. All these estimates of benefits are expressed in real term by using 2007-08 constant prices. The rate of returns and NB are then discounted using 10% interest rate for obtaining the efficiency of investment. First, the yearly total social benefits are estimated using the small-open economy model (Figure 4).

This is done by assigning a very high number to the demand elasticity parameter (ŋ) since in a small open-economy model, ŋ is perfectly elastic. The analysis is undertaken for each year 1996/97 to 2007/08 for ginger.

Ginger research and extension in Bangladesh seemed to be continued by three different organizations. The Organizations are Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural Research Council (BARC) and Department of Agricultural Extension (DAE). The ginger research and extension expenditure comprised the expenditure of three organizations are furnished in the following sequence.

The year wise expenditures behind variety development and dissemination for the new varieties of ginger to the farmers are shown in Table 5. The expenditures of BARI/SRC and BARC were estimated from 1996/97 to 2007/08. The accumulated expenditures over the years of BARI/SRC and BARC were estimated at Tk. 85.39 and 7.70 million, respectively. Extension expenditures and input cost change were estimated after development of improved variety, which has started since 2002/03. The cumulative expenditures of varietal dissemination by extension department and input cost changes were amounted at Tk. 12.47 and 20.20 million, respectively. Over the years, expenditures accruing for BARI/SRC, BARC, DAE and input cost change were Tk. 125.76 million.

Table 5. Ginger research and extension expenditure by sources 1996/97-2007/08

Year	Total SRC/BARI Research Expenditures (current Taka)	BARC Administrative Expenditures (current Taka)	Total Extension Expenditures (current Taka)	Input cost change (current Taka)	Total Expenditures (current Taka)	Total Expenditures (2007-08 Tk.)
1996/97	7788000	261250	0	0	8049250	14723300
1997/98	8699064	675850	0	0	9374914	16415928
1998/99	2882220	1181750	0	0	4063970	6777341
1999/00	1728804	1221000	0	0	2949804	4685034
2000/01	2132064	1114500	0	0	3246564	4880802
2001/02	1985280	645000	0	0	2630280	3730468
2002/03	3334320	173500	1396915	377259	5281994	7067297
2003/04	3859020	271300	1639660	836119	6606099	8338630
2004/05	14129808	301300	1887802	1727345	18046255	21489724
2005/06	13091496	442200	2113068	3341282	18988046	21331341
2006/07	11586960	724950	2686865	5636878	20635652	21870073
2007/08	14171520	690350	2745121	8282848	25889839	25889839
Total	85388556	7702950	12469431	20201731	125762667	157199777

Note : $1.00 =Tk. 80.00

For the analysis, the current total expenditures were converted to 2007/08 constant prices using the Bangladesh Middle Income Group CPI Index and it was Tk 157.20.

Table 6. Estimation of surplus from ginger research and extension investments

Year	Change in consumer surplus (Tk.)	Change in producer surplus (Tk.)	Change in total surplus (Tk.)	Total expenditure (Based on 2007-08 Tk.)	Net Benefit (Tk)
A	B	C	D=B+C	E	F=D-E
1996/97	0	0	0	14723300	-14723300
1997/98	0	0	0	16415928	-16415928
1998/99	0	0	0	6777341	-6777341
1999/00	0	0	0	4685034	-4685034
2000/01	0	0	0	4880802	-4880802
2001/02	0	0	0	3730468	-3730468
2002/03	0.130	11897564	11897564	7067297	4830267
2003/04	0.285	26124558	26124558	8338630	17785928
2004/05	0.889	82248975	82248976	21489724	60759252
2005/06	1.517	142159803	142159805	21331341	120828464
2006/07	1.302	124208315	124208316	21870073	102338244
2007/08	2.087	202872826	202872828	25889839	176982989
Total	6.21	589512041	589512047	157199777	432312271

Note : $1.00 =Tk. 80.00

The total changes over years in consumers' and producer' surplus were estimated Tk. 6.21 and Tk. 589.51 million, respectively from ginger research and extension. Consumers' surplus was very much lower compared to producers' surplus due to perfect elasticity of demand for ginger in the small-open economy market. The estimated total surplus/total benefits ranged from Tk. 11.90 million in 2002/03 to 202.87 million in 2007/08 and the total surplus accrued as Tk. 589.51 million from the ginger research and extension in Bangladesh. Besides, the total net benefits obtained from ginger research and extension was Tk. 432.31 million for the year 1996/97 to 2007/08 (Table 6).

3.3. Rate of return to ginger research and extension

The rates of returns are the indicators of the investment efficiency of the research programme. There are many types of measure that can be used to estimate the rates of return. Among them, Net Present Value (NPV) of benefit, External Rate of Return (ERR) and Internal Rate of Return (IRR) were considered as the rates of return to ginger research and extension investments in Bangladesh. For comparing the net benefits with the total research costs, Present Value of Research Costs (PVRC) was also calculated. All the estimates were calculated at constant (2007/08) prices with 10% discount rate. Table 7 was used to calculate the NPV, PVRC, ERR, IRR and BCR under small-open economy condition. Under open economy, the producers' benefits were found much higher compared to consumers' benefits since the elasticity of demand for ginger were very high.

Table 7 revealed that society was benefited substantially from the investment in ginger research and extension in Bangladesh. The NPV of benefit indicates the total social benefit for a country and it was found negative up to 2001/02 and then it was positive. It means that the country did not receive any benefit from ginger research up to 2001/02 (Table 6). After 2001/02, the country as a whole was benefited with a big amount and found increasing trend up to 2007/08. The NPV was found to be Tk 135.01 million while PVRC over the period was Tk 81.15 million for ginger research and extension investment. The ERR was found to be 312.50%. This means that the average taka spent on research and extension in ginger earn return 10%

annually from the start of the initial investment (1996/97) and is now paying off at the rate of 312.50% annually into perpetuity. In the benefit/cost mode, using 10% external interest rate, a one taka investment returned 31.25 taka over the period. The IRR of 32% means that on the average, each taka invested in ginger research and extension returned 32% annually from the date of the initial investment. It implies that the expenditure on ginger research and extension (Tk 81.15 million) could have been borrowed at 32 % real rate of interest without incurring loss (Table 7). The benefit cost ratio was found to be 3.75 for ginger. The IRR and BCR will be increased by increasing the adoption of improved variety of ginger. The value of the parameter indicated that the investment in research and extension of ginger in Bangladesh is a good and profitable investment.

3.4. Foreign exchange savings

The yearly increase in production due to research save the country's foreign exchange to a remarkable extends. First, the research induced productions for ginger for the past years was calculated by multiplying the country's total ginger production by their respective production function shifter k. Multiplying the results by world ginger price, foreign exchange savings was obtained. Considerable amounts of ginger are imported in Bangladesh every year to meet the internal demand for increasing population. The imported value of ginger was Tk. 570.53 million (BBS 2009). In reality, the amount imported is higher due to the illegal boarder trade of ginger from neighbouring countries. Thus, the increased production attributed to ginger improvement saved foreign exchange amounting to Tk. 762.84 million from ginger research and extension (Table 8).

Table 7. Estimated rates of returns to ginger research and extension

Name of crop	Net present value (NPV)	Present value of research cost (PVRC)	External Rare of Return (ERR)	Internal Rate of Return (IRR)	Benefit Cost Ratio (BCR)
	Million taka in 2007-08 constant prices		%		
Ginger	135.01	81.15	312.50	32	3.75

Note : $1.00 =Tk. 80.00

Table 8. Foreign exchange savings from investment in ginger research

Year	Import (cif) Price 2007-08 Taka	Supply Shifter K (percent)	Ginger Production (tons)	Increase in Production From Research (tons)	Foreign Exchange Savings (2007-08 Taka)
	A	B	C	D=BxC	E=AxD
2002-03	50158	0.0078	42825	335.30	16817901
2003-04	50986	0.0157	48185	754.52	38470364
2004-05	46311	0.0313	49405	1547.26	71655143
2005-06	43478	0.0548	57095	3129.16	136048856
2006-07	42522	0.0861	63000	5425.81	230715207
2007-08	36150	0.1174	63392	7444.87	269135542
	Total Foreign Exchange Savings:			Tk.	762843013

Note : $1.00 =Tk. 80.00

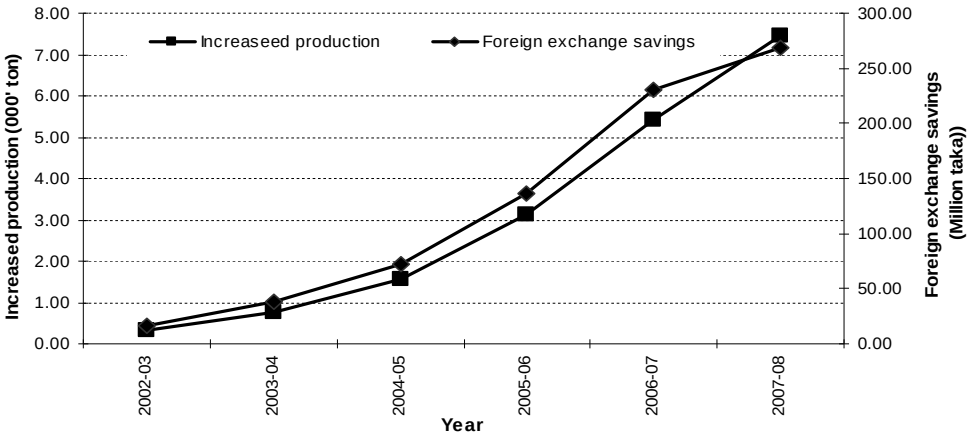

Figure 5. Foreign exchange savings due to ginger research and development over time

4. Conclusions and Recommendations

The empirical results indicate that the expenditure on ginger research and development paid a favourable rate of returns and the society were also enormously benefited out of it. The IRR to ginger research and development expenditure was found to be 32 per cent. A 32 per cent IRR on investment in ginger research and development is a good rate of return. The consumer's surplus is found to be very few only due to small open economy. However, this situation might not be a good sign for the economic prosperity. For the survival of the consumers, price support should be given by government.

The annual adoption rate of BARI Ginger-1 is not good because of non availability of seeds. Therefore, seed production programme should be undertaken largely by the government and non governmental organizations, so that the farmers can get quality seeds easily at a reasonable price.

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