Ecol. Eff. Br.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUBJECT: PP# 4G1470. Diquat on potatoes. Evaluation of the analytical method and residue data.

DATE: May 14, 1974

FROM:

TO: Coordination Branch
and Toxicology Branch, RD

The Ortho Division of the Chevron Chemical Co. proposes the establishment of a tolerance of 0.2 ppm for residues of the herbicide, diquat [6,7-dihydrodipryrido(1,2-a:2',1'-c)pyrazinediium] derived from the use of the dibromide salt and calculated as the cation in or on potatoes.

A 0.05 ppm tolerance for residues in sugarcane has been established, (Section 180.226). PP# 1F1101 proposing a tolerance of 0.01 ppm for residues in potable water is currently pending. Diquat is also currently registered as a non-food use on several grassy crops as well as sorghum and soybeans grown for seed.

In the proposed experimental program 18 lbs. of diquat ion (9 gallons of formulation) are to be applied to 48 acres in six states. The experimental program envolves less than 0.01% of the potato crop.

Conclusions

1a. We consider the fate of diquat on potatoes adequately defined. The only residue expected in potato tubers after applications of diquat to the vines is diquat per se.

b. For the purpose of this temporary tolerance we can consider the fate of diquat in animals adequately defined, if a label restriction against the feeding of treated cull potatoes to livestock is imposed. However, for a future permanent tolerance or for a significantly larger experimental program (if the temporary tolerance is extended) an additional ruminant metabolism study will be required.

2a. The proposed method of analysis is considered adequate for the purpose of this temporary tolerance proposal. However, for a future permanent tolerance spectrograms of standard solutions, control samples and fortified controls will be required. Also, additional method validation data demonstrating adequate recovery values at the proposed level of tolerance will be required for a permanent tolerance.

b. Methodology that permits the determination of diquat residues in the presence of paraquat in potatoes will be required for a future permanent tolerance.

3. The residue data submitted for potatoes demonstrates that the proposed 0.2 ppm tolerance level is adequate to cover residues resulting from the proposed use.

4a. Contingent upon the imposition of the label restriction prohibiting the feeding of treated cull potatoes to livestock, the proposed use falls under Category 3 of Section 180.6(a) with respect to meat, milk, poultry and eggs.

b. However, for a future permanent tolerance or for a significatly larger experimental program the label restriction would not be practical and therefore a poultry feeding study will be required.

c. In addition, if any additional residues of concern are detected in the ruminant metabolism study required above, enforcement methodology, residue data and tolerance proposals for these residues may also be required.

5. We would expect the level of inorganic bromides in potatoes treated in accor with use to be insignificant when compared to 75 ppm tolerance level currently established. Some substantiating data will be required in connection with a permanent tolerance request.

Recommendations

1. Contingent upon the imposition of a label restriction prohibiting the feeding of treated cull potatoes to livestock, we recommend for the establishment of the proposed temporary tolerance.

2. For a future permanent tolerance the following will be required.

   a. An additional ruminant metabolism study in which the radiolabeled diquat is fed continuously for the 7-10 period before sacraficing. Identification of the activity found in tissues and milk will be required for a permanent tolerance.

   b. Additional validation data demonstrating adequate recovery of diquat from potatoes fortified at the proposed level of tolerance.

   c. Spectrograms of standard solutions, control samples and fortified control samples analyzed according to the proposed method.

d. Methodology that permits the determination of diquat residues in the presence of paraquat on potatoes.

e. A poultry feeding study carried out at appropriate feeding levels.

f. If any additional residues of concern are found in the ruminant metabolism study required in "a" above, enforcement methodology, residue data and tolerance proposals for these residues may be required.

g. Data reflecting residues of inorganic bromides in potatoes treated in accord with the proposed use.

Detailed Considerations

Formulation

[redacted]

Proposed Use

Diquat is proposed for use as a desicant on potato vines prior to harvest. 1 to 2 pts. of formulation/acre are to be applied to potatoes in order to facilitate harvest and to hasten skin set. Two applications at the 1 pt/acre rate or one application at the 2 pts./acre (a total of 0.5 lbs./acre) are permitted. A minimum of 5 days between applications is recommended.

The use is limited to East of the Rocky Mountains. Diquat is not to be applied to potatoes which are to be stored for consumption or are to be used as seed; this may result in decomposition or failure of the seed pieces to germinate.

The nature of the use proposed requires an interval of time between application and harvest to effect vine kill. The PHI required will vary between 3 and 10 days depending on weather and application rate.

Ortho X-77 a non-ionic surfactant is to be added to the tank mix at the rate of 1 qt./100 gallons. The components of Ortho X-77 are cleared under Section 180.1001.

Nature of the Residue

Plant Metabolism: The metabolic fate of diquat in plants was first discussed in our review of PP# 7F0594 (see memo of 7/28/67 by J. Wolff). The modes of action and dissipation of diquat in or on plants are analogous to those of its cogener, paraquat.

Diquat has been considered not to degrade to any appreciable extent in plants (although small amounts may be metabolized) and we would expect dissipation of residues to occur chiefly by weathering and growth dilution. Herbicidal activity appears to involve formation of the free radical and subsequent oxidation to regenerate diquat along with hydrogen peroxide within the plant cell. Phytoxicity of diquat is dependant upon the availability of sunlight and oxygen. Thus, the evidence indicates that diquat, per se, is not toxic to plants, but rather it acts as a catalyst in the production of hydrogen peroxide.

Although little or no degradation of diquat occurs in the plant, residues on the plant surfaces do undergo photolysis. Since the treated plants, are killed in sunlight, the breakdown products build up on the surface of dead tissues with little if any translocation to viable tissue. The chief photodegradation product is 1,2,3,4-tetrahydro-1-oxo-pyrido [1,2-a]-5-pyrazidinium bromide with the monopyridone of diquat as a probable intermediate. Volatile degradation products apparently derived from these are also formed. Although the studies on tomatoes and maize generally show that decomposition products do not translocate into viable portions of the plants, small metabolic fragments-resulting from either photodecomposition or metabolism were incorporated into the tomato and maize plants metabolic pool.

Six potato plants grown under field conditions in a trial plot were sprayed with C^{14} ethylene bridge labeled diquat at a rate equivalent to 1.5 lbs. diquat ion per acre. After two weeks plants were analyzed both radiometrically and chemically. Comparison of the radiochemical and analytical data show that, within the limits of experimental error, all of the activity found in the potato tubers was parent compound. Further, no residues of any degradation products were detected in the tubers.

Diquat is rapidly absorbed and generally made unavailable to plants by soils at normal application rates. Absorption by clay granules is followed by microbial degradation.

We consider the fate of diquat on potatoes adequately defined. The parent compound will essentially be the only residue in the potato tubers and we do not expect the desicated vines to be fed to livestock.

Animal Metabolism: C^{14} radiolabeled diquat metabolism studies on rats and cattle have been submitted. The rat study involved oral and subcutaneous administration of C^{14} ethylene bridge labeled diquat. 96-101% of the orally administered activity and 93-98% of the subcutaneously administered activity was excreted in four days. 88-100% of the oral dose was excreted in the feces. Approximately 60-70% of the activity found in the feces was present as metabolites. No attempt was made to characterize the metabolites.

The fate of C^{14} ring labeled and ethylene bridge labeled diquat in cattle was investigated after single oral doses. However, we can draw only limited conclusions from studies of this type. It was reported that no diquat per se was detected in milk, and no detectable levels were found in muscle tissue. Activity, present as metabolites, was detected at low levels in liver and kidney tissues as well as milk. No attempt was made to characterize the metabolites, but the data appear to indicate that no pyridyl or bypyridyl metabolites were present.

We consider the fate of diquat in animals adequately defined for the purpose of this temporary tolerance proposal considering the fact that only 48 acres are to be treated in the experimental program. For a future permanent tolerance or for a more extensive experimental program (if the temporary tolerance is extended) an additional ruminant metabolism study will be required. In this additional study C^{14} labeled diquat should be fed continuously during the 7-10 day period before sacraficing and the radiolabeled metabolites should be identified.

Fate of Diquat upon Cooking: Diquat has been shown to be stable when refluxed for periods up to 5 hours in 6N H_2SO_4. Diquat has also been shown to be stable in the presence of strong base. We therefore conclude that there is little possibility of degradation during cooking.

Analytical Method

The analytical method is essentially the same as the procedure for paraquat. The diquat cation is liberated by refluxing with sulfuric acid. Following clean-up on an ion exchange column, diquat is reduced to the free radical form with sodium dithionite and the UV absorbance determined at 377 nm. The method for paraquat uses the same extraction and clean-up procedures but paraquat is determined at 394 nm.

A calculation is employed to correct for the background absorbance of the substrate. The absorbance of the control samples is assumed to be essentially linear with respect to wavelength in the area of interest. Thus, the absorbance of a residue sample is determined at the maximum absorbance (377 nm) and at 373 and 381 nm. The absorbance of a standard solution is also determined at these same points and the contribution of diquat alone is calculated assuming the displacement of the standard curve (by the background) is linear. An explanation of these calculations has been submitted, but no spectra or sample calculations have been made available. Spectra for standard solutions, control samples and fortified controls in order that we may further evaluate the proposed method will be required for a future permanent tolerance.

The analytical method was not tested in our laboratories in connection with PP# 7F0594 because it is essentially the same as the procedure for paraquat.

Six recovery values are reported for potato samples fortified at 0.05 ppm and 0.1 ppm diquat. Recoveries averaged 46% and 53% from the 0.05 and 0.1 ppm levels respectively. Although these values are low they were determined at levels of 1/4 and 1/2 the proposed tolerance. We consider the recovery data adequate for the purpose of this temporary tolerance; however, for a future permanent tolerance additional recovery data demonstrating adequate recoveries at the level of tolerance will be required.

A confirmatory procedure that will determine diquat in the presence of paraquat residues on potatoes will also be required for a future permanent tolerance.

No tolerances or methodology have been proposed for residues in meat, milk, poultry or eggs. If the label restriction discussed under <u>Meat, Milk, Poultry and Eggs</u> below is imposed, no methodology for residues in these commodities will be required for the purpose of this temporary tolerance. However, for a future permanent tolerance or for a more extensive experimental program (if the temporary tolerance is extended) appropriate tolerance proposals and enforcement methodology for residues in meat, milk, poultry and eggs will be needed. Further, if any additional residues of concern are found in the metabolism studies required above, methodology, validation data and tolerance proposals may be required for these compounds.

Residue Data

Residue studies have been submitted from five states across the country. In all of these tests potatoes were treated once at rates of 0.5 to 3.0 lbs. act/acre 5-36 days before harvest. Residue levels ranged from none detected to 0.08 ppm with the higher levels reported for potatoes treated at exaggerated rates. Residue levels reported for the proposed rate ranged from 0.0 to 0.02 ppm.

An additional study shows that under extreme conditions of draught and low light diquat residues may be significantly higher. Data from this study show residue levels as high as 0.1 ppm were found in one of five samples treated at proposed rate of 0.5 lbs. act/acre. Residue levels reported for higher application rates were proportionately higher. The phenomenon of higher residues of contact herbicides in tubers grown under these conditions is not unusual. The potatoes with these elevated levels of diquat were often damaged by stem rot.

We consider the residue data adequate to demonstrate that residues will not exceed the proposed 0.2 ppm tolerance.

Meat, Milk, Poultry and Eggs

Cull potatoes may be fed to cattle and poultry (to poultry as dried potato meal) at levels of up to 50% and 20% respectively. Real residues of diquat have been found in tubers at levels as high as 0.1 ppm. A 0.2 ppm tolerance has been proposed. Thus the proposed use could yield residues in the bovine diet of 0.1 ppm and 0.04 ppm in the poultry diet.

Cattle and sheep feeding data have been submitted in PP# 1F1101. Cattle were fed diets of 2.8 and 11 ppm for periods of 5 and 9 weeks. No detectable residues of diquat per se were found in the edible tissues by a method sensitive to 0.01 ppm. (Although 0.06 ppm were found in the intestine of one animal and 0.02 ppm detected in the rumen in a second.) Sheep were fed diets of up to 29 ppm for 29 days with no detectable residues of diquat resulting in their milk or tissues. However, as discussed in detail above, the bovine metabolism data are of only limited value and we can draw no final conclusions with regard to the fate of diquat in the ruminant. Further, no poultry feeding data have been submitted. It is therefore our judgement that a label restriction against the feeding of cull potatoes to livestock must be imposed. We can only consider this label restriction practical because of the limited nature of the experimental program. We would not consider this restriction practical for a future permanent tolerance or for a significantly larger experimental program, in the event the temporary tolerance is extended. Therefore, for a future permanent tolerance or for a larger experimental program a poultry feeding study will be required. Also, if the additional ruminant metabolism study required above shows that there are any additional residues of concern, enforcement methodology, residue data and appropriate tolerance proposal for these residues in meat,milk, poultry and eggs may be required.

Other Considerations

Diquat is formulated as the dibromide salt. No residue data have been submitted for the bromide ion. Assuming that all of the applied bromine (0.44 lbs./A) transfers to the potato, a level of approximately 15 ppm could result. We would expect actual bromide levels resulting in the tuber to be much lower because the bromine is being applied to the foliage in conjunction with a contact herbicide. Residues in the tuber are most likely to result from absorption or contact with bromides present in the soil as a result of spray run-off.

Thus, we would consider the actual bromide residues in potatoes to be insignificant from this use when compared to the 75 ppm tolerance level currently established. Some substantiating data will be required in connection with a permanent tolerance request.

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