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RETURNS TO INVESTMENT IN SUMMER ONION RESEARCH AND EXTENSION IN BANGLADESH

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ABSTRACT

The study estimated the rates of returns to investment on research and development of summer onion in Bangladesh. The *Economic Surplus Model* with ex-post analysis using secondary data was used to determine the returns to investment and its distribution between the production and consumption. Several discounting techniques were also used to assess the impact of summer onion research. The results revealed that the growth of area and production of onion increased manifolds due to farm level adoption of summer onion. The summer onion adoption rate was found increasing trend over the period. The yield of summer onion was 57.04% higher than the local variety. The internal rate of return (IRR), net present value (NPV), and benefit cost ratio (BCR) were estimated to be 25%, Tk.35.29 million and 3.09 respectively. Sensitivity analysis revealed that under various assumptions IRR ranged from 20 to 41%, NPV from Tk.18.37 to Tk.64.05 million, and BCR from 2.31 to 5.95. The results indicated that investment in research and development of summer onion was a good investment.

I. INTRODUCTION

Onion is one of the important spices crops in Bangladesh. It is widely used as spice in various ways in most of the cooked foods and for many other purposes. It adds flavour of distinctive pungent and has medicinal values also. Bangladesh requires about 1.46 million tons of onion per year, but it produces only 0.89 million tons and the rest of the onion are imported from neighbouring countries spending of Tk.7000 to Tk.8000 million per year (Bangladesh Bank, 2007). This shortage is mainly due to low yield and seasonality of onion production. The yield of onion is very low in Bangladesh as compared to the world average (FAO, 1999) possibly due to the lack of yielding variety and poor cultural practices done by the farmers.

Realizing the importance of onion, Bangladesh government established Spices Research Centre (SRC) in 1994 under Bangladesh Agricultural Research Institute (BARI) for developing high yielding variety and modern technology to increase the production of onion throughout the country. SRC has been working on spices research and development since 1995-1996. It has already released a number of high yielding onion varieties along with two summer onion varieties namely BARI Piaz 2 and BARI Piaz 3 in April, 2000. These two varieties are broadly cultivated in the farmers' fields since their release. These varieties are produced and consumed within the country. The BARI (Bangladesh Agricultural Research Institute), BARC (Bangladesh Agricultural Research Council) and DAE (Department of Agricultural Extension) to some extent, have strengthened their works to summer onion.

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However, for the research work of summer onion and its extension, the contribution of BARC, DAE and NCDP (Northwest Crop Diversification Program) are greatly associated with BARI.

Resources for agricultural research are scarce. Therefore, the efficient resource allocation and the necessity to justify their use to the society require the assessment of economic impacts of research. Without the economic analysis it would be hard to know the social value of scientific knowledge and technologies and to make judgments about the trade-offs in the allocation of the scare resources in research (Alston et al., 1998). The present analysis had the advantages to take the results and output from past summer onion research and its farm level extension in the country. Accordingly, this study provided information for the policy makers, donors, researchers, extension people and the public on the contribution and the rate of return to past investments in summer onion research in Bangladesh. The specific objectives of this study were to:

i) determine the growth rate of area, production and yield of summer onion;
ii) find the adoption of summer onion and its yield advantages over local variety, and
iii) estimate the rate of returns to summer onion research and development.

This paper has been organized into four sections. Following introduction, Section II discuses the sources of data and analytical procedures of the study. Results and discussion are presented in section III. Finally, policy implications of the study have been presented in section IV.

II. METHODOLOGY

Data Sources: For the present study, data on area, production, and yield of summer onion were collected from SRC and DAE; adoption rates were collected through informal scientist's interview; and harvest price and consumer price index (CPI) were collected from various issues of Statistical Yearbooks published by the Bangladesh Bureau of Statistics (Appendix 1). The demand and supply elasticities were taken from the study conducted by Day and Norton, 1993. Since SRC is the main organization for summer onion research, the research cost included mainly from SRC and the project NCDP. The extension and promotion activities were done by DAE and the related costs were collected from this organization. BARC mainly provided the administrative costs (Appendix 2). The on-farm yield data of summer onion varieties were collected from the SRC, Bogra. Data on the input cost change was calculated by the researcher through analyzing the cost of local variety onion and summer variety onion at farm level.

Analytical Procedure:

The collected data were analyzed using different statistical techniques. Which have been discussed below.

Estimation of growth rate: The semi-log function was used to estimate the growth rates of area, production, and yield of summer onion in different time period. The model is such as

$$Y = a.e^{bt}$$

or $\ln Y = \ln a + bt$

Where,

a = Intercept
Y= Production or Area or Yield of summer onion
b = Growth rate in ratio scale and when multiplied by 100, it express percentage growth i.e. annual growth rate
t = time period

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 summer onion research and extension. The analysis was done under closed-economy[1] market situation. The theoretical concept of ESM has been illustrated below.

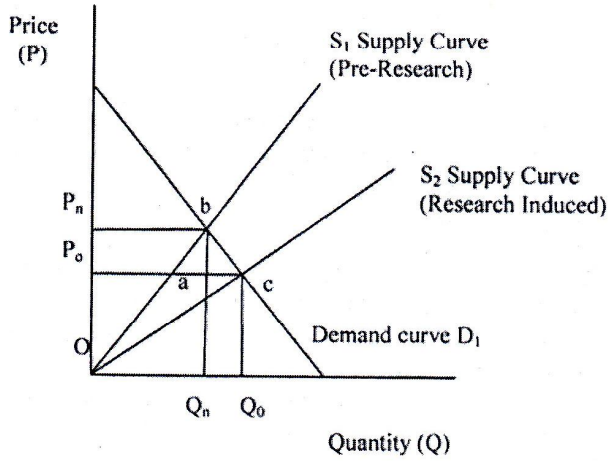
Theoretical concept of ESM: The concept of economic surplus was used to measure economic welfare and the changes in economic welfare from policy and other interventions (Alston *et. al.,* 1995, Currie *et al.,* 1971). Usually the economic surplus concept is adopted to estimate the benefits from the adoption of improved varieties. The components of economic surplus are consumer 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_nbaP_o in Figure-1. 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 Area P_nbO (Figure-1). 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 do it with less resource.

In either case, this is depicted by a shift to the right of the supply curve as shown in Fig.1 (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 and 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 1 as Area abc + Area P_nbaP_0. The shift in the supply curve (due to the adoption of an intervention) has decreased the price that consumers have to pay for the commodity.

[1]The closed-economy commodity market is defined as a commodity that is totally produced and consumed domestically and is neither imported nor exported.



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

Figure 1. Economic Surplus Model (Closed Economy).

Given a shift in the supply curve S_1 to S_2, the change in producer surplus is depicted 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) 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) 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.

Empirical approach: The Akino and Hayami (1975) approximation formulas for calculating changes to producer and consumer economic surplus for closed economy analysis are used in this study. Which are described below:

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

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

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

Where,

P_o = Price of summer onion (Tk/ton) (Existing market price)

Q_o = Production of summer onion (ton) (Existing production)

P_n = Price of summer onion (Tk/ton) that would exist in absence of research
Q_n = Quantity of the summer onion produced that would exist in absence of research
k = Horizontal supply shifter
γ = Price elasticity of onion 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 summer onion over the local variety weighed by the area sown to the improved summer onion. 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 1 (Gardiner *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,

Y_{it} = Yield of the improve summer onion in year t
Y_t = The yield of a base (or average yield of local variety onion) that has been grown in the past and that would still be grown if no new varieties had been developed
A_{it} = The proportion of the total area sown to summer onion in year t
n = The number of improved summer onion varieties

Estimation of net present value (NPV): The amount of total funds returned from the investment in research is called NPV. This was calculated using the following formula:

$$NPV = \sum_{t=1}^{n} (TSB_t - C_t)(1+r)^{-t}$$

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 change in input cost, if any, in each year to the research expenditure (C) and is the discount rate that results in a zero net present value of the benefits. The IRR is calculated as :

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

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).

III. RESULTS AND DISCUSSION

Growth rates of area, production and yield: Three periods were considered for the growth rate calculation of summer onion. First, from the year 2000-01 to 2003-04 i.e., before the extension work of Department of Agricultural Extension (DAE); second, from 2004-05 to 2007-08 i.e., when the DAE started to extension work for summer onion broadly through several project and third, from 2000-01 to 2007-08 i.e., the whole study period.

During the period from 2000-01 to 2006-07 the annual growth of area, production, and yield of summer onion were 114.50, 104.30 and -10.20% respectively (Table 1).

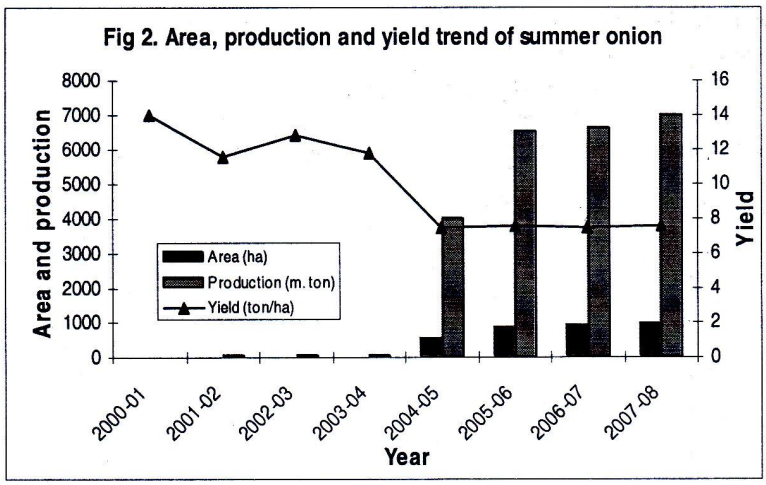
Table 1. Growth rates of area, production and yield of summer onion in Bangladesh

Particulars	Area (ha)	Production (MT)	Yield (ton/ha)
2000-01 to 2003-04			
Mean	2.97	36.41	12.58
C.V (%)	51.15	46.03	8.82
Growth rate (%)	37.24	33.05	-4.20
2004-05 to 2007-08			
Mean	802.18	6045.55	7.53
C.V (%)	22.53	22.71	0.52
Growth rate (%)	16.82	16.89	0.01
2000-01 to 2007-08			
Mean	402.57	3040.98	10.06
C.V (%)	110.11	109.68	27.79
Growth rate (%)	114.50	104.30	-10.20

Note: Growth rate are estimated by fitting semi-log function
Source: Subjective estimation of relevant scientist and extension worker and various local surveys

After the release of summer onion in April 2000, the area and production of summer onion increased dramatically. This indicates that the production of onion has been increased greatly due to higher adoption of summer onion varieties at farm level.

DAE started to expand summer onion cultivation since 2004/05 through several projects. In that time, growth rate of area, production and yield was positive. With the dissemination of summer onion largely at farmers' field, yield was decreased due to lack of proper management (Figure 2). Resulting this, growth of yield became negative.



Adoption of summer onion: The rate of adoption was 0.004% during 2000-01 and then gradually increased to 0.69% in 2007-08 (Table 2). Area of summer onion was jumped 5.08 ha (2003-04) to 534.05 ha (2004-05) due to implementation of spices development, quality seed production and extension policy of Bangladesh Government through several projects with the help of SRC of BARI, DAE, BADC, BAU and MoA. This increase in adopted area was mainly due to adoption by farmers for getting higher sales price because of off-season onion.

Table 2. Adoption of summer onion in Bangladesh

Year	Total area of onion (ha)	Total area of LVs onion (ha)	Total area of summer onion (ha)	% sown to LVs onion	% sown to summer onion
2000-01	34085.02	34083.55	1.47	99.996	0.004
2001-02	36894.74	36892.09	2.65	99.993	0.007
2002-03	37653.85	37651.19	2.66	99.993	0.007
2003-04	51967.61	51962.53	5.08	99.990	0.010
2004-05	86429.15	85895.10	534.05	99.382	0.618
2005-06	115789.47	114928.10	861.37	99.256	0.744
2006-07	128740.00	127853.26	886.74	99.311	0.689
2007-08	135177.00	134250.43	926.57	99.314	0.685

Note: Subjective estimation of relevant scientist and extension worker and various local surveys
(*Source*: Data on total area of onion from BBS)

Supply shifter k: The supply shifter k identifies the amount of production that can be attributed to the varietals improvement of research in each year (i.e., the shift in the supply curve). The shifter accounted for the yield advantage of summer onion over the local varieties. It was found that 0.39 percent more onion production was made available during 2007-08 because of farmers' adoption of BARI released summer onion variety.

Yield advantages: BARI released high yielding variety of summer onion was started to cultivate in the farmers field in 2000. Summer onion was used as the reference variety for all

the local varieties. The potential yield of summer onion was recorded as 10-13 t/ha (Akhter *et al.*, 2006) and that of local variety 6.98 t/ha. Thus the potential relative yield of summer onion over the local varieties was 57.04 percent (Table 3).

Table 3. Yield advantage of summer onion and supply shifter k.

Year	% area sown to summer onion	% area sown to LVs onion	Total onion area (ha)	Area under summer onion (ha)	Area sown to LVs onion(ha)	Supply shifter k
2000-01	0.004	99.996	34085.02	1.47	34083.55	0.00003
2001-02	0.007	99.993	36894.74	2.65	36892.09	0.00005
2002-03	0.007	99.993	37653.85	2.66	37651.19	0.00004
2003-04	0.010	99.990	51967.61	5.08	51962.53	0.00006
2004-05	0.618	99.382	86429.15	534.05	85895.10	0.00353
2005-06	0.744	99.256	115789.47	861.37	114928.10	0.00424
2006-07	0.689	99.311	128740.00	886.74	127853.26	0.00393
2007-08	0.685	99.314	135177.00	926.57	134250.43	0.00393

Note: LV= Local variety

Yield of summer onion	:	12.50 t/ha
Yield of local variety of onion	:	5.37 t/ha
Yield advantage of summer onion	:	57.04%

***Source*:** Akhter *et al.* (2006)

Net present value of benefit (NPV): The NPV of benefit indicates the total social benefit for a country and it was found negative up to 2003-04 and then it was positive. It means that the country did not receive any benefit from summer onion research up to 2003-04 (Table 4). After 2003-04, the country as a whole benefited with a big amount and found increasing trend up to 2007-08 (Table 4). However net social benefit from summer onion research was obtained Tk. 35.29 million. The findings also revealed that due to inelastic demand, all the benefits of the programme passed on the consumer estimated by consumer surplus, whereas the producer surpluses were negative.

Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR): Using parameter, the IRR was estimated to be 25 percent for summer onion research and extension (Table 4). It means that each taka invested in summer onion research and extension that provided returns by 25 percent annually from the date of investment. The benefit cost ratio was found to be 3.09 (Table 6). Both parameters clearly indicate that the investment in research and development of summer onion in Bangladesh is a good investment and highly profitable.

Table 4. Ex-post summer onion model

Year	Supply elasticity	Demand elasticity	Supply shifter k	Onion price (Tk/ton) p_n	Onion Quantity (ton) Q_n	Change in consumer surplus CS	Change in producer surplus PS
1995-96	0.10	0.40		10414.4	138190.00		
1996-97	0.10	0.40		11713.70	141835.00		
1997-98	0.10	0.40		20107.00	138430.00		
1998-99	0.10	0.40		30738.80	131090.00		
1999-00	0.10	0.40		17979.10	134245.00		
2000-01	0.10	0.40	0.00003	13023.90	126770.00	103592	-56502
2001-02	0.10	0.40	0.00005	17232.30	150015.00	259514	-141544
2002-03	0.10	0.40	0.00004	16933.50	153455.00	228255	-124496
2003-04	0.10	0.40	0.00006	15790.20	272230.00	539404	-294197
2004-05	0.10	0.40	0.00353	12777.50	589410.00	58314803	-31653662
2005-06	0.10	0.40	0.00424	16491.10	769000.00	118178403	-64084101
2006-07	0.10	0.40	0.00393	17325.10	894000.00	133685496	-72524635
2007-08	0.10	0.40	0.00393	17199.80	938700.00	139354026	-75599824

Table 4. Cont'd.....

Year	Supply elasticity	Demand elasticity	Supply shifter k	Change in total surplus TS	Research and extension cost C (Tk)	Input cost change (Tk)	Net Benefit (NB)
1995-96	0.10	0.40			1815344		-1815344
1996-97	0.10	0.40			5015703		-5015703
1997-98	0.10	0.40			5554317		-5554317
1998-99	0.10	0.40			3308751		-3308751
1999-00	0.10	0.40			2762295		-2762295
2000-01	0.10	0.40	0.00003	47089	3100872	8989	-3053783
2001-02	0.10	0.40	0.00005	117970	3109128	11438	-2991158
2002-03	0.10	0.40	0.00004	103759	3096160	11827	-2992401
2003-04	0.10	0.40	0.00006	245207	3335040	12551	-3089834
2004-05	0.10	0.40	0.00353	26661141	9179182	13764	17481959
2005-06	0.10	0.40	0.00424	54094301	8550213	20164	45544089
2006-07	0.10	0.40	0.00393	61160861	8521886	24159	52638975
2007-08	0.10	0.40	0.00393	63754203	9476194	20193	54278009

Table 4. Cont'd.....

Year	NPV	IRR	NPV of research cost	(Pn-Po)*	(Pn)**	Area (abc)	Area (aoc)	Area (PoPnba)
1995-96	35289045	25%	32144272					
1996-97								
1997-98								
1998-99								
1999-00								
2000-01						2	47088	103590
2001-02				1	17234	7	117963	259508
2002-03				2	16935	5	103754	228250
2003-04				2	15792	17	245190	539387
2004-05				2	12779	113236	26547905	58201567
2005-06				145	16636	276353	53817948	117902049
2006-07				184	17509	289466	60871395	133396030
2007-08				169	17369	301740	63452463	139052287

*Change in price in absence of new varieties; **Price in absence of new varieties

Sensitivity analysis: A sensitivity analysis was undertaken for the study. The base parameters included IRR (25 percent), NPV (Tk.35.29 million), and BCR (3.09). When the yearly supply shifter k was decreased by 25 percent, there was a decrease in the rate of return to 20 percent and the BCR was 2.31 (Table 5). When the supply shifter k was increased by 25 percent, the IRR increased to 30 percent and BCR 3.86. When the expenditure decreased by 25 percent, the IRR increased to 36 percent and BCR increased to 4.76. When the expenditure was increased by 25 percent, the IRR decreased to 26 percent and BCR 2.86. A simultaneous increase of 25 percent in the supply sifter and 25 percent decrease in expenditures gave rise to 41 percent IRR with BCR 5.95. Thus the sensitivity analysis revealed that under various assumptions about the research and extension expenditure, the IRR ranged from 20 to 41 percent, NPV from Tk.18.37 to Tk.64.05 million, and BCR from 2.31 to 5.95.

Table 5. Sensitivity analysis on the return to summer onion research and development

Parameters	IRR (%)	NPV (Million taka)	BCR (Discounted)
Base parameters	25	35.29	3.09
Supply shifter k decreased by 25%	20	18.37	2.31
Supply shifter k increased by 25%	30	52.25	3.86
Expenditure decreased by 25%	36	47.10	4.76
Expenditure increased by 25%	26	33.57	2.86
Expenditure decreased by 25% and supply shifter k increased by 25%	41	64.05	5.95

IV. POLICY IMPLICATIONS

The empirical results indicate that the expenditure on summer onion research and development pay a favourable rate of returns. The IRR to summer onion research and development expenditure was found to be 25 percent which is a good rate of return. The producer's surplus is found to be negative because summer onion was traded only in closed economy. But this situation might not be the good sign for the economic prosperity. However, price support should be provided by the government and other concerned authority for the survival of the summer onion producers.

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Appendix

Appendix 1. Harvest prices of onion during the period from 1995-96 to 2007-08.

Year	Harvest price of onion (Tk/ton)	Harvest price deflated (Tk) (Base 2007-08 = 100)	CPI National (Base 2007-08 = 100)
1995-96	6890	10414.4	66.20
1996-97	7690	11713.70	65.60
1997-98	13820	20107.00	68.70
1998-99	22700	30738.80	73.80
1999-00	13500	17979.10	75.10
2000-01	9680	13023.90	74.30
2001-02	12890	17232.30	74.80
2002-03	13140	16933.50	77.60
2003-04	12880	15790.20	81.60
2004-05	11060	12777.50	86.60
2005-06	16250	16491.10	98.50
2006-07	16800	17325.10	97.00
2007-08	17200	17199.80	100.00

Source: Bangladesh Bureau of Statistics

Appendix 2. Research and development expenditures for summer onion in Bangladesh

Year	SRC expenditure (current Taka) 5%	NCDP and Action Plan expenditure (current Taka) 10%	BARC expenditure (current Taka) (0.005%)	DAE expenditure (current Taka)	Total expenditure (current Taka)	Total expenditure deflated (Based 2007-08 Tk.)	CPI middle income group (Based 2007-08 Tk.)	Input cost change (current Tk)
1994/95	250000	-	-	-	250000	400586	62.41	-
1995/96	750000	-	451000	-	1201000	1815344	66.20	-
1996/97	2950000	-	342800	-	3292800	5015703	65.60	-
1997/98	3295100	-	522500	-	3817600	5554317	68.70	-
1998/99	1091750	-	1351700	-	2443450	3308751	73.80	-
1999/00	654850	-	1419285	-	2074135	2762295	75.10	-
2000/01	807600	-	1490249	185	2298035	3091883	74.30	8989
2001/02	752000	-	1564762	354	2317115	3097690	74.80	11438
2002/03	750000	-	1643000	372	2393372	3084333	77.60	11827
2003/04	984250	-	1725150	746	2710146	3322489	81.60	12551
2004/05	4861200	1177800	1811407	83052	7933460	9165418	86.60	13764
2005/06	4456400	1902600	1901978	144386	8405364	8530049	98.50	20164
2006/07	2639000	3447900	1997077	156172	8240149	8497727	97.00	24159
2007/08	3663000	3524900	2096930	171291	9456121	9456001	100.00	20193

Note: Spices Research Centre (SRC) of BARI expenditure included in research cost, administrative cost, capital items cost, manpower cost and other cost.