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# Multigene engineering

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The current global population of 6.4 billion is expected to reach 10 billion by the year 2050. The rate of agricultural yield at present is not sufficient to meet this demand and already malnutrition and starvation are taking a toll worldwide. In the past, productivity of primary producers, namely higher plants, has been accomplished through selective breeding programs but the success in this area have reached a plateau. Bringing new acreage under cultivation is not a viable option as much of the unutilized lands in developing nations is of marginal quality and serious environmental consequences prohibit agricultural development on remaining fertile preserves. The architects of the 'green revolution' envisioned that increased global carrying capacity would result from the development of new crop cultivars, the use of irrigation systems, and the application of chemical fertilizers and pesticides. Crop species have been genetically engineered to resist viral pathogens and insect pests, tolerate drought and herbicide treatment and to enhance nutritional value through the incorporation of novel DNA into the nuclear genome.

Plant metabolic engineering has the potential to provide for the needs of an expanding population. Environmentally benign biosynthesis of novel materials and pharmaceutical proteins along with the opportunity to improve the productivity and nutritive value of crop plants has focused considerable effort towards the genetic manipulation of crop species. The most important output traits that could be conferred through biotechnology often require the coordinated expression of several foreign genes. Many of the desired agronomic traits under development will require the simultaneous engineering of multiple genes or pathways. The ability to provide the coordinated expression of multiple genes to produce valuable agronomic traits is considered the Holy Grail of plant biotechnology but this area remains a challenging one for those involved in nuclear genetic engineering.

### *Nuclear genetic engineering:*

Multiple genes have been skillfully engineered via the nuclear genome. A significant step in multigene engineering has been the development of a rice variety that accumulates provitamin A. It is estimated that improved Vit.A nutrition can help to prevent over one to two million deaths each year among children aged one to two years. But there are some difficulties to introduce multiple genes into the nuclear genome.

### *Disadvantages of nuclear genetic engineering:*

- Position effect
- Gene silencing
- Stunted growth
- Sterility

One common concern arising from the use of nuclear transgenic crops expressing Bt toxins in suboptimal levels is the development of Bt-resistant pests. Plant-specific recommendations to reduce the development of Bt resistance include increasing Bt expression levels (high dose strategy), expressing the protein only in tissues highly sensitive to damage (tissue specific expression), or expressing multiple toxins (gene pyramiding).

The introduction of multiple genes via the nuclear genome requires the generation of individual transgenic plants and subsequent backcrosses to reconstitute the entire pathway or multi-subunit proteins.

Crop plants possess two genomes in addition to that of the nucleus, the organellar genomes of mitochondria and chloroplasts. Genetic engineering of higher plant chloroplasts may offer the potential to mitigate certain limitations of agricultural productivity. Technological advances, most notably the invention of the particle accelerator and the ability to express foreign genes in plastids, have provided the opportunity to explore the chloroplast genome as a new platform to address current and future demands for improved food production. The concept of chloroplast genetic engineering has been demonstrated to confer desirable plant traits including insect resistance, herbicide resistance, salt tolerance, drought tolerance, disease resistance, phytoremediation and reversible male sterility.

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