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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Description of Glyphosate Use in the U.S. as a Basis for Comparison to Glyphosate Use in Colombia for Coca Eradication [DP Barcode - not assigned]

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BEAD PEER REVIEW: June 26, 2002

INTRODUCTION: The Biological and Economic Analysis Division in the Office of Pesticide Programs within the Environmental Protection Agency has been asked to describe the use of glyphosate within the United States with a more detailed description of its use in forestry sites so that methods of use in the United States may be used as a basis for comparison to those used for coca eradication in Colombia (1).

SUMMARY: Glyphosate is the herbicide most widely used in the United States¹(2). In agriculture this popularity is due, in large part, to the development of crops that are highly tolerant to broadcast applications of glyphosate which allows growers to use this non-selective herbicide as their principal

¹EPA's (BEAD's) biannual pesticide sales and usage report estimates that in 1999, glyphosate was the most used conventional pesticide in the U.S. (83 to 95 million pounds of glyphosate applied) in all markets. It was second behind atrazine in the agricultural market (67 to 73 million pounds of glyphosate applied); and second behind 2,4-D in the non-agricultural market (16-22 million pounds of glyphosate applied). In the agricultural market, data for 2000 and 2001 suggest that the usage of glyphosate has increased to as much as 100 million pounds. Data is not yet available for 2000 and 2001 for the non-agricultural market.

method of weed control in certain crops. Growers have rapidly adopted glyphosate-based weed control programs with glyphosate tolerant crops because they are simple and economical (3). In addition, due to its unique properties, glyphosate is also widely used for non-agricultural weed control situations including home lawns and gardens, forestry and other non-crop sites where total vegetation control is desired.

Glyphosate must be applied to the target plant's foliage to be effective. Glyphosate is non-selective in action, controlling a wide variety of plants. Once absorbed, it circulates to untreated portions of the plant; and it has no residual activity after contact with soil. Glyphosate may be applied using hand-held, ground-driven or aerial equipment; the choice of equipment is determined by the site to be treated. Although higher rates of application are allowed, actual rates per application in agricultural sites average less than 0.75 pounds of the active ingredient glyphosate per acre (Table One). For the non-agricultural site, forestry, use is allowed at rates per application ranging from 2 to 10 pounds per acre (2.2 to 11.2 kilograms of active ingredient/hectare) of glyphosate in the form of the isopropylamine salt (6). This rate of use may also be expressed as 1.5 to 7.5 pounds per acre of acid equivalent (pure glyphosate acid; not a salt). A more detailed discussion of the use of glyphosate in the U.S. follows.

USE OF GLYPHOSATE IN THE UNITED STATES: Products containing glyphosate are registered with the U.S. Environmental Protection Agency, which means they may legally be used within the United States if used in accordance with label instructions.

Glyphosate may be used on over 400 crop and non-crop sites. The largest agricultural use sites include soybeans, cotton and field corn. The following table summarizes estimates of the use of glyphosate in three primary agricultural use sites.

Table One. 2000 Glyphosate Use in U.S. Agriculture: In Total and for the Three Major Use Sites

Site	Acres Grown (million acres)	Base Acres Treated (million acres) ¹	Percent of Crop Treated ²	Total Acres Treated (million acres) ³	Pounds Applied (million lbs ai)	Avg. Number of Apps	Avg. Application Rate (lbs ai/acre/app)
All Ag. Sites	-	-	-	102.7	73.5	-	-
Corn	73.8	6.6	9%	7.3	4.4	1.1	0.59
Cotton	14.4	8.1	56%	13.8	9.5	1.7	0.67
Soybeans	71.0	44.0	62%	57.2	41.8	1.3	0.68

Source: USDA, National Agricultural Statistics Service (NASS) 2000 field crop chemical use (May, 2001), and EPA proprietary data.

1. Base acres treated = acres treated 1 or more times with glyphosate.

2. Percent of crop treated = base acres treated with glyphosate divided by acres grown.

3. Total acres treated = base acres treated with glyphosate multiplied by the average number of applications of glyphosate.

In addition to agricultural use, EPA estimates that 16-22 million pounds of the technical grade active ingredient were applied to non-agricultural sites in 1999 (this is the most recent year for which adequate data are available). This estimate includes both home owner and professional applications as well as use on forested lands (11). Based on EPA data for 1999, an estimated 1-2 million pounds of glyphosate was applied to forest acres, with more than 650,000 forest acres treated.

AGRICULTURAL USES: In certain annual crops, glyphosate may be applied before planting (preplant) to control existing weeds; often replacing tillage as a weed control measure in “no-till” crop culture systems designed for reducing soil erosion. However, most of the glyphosate currently used in agricultural sites is used in a cropping system employing crop varieties that have been developed to be resistant to glyphosate so that glyphosate may be applied “over-the-top” of the resistant crop to kill susceptible weeds. The most prevalent of these systems is the Round-up Ready Soybean® system. These soybeans, which are highly tolerant to glyphosate, were marketed starting in 1996. Since then this system has been widely and rapidly adopted; in 1990-1991, glyphosate ranked 11th among conventional pesticides used in the U.S. with annual use estimated to be 18.7 million pounds (4). In 2000, glyphosate was the most widely used herbicide in soybeans; nearly 42 million pounds of glyphosate were applied to soybeans alone (2) with over 60 percent of soybeans surveyed by USDA’s National Agricultural Statistical Service treated with glyphosate (5). Round-up®, a glyphosate product marketed for agricultural use, is formulated with a surfactant during manufacture to facilitate foliar absorption. The following table (Table Two) summarizes the use rates specified in label instructions for Roundup Original™ product herbicide concentrate (12) which contains the isopropylamine salt of glyphosate for use in glyphosate-tolerant soybeans.

Table Two. Allowed Rate of the Isopropylamine Salt of Glyphosate Per Application In Tolerant Soybeans

Maximum for Application Timing	Quarts of Product/Acre	Pounds of Active Ingredient/Acre	Kilograms of Active Ingredient/Hectare
For Entire Season	8	8	9
Before Crop Emergence	5	5	5.6
In Crop	3	3	3.4
Up to Two Weeks Prior to Harvest	1	1	1.1

NON-AGRICULTURAL USES INCLUDING FORESTRY: BEAD has been asked to describe the use of glyphosate in U.S. forestry sites since that use most closely corresponds to the use of glyphosate in Colombia for coca control. For simplicity this document only refers to Accord® which is intended specifically for forestry use (6). This product contains the isopropylamine salt of glyphosate (41.5%), and is labeled for non-agricultural uses including Forestry Site Preparation and Utility Rights-of Way, Forestry Site Conifer and Hardwood Release, and Wetland Sites in the U.S.. Table Three describes the rates at which it may be used. It is recommended for use in site preparation prior to planting any tree species, including Christmas tree and silvicultural nursery sites (7). Specific

methods of application for forestry uses include: aerial spraying; spraying from a truck, backpack or hand-held sprayer; wipe application; frill treatment; cut stump treatment (7).

For forestry site preparation it may be applied using either ground or aerial equipment at rates from 2 to 10 pounds of isopropylamine salt of glyphosate active ingredient per acre which is equivalent to 2.2-11.2 kilograms of active ingredient per hectare (Table Three). It may also be applied using hand-held equipment. Product instructions specify that a non-ionic surfactant be added to the spray mixture for all forestry uses at a rate of 0.5 to 1.5 percent by spray volume (2 to 6 quarts of surfactant per 100 gallons of spray solution). It may also be combined with certain residual herbicides to extend the period of weed control beyond that obtained with glyphosate alone.

The isopropylamine salt of glyphosate may also be used in forestry conifer and hardwood release as a directed spray or by using selective equipment. This product may also be used in or around wetland sites generally at no more than 5 quarts of product per acre (5 lbs isopropylamine salt of glyphosate per acre which is equal to 5.6 kg/ha) using over-water broadcast application (6).

Table Three. Rate of the Isopropylamine Salt of Glyphosate Per Application For Certain Use Sites

Use Site	Quarts of Product/Acre	Pounds of Active Ingredient/Acre	Kilograms of Active Ingredient/Hectare
Forestry Site Preparation and Utility Rights-of Way	2-10	2-10	2.2-11.2
Forestry Site Conifer and Hardwood Release	2-10	2-10	2.2-11.2
Wetland Sites	2-5	2-5	2.2-5.6

PROPERTIES OF GLYPHOSATE: Glyphosate is a foliar-active herbicide; to exert herbicidal properties it must enter the plant through foliage (or in some cases, the stem). Glyphosate applied to foliage is absorbed by leaves and rapidly moves through the plant. It acts by preventing the plant from producing an essential amino acid. This reduces the production of protein in the plant, and inhibits plant growth.

Glyphosate has systemic activity, meaning that it circulates through the plant's vascular system; affecting the entire plant, not just the treated foliage. Other foliar-active herbicides, like paraquat for example, are contact herbicides; affecting only the portion of the plant onto which they are applied. After treatment with a contact herbicide, a plant may then regrow from untreated portions, often necessitating re-treatment for complete control. The advantage to a systemic herbicide is that if applied at an appropriate dose, it can kill an entire plant, thus preventing regrowth from an untreated plant part such as a root.

Glyphosate has no residual activity, once adsorbed to soil it quickly becomes unavailable to plants and no longer has herbicidal activity. This means that a plant that would ordinarily be susceptible to



glyphosate can be planted shortly after an application of glyphosate; this is common practice in U.S. agriculture. In contrast, some herbicides have month-long or even year-long residual activity which limits the plants that may be grown following their use.

Glyphosate is non-selective. Some herbicides are selective in their action, controlling only grassy weeds in a broadleaf crop like soybeans, for example. However, glyphosate exerts herbicidal action on a variety of plants; it is active on grasses, herbaceous plants including deep rooted perennial weeds, brush, some broadleaf trees and shrubs, and some conifers. However, glyphosate does not control all broadleaf woody plants. Plants vary in their susceptibility to glyphosate so the treatment dose is important. Plants of certain species and older plants are less susceptible to glyphosate. Timing is especially critical for effectiveness on some broadleaf woody plants and conifers.

FORMULATIONS OF GLYPHOSATE: Glyphosate and four salts of the parent glyphosate molecule are currently used as active ingredients in registered pesticide products in the U.S. (9). These products are registered with the U.S. EPA for use in the U.S. in many different crop, non-crop, industrial, and residential sites.

Table Four. Number of Products and Use Sites for Different Formulations of Glyphosate

Active Ingredient	Number of Products	Number of Sites
Glyphosate acid	28	more than 250
Ethanolamine salt	2	more than 200
Ammonium salt	16	more than 300
Isopropylamine salt	237	more than 400
Trimesium salt	6	more than 100
Sesquisodium salt	no currently active products	no active sites

GLYPHOSATE USED WITH SURFACTANT FOR FOLIAR ABSORPTION: Since glyphosate is only effective if absorbed by plant foliage, glyphosate is combined with a surfactant to facilitate its absorption. Many herbicide product concentrates, including glyphosate, are mixed with water before application. Without a surfactant, the aqueous spray mixture is repelled by the plant's waxy cuticle layer ("beads up"), and quickly runs off the plant's surface, preventing absorption.

Surfactants are commonly used as wetting agents with herbicides and in other products such as laundry and dishwashing detergent. Non-ionic surfactants, which are comprised of alcohols or fatty acids and considered an all-purpose surfactant are commonly used with glyphosate-containing products. Surfactants are frequently added during manufacture of the herbicide concentrate. If not, a non-ionic surfactant is generally mixed with the herbicide and water before spraying to enable the liquid to make better contact with the waxy cuticle of the plant. These glyphosate products, which are formulated without a surfactant, are considered "non-loaded" (10).

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REFERENCES:

- (1) Description of Use of Glyphosate in Coca Eradication in Colombia in attachment to a letter from Secretary of State Colin Powell to Environmental Protection Agency Administrator Governor Christine Whitman
- (2) Donaldson, D., T. Kiely, and A. Grube. Pesticide Industry Sales and Usage, 1998 and 1999 Market Estimates. June 2002. Biological and Economic Analysis Division, Office of Pesticide Programs, U.S. Environmental Protection Agency.
- (3) Gianessi, L.P., Silvers, C., Sankula, S., and Carpenter, J. Plant Biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture - An Analysis of 40 Case Studies. June 2002. National Center for Food and Agricultural Policy. Available on-line at <http://www.ncfap.org>.
- (4) Glyphosate - Reregistration Eligibility Decision. United States Environmental Protection Agency. September 1993.
- (5) Agricultural Chemical Usage - 2000 Field Crops Summary. May 2001. United States Department of Agriculture. National Agricultural Statistics Service.
- (6) Accord® Herbicide Specimen Label. Available on-line from CDMS.
- (7) Pesticide Fact Sheet. Prepared for the U.S. Department of Agriculture, Forest Service. Available on-line at "infoventures.com/e-hlth/pesticide/glyphos.html".
- (8) D. Lantagne., M. Koelling, and D. Dickman. Effective Herbicide Use in Christmas Tree Plantations. Michigan State University Extension.
- (9) U.S. Environmental Protection Agency, Office of Pesticide Programs. Search of the Reference Files System dated June 11, 2002.
- (10) Miller, P., and P. Westra. Crop Series: Production. Colorado State University. Available on-line @ <http://www.colostate.edu/depts/ipm/pdf/00559.pdf>
- (11) EPA Proprietary Information
- (12) Roundup Original Herbicide™ Supplemental Labeling for Postemergence Applications to Soybeans with Roundup Ready® Gene. Available online from CDMS.