Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses

DICAMBA

Dicamba is a selective herbicide used for post-emergence weed control in a number of agricultural crops, including barley, canary grass, fescue, oats, rye, wheat, corn, and sorghum (Alberta Agriculture 1989). Target weeds include buckwheat, cleavers, cow cockle, lady's-thumb, corn spurry, smartweeds, bindweed, ragwort, goldenrod, thistles, knapweed, poverty weed, pasture sage, sheep sorrel, and spurge. It is also used for brush control in pastures, rangeland, forest lands, roadsides, railways, and utility rights-of-way and in turf to control the growth of broadleaf weeds, brush, and vines (OMAF 1989).

Dicamba has low persistence, with a mean half-life of approximately 25 d (Altom and Stritzke 1973). Dicamba dissipation depends on the application rate, soil moisture content, temperature, organic matter content, and type of soil (Burnside and Lavy 1966; Nash 1989). It has a low affinity for most soil types and the potential to be highly mobile in soils, with greater mobility evident at higher pH (Grover 1977; Murray and Hall 1989). Low soil–water partition coefficients (K_d) for dicamba (0–0.11 $mL\cdot g^{-1}$), coupled with a high water solubility, give dicamba the potential to leach through agricultural soils and contaminate groundwater sources (Grover 1977; Rao and Davidson 1980). Microbial degradation appears to be the most important process controlling the fate of dicamba in agricultural soils (Smith 1973, 1974; Krueger et al. 1989). Suitable conditions of pH, temperature, soil moisture, percent organic matter, and soil composition that promote microbial growth in soil generally favour herbicide dissipation (Torstensson 1988) and have been reported to favour dicamba degradation in soil (Krueger et al. 1989). Photodegradation, hydrolysis, and volatilization appear to be relatively minor routes of dicamba degradation in soils (Scifres et al. 1973; Chau and Thompson 1978).

For more information on the use, environmental concentrations, and chemical properties of dicamba, see the fact sheet on dicamba in Chapter 4 of *Canadian Environmental Quality Guidelines*.

Water Quality Guideline Derivation

The Canadian water quality guidelines for dicamba for the protection of agricultural water uses were developed based on the CCME protocol (CCME 1993a).

Irrigation Water

Data exist for each of the three principal groups of nontarget crops that are irrigated in Canada: cereals, tame hay, and pastures; legumes; and other crop species. Cereal crops were relatively resistant to dicamba. In wheat, a NOEAR of 0 and a LOEAR of 0.12 $kg\cdot ha^{-1}$ a.i. per year were reported, based on an increase in deformed wheat plant heads (Ivany and Nass 1984). In the legume group, the soybean NOEAR and LOEAR were 0 and 0.011 $kg\cdot ha^{-1}$ a.i., respectively, based on a decrease in total yield (Auch and Arnold 1978). Of the "other crop species" tested, sunflowers were the most sensitive, with a NOEAR and LOEAR of 0.0004 and 0.0008 $kg\cdot ha^{-1}$ a.i., respectively, based on significant decreases (20 and 42%) in the dry weight of seedlings (Derksen 1989).

The geometric means of the LOEAR and the NOEAR for the three principal groups were divided by an uncertainty factor of 10 to determine the acceptable application rate (AAR). The AARs are then divided by the approximate Canadian annual irrigation rate of 10^7 $L\cdot ha^{-1}$ per year to calculate the SMATC. The resulting SMATCs were adopted as the guideline for that crop group, namely 0.6 $\mu g\cdot L^{-1}$ for cereals, tame hays and pastures, 0.06 $\mu g\cdot L^{-1}$ for legumes, and 0.006 $\mu g\cdot L^{-1}$ for other crops. The lowest value of 0.006 $\mu g\cdot L^{-1}$ is recommended as the overall Canadian water quality guideline for irrigation (CCME 1993b). Since this guideline is at the lowest detection limit of dicamba in water (0.01 $\mu g\cdot L^{-1}$), it should be considered in conjunction with a site-specific evaluation until better analytical detection methods are developed.

Livestock Water

Dicamba is readily absorbed, only partially metabolized, and rapidly excreted by mammals (Makary et al. 1986).

Table 1. Water quality guidelines for dicamba for the protection of agricultural water uses (CCME 1993b).

Use	Guideline value ($\mu g\cdot L^{-1}$)
Irrigation water	0.006
Livestock water	122

Dicamba does not bioaccumulate to an appreciable extent in animals according to the data available (St. John and Lisk 1969; Oehler and Ivie 1980).

Dicamba is low to moderately toxic to mammals and birds. Acute oral toxicities of dicamba to mammals indicate that sensitivities are similar across taxonomic groups (Worthing and Hance 1991). Acute oral LD_{50}s for mice, guinea pigs, and rabbits ranged from 566 to >4600 $mg \cdot kg^{-1}$ (Hayes 1982; USDE 1983). Acute oral LD_{50}s of dicamba in birds ranged from 673 $mg \cdot kg^{-1}$ in female pheasants (Pimental 1971) to >10 000 $mg \cdot kg^{-1}$ in mallard ducks and bobwhite quail (Ghassemi et al. 1981).

Rabbits were more sensitive to the developmental effects of dicamba than any other mammalian or avian species. Reduced fetal body weights and post-implantation losses were observed at 10 $mg \cdot kg^{-1}$ per day. This study was used to establish a generic mammalian no-observed-effect dose (NOED) of 3 $mg \cdot kg^{-1}$ per day and a lowest-observed-effect dose (LOED) of 10 $mg \cdot kg^{-1}$ per day (Wazeter et al. 1977). The geometric mean of the NOED and LOED from this study was divided by an uncertainty factor of 100 to result in an acceptable daily intake (ADI) level of 55 $\mu g \cdot kg^{-1}$ per day. Multiplying the ADI by the ratio of the animal body weight to water intake yielded an RC of 611 $\mu g \cdot L^{-1}$. To account for exposure to dicamba from sources other than water, the lowest RC is multiplied by an apportionment factor of 0.2 to give a water quality guideline of 122 $\mu g \cdot L^{-1}$ for the protection of livestock (CCME 1993b).

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For further scientific information, contact:

Environment Canada
Guidelines and Standards Division
351 St. Joseph Blvd.
Hull, QC K1A 0H3
Phone: (819) 953-1550
Facsimile: (819) 953-0461
E-mail: ceqg-rcqe@ec.gc.ca
Internet: http://www.ec.gc.ca

For additional copies, contact:

CCME Documents
c/o Manitoba Statutory Publications
200 Vaughan St.
Winnipeg, MB R3C 1T5
Phone: (204) 945-4664
Facsimile: (204) 945-7172
E-mail: spccme@chc.gov.mb.ca

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