MONURON

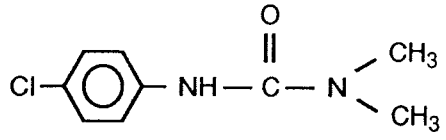
This substance was considered by a previous Working Group, in 1976 (IARC, 1976). Since that time, new data have become available, and these have been incorporated into the monograph and taken into consideration in the present evaluation.

1. Exposure Data

1.1 Chemical and physical data

1.1.1 *Synonyms, structural and molecular data*

Chem. Abstr. Serv. Reg. No.: 150-68-5
Chem. Abstr. Name: *N'*-(4-Chlorophenyl)-*N*,*N*-dimethylurea
IUPAC Systematic Name: 3-(4-Chlorophenyl)-1,1-dimethylurea; 3-(4-chlorophenyl)-1,1-dimethyluronium trichloroacetate
Synonyms: Chlorfenidim; *N*-(*para*-chlorophenyl)-*N'*,*N'*-dimethylurea; *N*-(4-chlorophenyl)-*N'*,*N'*-dimethylurea; 1-(4-chlorophenyl)-3,3-dimethylurea; 1-(*para*-chlorophenyl)-3,3-dimethylurea; 3-(*para*-chlorophenyl)-1,1-dimethylurea; CMU; 1,1-dimethyl-3-(*para*-chlorophenyl)urea; 1,1-dimethyl-3-(4-chlorophenyl)urea; *N*,*N*-dimethyl-*N'*-(4-chlorophenyl)urea



$C_9H_{11}ClN_2O$ Mol. wt: 198.65

1.1.2 *Chemical and physical properties*

(*a*) *Description*: Colourless crystals with a slight odour (Budavari, 1989; Royal Society of Chemistry, 1989)
(*b*) *Melting-point*: 174-175°C (Royal Society of Chemistry, 1989)
(*c*) *Spectroscopy data*: Infrared (prism [10667]; grating [28355]), ultraviolet [20884] and nuclear magnetic resonance (proton [16056]) spectral data have been reported (Sadtler Research Laboratories, 1980).
(*d*) *Solubility*: Slightly soluble in water (230 mg/l at 25°C) and benzene (3 g/kg at 27°C); moderately soluble in methanol (177 g/kg at 25°C), ethanol, acetone (52 g/kg at 27°C); practically insoluble in hydrocarbon solvents (Budavari, 1989; Royal Society of Chemistry, 1989)
(*e*) *Vapour pressure*: 5×10^{-7} mm Hg [0.7×10^{-7} kPa] at 25°C (Budavari, 1989)

(*f*) *Stability*: Stable toward oxygen and moisture under ordinary conditions at neutral pH; elevated temperatures and more acid or alkaline conditions increase the rate of hydrolysis (Budavari, 1989; Royal Society of Chemistry, 1989)

(*g*) *Conversion factor for airborne concentration*[1]: $mg/m^3 = 8.12 \times ppm$

1.1.3 *Trade names, technical products and impurities*

Some examples of trade names are: Karmex Monuron Herbicide; Karmex W. Monuron Herbicide; Telvar; Telvar Monuron Weedkiller; Televar W. Monuron Weedkiller

Monuron is available as a technical product at 97% active ingredient (US Environmental Protection Agency, 1983). A technical-grade sample of monuron analysed by liquid chromatography contained small amounts of 1,3-bis(4-chlorophenyl)urea (0.78%) and diuron (0.34%) as impurities (Sidwell & Ruzicka, 1976).

Monuron has been formulated as a wettable powder and as granules of monuron or monuron trichloroacetate or as an oil/water miscible liquid concentrate containing monuron trichloroacetate plus 2,4-D (see IARC, 1987). In the USSR, the commercial product usually contains 99% of the active ingredient (Izmerov, 1984; Royal Society of Chemistry, 1986; Worthing & Walker, 1987). Isomeric compounds may be present as impurities when monuron is produced by direct halogenation of aryldialkylureas (Izmerov, 1984).

1.1.4 *Analysis*

Selected methods for the analysis of monuron in various matrices are given in Table 1.

Table 1. Methods for the analysis of monuron

Sample matrix	Sample preparation	Assay procedure[a]	Reference
Specified fruit and vegetables	Alkaline hydrolysis to release *para*-chloroaniline; diazotize; couple with *N*-(1-naphthyl)ethylene-diamine; clean-up and separate resulting dyes on cellulose column	TLC	US Food and Drug Administration (1989)
Residues	Hydrolyse to *para*-chloroaniline using sodium hydroxide; distil; acidify distillate; wash with hexane or dichloromethane; neutralize; extract with hexane	GC/FID	Zweig (1964)

[a]Abbreviations: GC/FID, gas chromatography/flame ionization detector; TLC, thin-layer chromatography

1.2 Production and use

1.2.1 *Production*

Monuron was introduced in 1952 (US National Toxicology Program, 1988) and is prepared by reaction of *para*-chlorophenylisocyanate with dimethylamine (Izmerov, 1984).

[1]Calculated from: mg/m^3 = (molecular weight/24.45) × ppm, assuming standard temperature (25°C) and pressure (760 mm Hg [101.3 kPa])

In 1973, production in the USA was 230-400 tonnes, but larger quantities were produced earlier when its use was permitted on food crops (IARC, 1976). Production of monuron and its trichloroacetate salt was discontinued in Israel in 1984 and in the USA in 1988 (Meister, 1990).

1.2.2 *Use*

Monuron is a non-selective systemic herbicide which inhibits photosynthesis and is applied either pre- or post-emergence. It has been used for the control of many grasses and weeds in non-cropland areas, such as rights-of-way, industrial sites and drainage ditch banks (US Environmental Protection Agency, 1975; US National Technical Information Service, Environmental Protection Agency, 1983; Worthing & Walker, 1987; Royal Society of Chemistry, 1989).

Izmerov (1984) reported that, in some countries, monuron was used on potatoes, soya beans, peas and beans. In the USSR, monuron has been used on non-crop areas at doses ranging from 20-30 kg/ha, and at lower application rates on certain crops. Crops to which it has been applied include cotton, sugar-cane, pip gardens, vineyards, tea plantations, apple and pear trees and citrus plants at least three years old. Monuron has also been used in combination with other herbicides, such as chlorpropham and simazine (see monograph, p. 495), to control resistant weeds.

1.3 Occurrence

1.3.1 *Air*

In the air of the working zone of a sower, the highest concentrations of monuron ranged from 8.6 to 11 mg/m^3; monuron vapours were not detectable in the breathing zone of a tractor driver (Izmerov, 1984).

1.3.2 *Water*

In one investigation of the persistence of monuron in river water, acetone solutions of monuron were injected into water samples, which were exposed to natural and artificial light at room temperature. By the end of one week, 40% of the monuron remained; at two weeks, 30%; at four weeks, 20%; and at eight weeks none was detected (US Environmental Protection Agency, 1975).

1.3.3 *Soil*

Phytotoxic concentrations of monuron disappeared from the soil within one year. When applied at non-selective rates for total vegetation control, e.g., on rights-of-way, it retained its phytotoxic activity for several seasons. Heavier applications (20-200 lb/acre [23-230 kg/ha]) required up to three years to dissipate (US Environmental Protection Agency, 1975).

Monuron moves fast in light (sandy loam) soils. At large doses and on soils with a high moisture content (up to 75%), it may penetrate as deeply as 40 cm. Monuron applied at rates of 20-60 kg/ha persists in soil for 1.7 years or longer. At an application rate of 1.8 kg/ha, all of an applied dose of monuron is broken down within 1 year; at 3.6 kg/ha, only 85-90% of the chemical decomposes within the same time. In the hottest months, 36% of an applied dose was degraded, compared to 14% in cool months (Izmerov, 1984).

1.3.4 *Plants*

When citrus plants were treated with monuron at a rate of 10-16 kg/ha, it was found to have accumulated to 0.21-0.41 mg/kg in leaves two months later, in May; in September, accumulation ranged from 0.12 to 0.2 mg/kg. At application rates as high as 16 kg/ha, the peel of unripe fruits exhibited levels of monuron ranging from 0.01 to 0.02 mg/kg; no residue was detected in ripe fruit (Izmerov, 1984).

1.4 Regulations and guidelines

In the USSR, the maximum allowable concentration of monuron in workplace air is 2 mg/m^3. In the air of communities, the maximum allowable single concentration is 0.02 mg/m^3. The maximum allowable concentration for drinking-water is 5 mg/l (Izmerov, 1984).

National pesticide residue limits for monuron in foods are presented in Table 2.

Table 2. National pesticide residue limits for monuron in foods[a]

Country	Residue limit (mg/kg)	Commodities
Austria	1.0	Asparagus
	0.2	Fruit, potatoes, other vegetables
	0.1	Cereals
	0.05	Other
Belgium[b]	0.5	Pome fruit, cabbages and related plants
	0.2	Other vegetables
	0.1	Grains
	0.05[c]	Other fruit
	0[d] (0.05)	Other foodstuffs of vegetable origin
Germany[e]	1.0	Asparagus
	0.2	Vegetables (except asparagus), potatoes, fruit
	0.1	Cereals
	0.05	Other foods of plant origin
Italy[f]	0.1	Fruit, vegetables
Kenya	7	Asparagus
	1.0	Avocados, citrus fruits, grapes, grapefruit, cottonseed, kumquats, lemons, limes, oranges, pineapple, spinach, sugar-cane, tangerines
Netherlands[b]	0.5	Cabbage, pome fruits
	0.2	Other vegetables
	0.1	Cereals, potatoes
	0.05[c]	Other fruit
	0[d] (0.05)	Other
Spain[g]	0.5	Asparagus
	0.2	Other vegetables
	0.05	Potatoes
	0.02	Other plant products

Table 2 (contd)

Country	Residue limit (mg/kg)	Commodities
USSR[h]	0.005	Vegetables, pears, apples, grapes, citruses, tea, cotton-seed oil
	0	Potatoes

[a]From Health and Welfare Canada (1990)
[b]Calculated as 4-chloroaniline
[c]This figure is also the lower limit for determining residues in the corresponding product according to the standard method of analysis; traces of residues below the lower limit indicated for determining residues may be found in the product.
[d]Residues should not be present; the number in parentheses is the lower limit for residue determination according to the standard method of analysis, this limit having been used to reach the no-residue conclusion.
[e]Including decomposition and reaction products that still contain the 4-chloroaniline group, calculated in total as 4-chloroaniline
[f]From Royal Society of Chemistry (1989)
[g]Sum of monolinuron, buturon and monuron, expressed as 4-chloroaniline; not registered for agricultural use
[h]From Izmerov (1984)

2. Studies of Cancer in Humans

No data were available to the Working Group.

3. Studies of Cancer in Experimental Animals

The Working Group was aware of two studies in rats (Hodge *et al.*, 1958; Rubenchik *et al.*, 1970) and one study in mice (Rubenchik *et al.*, 1970) that were reported in the previous monograph (IARC, 1976). They did not consider these studies informative for the evaluation.

Oral administration

Mouse: In a screening study on a large number of compounds, groups of 18 male and 18 female (C57Bl/6 × C3H/Anf)F_1 and (C57Bl/6 × AKR)F_1 mice, seven days of age, received 215 mg/kg bw commercial monuron (95% pure) in 0.5% gelatine by stomach tube daily [not adjusted for increasing body weight] up to four weeks of age; subsequently, they were fed 517 mg/kg of diet. The dose was the maximum tolerated dose for infant and young mice but not necessarily for adults. The experiment was terminated when the mice were about 78 weeks of age, at which time there was no difference in survival. A significant increase in the incidence of lung adenomas was observed in males of the second strain (6/16) compared with combined controls (9/90) [$p < 0.01$]; in gelatin controls the incidence was 2/18 (US National Technical Information Service, 1968; Innes *et al.*, 1969).

Groups of 50 male and 50 female B6C3F_1 mice, seven to nine weeks old, were fed 0, 5000 or 10 000 mg/kg of diet monuron (purity, > 99%) for 103 weeks. Mean body weights of

treated female mice were significantly lower than those of controls. Survival of both control and low-dose male and female mice was significantly shorter than that of the high-dose group. In male mice, a dose-related decrease in the incidences of hepatocellular adenomas or carcinomas (control, 12/50; low-dose, 8/49; and high-dose 6/50) ($p < 0.05$, trend test) was noted. In female mice, there was also a decrease in the incidence of hepatocellular tumours; however, this was not dose-related. The incidence of malignant lymphomas was significantly reduced in treated females (control, 16/50; low-dose, 8/50; and high dose, 7/50) ($p < 0.01$ life-table test for trend) (US National Toxicology Program, 1988).

Rat: Groups of 50 male and 50 female Fischer 344/N rats, seven weeks old, were fed 0, 750 or 1500 mg/kg of diet monuron (purity, > 99%) for 103 weeks. The mean body weights of treated male and female rats were lower than those of controls throughout the study. Survival rates were higher in treated than in control animals, since 11 control male rats died at week 93 due to a malfunction in the room thermostat. In male rats, administration of monuron was associated with an increase in the incidence of renal tubular-cell adenomas (control, 0/50; low-dose, 2/50; high-dose, 7/50) and of renal tubular-cell adenocarcinomas (control, 0/50; low-dose, 1/50; high-dose, 8/50). The combined incidence of renal tumours in males was: control, 0/50; low-dose, 3/50; and high-dose, 15/50 ($p < 0.001$, incidental tumour test for trend). No such tumour was observed in females. The most frequent other change observed in the kidney of both male and female treated rats was cytomegaly of renal tubular epithelial cells (nuclear enlargement, multiple nucleoli and nuclei with many anaplastic characteristics). In the liver, the combined incidence of neoplastic nodules or carcinoma in males was: 1/50 control, 6/49 low-dose and 9/50 high-dose (incidental tumour test, $p = 0.04$). Significant negative trends were noted in the incidences of mononuclear cell leukaemia in male and female rats, of adrenal gland phaeochromocytomas ($p < 0.01$) and thyroid C-cell carcinomas ($p < 0.04$) in male rats and of mammary gland fibroadenomas ($p < 0.02$) in female rats (US National Toxicology Program, 1988).

4. Other Relevant Data

4.1 Absorption, distribution, metabolism and excretion

4.1.1 *Humans*

No data were available to the Working Group.

4.1.2 *Experimental systems*

Monuron is metabolized mainly by oxidative *N*-demethylation and aromatic hydroxylation, but some chlorinated aniline derivatives are also produced (Ernst & Bohme, 1965; Ernst, 1969). The principal urinary metabolites in rats are *N*-(4-chlorophenyl)urea (14.5% of dose), *N*-(2-hydroxy-4-chlorophenyl)urea (6.5%), *N*-(2-hydroxy-4-chlorophenyl)-*N'*-methylurea (1.5%), *N*-(3-hydroxy-4-chlorophenyl)urea (2.2%), *N*-(4-chlorophenyl)-*N'*-methylurea, *N*-(2-hydroxy-4-chlorophenyl)-*N,N'*-dimethylurea and 2-acetamido-5-chlorophenol. The metabolite yields indicate that hydroxylation favours the 2-position rather than the 3-position. Phenolic metabolites were excreted in the urine as conjugates. 4-Chloro-2-hydroxyaniline was excreted as the *N*-acetyl conjugate.

The detection of 4-chloroaniline-haemoglobin adducts by gas chromatography-mass spectrometry (estimated to be equivalent to 0.56% of the dose in rats given 1 mmol/kg monuron orally) confirms the availability of an aromatic amine metabolite *in vivo* (Sabbioni & Neumann, 1990).

There is indirect evidence that the *N*-demethylation reaction occurs *via* a relatively stable *N*-hydroxymethyl intermediate, which has been identified from mouse hepatic microsomal incubates *in vitro* and as conjugates from mouse urine *in vivo* (Ross *et al.*, 1981).

4.2 Toxic effects

4.2.1 *Humans*

No data were available to the Working Group.

4.2.2 *Experimental systems*

The oral LD_{50} for monuron in rats was 1480-3700 mg/kg bw, and the dermal LD_{50} in rabbits was > 2500 mg/kg bw (Ben-Dyke *et al.*, 1970).

Rats fed monuron for two years at 25-2500 mg/kg per day in the diet (0.0025-0.25%) developed only mild toxicity at the higher dose; slight growth retardation, mild anaemia and, in females only, slight splenic and hepatic enlargement were observed (Hodge *et al.*, 1958). In subsequent feeding studies (US National Toxicology Program, 1988), at dietary intakes of monuron (> 99% pure) of up to 12 000 ppm (mg/kg) in Fischer 344 rats and 50 000 ppm (mg/kg) in $B6C3F_1$ mice for 13 weeks and 750 and 500 ppm (mg/kg) (rats) and 5000 and 10 000 ppm (mg/kg) (mice) for two years, the kidney, liver and lympho/haematopoietic systems were targets for toxicity. The lymphocytic and haematopoietic tissue atrophy seen in both rats and mice at high doses in the 13-week studies was not seen in the two-year feeding studies. In the two-year studies, renal tubular epithelial hypertrophy was noted at high incidence in rats (48/50 low-dose males and 50/50 high-dose males; 12/50 low-dose females and 49/50 high-dose females). The nuclei of these cells were greatly enlarged, had anaplastic features and were sometimes multiple. In mice, there was no remarkable kidney lesion. Dose-dependent hepatocytic changes and degeneration observed in males (but not females) of both species and splenic haemosiderosis in female rats were the only other toxic effects clearly related to treatment in the two-year studies.

Short-term (2-18 weeks) feeding of monuron at 450 mg/kg to rats caused hepatocyte mitochondrial changes associated with altered activity of glycolytic enzymes (Rubenchik *et al.*, 1969).

In dogs, feeding of monuron at 2.5-25 mg/kg bw per day in the diet for one year produced no toxicity attributable to treatment (Hodge *et al.*, 1958).

The number and volume fraction of enzyme-specific altered foci in rat liver were increased when monuron was used as a promoter (750 or 1500 ppm [mg/kg] in the diet) subsequent to a single injection of *N*-nitrosodiethylamine (10 mg/kg bw intraperitoneally) 24 h after partial hepatectomy. The incidence of foci was not increased when monuron was used as an initiator (125 or 250 mg/kg bw intraperitoneally in a single dose after partial hepatectomy) followed by promotion with dietary phenobarbital (Maronpot *et al.*, 1989).

4.3 Reproductive and developmental effects

No data were available to the Working Group.

4.4 Genetic and related effects (see also Table 3 and Appendices 1 and 2)

4.4.1 *Humans*

No data were available to the Working Group.

4.4.2 *Experimental systems*

Monuron did not induce gene mutation in bacteria or yeast but did in plants. In mouse lymphoma L5178Y cells, conflicting results were obtained for mutation at the *tk* locus. Chromosomal aberrations were induced in plants, insects and cultured mammalian cells. Monuron induced sister chromatid exchange and morphological transformation but not unscheduled DNA synthesis in cultured mammalian cells.

Administration of monuron to mice *in vivo* induced chromosomal aberrations and micronucleus formation in bone-marrow cells and increased the frequency of morphologically abnormal sperm.

5. Summary of Data and Evaluation

5.1 Exposure data

Monuron is a nonselective systemic herbicide which inhibits photosynthesis. It was introduced in 1952 and has been used for the control of grasses and weeds in non-cropland areas, such as rights-of-way, industrial sites and drainage ditch banks. It has been used at lower application rates in agricultural areas in some countries as a pre- or post-emergence herbicide.

Monuron has been formulated for use as wettable powder and granules.

Exposure may occur during its production and use and, at much lower levels, from consumption of foods containing residues.

5.2 Carcinogenicity in humans

No data were available to the Working Group.

5.3 Carcinogenicity in experimental animals

Monuron was tested adequately for carcinogenicity in one study in mice and in one study in rats by oral administration. No increase in tumour incidence was found in mice. In rats, dose-related increased incidences of renal and liver-cell tumours were observed in males.

5.4 Other relevant data

Monuron forms chloroaniline–haemoglobin adducts in rats. In one study, it increased the number and volume fraction of enzyme-positive foci in rat liver.

No data were available on the genetic and related effects of monuron in humans.

Table 3. Genetic and related effects of monuron

Test system	Result[a]		Dose[b] LED/HID	Reference
	Without exogenous metabolic system	With exogenous metabolic system		
SA0, *Salmonella typhimurium* TA100, reverse mutation	–	–	500.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SA0, *Salmonella typhimurium* TA100, reverse mutation	–	–	2500.0000	US National Toxicology Program (1988)
SA5, *Salmonella typhimurium* TA1535, reverse mutation	–	–	500.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SA5, *Salmonella typhimurium* TA1535, reverse mutation	0	+	1.5000	Seiler (1978)
SA5, *Salmonella typhimurium* TA1535, reverse mutation	–	–	2500.0000	US National Toxicology Program (1988)
SA7, *Salmonella typhimurium* TA1537, reverse mutation	–	–	500.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SA7, *Salmonella typhimurium* TA1537, reverse mutation	–	–	2500.0000	US National Toxicology Program (1988)
SA8, *Salmonella typhimurium* TA1538, reverse mutation	–	–	500.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SA9, *Salmonella typhimurium* TA98, reverse mutation	–	–	2500.0000	US National Toxicology Program (1988)
SAS, *Salmonella typhimurium*, reverse mutation	–	0	0.0000	Andersen *et al.* (1972)
ECW, *Escherichia coli* WP2 *uvr*A, reverse mutation	–	–	500.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SCG, *Saccharomyces cerevisiae* D7, gene conversion	–	–	40000.0000	US National Technical Information Service, Environmental Protection Agency (1984)

Table 3 (contd)

Test system	Result[a]		Dose[b] LED/HID	Reference
	Without exogenous metabolic system	With exogenous metabolic system		
SCH, *Saccharomyces cerevisiae* D3, homozygosis by mitotic recombination	-	-	50000.0000	US National Technical Information Service, Environmental Protection Agency (1977)
SCH, *Saccharomyces cerevisiae* D7, homozygosis by mitotic recombination	-	-	40000.0000	US National Technical Information Service, Environmental Protection Agency (1984)
SCR, *Saccharomyces cerevisiae* D7, reverse mutation	-	-	40000.0000	US National Technical Information Service, Environmental Protection Agency (1984)
HSM, *Hordeum vulgare*, mutation	+	0	1000.0000	Wuu & Grant (1966)
HSC, *Hordeum vulgare*, chromosomal aberrations	+	0	500.0000	Wuu & Grant (1966)
HSC, *Hordeum vulgare*, chromosomal aberrations	+	0	500.0000	Wuu & Grant (1967)
* *Anopheles stephensi*, chromosomal aberrations	+	0	10.0000	Sharma *et al.* (1987)
G5T, Gene mutation, mouse lymphoma L5178Y cells *in vitro*, *tk* locus	(+)	+	20.0000	US National Technical Information Service, Environmental Protection Agency (1984)
G5T, Gene mutation, mouse lymphoma L5178Y cells *in vitro*, *tk* locus	-	-	1100.0000	McGregor *et al.* (1988)
SIC, Sister chromatid exchange, Chinese hamster ovary cells *in vitro*	-	+	250.0000	US National Technical Information Service, Environmental Protection Agency (1984)
SIC, Sister chromatid exchange, Chinese hamster ovary cells *in vitro*	+	+	100.0000	US National Toxicology Program (1988)
CIC, Chromosomal aberrations, Chinese hamster ovary cells *in vitro*	-	+	1300.0000	US National Toxicology Program (1988)
TCS, Cell transformation, Syrian hamster cells *in vitro*	+	0	5.0000	Amacher & Zelljadt (1983)
UHF, Unscheduled DNA synthesis, human lung fibroblasts WI38 *in vitro*	-	-	200.0000	US National Technical Information Service, Environmental Protection Agency (1984)

Table 3 (contd)

Test system	Result[a]		Dose[b] LED/HID	Reference
	Without exogenous metabolic system	With exogenous metabolic system		
CBA, Chromosomal aberrations, mouse bone marrow *in vivo*	+	0	14.4000 × 3 i.p.	Sharma *et al.* (1987)
MVM, Micronucleus test, mouse bone marrow *in vivo*	-	0	2000.0000 × 2 p.o.	Seiler (1978)
MVM, Micronucleus test, mouse bone marrow *in vivo*	+	0	2000.0000 × 2, oral	US National Technical Information Service, Environmental Protection Agency (1984)
MVM, Micronucleus test, mouse bone marrow *in vivo*	+	0	14.4000 × 3 i.p.	Sharma *et al.* (1987)
SPM, Sperm morphology, mouse *in vivo*	+	0	14.4000 × 3 i.p.	Sharma *et al.* (1987)

*Not displayed on profile

[a] +, positive; (+), weakly positive; -, negative; 0, not tested; ?, inconclusive (variable response in several experiments within an adequate study)

[b] In-vitro tests, μg/ml; in-vivo tests mg/kg bw

Monuron induced micronucleus formation, chromosomal aberrations and abnormal sperm in mice *in vivo*. It induced chromosomal aberrations in cultured mammalian cells, insects and plants, sister chromatid exchange and cell transformation in cultured mammalian cells and mutation in plants.

5.5 Evaluation[1]

No data were available from studies in humans.

There is *limited evidence* in experimental animals for the carcinogenicity of monuron.

Overall evaluation

Monuron *is not classifiable as to its carcinogenicity to humans (Group 3).*

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[1]For definition of the italicized terms, see Preamble, pp. 26-28.

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