Advanced Genetics Assignment

Question: What are the similarities and differences between Genetically Modified Organisms (GMOs) developed using traditional breeding methodologies and recombinant DNA and transgenic technologies. Explain and comment on advantages and potential problems with the use of GMOs.

(25 points)

Differences and similarities between traditional breeding and transgenic technologies

Conventional breeding, like recombinant DNA and transgenic technologies are purposed to improve yield, disease resistance, pest resistance and nutritional value of organisms of interest-usually plants and animals. However, recombinant DNA and transgenic technologies are faster and provide more precise strategies for these improvements. Chimeric gene constructs containing genes of interest are transferred between different species to improve quality and yield of resulting individuals (Prakash, 2001). One such improvement is geared towards development of biopharmaceutical ebola vaccine engineered in tobacco plant with the hope of conferring antibodies that target the ebola virus. Another GM trial is underway to target *Ae. Aegypti,* the dengue-fever vector by fatal reproduction through a gene that larval or pupal offspring leading to reduced fecundity and arrested reproduction of these vectors. Successful incorporation of these genes is screened with the aid of reporter genes and/or a selectable marker such as antibiotic resistance (or fluorescence) or metabolic conversion of substrates (such as galactose or glucose) by the newly formed expression construct. Conventional breeding on the other hand is dependent upon careful selection of parents with alleles of interest and crossing them to improve the quality and yield of subsequent generations. These conventional breeding techniques have been applied to improve both Mendelian and complex genes to facilitate improved milk yield by cattle, crop fitness during drought, and pest resistant plants (Halliburton, 2004).

Case studies of successful GMOs' advantages and potential problems

Insect herbivore-resistant plants containing *Bacillus thuringiensis* transgenes- they express Cry1Ab proteins toxic to insect pests by causing excessive uptake of water by the infesting insect's midgut. The potential benefits of this are- the reduced need of topical application of toxic chemical insecticides and improved yield. Pesticide spraying has been reduced by 380million lbs resulting in a 14% reduction in the environmental footprint of such chemicals. Using the China Bt rice, there has been improved yield leading to 80% lives saved. As good insects responsible for plant pollination also get affected by these insecticides, this GM approach reduces negative effects against non-targeted individuals. Thanks to cross-pollination, there are reported cases of non-Bt corn being introgressed with the Cry1Ab protein, conferring resistance to such pests as the corn-borer and reaping financial savings to farmers. In field trials, Bt crops fared better than those treated with insecticides (Rosi-Marshall *et al*., 2007).

The potential problems of this are- it could select for pests resistant to the toxic protein and also affect non-targeted insects whose midguts are susceptible to the Bt proteins or antibiotics. There is also the concern that selection for a specific trait such as pest resistance could compromise fitness of the organism and set it up for a population bottleneck if a new environmental strain to which they are collectively susceptible is encountered. There is ongoing concern that such byproducts of Bt corn as pollen and detritus enter headwater streams and could kill non-target stream insects which are important prey for aquatic predators (Rosi-Marshall *et al*., 2007).

Plants with resistance to broad spectrum herbicides- have the advantage of allowing integration of crops requiring minimal tillage with those requiring frequent tillage to reduce erosion, retain soil moisture and conserve soil micoflora (Hails, 2000).

The potential problem associated with this strategy is- Herbicide resistance weeds could develop from possible introgression from the target plants. There is concern that the Cry9 protein expressed in herbicide-resistant Starlink corn could be a mild allergen to humans (Bucchini and Goldman, 2002).

Plants that are resistant to viral pathogens- low expression of a gene coding for the protein coat of the pathogen (*cp* gene) causes 'immunization' of plants against pathogens. This has the potential advantage of reduced use of toxic chemicals that control insect vectors of the pathogns and reduced impact of the chemical on non-target insects and flora while effectively controlling plant diseases (Hails, 2000).

Potential problems associated with this are- transencapsidation of new pathogens such that they would have new recognition sites that allow them to infect plants that they couldn't otherwise have infected previously. This can be prevented by altering the recognition sites molecularly such that it is only specific to the target pathogen before introducing it in the transgenic plant. Novel viruses could occur from recombination of mRNA of the *cp* gene into other plant viruses. Moreover, a synergistic effect in an already infected plant between different pathogens could cause pronounced disease severity. (Rosi-Marshall, 2007).

Other general concerns surrounding recombinant DNA and transgenic technologies

Technologies previously thought to be safe were found to be harmful- Specifically, the insecticide dichlorodiphenyltrichloroethane (DDT) bioaccumulated in fish causing thinning of eggshells of such fish-eating birds as eagles. Chlorofluorocarbons (freon) were degradative to the ozone layer. These past occurrences continue to fan consumer mistrust of scientists. (Prakash, 2001).

Socioeconomic concerns also reduce the readiness to adopt recombinant DNA and transgenic technologies because large multinational companies that adopt these technologies would monopolize markets to the disadvantage of local or regional small scale farmers. The approach of transgenics is in conflict with certain religious opinios which view it as "playing God" to alter original traits of organisms. (Prakash, 2001).

References:

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Hails, R. S. (2000). Genetically modified plants–the debate continues. *Trends in ecology & evolution*, *15*(1), 14-18.

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