Notices

Federal Register
Vol. 63, No. 68
Thursday, April 9, 1998

This section of the FEDERAL REGISTER contains documents other than rules or proposed rules that are applicable to the public. Notices of hearings and investigations, committee meetings, agency decisions and rulings, delegations of authority, filing of petitions and applications and agency statements of organization and functions are examples of documents appearing in this section.

DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

[Docket No. 97-114-2]

Monsanto Co.; Availability of Determination of Nonregulated Status for Tomato Genetically Engineered for Insect Resistance

AGENCY: Animal and Plant Health Inspection Service, USDA.

ACTION: Notice.

SUMMARY: We are advising the public of our determination that the Monsanto Company's tomato line designated as 5345, which has been genetically engineered for resistance to certain lepidopteran insect pests, is no longer considered a regulated article under our regulations governing the introduction of certain genetically engineered organisms. Our determination is based on our evaluation of data submitted by Monsanto Company in its petition for a determination of nonregulated status, an analysis of other scientific data, and our review of comments received from the public in response to a previous notice announcing our receipt of the Monsanto Company's petition. This notice also announces the availability of our written determination document and its associated environmental assessment and finding of no significant impact.

EFFECTIVE DATE: March 26, 1998.

ADDRESSES: The determination, an environmental assessment and finding of no significant impact, the petition, and all written comments received regarding the petition may be inspected at USDA, room 1141, South Building, 14th Street and Independence Avenue SW., Washington, DC, between 8 a.m. and 4:30 p.m., Monday through Friday, except holidays. Persons wishing to inspect those documents are asked to call in advance of visiting at (202) 690-2817 to facilitate entry into the reading room.

FOR FURTHER INFORMATION CONTACT: Dr. Sivramiah Shantharam, Biotechnology and Biological Analysis, PPQ, APHIS, 4700 River Road Unit 147, Riverdale, MD 20737-1236; (301) 734-4882. To obtain a copy of the determination or the environmental assessment and finding of no significant impact, contact Ms. Kay Peterson at (301) 734-4885; e-mail: mkpeterson@aphis.usda.gov.

SUPPLEMENTARY INFORMATION:

Background

On October 14, 1997, the Animal and Plant Health Inspection Service (APHIS) received a petition (APHIS Petition No. 97-287-01p) from Monsanto Company (Monsanto) of St. Louis, MO, seeking a determination that a tomato line designated as 5345, which has been genetically engineered for resistance to certain lepidopteran insect pests, does not present a plant pest risk and, therefore, is not a regulated article under APHIS' regulations in 7 CFR part 340.

On November 28, 1997, APHIS published a notice in the **Federal Register** (62 FR 63312-63313, Docket No. 97-114-1) announcing that the Monsanto petition had been received and was available for public review. The notice also discussed the role of APHIS, the Environmental Protection Agency (EPA), and the Food and Drug Administration in regulating the subject tomato line and food products derived from it. In that notice, APHIS solicited written comments from the public as to whether this tomato line posed a plant pest risk. The comments were to have been received by APHIS on or before January 27, 1998. During the designated 60-day comment period, APHIS received two negative comments on the subject petition, both of which were from consumer policy organizations. The commenters argue that APHIS should deny the subject petition because the petitioner's insect pest resistance management strategies are inadequate based on recently published information in scientific journals. However, APHIS regulatory authority is based on an assessment of plant pest risk. EPA is the lead agency dealing with pest resistance management strategies for transgenic insect resistant plants, and EPA has established a pest resistance management working group to deal with pest resistance management issues. APHIS is working with EPA to examine the issues surrounding the development of pest resistance, and scientific consultations in public forums are being pursued in conjunction with the registration process under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 *et seq.*). While APHIS has carefully considered the comments submitted, our determination has not been affected by the points made by the commenters because they extend to authority exercised by EPA under FIFRA.

Analysis

Tomato line 5345 has been genetically engineered to express a CryIA(c) insect control protein derived from the common soil bacterium *Bacillus thuringiensis* subsp. *kurstaki* HD-73 (Btk). The subject tomato line also expresses the *nptII* gene, which codes for the enzyme neomycin phosphotransferase (NPTII) and has been used as a selectable marker in the development of the transgenic tomato plants. While tomato line 5345 contains the *aad* gene, tests indicate that the AAD protein is not expressed in the subject tomato plants. Expression of the added genes is controlled in part by noncoding DNA sequences derived from the plant pathogens *Agrobacterium tumefaciens* and cauliflower mosaic virus. The *Agrobacterium* transformation method was used to transfer the added genes into the UC82B parental tomato plants.

The subject tomato line has been considered a regulated article under APHIS' regulations in 7 CFR part 340 because it contains gene sequences derived from plant pathogens. However, evaluation of field data reports from field tests of this tomato line conducted under APHIS notifications since 1995 indicates that there were no deleterious effects on plants, nontarget organisms, or the environment as a result of the environmental release of tomato line 5345.

Determination

Based on its analysis of the data submitted by Monsanto and a review of other scientific data and field tests of the subject tomato line, as well as comments submitted by the public regarding the subject petition, APHIS has determined that tomato line 5345:

(1) Exhibits no plant pathogenic properties; (2) is no more likely to become a weed than tomato lines developed by traditional breeding techniques; (3) is unlikely to increase the weediness potential for any other cultivated or wild species with which it can interbreed; (4) will not cause damage to raw or processed agricultural commodities; and (5) will not harm threatened or endangered species or other organisms, such as bees, that are beneficial to agriculture. Therefore, APHIS has concluded that the subject tomato line and any progeny derived from hybrid crosses with other nontransformed tomato varieties will be as safe to grow as tomato in traditional breeding programs that are not subject to regulation under 7 CFR part 340.

The effect of this determination is that Monsanto's tomato line 5345 is no longer considered a regulated article under APHIS' regulations in 7 CFR part 340. Therefore, the requirements pertaining to regulated articles under those regulations no longer apply to the field testing, importation, or interstate movement of the subject tomato line or its progeny. However, importation of tomato line 5345 or seeds capable of propagation is still subject to the restrictions found in APHIS' foreign quarantine notices in 7 CFR part 319.

National Environmental Policy Act

An environmental assessment (EA) has been prepared to examine the potential environmental impacts associated with this determination. The EA was prepared in accordance with: (1) The National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 *et seq.*), (2) regulations of the Council on Environmental Quality for implementing the procedural provisions of NEPA (40 CFR parts 1500–1508), (3) USDA regulations implementing NEPA (7 CFR part 1b), and (4) APHIS' NEPA Implementing Procedures (7 CFR part 372). Based on that EA, APHIS has reached a finding of no significant impact (FONSI) with regard to its determination that Monsanto's tomato line 5345 and lines developed from it are no longer regulated articles under its regulations in 7 CFR part 340. Copies of the EA and the FONSI are available upon request from the individual listed under FOR FURTHER INFORMATION CONTACT.

Done in Washington, DC, this 3rd day of April 1998.

Craig A. Reed,

Acting Administrator, Animal and Plant Health Inspection Service.

[FR Doc. 98–9376 Filed 4–8–98; 8:45 am]

BILLING CODE 3410–34–P

Response to Monsanto Petition 97-287-01p for Determination of Nonregulated Status for Insect Resistant Tomato Line 5345

Environmental Assessment and Finding of No Significant Impact

March 1998

The Animal and Plant Health Inspection Service (APHIS), United States Department of Agriculture, has prepared an environmental assessment prior to issuing a determination in response to a petition (APHIS Number 97-287-01p) received from Monsanto Company regarding the status of insect resistant tomato line 5345 under APHIS regulations at 7 CFR Part 340. The tomato plants of the transformed line 5345, have been engineered with a gene that results in the expression of an insect control protein Cry1Ac isolated from *Bacillus thuringiensis* subsp.*kurstaki*. Based upon the analysis documented in its environmental assessment, APHIS has reached a finding of no significant impact on the environment from its determination that insect resistant tomato line 5345 shall no longer be a regulated article.

Rebecca Bech
Assistant Director
Scientific Services
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
U.S. Department of Agriculture
Date: MAR 26 1998

TABLE OF CONTENTS

APPENDICES

I. SUMMARY

The Animal and Plant Health Inspection Service (APHIS), U.S. Department of Agriculture (USDA), has prepared an Environmental Assessment (EA) in response to a petition (APHIS Number 97-287-01p) from Monsanto Company regarding insect resistant tomato line 5345 and its derivatives. Monsanto seeks a determination that the tomato line 5345 does not present a plant pest risk and should therefore no longer be a regulated article under regulations at 7 CFR Part 340. Insect resistant tomato line 5345 has been genetically engineered to express the *Cry1Ac* gene that results in the expression of toxic protein Cry1Ac, which confers resistance to certain lepidopteran insects.

Monsanto submitted its petition after the completion of field tests of the insect resistant tomato line at 29 sites within USA under notifications 94-362-01N, 95-138-04N, 95-151-04N, 95-216-03N, 96-011-01N, 96-247-14N, 97-013-01N, 97-015-02N, and 97-182-04N. These field tests have demonstrated no deleterious effects on plants, nontarget organisms, or the environment. Field trials in the United States were performed under conditions of physical and reproductive confinement. This EA specifically addresses the potential for impacts to the human environment through unrestricted use in agriculture of insect resistant tomato.

APHIS has considered all the information provided by Monsanto in its petition as well as other scientific data and public comments relating to the potential plant pest risk of insect resistant tomato. A thorough evaluation of the potential for significant impact to the human environment through the unconfined agricultural use of insect resistant tomato has brought APHIS to a Finding of No Significant Impact (FONSI). This conclusion is based upon (1) the purpose of the genetic modification; (2) the fact that this modification will not increase the weediness of tomato or any sexually compatible plants; and (3) the fact that this modification will not negatively effect any nontarget organisms, including beneficials. In conjunction with the FONSI, APHIS has made the determination that the insect resistant tomato line 5345 and its progeny have no potential to pose a plant pest risk, and therefore is no longer a regulated article (see Appendix A).

II. INTRODUCTION

This EA examines potential environmental impacts from the unrestricted introduction of insect resistant tomato line 5345. Since 1995, insect resistant tomato line 5345 was field tested at 29 sites in USA under the following notifications 94-362-01N, 95-138-04N, 95-151-04N, 95-216-03N, 96-011-01N, 96-247-14N, 97-013-01N, 97-015-02N, and 97-182-04N. Monsanto has presented field data reports for all the above field tests none of which report any adverse effect on the plant themselves or on any other non-target organisms. These reports contain information on plant height at crop maturity,

yield, maturity dates, inheritance and segregation data, protein toxin expression data, and its effects on both target and non-target organisms. All these agronomic traits fall well within the range of the nontransformed species. The only significant consistent difference between the insect resistant tomato line 5345 and the parent variety is the in the expression of the insect toxic protein Cry1Ac.

All field trials in the United States were performed under conditions of physical and reproductive confinement. Further discussions of the biology of tomato as well as of the genetic components of insect resistance tomato line 5345 are found in APHIS Determination of Nonregulated Status (Appendix A).

Prior to approving a notification for field release, APHIS analyzes the potential impacts associated with the proposed introduction with the help of environmental assessment (EA) prepared prior to the promulgation of the notification rules where potential environmental impacts are addressed in accordance with regulations and guidelines implementing the National Environmental Policy Act (NEPA), as amended (42 U.S.C. 4321 *et seq.*); 40 CFR Parts 1500-1508; 7 CFR Part 1b; 7 CFR Part 372. APHIS also evaluates the potential for significant impact to the human environment from its determination of nonregulated status.

A genetically engineered organism is considered a regulated article if the donor organism, recipient organism, vector or vector agent used in engineering the organism belongs to one of the taxa listed in the regulation and is also a plant pest, or if there is reason to believe that it is a plant pest. The transgenic tomato plants described in the Monsanto petition have been considered regulated articles because noncoding DNA regulatory sequences are derived from cauliflower mosaic virus, a plant pathogen, and because *Agrobacterium tumefaciens* was used as a vector agent.

III. PURPOSE AND NEED

The purpose of this EA is to ascertain whether the approval of a petition submitted to USDA/APHIS for the determination of nonregulated status of insect resistant tomato, which will allow the unconfined introduction of the article, will have a significant impact on the environment. A petition was submitted to APHIS pursuant to regulations codified in 7 CFR Part 340 entitled "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." The regulations govern the introduction (importation, interstate movement, or release into the environment) of certain genetically engineered organisms and products. An organism is not subject to the regulatory requirements of 7 CFR Part 340 when it is demonstrated not to present a plant pest risk. Section 340.6 of the regulations, entitled "Petition Process for Determination of Nonregulated Status," provides that a person may petition the Agency to evaluate submitted data and determine that a particular regulated article does not present a plant pest risk and should no longer be regulated. If the agency determines

that the regulated article does not present a risk of introduction or dissemination of a plant pest, the petition would be granted, thereby allowing for unregulated introduction of the article in question. Notifications under those regulations will no longer be required from APHIS for field testing, importation, or interstate movement of that article or its progeny. Normal agronomic practices with it, e.g., cultivation, propagation, movement, and cross-breeding could then be conducted without APHIS approval.

The Food and Drug Administration (FDA) has authority to ensure the safety and wholesomeness of all food(s). The FDA policy statement concerning the regulation of foods derived from new plant varieties, including genetically engineered plants, was published in the Federal Register on May 29, 1992 (57 FR 22984-23005). Regulatory oversight for the safety of any food or feed products derived from insect resistant tomato lines is under the jurisdiction of the FDA. Monsanto has indicated that they are in consultation with the FDA.

The Environmental Protection Agency (EPA) is responsible for the regulation of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended, (7 U.S.C. 136 *et seq.*). FIFRA requires that all pesticides, including insecticides, be registered prior to distribution or sale, unless exempt by EPA regulation. Under the Federal Food, Drug, and Cosmetic Act (FFDCA), as amended (21 U.S.C. 301 *et seq.*), pesticides added to (or contained in) raw agricultural commodities generally are considered to be unsafe unless a tolerance or exemption from tolerance has been established. Residue tolerances for pesticides are established by EPA under the FFDCA, and the FDA enforces the tolerances set by the EPA.

IV. ALTERNATIVES

In the course of preparing the environmental assessment for this petition, APHIS considered the following three alternatives: (1) deny the petition so that insect resistant tomato would continue to be regulated under 7 CFR Part 340; (2) approve the petition, with geographical limitations; and (3) approve the petition, so that permits would no longer be required from APHIS under 7 CFR Part 340 for insect resistant tomato when grown in the United States and its territories. Based on the biology of tomato, the nature of the genetic change, data and information presented by Monsanto, and scientific literature and comments from the public, APHIS could find no basis for denying the petition (Alternative 1), or for imposing geographical limitations on the use of insect resistant tomato (Alternative 2).

V. AFFECTED ENVIRONMENT AND POTENTIAL ENVIRONMENTAL IMPACTS

Potential impacts to be addressed in this EA are those that pertain to the use of insect resistant tomato line 5345 in the absence of confinement.

Potential impacts based on increased weediness of insect resistant tomato relative to traditionally bred tomatoes.

Almost all definitions of weediness stress as core attributes the undesirable nature of weeds from the point of view of humans; from this core, individual definitions differ in approach and emphasis (Baker, 1965; de Wet and Harlan, 1975; Muenscher, 1980). In further analysis of weediness, Baker (1965) listed 12 common weed attributes, almost all pertaining to sexual and asexual reproduction, which can be used as an imperfect guide to the likelihood that a plant will behave as a weed. Keeler (1989) and Tiedje et al. (1989) have adapted and analyzed Baker's list to develop admittedly imperfect guides to the weediness potential of transgenic plants; both authors emphasize the importance of looking at the parent plant and the nature of the specific genetic changes.

Despite its ability to potentially volunteer, escape from cultivated fields, and form temporary occasional populations, the parent plant in this petition, *Lycopersicon esculentum*, is not a weed under conditions found in the United States. *L. esculentum* is not listed as a weed in Weed Science Society of America (1989). The comprehensive world list of Holm et al. (1991) does not list it as a serious or principal weed anywhere in the world; Monsanto has submitted substantial evidence to indicate the lack of weedy nature of transformed tomatoes under agricultural conditions. They have submitted data on germination, seed production, pest and disease resistance, response to salinity and stress, seed dormancy, and sensitivity to target insects, and other fitness characteristics. None of these characteristics show an increase in weediness potential.

The insect resistance trait is unlikely to increase weediness of this tomato line because it confers pest resistance and does not alter reproductive biology or change any physiology related to survival, does not confer a competitive advantage favoring the tomato plants over unmodified varieties. To increase weediness of the tomato plant there would have to be distinct reproductive and seed dormancy advantage conferred on the insect resistant tomato line 5345.

Potential impacts from out crossing of insect resistant tomato line 5345 tomato to wild relatives

Tomato is an annual, day neutral crop, takes about-4-6 months from seed to fruit harvest. Commercially grown tomatoes are naturally self-pollinating (99%) (Rick, 1976). Tomatoes are not wind pollinated. The self pollinating nature of tomatoes has made them ideal candidates for pedigreed method of breeding high yielding tomato cultivars. *L. pimpinellifolium* (currant tomato) which is native to Ecuador and Peru is the only species with which cultivated tomato can interbreed by natural hybridization (Rick, 1976). "Currant" tomato is a weedy, short lived perennial plant that is not grown commercially. Any other kind of hybridization among members of *Solanaceae* is accomplished by manual pollination. In any event, hybrids from such crosses are sterile. All these factors clearly indicate that out crossing from tomatoes is minimal and non-existent, and there seems to be no chance of transferring the insect toxin gene to non-target plants.

Potential impact on nontarget organisms, including beneficial organisms such as bees and earthworms, and endangered or threatened species

There is no reason to believe that deleterious effects or significant impacts on nontarget organisms, including beneficial organisms and endangered or threatened species, would result from the cultivation of insect resistant tomato. Neither the Cry1Ac toxin protein nor the gene *Cry1Ac* that produces it is known to have any toxic properties against non-target organisms.

Consideration of potential environmental impacts associated with the cultivation of insect resistant tomato line 5345 outside the United States

APHIS has also considered potential environmental impacts outside the United States and its territories associated with the potential approval of this insect resistant tomato in the United States.

Several factors contribute to the conclusion that there should be no impacts abroad from cultivation of this tomato line or its progeny.

Any international traffic in tomatoes subject to this determination would be fully subject to national and regional phytosanitary standards promulgated under the International Plant Protection Convention (IPPC). The IPPC has set a standard for the reciprocal acceptance of phytosanitary certification among the nations that have signed or acceded to the Convention (105 countries as of October, 1996). The treaty, now administered by a Secretariat housed with the Food and Agriculture Organization in Rome, came into force on April 3, 1952, and establishes standards to facilitate the safe movement of plant materials across international boundaries. Plant biotechnology products are fully subject to national legislation and regulations, or regional standards and guidelines

promulgated under the IPPC. The vast majority of IPPC signatories have promulgated, and are now administering, such legislation or guidelines. The IPPC has also led to the creation of Regional Plant Protection Organizations (RPPOs) to facilitate regional harmonization of phytosanitary standards.

Issues that may relate to commercialization of particular agricultural commodities produced through biotechnology are being addressed in international forums. APHIS has played a role in working toward harmonization of biosafety and biotechnology guidelines and regulations included within the RPPO for our region, the North American Plant Protection Organization (NAPPO), which includes Mexico, Canada, and the United States. NAPPO's Biotechnology Panel advises NAPPO on biotechnology issues as they relate to plant protection.

APHIS participates regularly in biotechnology policy discussions at forums sponsored by the European Union and the Organization for Economic Cooperation and Development. In addition, APHIS periodically holds bilateral or quadrilateral discussions on biotechnology regulatory issues with other countries, most often Canada and Mexico. APHIS also acts as a consultant for the development of biotechnology guidelines and regulations, and has interacted with governments around the world in this manner, including those in regions where tomato originated or is cultivated in significant quantities (e.g., China, Japan, Korea, Association of South East Asian Nations member States, India, Pakistan, African States, and more). We have participated in numerous conferences intended to enhance international cooperation on safety in biotechnology, and sponsored several workshops on safeguards for planned introductions of transgenic crops (crucifers, maize, wheat, potatoes, rice, tomatoes) most of which have included consideration of international biosafety issues.

In the course of these wide-ranging studies and interactions, APHIS has not identified any impacts on the environment that might be relevant to insect resistant tomato from the unconfined cultivation of these tomato lines in the United States and its territories, or abroad. In addition to the assurance provided by the analysis leading APHIS to a finding of no significant impact for the introduction of this tomato, it should be noted that all the considerable, existing national and international regulatory authorities and phytosanitary regimes that currently apply to introductions of new tomato cultivars internationally apply equally to those covered by this determination.

Potential impacts on biodiversity.

Our analysis determined that genetically engineered insect resistant tomato line 5345 is no more likely to become weed than lines developed by traditional breeding techniques, is unlikely to increase the weediness potential of any other cultivated plant or native wild species with which it can interbreed, and will not harm threatened and endangered species and non-target organisms. Based on this analysis, APHIS concludes that there is no potential impact of this line on biodiversity.

Potential impacts on agricultural and cultivation practices.

Based on APHIS analysis, there is unlikely to be any significant adverse impact on agricultural practices associated with the use of this line.

Potential damage to raw or processed agricultural commodities.

An analysis of the components and processing characteristics of this line reveals no differences in any component that could have an indirect plant pest effect on any raw or processed plant commodity.

VI. CONCLUSIONS

In accordance with the requirements of NEPA, APHIS has considered the potential for significant impact on the environment of a proposed action, i.e, reaching the determination that insect resistant tomato line 5345 or its progeny present plant pest risk and should no longer be considered a regulated article under the regulations at 7 CFR Part 340. After careful analysis of the available information, APHIS concludes that its proposed action will not have a significant impact on the environment, and that the proper alternative is to approve the petition. This conclusion is based on factors discussed herein or in the determination included as appendix A, as well as the following conclusions:

1. A gene *Cry1Ac* from *Bacillus thuringiensis* subsp. *kurstaki* has been inserted into the genome of tomato to confer resistance to certain lepidopteran insect pests. In nature, chromosomal genetic material from plants can only be transferred to another sexually compatible flowering plant by cross-pollination. Neither the gene that results in accumulation of the insect toxin, nor the gene itself, nor its associated regulatory sequences, confers on insect resistant tomato line 5345 or its progeny any plant pest characteristic.

2. In nature, the gene that results in accumulation of the insect toxin protein will not provide insect resistant tomato line 5345 or its progeny with any measurable selective advantage over nontransformed tomato plants in their ability to disseminate or to become established in the environment. There is no reason to believe that insect resistant tomatoes exhibit any increased weediness relative to that of traditional varieties.

3. The use of insect resistant tomato line 5345 or its progeny in agriculture will not lead to an increase in weediness in any plant with which it can successfully interbreed.

4. The use of insect resistant tomato line 5345 or its progeny in agriculture will not cause damage to raw or processed agricultural commodities.

5. The use of insect resistant tomato line 5345 or its progeny in agriculture will not have a significant impact on any beneficial organisms in the environment, or on any threatened or endangered species.

VII. LITERATURE CITED

Baker, H. G. 1965. Characteristics and Modes of Origin of Weeds. In: The Genetics of Colonizing Species. pp. 147-172. Baker, H. G., Stebbins, G. L. (eds.). Academic Press, New York and London.

Bailey, L. H. 1949. Manual of Cultivated Plants. Macmillan Publishing Company, New York. 1116 pp.

de Wet, J. M. J., Harlan, J. R. 1975. Weeds and Domesticates: Evolution in the Man-Made Habitat. Economic Botany. 29:99-107.

Holm, L., Pancho, J. V., Herbarger, J. P., Plucknett, D. L. 1979. A Geographical Atlas of World Weeds. John Wiley and Sons, New York. 391 pp.

Keeler, K. 1989. Can genetically engineered crops become weeds? Bio/Technology 7:1134-1139.

Muenscher, W. C. 1980. Weeds. Second Edition. Cornell University Press, Ithaca and London. 586 pp.

Office of Technology Assessment, United States Congress. 1988. New Developments in Biotechnology-- 3. Field-Testing Engineered Organisms: Genetic and Ecological Issues. U.S. Government Printing Office, Washington, DC. 150 pp.

Rick, C. M. 1976. Tomato. In Evolution of Crop Plants. N. W. Simmonds, ed. Longman, N.Y. pp.268-272.

Rick, C. M. 1978. The Tomato. Sci. Amer. 239:76-87.

Tiedje, J. M., Colwell, R. K., Grossman, Y. L., Hodson, R. E., Lenski, R. E., Mack, R. N., Regal, P. J. 1989. The Planned Introduction of Genetically Engineered Organisms: Ecological Considerations and Recommendations. Ecology 70:298-315.

Weed Science Society of America. 1989. Composite List of Weeds. WSSA. Champaign, Illinois.

VIII. REVIEWERS

Biotechnology and Biological Analysis

Rebecca Bech, Assistant Director
Subhash Gupta, Ph.D., Biotechnologist
David S. Heron, Ph.D., Biotechnologist
Susan Koehler, Ph.D., Biotechnologist
James Lackey, Ph.D., Biological Safety Officer (Reviewer)
Vedpal Malik, Ph.D., Biotechnologist (Reviewer)
Sivramiah Shantharam, Ph.D., Team Leader, (Principal Reviewer)
James L. White, Ph.D., Team Leader, Plants Branch
Shirley Ingebritsen (Reviewer)

IX. AGENCY CONTACT

Ms. Kay Peterson, Regulatory Analyst
Biotechnology and Scientific Services
USDA, APHIS, BSS
4700 River Road, Unit 147
Riverdale, MD 20737-1237

Phone: (301) 734-7612
Fax: (301) 734-8669

RESPONSE TO MONSANTO PETITION 97-287-01p FOR DETERMINATION OF NONREGULATED STATUS OF INSECT RESISTANT TOMATO LINE 5345

March 1998

Prepared by
United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Scientific Services

TABLE OF CONTENTS

I. SUMMARY

The Animal and Plant Health Inspection Service (APHIS) has determined, based on a review of scientific data and information that transgenic insect resistant tomato line 5345 (*Lycopersicon esculentum* L.) derived by introducing the endotoxin gene *Cry1Ac* cloned from *Bacillus thuringinesis* subsp. *kurstaki*, and any progeny derived from it do not present any plant pest risk, and therefore are longer considered regulated articles under 7 CFR Part 340. As a result of this determination, approval under those regulations will no longer be required from APHIS for planting, importation, or interstate movement of the above mentioned insect resistant tomato line 5345 or its progeny. Importation of insect resistant tomato line 5345 and its derivatives, and nursery stock or seeds capable of propagation are still subject to restrictions found in the Foreign Quarantine Notice regulations at 7 CFR Part 319. Variety registration and/or seed certification for individual insect resistant tomato line 5345 and its derivatives may involve future actions by the U.S. Plant Variety Protection Office and State Seed Certification officials.

The APHIS determination has been made in response to a petition from Monsanto Company, St. Louis, Missouri, dated October 14, 1997. The petition seeks a determination from APHIS that insect resistant tomato line 5345 and its progeny do not present a plant pest risk and are therefore no longer regulated articles. On November 28, 1997, APHIS announced receipt of the Monsanto petition in the Federal Register (62 FR 63312-63313) and stated that the petition was available for public review. APHIS also indicated its role, as well as those of the Food and Drug Administration (FDA) and Environmental Protection Agency (EPA), in regulation of insect resistant tomato, and food products derived from it. APHIS invited written comments on whether insect resistant tomato line 5345 and its progeny poses a plant pest risk, to be submitted on or before January 27, 1998. Two comments were received.

Insect resistant tomato line 5345 has been described by Monsanto as any *L. esculentum* cultivar or progeny resulting from it. 5345 line of tomato has a stably integrated gene *Cry1Ac* from *B. thuringiensis* subsp. *kurstaki*, which encodes the insecticidal toxin protein (delta-endotoxin) (Cry1Ac), with 35S promoter and terminator from cauliflower mosaic virus. The Cry1Ac toxin protein is active against certain lepidopteran insect pests of tomato such as tomato caterpillar, tomato pinworm, tomato fruitworm, tomato hornworm, potato tuber moth, and cabbage looper. The toxin protein is active in the insect larval stage by disrupting its stomach linings.

APHIS regulations 7 CFR Part 340, promulgated pursuant to authority granted by the Federal Plant Pest Act (FPPA), (7 U.S.C. 150aa-150jj) as amended, and the Plant Quarantine Act (PQA), (7 U.S.C. 151-164a, 166-167) as amended, regulate the introduction (importation, interstate movement, or release into the environment) of certain genetically engineered organisms and products. An organism is not subject to the regulatory requirements of Part 340 when it is demonstrated not to present a plant

pest risk. Section 340.6 of the regulations, entitled "Petition Process for Determination of Nonregulated Status", provides that a person may petition the Agency to evaluate submitted data and or any other relevant information, and determine that a regulated article in question does not present a plant pest risk, and therefore should no longer be regulated. If the agency determines that the regulated article does not present a risk of introduction or dissemination of a plant pest, the petition would be granted that would allow for introduction of the regulated article (organisms) in question without permits or notifications under 7 CFR Part 340. In this instance, they are insect resistant tomato line 5345.

Insect resistant tomato line 5345 has been considered a "regulated article" because it contains noncoding DNA regulatory sequences derived from cauliflower mosaic virus, a plant pathogen, and because *Agrobacterium tumefaciens* was used as a vector agent.

Field testing of insect resistanct tomato has been conducted with APHIS approval from 1994 through to 1997. Monsanto submitted its petition after the completion of field tests of insect resistant tomato at 29 sites in the major growing states. All field trials were performed under conditions of physical and reproductive confinement.

APHIS has determined that the insect resistant tomato identified in the petition does not present a plant pest risk, and therefore, will no longer be considered a regulated article under APHIS regulations at 7 CFR Part 340. The Agency decision is based on an analysis of data provided to APHIS by Monsanto as well as other scientific data relating to the potential plant pest risk of insect resistant tomato. Monsanto provided both general and specific information and data from field testing of insect resistant tomato. We have determined that insect resistant tomato: (1) exhibits no plant pathogenic properties; (2) is no more likely to become a weed than its non-engineered parental varieties; (3) is unlikely to increase the weediness potential of any other cultivated plant or native wild species with which they can breed; (4) will not cause damage to raw or processed agricultural commodities; and (5) is unlikely to harm other organisms, such as threatened or endangered species, or bees and earthworms that are beneficial to agriculture. APHIS has also concluded that there is a reasonable certainty that new progeny varieties bred from insect resistant tomato will not exhibit new plant pest properties, i.e., properties substantially different from any observed for the field tested insect resistant tomato, or those observed for tomato in traditional breeding programs.

The potential environmental impacts associated with this determination have been examined in accordance with regulations and guidelines implementing the National Environmental Policy Act (NEPA), as amended (42 U.S.C. 4321 *et seq.*); 40 CFR Parts 1500-1508; 7 CFR Part 1b; 7 CFR Part 372. An Environmental Assessment (EA) was prepared and a Finding of No Significant Impact (FONSI) was reached by APHIS for the determination that insect resistant tomato is no longer a regulated article under its regulations at 7 CFR Part 340. The EA and FONSI are available from APHIS upon written request.

This document consists of two parts: (1) background information which provides the regulatory framework under which APHIS has regulated the field testing, interstate movement, and importation of insect resistant tomato; and (2) analysis of the key factors relevant to the APHIS decision that insect resistant tomato does not present a plant pest risk.

II. BACKGROUND

USDA Regulatory Authority. APHIS regulations, which were promulgated pursuant to authority granted by the Federal Plant Pest Act (FPPA), (7 U.S.C. 150aa-150jj) as amended, and the Plant Quarantine Act (PQA), (7 U.S.C. 151-164a, 166-167) as amended, regulate the introduction (importation, interstate movement, or release into the environment) of certain genetically engineered organisms and products. A genetically engineered organism is deemed a regulated article either if the donor organism, recipient organism, vector or vector agent used in engineering the organism belongs to one of the taxa listed in § 340.2 of the regulations and is also a plant pest; if it is unclassified; or if APHIS has reason to believe that the genetically engineered organism presents a plant pest risk.

Prior to the introduction of a regulated article, a person is required under § 340.1 of the regulations to either (1) notify APHIS in accordance with § 340.3 or (2) obtain a permit in accordance with § 340.4. Introduction under notification (§ 340.3) requires that the introduction meets specified eligibility criteria and performance standards. The eligibility criteria impose limitations on the types of genetic modifications that qualify for notification, and the performance standards impose limitations on how the introduction may be conducted. Under § 340.4, a permit is granted for a field trial when APHIS has determined that the conduct of the field trial, under the conditions specified by the applicant and/or stipulated by APHIS, does not pose a plant pest risk.

The FPPA gives USDA authority to regulate plant pests and other articles to prevent direct or indirect injury, disease, or damage to plants, plant products, and crops. The PQA provides an additional level of protection by enabling USDA to regulate the importation and movement of nursery stock and other plants which may harbor injurious pests or diseases, and requires that they be grown under certain conditions after importation. For certain genetically engineered organisms, field testing may be required to verify that they exhibit the expected biological properties, and to demonstrate that although derived using components from plant pests, they do not possess plant pest characteristics.

An organism is no longer subject to the regulatory requirements of 7 CFR Part 340 when it is demonstrated not to present a plant pest risk. Section 340.6 of the regulations, entitled "Petition Process for Determination of Nonregulated Status", provides that a person may petition the Agency to evaluate submitted data and

determine that a particular regulated article does not present a plant pest risk and should no longer be regulated. If the agency determines that the regulated article does not present a risk of introduction or dissemination of a plant pest, the petition may be granted. A petition may be granted in whole or in part.

Insect resistant tomato was considered a "regulated article" because it contains noncoding DNA regulatory sequences derived from cauliflower mosaic virus, a plant pathogen, and because *Agrobacterium tumefaciens* was used as a vector agent.

APHIS believes it prudent to provide assurance prior to commercialization that organisms, such as insect resistant tomato developed in part from plant pest sequences, do not pose any potential plant pest risk. Such assurance may aid the entry of new plant varieties into commerce or into breeding and development programs. The decision by APHIS that insect resistant tomato is no longer a regulated article is based in part on evidence provided by Monsanto concerning the biological properties of the insect resistant tomato, and its similarity to other varieties of tomato grown using standard agricultural practices for commercial sale or private use. Insect resistant tomato does not cause undue adverse effects on the environment as a result of these releases.

The fact that APHIS regulates genetically engineered organisms having plant pest components does not carry with it the presumption that the presence of part of a plant pest makes a whole plant pest or that plants or genes are pathogenic. The regulations are based on the premise that when plants are developed using biological vectors from pathogenic sources, transforming material from pathogenic sources, or pathogens are used as yector agents, that they should be evaluated to assure that there is not a plant pest risk. For each release permit application APHIS performs a review that allows a verification of the biology and procedures used; assesses the degree of uncertainty and familiarity; evaluate mitigating factors and agricultural practices of the crop in question and allows the identification of any predictable hazards. The overall aims of APHIS regulations in the Code of Federal Regulations at 7 CFR Part 340 are to allow for the safe testing of genetically engineered organisms under an appropriate level of oversight, and to enable any issues of potential or hypothetical risks to be addressed early enough in the development of the new organisms to allow for the safe use and application of biotechnology in agriculture.

A certification that an organism does not present a plant pest risk means that there is reasonable certainty that the organism cannot directly or indirectly cause disease, injury, or damage either when grown in the field, or when stored, sold, or processed. This approach is considerably broader than a narrow definition of plant pest risk arising from microbial or animal pathogens, including insect pests. Other traits, such as increased weediness, and harmful effects on beneficial organisms, such as earthworms and bees, are clearly subsumed within what is meant by direct or indirect plant pest risk. In APHIS regulations at 7 CFR Part 340, a "plant pest" is defined as: "Any living stage (including active and dormant forms) of insects, mites, nematodes, slugs, snails,

protozoa, or other invertebrate animals, bacteria, fungi, other parasitic plants or reproductive parts thereof; viruses; or any organisms similar to or allied with any of the foregoing; or any infectious agents or substances, which can directly or indirectly injure or cause disease or damage in or to any plants or parts thereof, or any processed, manufactured, or other products of plants."

Lack of plant pest risk may be arrived at when there is evidence that the plant under consideration: (1) exhibits no plant pathogenic properties; (2) is no more likely to become a weed than its non-engineered parental varieties; (3) is unlikely to increase the weediness potential for any other cultivated plant or native wild species with which the organism can interbreed; (4) does not cause damage to processed agricultural commodities; and (5) is unlikely to harm other organisms, such as bees, that are beneficial to agriculture. In addition, because the Monsanto petition seeks a determination regarding insect resistant tomato, it should be established that there is a reasonable certainty that any new insect resistant tomato varieties bred from this insect resistant tomato will exhibit plant pest properties not different from any observed for tomato in traditional breeding programs or as seen in the development of insect resistant tomato.

Oversight by Other Federal Agencies. The EPA regulates the use of pesticide chemicals, including herbicides, in the environment. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, (7 U.S.C. 136 et seq.), EPA has the authority to regulate the testing, sale, distribution, use, storage, and disposal of pesticides. Before a pesticide may be sold, distributed, or used in the United States, it must be registered under FIFRA Section 3. For a pesticide that is already registered, the use of the pesticide on a new crop plant (i.e., use on a crop for which the pesticide is not already registered) requires EPA approval of an amendment to the registration. In determining whether to approve the new use of the pesticide, EPA considers the possibility of adverse effects to human health and the environment from the new use. Under the Federal Food, Drug and Cosmetic Act (FFDCA), as amended, (21 U.S.C. 201 et seq.), EPA also has responsibility for establishing tolerances for pesticide residues on food or feed. EPA has granted exemptions from the requirement of tolerances for residues of the Cry1A(c) and NPTII proteins and the genetic material necessary for their production in all plants.

The FFDCA provides FDA with authority to ensure the safety and wholesomeness of all food(s). FDA policy statement concerning the regulation of foods derived from new plant varieties, including genetically engineered plants, was published in the Federal Register on May 29, 1992 (57 FR 22984-23005). Regulatory oversight for the safety of any food or feed products derived from insect resistant tomato is under the jurisdiction of the FDA. Monsanto has indicated that they are in consultation with the FDA.

III. ANALYSIS OF THE PROPERTIES OF INSECT RESISTANT TOMATO

A brief description of the biology of tomato and tomato cultivation practices is expected to be helpful in specific environmental and biosafety issues applicable to insect resistant tomato. In addition, to reach its determination that insect resistant tomato does not present a plant pest risk, APHIS has analyzed basic information on the biology of tomato but also data presented by Monsanto and scientific data on other topics relevant to a discussion of plant pest risk. Based on the data, APHIS has arrived at a series of conclusions regarding the properties of insect resistant tomato.

Biology and Cultivation of Tomato.

L. esculentum L., the cultivated tomato originated in Latin America (Mexico) and domesticated by the natives in pre-Cambrian times (Jenkins, 1948; Rick, 1976). This is evidenced by large similarities between the wild tomato variety of Mexico *L. esculentum* var. *cerasiforme*. Tomato was introduced into the United States from Europe (Rick, 1978).

Tomato is a member of the family *Solananceae* and is widely distributed in the Andean region of Peru, Chile, and South America. Genus *Lycopersicon* is divided into two subgenera: *Eulycopersicon* and *Eripersicon*. Fruits of the former subgenus are big and red at maturity while that of the latter are small and green at maturity. The present day cultivated tomato belongs to the subgenus *Eulycopersicon*. Other members of *Eulycopersicon* like *E. pimpinellifolium* and *L. cheesmanii* occur in the coastal regions of Peru and Ecuador as wild populations. *L. cheesmanii* is endemic to Galapagos islands off Ecuador and has never been reported to from any other part of the world (Rick and Forbes, 1975a). *L. cerasiforme* occur as weeds in Africa and Southeast Asia.

Tomato is diploid and contains 12 pairs of chromosomes. The genetics of tomato is extremely well characterized. Its genomic map is perhaps the best studied among crop plants with about 200 morphological and 1000 molecular markers having been identified (Tanksley, 1993). Numerous cytogenetics stocks have been developed for tomato, including a full set of trisomics, which has greatly facilitated the study genetics and cytogenetics of this species.

Sexual Reproduction and Inter-specific Crosses in Tomato.

Tomato is a 99% self pollinating crop under field conditions in the United States. Because of this reason, tomato is the ideal pedigreed crop for breeding programs. Tomato is an annual, day neutral crop that grows in temperate climates. Through repeated back crossings homozygous lines are derived. Tomato pollen is binucleate and can be stored for up to 6 months under low temperature and humidity. Occasional cross-pollination is attributed to bees.

All the fruit bearing esculentums are naturally self pollinating, but are sexually compatible with each other. Hybrids are derived only through manual crossing. The hybrids are fertile. *L. pimpinellifolium* is the source of disease resistance genes and other agronomic importance in tomato breeding programs.

The green fruited lycopersicons are distantly related to tomato, mostly self incompatible, and occur as variable populations in the coastal regions of Peru, Chile, and Ecuador. These are not found in any other part of the world. Hybrids can be obtained by manual crossing with red tomatoes although in some instances embryo rescue is also used. Interspecific hybrids are robust and demonstrate varying levels of fertility. Sterility is common in these hybrids which serves as a barrier to gen flow among interspecific hybrids. Genus *Solanum* and genus *Lycopersicon* are not sexually compatible at all. Rare crosses obtained between the two are highly sterile.

Neither the introduced genes, and their products, nor the added regulatory sequences controlling their expression presents a plant pest risk in insect resistant tomato.

The standard recombinant DNA technology to introduce the genes into plant cells (transformation) uses a recombinant plasmid (vector) molecule which is complex chimera of DNA sequences drawn from various organisms. Some of these organisms from which these DNA sequences are derived are known plant pests, and as such the transgenic crop plants or organisms become regulated articles under 7 CFR 340.

The introduction of the vector DNA does not present a plant pest risk in insect resistant tomato identified in the present petition. The vector system used to transfer the *Cry1Ac* gene into the tomato nuclear genome, does not contain any disease causing sequences from the native tumor-inducing (Ti) plasmid system used by the plant pathogenic bacterium *Agrobacterium tumefaciens* for plant infection and gene transfer (Zambryski, 1992). Additionally, there are DNA sequences derived from cauliflower mosaic virus, a plant pathogen that is on the list of regulated articles in 7 CFR Part 340. In addition, two marker genes *nptII* and *aad* are also incorporated into the tomato line 5345. Only the gene *nptII* that codes for the enzyme neomycin phosphotransferase that detoxifies the antibiotic (drug) kanamycin is expressed in the plants. Since *aad* coding for streptomycin/spectinomycin resistance is under the influence of a bacterial promoter, it is not expressed in plants. None of these marker genes code for any plant pest property, and as such are of no consequences.

A. tumefaciens is the causal agent of a plant disease called crown gall, and *A. rhizogenes* causes hairy root disease. In insect resistant tomato, none of the introduced coding regions or the regulatory sequences confer any plant pest risk. The vector system was used as a part of transformation method known as agro-infection that involves incubating the hypocotyl explants from 7 day old seedlings of tomato with *A. tumefaciens* containing a binary vector to accomplish the stable gene transfer.

Monsanto states that the *Cry1Ac* gene in insect resistant tomato is transmitted through meiosis in a Mendelian fashion.

Monsanto analyzed the physical structure of the integrated genetic material in insect resistant tomato. Southern analyses demonstrate that there is a single copy of the *Cry1Ac* gene, and that it is transmitted to offspring in a stable Mendelian manner.

Despite the presence of certain pathogen-derived sequences in the insect resistant tomato genome, no crown gall, hairy root or CaMV disease symptoms were observed by Monsanto under the field conditions. Furthermore, Monsanto provides evidence that expression of the introduced gene does not result in disease symptoms or the synthesis of products toxic to other organisms other than the target insect pests of tomato. Monsanto monitored the insect resistant tomato field trials to verify that the severity of any disease or insect infestation of the transgenic plants and found that they did not differ from that of the parental line. No difference in disease and insect susceptibility other than the target insect pests was observed at the sites where insect resistant tomato was tested.

Insect resistant tomato is neither a weed nor have any significant potential to become a weed, and do not transmit weedy characteristics to sexually compatible plants.

Weediness can be broadly defined as any capacity for invasion of natural habitats (Baker, 1965; Bailey, 1949). Tomato is not a weed in the United States and there are no weedy relatives of tomato in the United States (Holm *et al* 1979; Reed, 1970; Muenscher, 1980; Munz, 1968). The insect resistance trait engineered into the tomato line 5345 does not confer any weedy characteristic to the plants in question. Since the cultivated tomato is a self-pollinating plant and no out crosses can take place without human intervention, there is no chance for transmitting the introduced gene from the engineered tomato line 5345. As such there is no potential for the insect resistant tomato to either become a weed or transit weedy characteristics to other plants. Weediness may be affected by seed dormancy and seed persistence. Field trials do not show any difference between the transgenic plants and nontransgenic plants.

Insect Resistant Tomato will not cause damage to agricultural commodities.

Cultivated inbred lines of tomato have extremely low levels of toxicants. Monsanto has been in direct consultation with the Food and Drug Administration (FDA) to assure that insect resistant tomatoes are safe for human and animal consumption in. The Cry1Ac toxin poses no safety concern to other beneficial insects, mammals, and humans. The NPTII enzyme has lso been found to be safe for human consumption by FDA in 1994.

Information provided by Monsanto regarding the components and processing characteristics of insect resistant tomato revealed no differences in any component that

could have a direct or indirect plant pest effect on any processed commodity.

Insect Resistant Tomato will not be harmful to endangered or threatened species or beneficial organisms, including bees.

There is no reason to believe that deleterious effects on beneficial organisms could result from the cultivation of insect resistant tomato. Monsanto has provided sufficient information and data regarding the non-toxicity of Cry1Ac against non-target insects including the beneficials, nematodes, mammals, and humans. Results of trials in the United States do not reveal any noticeable adverse effects on beneficial organisms. APHIS has not identified any other potential mechanisms for deleterious effects on beneficial organisms, and endangered or threatened organisms.

IV. PUBLIC COMMENTS.

APHIS received two negative public comments on this petition. The two comments are from consumer policy organizations. The basic argument of these two negative comments is that the insect pest resistance management strategies articulated by the petitioner are inadequate based on recently published information in scientific journals. However, APHIS regulatory authority is based on assessment of plant pest risk. EPA is the lead agency dealing with the issue of pest resistance management vis-a-vis transgenic insect resistant plants. EPA has set up a pest resistance management working group to tackle the issue. APHIS is working with EPA to examine all the issues surrounding the pest resistance management issue, and extensive scientific consultations in publiç fora are being pursued to proceed cautiously toward the registration of the regulated article under Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

V. CONCLUSIONS

APHIS has determined that insect resistant tomato line 5345 will no longer be considered a regulated article under APHIS regulations at 7 CFR Part 340. Permits or notifications under those regulations will no longer be required from APHIS for field testing, importation, or interstate movement of insect resistant tomato 5345 or its progeny. Importation of insect resistant tomato, and nursery stock or seeds capable of propagation, is still, however, subject to the restrictions found in the Foreign Quarantine Notice regulations at 7 CFR Part 319. This determination has been made based on an analysis which revealed that the insect resistant tomato: (1) exhibits no plant pathogenic properties; (2) is no more likely to become a weed than its non-engineered parental variety; (3) is unlikely to increase the weediness potential for any other cultivated plant or native wild species with which the organisms can interbreed; (4) will not cause damage to raw or processed agricultural commodities; and (5) is unlikely to harm endangered or threatened species or other organisms, such as bees, that are beneficial to agriculture. APHIS has also concluded that there is a reasonable certainty that new progeny varieties bred from insect resistant tomato will not exhibit new plant pest properties, i.e., properties substantially different from any observed for the field tested insect resistant tomato, or those observed for standard tomato in traditional breeding programs.

Rebecca Bech
Assistant Director
Scientific Services
USDA, APHIS, PPQ
Date: MAR 2 3 2000

VI. REFERENCES

Baker, H. G. 1965. Characteristics and Modes of Origin of Weeds. In: The Genetics of Colonizing Species. pp. 147-172. Baker, H. G., Stebbins, G. L. (Eds.). Academic Press, New York and London.

Bailey, L. H. 1949. Manual of Cultivated Plants. Macmillan Publishing Company, New York. 1116 pp.

Holm, L., Pancho, J. V., Herbarger, J. P., Plucknett, D. L. 1979. A Geographical Atlas of World Weeds. John Wiley and Sons, New York. 391 pp.

Jenkins, J. A. 1948. The origin of the cultivated tomato. Eco. Bot. 2: 379-392.

Muenscher, W. C. 1980. Weeds. Second Edition. Cornell University Press, Ithaca and London. 586 pp.

Munz, P. A. 1968. A California Flora. University of California Press, Berkeley and Los Angeles. 1681 pp.

Reed, C. F. 1970. Selected Weeds of the United States. Agriculture Handbook No. 366. Agricultural Research Service, United States Department of Agriculture, Washington, D.C. 463 pp.

Rick, C. M. 1976. Tomato. In Evolution of Crop Plants. N. W. Sommonds. (Ed.) Longman, New York. pp. 268-272.

Rick, C. M. 1978. The Tomato. Sci. Amer. 239; 76-87.

Rick, C. M., Fobes, J. F. 1975. Allozymes of Galapagos Tomatoes: plymorphism, geographic distribution, and affinities. Evolution 29: 443-457.

Tanksley, S. D. 1993. Linkage map of Tomato *Lycopersicon esculentum* L. In: Genetic Maps. S. O'Brein (Ed.). Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. pp. 6.39-6.60.

Zambryski, P. 1992. Chronicles from the *Agrobacterium*-plant cell DNA transfer story. Ann. Rev. Genet. 43: 465-490.