

BIOTECHNOLOGY INNOVATION AND COMMERCIALIZATION CONTEMPORARY CHALLENGES AND OPPORTUNITIES IN NEPAL

Abstract

Agriculture is the major sector of Nepalese economy. It provides employment opportunities to 66 percent of the total population and contributes about 36 percent in the GDP. Therefore, the development of agriculture sector is the key for development of national economy. However the lack of improved varieties seems to be a root cause for low agricultural production and poor economic growth of the country. If this situation persists, the significant part of the country's economy will have to be spent on import of agricultural commodities in the future. Hence it is high time to go for advanced technologies that enhance agricultural produce to ensure food security in Nepal. In this context, biotechnological innovation and commercialization has great potential for agriculture and economic development of the country. Advanced researches on biotechnology for crop improvements and development and commercialization of GM crops could give definite direction to the agriculture of the country.

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Introduction

Biotechnology has wide applications in almost all branches of biological sciences including medical, agriculture, veterinary, food, environment and energy production. The emergence of new biotechnologies and evolution of older biotechnologies, associated with availability of ocean of newly developed knowledge and techniques, has made biotechnology an arena possessing immense practical utility and tremendous economic potential in different sectors. The promise of biotechnology has now been realized in developed countries. But this is generally not so with the developing countries. Most developing countries are still challenged on how best to build capacity that would enable them to use the advances in agricultural biotechnology and to take advantage of knowledge and products from other countries.

Biotechnology in Nepal is at a very preliminary stage. Plant tissue culture is the major biotech activity of the public and private sectors where the public laboratories develop protocols for *in vitro* propagation of different plant species while private laboratories use them commercially. Few public sector laboratories such as NAST (Nepal Academy of Science and Technology) and NARC (Nepal Agricultural Research Council) have initiated researches on molecular/DNA technology. NARC has recently integrated the Marker Assisted Selection (MAS) in

conventional breeding program which is the main method of crop improvement. However, researches on Marker Assisted Selection are negligible and those on Genetic Transformation and GM (Genetically Modified) crops are practically none. Thus the country is way behind in using modern biotechnology, and hence the days ahead are challenging.

As modern biotechnology has evolved with highly sophisticated and expensive technologies, it is very difficult for a least developed country like Nepal to afford the costs involved in infrastructure and human resource (HR) development by its own, despite its utmost importance in national development. Due to various constraints, Nepal has lagged behind in biotechnology and with the existing HR, infrastructure and budget allocation by government in research and development in Biotechnology, it is difficult for Nepal to keep pace with the rapidly evolving newer technological advancements in modern biotechnology. A strong national commitment is needed for the overall development of biotechnology in various sectors for economic development of the nation as a whole. There are many areas in various biotechnology sectors in which regional cooperation can be initiated. In this context SAARC (South Asian Association for Regional Cooperation) could be a relevant forum to exchange cooperation in various areas of biotechnology among various member countries of this region.

Group of organisms	Nepal's representation as compared to the number of species in the world (%)
Lichens	2.3
Fungi	2.4
Algae	2.6
Bryophytes	5.1
Pteridophytes	3.4
Gymnosperm	5.1
Angiosperm	2.7
Spider	0.2
Other insects	0.7
Butterflies and Moths	2.6
Birds	9.3
Reptiles	1.6
Amphibians	1.0
Fish	1.0
Mammals	4.5

Table 1. Nepal's richness in organisms as compared to the world

Biotechnology for Nepalese economy

Agriculture is the major sector of Nepalese economy. It provides employment opportunities to 66 percent of the total population and contributes about 36 percent in the GDP. Therefore, the development of agriculture sector is the key for development of national economy (Ministry of Agriculture and Cooperative, 2010).

Owing to insufficient agricultural production, every year Nepal imports several agricultural commodities (such as food grains, pulses, fruits, vegetables etc.) from its neighboring countries, mostly India and China. Thus Nepal incurs billions of its currency on the purchase of agriculture commodities despite itself being an agricultural country. Because of low or no use of improved varieties, the country's agricultural production is itself low. Moreover, the high input and low government subsidies result in high cost of cultivation in Nepal, because of which Nepalese farmers can hardly com-

pete for their agricultural and herbal products in the international market. Instead, the high price of the local commodities creates a favorable environment for relatively cheaper foreign products in the Nepalese market.

Thus the lack of improved varieties seems to be a root cause for low agricultural production and low economic growth of the country. If this situation persists, the significant amount of money will have to be spent on import of the agricultural commodities in future. In this context, biotechnological innovation and commercialization has great potentialities for the agriculture and economic development of the country.

The global agriculture system is under the threats of global climate change and biotic and abiotic stresses. Nepal will also have to face these challenges. But by observing the current agricultural situation of the country, Nepalese farmers seem to be severe victims of the changing global situation. Our research and development does not ensure plant diversity and food security for upcoming situations. Thus the country has to strengthen its research in order to prevent Nepalese agriculture from the adversities of changing environmental conditions. In this respect, the researches on the biotechnology for crop improvements and the development and commercialization of GM crops could give definite direction to the agriculture of the country.

Immediate need for agricultural biotechnology

The immediate needs for agricultural biotechnology in Nepal are viewed as the following (Bimb et. al, 2009):

- Conservation and utilization of rich diversity;
- Regeneration, characterization and evaluation of plant germplasm;
- Food security and food safety;
- Value addition and quality seed, seedling and sapling production;

- Compete for agricultural and herbal products in international market (WTO);
- Bioprospecting; and
- Biosafety.

Conservation and utilization of rich diversity

Nepal's biological diversity is a reflection of the nation's peculiar geographical structure and climatic diversity. Because of it there is diversity in habitat, plants and animals. The seasonal variation in the climate such as the heavy rains in the monsoon, snow fall in the winter and high temperatures in the summer have been reasons for diversity in the animal and plant species. The productive capacity of the land also differs according to the variation in soil structure of the different geological landscape.

The species diversity differs according to altitudes in Nepal. The ecosystem in the Terai and Siwalik range, with altitude between 60 to 1000m above the mean sea level, is important from the point of view of conservation of the world's endangered species. Accordingly, five protected areas have been established in this region, among them the Chitwan National Park is listed in the world heritage site too. The biological diversity in the Terai is at high risk because of the increasing population in the region. The middle hill region, with elevation ranging from 1000 to 3000m above mean sea level, is recognized as the biodiversity rich area. About 32 percent of the total forest area lies in this region. Protected areas in the high mountain region above 3000m cover about 78.52 percent of the region. There are 38 ecosystems in this region. Nepal, though geographically small, is rich in biodiversity. Nepal represents 0.1 percent of the terrestrial area of the earth but it has 118 ecosystems and comparatively higher presence of different plants and animal species of the world. The data in the table 1 shows its richness in biological diversity.

In developing nations, the sustainability of agricultural ecosystem depends on many things including diversity of the local landraces too. In Nepal, agricultural occupation has been adopted as a life supporting system in tropical, temperate and sub-alpine zones. Knowingly or unknowingly, our farmers have been conserving agricultural biodiversity substantially contributing to the development and expansion of new agricultural biotechnology. In this regard, it is of prime concern to conserve, use and manage the existing biodiversity in this sector.

Regeneration, characterization and evaluation of plant germplasm

National Agriculture Genetic Resources Centre (NAGRC/Gene Bank) was established in 2010 under Nepal Agriculture Research Council for short term and long term conservation of plant germplasm of Nepal. NAGRC has got a number of plant accessions of different crops for their successful conservation (Table 2).

Short term storage conditions

Required temperature = 10°C
 Required humidity = 40%
 Area = 400 sq. feet
 Period of storage = 5 years

In addition to short term and long term conservation, NAGRC has the responsibility of the regeneration and characterization of existing germplasm. At present, the Centre is undertaking only morphological characterization of the germplasm under regeneration. Molecular characterization and evaluation are yet to be done. Owing to financial constraints, the Centre is unable to operate its own Molecular Lab. So the biotechnological and molecular researches are the immediate requirements of the Centre without which the goal of conservation program will be delayed. Conservation without molecular characterization and evaluation will be rather expensive for the country.

S.no.	Crop	Number of genus	Total number of accessions
1	Cereal crops	20	6,075
2	Pulses	22	3,357
3	Oilseeds	10	640
4	Vegetable crops	20	603
5	Spices	10	75
6	Fiber crops	03	11
7	Miscellaneous (Coffee, Tobacco etc.)	05	20
	TOTAL	90	10,781

Table 2. Total number of accessions conserved in the gene bank

Source: National Agriculture Genetic Resources Centre (NAGRC/Gene Bank)

Year	Total edible production	Total requirement	Balance	Balance %
1999/00	4,451,939	4,383,443	68,496	1.56
2000/01	4,513,179	4,424,192	88,987	2.01
2001/02	4,543,049	4,463,027	80,022	1.79
2002/03	4,653,385	4,619,962	33,423	0.72
2003/04	4,884,371	4,671,344	213,027	4.56
2004/05	4,942,553	4,779,710	162,843	3.60
2005/06	4,869,440	4,890,993	-21,553	-0.44
2006/07	4,815,284	4,995,194	-179,910	-3.60
2007/08	5,195,211	5,172,844	22,367	0.43
2008/09	5,160,400	5,293,316	-132,916	-2.51

Table 3. Edible cereal production and balance (MT)

Food security and food safety

The natural resources of Nepal are of high economic value. The country has got a total land area of 147,181 sq. km., out of which only 20 percent is suitable for agricultural cultivation; this is a factor for limiting important economic activities in Nepal. The projected population of the country for the year 2011 is 28.58 million with a population density of 194 persons per sq. km. and the annual population growth rate of 2.25% (Central Bureau of Statistics, Nepal 2009). Hence there is an increasing demand for food and energy in the country.

Food availability in Nepal is mainly a function of agricultural performance. Although the contribution of agriculture to gross domestic product (GDP)

has been declining over time it is still the largest economic sector employing 65 percent of economically active population and sharing 32.4 percent in the GDP (Economic Survey, 2009). Nepal was food secured and was a net food exporter until the early 1980s. From 1990s the population growth outstripped cereals production and the country over the past two decades has been experiencing sporadic food shortages at the national level. The contributory factors in food deficit are severe weather conditions like drought, flood, landslides, hailstorm etc., but the magnitude of food deficit usually is small, less than one percent of the total food requirement but in some years it was higher than one percent (Table 3).

Although, the agricultural sector is the major income source and liveli-

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hood of over 50% of the total households and provides employment to about two-third of the total population, Nepal is unable to produce agricultural products to feed its population. The problem of food scarcity is widely spreading in several mountainous regions of the country. Food and energy shortage have been the major problems of the country. In this context, efforts on biotechnological research and development should be highly concentrated to overcome the problem of food crisis in the immediate and far future.

The increase in agricultural production through the improvement of Agronomic practices and traditional breeding have failed to bring quantum jump in the country's production for the past few years. Hence the application and use of modern biotechnological tools in Nepalese agriculture could play a significant role in increasing the country's food grain production. In order to meet out the gaps in the demand of food commodities, genetically modified (GM) products may play vital role in ensuring food security in the country. The acceptance of GM foods could save the country from food shortage which seems likely to create more panic in the coming years.

Moreover, the development of high yielding and resistant crops by the use of modern biotechnology and their commercialization would be the best approach to enhance the food grain production of the country. The commercialization of GM crops in Nepal could save the country from food crisis. Additionally, it will help to reach the state of self sufficiency in food grain

production. However, there are certain restrictions and challenges in the use of modern biotechnology for their adoption and application in Nepal.

Challenges in biotechnology

The major challenges in the field of biotechnology in Nepal are summarized below:

- **Lack of technical manpower:** Only few people are trained in the field of biotechnology. Some educational institutions are offering biotechnology education in Nepal. Hence due to low educational opportunities, the country lacks technical and skilled human resources.
- **Poor Institutional infrastructure:** Biotechnology has been recently introduced in most of the institutions but they are not well equipped.
- **Lack of resources for biotechnological research:** The low budget allocation for the research and development, poor infrastructure and low private and public sector investments are the major challenges in the development of biotechnology in Nepal.
- **Commercialization of the product:** Some biotechnology laboratory working in the field of floriculture and pharmaceuticals are producing flower saplings and drugs/antibiotics.
- **Lack of biosafety legislation:** A though a draft has been formulated concerning the applications and use of modern biotechnology, it has not been ratified yet. The lack of proper biotechnology policies in the past and their biosafety legislation have been the major hindrances for the advancement of the technology in Nepal.

Government policy/legislation regarding application of biotechnology

Recently, Nepal Government has ratified National Biotechnology Policy

(NBP, 2006). Prior to this, Ministry of Forestry and Soil Conservation (MoFSC) has published Biosafety Guidelines (2005) with regards to safe handling and use of modern biotechnology products (Biosafety guidelines, 2005). Recently, MoFSC has developed National Biosafety Framework (NBF, 2007) comprising policy, legal, technical and administrative aspects of biosafety to safeguard the biological diversity, human health and environment from the possible adverse effects of Genetically Modified Organisms (GMOs) and their products as per CBD-CPB requirements (Convention on Biological Diversity-Cartagena Protocol on Biosafety). Besides these, a number of national policy and legal documents exist in various disciplines and sub-sectors within various institution's mandate and objectives that are directly or indirectly related to biotechnology, biodiversity and biosafety. Following are the list of some of them.

Millennium Development Goals (MDGs), 2000

The MDGs have aimed at reducing by half the number of people suffering from hunger during the period from the year 2000 to 2015. It is in this context that biotechnology along with biosafety has to be adopted and utilized, though nothing has been directly stated as to using biotechnology as such in its goals. The MDGs include decreasing environmental degradation and integrating sustainable development concept into policies. The MDGs, 2000 has the target of minimizing poverty and hunger and ensuring environmental sustainability, which could be achieved by paying adequate attention to biosafety while using biotechnology to increase productivity.

National seed policy, 1997

This policy has emphasized on conserving agro-biodiversity and establishing variety rights over seed as the local seed varieties are important for developing new seed varieties. It

states to conduct study and research on GMO seed and plants and they will be released to public use only if the study, research and test conducted in presence of the competent authority show that adverse effect on local living beings and environment is not likely to occur.

The National Wetland Policy, 2002

Wetlands are considered as fertile lands for agriculture and rich from the point of view of biological diversity. These wetlands provide habitat for several species of wildlife and lie within various ecosystems of high-mountain and low-land plain. The wetlands of the country's low-lands alone support 32 species of mammals, 461 species of birds (among which 15 species are rare), 9 species of turtle, 20 species of snake and 28 species of fish. The primary goal of the National Wetland Policy is to conserve and manage wetland resources wisely and in a sustainable way with local people's participation. The policy also aims to put the conservation and management aspects of wetlands conservation within the framework of broader environmental management. The National Wetland Policy has stressed on taking concrete steps in banning unwarranted entry of alien GMOs that may displace and destroy endemic species and destroy wetland biodiversity. It emphasizes to take concrete steps to stop the infiltration of invasive plants and animals, creatures and genetically altered or other living organisms into the country that are likely to invade, displace and destroy endemic species as well as other wetlands biodiversity and take necessary actions to control and manage the invaders that have already found their way into the country.

Science and Technology Policy, 2004

The Science and Technology Policy, 2004 has laid emphasis on using science and technology to increase

The biotechnology policy underscores the role of research, development and transfer of biotechnology to promote production and maintain public health and environment.

productivity, and carry out studies, research and development activities in the field of biotechnology. It has tried to create an environment for maximum utilization of knowledge and skill of science and technology personnel available in regional and international arena by promoting mutual cooperation with the bilateral, multilateral, regional and international organisations.

Biotechnology Policy, 2006

This was formulated by the Ministry of Science and Technology, Government of Nepal. The overall objective of the biotechnology policy is to contribute to poverty alleviation through the development, extension and application of biotechnology in comparatively beneficial sectors and thereby establishing it as a strong means of the national development, environmental conservation and public well being. It has recognized biological resources at the centre of policy i.e., utilization of biological resources through the combination of traditional knowledge as well as modern technology. The policy underscores the role of research, development and transfer of biotechnology to promote production and maintain public health and environment.

Biosafety Guidelines, 2005

Giving due consideration to conservation of environment and biodiversity as well as to promoting public health, and aiming for developing and extending scope of biotechnology, the Ministry of Forests and Soil Conservation has framed Biosafety Guidelines, 2005. While assessing any potential risks posed by GMOs or their products, and conducting regulatory procedures, the

guidelines point out to pay more attention to the GMO or GMO products than to molecular or multi-cellular methodology applied for producing these materials. It also points out that step by step GMOs or their products may be released one after another by taking due precaution, prior to releasing GMO or products thereof. It is to be ensured that no adverse effect to the human health or environment is observed at each stage of the risk assessment. According to the guidelines, if any harm is not detected by the release of GMOs or their products the control on such GMOs or products thereof may be relaxed. It sets out the directives of disallowing the entry of such organisms or material in the market unless the field test of these materials, developed as a result of research and development, ensure no adverse effect to the ecosystem and human health.

Agricultural Policy, 2005

The Agricultural Policy, 2005 has a provision of regulating GMOs, promoting the production and use of productive hybrid species, developing standards for food, controlling its quality and certifying the food products. It has also provisions of regulating agricultural products according to the international treaties and agreements as well as to the national need. The policy states to develop, extend and use suitable agricultural technologies by utilizing the local potentialities, comparative advantage and available special opportunities, which will boost agricultural production and productivity, and emphasizes on commercialization as well as diversification of agriculture to increase income generation and additional employment opportunities.

Gaps and weakness

In totality, the existing policies, strategies and plans have stressed on minimizing poverty and hunger, regulating the use of biotechnology and GMOs for easy access by people to nutritious food and on taking concrete steps in

prohibiting the unwarranted entry of GMOs that may have adverse effects on biodiversity. The Seed Policy states that GMO seed and plants shall be released to the public, if the result of test of GMO seed and plants shows that adverse effect on local living things and the environment is not likely to occur.

The Cartagena Protocol on Biosafety stresses on adopting necessary measures in order to avoid or minimize the adverse effect on the human health, biodiversity and environment likely to be caused from the use of GMOs for agriculture, animal husbandry, fishery, forestry or processing. The existing Seed Policy is focused on seed and plants including GMO seed and plants to be used for agriculture sector.

However, the reviewed policy document lacks clear provisions on safeguarding human health, environment and biodiversity from negative impacts that may occur during the trans-border movement, operation, storage and use of GMOs produced by using modern biotechnology or the materials containing GMOs, and on managing risks associated with such materials and acquiring public participation in the overall aspect of biosafety.

Conclusion

Nepal is small and primarily an agricultural country, but still, there is scarcity of food in the Himalayan and the mountainous regions, where the agricultural systems are traditional. So, on one hand, it is required to increase food production to the extent possible in the limited arable land in the remote areas, on the other hand

the threats of potential adverse effects on the Nepalese territories, agricultural system or environment from GMOs cannot be taken lightly when both her big neighbors, India and China, are adopting the cultivation of GMO crops. Hence, there is a great possibility that in the name of high yielding varieties, seeds with GMOs may be imported to Nepal from neighboring countries. Moreover, there is threat of disappearance of local crop varieties through cross pollination among GMO crops cultivated in bordering India. Similarly, there is high probability that the imported processed food items made through biotechnology techniques may contain GMOs. But the country is not well prepared to deal with the problem of biosafety. So, it requires a well defined system and a set of guidelines to monitor and regulate the entry and release of GMOs in its territory.

Of course, there is a need for a national biotechnology coordinating agency in Nepal. Apart from this, investment is needed from public and private sectors for research, human resource development and infrastructure. Market size is small to attract foreign private sector investment. Hence the country needs program and policies for fostering and nurturing local entrepreneurship. Moreover, we can greatly benefit from knowledge and experience of India

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BioNet Asia Pacific

BioNet Asia Pacific (BNAP) is comprised of industry associations representing the countries and regions in the Asia Pacific region who have recognised the benefit of strengthened collaborations in the region and come together to establish a dynamic business and information exchange vehicle for the development of regional biotechnology. The creation of this virtual biotechnology marketplace enables Asia Pacific based companies to search for relevant partners and has centralised opportunities and strengths from the region into a connected universe. Entry into this universe allows access to data on Asia Pacific based trade and investment opportunities, partnering needs, product information, company profiles, up-to-date contact details. Currently ten members sit on the committee with members from Australia, India, Republic of Korea, Japan, Malaysia, New Zealand, Singapore, Taiwan province of China, Thailand and The United Arab Emirates.

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