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The use of Terminal Technology (Gurt) in Producing New Seed Varieties and Their Impact on Farmers

Rehmat kabir[1], Tajudin[2], Muhammad Tayyab Mehmood[3], Muhammad Asad[4], Asif Iqbal[5], Hafiz Muhammad Kashif[6]

1. Senior Scientific officer,Pakistan Agricultural Research Council,Station Chilas,Gilgit-Baltistan, Pakistan
2. Senior scientific officer, Pakistan Agricultural Research Council,Mountain Agricultural Research Centre,Juglot, Gilgit-Baltistan, Pakistan
3. Institute of Soil and Environmental Science, University of Agriculture Faisalabad, Pakistan
4. Lecturer Biotech, KhwajaFareedUniversity of Engineering &Information Technology, Rahim Yar Khan, Pakistan
5. Department of Microbiology, Hazara University Mansehra, Pakistan
6. Scientific Officer, Citrus Research Institute, Sargodha, Pakistan

Corresponding Author:-Rehmatkabir, rehmatk1972@gmail.com

Abstract:

In order to ensure a return on investment by protecting plant varieties, genetic use restriction technologies (GURTs) were developed and these are among the most disputed and controversial genetic engineering technologies because these techniques has been envisioned as a technique to compel the farmers to rely on the seed monopolies of multinational companies. In this review paper, the current proposed technologies have been described in detail and a comparison has been explained with respect to the gene flow, art of seed saving and multiple analysis with concern of the future prospective of GURTs in terms of benefits, possible impact on farmers, hypothetical analysis on agriculture, speculative dangers to the environment and that led to the restriction of this technology were creating problems about intellectual property rights.

Introduction

Genetic use restriction technologies (GURTs) were developed to restrict genetic resources as well as phenotypic traits which are associated with genetic material. GURTs were originally protected to protect novel crop varieties from "unauthorized" exploitation (Oliver et al. 1998; Pendleton*at el* 2004).

There are a number of recent patent applications, experimental procedures referred to as "genetic use restriction technologies" (GURTs) have been reported that provide specialized genetic switch mechanisms that restrict the unlawful use of genetic information. The biotechnology and seed business is advertising this technology as a “biosafety“ solution to mask its actual purpose as a biological way of prohibiting farmers from conserving and re-using proprietary seed. This

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method has not yet been marketed or field tested although testing are now being undertaken in greenhouses in the United States (Malav and Gaur, 2017).

Plant fertility or seed development can be controlled through the use of a chemical inducer that will allow the plant to grow and produce seeds but will cause each of those seeds to produce a cell toxin that will prevent replanting, thus allowing the manufacturers of the plant to maintain their ability to produce second-generation sterile seeds. This technology is known as Variety-GURT (also known as suicide/sterile seed/gene technology, or terminator technology) (Lombardo, L., 2014).

With a specific focus on sterile seed technologies, this study will evaluate existing technical and related literature on GURTs in order to identify the possible advantages, hazards, and costs associated with the use of GURTs in arable crop production. We'll also look at how new GURTs stack up against hybrid seed technology, a more well-established GURT type that has been around for decades. It is important to understand the possible advantages, hazards, and costs of genetically modified organisms (GURTs) for farmers, plant breeders, governments, and society as a whole. The purpose of this article is to provide scientists, students, administrators, and policy advisors in a variety of organizations with information on GURTs and the possible consequences of their adoption. The work is available for free download here.

CURRENT STATUS OF GENETIC USE RESTRICTION TECHNOLOGIES

There are now two primary types of GURTs: those based on variety and those based on characteristic (Visser et al. 2001; Eaton et al. 2002; Pendleton 2004). GURTS that are based on variety (V-GURTs) limit the usage of a certain variety as a whole by prohibiting its reproduction. T-GURTs (Characteristic-based GURTs) are GURTs that govern the expression of a certain trait.

Trait-based GURTs

T-GURTs are genetically engineered plants in which a gene or genes that contribute a single characteristic are activated or inactivated using chemical inducers (Visser et al. 2001; Pendleton 2004). In contrast to V-GURTs, which result in sterile seeds, T-GURTs do not impair the viability of seeds. Toxic pest resistance, stress tolerance, nutrition production, seed or flower development are some of the traits that might be influenced by TGURTs (Gupta 1998; Pendleton 2004).

In order to safeguard the intellectual property (i.e., the "value-added" transgenic feature of interest) of plant breeders in newly generated varieties, TGURTs use a biological mechanism that restricts access to the newly developed varieties (Eaton et al. 2002). Induction chemicals may be used to activate these characteristics when they were required. If, for example, an insecticidal gene (e.g., Bt) is controlled by an inducible promoter, it may stay inactive until an insect pest epidemic warranted the use of a chemical to trigger the synthesis of gene products that are harmful to insects. However, the final "trigger" of this technology might be controlled by farmers, since the inducer chemical would most likely be under the ownership and licence of a seed corporation (Pendleton 2004).

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The molecular process used in both forms of GURTS is quite similar, and there is typically little differentiation made in the literature between the two types of GURTS (Federation of German Scientists and EcoNexus 2006). V-GURTs (also known as "sterile seed technology" or "terminator technology" in colloquial use) will be the primary subject of this study; however, GURTs in general will be discussed as well.

V-GURTs

For V-GURTs, there are basically three main ways of restricting their use (Visser et al., 2001). The USDA and Delta & Pine Land define the initial mode of action in their patent (U.S. 5,723,765). (Nominally the first V-GURT). Three genes (transgenes), two from bacteria and one from a different plant, are transferred into a plant's cells as part of this GURT.

1- Genes that generate cytotoxic proteins are known as terminator or lethal genes because they are under the control of a LEA promoter that is linked to a DNA spacer (blocking) sequence flanked by specific excision sites (lox sequence), which prevents the terminator gene from being activated. Plant Saponariaofficinalis produces RIP, also known as saporin, which is reported in the '765 patent. The patent claims that RIP prevents plant cells from producing proteins (Jiang et al., 2008). The patent application did not reveal where the genes came from or how they were transformed.

2- The Tet repressor represses the expression of one or more tet operons in a phage P1 site-specific recombinase gene, which is controlled by a constitutively active promoter (for example, CaMV 35S). Toxic gene-related excision sites surrounding this gene's blocking sequence are cut by a protein (Cre) encoded by this gene.

3- Tet repression gene Tn10, which is controlled by a constitutive promoter and encodes a protein that attaches to the Tet operon and prevents production of recombinase. The repressor cannot bind to the operon if an external stimulus (inducer) is present. There are a variety of external stimuli, including agrochemicals and antibiotics, which are often created by seed firms that use the same limitation technologies. Tetracycline is used as a chemical inducer in the instance of U.S. patent number 5,723,765 (Jefferson et al., 1999), but later DPL declared that the tetracycline-inducible expression system (in a patent on Escherichia coli) is not the best option (Working Group on Article 8(j), 2006).

To be marketed to the customer (and usually the farmer), these seeds must first be exposed to the inducer, which disables the repressor. The ribosomal inactivating protein is now directly controlled by the late embryogenesis abundant promoter. The LEA promoter restricts gene transcription to late embryonic stages, when the seed has acquired most of its storage oil and protein and is drying up for the dormant period (Hundertmark and Hincha, 2008).

The ribosomal inactivating protein kills all embryos at the conclusion of development (the terminator gene). This way, farmers may purchase seeds that will germinate in the field and grow consistently. This year's crop will be sterile, unable to be kept for future plantings. The RIP's patent states it is non-toxic to organisms other than plants, although this claim has been

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questioned (Crouch, 1998). The recombinase gene is linked directly to an inducible promoter (Oliver et al., 1998).

The genes were put into different transgenic founder lines that were subsequently cross-pollinated to generate a genome that included the whole set of TPS genes in the target crop (Oliver and Velten, 2001). Also, producing "terminator hybrid seeds" (Gupta, 1998; Lehmann, 1998; Pendleton, 2004). Because pollen possesses the dominant protein synthesis inhibitor gene, the traits cannot be passed on to closely related weedy species (Oliver and Velten, 2001).

For comparable outcomes, it has been suggested to employ different stimuli like temperature or osmotic stress, or aberrant amounts of plant hormones as the cytotoxic element that induces cell death, inside the same transgenic design (Daniell, 2002). ethanol, hormones (like dexamethasone), salicylic acid, pesticides, and heavy metals (like copper) may all cause ecstasy (Gatz, 1996; Padidam, 2003). Despite the harsh criticism, the notion remains theoretical for now, since none of the variations has been fully implemented.

As for V-second GURT's mode of action, it is characterized by the presence of a gene encoding a disrupter protein that is consistently active in the seed and hence sterile. The gene promoter is regulated by an operator sequence in the gene's DNA. A second repressor protein, whose gene is controlled by a chemical promoter, may attach to the operator and prevent the disrupter protein from being produced. In order to inactivate the disrupter gene that causes sterility, the breeder must administer the precise chemical inducer throughout the seed multiplication process, with the treatment being halted only at the moment of seed sale.

The English agricultural company Zeneca Ltd. received patents for this type of mechanism in 1992, 1993, and 1998, under the titles 'Hybrid Seed Production,' 'Plant Gene Construct Comprising Male Flower Specific Promoters,' and 'Plant Gene Construct Comprising Male Flower Specific Promoters,' respectively (patent US 5,808,034 A).

In addition, the ‘second type' V-GURT is compatible with another technology, the so-called recoverable block of function, which is meant for gene flow control in transgenic plants (RBF). In tobacco, the RBF is made up of a blocking sequence (encoding a barnase) connected to the target gene and a recovery sequence (encoding a barstar), both produced under the direction of sulfhydryl endopeptidase (SH-EP) or heat shock (HS) promoters. In the natural environment, barnase expression in embryos and sprouts induces cell death or prevents sexual reproduction (by inhibiting mRNA synthesis and germination).

There are three ways to extend the shelf life of vegetative reproduced items like tuber and root crops and ornamental plants. Plant organs such as cotyledons, leaves, and stems are preserved in order to extend their shelf life. A continually active gene is involved in this process, which was patented by Zeneca (Syngenta) in 2001 and stops seed proliferation. With regular use of a chemical that activates another gene, the plant's expression of the blocking gene may progressively diminish. Lin and colleagues describe another method for creating selectively terminable transgenic plants that does not need protein-encoding genes (2008).

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An RNA interference cassette was introduced into transgenic plants containing the glyphosate tolerance gene 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Lin et al. (2008) found an RNA interference cassette including the CaMV35S promoter and an inverted repeat sequence of the cytochrome P450 gene CYP81A6, which produces the enzyme responsible for bentazon detoxification in rice (Lin et al., 2008). (Lin et al., 2008). (Li et al.) The spraying of bentazon or nicosulfuron on glyphosate-tolerant transgenic plants killed them all. This method is used to introduce a second transgene expressing the Bt insecticidal protein Cry1Ab (Liu et al., 2012).

To be comprehensive, Schernthaner et al. (2003) presented a single repressor confinement system based on the simultaneous insertion of a seed-lethal gene related to a new trait (SL-NT) and a repressor gene (R) at the same locus on homologous chromosomes. A cross of the parents' lines will generate viable seeds with the genotype SL-NT/R, proving the parents' success. The seed lethality gene is triggered in the seed embryo when gametes having the SL-NT allele are placed into a non-GM plant that does not include an R element. Unlike V-GURTs, this method does not employ an external inducer to create sterile seeds.

COMPARISON OF GURTS AND HYBRID SEED TECHNOLOGY

Hybrid seed technologies are similar enough to GURTs that they may be used to evaluate the possible advantages, risks, and costs associated with their adoption. Plant breeding and food production may benefit from hybrid technology because of their many advantages (van Wijk 1994). Crop uniformity and maturity, as well as built-in protection against seed saving, are all benefits of high yield potential. There are several similarities between hybrid technologies and genetically modified organisms (GURTs), which have long been seen as a major motivator for the growth of the private crop breeding sector (van Wijk, 1994; Goeschl, Swanson, 2003; Pendleton, 2004). Several key crops, including maize, sorghum, rice, and a variety of vegetables, have been successfully hybridised for commercial use (Eaton et al. 2002). Due of the lack of financial viability of seed replanting, both GURTs and hybrid seed technologies provide breeders with some sort of intellectual property protection. In this way, farmers are discouraged from preserving seed with either method, and both may be utilized as a tool for limiting access (Gupta 1998; Goeschl and Swanson 2003; Pendleton 2004).

These qualities are supplied in a more absolute form for GURTs, since yield loss from replanting GURT seeds is 100% and seed reproduction for breeding purposes is impossible (Goeschl and Swanson 2003). Replanting hybrid seeds often results in a large decrease in production, however F2 generations may still be cultivated by the farmer and utilized for breeding reasons (Visser et al. 2001).

Farmers are now forced to purchase external seeds for each growing season, similar to how GURTs force them to do so. This might result in a loss of autonomy and a financial strain for certain farmers (van Wijk 1994). If they are to be commercially viable, hybrids must normally provide 15 to 20% greater yields than open-pollinated types in order to balance the recurrent costs associated with purchasing seeds from seed companies (Lehmann 1998).

Generally, hybrid F1 generations display higher vigour or heterosis (Lehmann 1998; Yadav et al. 2000), although GURTs do not provide yield gains per se. Rather than that, GURTs may be used

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for any proprietary seeds, and the market will decide the cost-benefit analysis. However, it is conceivable to use hybrid seed technology in a modified V-GURT method in which distinct terminator gene components are put in each hybrid parent (Gupta 1998; Lehmann 1998; Pendleton 2004). The F1 generation would thereafter create sterile seed in this way. While all contemporary GURTs are generated by genetic engineering, hybrids do not have to be. Thus, although genetically engineered (GE or genetically modified, GM) hybrids exist, not all hybrids must be GM, but all GURTs are now required to be GM by definition. Thus, conventional non-GM hybrid crops do not face the market limitations that certain states now impose on GM crops (Van Acker 2006).

Application of GURT

Reducing admixture

Admixture reduction Seeds have the ability to travel farther and stay viable for longer periods of time than pollen. To decrease the spread of a transgene, any device that lowers the degree of seed mixing or admixture (the accidental inclusion of transgenic material in non-transgenic seed batches) or seed loss during harvesting might be beneficial. Reducing the reintroduction of transgenes by removing transgenic seed during seed washing might be beneficial. Feral or volunteer crops refilled from the seed bank may contribute to gene flow via seed mobility and give additional chances for gene flow. GURTs include any technique that reduces seed cracking (Konishi et al 2006), or allows seeds harboring the transgene to be mechanically sorted by, for example, seed size, seed weight, or seed color. Genes that influence seed size, weight, and colour are found in a wide range of species (Mahmood et al 2005; Jofuku at el 2005; Ma et al 2005), and some of these genetic techniques have been patented (Krebbers et al 1999; Slade et al 2006).

Although most of these features, including seed size, are impacted by environmental factors, it is doubtful that they will be sufficiently resilient to be classified as a GURT. When it comes to practical considerations, supplementary characteristics such as seed size, or readily monitored visual indications such as seed color, would only be included in most breeding programmers provided they did not have any detrimental yield or composition consequences. Once seed harboring a transgene has been planted in a seed bank,the management of seed, seedling, and plant viability constitute the fundamental processes for managing the persistence of a transgenic characteristic in the environment. In order to manage seed viability, seedling establishment, and plant development, a range of alternative procedures have been presented throughout the years.

Intellectual property protection

The original V-GURT patent holders' intentions for terminator technology's future development are clear: Delta & Pine Land Company Vice President Harry Collins stated at the FAO meeting in Rome, Italy in October 1998 that "the centuries old practise of farmer saved seed is really a gross disadvantage to third world farmers who inadvertently become locked into obsolete varieties because they take the "easy road," and not planning." According to USDA spokeswoman Willard Phelps, "Our strategy is a type of self-policing the illicit use of American technology" (March 29, 1998).

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Also, "this strategy is aimed to increase the value of proprietary seed owned by US seed companies and establish new markets in the Second and Third Worlds." "My main worry is protecting American technology," said Melvin J. Oliver, the technique's creator, in March 1998. Our main mission is to safeguard and improve US agriculture's competitiveness in global markets. Technology cannot be protected else." While intellectual property is protected locally via patents and internationally through the UPOV and the WTO Trade-Related Aspects Intellectual Property Rights (TRIPS) Agreement (Article 27.3b2), monitoring unauthorized patent infringement is a major challenge for both organizations. Furthermore, many governments (mainly poor countries) do not safeguard plant varieties or biotechnological breakthroughs, or do so inefficiently or expensively. A permanent physical protection, like GURTs, would help circumvent intellectual property laws and other legal systems that need patents or licenses to expire (generally 20 years).

Patented GURT technology will remain useful for industrial and biotech research. It prevents competitors from using seeds in their breeding programmes, while also restricting farmers from using stored seeds or exploiting a desirable trait without paying for (patented) chemicals. Employing GURTs to get legal, regulatory, or contractual concessions from governments or customers may be a strategy.

Outcrossing occurs in the second and every other generation of hybrid seeds, resulting in substantially reduced plant performance in following generations (insofar as the first rationale of hybridization is to obtain more valuable plants by incorporating desired traits). Many self-fertilizing crops, such as rice, wheat, soya bean, cotton, and horticultural crops, are impractical or ineffective for hybridization, however GURTs may be utilized to any seed-propagated crop (Jefferson and colleagues, 1999). Lehmann, 1998 However, V-GURTs would not hinder clonal proliferation of plants such as grasses, shrubs, and trees (Committee on the Biological Confinement of Genetically Engineered Organisms, 2004).

Selection against transgenic plants:

Viability mechanisms in seeds and seedlings limit the ability of a transgenic plant to germinate and grow. To retain seed solid characteristics or as a GURT (genetically modified organism). Generating sterility in seeds by genetic engineering is controversial since it prevents seeds from growing. The original patent stated: (Oliver et al 1998). A gene's expression may modify phenotypic or produce a toxin when connected to a tissue-specific promoter. A blocking region separates the gene from the promoter, bordered on each side by excision sequences. Alternatively, the gene and promoter might be coupled to a developmental promoter. The second component encodes and inhibits an enzyme specific for excision sequences linked to a tissue-specific promoter. The second gene's promoter is repressible. The last gene encodes the repressor unique to repressible promoters.

The second gene is triggered by a chemical stimulant that binds to the repressor connected to promoter 2. Then gene 2's recombinase would splice off the blocking region preventing the LEA promoter from activating. The toxic gene would be activated late in development, killing all plant embryos. This would produce sterile seed that could still be harvested for nourishment.

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Any technique that depends on an inducible or repressible system must be agronomically evaluated. Inefficient induction, repression, and expression without induction may decrease system effectiveness. These systems have been established in the laboratory and their resilience in the field has yet to be verified (Moore et al 2006). Also, spraying the chemical necessary for induction or repression is questionable. Antibiotics and vertebrate hormones, which are often utilised in inducible systems, are likely to be regarded unsuitable for agronomy.

Conditional selection and transgene mitigation

Suicide genes, or conditionally lethal factors, may be beneficial in managing transgenic volunteers. Because the transgenic is associated with a conditional lethal gene, unwanted volunteer plants may be removed without harming other plants. With a conditional lethal gene, an inert toxin (which does not affect non-transgenic plants) may become an active toxin that kills transgenic plants. In the same manner that yeast mutants are typically chosen using specific organic analogues, specialized chemical analogues may be used as selection agents. Conditional lethality may also be utilized as a safety measure when combined with another GURT.

One example of a conditional lethal system uses the Agrobacterium IAAH gene (. This gene converts naphthalene acetomide to indole acetic acid (IAA), and vice versa (NAA). Plants that do not make IAAH experience epinasty and may not recover from treatment with indoleacetomide. Adding an auxin transport inhibitor enhances hazardous auxin production and its environmental impact. The other technique uses a marker gene, dao1, encoding D-amino acid oxidase (Fabijanskiet al 2006). Depending on the substrate, this gene may cause positive or negative selection. Plants are poisoned by dalanine and D-serine, but the DAAO enzyme digests them, creating a positive selection mechanism. To the contrary, D-isoleucine and D-valine act as a negative selection mechanism, since they are transformed into damaging keto acids, 3-methyl-2-oxopentanoate and 3-methyl2-oxobutyrate, respectively.

These technologies enable for selection of transgenic plants while simultaneously providing a method to reduce the transgene when selection pressure is applied. Conditional lethality requires a safe, effective, and cost-effective protoxin, toxin, or similar. Using these compounds in the field to effectively eliminate transgenic plants may prove to be an ecological and technological challenge. The tandem building strategy reduces the possibility of transgenic installation in volunteers or associated weedy relatives by pairing a gene of interest with an unsuitable gene (Gressel et al 1999) For example, the semi-dominant dwarfing gene Dgai was used to disfavour plants carrying the transgene.

To illustrate this, researchers used the model systems of tobacco and canola (Brassica napus) to show that when cultivated alongside wild-type segregants, TM transgenics had a higher reproductive fitness than wild type (Al-Ahmad et al 2006). In natural environments, these TM systems may be particularly successful in reducing volunteer plants. To our knowledge, no field-tested conditional lethal devices exist.

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Other possible benefits

The major agronomic benefits of this technology are related to V-GURTs, which may be used to prevent preharvest sprouting (Budd, 2004; Pilger, 2002) and allow seed suppliers to produce more varieties with V-GURTs (Louwaars et al, 2002).Seed saving may increase competition by encouraging private firms to enter the market for self-fertilizing cultivars (FAO, 2002).

Breeders' main source of income would be seed sales. Increasing investment in plant breeding research and development might boost productivity and (contrarily) agricultural biodiversity by enabling breeders to exploit a wider gene pool or generate more varieties (Louwaars et al., 2002). According to Eatingon and van Tongeren (2002), reduced breeding expenses and enforcement costs for plant variety protection may benefit governments.

Farmers may also profit from new (better) varieties with higher yield potential and improved pest resistance in return for higher seed (or chemical) prices (Mukherjee and Senthil Kumar, 2014). These benefits may lead to lower food costs (Eaton and van Tongeren) (2002). According to Goeschl and Swanson (2003), the most developed nations would benefit from GURTs while the least developed would lose out (especially in the short term).

Concerns and limitation of GURTS

Sustainability in Agriculture

One of the key concerns against GURTs, especially terminator technology, is the effect on biodiversity, sustainable agricultural growth, and farmers' access to and use of genetic resources. On the one hand, the introduction of new uniform GURT-protected varieties threatens to displace adapted or selected (possibly less productive) autochthonous cultivars and wild relative species, reducing genetic diversity in fields, harming local germplasms (or at least landraces), and disrupting crop coevolution at the farm level (FAO, 2001a; Visser et al., 2001). Such a policy would conflict with the European Directive 2008/62/EC, which protects endangered seed varieties of agricultural crops and states that "landraces and varieties naturally adapted to local and regional conditions and threatened by genetic erosion (conservation varieties) should be grown and marketed even where they do not comply with the general requirements as to variety acceptance and marketing."

Induce competition with wild species, and eventually transfer allergens and antibiotic resistance as food/feed (Working Group on Article 8(j), 2006). Antibiotics such as tetracyclines, although innocuous to people and plants, may negatively influence soil ecology, especially microflora and fauna, increasing the incidence of antibiotic-resistant bacteria (Mariani, 2001; Mukherjee and Senthil Kumar, 2014). The use of GURTs that prevent pollen formation in plants might have a detrimental ecological impact on certain pollen feeding insects, according to Giovannetti (2003b).

Socially, GURTs would limit the fair and equitable sharing of benefits arising from their utilisation provided by the Nagoya Protocol of the Convention on Biological Diversity (and Article 10 of the International Treaty on Plant Genetic Resources for Food and Agriculture) due to increased dependence on ‘industrial' costly seeds and chemical inducers that would create a

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companies' monopoly over markets (with an unbalanced distribution). Also in 2003, the Ad Hoc Technical Expert Group (AHTEG) reported on the potential impacts of GURTs on smallholder farmers, indigenous and local communities, and farmers' rights, including: reduction and limitation of traditional seed exchange and participatory plant breeding; reduction of traditional knowledge and innovation capacity for informal crop genetic improvement, local agrobiodiversity and protection.

A major concern is that this technology will benefit giant multinational firms at the expense of local farmers (Mukherjee and Senthil Kumar, 2014). The international policy framework on plant genetic resources is further hampered by GURTs, according to Gar (2002). Eventually, the adoption of GURT-transformed crops may be detrimental for enterprises exporting to Europe, which has long opposed GMOs (IIPTA, 2012).

Risk of transgene escape

Some problems concern the efficiency of GURTs in stopping gene flow, whereas others concern their practicality. The prevention of flower or seed development and the inducible expression of the GM trait would need a 100% effective application of a chemical inducer to prevent the escape of a nonfunctioning transgene through seed and pollen. Because some seeds may not react or take up enough inducer to activate the recombinase, they may produce viable GM plants capable of transmitting the inserted trait and having the opposite impact intended.

Other technical concerns include gene escape across generations, gene mutation, unintentional activation of sleeper genes, promoter instability, and horizontal spread of GM pollen to nontarget animals (e.g. birds, insects, soil biota) (FAO, 2002; Working Group on Article 8(j), 2006). Inducer-blocked/activated expression of a GURT characteristic may occur naturally or unwillingly (Pendleton, 2004; Working Group on Article 8(j), 2006).

Several complaints have targeted terminator technology. The technique would fail if the three genes, namely the toxic protein gene, the recombinase gene, and the repressor gene, did not segregate together during reproduction (Daniell, 2002); gene silencing because the LEA promoter may be silencing, resulting in system failure (RIP would not be produced); and introgression of a GM trait w (Giovannetti, 2003). Given the many gene recombination events required to outcross, the chance is minimal (FAO, 2001a). The FAO also cautions that GURT-modified seeds introduced commercially or as food assistance might contaminate conventional kinds and reduce fertility (FAO, 2001b).

Conclusions

Despite widespread public concern and debate about GURTs, many of the technologies have yet to be implemented or tested in the field (Chapman et al 2006). Their effectiveness in preventing transgenic mobility and environmental safety have yet to be shown. Although several GURTs mechanisms exist to decrease transgene transmission, no technique can totally block gene movement. It's critical to understand how a transgene might escape or survive in an agricultural setting.For most commercial crops, seed admixture or a plant's capacity to generate volunteers is likely to be more significant than gene transfer to wild relatives. In fact, although there are

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various ways to prevent pollen-borne trait transfer, the impact of pollen-borne gene mobility may be minor compared to the issues generated by seed mixing. Also, any GURT must be considered for its ecological effect. For example, a GURT that impairs normal pollen synthesis may have an ecological effect on pollen-dependent species.Conditional lethality techniques for eliminating transgenic plants. This gene turns an inert toxin (protoxin) or an organic counterpart that does not harm non-transgenic plants into an active toxin or compound that kills transgenic plants (Fabijanski et al 2006). ‘Reduced to practise' in patenting means the system works in a specific crop. Review TRENDS in Plant Science Vol.12 No.4 181 www.sciencedirect.com although GURTs are unlikely to resolve a philosophical scepticism of transgenic technology, they certainly raise paradoxical difficulties. Regulators favor simplified transgenic constructions, which may restrict employing extra genes, even if safe (Beckie et al 2006). Second, if the public is concerned about transgenic intake, will they tolerate an extra gene in their food? In the framework of risk analysis, both scientific and ‘non-scientific' elements must be considered (Johnson et al 2007).

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