Integrating Biotechnology with Agricultural and Food Engineering to Power Agricultural and Food Production

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OVER the last 50 years, agricultural and food engineering has contributed significantly towards enhancing agricultural and food production in the world. Recent research and development efforts worldwide are focused on the development and application of biotechnology to transform and enhance value creation in the agriculture and food industry. At the same time, research efforts are being undertaken towards integrating biotechnology with appropriate agricultural and food engineering with the aim of commercialising and sustaining the application of biotechnology in agricultural and food production.

The usage of biotechnology for the agricultural and food industry has been proven to provide value added benefits. These includes:

- Most crop fertility and nutrition products today are chemically based which can be harmful to the environment and has detrimental effects to the soil and human health in the long run. In addition, the use of chemicals is not a sustainable practise. Biotechnology enables the use of naturally available microorganism (from different soil, plants, sea life, *etc.*) as growth inputs to improve yield and productivity. For example, the use of bio-fertilisers, bio-pesticides, bio controls and plant & soil enhancers.
- In the livestock sector, the use of artificial insemination and embryo transfer has not only improved the quality of animals, but also increased the quantity of animals bred in a short time.
- The use of advanced molecular and extraction technologies including:
  - i) The use of molecular tools such as Marker Assisted Selection (MAS) has shortened breeding times and are able to accurately determine traits of interest at the molecular level (*i.e.* no trial and error is required as in conventional breeding) thereby increasing the breeding accuracy. Examples of traits of interest include disease resistant crops (*e.g.* blast resistance in rice and ring spot virus in papaya), high yielding crops with highly desired components (*e.g.* oil palm, rubber and pepper) disease resistant aquaculture products (*e.g.* white spot virus resistant prawns and irido virus resistant fish), elite animals (*e.g.* fast growing goats with high meat yields) and many others.

  - ii) The use of Supercritical Fluid Extraction and Particle Sizing Technology. This technology is able to extract and separate components into its pure form in an environmentally clean, safe and sustainable manner.

The extracts obtained are targeted and of a high purity for specific niche industries (*e.g.* food and flavour, natural

wellness and health supplements). The products obtained have a higher value and have specific applications. In addition, the technology also enables the extracts to be sized according to the end application resulting in the improved delivery and efficacy of the products.

It is not surprising that the government has embarked on the policy of promoting biotechnology as a new engine of growth and wealth creation for the Malaysian economy. In line with this, the government has been very supportive in this area, and recent steps taken by the government towards this includes:

- In the recent Budget, the government had announced an allocation of RM3.8 billion for the agriculture industry. Some of the targeted areas to be developed are natural products, crops and aquaculture.
- Two Entry Point Projects (EPP) have been approved in the recent Economic Transformation Programme (ETP). The projects approved are:
  i) Seed Industry Development. This EPP covers the use of the MAS platform by CMDV to provide high-quality breeding material for the industry.
  ii) Attracting FDI for agricultural biotechnology. This EPP focuses on attracting FDI into the country in the various areas involving agro biotech such as bio-yield enhancers, bio-pesticides, flavours and fragrances, aquaculture, natural products, *etc*.

CAPITALISING ON MALAYSIA'S BIODIVERSITY

Malaysia is the 12th most diverse nation in the world and 4th in Asia (after China, Indonesia and India). Health related products are primarily derived from herbs, plants and crops (*e.g.* vitamin E from oil palm) and various efforts are being undertaken by the government to capitalise on the country's biodiversity to promote and commercialise discoveries in health related products. The country is extremely rich in species and genetic diversity, from its tropical rainforests and highlands, to its freshwater and marine ecosystems. Our unique and diverse natural resources are a source of treasure which has yet to be fully exploited for our economic wellbeing.

According to estimates from the Malaysian Herbal Corporation, the Malaysian natural products industry was worth about RM8 billion in 2005, with flavours & fragrances at RM2.5 billion, pharmaceuticals/nutraceuticals at RM1.4 billion, and herbal remedies at RM3.3 billion. This industry is considered to be one of the most dynamic small and medium enterprises (SME) sectors, with the market expected to reach RM10 billion by 2010. However, most of the products marketed in Malaysia are imported mainly from China, India, Indonesia, United States and Australia. Malaysia has great potential to emerge as a regional player in the application of new biotechnology tools to enhance the seed breeding industry, especially for the improvement of indigenous food and non-food crops, due to several reasons:

i) Centre of biodiversity for a number of commercial crops such as orchids, azaleas, rhododendrons, *etc*.

ii) The availability of micro-climates – highlands, lowlands, coastal, marine and freshwater habitats.
iii) Food security issues – Malaysia needs to improve its planting materials in order to address this pressing issue.

Efforts by the government include the launching of several initiatives to capitalise on the country's biodiversity since the 1980s. Among the notable initiatives was the multi-institutional (Ministry of Science, Technology and Innovation (MOSTI), Forest Research Institute Malaysia (FRIM), universities, *etc*) collaboration with MIT on the R&D of selected herbs. Other than that, the attempt at discovery and commercialisation was quite disparate in manner with universities, Malaysian Agricultural Research and Development Institute (MARDI), FRIM and other research institutes pursuing their own programs. At the state level, Sarawak has been in the forefront with the establishment of the Sarawak Biodiversity Centre. On the GLC side, Khazanah has invested in Biotropics. On the other hand, BiotechCorp has been actively engaging the related biodiversity centres in Malaysia to enable them to partner with multinational corporations to undertake research projects in natural drug discovery programs. For example,

the following are several projects undertaken by the various BiotechCorp:

i) Sarawak Biodiversity Centre and Novartis
ii) Sarawak Biodiversity Centre and Astellas (through Nimura Genetic Solutions Sdn Bhd)
iii) Sabah Biodiversity Centre and Lonza
iv) Sabah Forestry Department and BioCapital (Taiwanese company)

GOVERNMENT INCENTIVES ON BIO-PROCESSING

The government, through its agencies, offers various incentives and funding to support the growth of industrial bio-processing and bio-manufacturing. These include:

BiotechCorp:

Under the RMK9, BiotechCorp provides funding to BioNexus status companies under its Biotechnology Commercialisation Grant. Three components of the Commercialisation Grant are as follows:

i) Seed fund to finance the start up cost in setting up biotech companies.
ii) R&D matching fund objective to finance the development of new or improved products and/or processes and/or technologies.
iii) International business development fund to promote the expansion of BioNexus status companies on the global market.

MIDA

MIDA provides the following incentives for companies that have been awarded the BioNexus status by Biotechcorp. Exemption from tax on 100% statutory income:

- for a period of 10 consecutive years of assessment from the first year the company derived statutory income from the new business, or
- for a period of five consecutive years of assessment from the first year the company derived statutory income from the existing business and expansion project
- Concessionary tax rate of 20% on statutory income from qualifying activities for 10 years upon the expiry of the tax exemption period
- Tax exemption on dividends distributed by a BioNexus status company
- Exemption of import duty and sales tax on raw materials/components and machinery and equipment
- Double deduction on expenditure incurred for R&D
- Double deduction on expenditure incurred for the promotion of exports
- Buildings used solely for the purpose of biotechnology activities will be eligible for Industrial Building Allowance to be claimed over a period of 10 years.

MIDA also provides a tax deduction equivalent to the total investment made in seed capital and early stage financing for eligible BioNexus status company. BioNexus status company undertaking merger and acquisition with a biotechnology company is eligible for the exemption of stamp duty and real property gain tax within a period of five years until 31 December 2011.

Green Technology Financing Scheme

In the budget speech for 2010, Dato' Seri Najib Tun Abdul Razak, the Prime Minister of Malaysia, announced the establishment of the Green Technology Financing Scheme amounting to RM1.5 billion as an effort to improve the supply and utilisation of green technology. The scheme could benefit companies who are producers and users of green technology.

Malaysian Technology Development Corporation

Malaysian Technology Development Corporation (MTDC) was set up by the government in 1992 to spearhead the development of technology businesses in Malaysia. Its initial role was to concentrate on the promotion and commercialisation of local research and invests in new ventures that can bring in new technologies from abroad. From those investment activities, MTDC has evolved to become a venture capital outfit and has been the leading venture capitalist in the country long before the concept became familiar and accepted in Malaysia.

Malaysian Life Sciences Capital Fund

The Malaysian Life Sciences Capital Fund was founded in late 2006 and is a life sciences venture fund specialising in early stage investments in the areas of agriculture, industrial and healthcare biotechnology. Co-managed by MTDC and Burrill & Co., the fund has US$150 million in committed capitals.

Malaysia Debt Ventures Bhd

Malaysia Debt Ventures Bhd (MDV) is an innovative financier and development facilitator for biotechnology, ICT and other high-growth sectors in Malaysia. Incorporated on 23 April 2002 as a wholly owned subsidiary of the Minister of Finance, Inc., MDV has been entrusted to manage funds of RM2.5 billion for the financing of projects in these industry sectors. For biotechnology products, MDV also provides competitively priced financing products, with financing amount up to RM120 million.

Bank Perusahaan Kecil and Sederhana Malaysia Bhd

The Bank Perusahaan Kecil and Sederhana Malaysia Bhd (SME Bank) started its new function on 3 October 2005 as a development financial institution to nurture and meet the unique needs of SMEs. As a one-stop financial centre responding to the funding and business growth needs of Malaysian SMEs, the bank complements the existing products and services offered by commercial banks through a comprehensive and integrated financial and business advisory services.

Ministry of Science, Technology and Innovation

In supporting the development of biotechnology industry in Malaysia, MOSTI provides the following funds for biotechnology:



- *Science Fund* - Development of new products or processes up to proof-of-concept; enhancement of research capability.
- *Inno Fund* - To encourage participation from micro entrepreneurs/individuals and groups from the community in services and products.
- *Techno Fund* - Pre-commercialisation on activities, comprises development and up-scaling of new and novel technologies from lab scale prototype up to commercial ready.
- *Agro* – Biotechnology R&D initiatives - R&D in strategic areas of agro-biotech that will lead to the modernisation and transformation of the agricultural sector.
- *Genomic and Molecular Biology R&D Initiatives* - Generation of intellectual properties and technologies for application in modern bio-manufacturing of high value products such as biocatalysts, fine chemicals and diagnostics.
- *Pharmaceutical and Nutraceutical R&D Initiatives* - To develop proof-of-concept products or services developed by local scientists to comply with the international standards imposed by the regulatory authorities such as good research practice and good laboratory practice.

FOOD SECURITY AND GENETIC ENGINEERING

Food security and sovereignty is becoming an important issue today whereby countries are securing land globally to specifically meet their needs. Genetic Engineering (GE) is only one of the solutions to increase food production in terms of developing crops that are disease/salt/water/*etc.* resistant. It will help increase the productivity and yield, and make better use of arable planting areas.

GE crops are crops targeted against disease and abiotic stress, and thus may not necessarily directly increase the crop yield itself. In order to increase crop yield, we need desired high yielding traits. High yield crops can also be developed using MAS technology and has been acquired by BiotechCorp. The technology shall be housed in MARDI for use by entrepreneurs to develop disease resistant and higher yielding crops and animals. Widespread malnutrition is a concerted effort and it is important not only to produce sufficient food, but also ensure the price of food is right and the masses in malnourished countries receive the food. This will require the intervention of governments.

ENVIRONMENTAL SUSTAINABILITY AND GENETIC ENGINEERING

With the declining availability of arable land worldwide, there is no choice but to produce more food to feed the increasing population within the limited land area available for food production. Thus, high yielding, shorter rotation, disease/pest resistant, environmentally tolerant crops has to be developed, and quickly too. This is only possible with the aid of technology such as biotechnology, including modern biotechnology, or recombinant DNA technology (commonly known as genetically modified (GM)) and MAS.

Furthermore, the use of these technologies, including GM, not only allows the increase in food production per unit land area available to mankind, but also contributes to the preservation of the environment, *e.g.* the use of BT crops reduces the need for pesticide application. The use of pest and disease tolerant or resistant varieties minimises the application of harmful agrochemicals for the control of pest and disease, as in the case of traditional farming practices. In addition, the isolation, cultivation and application of beneficial microbes (also an area of biotechnology) enhance nutrient absorption, thus reducing food production cost significantly. This in turn reduces the application of fertiliser, thus ensuring environmental sustainability.

Moreover, with the increasing population and the need for development, and with the effect of global warming, very often only degraded and/or marginal land are available for food production. Thus, to circumvent this critical shortfall in food production, the development of draught, heat, and/or salt tolerant crop varieties is often the only way to produce more food to feed the ever growing population.

GENETICALLY MODIFIED FOOD AND HEALTH RISKS

To date, there has been no scientific proof of any health and/or environmental risk with any GM crops. Nevertheless, there is always a need to scientifically evaluate all food to ensure



its safety and suitability for human consumption; this includes GM crop based food produce. Although our forefathers have been involved in genetically modifying crops for food production, they only had access to conventional, slow and unpredictable methodologies, *e.g.* selection and breeding. However, with the discovery of modern biotechnology such as recombinant DNA technology, it is now possible to select desired gene(s) encoding for a specific trait and have this transferred into our crop of desire with the same result as in the case of traditional breeding, but quicker and more precise (where unwanted traits from the donor is not transferred together).

Furthermore, with the advancement in science, it is now possible to use non-antibiotic resistance gene(s) in the production of GM crops. In addition, in the event an antibiotic gene(s) is used in the development of a particular GM crop, it is now possible to slice the said gene(s) out of the said crop before the crop is transferred out of the laboratory, thus making it safer for the environment and humans.

PREVENTIVE MEASURES BY BIOTECH COMPANIES

Although, agriculture biotechnology has been in existence from as early as 8000 BC, its subsequent development has been less rapid if compared to medical biotechnology. This reason for this is because direct human health, including disease prevention and cure, has been the focus of medical biotechnology, and as this needed immediate attention, it progressed rapidly. On the other hand, agriculture biotechnology focused on the application of suitable technology towards enhancing the production of food, fibre and shelter requirements of the world population.

Nevertheless, most of the medicine available to mankind is derived from plants in one form or another. Thus, agriculture biotechnology would have been used in the early stages of identifying, propagating and producing extracts from the various medicinal and herbal plants available to mankind on this planet. Thereafter, turning these botanicals into medicine was the focus of medical biotechnology. Therefore, it is not possible to completely separate them; they are indeed interconnected, especially when food is the main component of human health.

AGRICULTURAL BIOTECHNOLOGY AND MEDICINE

Biotech companies worldwide are governed by the law of the land they operate from, *e.g.* Malaysian biotech companies are governed by the Malaysian laws and legislation on biosafety, environment, etc. Thus, any company, be it biotech or otherwise, will need to abide by the existing laws of the land. Furthermore, if these companies were to engage in international business, they would then be required to abide by international laws and legislation as well in order to remain in business.

It is more important for sovereign nations to enforce its existing laws, and their respective legislation accordingly; this will ensure adequate protection to its people and its environment. Nevertheless, scientists involved in R&D, including biotechnology, are also responsible citizens who care for the environment their family lives in, and certainly would not jeopardise this or place both their family and the environment in danger.

CONCLUDING REMARKS

The law of nature applies to the biotech scenario too, where if "small time" farmers do not survive and/or do not make enough to survive, they will not be farming. Thus, the demand for the product and/or technology developed by the profit-driven agriculture biotechnology companies will also diminish. Therefore, it is in the best interest of the profit-oriented agriculture companies to ensure that they do not hold "small time" farmers at ransom by making them totally dependent on their technology and/or product. There is an element of corporate social responsibility that all modern day profit-driven corporations have to consider for their continuous existence, and this applies to biotech companies as well.

However, the economic scale of events is also critical, where with escalating costs; "small time" farmers are often driven out of business mainly due to the cost input required versus the return on investment. On the contrary, the availability of high-yielding crop varieties with minimal input requirements from the so called profit-driven agriculture biotechnology companies may come as a saviour to these "small time" farmers in ensuring decent returns on their investment. ■