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BIOSAFETY REVIEW AND ENVIRONMENTAL ASSESSMENT FOR THE FIELD RELEASE OF GENETICALLY ENGINEERED CROP PLANTS AND MICROBES IN THE UNITED STATES[1]

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ABSTRACT

The United States Department of Agriculture (USDA), Food and Drug Administration (FDA), and Environmental Protection Agency (EPA) are the focal points of biosafety regulations for field testing and release of genetically engineered plants in the United States. Public interest advocacy groups, environmental activists, and industry and consumer groups also play a role in the development of biosafety regulations. Before release of transgenic plants, applications are made to Animal and Plant Health Inspection Services (APHIS) for field testing or importation of genetically engineered organisms, after which an environmental assessment is prepared to evaluate the potential impact of the release of the transgenic organism (crop) into the environment. The first genetically engineered crop, the FLAVR SAVR variety of tomatoes, is now on market, and many more are in the pipeline to commercialisation.

Key Words: **APHIS, biosafety, field testing, transgenic plants, USDA**

RÉSUMÉ

Le Département de l'Agriculture des Etats Unis (USDA), le Bureau de l'Administration des Aliments et Médicaments (FDA) et l'agence de protection de l'environnement (EPA) sont les foyers de développement de réglementations de biosécurité pour des essais en champs et la dissémination des plantes génétiquement manipulées aux Etats Unis. Les groupes de défense d'intêret public, les activistes de l'environnement ainsi que les groupes de consommateurs et d'industries jouent aussi un rôle dans le développement des réglementations de biosécurité. Avant la diffusion des plantes transgéniques, une demande est faite auprès du service d'inspection de la santé des plantes et animaux (APHIS) pour l'essai en champ ou l'importation d'organismes génétiquement manipulés, afin qu'après soit effectuée une évaluation qui permet de déterminer l'impact potentiel d'organismes (plantes) transgéniques sur l'environnement. La variété de tomates FLAVR SAVR est la première culture génétiquement manipulée qui est en ce moment sur le marché; beaucoup d'autres sont en voie d'être commercialisées.

Mots Clés: **APHIS, biosécurité, essais en champs, plantes transgéniques, USDA**

[1] *This article should not be construed as an official policy of USDA or APHIS. Instead, it is meant for information purposes only.*

INTRODUCTION

Although modern recombinant DNA based biotechnology is relatively new, it has far outpaced any other field of scientific endeavour in terms of progress and achievements. To characterise the progress and achievements in biotechnology within a short span of 15-20 years as "fantastic" is an understatement. It is no longer uncommon to see quick application of identifying and cloning a useful gene being deployed in another organism within a span of three to five years. In fact, the very essence of modern day biotechnology has been to rapidly develop or genetically alter or engineer organisms to perform desired functions, and produce products such as biologically active molecules, pharmaceutical, vaccines, drugs, antibiotics, industrial enzymes, biocontrol agents and proteins which hitherto was constrained by the existing industrial technologies. Biotechnology applied to agriculture and plants in particular has lagged a pace or two behind biomedical biotechnologies. But, certainly not too far behind. In fact, genetically engineered crop plants and microbes are knocking on the doors of commercialisation. A variety of genetically engineered crop plants exhibiting resistence to insects herbicides, viruses and having nutritional and post-harvest quality characteristsics have been developed. Thousands of field trials involving almost all plants of agricultural importance have been field tested in the United States (Fig. 1). Private sector companies have garnered the lead in the number of field trials in the United States (Figs. 2 and 3). Many other genetically engineered minor crops and microorganisms have also been field tested in the United States (Table 1). The first genetically

TABLE 1. Field releases*: Infrequent crops and microorganisms (1987-6/30/95

Infrequent crops:	(<3 issues)	Microorganisms: (Issued)
Amelanchier laevis	Pea	Clavibacter
Arabidopsis thaliana	Peanut	*Cryphonetria parasitica*
Barley	Pepper	*Fusarium graminearum*
Belladona	Petunia	*Pseudomonas putida*
Brassica oleracea	Plum	*Pseudomonas syringae*
Chrysanthemum	Poplar	*Rhizobium fredii*
Cranberry	Spruce	*Rhizobium leguminosarum*
Creeping bentgrass	Sweetgum	TMV
Eggplant	Watermelon	*Xanthomonas campestris*
Gladiolus	Wheat	
Papaya		

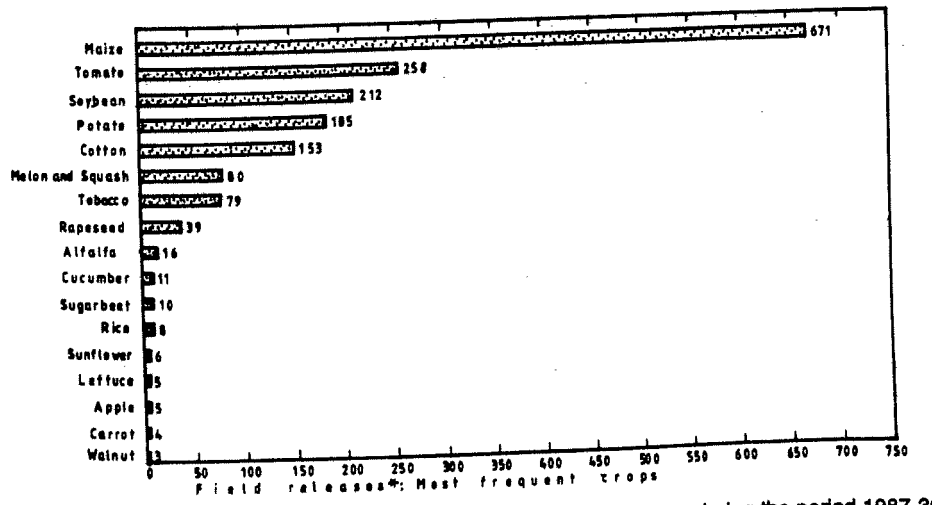

Figure 1. Genetically engineered crop plants field tested in the United States during the period 1987-30 June 1995. * Permits issued and notifications acknowledged.

engineered vegetable crop on super market shelves is the FLAVR SAVR variety of tomatoes. Many more are in the pipeline, and will most likely enter the market early next year (Table 2). But, this road to commercialisation was not easy as the developers of such genetically engineered plants had to subject their products to biosafety review and environmental risk assessment to satisfy the biotechnology regulations of the three federal agencies, viz. United States Department of Agriculture (USDA), Food and Drug Administration(FDA), and Environmental Protection Agency (EPA). Public interest advocacy groups, environmental activists, environmental lobby groups, industry and consumer groups have played very important roles in the development of biotechnology regulatory policies in the United States.

FEDERAL POLICY

In 1994, the US Federal Government spent 4.3 billion dollars for biotechnology research and development. At the same time, the federal government made a commitment to the public that the products of biotechnology are safe healthwise and to the environment. Such a commitment is shared by USDA, FDA, and EPA. The federal policy for the regulation of biotechnology was published in the final form in

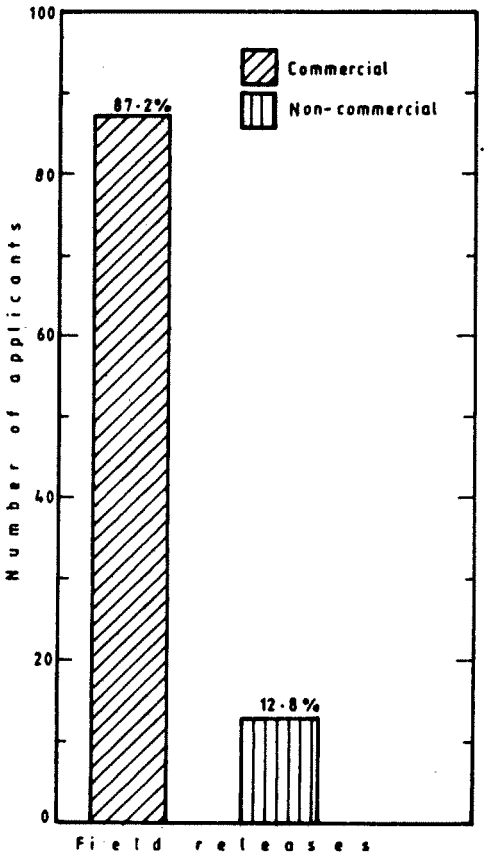

Figure 3. Proportion of commercial and non-commercial sector companies conducting field trials with genetically engineered crop plants in the United States during the period 1987-30 June 1995

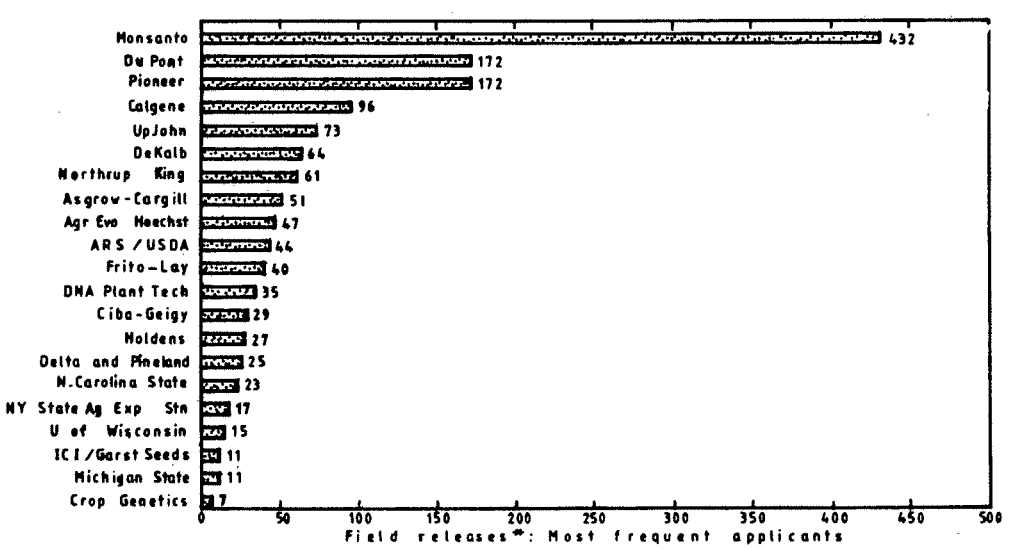

Figure 2. Institutions conducting field trials with genetically engineered crop plants in the United States. * Permits issued and notification acknowledged.

1986 (OSTP, 1986), and was further elaborated in 1990 and 1992 (OSTP, 1990, 1992). The most significant point of this policy statement is that the products of recombinant DNA technology are not different fundamentally from conventional products, and, therefore, existing laws should be sufficient to provide adequate regulatory oversight for products or organisms developed through recombinant DNA technology. USDA biotechnology regulatory policy has always been consistent with policy established by OSTP. The administration's policy objectives have been clearly delineated in an Executive Order 12866 (Federal Register 58, 51735-51744, October 4, 1993) which in essence states that "each regulatory agency shall, to a reasonable extent assess the degree and nature of the risks posed by various substances or activities within its jurisdiction, that each agency shall avoid duplicative regulations that are unnecessarily burdensome, and take into consideration the cumulative cost of regulations". The executive order also emphasises the criterion for establishing a need for regulation based on a scientific basis for risk assessment.

USDA/APHIS RESPONSIBILITIES

USDA biotechnology regulations that govern the introduction of genetically engineered organisms into the environment are based on the Federal Plant Pest Act, and Federal Quarantine Act which, in essence, seeks to prevent the introduction of any real or potential plant pests into the environment. Since USDA became a signatory to the federally coordinated framework of biotechnology regulations, the Animal and Plant Health Inspection Service (APHIS) promulgated its biotechnology regulations (7 CFR Part 340) in 1986 (OSTP, 1986), almost 1590 field trials in 6133 sites (Fig. 4) involving the release of genetically engineered plants and microorganisms of agricultural importance have been conducted in the United States. United States leads the world in biotechnology, and in the number of field trials conducted of genetically engineered organisms. For this purpose, APHIS has a list of plant pests or regulated articles identified (7 CFR Part 340), and also provides for the regulatory definition of a plant pest (USDA/APHIS, 1987). Consequently, all genetically engineered organisms that have been developed by employing either a whole plant pest organism or a part of a plant pest have been deemed to be regulated articles. This regulatory trigger calls for the applicant to apply to APHIS for a field testing permit or an inter-state movement permit or an importation permit for genetically engineered organisms permit. Using a procedural

TABLE 2. Crops under regulatory review and petitions approved by USDA/APHIS

Applicant	Crop	Category/Phenotype
Calgene	Tomato	PQ/Fruit ripening altered
Upjohn	Squash	VR/VR/WMV2 Resistant/ZYMV resistant
Calgene	Cotton	HT/Bromoxynil tolerant
Monsanto	Soybean	HT/Glyphosate tolerant
Calgene	Rapeseed	PQ/Oil profile altered
Zeneca	Tomato	PQ/Fruit polygalacturonase level decreased
Calgene	Tomato	PQ/Fruit ripening altered
DNA Plant Tech	Tomato	PQ/Fruit ripening altered
Calgene	Tomato	PQ/Fruit ripening altered
Monsanto	Potato	IR/Coleopteran resistant
Zeneca & Petoseed	Tomato	PQ/Fruit polygalacturonase level decreased
Monsanto	Cotton	IR/Lepidopteran resistant
Ciba-Geigy	Corn	IR/Lepidopteran resistant
AgrEvo	Corn	HT/Phosphinothricin tolerant
Calgene	Tomato	PQ/Fruit ripening altered
Monsanto	Cotton	IR/Lepidopteran resistant
Monsanto	Tomato	PQ/Fruit ripening altered
Monsanto	Corn	IR/Lepidopteran resistant
Calgene	Tomato	PQ/Fruit ripening altered
DeKalb	Corn	HT/Phosphinothricin tolerant
Calgene	Tomato	PW/Fruit ripening altered

statute, the National Environment Policy Act (NEPA), an environmental assessment is prepared to evaluate the potential impacts of the regulated organism on the environment and also the nature of the environment into which it is being introduced.

From the beginning, USDA biotechnology regulations have been deliberately flexible so that it is relatively easier to modify them to accomodate changing needs of the rapidly advancing field of biotechnology and genetic engineering. APHIS uses up-to-date scientific and technological information to avoid regulatory duplication, and has tried to establish the need to review products of biotechnology and genetic engineering that are commensurate with the risk. In addition, it uses guidance documents emanating from numerous international scientific consultations as opposed to enforcing rigid and mandatory requirements (NRC, 1989; Tiedje *et al.*, 1989; Anonymous, 1990; McCammon and Dwyer, 1990; OSTP, 1990). Some of the important categories of genetically engineered plants and their distribution among field trials, is shown in Fig. 5. At the initial stages of implementing the biotechnology regulations governing field tests, all the applications were reviewed on a case by case basis with the help of an environmental assessment prepared for each one of the applications, and contained field tests were conducted under an APHIS permit. Over the past seven and a half years, APHIS has revised its regulations several times to keep pace not only with the development of technology, but also

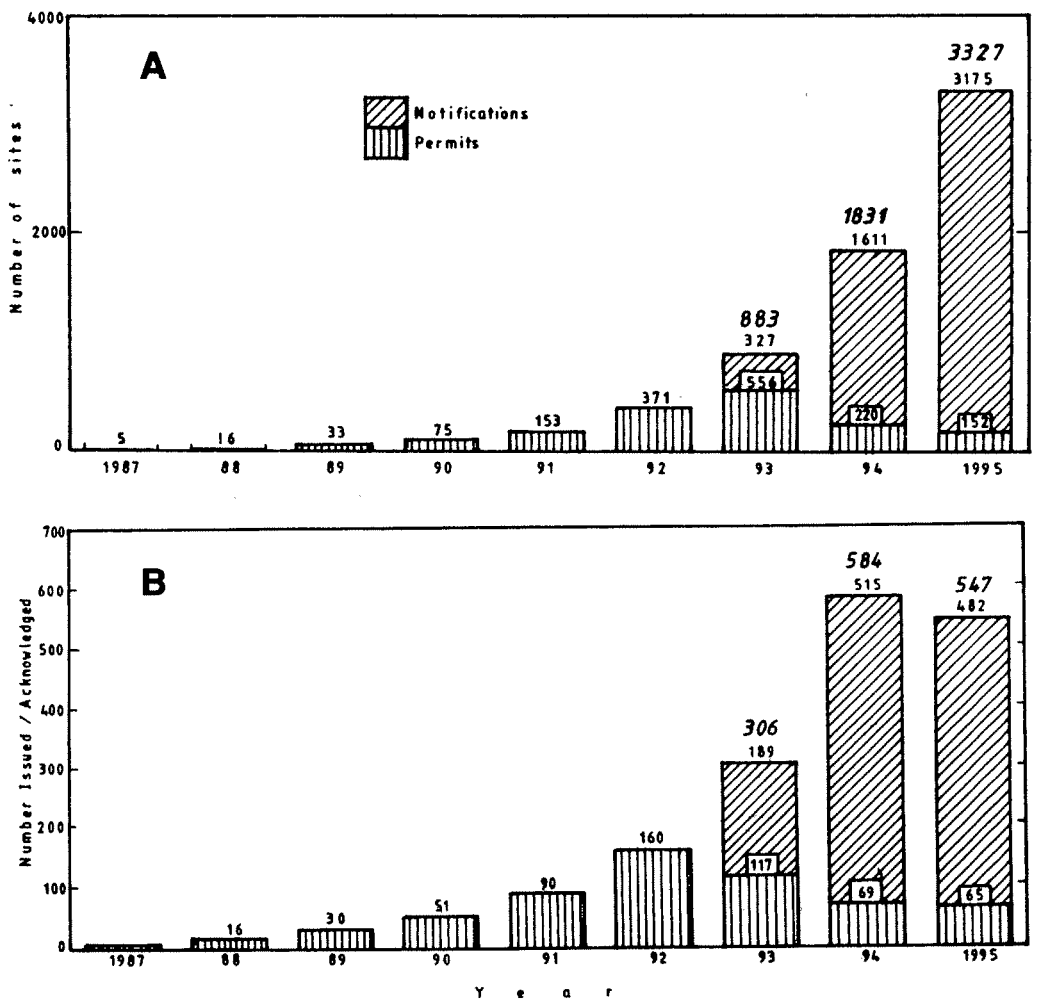

Figure 5. Number of sites of field releases (A) and number of permits issued (B) of genetically engineered crop plants in the United States during the period 1987-30 June 1995. * Permits issued and Notifications Acknowledged.

with its own wealth of experience with thousands of field trials. Still, APHIS biotechnology regulations are based on Federal Plant Pest Act and Federal Quarantine Act which basically seeks to prevent the introduction of any plant pest into the agricultural environment of the country, and the National Environmental Policy Act (NEPA) by way of environmental assessments assures the general public that there is no significant impact to the environment. This permit system was carried on for almost five years when APHIS, using its well established policy of flexibility with their biotechnology regulations, decided to review field tests that had taken place under the permit system, and also reviewed the fields test data to produce a new set of regulations where, in a notification system (USDA/APHIS, 1993), was introduced to ease the regulatory burden on a select group of plants, viz., tomato, maize, tobacco, cotton, potato, and soybeans as they formed the bulk of the field tests conducted under the permit system with which APHIS had vast experience and familiarity. Under the notification system, 932 field trials at 4,597 sites have been conducted without a permit or any environmental assessment (Fig. 6), thus saving

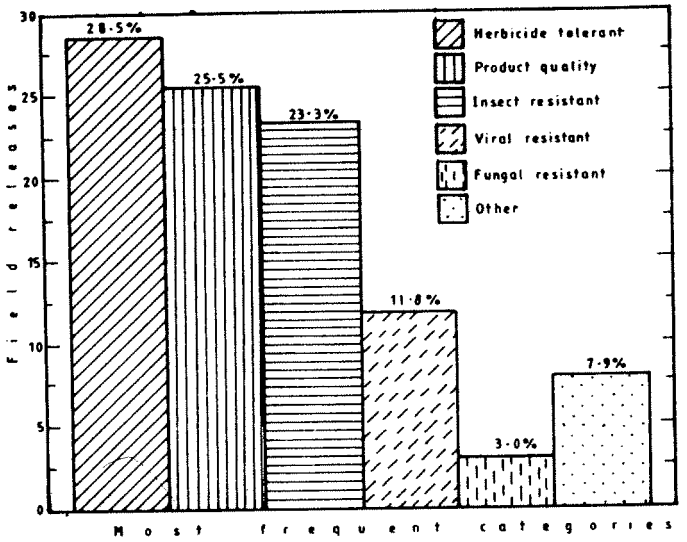

Figure 5. Categories of genetically engineered plants and their distribution among field trials in the United States during the period 1987-30 June 1995. * Product quality refers to agronomic properties.

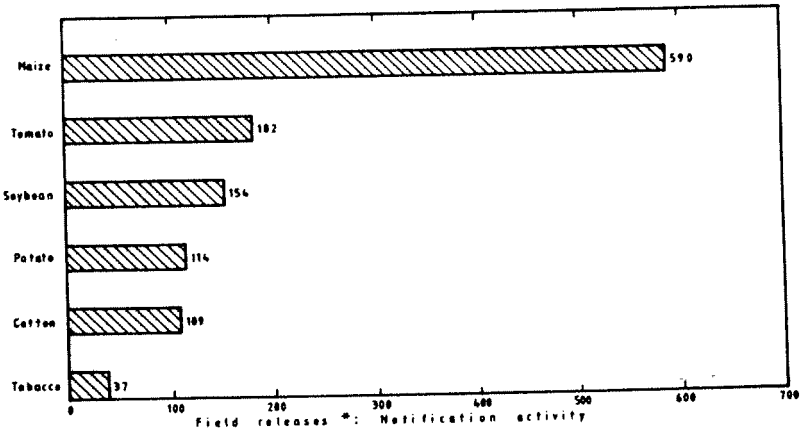

Figure 6.Field releases of genetically engineered crop plants under the Notification system (not requiring permits) in the United States during the period 30 April 1993-30 June 1995. * Notifications acknowledged.

both time and money for all people involved. The notification procedure for the bulk of genetically engineered crops that are field tested was hailed as a progressive, landmark step by the biotechnology industry and the rest of the scientific community. After merely two and a half years of the notification process in place, APHIS started receiving petitions for determination of nonregulatory status that turned out to be essentially the first step toward commercialisation. This year, APHIS has come a long way in planning to extend the notification system to other crop species for the purposes of field testing. The extension of the notifications to almost all crops would result in considerable savings of resources for both the applicant and the agency. A petition filing system was introduced in 1993 by APHIS to enable the applicants to seek regulatory relief for their tested time and proven to be safe from plant pest risk genetically engineered crop plants. Such determination of any genetically engineered crop plant to be no longer a regulated article which would essentially allow for uncontained and unrestricted cultivation of that plant anywhere within the country.

Currently, around 14 crops have been removed from APHIS regulatory review under the petition rule (Table 3). Another 14 petitions (Table 3) are under the agency review for a determination as non-regulated articles. This petition rule is once again a significant milestone in the APHIS biotechnology regulatory policy that immediately paved way for commercialisation. At the moment, APHIS is preparing to propose a further modification to the petition process where, in regulated organisms that are significantly similar to the already non-regulated article under the petition process, will allow the applicant to develop performance standards for environmental introduction without any regulatory review. Once the applicants are able to certify that the additional lines of already non-regulated articles meet the petition approval performance standards, they need not go through the elaborate petition process. This rapid petitioning process should encourage other applicants to speed up their product development, after which those products will be removed from the regulatory oversight. Once again, these steps to improve the regulatory review for safety should result in considerable reduction of Government resources, and at the same time reduce developmental costs to the applicants. The resources thus saved can be redirected in reviewing novel and new generations of biotechnology products for biosafety and environmental impact. By providing for a flexible regulatory policy from the beginning, APHIS has played a crucial role in the development of safe biotechnology products, and has provided leadership around the world for the development of internationally harmonised regulatory polices to achieve safe product certification, and transfer of safe biotechnology products (Medley, 1990, 1991, 1993; Medley and McCammon, 1995).

APHIS has constantly strived to invest in ably qualified scientific personnel, and for the maintenance of their scientific and professional competence so that the agency can effectively

TABLE 3. Field Releases[a]: Infrequent Crops and Micro-organisms 1987 - 1995[b]

Infrequent Crops: (less than 3 issues)		Micro-organisms (issued):
Amelanchier laevis	Pea	
Arabidopsis thaliana	Peanut	Clavibacter
Barley	Pepper	*Cryphonectria parasitica*
Belladonna	Petunia	*Fusarium graminearum*
Brassica oleracea	Plum	*Pseudomonas putida*
Chrysanthemum	Poplar	*Pseudomonas syringae*
Cranberry	Spruce	*Rhizobium fredii*
Creeping bentgrass	Sweetgum	*Rhizobium leguminosarum*
Eggplant	Watermelon	TMV
Gladiolus	Wheat	*Xanthomonas campestris*
Papaya		

[a] Permits issued and notifications acknowledged
[b] as of 30 June 1995

monitor developments in biotechnology to meet the rapidly evolving regulatory challenges. APHIS also believes in positioning its regulatory policies in a strategic manner by focusing on having clearly identifiable regulatory triggers that are consistent, easily understood and transparent, effective and responsive, flexible and dynamic, and rise up to the ever changing challenges of domestic and international needs (Medley and McCammon, 1995). To that end, APHIS made forays into the world of internet service (World wide Web) to instantly transfer information on its regulatory activities to the public. This world-wide-web server provides a wide range of on-line services such as information on regulations, how to obtain permits, how to notify, how to petition, updates on all current and pending rules and regulations in the Federal Register notices, and the proposed new regulations and/or policies. Daily updates on current and pending applications for the agency regulatory review are posted for the benefit of the general public. APHIS has provided strong leadership in trying to achieve international harmonisation of biotechnology regulations by sharing its own wealth of experiences in overseeing field trials in the United States by participating in several international biosafety training workshops, seminars and conferences. APHIS strongly believes that biosafety and environmental impact assessment are only one facet of the biotechnology regulations. More importantly, regulations provide an excellent opportunity to offer product certification, technology assessment, and play a crucial role in technology transfer which in turn is important for international trade. It is the cherished hope of APHIS that by achieving international harmonisation of biotechnology regulatory policies, all the artificial trade barriers that have nothing to do with safety concerns will be out of the way for the conduct of free trade.

REFERENCES

Anonymous, 1990. *Workshop Report on Safeguards for the Introduction of Transgenic Corn and Wheat.* Keystone, Colorado. USDA, APHIS, BBEP.

McCammon, S. L. and Dwyer, S. G. (Eds.). 1990. *Proceedings of Workshop on Safeguards for the Planned Introduction of oilseed Crucifers.* Cornell University, Ithaca, NY, 33pp.

Medley, T. L. 1990. APHIS seeks to aid tech transfer while ensuring environmental safety. *Genetic Engineering News* 10, N8.

Medley, T. L. 1991. Domestic and international regulatory responsibilities of USDA-Global harmonization. American Association for the Advancement of Science Annual Meeting, Publication 91-02S; Section 24-pp. 56.

Medley, T. L. 1993. USDA's oversight approach for plants produced through biotechnology. In: *Bio Europe 1993, International Conference and Proceedings.* Senior Advisory Group on Biotechnology, Belgium, pp. 117-129.

Medley, T. L. and McCammon, S. L. 1995. Strategic regulations for safe development of transgenic plants. In: *Biotechnology.* Brauer, D. (Ed.), 12: 197-211. Second Edition. Legal, Economic and Ethical Dimensions.

NRC (National Research Council) 1989. *Field Testing of Genetically Modified organisms: Framework for Decisions.* Washington, DC. National Academy Press, 170 pp.

OSTP (Office of Science and Technology Policy), 1986. Coordinated Framework for Regulation of Biotechnology: Announcement of Policy and Notice for Public Comment. *Federal Register* 51: 23303-23393.

OSTP (Office of Science and Technology Policy), 1990. Principles for Federal oversight of Biotechnology: Planned Introduction into the Environment of Organisms with Modified Hereditary Traits. *Federal Register* 55: 31118-31121.

OSTP (Office of Science and Technology Policy), 1992. Exercise of Federal Oversight of Biotechnology Within Scope of Statutory Authority: Planned Introductions of Biotechnology Products into the Environment. *Federal Register* 57: 6753-6762.

Tiedje, J. M., Colwell, R.K., Grossman, Y. L., Hodson, R., Lenski, R.E., Mack, N. and Regal, P. J. 1989. The planned introduction of genetically engineered organisms: Ecological considerations and recommendations. *Ecology* 70: 298-315.

USDA/APHIS, 1987. Introduction of Organisms and Products Altered or Produced Through Genetic Engineering Which are Plant Pests or Which There is Reason to Believe are Plant Pests. *Federal Register* 52: 22892-22915.

USDA/APHIS, 1993. Genetically Engineered Organisms and Products: Notification Procedures for the Introduction of Certain Regulated Articles; and Petition for Nonregulated Status: Final Rule. *Federal Register* 58: 17044-17059.