5.13 DIQUAT (031)

TOXICOLOGY

Diquat is the ISO-approved name for 6,7-dihydrodipyrido[1,2-a:2′,1′-c]pyrazinediium dibromide (IUPAC), for which the CAS number is 85-00-7. The CAS number for diquat ion is 2764-72-9. Diquat is a non-selective, quick-acting contact herbicide and desiccant, causing injury only to the parts of the plant to which it is applied. Diquat interacts with the electron transfer components associated with Photosystem I, which causes inhibition of photosynthesis. It is also used as an aquatic algicide.

Diquat was previously evaluated by JMPR in 1970, 1972, 1977 and 1993. An ADI of 0–0.008 mg diquat ion/kg bw was allocated in 1977. In 1993, JMPR established an ADI of 0–0.002 mg diquat ion/kg bw based on a NOAEL of 0.19 mg diquat ion/kg bw per day identified in a 2-year study of toxicity and carcinogenicity in rats, using a safety factor of 100. Diquat was reviewed at the present Meeting as part of the periodic review programme of CCPR.

Since the last review by JMPR, the following new studies on diquat have been submitted: acute and subchronic neurotoxicity studies, an immunotoxicity study, metabolism studies and a re-evaluation of cataract observations in previous long-term studies. All dose values are expressed as diquat ion. Some of the studies do not comply with GLP, as most of the data were generated before the implementation of GLP regulations. Overall, the Meeting considered that the database was adequate for the risk assessment.

Biochemical aspects

When administered orally, [^{14}C]diquat is poorly absorbed (< 10%) from the gastrointestinal tract of rats and eliminated mainly via the faeces (about 94%) during the first 24 hours. The small amount absorbed is rapidly eliminated via the urine (about 6%). Biliary excretion represented less than 5% of the administered dose. Peak tissue and blood levels were seen at approximately 2 hours, followed by a rapid decline. Liver, kidney, gastrointestinal tract and lung had the highest residues immediately following dosing; at 96 hours, significant residues were seen primarily in the eye lens.

After oral administration of [^{14}C]diquat to rats (45 mg diquat ion/kg bw), the major excreted product was diquat in both urine (about 6% of the dose) and faeces (about 89% of the dose); diquat monopyridone was the main metabolite in the faeces (5% of dose), but a minor one in the urine. In another oral study in rats (100 mg diquat ion/kg bw), small amounts of diquat dipyridone and picolinic acid were found, in addition to the monopyridone, in urine. The biotransformation of diquat is postulated to proceed either by progressive oxidation of the pyridine rings to form diquat monopyridone and diquat dipyridone or by the cleavage of one of the pyridine rings to form picolinic acid, possibly via pyridine-2-carboxamide as an intermediary metabolite, although this was not identified.

Toxicological data

The acute oral LD_{50} in rats was 214 mg diquat ion/kg bw. There were no mortalities or clinical signs of toxicity at 100 mg/kg bw. The acute dermal LD_{50} in rats was greater than 424 mg diquat ion/kg bw. The 4-hour acute inhalation LC_{50} in rats was 0.121 mg/L. Diquat was moderately to severely irritating to rabbit skin and mildly irritating to rabbit eyes. Diquat was a skin sensitizer in the Magnusson and Kligman test.

Unlike paraquat, diquat is not actively taken up by lung slices, and lung toxicity is not characteristic of diquat poisoning. The eye was the main target organ following short-term repeated exposure in rats and dogs. In addition, effects on kidney, liver and haematological parameters were also observed.

In a 90-day toxicity study in rats using dietary concentrations of 0, 20, 100 and 500 ppm (equal to 0, 1.7, 8.5 and 39.5 mg diquat ion/kg bw per day for males and 0, 1.9, 9.2 and 41.5 mg diquat ion/kg bw per day for females, respectively), the NOAEL was 100 ppm (equal to 8.5 mg diquat ion/kg bw per day), based on decreased body weight gain, feed consumption, changes in clinical chemistry parameters, increased urine volume, decreased urinary specific gravity, minor changes in haematological values and erosion of the tongue and oral cavity and ocular changes at 500 ppm (equal to 39.5 mg/kg bw per day). An investigative 90-day toxicity study in rats was conducted at dietary concentrations of 0, 30, 60 and 300 ppm diquat ion (equal to 0, 2.4, 4.7 and 23.2 mg diquat ion/kg bw per day for males and 0, 2.7, 5.0 and 25.3 mg diquat ion/kg bw per day for females, respectively) to determine the NOAEL for cataract formation in rats. The NOAEL was 60 ppm (equal to 4.7 mg diquat ion/kg bw per day) for ocular lesions and lens opacities evident at 300 ppm (equal to 23.2 mg diquat ion/kg bw per day). The overall NOAEL in the 90-day toxicity studies in rats was 100 ppm (equal to 8.5 mg diquat ion/kg bw per day), with an overall LOAEL of 300 ppm (equal to 23.2 mg diquat ion/kg bw per day).

In a 1-year feeding study in dogs, with achieved dietary intakes of 0, 0.46, 2.42 and 11.48 mg diquat ion/kg bw per day for males and 0, 0.53, 2.53 and 13.21 mg diquat ion/kg bw per day for females, the NOAEL was 0.53 mg diquat ion/kg bw per day, based on lens opacity (cataracts) in females at 2.53 mg diquat ion/kg bw per day.

In a 2-year toxicity and carcinogenicity study in mice using dietary concentrations of 0, 30, 100 and 300 ppm (equal to 0, 3.56, 11.96 and 37.83 mg diquat ion/kg bw per day for males and 0, 4.78, 16.03 and 48.27 mg diquat ion/kg bw per day for females, respectively), the NOAEL was 30 ppm (equal to 3.56 mg diquat ion/kg bw per day), based on reduction in body weight gain, increased relative kidney weights and ocular discharges at 100 ppm (equal to 11.96 mg diquat ion/kg bw per day) and above. There was no evidence of carcinogenicity in mice at doses up to and including 300 ppm (equal to 37.83 mg diquat ion/kg bw per day), the highest dose tested.

A 2-year study of toxicity and carcinogenicity in rats was conducted using dietary concentrations of 0, 5, 15, 75 and 375 ppm (equal to 0, 0.19, 0.58, 2.91 and 14.88 mg diquat ion/kg bw per day for males and 0, 0.24, 0.72, 3.64 and 19.44 mg diquat ion/kg bw per day for females, respectively). There were no effects on survival, changes in haematology, clinical chemistry or urine analysis parameters or neoplastic changes that were considered to be of toxicological significance at any dose level. A treatment-related incidence of opacities of the lens was found in male and female animals receiving 75 and 375 ppm. Among rats receiving 375 ppm, these lesions progressed to total opacification of the lens, affecting all surviving rats receiving 375 ppm when examined at week 104. A low, but slightly higher than in controls, incidence of rats with opacities was seen in the 15 ppm group at 104 weeks only. Cataractous change was observed in the lenses of rats at 75 and 375 ppm. The NOAEL was concluded to be 5 ppm (equal to 0.19 mg diquat ion/kg bw per day) in the 1993 JMPR evaluation. Since that evaluation, the cataract data at 15 ppm have been re-evaluated by the original pathologists. Cataracts were seen in controls and all dose groups, and the incidence and severity were dose related. The present Meeting noted the conclusion of the re-evaluation of the cataract data: that, in contrast to the observations at 75 and 375 ppm, there was no evidence of progression of the disease at 15 ppm that differed from the controls. The present Meeting identified the NOAEL as 15 ppm (equal to 0.58 mg diquat ion/kg bw per day), as the incidence and severity were comparable with those of the controls. There was no evidence of carcinogenicity in this study.

The Meeting concluded that diquat is not carcinogenic in mice or rats.

Diquat was tested for genotoxicity in vitro and in vivo in an adequate range of assays. It gave an equivocal response in the absence of metabolic activation and a positive response in the presence of metabolic activation in the mammalian cell cytogenic assay; however, it was negative in the in vivo mouse micronucleus assay and dominant lethal assay.

The Meeting concluded that diquat is unlikely to be genotoxic in vivo.

On the basis of the lack of genotoxicity in vivo and the absence of carcinogenicity in mice and rats, the Meeting concluded that diquat is unlikely to pose a carcinogenic risk to humans from the diet.

In a two-generation study of reproductive toxicity in rats using dietary concentrations of 0, 16, 80 and 400/240 ppm (equal to 0, 1.6, 7.9 and 38.7 mg diquat ion/kg bw per day for males and 0, 1.7, 8.4 and 40.4 mg diquat ion/kg bw per day for females, respectively), the NOAEL for parental systemic toxicity was 16 ppm (equal to 1.6 mg diquat ion/kg bw per day), based on a low incidence of mouth lesions in both generations and a slightly increased incidence of cataracts at 80 ppm (equal to 7.9 mg diquat ion/kg bw per day). The NOAEL for reproductive toxicity was 400/240 ppm (equal to 38.7 mg diquat ion/kg bw per day), the highest dose tested. The NOAEL for offspring toxicity was 80 ppm (equal to 7.9 mg diquat ion/kg bw per day), based on decreased pup body weights seen in both generations at 400/240 ppm (equal to 38.7 mg diquat ion/kg bw per day).

In a developmental toxicity study in rats that tested gavage doses of 0, 12 and 40 mg diquat ion/kg bw per day, the NOAEL for maternal toxicity was 12 mg diquat ion/kg bw per day, based on reduced body weights and feed consumption seen at 40 mg diquat ion/kg bw per day. The NOAEL for embryo and fetal toxicity was 12 mg diquat ion/kg bw per day, based on reduced fetal weight, haemorrhagic kidney and increased incidence of soft tissue and minor skeletal anomalies at 40 mg diquat ion/kg bw per day.

In a developmental toxicity study in rabbits that tested gavage doses of 0, 1, 3 and 10 mg diquat ion/kg bw per day, the NOAEL for maternal toxicity was 1 mg diquat ion/kg bw per day, based on reduced weight gain and feed consumption at 3 mg diquat ion/kg bw per day. The NOAEL for embryo and fetal toxicity was 3 mg diquat ion/kg bw per day, based on skeletal anomalies at 10 mg diquat ion/kg bw per day.

The Meeting concluded that diquat is not teratogenic in rats or rabbits.

Diquat has been tested for neurotoxicity in acute and repeated-dose studies in rats. In neither study was there any indication of neurotoxicity. In an acute neurotoxicity study in rats that tested gavage doses of 0, 25, 75 and 150 mg diquat ion/kg bw per day, the NOAEL for general toxicity was 75 mg diquat ion/kg bw, based on a range of findings, including clinical signs, at 150 mg diquat ion/kg bw. In the 90-day study of neurotoxicity in rats using dietary concentrations of 0, 20, 100 and 400 ppm (equal to 0, 1.6, 7.9 and 32.4 mg/kg bw per day for males and 0, 1.9, 9.5 and 38.5 mg/kg bw per day for females, respectively), the NOAEL for systemic toxicity was 100 ppm (equal to 7.9 mg diquat ion/kg bw per day), based on evidence of eye lesions and reductions in body weight gain and feed consumption at 400 ppm (equal to 32.4 mg/kg bw per day).

The Meeting concluded that diquat is not neurotoxic.

In a 28-day study of immunotoxicity in female mice using dietary concentrations of 0, 100, 200 and 350 ppm (equal to 0, 23, 44 and 81 mg diquat ion/kg bw per day), there was no evidence of immunotoxicity at doses up to 350 ppm (equal to 81 mg diquat ion/kg bw per day).

Toxicological data on metabolites and/or degradates

Diquat monopyridone [6,7-dihydro-4-oxodipyrido(1,2-a:2′,1′-c) pyrazinium], the major metabolite following oral dosing, was less toxic than the parent compound. The oral LD_{50} for diquat monopyridone was greater than 4000 mg/kg bw. Male and female rats orally administered diquat monopyridone at a dose of 1000 mg/kg bw per day, 5 days/week, for 2 weeks showed no clinical, haematological, biochemical or histopathological abnormalities, except for a decreased number of lymphocytes in both males and females. 1,2,3,4-Tetrahydro-1-oxopyrido(1,2-a)-5-pyrazinium salt (TOPPS), a metabolite in livestock but not in rats, was less toxic than the parent compound. The acute oral LD_{50} of TOPPS in rats was 2449 mg/kg bw. There was no evidence of genotoxicity in the deoxyribonucleic acid (DNA) repair test.

Human data

No reports of adverse health effects in manufacturing plant personnel were provided. In humans, intestinal paralysis and fluid loss are prominent features of diquat intoxication and may lead to abdominal distension, tissue dehydration, hypotensive shock and severe cerebrovascular complications due to brainstem infarction and/or intracranial haemorrhage.

The Meeting concluded that the existing database on diquat was adequate to characterize the potential hazards to fetuses, infants and children.

Toxicological evaluation

The Meeting established an ADI of 0–0.006 mg diquat ion/kg bw on the basis of a NOAEL of 0.58 mg diquat ion/kg bw per day in the 2-year carcinogenicity study in rats on the basis of cataracts seen at 2.9 mg diquat ion/kg bw per day. A safety factor of 100 was applied. This ADI is supported by the NOAEL of 0.46 mg diquat ion/kg bw per day observed in a 1-year toxicity study in dogs on the basis of cataracts seen at the LOAEL of 2.53 mg diquat ion/kg bw per day. The present ADI is based on the same study and end-point selected by the 1993 JMPR, but using a different NOAEL value. The current Meeting identified the NOAEL as 0.58 mg diquat ion/kg bw per day, as the incidence and progression with time and severity of cataracts at this dose were comparable to those in the controls.

An ARfD of 0.8 mg/kg bw was established on the basis of a NOAEL of 75 mg diquat ion/kg bw in an acute neurotoxicity study in rats, based on clinical signs and decreased body weight gains in the 1st week and decreased feed consumption seen at the LOAEL of 150 mg diquat ion/kg bw. A safety factor of 100 was applied. This ARfD is further supported by the acute oral toxicity study in rats (LD_{50} = 214 mg/kg bw) in which no mortality or clinical signs of toxicity were observed at 100 mg/kg bw. The Meeting considered reductions in body weight gain seen at the start of gavage dosing in several studies (e.g. developmental toxicity studies) to be secondary to gastrointestinal irritation and not relevant to establishing an ARfD. The Meeting concluded that the critical effects in the longer-term studies of eye lesions were not likely to be produced following a single dose, as the eye lesions were normally evident only after several weeks of continuous dosing.

A toxicological monograph was prepared.

Levels relevant to risk assessment of diquat

Species	Study	Effect	NOAEL	LOAEL
Mouse	Two-year study of toxicity and carcinogenicity[a]	Toxicity	30 ppm, equal to 3.6 mg diquat ion/kg bw per day	100 ppm, equal to 12.0 mg diquat ion/kg bw per day
		Carcinogenicity	300 ppm, equal to 37.8 mg diquat ion/kg bw per day[b]	—
Rat	Acute neurotoxicity study[c]	Toxicity	75 mg diquat ion/kg bw	150 mg diquat ion/kg bw
	Ninety-day studies of toxicity[a,d]	Toxicity	100 ppm, equal to 8.5 mg diquat ion/kg bw per day	300 ppm, equal to 23.2 mg diquat ion/kg bw per day
	Two-year study of toxicity and carcinogenicity[a]	Toxicity	15 ppm, equal to 0.58 mg diquat ion/kg bw per day	75 ppm, equal to 2.9 mg diquat ion/kg bw per day
		Carcinogenicity	375 ppm, equal to 14.9 mg diquat ion/kg bw per day[b]	—

Species	Study	Effect	NOAEL	LOAEL
	Two-generation study of reproductive toxicity[a]	Reproductive toxicity	400/240 ppm, equal to 38.7 mg diquat ion/kg bw per day[b]	—
		Parental toxicity	16 ppm, equal to 1.6 mg diquat ion/kg bw per day	80 ppm, equal to 7.9 mg diquat ion/kg bw per day
		Offspring toxicity	80 ppm, equal to 7.9 mg diquat ion/kg bw per day	400/240 ppm, equal to 38.7 mg diquat ion/kg bw per day
	Developmental toxicity study[c]	Maternal toxicity	12 mg diquat ion/kg bw per day	40 mg diquat ion/kg bw per day
		Embryo and fetal toxicity	12 mg diquat ion/kg bw per day	40 mg diquat ion/kg bw per day
Rabbit	Developmental toxicity study[c]	Maternal toxicity	1 mg diquat ion/kg bw per day	3 mg diquat/kg bw per day
		Embryo and fetal toxicity	3 mg diquat ion/kg bw per day	10 mg diquat ion/kg bw per day
Dog	One-year study of toxicity[a]	Toxicity	0.46 mg diquat ion/kg bw per day	2.53 mg diquat ion/kg bw per day

[a] Dietary administration.

[b] Highest dose tested.

[c] Gavage administration.

[d] Two or more studies combined.

Estimate of acceptable daily intake

0–0.006 mg/kg bw

Estimate of acute reference dose

0.8 mg/kg bw

Information that would be useful for the continued evaluation of the compound

Results from epidemiological, occupational health and other such observational studies of human exposure

Critical end-points for setting guidance values for exposure to diquat

Absorption, distribution, excretion and metabolism in mammals	
Rate and extent of oral absorption	Poor, ~10% in rat
Dermal absorption	About 6% in 24 h, rat skin
Distribution	Widely distributed, highest levels in eye lens
Potential for accumulation	Potential accumulation only in eye lens
Rate and extent of excretion	Rapid, absorbed dose extensively excreted (> 90%) in urine and bile within 96 h

Metabolism in animals	Metabolism was limited, with < 20% of the urinary residues (< 1% of the administered dose) consisting of metabolites
Toxicologically significant compounds in animals, plants and the environment	Diquat ion
Acute toxicity	
Rat, LD_{50}, oral	214 mg diquat ion/kg bw
Rat, LD_{50}, dermal	> 424 mg diquat ion/kg bw
Rat, LC_{50}, inhalation	0.121 mg diquat ion/l
Rabbit, dermal irritation	Moderately to severely irritating
Rabbit, ocular irritation	Mildly irritating
Dermal sensitization	Sensitizing (Magnusson and Kligman)
Short-term studies of toxicity	
Target/critical effect	Cataract, body weight (rat, dog)
Lowest relevant oral NOAEL	0.46 mg diquat ion/kg bw per day (dog)
Lowest relevant dermal NOAEL	No data
Lowest relevant inhalation NOAEC	No data
Long-term studies of toxicity and carcinogenicity	
Target/critical effect	Cataract (rat), kidney lesions (mouse)
Lowest relevant NOAEL	0.58 mg diquat ion/kg bw per day (rat)
Carcinogenicity	Unlikely to pose a carcinogenic risk to humans from the diet
Genotoxicity	
	Not genotoxic in vivo
Reproductive toxicity	
Target/critical effect	No reproductive toxicity
Lowest relevant parental NOAEL	1.6 mg diquat ion/kg bw per day
Lowest relevant offspring NOAEL	7.9 mg diquat ion/kg bw per day
Lowest relevant reproductive NOAEL	38.7 mg diquat ion/kg bw per day, the highest dose tested
Developmental toxicity	
Target/critical effect	Reduced body weight, delayed ossification; skeletal anomalies at maternally toxic doses
Lowest relevant maternal NOAEL	1 mg diquat ion/kg bw per day (rabbit)
Lowest relevant embryo and fetal NOAEL	3 mg diquat ion/kg bw per day (rabbit)
Neurotoxicity	
Acute and subchronic neurotoxicity	Not neurotoxic
Other toxicological studies	
Immunotoxicity	Not immunotoxic
Studies on metabolites	Diquat monopyridone, diquat dipyridone and TOPPS were less toxic than parent diquat
Medical data	
	No reports submitted; characteristics of intoxication

obtained from published literature

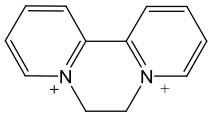
Summary

	Value	Study	Safety factor
ADI	0–0.006 mg/kg bw	Two-year study of carcinogenicity in rats	100
ARfD	0.8 mg/kg bw	Acute study of neurotoxicity in rats	100

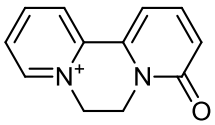
RESIDUE AND ANALYTICAL ASPECTS

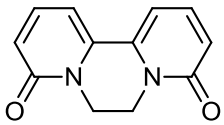
Diquat is a non-selective contact herbicide with uses on many crops. Diquat has been evaluated several times by the JMPR with the initial evaluation in 1970 and the latest in 1994. Diquat was scheduled at the 44th session of the CCPR (2012) for periodic re-evaluation of toxicology and residues by the 2013 JMPR.

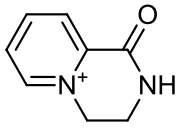
The Meeting received information on the metabolism of diquat in animals, on crops, methods of residue analysis, freezer storage stability, GAP information, supervised residue trials, fate of residue during storage and processing, and livestock feeding studies.

Diquat is 6,7-dihydrodipyrido[1,2-a:2',1'-c]pyrazinediium dibromide. 

Metabolites referred to in the appraisal are addressed by their common names:

Diquat monopyridone 

Diquat dipyridone 

TOPPS 

Animal metabolism

Metabolism of diquat in goats and hens involves formation of diquat dipyridone and diquat monopyridone. TRR are expressed in terms of diquat ion.

In a study where a lactating goat was orally treated once daily for 7 consecutive days with ring labelled [^{14}C]-diquat at a dose equivalent to 90 ppm in the feed, approximately 97% of the administered dose was recovered with the majority in the excreta (84% faeces, < 1% urine) or gastrointestinal tract (12%). The radioactivity in the tissues ranged from 0.003 in fat to 0.079 mg equiv/kg in kidney. TRR values in milk were up to 0.015 mg equiv/kg during the dosing period with levels not reaching a plateau after seven days of dosing. Major components of the ^{14}C residues were

unchanged diquat ion (liver 22% TRR), diquat dipyridone (kidney 29% TRR, liver 33% TRR, muscle 46% TRR, fat 20% TRR, milk 82% TRR) and diquat monopyridone (kidney 21% TRR, liver 13% TRR, muscle 13% TRR).

Laying hens were orally treated once daily in experiments where a single hen received a single dose at 4-5 ppm, five daily doses at 4–5 ppm or 14 doses daily doses at 0.4–0.5 ppm. By three days after administering the last dose the majority (> 94%) of the dose was recovered in the excreta. Radioactivity in tissues of hens dosed at 0.4-0.5 ppm ranged from 0.00010 mg equiv/kg in fat to 0.00045 mg equiv/kg in kidney. The ^{14}C levels in egg whites and yolks reached a plateau of 0.00003 and 0.00014 mg equiv/kg respectively by seven days of dosing. Yolk from day 9+10 eggs contained diquat ion (26% TRR), yolks from day 7 contained diquat monopyridone (85% TRR) and egg yolks from day 11 contained TOPPS (10% TRR).

In another study laying hens were each given daily doses of ^{14}C-ring labelled diquat by oral gavage for 4 days at the equivalent of 32 ppm in the diet. At sacrifice 18 hours after the last dose, radioactive residues in the muscle, fat and eggs were all < 0.01 mg equiv/kg. Levels of radioactivity in liver and kidney were 0.045 and 0.058 mg equiv/kg respectively with unchanged diquat (liver 48% TRR, kidney 12% TRR) and diquat monopyridone (liver 3.9% TRR, kidney 15% TRR) the main residue components. Minor components identified were TOPPS (liver 1.8% TRR, kidney 3.9% TRR) and diquat dipyridone (liver 3.1% TRR, kidney 6.6% TRR).

In an additional study laying hens fed a diet containing powdered grain harvested from barley plants treated with [^{14}C]-diquat, the dose was equivalent to 1 to 1.5 ppm in the feed for 11 consecutive days with hens sacrificed 4 hours or 7 days after the last exposure. The major components of the ^{14}C in the grain were diquat ion (17% TRR) and TOPPS (8.7% TRR). Most of the administered dose was recovered in the excreta (84–89%) with less than 0.1% recovered in eggs. Radioactive residues in egg white reached a plateau by day 5 of dosing with a maximum level of 0.0006 mg equiv/kg while egg yolk reached a plateau by day 8 with a maximum residue of 0.0039 mg equiv/kg. In tissues at sacrifice 4 hours after last exposure, ^{14}C residues were highest in kidney (0.014 mg equiv/kg) and much lower in muscle and fat at 0.0009 and 0.0022 mg equiv/kg respectively. Diquat ion was a minor component of the ^{14}C residues in egg yolk at 0.9% TRR with TOPPS and diquat monopyridone present at 3.5 and 3.0% TRR respectively.

Metabolism in laboratory animals (rat) was summarized and evaluated by the WHO panel of the JMPR in the present meeting. The metabolism of diquat in ruminants and laying hens is adequately understood. In both goats and hens diquat is oxidised to form diquat monopyridone and diquat dipyridone. TOPPS is found as a minor metabolite (< 10% TRR) in hens but was not detected in studies of the metabolism of diquat by goats or rats.

Plant metabolism

Diquat is used for two different situations:

- Directed sprays for weed control (crop not intentionally treated)
- Use as a crop desiccant to facilitate crop harvest (crop treated)

Plant metabolism studies were conducted with diquat to investigate these two situations.

Application prior to crop emergence

A single application of ^{14}C-diquat was made to soil into which tomato seeds had been sown prior to emergence. Residues in mature fruit and leaves harvested 112 days after application were < 0.001 and 0.002 mg equiv/kg respectively and were not analysed further.

Crop desiccation

The use of diquat as a pre-harvest desiccant was investigated in potato and rape following foliar spray application to the crop. Since the plants are senescent at the time of application or die quickly after application, metabolism is essentially stopped and translocation from the treated parts of the crops into other plant parts such as seeds and roots is reduced. Following use as a crop desiccant, diquat ion was the major component of the ^{14}C residue in the skin and flesh of potato tubers accounting for more than 70% of TRR with no other individual component comprising more than 10% TRR. The major component in rape seed harvested from crops, following pre-harvest desiccation, was diquat ion at 48% TRR with smaller amounts of TOPPS (7.8% TRR) and diquat monopyridone (2.0% TRR).

The metabolism of diquat by plants is well understood. Following directed application to weeds using shielded sprayers there is minimal contact of the crop with diquat. A portion of the spray will reach the soil, but as described later, diquat is strongly absorbed by soil components such that it is largely unavailable for uptake by plant roots.

Following use as a pre-harvest desiccant, diquat ion is the major component of the ^{14}C residue in those parts exposed to direct sprays with TOPPS and diquat monopyridone present as minor components. Only low levels of radioactivity are found in plant parts such as potato tubers that are not directly exposed to the spray (< 0.05 mg equiv/kg).

Environmental fate

The Meeting received information on soil aerobic metabolism, soil photolysis and aqueous hydrolysis properties of [^{14}C]-diquat. Studies were also received on the behaviour of [^{14}C]-diquat in a rotational crop situation.

Diquat residues are persistent in soils, however residues in soil are strongly bound to soil components and not available for uptake by plants. As such, residues in soil should not contribute significantly to the residues in succeeding crops.

In soil incubation studies under aerobic conditions in the dark, diquat disappeared with a half-life that was > 290 days. In the absence of soil, diquat was rapidly and extensively degraded by soil micro-organisms normally found in soil pore water to give a small number of non-volatile degradation products (not identified) with mineralisation to CO_2. The DT50 for degradation in solutions of soil micro-organisms is rapid at < 1 week. Addition of clay to these solutions essentially stopped further degradation confirming that sorbed diquat is not available for biological degradation.

The degradation product TOPPS is also persistent in soils. Studies on the aerobic soil degradation of the diquat metabolite TOPPS estimated DT_{50} values for degradation of 28 to 757 days.

Soil photolysis has negligible effect on degradation. In a study with application of ^{14}C-diquat on the surface of a sterilised loam soil, the DT_{50}s for photolytic degradation on dry and wet soil were 237 and 37 days respectively.

In a study of aqueous photolysis the DT_{50} for degradation was 31 hours. The major degradation product was TOPPS with smaller amounts of diquat monopyridone and 1-hydroxy-3,4-dihydro-1H-pyrido[1,2-a]pyrazine-2-carboxylic acid formed.

In a confined rotational crop study with wheat, lettuce and carrot, a plot of sandy loam soil was treated with [^{14}C]-diquat at the equivalent of 1.1 kg ai/ha and crops sown 30, 120 and 365 days. At normal commercial harvest, crops grown in soil containing ^{14}C-diquat showed negligible uptake of radioactivity (TRR up to 0.02 mg equiv/kg). Residues above the LOD of 0.008 mg equiv/kg could have been due to contamination with adhering soil. Crops grown in rotation with diquat-treated crops are not expected to contain residues of diquat ion or diquat degradation products. Diquat residues in soil should contribute little to residue levels in rotational crops.

Methods of analysis

The Meeting received description and validation data for analytical methods for residue analysis of diquat in various plant and animal commodities. Early methods used in field trials generally involved extraction of residues by reflux with sulphuric acid with clean-up on cation exchange columns. Following reduction of diquat ion with alkaline dithionite or sodium borohydride, detection was initially achieved spectrophotometrically (350–450 nm). In more recent methods the diquat ion recovered from the cation exchange column is subjected to HPLC-UV or GC-NPD for quantitation. In the case of animal commodities, trichloroacetic acid is sometimes used in place of sulphuric acid for the extraction step. LOQs were in the range 0.01 to 0.1 mg/kg.

The most recent advance in methods has been the use of LC-MS/MS which allows for the clean-up steps to be omitted with LOQs of 0.005 mg/kg for animal commodities, 0.006 mg/kg for potato and barley and 0.02 mg/kg for citrus.

The efficiency of the acid extraction step has been demonstrated during the metabolism studies where the majority of the total radioactive residue (TRR) was recovered in the acid extracts.

Multi-residue methods are currently not validated for diquat.

Stability of pesticide residues in stored analytical samples

The Meeting received information on the stability of diquat in samples of commodities from crops stored frozen.

Diquat is stable for at least 24 months in homogenised samples of spinach, wheat grain, wheat straw, rape seed, lentils, orange fruit and potato tubers fortified with diquat and stored frozen.

The periods of demonstrated stability cover the frozen storage intervals used in the residue studies.

Definition of the residue

In metabolism studies of diquat in goats and hens diquat ion was a significant component of the residue in hen (48% TRR liver; 12% TRR kidney) and goat (22% TRR liver; 4.3% TRR kidney) tissues. Other major components were diquat monopyridone (13% TRR liver; 13% muscle) and diquat dipyridone (33% TRR liver; 29% kidney; 20-46% muscle and fat; > 80% milk) with small amounts of TOPPS (1.8% liver; 3.9% kidney) formed in hens. Radioactivity in egg yolks comprised mostly diquat monopyridine (up to 85% TRR) and diquat ion (up to 26% TRR) with smaller amounts of TOPPS (up to 10%TRR).

The major components of the residue in livestock are diquat ion, diquat monopyridone and diquat dipyridone and should be considered for inclusion in the residue definition for compliance with MRLs and estimation of dietary intake in animal commodities. However, at realistic livestock exposures no residues of diquat ion, diquat monopyridone or diquat dipyridone are expected. Additionally, current analytical methods for tissues have only been validated for determination of residues of diquat. Noting the above, the Meeting considered diquat ion to be a suitable as a residue definition for compliance with MRLs and estimation of dietary intake for animal commodities.

The log P_{ow} for diquat is -4.6 suggesting diquat residues are not fat soluble. There was only a small difference in residue levels in muscle and fat confirming diquat ion does not preferentially partition into fat and that the residue should not be classed as fat soluble. The Meeting decided that residues of diquat are not fat soluble.

Diquat is used on crops for two different situations:

- Directed sprays or pre-emergent application for weed control (crop not intentionally treated)
- Use as a crop desiccant to facilitate crop harvest (crop treated)

No residues are expected in situations where crops are not directly sprayed (directed sprays for weed control, pre-emergent or pre-sowing applications). The conclusion is supported by the results of confined crop rotation studies where soil residues were not taken up by crops.

Following use as a crop desiccant, diquat ion was the major component of the residue in flesh and skins of potato tubers and in rape seeds accounting for more than 70% of TRR in potatoes and 48% TRR in rape seeds. TOPPS was also detected in rape seed but represented less than 10% of the TRR. In plants, the majority of diquat-related residues in crops are accounted for in the previous residue definition; diquat ion.

Based on the above the Meeting confirmed the previous residue definition for compliance with MRLs and estimation of dietary intake for plant commodities.

Definition of the residue for compliance with MRL and estimation of dietary intake (animal and plant commodities): *diquat ion*

The residue is not fat soluble.

Results of supervised residue trials on crops

The Meeting received supervised residue trial data for diquat on citrus fruits, pome fruits, strawberries, banana, tomato, pulses, carrots, potatoes, rape, sunflower and coffee as well as for some animal feed commodities.

As no data were available for alfalfa fodder, barley, maize, oats, rice, sorghum and wheat the the Meeting agreed to withdraw previous recommendations for these commodities.

A range of uses for diquat involve the application to weeds growing under trees in a variety of countries. The Meeting noted the results of soil aerobic metabolism and confined rotational crop studies that show that diquat in soil is not available for plant uptake. As application to weeds growing under trees is not expected to result in residues in harvested commodities the Meeting decided to evaluate the use on tree crops together, using the data on the crops supplied as mutual support for recommendations for those commodities with approved use-patterns. Diquat is approved for weed control in citrus fruit (Brazil, Costa Rica, Dominican Republic), pome fruit (Slovakia), banana/plantain (Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Nicaragua, Panama), cashews (Dominican Republic), coffee (Belize, Brazil, Costa Rica, Dominican Republic, El Salvador, Guatemala, Nicaragua, Panama), stone fruit (Slovakia) and also apple and other fruit trees (Canada, USA).

Tree crops (application to weeds)

Field trials involving citrus orchards where diquat was applied to weeds were conducted in Brazil and were available to the Meeting.

The GAP for citrus in Brazil is application directed to weeds at 0.5 kg ai/ha with a PHI of 14 days. In the trials matching this GAP diquat residues in ranked order were (n=3): < 0.01 (2), < 0.02 mg/kg. Residues in trials on citrus that utilized rates higher than permitted in Brazil were < 0.01 (2) mg/kg.

Field trials involving apples were conducted in Europe were made available to the Meeting. The GAP for apples in Slovakia is application directed to weeds at 1.0 kg ai/ha with a PHI not specified (unnecessary). In twelve trials matching this GAP and with PHIs ranging from 0 to 171 days residues were (n=12): < 0.01 (10), < 0.05 (2) mg/kg.

Diquat is permitted to be used for weed control in banana plantations in various countries of central America (Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Nicaragua, Panama) with an application rate of 0.6 kg ai/ha and no PHI required. In six trials from Costa Rica, Ecuador and Guatemala that matched GAP residues were < 0.05 mg/kg.

Diquat is approved in a range of Central and South American countries for weed control in coffee plantations including Belize, Brazil, Costa Rica, Dominican Republic, El Salvador, Guatemala, Nicaragua and Panama with maximum application rate of 0.5–0.6 kg ai/ha and a PHI typically 0 days. In trials from Costa Rica and Guatemala residues in coffee beans were < 0.05 (6) mg/kg.

The Meeting concluded that residues of diquat are not expected in harvested commodities from tree crops when application is to the weeds. The Meeting considered an LOQ of 0.02 mg/kg achievable and decided to estimate an STMR of 0 mg/kg, an HR of 0 mg/kg and a maximum residue level of 0.02 (*) mg/kg for citrus fruit, pome fruit, banana and coffee beans and to extrapolate the values to cashew apple (including cajou), cashew nuts and stone fruit.

Berries and other small fruit (application to weeds)

Strawberries

Trials were available from the UK. The GAP for strawberry in Sweden is a single application to weeds at 0.5 kg ai/ha before flowering or after harvest (use of spray shield) with no PHI required.

Residues in three trials from the UK at > 1.4 times the GAP of Sweden were: < 0.05 (3) mg/kg.

The Meeting utilized trials approximating the GAP of Sweden to estimate a maximum residue level for strawberries. Noting the exaggerated rates used in the three trials, the long interval between application and harvest and the requirement for a physical barrier when spraying, the Meeting estimated a maximum residue level of 0.05 * mg/kg, an STMR of 0 mg/kg and an HR of 0 mg/kg for strawberries.

Fruiting vegetables other than Cucurbits

Diquat is permitted to be used for weed control in row crops (includes tomatoes) in Spain with an application rate of 0.45 kg ai/ha and using spray protectors or shields, PHI 15 days.

Only one trial utilized a spray screen. The application rate was 2 times the GAP of Spain and residues were < 0.01 mg/kg. In another seven trials where the application rate was 2 times the maximum application rate of Spain and that did not use a spray shield the residues were also < 0.01 (7) mg/kg. The Meeting considered there is no expectation of residues above the LOQ for tomatoes and agreed to extrapolate the conclusion to fruiting vegetables other than cucurbits except sweet corn and fungi.

The Meeting estimated a maximum residue level of 0.01* mg/kg, an STMR of 0 mg/kg and an HR of 0 mg/kg for fruiting vegetables, other than cucurbits (except sweetcorn, fungi and mushrooms).

Pulses (pre-harvest desiccation)

Residue data from trials in common beans were made available from Germany and the USA for pre-harvest desiccation. The use pattern in Germany is 0.6 kg ai/ha with a PHI of 5 days. Analytical recoveries reported for trials from Germany on beans were low making the trials unsuitable for estimating maximum residue levels. The use pattern in Canada is for pre-harvest desiccation of beans at up to 0.41 kg ai/ha for ground application and 0.55 kg ai/ha for aerial application with a PHI of 4 days. In eight trials conducted in the USA approximating Canadian GAP residues were < 0.05 (8) mg/kg. The Meeting estimated an STMR of 0.05 mg/kg and a maximum residue level of 0.05* mg/kg for beans, dry replacing the previous recommendation of 0.2 mg/kg.

In Canada, diquat is permitted for pre-harvest desiccation of peas at up to 0.41 kg ai/ha for ground application and 0.55 kg ai/ha for aerial application with a PHI of 4 days. In five trials conducted in the USA approximating Canada GAP residues were: 0.05, 0.05, 0.09, 0.11 and 0.56 mg/kg. The Meeting considered five trials insufficient to estimate a maximum residue level for peas dry.

Pre-harvest desiccation sprays are permitted in Slovakia on peas at up to 0.8 kg ai/ha with a PHI of 6 days. In nine trials conducted in Europe, residues following a pre-harvest desiccation application at 0.6 kg ai/ha and after a 6 day PHI were: 0.03, 0.04, 0.04, 0.04, 0.05, 0.05, 0.06, 0.10, 0.15 mg/kg. The Meeting estimated an STMR of 0.05 mg/kg and a maximum residue level of 0.3 mg/kg for peas, dry confirming the previous recommendation.

In Canada, pre-harvest desiccation sprays are permitted in lentils at up to 0.41 kg ai/ha for ground application and 0.55 kg ai/ha for aerial application with a PHI of 4 days. In three trials conducted in USA with application at 0.42 kg ai/ha residues were < 0.05, 0.13 and 0.54 mg/kg at 4 days after application. The Meeting considered three trials insufficient to estimate a maximum residue level for diquat in lentils and withdrew its previous recommendation of 0.2 mg/kg.

In Canada, pre-harvest desiccation sprays are permitted in soya beans at up to 0.56 kg ai/ha with a PHI of 4 days. In seven trials conducted in USA at 0.56 kg ai/ha residues were < 0.01, 0.02, 0.03, 0.03, 0.04, 0.09, 0.16 mg/kg in samples harvested 7 to 10 days after application. The Meeting noted there was little decline in residues between 4 and 10 days and decided to use the data to estimate an STMR of 0.03 mg/kg and a maximum residue level of 0.3 mg/kg for soya beans (dry) replacing its previous recommendation of 0.2 mg/kg.

Carrots (directed application for weed control)

In Spain diquat is approved for general weed control in row crops including carrots (GAP: 0.45 kg ai/ha using spray protectors, PHI 15 days). In three trials in Germany and Italy that used spray shields and with application rates that were two times GAP of Spain residues were: 0.01, < 0.02, < 0.02 mg/kg.

The Meeting considered three trials insufficient to estimate a maximum residue level for carrots.

Potato (pre-harvest desiccation)

Diquat is approved for pre-harvest desiccation of potato crops in various countries. Pre-harvest desiccation use-patterns approved in various countries include Austria (GAP: 0.5 kg ai/ha, PHI 10 days), Brazil (GAP 0.5 kg ai/ha, PHI 7 days), Canada (GAP 2×0.84 kg ai/ha, PHI 0 days), Germany (GAP: 1 kg ai/ha, PHI 10 days), the Netherlands (GAP: 0.8 kg ai/ha, max 2 sprays and 1 kg ai/ha per crop, PHI 0 days), Spain (GAP: 0.8 kg ai/ha, PHI 15 days), the UK (GAP: 1.0 kg ai/ha, max 2 sprays and 1 kg ai/ha per crop, PHI 0 days or 14 days if storing potatoes) and the USA (GAP:0.56 kg ai/ha, PHI 7 days).

In trials in Europe approximating the GAP of the UK residues were: < 0.01 (10), 0.01, 0.01, 0.01, 0.01, 0.02, 0.02 mg/kg.

In trials conducted according to the GAP of USA residues were: < 0.05 (6), 0.06, 0.06 mg/kg.

Using the residue data from the USA, the Meeting estimated an STMR of 0.05 mg/kg, an HR of 0.06 mg/kg and a maximum residue level of 0.1 mg/kg for potato replacing the previous recommendation of 0.05 mg/kg.

Rape seed, (pre-harvest desiccation)

Diquat is approved for pre-harvest desiccation of oilseed rape in Austria (GAP: 0.6 kg ai/ha, PHI 5 days), Canada (GAP: 0.41 kg ai/ha, PHI 14 days), Germany (GAP: 0.6 kg ai/ha, PHI 5 days), the UK (GAP: 0.6 kg ai/ha, PHI 7-10 days) and the USA (GAP: 0.56 kg ai/ha, PHI 7 days).

Residues in rape seeds from trials conducted in Europe approximating German GAP were (n=12): 0.02, 0.03, 0.03, 0.05, 0.06, 0.07, 0.08, 0.10, 0.12, 0.22, 0.27, 0.33, 0.38, 0.42, 0.44, 0.45 mg/kg.

In trials approximating GAP in the USA total residues in rape seeds were (n=9): 0.06, 0.24, 0.30, 0.30, 0.46, 0.48, 0.52, 0.72, 0.82 mg/kg.

The Meeting considered the trials from the USA would lead to the higher maximum residue level and estimated an STMR of 0.49 mg/kg and a maximum residue level of 1.5 mg/kg for rape seed replacing its previous recommendation of 2 mg/kg.

Sunflower seed (pre-harvest desiccation)

Diquat is approved for pre-harvest desiccation of sunflowers in Canada (GAP: 0.41 kg ai/ha, PHI 15 days) and Slovakia (GAP: 0.6 kg ai/ha, PHI 6 days). Residues in trials from France approximating Slovakian GAP were (n=13): < 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.11, 0.15, 0.19, 0.41, 0.46, 0.54 mg/kg.

The Meeting estimated an STMR of 0.11 mg/kg and a maximum residue level of 0.9 mg/kg for sunflower seed replacing its previous recommendation of 1 mg/kg.

Animal feeds

Pea fodder (pre-harvest desiccation)

Residue levels occurring in pea straw were evaluated. In four trials conducted in the UK approximating GAPs in Austria (0.6 kg ai/ha, PHI 5 days) and France (0.6 kg ai/ha, PHI 4 days) residues in pea straw were 3.6, 14, 18, 25 mg/kg all on an as received basis. The Meeting estimated median and highest residues of 16 and 25 mg/kg on an as received basis for residues of diquat in pea straw.

The Meeting estimated a median residue of 16 mg/kg, a highest residue of 25 mg/kg (both on an as received basis) and a maximum residue level of 50 mg/kg for pea fodder (on a dry weight basis).

The Meeting received two trials conducted in France that measured residues in soya bean forage. The meeting considered two trials insufficient to make recommends for soya bean forage.

Fate of residues during processing

The Meeting received information on the fate of incurred residues of diquat during the processing of soya bean, oilseed rape/canola and sunflower seeds. Studies of the hydrolysis of diquat under a range of conditions showed diquat is stable.

Summary of selected processing factors for diquat

Raw commodity	Processed commodity	Individual PF	Best estimate PF	$STMR_{RAC}$ (mg/kg)	$STMR_{RAC}$ × PF (mg/kg)
Soya bean	Hulls	2.6 3.6	3.1	0.03	0.093
	Meal	0.7 1.0	0.85		0.0255
	Oil	< 0.04 < 0.07	< 0.055		< 0.00165
Rape/canola	Meal	0.17 0.20 0.58 0.76	0.39	0.49	0.19

Raw commodity	Processed commodity	Individual PF	Best estimate PF	$STMR_{RAC}$ (mg/kg)	$STMR_{RAC}$ × PF (mg/kg)
	Oil	< 0.01 < 0.01 < 0.03 < 0.03	< 0.02		< 0.0098
Sunflower seed	Oil	< 0.1 < 0.1 < 0.1 < 0.5 < 0.6 < 0.6 < 0.7 < 0.8 < 0.8 <1	< 0.6	0.11	< 0.066
	Cake	1 1 1.2 1.2 1.2 1.2 1.3 1.3 1.3 1.3	1.2		0.132

Residues are not expected in oils obtained from treated crops.

Residues in animal commodities

Farm animal feeding studies

The Meeting received information on the residue levels arising in tissues and milk when dairy cows were fed a diet containing incurred residues of diquat at dietary levels of 18, 50 and 84 ppm for 30 consecutive days. There were no residues of diquat at or above the LOQ (0.001 mg/kg) in any of the milk samples from any of the dose groups, throughout the duration of the study. There were no residues of diquat at or above the LOQ (0.01 mg/kg) in any of the tissue samples (liver, kidney, fat and muscle) from any of the dose groups.

The Meeting also received information on the residue levels arising in tissues and eggs, when laying hens were fed a diet containing diquat at total dietary levels of 1, 5 and 10 ppm diquat for 21 or 28 consecutive days. No residues of diquat above the LOQ (< 0.01 mg/kg) were found in any of the egg, fat, muscle, skin, liver or heart samples.

Animal commodity maximum residue levels

Dietary burden calculations for beef cattle and dairy cattle and poultry are provided below. The dietary burdens were estimated using the OECD diets listed in Appendix IX of the 2009 edition of the FAO Manual.

Summary of livestock dietary burden (ppm of dry matter diet)

	US-Canada		EU		Australia		Japan	
	max	mean	Max	Mean	max	Mean	max	Mean
Beef cattle	0.12	0.09	7.3	4.7	28 [a]	18 [c]	0.09	0.09
Dairy cattle	2.9	1.9	8.7	5.6	20 [b]	13 [d]	0.09	0.09
Poultry Broiler	0.06	0.06	0.11	0.10	0.08	0.08	0.04	0.04
Poultry Layer	0.06	0.06	2.9 [e]	1.9 [f g]	0.08	0.08	0.05	0.05

[a] Highest maximum beef or dairy cattle dietary burden suitable for MRL estimates for mammalian meat

[b] Highest maximum dairy cattle dietary burden suitable for MRL estimates for mammalian milk

[c] Highest mean beef or dairy cattle dietary burden suitable for STMR estimates for mammalian meat.

[d] Highest mean dairy cattle dietary burden suitable for STMR estimates for milk.

[e] Highest maximum poultry dietary burden suitable for MRL estimates for poultry meat and eggs.

[f] Highest mean poultry dietary burden suitable for STMR estimates for poultry meat.

[g] Highest mean poultry dietary burden suitable for STMR estimates for poultry eggs.

Animal commodity maximum residue levels

The Meeting concluded that at the maximum estimated dietary burdens for cattle of 28 ppm and 2.9 ppm for poultry no residues are expected in tissues, milk and eggs.

The Meeting estimated HR and STMR values of 0 for milk, muscle, edible offal and fat. The Meeting estimated the following maximum residue levels: milk 0.001* mg/kg; meat (mammalian except marine mammals) 0.01* mg/kg and edible offal 0.01* mg/kg to replace its previous recommendations of: milk 0.01 mg/kg; meat (mammalian except marine mammals) 0.05 mg/kg and edible offal 0.05 mg/kg.

For poultry no residues are expected. The Meeting estimated the following maximum residue levels for poultry commodities: poultry meat 0.01* mg/kg; poultry edible offal 0.01* mg/kg and eggs 0.01* mg/kg to replace its previous recommendations of: eggs 0.05 mg/kg; poultry meat 0.05 mg/kg and poultry edible offal 0.05 mg/kg.

The Meeting estimated the following STMR values: poultry meat 0 mg/kg; poultry fat 0 mg/kg; poultry edible offal 0 mg/kg and eggs 0 mg/kg.

RECOMMENDATIONS

On the basis of the data obtained from supervised residue trials the Meeting concluded that the residue levels listed below are suitable for establishing maximum residue limits and for IEDI and IESTI assessment.

Definition of the residue for compliance with MRL and for estimation of dietary intake (for animal and plant commodities):

Definition of the residue for compliance with MRL and estimation of dietary intake (for animal and plant commodities): *Diquat ion.*

The residue is not fat soluble.

DIETARY RISK ASSESSMENT

Long-term intake

The WHO Panel of the 2013 JMPR established an Acceptable Daily Intake (ADI) of 0–0.006 mg/kg bw for diquat.

The evaluation of diquat resulted in recommendations for MRLs and STMR values for 30 raw and processed commodities. Where data on consumption were available for the listed food commodities, dietary intakes were calculated for the 13 GEMS/Food Consumption Cluster Diets. The results are shown in Annex 3.

The IEDIs in the thirteen Cluster Diets, based on the estimated STMRs were 0–4% of the maximum ADI (0.006 mg/kg bw). The Meeting concluded that the long-term intake of residues of diquat from uses that have been considered by the JMPR is unlikely to present a public health concern.

Short-term intake

The WHO Panel of the 2013 JMPR established an Acute Reference Dose (ARfD) of 0.8 mg/kg bw for diquat. The IESTIs represented 0% of the ARfD of 0.8 mg/kg bw.

The Meeting concluded that the short-term intake of residues of diquat resulting from uses that have been considered by the JMPR is unlikely to present a public health concern.