The Effect of Dilution Water Quality on Herbicide Efficacy

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Abstract

The antagonistic effect of Ca^{++} and Mg^{++} ions on the efficacy of glyphosate (Roundup) has been well documented for some time but there is relatively little information available on the effect of other ions on glyphosate or other herbicides. Field trials were conducted at Saskatoon in 1989 and 1990 to determine the effect of dilution water ion content on the efficacy of several herbicides. Water sources examined were: Saskatoon (surface, fresh, low mineralization), Goodale (artesian well, hard, high Ca^{++} + Mg^{++}), Zelma (well, hard, high Fe^{+++}), Outlook (well, soft, high Na^{+}), Unity (well, soft, medium HCO_3^-), Maple Creek (well, soft, high HCO_3^-) Recommended and less than recommended rates of selected herbicides were applied in four replicate field trials using standard flat fan nozzles that delivered 130 L/ha (1989) or 110 L/ha (1990) of spray mixture. Herbicide X water combinations that have resulted in reduced weed control as compared to Saskatoon water as the check are: glyphosate (Roundup) X Goodale or Zelma, sethoxydim (Poast) X Unity or Maple Creek, clethodim (Select) X Unity or Maple Creek, 2,4-D amine X Goodale, Outlook or Unity. Imazamethabenz (Assert) was not affected initially but plants treated with water from Unity or Maple Creek recovered more rapidly than those treated with Saskatoon water. Fenoxaprop-ethyl (Excel), 2,4-D ester, and glufosinate ammonium (Ignite, Harvest) were not affected by water source.

Introduction

Antagonism of several herbicides by various ions dissolved in herbicide dilution water has been reported in the scientific literature. Several cations such as Ca^{++}, Mg^{++}, Fe^{++}, Fe^{+++}, Na^{+}, Zn^{++} (Buhler and Burnside, 1983), Ca^{++} (Sandberg et al., 1978, Shea and Tupy, 1984), Al^{+++} (Stahlman and Phillips, 1979) and Fe^{++}, Fe^{+++} and Al^{+++} (Hensley et al, 1978) have all been shown to reduce the efficacy of glyphosate. Other compounds such as sodium bicarbonate have been reported to reduce the efficacy of sethoxydim (Nalewaja et al, 1989), 2,4-D amine (Nalewaja et al, 1990) and glyphosate (Shea and Tupy, 1984).

On the other hand, some ions enhance the efficacy of certain herbicides and may be used to overcome the antagonistic effects of other dissolved ions. Ammonium sulphate (21-0-0-24) fertilizer, ammonium nitrate (34-0-0) fertilizer or a mixture of urea and ammonium nitrate (28-0-0 liquid fertilizer) have been reported to improve the efficacy of sethoxydim (Nalewaja, 1989). Low concentrations of ammonium sulphate also improve the efficacy of glyphosate but concentrations >10% w/v were antagonistic (Turner and Loader, 1980). They also reported that ammonium sulphate and sodium sulphate enhanced the phytotoxicity of dichlorprop (Turner and Loader, 1984).

It also appears that the antagonistic effects of cations may be dependant on the anions with which they are associated. Wills and McWhorter (1985) reported that salts of zinc and iron reduced the efficacy of glyphosate but zinc phosphate and ferric phosphate did not.

These results from the literature and others not cited here suggest that mineral ions dissolved in water used for preparing herbicide spray mixtures can have a considerable negative or positive effect on the efficacy of various herbicides. However, this area is not yet well understood and, with the exception of glyphosate, there are no guidelines for farmers to follow in terms of the quality of the water they use for applying herbicides as it relates to ion content.

The purpose of this study was to determine if the high mineral ion concentrations commonly found in many Saskatchewan water sources are antagonistic towards some of the major herbicides used in the province. Water sources were chosen on the basis of known mineral content as determined by the soil salinity project recently completed by the Department of Soil Science at the University of Saskatchewan. The water sources examined and their mineral ion contents are shown in Table 1.

Table 1. Water Sources and Characteristics, Water Quality Field Experiments, 1989-90.

Location	uS/cm	ppm Ca+Mg	ppm Bicarb	ppm Iron
Saskatoon	380	50	50	<1
Goodale	3000	395	517	5
Zelma	1200	137	604	>10
Outlook	9500	127	185	low
Unity	1700	7	675	n.d.
M. Creek	1900	3	956	n.d.

Saskatoon water is obtained from the City of Saskatoon water supply and is typical of mountain fed river systems. Goodale water is hard and is from an artesian well typical of glacial intertill aquifers. Zelma water has low mineralization but has high iron content. Many intertill glacial aquifers are very hard and also contain high iron. When exposed to air, much of the iron precipitates and this precipitate may act in the same manner as other particulate matter. Outlook water is the most highly mineralized but nearly all the minerals are NaCl and so it is classified as soft. Unity water represents a soft, medium bicarbonate water that has low sulphate and chloride content. Maple Creek water is high in bicarbonate but has almost no sulphate or chloride.

MATERIALS AND METHODS:

Field experiments were conducted at the Kernen Crop Research Farm in 1989 and 1990. Treatments were arranged in split-plot designs with four replications with water sources constituting the main-plots and herbicide treatments the sub-plots. Treatments were applied with bicycle wheel small plot sprayers equipped with four 80^0 flat fan nozzles that delivered a total spray volume of 130 L/ha (1989) and 110 L/ha (1990) when operated at a pressure of 275 kPa and 5 kmh. Herbicides were applied over a range of rates with the maximum rate being the recommended label rate. High water volumes and sub-label herbicide rates were used to increase the chances of detecting low levels of antagonism. Canola was used as the test species for the 2,4-D trials and tame oat was used for the grass killer trials. Herbicides were applied at the latest recommended stage to improve the likelihood of detecting low levels of antagonism. Treatments were assessed using a combination of visual ratings for weed control as approved by the Expert Committe on Weeds (Western Canada Section) and by whole plant dry matter sampling approximately two and six weeks after treatment. In 1989, canola seed yield was determined because a high proportion of plants survived and set seed. The water sources described above were tested with various herbicides during the two year period. However, not all possible water X herbicide combinations due to a lack of space and time. The Saskatoon water source was included as a check in all tests.

RESULTS AND DISCUSSION:

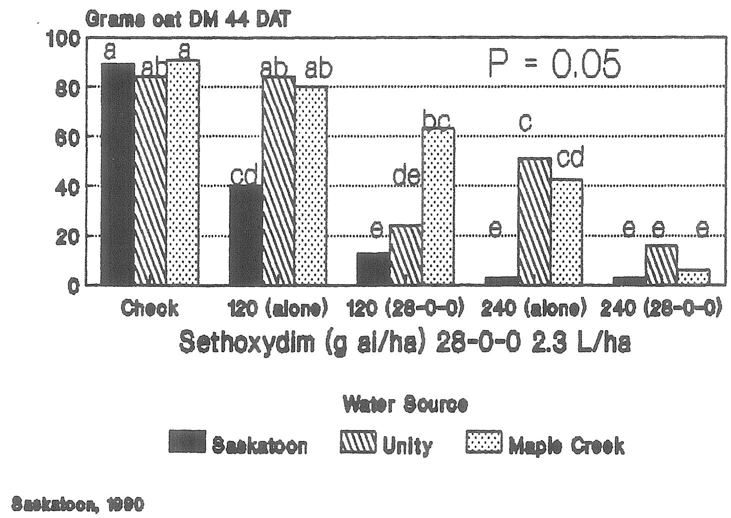
Sethoxydim (Poast), clethodim (Select), glyphosate (Roundup) and 2,4-D amine were antagonized by one or more water sources and results obtained with each are presented.

Sethoxydim

The effect of bicarbonate ion and the adjuvant, ammonium nitrate + urea (1:1) (commercial 28-0-0 liquid fertilizer), on the control of tame oat is shown in Figure 1.

Medium and high bicarbonate ion concentration reduced the control of oat by a similar amount when the herbicide was applied at the recommended rate or at one-half the recommended rate. The addition of 28-0-0 at 2.3 L/ha overcame this antagonism at the recommended rate of sethoxydim. At one-half the recommended rate of herbicide, the addition of 28-0-0 overcame the antagonism caused by medium bicarbonate water but was not effective in the high bicarbonate water. The addition of 28-0-0 to the Saskatoon water source significantly improved control with the half rate of herbicide even though antagonism was not a factor.

Fig. 1 Effect of water source and adjuvant on control of oat with sethoxydim.



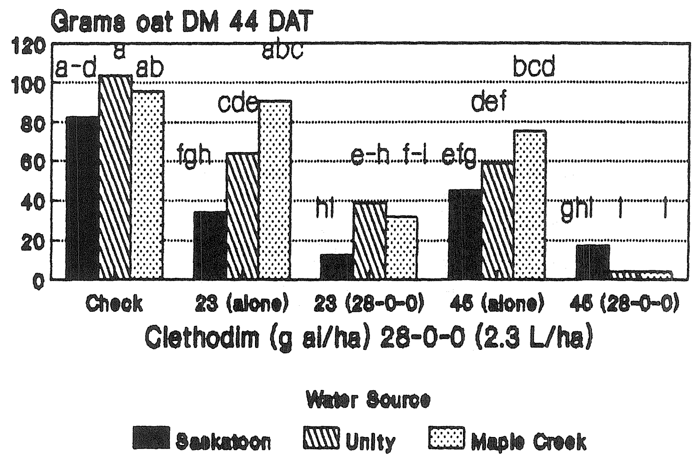
Clethodim

Clethodim is an experimental herbicide with chemical properties similar to sethoxydim. It will be marketed under the trade name Select, if and when it recieves registration. As shown in Figure 2. the response of clethodim to bicarbonate ion was very similar to that of sethoxydim.

Glyphosate

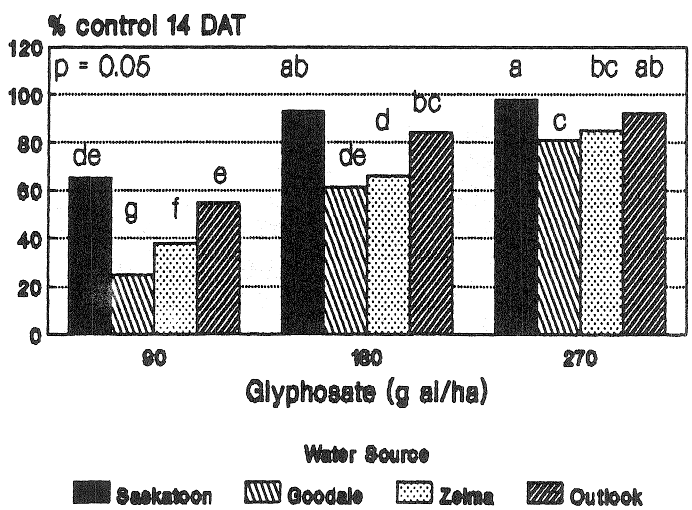
Glyphosate was tested in waters containing Ca + Mg, Fe or NaCl. Based on visual assessments 14 days after treatment (Figure 3), water sources containing either Ca + Mg or Fe resulted in some antagonism with Ca + Mg appearing to be more antagonistic than Fe. Similar effects were noted when dry matter production 44 days after treatment was measured (Figure 4). In this case, NaCl resulted in about the same degree of antagonism as did Fe.

Fig.2 Effect of water source and adjuvant on control of oat with clethodim.



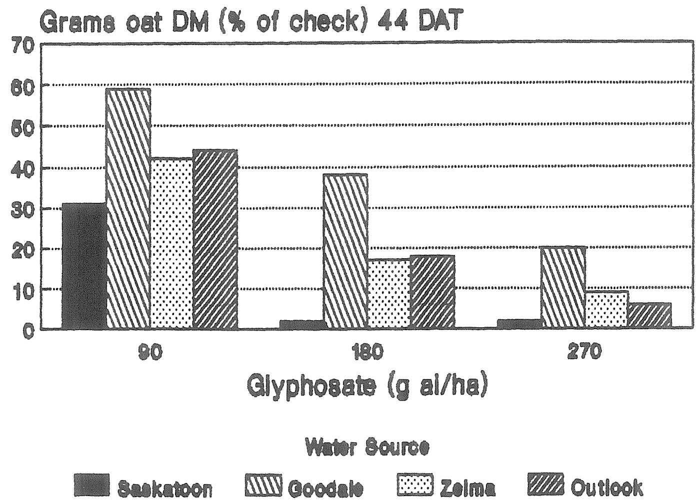
Saskatoon, 1990

Fig.3 Effect of water source on control of oat with glyphosate.



Saskatoon, 1990

Fig.4 Effect of water source on control of oat with glyphosate.

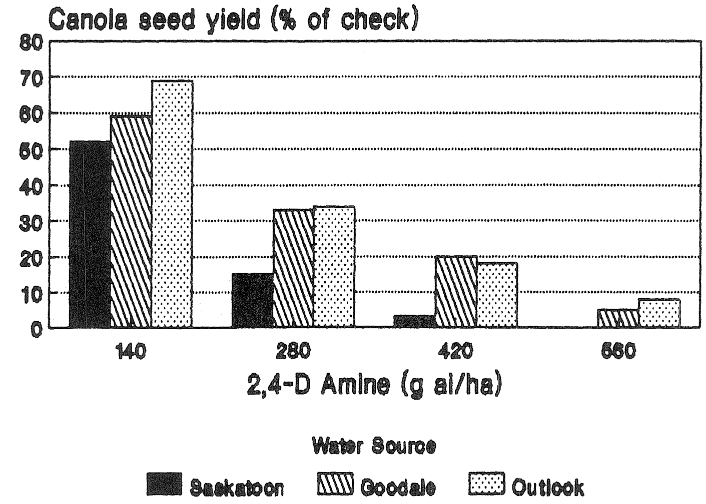


Saskatoon, 1990

2,4-D Amine

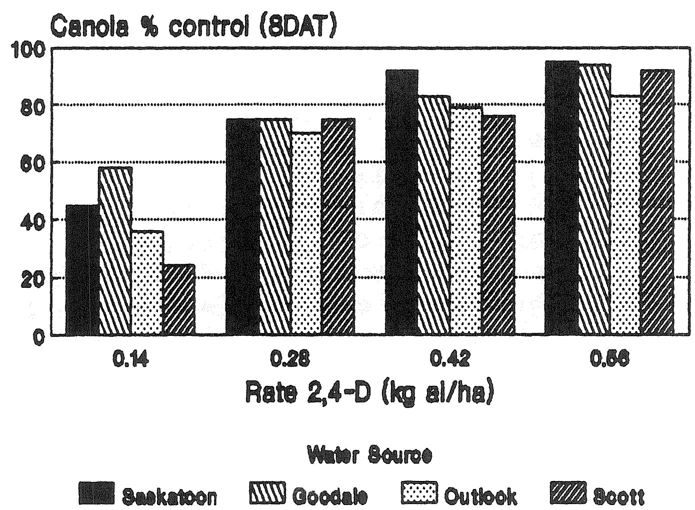
Field tests were conducted in both years. In 1989, the efficacy of this product was reduced by a similar amount by waters containing Ca + Mg or NaCl as shown in Figure 5. The degree of antagonism was substantial and was evident throughout the growing season across the range of rates tested. In 1990, water containing a medium level of bicarbonate was added to this test and results were somewhat different than those obtained the previous year. Slight antagonism due to NaCl and bicarbonate was apparent eight days after treatment only at the lowest rate of 2,4-D application. This effect was temporary and was not reflected in dry matter production measured later in the season. Water containing Ca + Mg did not antagonize 2,4-D amine in 1990. The different results obtained in the two years may be due to the fact that growing conditions were more favorable in the first half of the 1990 growing season and so the plants were more susceptible to herbicide injury than they were the year previous. 2,4-D ester was tested in identical experiments in both years. None of the waters tested antagonized this formulation.

Fig.5 Effect of water source on efficacy of 2,4-D amine.



Saskatoon, 1989

Fig.6 Effect of water source on efficacy of 2,4-D amine.



Saskatoon, 1990

Summary and Conclusions

Several common Saskatchewan ground water sources have been shown to antagonize a number of commonly used herbicides. Sethoxydim (Poast) and clethodim (Select) are antagonized by well water from Unity and Maple Creek that contains moderate and high levels of bicarbonate, respectively. Glyphosate is antagonized by water containing Ca + Mg (Goodale), Fe (Zelma) and possibly NaCl (Outlook). 2,4-D amine is antagonized by water containing Ca + Mg, NaCl or bicarbonate. Products which do not appear to be affected by water source on the basis of prelininary testing (data not shown) are diclofop-methyl (Hoe-Grass), fenoxaprop-ethyl (Excel, Laser, Puma), imazamethabenz (Assert) glufosinate ammonium (Ignite, Harvest), diquat (Reglone) and 2,4-D ester.

The degree to which mineral ion induced antagonism is manifested in poor weed control throughout the province is still unknown but it appears that it could be a significant problem. Considerably more research will be necessary to screen other water X herbicide combinations and to investigate methods of reducing the antagonistic effects of problem waters. Before specific guidelines can be prepared, it will be necessary to further document the degree of antagonism caused by each water source and to define the conditions under which it is most likely to occur. The puzzle is a complex one which is compounded because the level of antagonism appears to be related to growing conditions and may also be related to the stage of weed growth at the time of applicaton.

In the absence of specific guidelines for particular water sources, farmers who suspect they may be using an antagonistic water should consider the following:

(1) Send a water sample to the Saskatchewan Soil Testing Lab for an irrigation water test if the ion content of the water is unknown.
(2) Seek a more suitable water source if that is a practical alternative.
(3) If (2) is not feasible, use the minimum amount of water/acre necessary to obtain good weed coverage and maintain adequate crop safety.
(4) Use the maximum recommended herbicide rate.
(5) Use adjuvants as recommended on product labels.
(6) Apply products as close to the optimum time as possible and avoid spraying in weather conditions that may further reduce the efficacy of the product.
(7) Use the ester formulation of 2,4-D rather than the amine wherever possible.

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