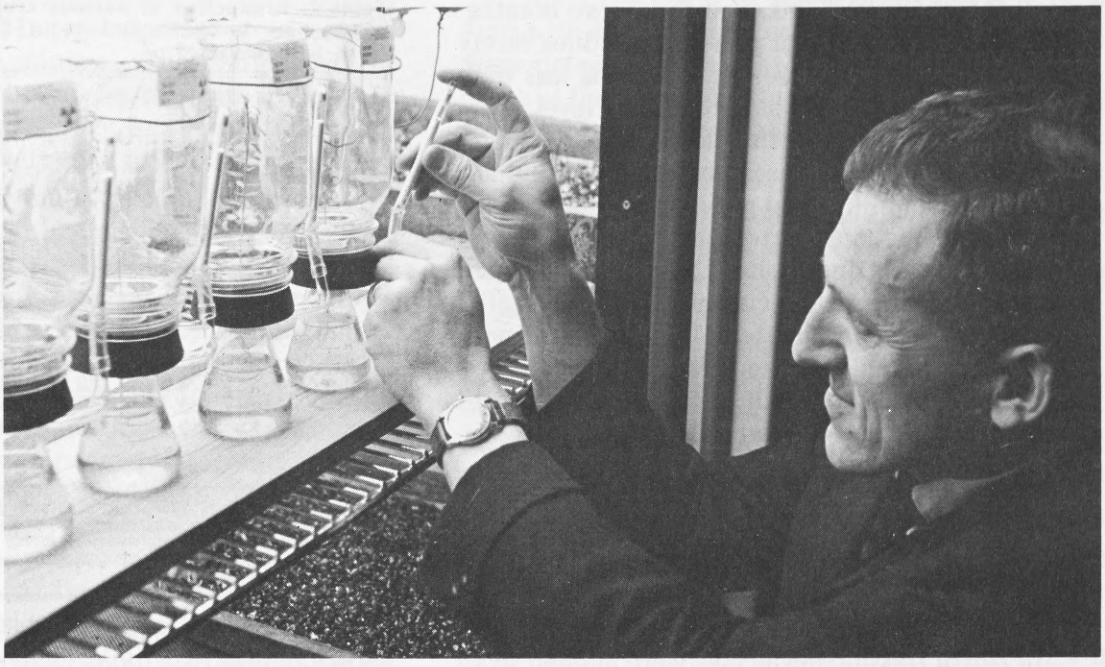

Dr. Nalewaja checks herbicide volatility from plants as influenced by spray solution additives.

HERBICIDES

in North Dakota's Environment

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In our "uptight society" of today, one must be relevant; and to be relevant, one must speak up, about or in regard to pollution. Pollution was born with the dawn of civilization, but now occupies front page attention as Americans contend with their problems.

Big city air smarts our eyes and chokes our lungs. Blotchy blue to ghastly green now often describes the deplorable to dangerous condition of many rivers and lakes. The carcinogenic contamination of cranberries, the mercury malady of ducks and the DDT diet of salmon have resulted in emotionalism expelling enlightenment. Pollution is a by-product of our complex civilization; and man has always been able to solve his man-made problems. Therefore, a call for "reason" seems in order regarding the problem of pollution.

Journalists have exploited and exaggerated the voices of uninformed protestors against the use of 2,4,5-T to defoliate the jungle of Viet Nam because of possible teratogenic effects to man which have never been conclusively validated by respectable research reports. We must all realize and live with the fact that some degree of pollution of our environment accompanies technological advancement.

Pesticides are applied to less than five per cent of the land in the United States. Agricultural scientists are constantly guarding this soil, the food

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we eat, the water we drink, and the air we breathe. Studies have reported that pesticide residues rarely occur in food, and if present, the level is less than one per cent of the legal safe tolerance level. Pesticides used properly as the label directs do not endanger and in many cases protect man, animals, and plants from injury and prevent pollution of our environment. We must strive for "tolerable" levels of pollution while increasing the search for both biological and selective chemical methods essential to increased food production. With our stomachs full of delicious and nutritious food, it is nearly impossible to imagine that half of the people on earth are badly fed or close to starvation.

So, let us talk of food priorities. Agricultural research has touched every phase of farming from soil made rich with fertilizers to grain kept weed-free with herbicides, resulting in crop yields higher in both quality and quantity.

In North Dakota, herbicides were applied to an estimated 10 million acres in 1969 (11). Approximately 8.5 million, or 85 per cent of these acres, received an application of either 2,4-D or MCPA (Table 1). Thus, over 30 per cent of the crop area in the state is treated with a herbicide, mainly 2, 4-D.

Now let us consider 2,4-D in relation to North Dakota's economy and world health. The 1969 production of various crops and their average value, as well as potential loss from infestations of 100 wild mustard (**Brassica kaber** L.) plants per square yard, are presented in Table 2. If the use of all herbicides were discontinued in North Dakota, crop yields would be reduced drastically.

Let us consider only the socio-economic impact to the state if 2,4-D and MCPA were discontinued for use in grains for broadleaf weed control. MCPA and 2,4-D are effective especially to control wild mustard. Despite extensive use of these herbicides, wild mustard constantly presents an infestation hazard because of dormant seeds in the soil, and seeds produced by wild mustard plants that survive the spraying operation. The potential hazard from

Table 1. Herbicides and acres treated in North Dakota, 1969.

Herbicide	Acres
2,4-D	7,064,338
MCPA	1,468,701
Dicamba	356,870
Bromoxynil	41,370
Dalapon and TCA	75,515
Diallate and triallate	389,379
Barban	674,781
Atrazine	119,643
Simazine	9,126
Amiben, trifluralin, and propachlor	69,052

Table 2. Production of various crops with prices received by farmers in North Dakota in 1969 and potential loss from wild mustard.

	1969 Production (million bu.)	Per cent loss[1] 100 WM/sq. yd.	Potential bu. loss (million)	Crop price[2] per bu. (dollars)	Potential loss (million dollars)
Wheat	203.6	36	73.3	$1.35	$ 99.0
Barley	92.6	29	26.9	.73	19.6
Oats	139.4	32	44.6	.50	22.3
Flax	19.1	88	16.8	2.60	43.7
Total					$184.6

[1]Average loss from 100 wild mustard plants per sq. yd. over 3 years, except flax which was 2 years (6).
[2]1969 preliminary season average price received by farmers for all wheat. Price does not include any U.S. government certificate payments (13).

wild mustard becomes evident as one travels in the state and observes fields heavily infested or streaked with yellow wild mustard plants in bloom, missed because of inadequate sprayer coverage.

We conservatively estimate that if the use of 2,4-D or MCPA is discontinued, wild mustard infestations will increase and reach 100 plants per square yard within three years. At 100 wild mustard plants per square yard, the economic loss to North Dakota could exceed $175 million annually in small grains and flax. This is based upon the average per cent yield decrease over three years from 100 wild mustard plants per square yard in wheat, barley, oats or flax and the 1969 prices and yields, (7, 18). The loss value does not include $9.8 million estimated as the cost of applying MCPA and 2,4-D which is presently used to control wild mustard. At present, a good substitute for 2,4-D or MCPA is not available for wild mustard control.

A value of $175 million has little tangible meaning in itself. However, with this amount, each man, woman, and child in North Dakota could purchase a color television set every year. The $175 million loss also could buy enough wheat to make loaves of bread to circle the earth 45 times, or make 4.7 trips to the moon. Or more important in a hungry world, this economic loss converted to wheat could feed 13 million people for one year, based on 2,500 calories per day and FAO calories in wheat.

Thus far, we have considered only wild mustard in small grains and flax. A story equally as startling could be told for other weeds in small grains and all weeds in other crops. Data in Table 1 indicate the acres treated with various herbicides in North Dakota. MCPA and 2, 4-D are the primary herbicides used extensively.

Possible hazards to the people of North Dakota from the use of 2,4-D for broadleaf weed control in small grains are minimal. The oral toxicity of 2,4-D is similar to that of aspirin, with an LD_{50} to rats of 1.5 g/kg and 1.75 g/kg, respectively (14). Thus 2,4-D is relatively safe to handle or apply.

Carcinogenic or mutagenic effects from 2,4-D have not resulted even from sublethal massive doses (19). However, certain compounds of 2,4-D have been implicated as teratogenic to rats and mice from daily (from 6th to 14th day of pregnancy) subcutaneous injections of massive doses (90 to 130 ul/kg of body weight) in dimethylsulfoxide (DMSO) (19). These results were not consistent in all studies and no significant teratogenity was observed with doses below 90 ul/kg body wt. If people can be compared to mice, a teratogenic effect would require a daily injection of more than 4.5 g per 50 kg woman. At the 0.5 ppm tolerance level in wheat, [actual residues are seldom detected (4)], the 4.5 g intake would require a woman to eat 19,824 lbs of wheat each day early in her pregnancy.

The acute toxicity of 2,4-D is very low. Now let us consider the possibility of long term buildup and possible disruption of our ecosystem.

The breakdown of 2,4-D and MCPA in the soil by microorganisms is well documented. The disappearance of 2,4-D from the soil was increased when warm, high in moisture and organic content; all conditions related to rapid microbial activity (3). Sterilization of soil increased the residue from 2,4-D, further revealing the role of microorganisms in 2,4-D breakdown (3). Additional evidence for microbial breakdown of 2,4-D and MCPA was demonstrated by Audus (3) who found the rate of breakdown accelerated after a lag phase and that this lag phase was nonexistent in soils previously treated with these herbicides. Conclusive evidence of microbial breakdown of 2,4-D was established with the isolation of microorganisms which used 2,4-D as their sole source of energy (3).

Thus the biodegradable nature of 2,4-D and MCPA has been substantiated. In addition, these herbicides will not accumulate in the soil and should not present any hazard to our soils as an important basic resource. Other studies (3) indicate that at normal rates 2,4-D and MCPA do not affect the beneficial microorganisms in the soil.

Clean water is a concern of everyone; therefore, what is the fate of 2,4-D in water? Manigold and Schulz (10) occasionally found 2,4-D (less than 1 ppm) when monitoring streams in the western United States. In North Dakota, possible contamination of our water could occur from herbicide drift, runoff or treatment for aquatic weeds.

After treatment of 150 acres of forest in Scotland with 40 lb/A of an ester of 2,4-D, 1.5 to 2 ppm were detected in the runoff water (1). Esters, because of their nonsolubility in water, are considered more subject to runoff than the amines.

Once the herbicides are in the water, they are subjected to photodegradation (3) as well as microbial breakdown. Fewer studies involve the breakdown of 2,4-D in water than in soil. Aly and Faust (2) and Robson (12) have observed that 2,4-D breakdown in water was enhanced by mud from a lake previously treated with 2,4-D. Robson (12) also demonstrated that organisms adapted to breakdown MCPA would also degrade 2,4-D. From these results, it appears that 2,4-D also is biodegradable in water and should not be a problem in North Dakota.

In water, 2,4-D has not resulted in any phenol residues (2) or reduced water quality in any other way. Also, 2,4-D accumulation in fish was not detected (16, 15, 20). For aquatic weed control, 2,4-D has opened waters for sport fishing and promoted native plants that have attracted waterfowl (6, 11, 15).

In North Dakota, 2,4-D is the herbicide most extensively used. The previous discussion indicates that no danger to man or animal exists from 2,4-D's direct toxicity or from a long term buildup. However, the hazard from 2,4-D drift to non-target plants is a problem. Therefore, application should not be made in excessive winds, as spray drift may damage susceptible vegetation. Also, high volatile esters of 2,4-D often are applied, and under certain conditions, vapor drift could result in damage to susceptible plants. Damage to North Dakota vegetation from atmospheric drift cannot be justified and for the most part can be eliminated.

Table 1 lists herbicides used in North Dakota in addition to 2,4-D and MCPA. In this paper 2,4-D and MCPA were given major discussion because of their importance to North Dakota agriculture. Similar discussions could be given for each of the other herbicides listed, as none of these present any toxicity or residue accumulation problems. Atrazine and simazine are more persistent in the soil than the others but present no long term hazards. They are biodegradable, but slower in breakdown than 2,4-D.

In addition to yield reductions caused by weed competition, weeds also are polluters of our environment. Pasture weeds such as arrowgrass (**Triglochin maritima** and **T. palustris**), death camas (**Zigadenus** spp.), dogbane (**Apocynum cannabinum**), locoweed (**Oxytropis lambertii**), and water hemlock (**Cicuta maculata**) annually kill three to five per

cent of the cattle, sheep, and horses on ranges in the western states alone (17).

Poisonous weeds are a major cause of birth defects in animals and are much more common than those alleged to be caused by man-made chemicals (9). Weeds identified as being associated with teratogenic effects or congenital malformations include locoweed (**Oxytropis lambertii**), western false hellbore (**Veratrum californicum**), and western locoweed (**Astragalus wootonii**).

Abortions and congenital skeletal malformations frequently occur in cows and ewes foraging on poisonous species of locoweed. The toxic lupines produce marked congenital deformities known as "crooked calf disease." In severe cases, the forelegs are useless. Cleft palate also may occur and occasionally the neck and back may be deformed. Ewes and nanny goats eating western false hellbore 14 days after conception produce young in extreme cases with cyclopia (single median eye), a shortened upper jaw and protruding lower jaw. In less severe cases, the young may have normal eyes and only a shortening of the upper jaw (9).

Every year many people, and especially children, are poisoned accidentally from contact with stinging nettles (**Urtica procera**) and poison ivy (**Rhus radicans**). These weeds cause severe skin inflammations and painful water blisters (5).

The annual ragweeds (**Ambrosia trifida**) and (**A. artemisifolia**) are the bane of hay fever victims. It is estimated that one million tons of ragweed pollen are produced annually in the United States. Ragweed affects more people in the United States than does smog (8).

It is conservatively estimated that North Dakotans annually spend $20,000,000 for anti-histaminic preparations, 90 per cent of which is for anti-allergy preparations (13).

Anti-pesticide groups have advocated the use of the hoe in place of the mechanical application of herbicides. Now, imagine yourself with a hoe in one of North Dakota's fields of either small grains or flax in six-inch rows. Hand hoeing would be extremely difficult or impossible. The estimated $9.3 million cost for wild mustard control with 2,4-D and MCPA would be increased to more than $170 million for hoeing, based on a $20 per acre rate and disregarding the crop damage from the hoe and hoer. Hoeing an acre a day per person would be about all that could be undertaken. The maximum time available to remove the weeds from a given field is less than two weeks; i.e., after emergence of weeds and before competition becomes excessive. This would require a small well-disciplined army or a large group of protesters.

A concerned and concentrated effort must be made to limit population growth and to alleviate the malnutrition and starvation of the people now inhabiting this planet. Each and every healthy human being must feel compassion and the commitment to produce nutritious but not necessarily the highest quality food and to distribute food products around the world disregarding political, ethnic and religious boundaries. A hungry, crowded world necessitates an intensive and increased agricultural production dependent upon herbicides and other chemicals.

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