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Agricultural Biotechnology - The Science And Fiction

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In the past two decades, biotechnology was perceived as a potential area that can contribute to agricultural sustainability. Biotechnology is a vast assembly of powerful techniques, which are expected to yield potential benefits that extend the capacity of world agriculture to sustain exploding population. Since biotechnology comprises many aspects, it is important to choose the most relevant ones that positively support the required developments.

Briefly discussed below are the technologies (Plant tissue culture and Genetic Engineering), their appropriateness and reported effects and the major issues concerning the common man.

Technologies

Plant Tissue Culture in the context of seed production

In nature various genes of an organism act and interact in different ways to produce the manifested characters and related variations. The marginal differences between individuals in populations imply that they are important for survival. An important law of natural selection, "survival of the fittest" is compromised in the premise "mass multiplication of elite plants to produce true to type descendants". As survival depends on fitness, residual variation is an important fitness indicator ensuring survival species[1].

While the natural mutation process affects only a few plants, every tissue culture derived individual is a potential mutant. Somaclonal variation that stimulates the mutation process, may be considered as the biotechnology equivalent of mutation breeding. Somaclonal variation is a universal outcome of tissue culture. It was projected as a useful means of inducing genetic variations that can be utilized in plant breeding. However, whether it is a substitute or large supplement to natural genetic variations that are conventionally used in plant breeding needs to be judged.

In practice, production of seed is a much cheaper affair than the "mass multiplication" of tissue culture plantlets. Given the advantages of production cost and natural selection endowments of seed, it will be the obvious choice of farmers. Thus, tissue culture appears not to be a substitute to traditional seed propagation in the foreseeable future[2].

Genetic Engineering

Diversity of living organisms is an endowment of the Mother Nature. Biodiversity, whether it pertains to crop plants or wild weeds is a reflection of the capacity of nature to genetically engineer its various species for sustenance and survival. Plant breeding that produced today's crop plants used this elementary principle to evolve crop varieties by transferring genes from wild varieties and related species to crop plants[3].

Artificial selection of plants from hybrid and backcross lineages is first order genetic engineering that works in unison with natural selection. This process ensures fitness of the descendants and their survival and possible better performance over their parents in a variety of agricultural contexts like yield and resistance to biotic and abiotic adversaries such as insect pests, diseases drought, salt stress etc. The superiority of this process lies in the fact that it exploits the genomic homologies of crop plants and their relatives existing in nature itself.

In contrast, genetic engineering is totally artificial[3] (as to the choice of sources of genes) and random (as to the integration of genes in the crop plant genome) and its products have very little chance of being selected positively by nature. Transmission of engineered genes to the next generation (inheritance) appears to be a major problem as breakdown of the target trait expression was generally observed in the seed descendants of transgenic plants. In the genetic engineering experiments, available results indicate that additional genes conditioning particular characters lead to total suppression of the character, a phenomenon called co-suppression[4]. This leads to the question of stability of genetically engineered crop plants in nature.

In the experience of plant breeders, resistance to pests and pathogens transferred to crop plants even from natural sources were defeated by the respective adversaries over a period of time and keeping alternative sources in the germplasm banks is practiced to combat this eventuality. This happened even in the case of genetically engineered pest resistance of cotton[5,6]. This means that genetically engineered resistance is not different from what is available in nature.

Now the big question - Does this justify the multi-million dollar expenditure on genetic engineering?

Appropriateness and effects

It becomes important to consider the effects of the twin processes of tissue culture and genetic engineering on the performance of genetic engineering products. True to the expectations, reduced yields of genetically engineered crops were reported[7]. However, a point of appreciation is in order. The harsh treatment meted out to the plant tissues through tissue culture and genetic engineering protocols should have ensured their death. Instead, these tissues produced plants which produced yields, albeit lower. If these plants are also carrying transgenes and expressing them, it may be possible to naturalize them through appropriate selection techniques in the mainstream plant breeding. This calls for joint efforts of the proponents of genetic engineering and plant breeding. If it happens at an early date, it may constitute a good alternative to the notion of genetic engineering as the putative sole

possibility of feeding the hungry of the world. Besides the scientific pitfalls described above, genetic engineering products were also questioned on account of the controversial effects of their consumption. A major concern about the genetically modified foods is their potential to be toxic or allergenic. Soybean carrying a gene of Brazilnut was found to be toxic[3]. Shiva[7] rightly pointed out that the increase of IGF-1 like growth factor in the milk of cattle administered with recombinant bovine growth hormone and vitamin-A in golden rice rendered them risky for consumption. The likely risks of consuming these foods include prostrate, colon or post-menopausal breast cancer and hyper-vitaminosis. These and several other ill effects of GM foods raise the issue of food safety. It was said that, "the problem with biotech miracle is that its products are being prematurely introduced into the market, its promises and benefits are being exaggerated and its costs and risks are being denied and ignored".

Issues of concern

Intellectual property rights

Besides the above shortcomings, most of the transgenic crop plants are generated through the research and development efforts of multi national companies and are protected by intellectual property rights. This takes the question of exploiting the genetically engineered crop plants into the realm of subsistence farming practiced by many small farmers in the developing countries. These farmers can not afford to purchase the patented seeds of genetically engineered crops every year and the terminator and other gene protection technologies compromise the possibility of their saving seed from the previous crop. Thus, the utility of genetically engineered crops in alleviating world hunger is not clear. However, an important ethical question that can be raised in this context is regarding the origin of crop plants. Of all the known crop plant species, only about twenty provide 90% of the dietary calories to the world population and all these species are known to have originated in the third world developing countries. What are the rights of the people of developing countries on those species ?

Economic Aspects

A significant point that emerges in the context of world hunger is about the economic feasibility and viability of genetically engineered crops for the subsistence farmers who contribute significantly to the food needs. Many of the multi national corporations are more powerful than the governments of some developing countries and can force their way into the world markets and thrust their products on the people. Thus, developing countries may find themselves at the receiving end in the biotech trade paying premia and royalties for uncertain products. This, in turn, will have a serious impact on their economy and food security.

Conclusion

In spite of all the great potential, biotechnology at its present state of development can not replace conventional tools of plant breeding that were evolved to work in tune with natural selection, the great directing force behind the evolution of all organisms. As already stated, the various bio-techniques are originally thought to supplement the various tools that the breeders were using to improve crop plants. Current levels of diversion of fiscal and human resources towards agricultural biotechnology research indicate a trend that may culminate in giving the main stream status to biotechnology leaving conventional plant breeding in the lurch[8,9,10]. This is likely to have serious implications for the subsistence cropping systems that supply a major part of the dietary calories to the teaming millions of the bludgeoning world population. A much more realistic, integrated and equanimitous approach to agricultural research and the position of biotechnology appears to be the need of the hour. We have to think of biotechnology as a possible supplement to food security than looking for alternatives to biotechnology to attain food security.

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Themes for Leisa India

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Access to and control over resources

Many different systems and arrangements determine who has access to and control over natural resources like land, water, trees, grazing, manure etc., and under what conditions. Systems of access and control change and evolve over time and range from formal to informal, from traditional to new, from collective to private. This issue of LEISA India will try to bring into focus some of the practical aspects of these different systems and arrangements. We invite you to share your experiences.

Deadline for contributions is 30th September 2003

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Rehabilitation of degraded land

This issue of LEISA India will deal with practices that contribute to maintaining productive soil and rehabilitating land that has been degraded. Please contribute your experiences, ideas and solutions.

Deadline for contributions is 31st October 2003

Please ignore the deadlines given in the international edition as deadlines for other themes are over. (as announced in previous LEISA India issue)

The Terminator Seeds and the Gene Modified Organism

A.N.Channappagoudar

Modern technologies involved in the production of new seeds of high yielding varieties of crops are too complex to be understood by farmers though it is being said that they are useful and beneficial. Moreover, these technologies are highly complex to be followed by a farmer in seed production thus making him totally dependent on multinationals for procuring the required seeds whenever needed.

The vigour, of either nucleus seeds or the foundation seeds is bound to vary depending on the environmental as well as local factors. Therefore the same vigour cannot be maintained equally at all the seed production centres or in all farmers' fields. This results in yield variation across regions whereas the costs remain the same. It is a fact that the farmers have to go in for purchase of new seeds every year. This process is not only burdensome but also a very expensive option to the farmers. On the other hand, there is no guarantee of yield stability year after year.

It is a well known fact that the pollen grains may spread around 5 to 6 kilometers surrounding the new seed production farms even though they are grown under perfectly controlled conditions. This in effect not only destroys the diversities of the local varieties of similar crops but also results in low yields and reduction in seed germination rate of similar types of crops in the next season.

Experience has shown that very often the so-called high yielding varieties perform poorly as against the local varieties. The higher yields, even if obtained, would call for high input investment and timely technical supervision. Therefore, farmers who generally have a low risk taking ability would rather prefer guaranteed low yields than high yields associated with risk and uncertainty.

On the one hand, the health of our soils has deteriorated to a great extent serious soil erosion, excessive use of chemical fertilizers, pesticides and fungicides. On the other, application of biological field practices and organic manure has been grossly neglected resulting in the present situation of our farming. In this background, the use of the new seeds of high yielding varieties of crops is just like "giving a very costly injection to a sick man sleeping on the death bed to make him able to get up and sit on the same deathbed".

To achieve food security, there are many cheaper and better alternatives.

Firstly, we have to go back to the organic way of farming. By adopting the organic way of farming we can improve the health of our cultivable land that is bound to give higher yield of good quality with a very low input and less effort. The crops grown with healthy seeds sown in at an appropriate time in healthy soils will also be resistant to pests and plant diseases, there by reducing the use of pesticides and fungicides as well.

Secondly, the loss of rainwater going out of the fields as run off should be prevented to arrest both soil erosion and loss of soil fertility. The harvested water can be recycled back to the fields thus maintaining the soil moisture at the required level. By maintaining soil nutritional status and the soil moisture level, the investments on inputs could be reduced.

Last but not the least, mutation in plants takes place in all crops during the period of the plant growth. This is a phenomenon that takes place in the growing plants only on account of modified genes. Much work has not been done to develop better quality seeds out of these positive mutant seeds. This can be done only by means of selections but not by hybridization. The good seeds (positive mutant seeds) of naturally modified gene, will never adversely affect the germinating embryo for the consequential germination of the seeds sown year after year, where as, the seeds (non mutant seeds) of artificially modified genes will affect the germinating embryo for consequential germination even in the next year.

So, the preference must be given for the multiplication of the positive and natural mutant seeds of all the crops in general. Much work has to be done in this regard in the interest of the farmers at large. These seeds are bound to give higher yields, Therefore, only by means of selection of better seeds out of such multiplied positive mutant seeds every year we can sow the selected seeds without affecting our agricultural yields and without any kind of deterioration either in quantity or quality of the end product. In the case of positive mutant plant seeds there is no question of termination of gene product or their genetic value, no deterioration of embryo of the seeds for the consequential germination of seeds,. no poisoning of the end product to make the same, pest resistant, even if sown year after year. The farmers can go on selecting the seeds from their own field crop production year after year. They can also multiply the mutant seeds for their use in their own fields without much labour and much trouble. This process is also acceptable to the farmers in general because of its ease as well as being economical. This process will also not affect either the diversity of the general crops or ecological balance of the nature as well.

If these technologies are pursued, we would be promoting 'uncultured' agriculture. When such things are available in our back yards there is no need for the farmers to go in for purchase of hybrid and genetically mutation seeds of high yielding varieties of crops which are not only expensive but also their productive integrity is uncertain.

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The editors have taken every care to ensure that the contents of this magazine are as accurate as possible. The authors have ultimate responsibility, however, for the content of individual articles.

The editors encourage readers to photocopy and circulate magazine articles.

"GOLDEN RICE"

Golden rice has been heralded as the miracle cure for malnutrition and hunger of which 800 millions suffer. But who could possibly object to rice engineered to produce vitamin A, a deficiency found in nearly 3 million children largely in the Third World? However, herbicide resistant and toxin producing genetically engineered plants can be objectionable because of their ecological and social costs.

The problem is that vitamin A rice will not remove Vitamin A Deficiency (VAD). Currently, it is not even known how much vitamin A the genetically engineered rice will produce. The goal is 33.3 % micrograms / 100 gms of rice. Even if this goal is reached after a few years, it will be totally ineffective in removing VAD. Since the daily average requirements of vitamin A is 750 micrograms. If one serving contains 30 gms of rice according to dry weight basis, vitamin A rice would only provide 9.9 micrograms which is 1.32 % of the required allowance.

Researchers have introduced three new genes into rice, two from daffodils and one from a microorganism. The transgenic rice is yellow in colour and produces Beta-carotene, a precursor to vitamin A.. However, the production of Beta carotene will be only 2.8 % of that obtained from amaranth leaves and 2.4 % of that obtained from coriander leaves, curry leaves and drumstick leaves.

Even the World Bank has admitted that the use of local plants, particularly the vitamin A rich green leafy vegetables and fruits have dramatically reduced VAD threatened children over the past 20 years in a very low cost and efficient way. Given the diversity of plants and crops in the Third World, farmers, especially women have bred and used crops which are rich sources of vitamin A such as Coriander, Amaranth, Carrot, Pumpkin, Mango and Jackfruit in their diet. Thus a far more efficient route to removing vitamin A deficiency is biodiversity conservation, propagation and use of plants that are naturally rich in vitamin A. For instance, women in West Bengal use more than 200 varieties of field greens. Therefore, higher the crop diversity, better is the uptake of pro-vitamin A.

While the complicated technology transfer package of "Golden Rice" will not solve vitamin A problems in India, it would serve as a very effective strategy for corporate takeover of rice production, thereby increasing the dependency of farmers on them, using the public sector as a Trojan Horse.

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AME Foundation promotes sustainable livelihoods through combining indigenous knowledge and innovative technologies for Low-External-Input natural resource management. AME is an innovative training programme and resource centre enhancing synergies between institutions and individuals involved in sustainable agriculture. **www.amefound.org**

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LEISA is about Low-External-Input and Sustainable Agriculture. It is about the technical and social options open to farmers who seek to improve productivity and income in an ecologically sound way. LEISA is about the optimal use of local resources and natural processes and, if necessary, the safe and efficient use of external inputs. It is about the empowerment of male and female farmers and the communities who seek to build their future on the bases of their own knowledge, skills, values, culture and institutions. LEISA is also about participatory methodologies to strengthen the capacity of farmers and other actors, to improve agriculture and adapt it to changing needs and conditions. LEISA seeks to combine indigenous and scientific knowledge and to influence policy formulation to create a conducive environment for its further development. LEISA is a concept, an approach and a political message.