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Genetically engineered (GE) papaya – unknown plant

Summary

Genetic engineering is a crude and old fashioned technology. The mechanism by which genetically engineered (GE) papaya is resistant to Papaya Ringspot virus (PRSV) is not known. The environmental risks of GE papaya are difficult to define because of the lack of scientific understanding about ecological interactions and possibility of unexpected effects. Possible environmental effects include the creation of new strains of viruses with unknown consequences. In addition, papaya has a high frequency of outcrossing, with the possibility of GE contamination of non-GE papaya seed and loss of export markets. Indeed, organic seed producers were advised to take special precautions against GE contamination in Hawaii. Human health risks include the use of antibiotic marker resistance genes. Advances are being made to produce a non-GE papaya that is resistant to PRSV using a different approach, that of marker assisted selection. GE papaya poses unpredictable and unexpected risks with unknown consequences to the environment. The precautionary principle should be employed and there should be no releases of GE papaya to the environment. Resources should be redirected developing the alternatives to GE papaya.

Introduction

The Papaya Ringspot virus (PRSV) affects papaya plantations in Hawaii, Florida, South America, Africa, Australia and SE Asia. Papaya has been genetically engineered to be resistant to the PRSV. GE (genetically engineered) papaya has been grown in Hawaii in recent years and now it is suggested that Thailand could grow GE papaya. But GE is a crude and imprecise technology, subject to unexpected and unpredictable effects. In addition, the situation in Thailand is very different from Hawaii: it is not so geographically isolated and there are many different types of PRSV. In addition, the GE papaya for Thailand has been developed in the laboratory completely separately from the Hawaiian GE papaya, so any assurances on the safety of the GE papaya in Hawaii do not apply to the Thai GE papaya.

This briefing examines some of the risks of GE papaya in Thailand. It is based on a scientific report[1] written by the Institute for Applied Ecology, Germany, commissioned by Greenpeace.

Genetically Engineered Papaya – crude science

GE is a crude and old fashioned technology. Artificial genetic constructs are inserted randomly and often forcibly into an organism. GE relies on a theory developed in the 1950s and assumes that each gene has only one function. However, today it is known that genes are much more complex than this[2]. Gene expression is controlled by complex regulatory networks in a manner that is far from being fully understood. GE can never produce an organism that is acceptable to be released into the environment and food chain because it cannot incorporate the complex regulatory networks now known to exist in organisms such as plants.

No one knows how GE papaya is resistant to PRSV.

The GE papaya contains a gene from the PRSV but the exact mechanism of how GE papaya is resistant to PRSV isn't known. The theory of how it works has changed as more becomes known about how DNA and viruses function. Indeed, a new theory on how GE papaya is resistant to PRSV (called "RNA silencing") was published only this year[3].

The GE papaya may work because of the crude methods of GE. The GE engineering technique used for papaya is biolistics or particle bombardment. This technique often unintentionally produces multiple copies of the inserted gene and additional, partial fragments of the gene. It has been suggested that the resistance of GE papaya to the virus is due, in part, to these unintended additional copies and fragments[4].

Environmental risks of GE papaya

The environmental risks of GE papaya cannot be predicted with any certainty. It is unknown how this

GE papaya will impact ecosystem or how it will interact with the many other organisms present in the environment. There are almost no studies examining the interaction of GE papaya with other organisms, or indeed other viruses. There are no other GE crops resistant to viruses grown commercially in the world apart from GE papaya in the geographically isolated islands of Hawaii. Therefore, any risk assessment is guess work, as it is not even known how many and what kind of environmental interactions (e.g. with other organisms) exist and need to be assessed. However, risks include the possibility of the creation of new strains of viruses and irreversible spread of the gene through the papaya population.

1) Creation of new virus strains

The interaction of GE papaya with other viruses that also infect the plant can produce new strains of viruses. A virus infecting a GE papaya plant could be altered in a number of different ways.

1) the range of organisms that the virus can infect could change, e.g. a virus could start infecting other types of plants which is did not previously;
2) the way the virus is carried could change, e.g. a virus not previously passed on by insects could become carried by insects;
3) the strength (or virulence) of the virus could be altered
4) or recombination could produce a new virus.

The consequences of any of these happening are completely unknown.

How likely is the creation of new virus strains from GE papaya? It isn't known how likely interactions that may create new strains of viruses are. The research simply has not been done – how new strains of viruses evolve isn't well understood. In addition, studies of the GE papaya grown in Hawaii (e.g. on resistance to multiple strains of PRSV) can't be applied to the GE papaya for Thailand, as the GE papaya for Thailand has been produced completely separately to the GE papaya grown in Hawaii[5].

The geographical isolation of Hawaii means that the GE papaya grown there isn't exposed to so many viruses. In areas such as South-East Asia there are a great many types of virus of the same family (potyviruses), unlike Hawaii and indeed, a great variety of PRSV types, e.g. Chiang Mai isolate. There are also many viruses that infect papaya plants at the same time as PRSV, again a different situation to Hawaii. Therefore, there is a greater chance of interaction between GE papaya and other viruses in areas such as South East Asia.

There are two other factors, related to the genetic engineering itself that increase the chance for interaction between the GE papaya and incoming viruses. The genetic insert in GE papaya is always "on", i.e. it does not switch off and on and is therefore producing protein all the time in every cell of the plant. Therefore, any virus infecting the plant will automatically be exposed to protein, increasing the risk of interaction between the incoming virus and the GE papaya. In natural conditions, two different viruses do not affect the same cell at the same time but this effectively could happen with the GE papaya.

Hence, there are important differences between a virus infecting GE papaya and natural co-infection of viruses. These differences may be important in producing new strains of viruses, but knowledge of viruses and their evolution is so limited, that predictions simply cannot be made.

2) Contamination of non-GE papaya is inevitable

Research in Hawaii[6] showed considerable GE contamination of neighbouring non-GE female papaya plants (43 % of the seeds analysed) within 25 metres of the GE papaya field. Indeed, organic seed producers were advised to take special precautions against GE contamination in Hawaii, by covering the unopened flower bud with a paper bag to ensure self-pollination. It is clear that outcrossing of GE papaya to neighbouring fields of non-GE papaya will occur over considerable distances. Hence, any growing of GE papaya would be irreversibly spread the GE gene because the papaya would pollinate with other papaya plants. There can be no recall once GE papaya is released to the environment.

The consequences of GE contamination are not predictable because GE is such a crude technology. There have been several examples of unexpected effects of commercial GE plants; some of these only became obvious when the GE plant was under stress, such as drought or high temperatures. For example, Monsanto's Roundup Ready soya gave rise to unexpected crop losses in hot, dry weather due to stem splitting caused, most probably, by increased lignin[7]. Therefore, the spreading of a gene through the population of papayas could have unintended consequences.
GE contamination of papaya plants could increase the likelihood of virus recombination, because of the

greater abundance of GE papaya plants. Importantly, GE contamination would restrict seed production for non-GE papaya and could impact the export market for Thai papaya.

Human health risks of GE papaya

1) Allergies to GE papaya

A recent study[8] has shown that there are similarities between the protein produced by the inserted gene in GE papaya and allergenic proteins. Although not conclusive, it demonstrates that there are questions regarding the food safety of GE papaya, and this similarity to allergenic proteins certainly requires extensive pre-market safety assessment.

2) Antibiotic resistance marker genes

The GE papaya contains the resistance marker gene, nptII, for the antibiotic, kanamycin. Concern over the build up of antibiotic resistance restricting the use of antibiotics in human and animal medicine has resulted in the use of antibiotic markers no longer being acceptable in Europe from 2004 (Directive 2001/18) and a phase out is recommended by the Joint FAO/WHO Food Standards Programme, Codex Ad Hoc Task Force on Foods Derived from Biotechnology. This implies a worldwide recommendation not to approve genetically modified crops containing antibiotic resistance marker genes.

Are there alternatives?

Non GE-papayas that are resistant to PRSV are being developed, e.g. by crosses with other types of papaya[9]. Indeed, the search for papayas resistant to PRSV is a principal reason cited for conservation of papayas in Southern Ecuador (a centre of diversity for papayas)[10]. Such crosses have previously resulted in low pollen fertility, but efforts are currently underway to improve pollen fertility[11]. These research efforts use marker assisted selection, a modern biotechnological approach that does not result in a GE crop being released to the environment.

Conclusion

GE papaya poses unpredictable and unexpected risks with unknown consequences to the environment. The precautionary principle should be employed and there should be no releases of GE papaya to the environment. Resources should be redirected developing the alternatives to GE papaya.

Notes

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