



RESEARCH PAPER

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## Biotechnology revolutionized potato production and its contribution in agricultural GDP of Bangladesh

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### Abstract

Agricultural biotechnology plays vital role in crop improvement; subsequently contribute to increase production and countries GDP. Secondary data were used to estimate growth rate of production, area, yield and export of potato applying compound growth rate. Result revealed that the compound annual growth rate was 0.9% for production, 0.2% for yield, 0.7% for area and 4.7% for export during pre-biotechnology period while it was 9.0%, 3.3%, 5.4% and 40.5% in biotechnology period, respectively. We also Fig. out how this technology changes the scenario of potato production and its impacts on Bangladesh GDP. Our findings reveal that after adaptation of biotechnology in seed potato the yield dramatically increases. That reduces the dependency on imported seed and increases potato export. Our study suggests that implementation of biotechnology in potato seed production is a breakthrough for Bangladesh agriculture and it could be a model for other crop improvement to ensure food security.

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## Introduction

Biotechnology is a system or method that use living organism (or a part of an organism called tissue) to generate products for human welfare. The UN Convention on Biological Diversity defines biotechnology as “any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use”. Very beginning of the human civilization food processing technology and medicine production technique has been invented and in the modern era those processes known as biotechnology. During the late 20<sup>th</sup> to early 21<sup>st</sup> century biotechnology has expanded in to diverse branch of sciences such as agricultural, medical, pharmaceutical and food sciences. Consequently biotechnology becomes one of the very important branches of modern science. It is blessing of science and its application dramatically improves our lives and health of plant. It is very ancient technology but still using for humankind, for example, use yeast to make bread and bacteria to make yoghurt, these technology were discovered more than 6000 years ago, surprisingly, still today we are using same technology to make bread and yoghurt.

Agricultural biotechnology is one of the important sub branches of the modern biotechnology that lead to increase yields, prevent damage of crops from insects and pests and reduce farming's impact on the environment. More than 18 million farmers around the world using agricultural biotechnology to meet the global food demand. Recent advances in this field help the farmer to increase the yield of crop with less use of fewer inputs such as pesticides, fertilizer, irrigation that make them economically more profitable. Consequently, agricultural biotechnology can improve food security and reduce poverty through (i) increase crop and animal productivity; (ii) improve nutritional quality; (iii) broaden tolerance of crops for drought, salinity, and other abiotic stresses; and (iv) increase resistance of crops to pests and diseases. It has the potential to reduce the dependency of agriculture on chemicals, lower cost of raw materials and enhance environmental sustainability.

While other countries including developing and developed countries have made or are making impressive progress in biotechnology, however, Bangladesh has not yet made much headway in this field. Some work has been initiated using the techniques of genetic engineering for the improvement of plants, animals, industrial micro-organisms and also to combat environmental pollution problems.

Agriculture is the single largest producing sector of Bangladesh economy and it contributes about 19% to the country's GDP, about 11% of which is contributed by the crop sector alone (BBS, 2012). Almost 48% of the labour forces are involved in agriculture among them about 37% being employed in the crop sector (MOA, 2009). Bangladesh is losing good quality agricultural land by approximately 80,000 hectare annually due to urbanization, building of new and deteriorating land quality due to degradation, soil fertility problems, soil erosion and soil salinity. In order to produce more food for the increasing population, growth rate 1.6%, so it is very important to increase in agricultural productivity (Bank, 2005). Agricultural biotechnology can play an important role to address the above issues. Potato is the first major food crop where biotechnology has been successfully applied (Bajaj, 1987). Biotechnology-based tools are now broadly used to enhance and expand the traditional remit of potato in food production (Mullins *et al.*, 2006). Potato production has continuously increased over the past years in both developed and developing countries due to biotechnological advances (Lutaladio and Castaldi 2009).

Potato is one of the leading food crops in Bangladesh and it ranks third after rice and wheat in respect of growing area and second after rice in respect of production. The yield of potato is highest within a short period of time and can be cultivated in all agro-ecological zones of Bangladesh. Potato is the second alternative to our main food (rice), next to wheat. In recent years, potato has become an important food security crop, especially during extreme flooding during the monsoon. Potato is the only crop for which seed stocks are kept in cold stores ready for immediate planting after floods.

But many farmers in Bangladesh still use ware potato production technology for producing seed. Seed produced through the informal system is of poor quality and of unknown origin and generation number. This poor quality seed is a major constraint to increased productivity. Potato productivity can be increased by good quality disease resistance seed through tissue culture technology (Ilangantileke *et al.*, 2001).

Several researches have been conducted on potato production and marketing system of Bangladesh. By using Cobb-Douglas production function, Hossain and Miah (Hossain and Miah 2009) estimated the post-harvest losses of potato and technical efficiency of potato cold storages of some selected potato growing area of Bangladesh. Hossain *et al.* (2008) estimated the technical efficiency of Bangladeshi potato producers. Potato marketing system was analyzed by Moazzem and Fujita (2004). Impact of potato to reduce the poverty of rural farmers was examined by Ilangantileke *et al.* (2001). However, so far, the impact of biotechnology in increasing the productivity growth rate of potato is not well studied in Bangladesh. To address this research gap present study estimated compound growth rate of potato for the pre and post biotechnology period in Bangladesh. Along with growth rate the study also estimate the contributions of potato to the country's GDP. The structure of the paper is organized as follows. Section 2 describes present status of plant biotechnology in Bangladesh. Section 3 describes the data and methodology. Section 4 reports and interprets the empirical results. Section 5 represents opportunity and challenges of biotechnology in Bangladesh. Finally, some concluding remarks are presented in section 6.

#### *Present Status of plant biotechnology in Bangladesh*

Bangladesh has a long history in biotechnology which was started in late 1970s in the Department of Botany, University of Dhaka through the systematic invest to agricultural biotechnology. It was initiated to generate an appropriate plant biotechnology and within 10-12 years the plant biotechnology program spread to different universities and R & D organizations.

Some government research institutes and universities has been achieved substantial progress developing transgenic plants of some key crop plants (rice, jute, brinjal, grain legumes, potato, etc.), mostly for higher yields, disease resistance, and stress tolerance etc. Tissue cultured crops of various vegetables, forest plants, ornamental, fruit trees and medicinal plants are in commercial cultivation.

Golden rice are in confinement trial level at BRRI has been approved by the Technical committee on Crop Biotechnology of the Ministry of Agriculture. BR 29 and BR 28, the most popular rice varieties of BRRI, have been transformed at IRRI. The golden rice transformants of BR-29 is already under trial in greenhouse condition at BRRI. Bangladesh Agricultural Research Institute (BARI) has performed two cycles of confined field trails of fruit and shoots borer resistant Bt-brinjal at multiple locations. Bt-brinjal could make a significant contribution to get relief from the pesticide residue problem and to minimize the production loss.

The major constraint of potato cultivation is its vulnerability to virus and other pest that create great havoc to the potato industry. The viruses and other diseases of potato can be eliminated by using meristem culture technique; around 20 biotech labs in the universities, research institutes, government and private organization in Bangladesh using meristem culture technique to produce virus free seed potato. The meristem culture-derived plantlets from the biotech labs are cultured sequentially to produce the breeder seed, foundation seed and certified seeds. Import of seed potato has fallen dramatically and our country is saving huge foreign currency due to wide spread of this meristem culture-based disease-free seed potato production system in Biotech laboratories.

In order to boost up the potato breeding programme in Bangladesh, Department of Botany, University of Rajshahi Bangladesh lunch potato development project through conventional and biotechnological approach in the early ninety.

The researcher of this project successfully invented a sustainable disease free seed potato production system with very low cost. In 1996 a private tissue culture company RANTIC ltd. has been set up for commercial seed potato production with the active support of the researchers of the Department of Botany.

In the late ninety first time tissue culture derived seed potato release in seed market at Bangladesh by RANTIC laboratories and creates exemplary success in using tissue culture technology to seed potato production in Bangladesh. The achievement of RANTIC Ltd. motivated other organizations from private sector entrepreneurs as well as from GOs (BADC) and NGOs to invest capital to build tissue culture based commercial laboratories. BRAC also started disease free seed potato production in 1996 (Srivastava, 2010) for enhancing potato production at Bangladesh. Each year around 2000 tons of seed potato produces by BRAC (Biswas, 2003). At the moment there are 65 plant tissue culture laboratories established in different parts of the Bangladesh to produce seed potato.

Bangladesh Agriculture Research Institute (BARI) has also developed late blight resistant RB potato using its own cultivars in 2006 in collaboration with Wisconsin University and Indonesian University which are currently under greenhouse and field trial. Scientists from BARI's Tuber Crops Research Center (TCRC) developed the transgenic lines by crossing the leading Bangladeshi varieties (Diamant, Cardinal, Multa, Granula, Local) with transgenic variety Katahdin at Wisconsin University and Indonesian University. BARI brought back these lines in 2006 and tested them in greenhouse and multi-location field trial (MOISCT, 2011).

## Materials and methods

### Data and Methodology

The present study is mainly based on secondary data from various national and international sources. Data were collected from Bangladesh Bureau of Statistics (BBS), Bangladesh Economic Review and FAOSTAT, covering the period 1971-72 to 2012-13. Microsoft Excel and SPSS program was applied for analyzing data in a meaningful way.

The entire study period was split into two sub periods to evaluate the impact of biotechnology in potato production. The sub periods are Period I: 1971-72 to 1990-91 (before using tissue culture seed potato) and Period II: 1991-92 to 2012-13 (after using tissue culture seed potato). Here it is also mentioned that in mid 90's some private organization commercially initiated disease free seed potato production through tissue culture technique. Then it expands day by day.

In this research we estimated Compound Growth Rate (CGR) of area, yield, production and export of potato in Bangladesh for each period to show the growth performance of potato. The CGR are found more suitable for any comparison of growth between two periods. It is more appreciable to analyze the movement of agricultural crops in terms of compound rather than linear growth rate (adi Shadmehri, 2008; Dandekar, 1980). Hence, we compute the Compound Growth Rate (CGR) for potato which can be calculated by fitting a semi-log trend equation:

$$\log Y_t = \alpha + t\beta + \varepsilon_t \quad (1)$$

Where,

$Y_t$  = Area, yield, production and export of potato in  $t^{\text{th}}$  year respectively.

$t$  = Year (1, 2...n)

$\alpha$  &  $\beta$  = parameters to be calculated, and

$\varepsilon$  = random error term.

Ordinary Least Squares (OLS) technique was used to calculate the equation (1). The t-test was employed to test the significance of  $\beta$ . This equation is generally based consideration that the agricultural output change in a given year would depend on the output in preceding year (adi Shadmehri, 2008; Dandekar, 1980; Deosthali and Nikam, 2004; Minhas, 1996; Singh *et al.* 1997). We can estimate the CGR by the following equation:

$$CGR = [(Antilog of \beta - 1) * 100] \quad (2)$$

## Result

In this section we Fig. out how the tissue culture technique changes the potato productivity and its impact on the agricultural GDP in Bangladesh. All the analysis and findings are presented in different subsection as mention bellow.

*Present Potato scenario in Bangladesh*

The percentage changes of potato production growth during the year 2012 to 2013 of top ten leading potato producing countries are calculated, compare and presented in Table 1.

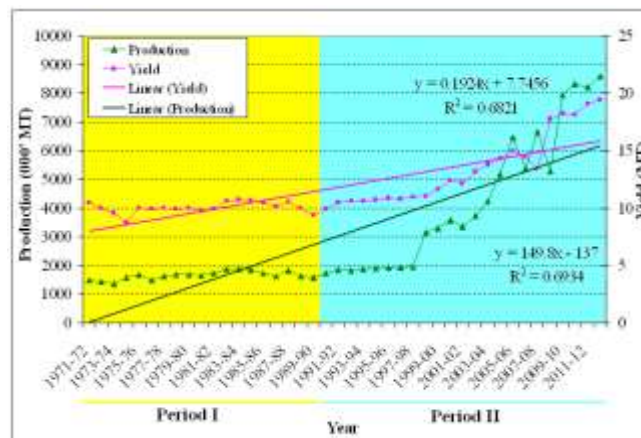
The result reveals that in the year 2012 and 2013 China is the leading potato producer in the world and its

growth changes is recorded 9.9% that is the highest among other leading potato producing countries. While Bangladesh stands seven and growth changes are recorded 4.8%. Here we noticed that most of the European countries decline their potato growth changes during the year 2012 to 2013.

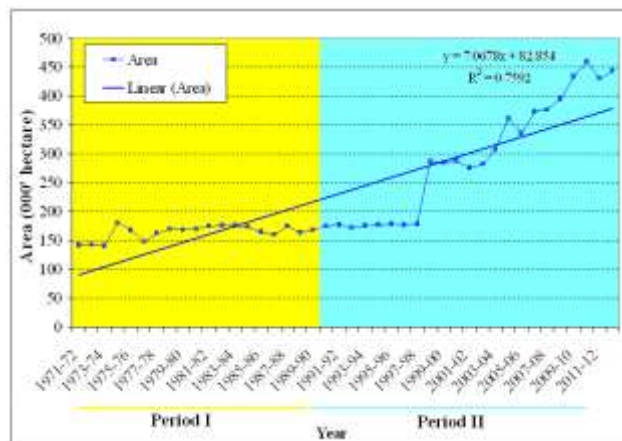
**Table 1.** Top ten potato producers in the world in 2012 and 2013.

Country	Region of location	Rank Y12/Y13@	production (000' MT)		% of growth Changes during the year 2012 to 2013
			2013	2012	
China	Asia	1/1	95942	87260	9.9
India	Asia	2/2	45344	41483	9.3
Russian Federation	Europe	3/3	30199	29533	2.3
Ukraine	Europe	4/4	22259	23250	-4.3
United States of America	North America	5/5	19844	20991	-5.5
Germany	Europe	6/6	9670	10666	-9.3
Bangladesh	Asia	8/7	8603	8205	4.8
France	Europe	9/8	6975	6766	3.1
Netherlands	Europe	7/9	6801	9092	-25.2
Poland	Europe	10/10	6334	6341	-0.1

Data Source: FAOSTAT; @ Y12 =Year 2012 and Y13= Year 2013.



**Fig. 1.** Potato production and yield trend of Bangladesh.



**Fig. 2.** Trend of potato production area coverage in Bangladesh.

*Compound growth rate of production, area, yield and export of Bangladesh potato*

Potato production and yield trend of Bangladesh over the period I (pre-biotechnology era) and period II (biotechnology era) is estimated and presented in the Fig. 1. The result showed that both production and yield dramatically increase in the period II. In the beginning of period II the production and yield trends was slow and it was similar to the period I, after 1999-2000 this trends start uplifting and increasing continually. Consequently, during the time period 2011-2012 it is recorded highest value for production and yield (Fig. 1). Fig. 1 also represent that the potato production followed a steady trend from the period 1971/72 to 1997/98 and in some periods it seems to be declining. Then it follows a considerable increasing trend of potato production.

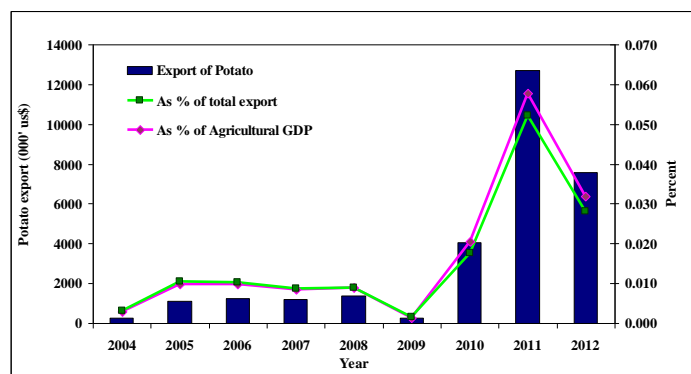
Trend of potato production area coverage in Bangladesh is calculated and presented in Fig. 2. The result showed that the area of production increase significantly in the Period II and it reached highest 460 thousand hectares in the time period of 2010/11.

During the Period I and beginning of the Period II the area of production was below 200 thousand hectors but it was jump over the 275 thousand hectors in the time period 1999-2000 and continuously increased. Compound Growth Rate (CGR) for area, yield, production and export of potato for the pre and post biotechnology period in Bangladesh are presented in Table 2. This result revealed that the CGR for all of the cases are positive but the values are very small in pre-biotechnology period ranging from 0.2-0.9; but it is higher in post biotechnology period ranging from 3.3-9.0. Estimated CGR of potato production is 4.4% during the whole period 1971/72 to 2012/13.

The yield growth rate is estimated at 0.2% in pre-biotechnological period relative to 3.3% during the biotechnological period. The acreage CGR turned out 0.7% and 5.4% during pre-biotechnological and biotechnological period, respectively. It is also revealed from the table that the compound growth rate for the export volume is 18.4% for the overall period while it is 4.7% in pre-biotechnology period and 40.5% during the biotechnology period.

**Table 2.** Compound Growth Rate (CGR) of area, yield, production and export of potato for the pre and biotechnology period in Bangladesh.

Time period	Area	Yield	Production	Export
Period I (1971/72-90/91)	0.7 %	0.2%	0.9%	4.7%
Period II (1991/92-2012/13)	5.4%	3.3%	9.0%	40.5%
OverAll period (1971/72-2012/13)	2.8%	1.5%	4.4%	18.4%



**Fig. 3.** Trends of potato export and as a percentage of agricultural GDP and total export earning.

*Trends of potato export and its contribution to GDP*  
We estimate the potato export in terms of agricultural GDP and total export earnings from 2004 to 2012 and

presented in Fig. 3. In general the potato export flow shows a significant growth during the studied period (from 2004 to 2012).

In 2004, potato export in terms of agricultural GDP is at 0.003 percent and in terms of total export earning it is also 0.003 percent. In 2011 export value of potato in terms of agricultural GDP and total export earnings was significantly increased by 0.06 percent and 0.05 percent respectively.

## Discussion

### *Present Potato production scenario in Bangladesh*

Before 1990s, Europe, North America and former Soviet Union's countries were the major potato producing and consuming country. After 90's the global potato production and consumption scenario has been changed. Both production and consumer demand of potato has been dramatically increased in Asia, Africa and Latin America (Islam and De Silva, 2011). Since 1993, China emergence as the world's leading potato producer (Wang and Zhang, 2004) and till today China is the largest potato producing country in the world. A comparative analysis of potato production has been performed to understand the present scenario of potato production around the world and the position of Bangladesh for potato production (Table 1). This result showed that Bangladesh is the 3<sup>rd</sup> largest potato producing country in Asia and it ranked 7<sup>th</sup> in world potato production in the year of 2013. According to FAO reports Bangladesh achieved the seventh rank with 8.6 million tons of potato production in the year 2013, while it was around 3.0 million tonnes in 2002. In addition in the year 2015 potato production recorded 92.54 million tons (FAOSTAT, 2015; Mahmud, 2015). Five countries follow an increasing change in their potato production while other five countries have decreasing changes. Among five increasing growth changes countries Bangladesh located in third position. This result reveals that potato production in Bangladesh increases significantly compare to the other leading potato producing countries.

### *Compound growth rate of production, area, yield and export of Bangladesh potato*

Bangladesh adopted biotechnology in potato production system in the year of 1990. Therefore, in this study we divided our study period in to two parts based on the biotechnology adoption in this sector.

Period I allocated from the year 1971/72 to 1990/91; it was the pre-biotechnology era for potato production in Bangladesh. While Period II allocated from the year 1991/92 to 2012/13 and designated as post-biotechnology era of potato production sector in Bangladesh. The main purpose of this division was finding the clear picture of effects of biotechnology on the potato productivity and its subsequent effect on GDP of Bangladesh. Fig. 1 and 2 depict the potato production, area coverage and yield trend in Bangladesh during the time period 1971/72 to 2012/13. The Average yield rate was 10.1 ton per hectare up to 1990/91 from 1971/72. And after that the average yield rate from 1991/92 to 2012/13 was increasing to 13.6 ton per hectare due to use of high yielding variety (HYV) and commercial introduction of disease resistance seed of potato through tissue culture.

At the very beginning of biotechnology the production of potato (Period II) was 1700-1800 thousand metric ton. Prior to 2010/11, about 460 thousand hectares of land were under potato cultivation which provided a total production of about 8326 thousand metric tons with an average yield of 18 ton/ha. In 2011/2012 Bangladesh increased the total yields harvested to about 8205 thousand metric tons from 430 thousand hectares of land. After that potato production has increased by 8603 thousand metric tons during the period 2012/13 due to the blessing of biotechnology which is presented in the Fig. 1.

Compound Growth Rate (CGR) of pre-biotechnology and biotechnology era and overall the study period for area, yield, production and export of potato have been estimated (Table 2) and result demonstrated that CGR significantly increase in biotechnology era. For example the value of CGR for production was 0.9% in pre-biotechnology period and it was jumped to 9.0% during the biotechnology era. The yield CGR significantly increases in the post-biotechnology era that was 16 fold higher than the pre-biotechnology era. These results suggest that the production of potato in Bangladesh significantly influence by the advance technology adaptation.

The total production of potato is increase when the production per unit area increases over the period of 1971/71 to 2012/13. Again the fluctuation of yield per hectare as well as production of potato is common due to disaster like drought, cyclone, flood, sidr etc. which causes damage to the country's food crops almost every year. Export volume growth rate has steadily increased during the biotechnology period that may be attributed to the yield and production increase and may be cause of government incentives to the exporters. Cash incentive to the exporter, provided by the Government on the export volume, worked as a catalyst to increase export during the last few fiscal year. Bangladesh government provides 20% cash incentives to the potato exporters from the fiscal year 2011/12 if the shipment was made in February to April. But during the current fiscal year potato exporters are entitled to receive a 20% cash incentives throughout the year (Islam and De Silva, 2011).

#### *Trends of potato export and its contribution to GDP*

Potato export from Bangladesh was started in the 1980s and it was continuously increasing mainly after nineties and reduces the import of potato in Bangladesh due to seed potato production at commercial level. In the early nineties a number of privet entrepreneurs and NGOs are involved on plant tissue culture and commercially produced the virus free seed potato. As a result the good quality potato seed become in the market with low price compare to the imported seed, that leads the reducing our dependency on imported potato and increase our potato export. In order to Fig. out the trends of potato export and its contribution to the Bangladesh GDP, we estimated potato export as a percentage of total export and percentage of agricultural GDP of Bangladesh from 2004 to 2012, and plotted them with the export of potato (Fig. 3). The result shows that there was a sharp decline in potato exports in the year of 2009, this was due to low quantities of potato production in 2009 (Fig. 1). As opined by industry expert, there was a potato glut in 2008 and as a result farmer did not get their expected price and they sell their product at low price. In the next year many farmers did not cultivate potato and they invested a low amount in potato production resulted the overall setback of potato in 2009.

The export value of potato from Bangladesh was highest during the year 2011 (Fig. 3) and it was 12696 thousand USD reflecting 213 percent rise over the previous year. Though the production volume is high (8603 thousands metric ton) in 2012-13 but the export volume is comparatively low.

During the period under review, potato is being exported in small quantities to some countries in the Middle East, Malaysia and the European Unions (EU). Major export markets of Bangladeshi potato and potato products are Republic of Korea, Italy, Singapore, Malaysia, U.K, India and U.A.E. Along with these markets, recently Bangladesh started to export potato to such new markets as Russia, Sri Lanka and Vietnam (Islam and De Silva 2011).

#### *Opportunity and Challenges towards agricultural biotechnology in Bangladesh*

Bangladesh has great potentials for the development of plant biotechnology. The opportunities of biotechnology are enormous not only in the field of agriculture but also in health care, industrial upliftment, energy development, environmental development or bioremediation. Agricultural biotechnology, offers enormous potential to speed up the development of plant varieties with pro-poor traits such as drought tolerance, pest resistance or tolerance, higher yields, increased nutritional value, among others.

Bangladesh has become vulnerable to climate change, experiences frequent cyclone, flood and drought. The farmers of Bangladesh are very much positive towards accepting new technologies and products developed through modern biotechnology. Biotechnology is often presented as promising a new phase of productivity growth, including new production systems less dependent on chemical inputs.

Agricultural biotechnology is expected to contribute substantially in our country to poverty reduction and food security through increased productivity, lower production costs and food prices, and improved nutrition. But this emerging technology has some challenges like:



- (i) It requires heavy investment
- (ii) Development the laboratory infrastructure
- (iii) Commercialization issue
- (iv) Biosafety issue
- (v) Bioethical issue
- (vi) It needs to create public awareness
- (vii) Specialized expertise is need to the research in the various field of biotechnology.

### Conclusion

Although plant biotechnology started in late 1970 but it was not sustainable before early 90's, after some private organization commercially initiate disease free seed potato production through tissue culture technique in mid 90's. The growth rate of production, area, yield and export of potato has sharply increased due to the introduction of tissue culture seed potato and adaptation of new production technology. Now a day's potato has become one of the most productive crops that can play a significant role in ensuring food security (<http://agmarknet.nic.in/profile-potato.pdf>). A developing country like Bangladesh needs not only the quantity of food but sufficient quantity and quality of a balanced nutritious food. So the main policy goal of biotechnology is to enhance food security, poverty alleviation and health and livelihood security. The opportunities in biotechnology are enormous and multi-faceted with respect to diversity and market value. However, for Bangladesh the areas of national interest include agriculture-food and other crops, livestock and fisheries, forestry and environment, health care and nutrition, biodiversity conservation and other biotech products and processes. Where 40 percent of total population lives under poverty line in Bangladesh and yearly huge amount of food are imported from other country then Agricultural biotechnology has a great opportunity to reduce poverty and make a strong economy by converting import to export oriented economy. Our findings suggests that introducing tissue culture technique in other crops, the seed production system can be benefited and it will strong our economy by reducing the dependency of seed from other country and meet the demand of our ever increasing population.

It is expected that Bangladesh will achieve food security, poverty alleviation, health, nutrition and livelihood improvement, and sustainable environment by 2021 through the application of biotechnology (MOISCT 2011).

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