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CHEMICALS USED ON FOUR CROPS IN MINNESOTA DURING 1991

JULY 1993

Minnesota Pesticide Impact Assessment Program

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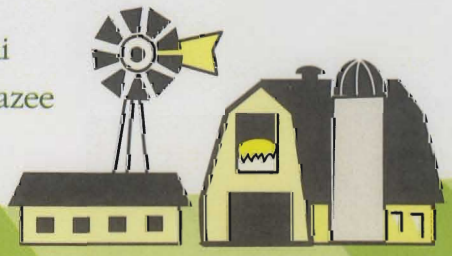

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INTRODUCTION

All pesticides distributed or sold in interstate commerce must be federally registered and labeled according to the statutes of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947. Until 1970, FIFRA was administered by the United States Department of Agriculture (USDA). After 1970, the Environmental Protection Agency (EPA) assumed the responsibilities of regulating pesticides in the United States. The Federal Environmental Pesticide Control Act (FEPCA) of 1972 overhauled FIFRA and increased EPA's authority to regulate pesticides. Under FEPCA, EPA classified pesticides as general or restricted use, and registered pesticides only if they did not cause "unreasonable adverse effects" on human health or the environment.

Approximately 35,000 to 40,000 pesticide products, representing about 600 active ingredients, are registered by EPA under FIFRA (Conner 1990). According to FEPCA, EPA must register pesticides only if the risks associated with their use do not exceed pre-established criteria known as "risk-triggers." The triggers include oncogenicity (tumor formation), mutagenicity (heritable genetic effects), chronic (long-term) toxic effects, acute (immediate) hazards to humans and animals, endangered species and other wildlife. The 1975, 1978, and 1980 amendments to FIFRA required that data packages of pesticides be brought up to modern standards, and pesticides exceeding the pre-established risk triggers be reviewed and reregistered. In addition, the 1975 amendment emphasized that benefits accrued from pesticide use be considered in the reregistration process. The 1988 amendment to FIFRA required EPA to reregister all pesticides first registered before 1 November 1984, and to complete the reregistration process by 1997.

In order to develop beneficial information on pesticides, the National Agricultural Pesticide Impact Assessment Program (NAPIAP) was established by USDA in 1976, in an effort to pool knowledge and resources of nine USDA agencies, and their cooperators in the State Agricultural Experiment Stations (SAES), State Cooperative Extension Services (SCES), and State Departments of Agriculture. The role of USDA in the regulatory process is legislated by FIFRA, and the procedural guidelines were established by a Memorandum of Agreement with EPA. The Pesticide Impact Assessment Program (PIAP) is generally located within the Extension Service in each state.

NAPIAP, as it now performs, provides information on pesticide benefits to USDA, which in turn compiles it for submission to EPA. Information generated by NAPIAP includes benefits of the review pesticide to US agriculture, and yield and quality impacts if the pesticide is suspended or canceled. Economic benefits and impacts of pesticides being reregistered are evaluated by NAPIAP economists using econometric models from the following information: amount of pesticide used, biological efficacy and cost of pesticide, availability and cost of alternative chemical and nonchemical methods, and crop yield in the presence or absence of the pesticide. Quantitative information on these aspects is generally obtained through pesticide use surveys. Therefore, pesticide use surveys are important for defining the role of pesticides in Minnesota agriculture, and for providing quantitative information on possible impacts of suspension or cancellation of a pesticide.

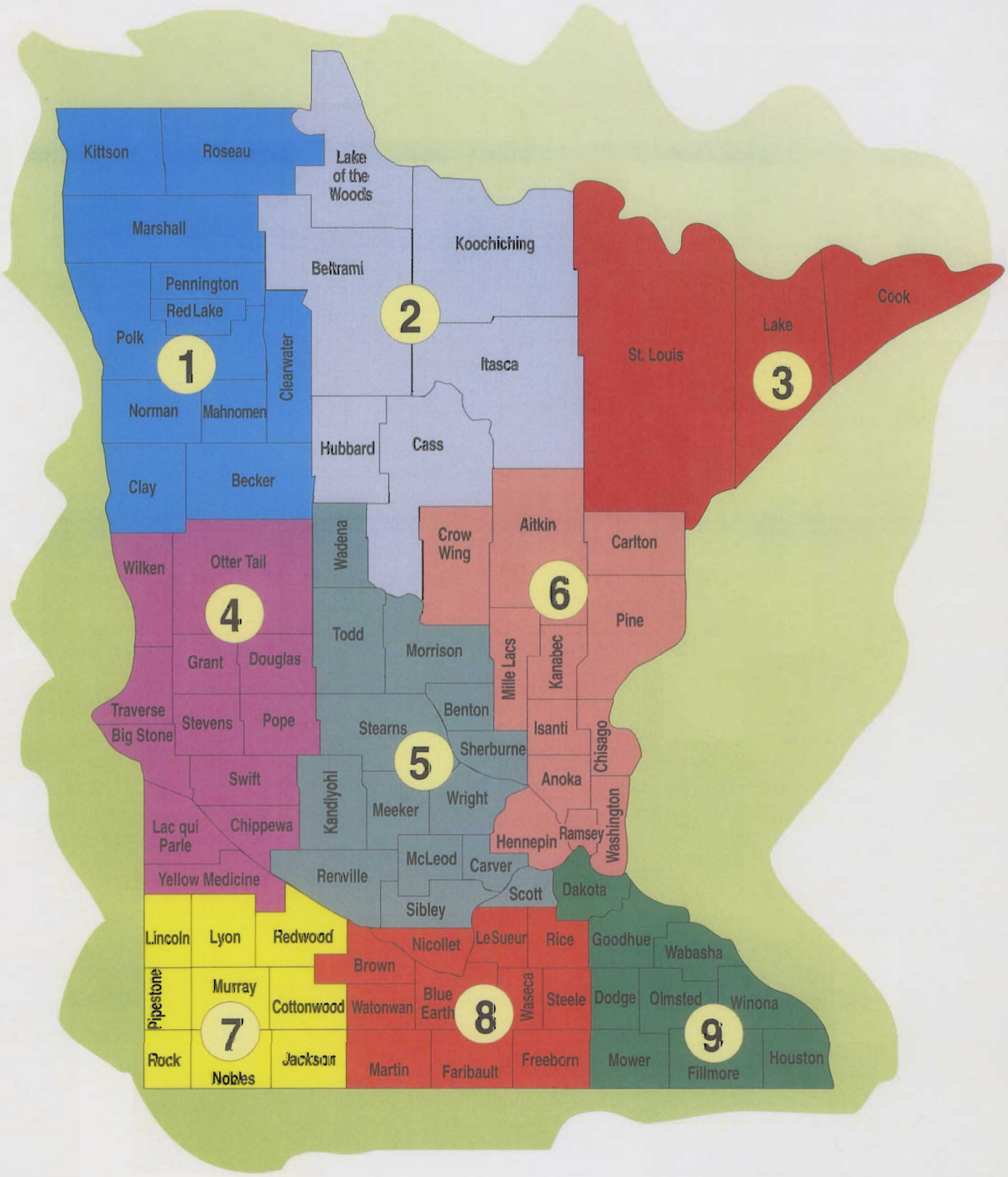


Figure 1. Federal agricultural reporting regions in Minnesota

Survey Procedures

During 1991, the Minnesota Pesticide Impact Assessment Program (MPIAP) collaborated with the Minnesota Agricultural Statistics Service (local branch of the National Agricultural Statistics Service [NASS]), in conducting fertilizer and pesticide use surveys on corn, spring wheat, soybeans, and potatoes. An area-frame sampling technique was used for surveying growers. This technique is frequently used by NASS for conducting agricultural surveys (Anonymous 1983). Briefly, this technique involves stratifying land uses in the State into agricultural and nonagricultural land. Land uses in each county are identified by aerial photographs, quadrangle maps or satellite imagery, and general knowledge of current land uses based on previous surveys and county highway maps. The land-use strata include land devoted to intensive agriculture, extensive agriculture, cities and towns, range, nonagricultural land, and water. Each stratum in a county is further subdivided into blocks called primary sampling units. The size of primary sampling units may vary from 0.2 to 10 square miles, depending on intensity of land use. The primary sampling units are further divided into segments of uniform size of approximately 1 square mile. About 650 acres (± 65 acres) are generally present in a square mile segment.

For determining chemicals used by growers, a random sample of segments (fields) was selected for each crop so that the probability of selecting a particular field was directly proportional to the total acres planted to that crop. Growers operating the sample fields were personally interviewed to obtain information on chemical applications made to the crop acres selected at random. Specific questionnaires developed for each crop were used for collecting chemical use data. Data were collected between May and December of 1991. Data from 1,500 growers form the basis of this report.

In Minnesota, there are nine federal agricultural reporting regions or districts (Fig. 1). For presenting results of this survey, some adjacent agricultural reporting regions were combined because of limited data from individual regions. Thus, for corn and soybeans, chemical use data were presented from six regions; for spring wheat and potatoes from three and two regions, respectively. In this report, nitrogen, phosphate, and potash fertilizers and herbicides used on all four crops are presented. Because of insufficient reports, insecticide use data were presented only for corn and potatoes; fungicide data were presented only for spring wheat and potatoes. Data were not presented if there were fewer than twenty reports per chemical per region, and if a chemical was used on less than one percent of the crop acres.

RESULTS*

CORN

Minnesota is one of the leading states in corn production, and in 1991 ranked fourth among ten north central states (Anonymous 1992). The top ten leading counties in corn production are all located in southern Minnesota. In 1991, corn was planted on 6.6 million acres. Figure 2 shows the six corn regions, and Table 1 shows corn acres planted in each of the six regions. Agricultural reporting region 3 had the highest planted acreage (22% of the total) and region 1 had the lowest planted acreage (7%). The fertilizer and pesticide use data from the six regions are shown in Tables 2-4.

Table 1. Corn acreage planted in the six agricultural reporting regions

Region	Acres
1	439,100
2	1,130,900
3	1,416,300
4	1,314,500
5	1,338,200
6	961,000
State	**6,600,000**

* Common and trade names of pesticides mentioned in text and tables are listed in Appendix I.

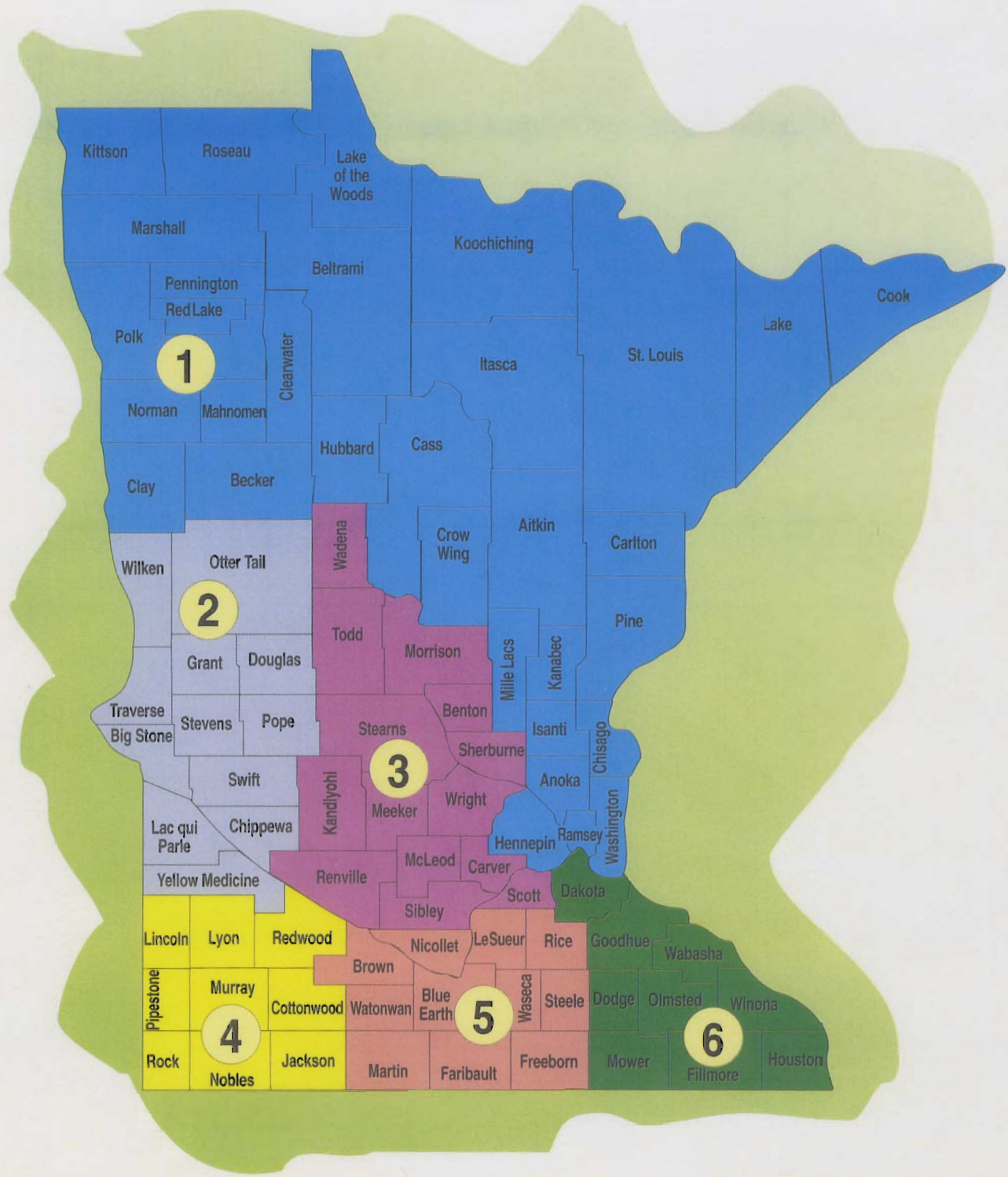


Figure 2. Corn regions

Fertilizer usage: Among the six regions, about 91–99, 78–93, and 75–92% of the corn acreage was treated with nitrogen, phosphate, and potash, respectively (Table 2). The average number of treatments suggest that a majority of growers applied nitrogen twice, whereas phosphate and potash were applied only once. The rate per acre of each fertilizer varied greatly among regions. Averaged across regions, nitrogen, phosphate, and potash were applied at the rate of 64, 45, and 56 pounds per acre, respectively. Across the regions, about 2.5 and 2.0 times more nitrogen was applied than phosphate and potash, respectively.

Table 2. Fertilizer usage on corn

Fertilizer	Region	Percent acres treated	Average number of treatments	Rate per treatment (lbs/acre)	Total amount applied (lbs)
Nitrogen	1	90.91	1.73	51.08	35,248
(N = 630)[1]	2	95.10	1.74	56.79	106,629
	3	98.55	1.66	72.01	167,354
	4	96.58	1.44	82.09	150,336
	5	97.52	1.74	64.94	147,540
	6	98.00	1.78	58.54	98,094
	State	**96.11**	**1.70**	**64.24**	**705,200**
Phosphate	1	88.64	1.08	38.07	15,942
(N = 556)	2	93.14	1.16	48.09	58,602
	3	86.96	1.12	42.27	58,081
	4	79.45	1.06	54.18	59,955
	5	77.69	1.17	42.79	52,018
	6	92.00	1.11	37.57	36,802
	State	**86.36**	**1.10**	**44.82**	**281,400**
Potash	1	90.91	1.23	63.59	31,197
(N = 541)	2	85.29	1.16	34.61	38,887
	3	92.03	1.10	61.40	88,516
	4	75.34	1.08	52.06	55,965
	5	76.86	1.20	53.77	66,824
	6	84.00	1.12	71.62	64,911
	State	**84.07**	**1.15**	**56.18**	**346,300**

[1] N, number of survey reports for the whole State.

Insecticide usage: Insecticides were used on 13% of the corn acres. Sufficient data were available on only four insecticides (Table 3). These insecticides were: chlorpyrifos, permethrin, phorate, and terbufos. Carbofuran, ethoprop, fonofos, tefluthrin, and trimethacarb were also used on corn, but limited data were available for presentation. In some regions, there were insufficient reports to publish data on the four insecticides listed in Table 3 or these insecticides were used on less than one percent of the acres. Across the regions less than 12 percent of the total acres were treated with each of the four insecticides.

Table 3. Insecticide usage on corn

Insecticide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Chlorpyrifos	1	—[2]	—[2]	—[2]
(N = 26)[1]	2	2.94	1.07	35,700
	3	5.88	0.79	65,400
	4	2.05	0.77	20,800
	5	—[2]	—[2]	—[2]
	6	11.88	1.13	129,100
	State	**5.69**	**0.94**	**251,000**
Permethrin	1	4.44	0.08	1,500
(N = 10)	2	5.88	0.21	14,100
	3	—[2]	—[2]	—[2]
	4	—[2]	—[2]	—[2]
	5	—[3]	0.09	1,000
	6	—[3]	0.04	400
	State	**5.16**	**0.11**	**17,000**
Phorate	1	2.22	1.59	15,500
(N = 17)	2	2.94	1.19	39,600
	3	2.94	1.22	50,700
	4	—[3]	0.60	5,400
	5	1.63	0.89	19,500
	6	5.94	1.16	66,300
	State	**3.13**	**1.11**	**197,000**
Terbufos	1	—[2]	—[2]	—[2]
(N=17)	2	—[3]	1.06	11,700
	3	1.47	0.90	18,.800
	4	1.37	1.36	24,500
	5	4.07	1.35	73,400
	6	6.93	1.29	85,600
	State	**3.46**	**1.19**	**214,000**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for this insecticide.

[3] The insecticide was used on less than one percent of the acres.

Herbicide usage: Herbicides were applied to 96% of the corn acres. Data on eleven herbicides are shown in Table 4. Nine other herbicides that were not listed in Table 4, because of limited data, include: bentazon, butylate, diuron, glyphosate, primisulfuron, simazine, thifensulfuron, tribenuron-methyl, and tridiphane. On average, atrazine was applied to a greater percentage of acres than the other herbicides. The percent acres treated with individual herbicides varied among regions.

Table 4. Herbicide usage on corn

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
2,4-D	1	8.89	0.22	8,500
(N = 81)[1]	2	6.86	0.32	25,100
	3	8.82	0.75	93,600
	4	28.08	0.43	157,400
	5	10.57	0.42	59,000
	6	3.96	0.27	10,400
	State	**11.20**	**0.40**	**354,000**
Alachlor	1	11.11	2.10	102,600
(N = 159)	2	8.82	2.84	283,500
	3	34.56	2.31	1,131,600
	4	19.18	1.78	448,900
	5	29.27	2.74	1,072,800
	6	33.66	2.29	739,600
	State	**22.76**	**2.34**	**3,779,000**
Atrazine	1	55.56	1.05	255,500
(N = 206)	2	21.57	0.64	156,600
	3	36.03	0.71	361,900
	4	14.38	0.53	99,700
	5	25.20	0.66	222,700
	6	57.43	1.06	587,600
	State	**35.03**	**0.78**	**1,684,000**
Bromoxynil	1	—[2]	—[2]	—[2]
(N = 112)	2	10.78	0.28	34,200
	3	21.32	0.24	73,300
	4	15.07	0.24	48,500
	5	25.20	0.33	111,600
	6	18.81	0.32	58,400
	State	**18.24**	**0.28**	**3,26,000**
Cyanazine	1	15.56	1.01	69,000
(N = 107)	2	17.65	1.35	268,700
	3	16.91	1.77	422,900
	4	17.12	1.79	403,200
	5	6.50	1.78	154,600
	6	25.74	1.50	371,600
	State	**16.58**	**1.53**	**1,690,000**

Table 4. Herbicide usage on corn (continued)

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Dicamba	1	15.96	0.26	17,900
(N = 195)	2	41.18	0.28	129,300
	3	25.74	0.29	106,000
	4	36.99	0.29	138,700
	5	21.95	0.43	125,800
	6	29.70	0.34	97,300
	State	**28.59**	**0.32**	**615,000**
EPTC	1	8.89	4.08	159,200
(N = 96)	2	25.49	4.17	1,202,500
	3	13.24	4.48	839,300
	4	18.49	4.64	1,128,400
	5	12.20	4.47	729,300
	6	5.94	5.09	290,300
	State	**14.04**	**4.49**	**4,349,000**
Metolachlor	1	20.00	1.87	164,000
(N = 164)	2	16.67	1.67	314,500
	3	22.79	2.30	741,700
	4	29.45	2.22	860,300
	5	28.46	2.53	962,800
	6	28.71	2.17	597,700
	State	**24.35**	**2.13**	**3,641,000**
Nicosulfuron	1	15.56	0.03	2,100
(N = 103)	2	26.47	0.03	8,100
	3	14.71	0.03	6,600
	4	10.96	0.03	3,900
	5	21.14	0.03	7,300
	6	6.93	0.03	2,000
	State	**15.96**	**0.03**	**30,000**
Pendimethalin	1	8.89	1.13	44,300
(N = 43)	2	5.88	0.84	55,900
	3	12.50	1.23	217,100
	4	1.37	1.42	25,500
	5	—[2]	—[2]	—[2]
	6	13.86	1.35	180,200
	State	**8.50**	**1.19**	**523,000**
Propachlor	1	—[2]	—[2]	—[2]
(N = 23)	2	5.88	1.71	113,400
	3	2.94	2.22	92,500
	4	3.42	1.78	79,900
	5	6.50	2.20	191,200
	6	—[2]	—[2]	—[2]
	State	**4.69**	**1.98**	**477,000**

[1] N, number of survey reports for the whole State.
[2] Insufficient reports to publish data for this herbicide.

SOYBEANS

In 1991, Minnesota ranked third in the production of soybeans behind Iowa and Illinois (Anonymous 1992). Pesticide use data on soybeans are presented for the same six regions discussed previously for corn (Fig. 3). Of the 5.5 million acres devoted to soybeans, about 25% of the total acres were planted in regions 4 and 5, and 23% in region 2 (Table 5).

Table 5. Soybean acreage in the six agricultural reporting regions

Region	Acres
1	271,900
2	1,241,600
3	808,500
4	1,353,300
5	1,366,200
6	458,500
State	**5,500,000**

Fertilizer usage: On average, 12, 10, and 10% of soybean acres in the State were treated with nitrogen, potash, and phosphate fertilizer, respectively (Table 6). The percent acreage treated with all three fertilizers was greatest in region 1, followed by region 3. In general, all three fertilizers were applied only once. The amount of nitrogen applied per treatment varied greatly among regions compared with phosphate and potash.

Table 6. Fertilizer usage on soybeans

Fertilizer	Region	Percent areas treated	Average number of treatments	Rate per treatment (lbs/acre)	Total amount applied (lbs)
Nitrogen	1	44.83	1.08	14.19	2,050,700
(N = 56)[1]	2	3.37	1.00	7.57	348,700
	3	18.31	1.00	14.36	234,000
	4	13.82	1.06	39.18	8,542,800
	5	6.02	1.25	101.32	11,458,600
	6	10.00	1.00	15.04	759,200
	State	**16.05**	**1.07**	**31.94**	**23,394,000**
Phosphate	1	44.83	1.08	26.90	3,677,700
(N = 47)	2	5.62	1.00	31.60	2,302,100
	3	18.31	1.00	36.84	5,681,100
	4	9.76	1.00	57.00	7,839,500
	5	2.26	1.00	60.80	1,951,800
	6	5.00	1.00	69.00	1,647,800
	State	**14.29**	**1.01**	**46.89**	**23,100,000**
Potash	1	51.72	1.20	49.54	8,951,900
(N = 47)	2	3.37	1.00	34.07	1,526,700
	3	18.31	1.00	61.49	9,746,700
	4	9.76	1.00	34.58	4,889,300
	5	2.26	1.00	72.00	2,376,000
	6	5.00	1.00	90.00	2,209,400
	State	**15.07**	**1.03**	**56.95**	**29,700,000**

[1] N, number of survey reports for the whole State.

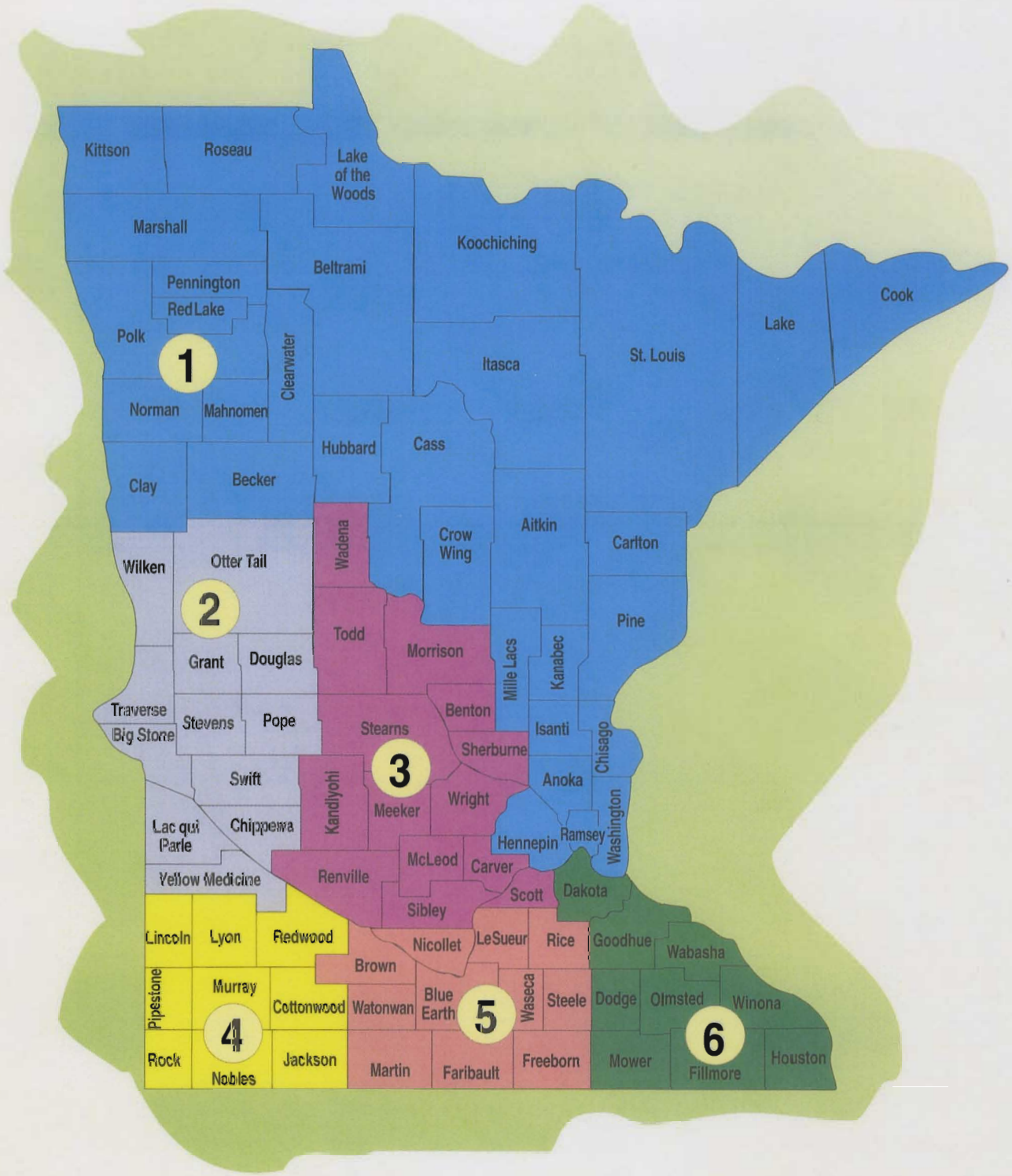


Figure 3. Soybean regions

Herbicide usage: Herbicides were used on 95% of the soybean acres. Out of a total of twenty five herbicides used on soybeans, data on eleven herbicides were insufficient to be included in Table 7. These eleven herbicides were: 2,4-D, chloramben, chlorimuron ethyl, clomazone, fenoxaprop-ethyl, imazaquin, lactofen, linuron, naptalam, paraquat, and propachlor. Statewide, imazethapyr was applied to a greater percentage of soybean acreage followed by trifluralin, when compared with the other herbicides. Only five percent of the overall state acreage was treated with each of seven different herbicides (see Table 7).

Table 7. Herbicide usage on soybeans

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Acifluorfen	1	10.34	0.10	2,800
(N = 23)[1]	2	15.73	0.18	35,800
	3	1.43	0.16	1,900
	4	—[2]	—[2]	—[2]
	5	3.76	0.34	17,500
	6	—[2]	—[2]	—[2]
	State	**7.82**	**0.20**	**58,000**
Alachlor	1	3.45	2.06	19,300
(N = 48)	2	6.74	2.74	229,400
	3	27.14	2.91	638,400
	4	7.38	2.82	281,800
	5	9.02	2.82	348,100
	6	5.00	2.05	47,000
	State	**9.79**	**2.57**	**1,564,000**
Bentazon	1	20.69	0.54	30,300
(N = 52)	2	24.72	0.72	221,600
	3	7.14	0.67	38,700
	4	4.10	0.53	29,200
	5	9.02	0.87	106,600
	6	10.00	0.62	28,600
	State	**12.61**	**0.66**	**4,55,000**
Ethalfluralin	1	3.45	1.08	10,100
(N = 24)	2	12.36	0.80	122,600
	3	7.14	0.87	50,100
	4	3.28	0.63	28,100
	5	2.26	0.78	24,100
	6	—[2]	—[2]	—[2]
	State	**5.68**	**0.83**	**235,000**

Table 7. Herbicide usage on soybeans (continued)

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Fluazifop-p-butyl	1	6.90	0.20	3,700
(N = 21)	2	—[2]	—[2]	—[2]
	3	2.86	0.10	2,400
	4	5.74	0.06	5,000
	5	6.02	0.13	.10,300
	6	10.00	0.08	3,600
	State	**6.30**	**0.11**	**25,000**
Glyphosate	1	—[2]	—[2]	—[2]
(N = 16)	2	3.37	0.69	28,800
	3	4.29	0.35	12,000
	4	6.56	0.62	54,900
	5	1.50	1.04	21,300
	6	—[2]	—[2]	—[2]
	State	**3.93**	**0.68**	**117,000**
Imazethapyr	1	—[2]	—[2]	—[2]
(N = 240)	2	31.46	0.06	22,200
	3	45.71	0.06	21,600
	4	63.11	0.05	44,700
	5	62.41	0.06	49,900
	6	75.00	0.06	20,600
	State	**55.54**	**0.06**	**159,000**
Metolachlor	1	10.34	1.41	39,700
(N = 21)	2	—[2]	—[2]	—[2]
	3	12.86	1.18	123,000
	4	4.10	1.61	89,300
	5	2.26	1.54	47,600
	6	5.00	0.85	19,400
	State	**6.91**	**1.32**	**319,000**
Metribuzin	1	—[2]	—[2]	—[2]
(N = 21)	2	6.74	0.34	28,100
	3	11.43	0.21	19,600
	4	3.28	0.17	7,600
	5	2.26	0.31	9,700
	6	—[2]	—[2]	—[2]
	State	**5.93**	**0.26**	**65,000**

Table 7. Herbicide usage on soybeans (continued)

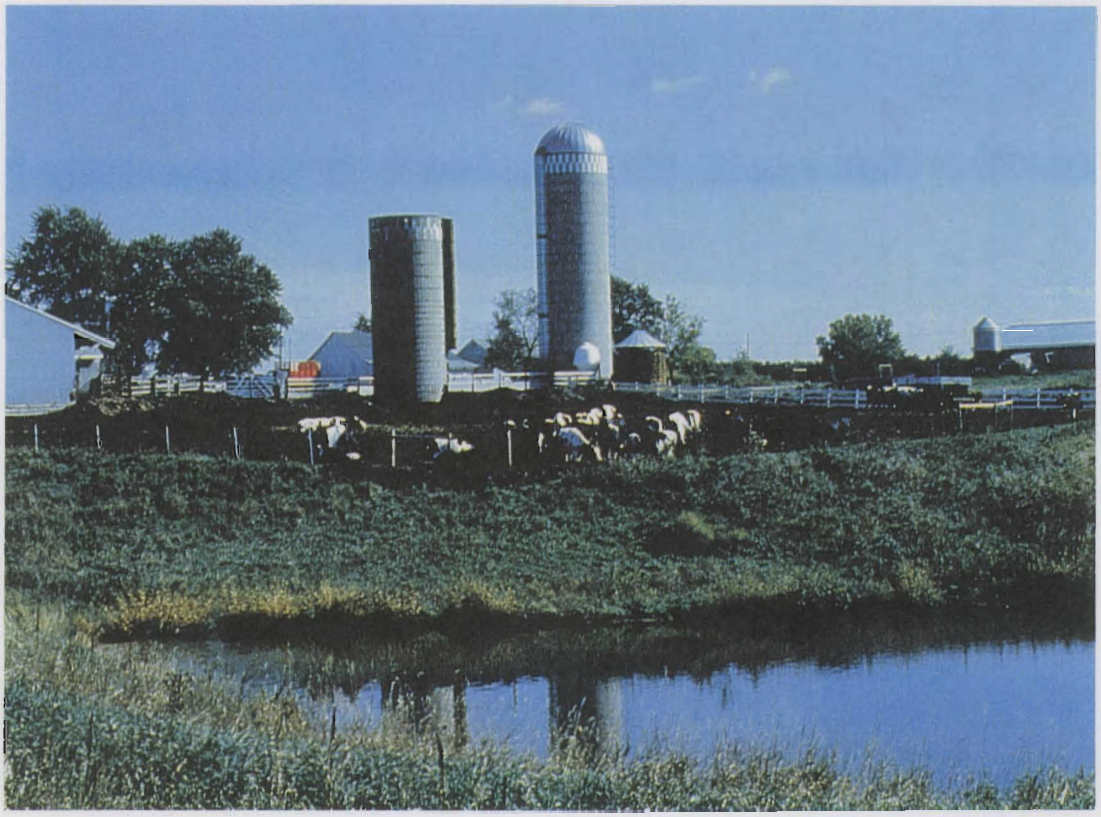
Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Pendimethalin	1	17.24	0.74	34,500
(N = 38)	2	5.62	1.00	69,800
	3	12.86	1.23	127,600
	4	4.92	0.94	62,500
	5	7.52	1.13	116,500
	6	15.00	1.14	78,100
	State	**10.53**	**1.03**	**489,000**
Quizalofop-ethyl	1	—[2]	—[2]	—[2]
(N = 11)	2	3.37	0.01	500
	3	1.43	0.03	400
	4	—[3]	NA	500
	5	3.76	0.06	3,300
	6	5.00	0.06	1,300
	State	**3.39**	**0.04**	**6,000**
Sethoxydim	1	17.24	0.29	13,500
(N = 23)	2	3.37	0.24	10,100
	3	4.29	0.21	7,200
	4	4.10	0.29	16,100
	5	5.26	0.28	20,100
	6	—[2]	—[2]	—[2]
	State	**6.85**	**0.26**	**67,000**
Thifensulfuron	1	6.90	0.005	100
(N = 23)	2	2.25	0.004	100
	3	—[2]	—[2]	—[2]
	4	4.10	0.004	200
	5	7.52	0.003	300
	6	20.00	0.003	300
	State	**8.15**	**0.004**	**1,000**
Trifluralin	1	34.48	0.79	73,600
(N = 192)	2	64.04	0.82	655,800
	3	47.14	0.65	246,200
	4	50.00	0.82	556,600
	5	20.30	0.73	203,200
	6	20.00	0.63	576,000
	State	**39.33**	**0.74**	**2,311,400**

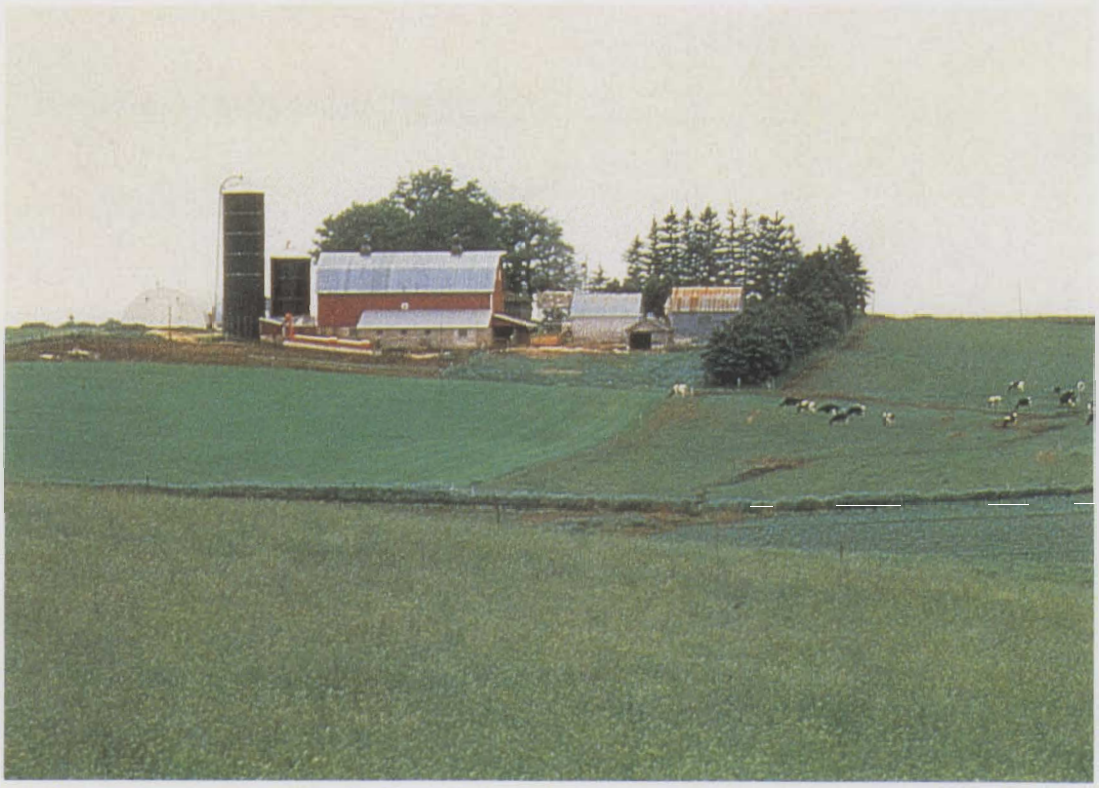
[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for this herbicide.

[3] The herbicide was used on less than one percent of the acres.

NA, Data not available.





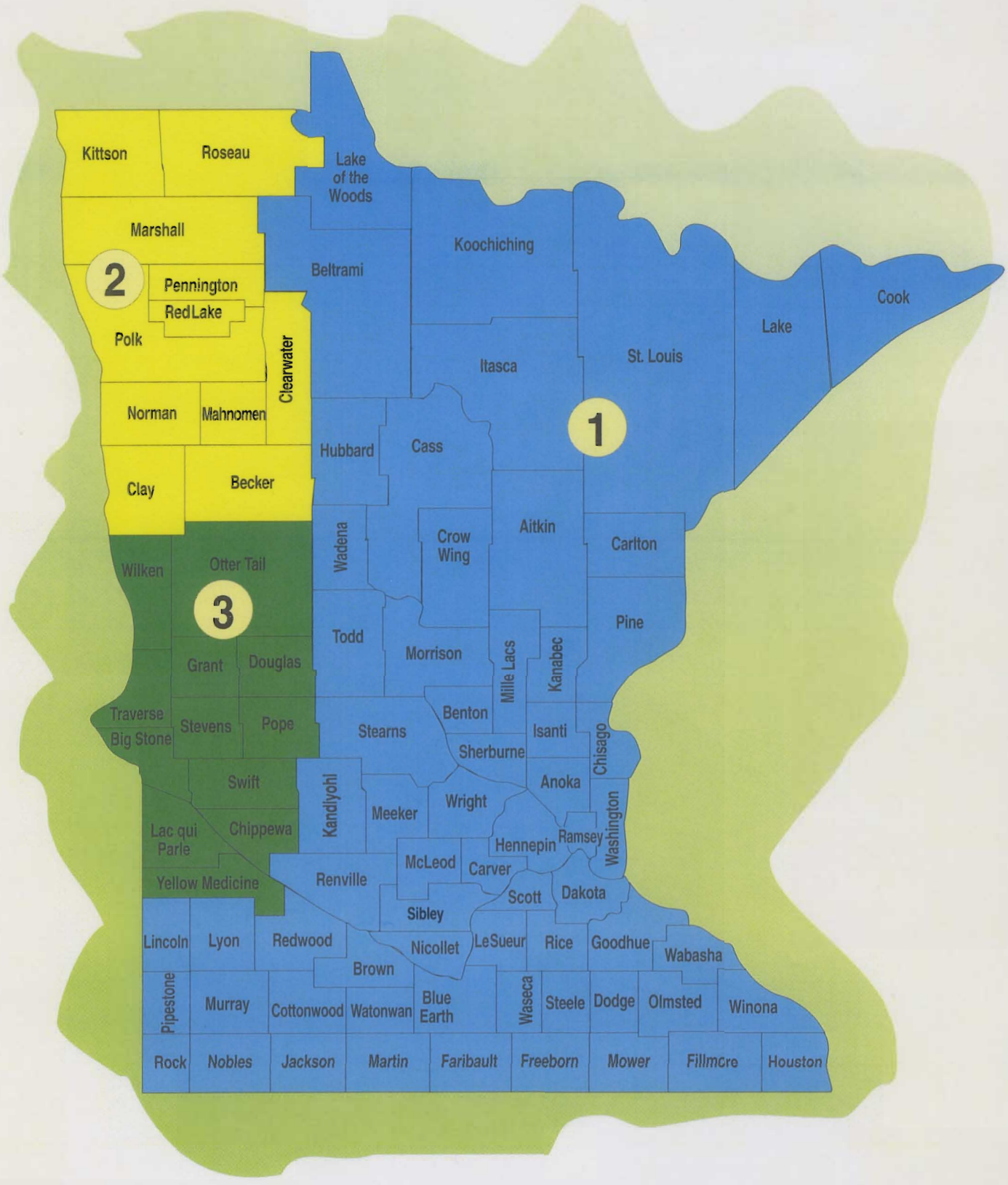


Figure 4. Spring wheat regions

Spring Wheat

Minnesota ranked third during 1991 in spring wheat production behind North Dakota and Montana (Anonymous 1992). For reporting survey results, the State was divided into three regions (Fig. 3). About 70% of wheat acreage was in northwestern Minnesota (Table 8).

Table 8. Spring wheat acreage in the three agricultural reporting regions

Region	Acres
1	87,200
2	1,469,500
3	543,300
State	**2,100,000**

Fertilizer usage: Nitrogen, phosphate, and potash were applied to 96, 93, and 78% of the spring wheat acreage, respectively (Table 9). On average, nitrogen was applied twice whereas the other two fertilizers were applied only once during the year. For each fertilizer, the rate per application was essentially similar among regions. Statewide, about 2.5 and 4 times more nitrogen was applied to the crop acres than phosphate and potash, respectively.

Table 9. Fertilizer usage on spring wheat

Fertilizer	Region	Percent acres treated	Average number of treatments	Rate per treatment (lbs/acre)	Total amount applied (lbs)
Nitrogen	1	100.00	1.30	53.46	6,062,000
(N = 132)[1]	2	98.95	1.81	50.54	132,936,000
	3	87.50	1.32	54.43	34,202,000
	State	**95.50**	**1.48**	**52.81**	**173,200,000**
Phosphate	1	100.00	1.00	28.00	2,424,700
(N = 126)	2	92.63	1.06	32.68	46,694,600
	3	87.50	1.07	39.30	19,880,700
	State	**93.38**	**1.04**	**33.33**	**69,000,000**
Potash	1	100.00	1.00	26.00	2,297,000
(N = 91)	2	60.00	1.16	30.20	31,236,900
	3	75.00	1.08	20.94	9,366,100
	State	**78.33**	**1.08**	**25.71**	**42,900,000**

[1] N, number of survey reports for the whole State.

Insecticide usage: Insecticides were used on six percent of the acres. There was very limited data collected from survey reports on the following insecticides: carbofuran, malathion, and methyl parathion. Therefore, reliable estimates on these chemicals were unavailable for presentation.

Herbicide usage: About 97% of the acres were treated with herbicides. MCPA was applied to 54% (range among regions, 30–66%) of spring wheat acreage (Table 10). Bromoxynil and 2,4-D were applied to 25% of the total crop acreage in the State. Four other herbicides, clopyralid, difenzoquat, propanil, and trifluralin, were reported in the survey questionnaires. However, data on these chemicals were insufficient for presentation. The total amount of each of the herbicides applied to wheat was greater in region 2 than in the other regions.

Table 10. Herbicide usage on spring wheat

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
2,4-D	1	30.00	0.39	10,100
(N = 46)[1]	2	28.42	0.25	104,900
	3	50.00	0.34	92,000
	State	**36.14**	**0.33**	**207,000**
Bromoxynil	1	—[2]	—[2]	—[2]
(N = 46)	2	47.37	0.23	160,800
	3	3.13	0.25	4,200
	State	**25.25**	**0.24**	**165,000**
Dicamba	1	—[2]	—[2]	—[2]
(N = 9)	2	3.16	0.10	4,500
	3	18.75	0.07	7,500
	State	**10.95**	**0.09**	**12,000**
Diclofop-methyl	1	—[2]	—[2]	—[2]
(N = 11)	2	9.47	0.74	102,900
	3	6.25	0.95	32,100
	State	**7.86**	**0.85**	**135,000**
Fenoxaprop-ethyl	1	—[2]	—[2]	—[2]
(N = 21)	2	16.84	0.11	28,400
	3	15.63	0.14	11,600
	State	**16.23**	**0.13**	**40,000**
Imazamethabenz-methyl	1	—[2]	—[2]	—[2]
(N = 15)	2	—[2]	—[2]	—[2]
	3	—[2]	—[2]	—[2]
	State	**11.00**	**0.30**	**70,000**

Table 10. Herbicide usage on spring wheat (continued)

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
MCPA	1	30.00	0.24	6,300
(N = 88)	2	67.37	0.310	310,600
	3	65.63	0.360	129,100
	State	**54.33**	**0.30**	**446,000**
Thifensulfuron	1	—[2]	—[2]	—[2]
(N = 19)	2	18.95	0.010	2,900
	3	3.13	0.010	100
	State	**11.04**	**0.01**	**3,000**
Triallate	1	—[2]	—[2]	—[2]
(N = 7)	2	—[2]	—[2]	—[2]
	3	—[2]	—[2]	—[2]
	State	**5.00**	**1.12**	**120,000**
Tribenuron-methyl	1	10.00	0.011	100
(N = 21)	2	18.95	0.006	1,700
	3	6.25	0.006	200
	State	**11.73**	**0.008**	**2,000**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for this herbicide.

Fungicide usage: Fungicides were used on six percent of the acres. Propiconazole was the only fungicide for which some information was available. However, the data obtained from surveys were limited for presenting use estimates at the regional level. Only six percent of the spring wheat acreage in the State was treated with this fungicide. The rate per crop year was 0.11 pounds AI per acre, and the total amount of AI used in the State during 1991 was 13,000 pounds. Mancozeb was listed as one of the chemicals used by the respondents, but reliable estimates on percent acres treated, rates and amounts applied could not be obtained.

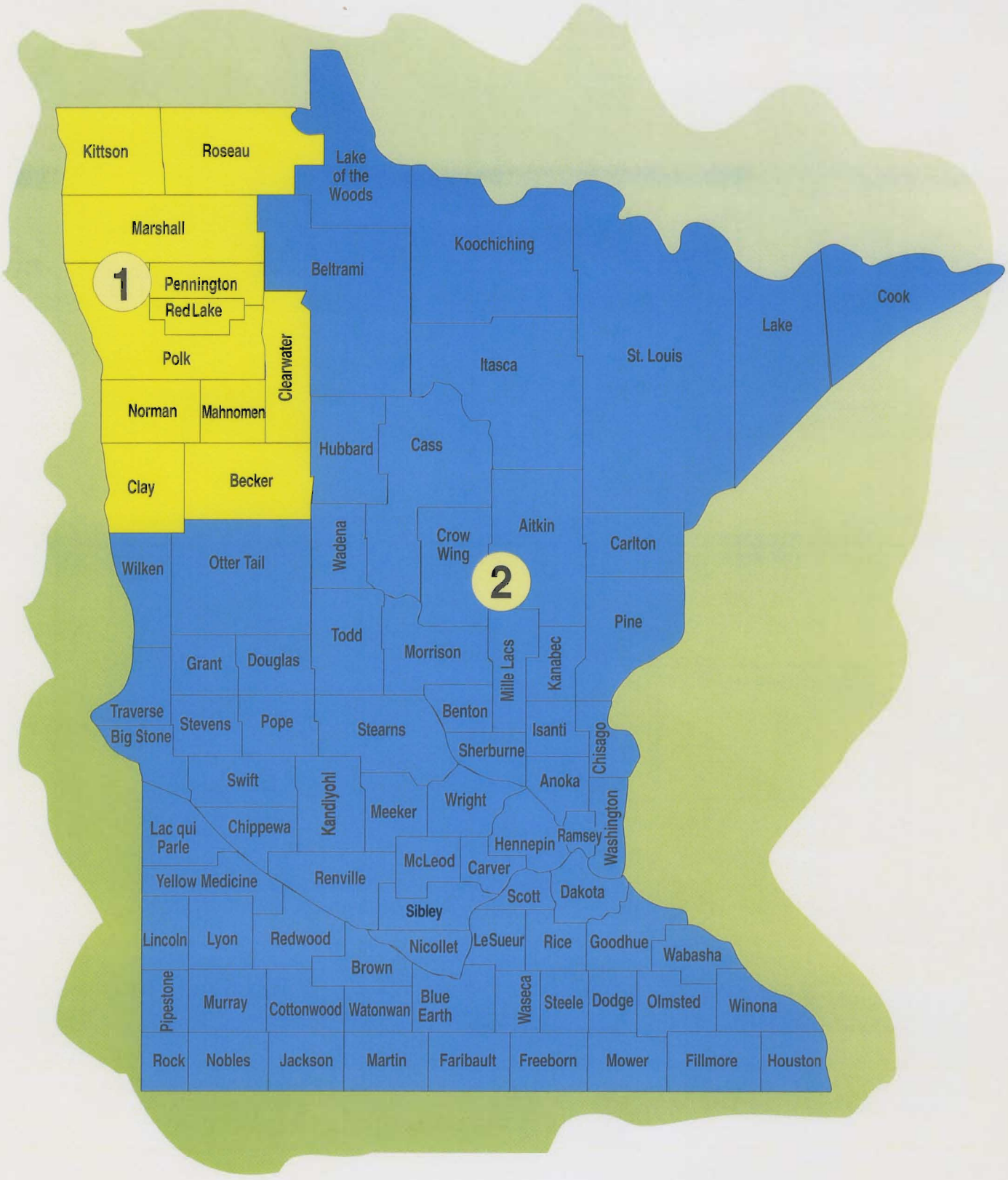


Figure 5. Potato regions

POTATOES

Most of the potatoes in Minnesota are grown in the Red River Valley area (Fig. 5, region 1). In 1991, Minnesota ranked seventh in potato production in the United States; the top six potato producing states in descending order were: Idaho, Washington, North Dakota, Colorado, Wisconsin, and Oregon (Anonymous 1992). About 68% of potato acreage is in northwestern Minnesota, and the remainder of the acreage is scattered across central and southern Minnesota (Table 11).

Table 11. Potato acreage in the two agricultural reporting regions

Region	Acres
1	52,600
2	24,400
State	**77,000**

Fertilizer usage: All planted potato acreage in region 2 was treated with nitrogen, phosphate, and potash fertilizers (Table 12). Nitrogen was applied to all the potato acreage in region 1; only 97 and 73% of the acreage was treated with phosphate and potash fertilizers, respectively. A majority of respondents applied nitrogen twice to their crop, whereas the other two fertilizers were mostly applied once. The rates of all three fertilizers were higher in region 2 than in region 1.

Table 12. Fertilizer usage on potatoes

Fertilizer	Region	Percent areas treated	Average number of treatments	Rate per treatment (lbs/acre)	Total amount applied (lbs)
Nitrogen	1	100.00	1.87	40.33	3,854,600
(N = 127)[1]	2	100.00	1.86	71.05	3,145,400
	State	**100.00**	**1.87**	**55.70**	**7,000,000**
Phosphate	1	97.14	1.42	52.44	3,786,600
(N = 124)	2	100.00	1.09	76.08	2,013,400
	State	**98.57**	**1.26**	**64.26**	**5,800,000**
Potash	1	73.33	1.18	70.94	3,024,100
(N = 99)	2	100.00	1.59	178.40	6,475,900
	State	**86.67**	**1.39**	**124.67**	**9,500,000**

[1] N, number of survey reports for the whole State.

Insecticide usage: All potato acres (100%) were treated with insecticides. Data on carbofuran, endosulfan, esfenvalerate, phorate, and phosphamidon are presented in Table 13. For some of these insecticides, there were limited number of surveys to obtain regional information. Azinphos-methyl, carbaryl, diazinon, methamidophos, and permethrin were used on potatoes. However, adequate information on these chemicals was not presented in the survey reports to estimate rates and amounts used. Less than 50% of the crop acreage was treated with each of the five insecticides. The amount of phorate and esfenvalerate applied in region 2 was greater than in region 1.

Table 13. Insecticide usage on potatoes

Insecticide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Carbofuran	1	—[2]	—[2]	—[2]
(N = 56)[1]	2	—[2]	—[2]	—[2]
	State	**39.00**	**0.63**	**19.00**
Endosulfan	1	—[2]	—[2]	—[2]
(N = 36)	2	—[2]	—[2]	—[2]
	State	**25.00**	**0.62**	**12.00**
Esfenvalerate	1	29.52	0.05	0.7
(N = 41)	2	45.45	0.03	0.3
	State	**37.49**	**0.04**	**1.00**
Phorate	1	30.48	2.66	42.7
(N = 50)	2	81.82	2.07	41.3
	State	**45.00**	**2.37**	**84.00**
Phosphamidon	1	—[2]	—[2]	—[2]
(N = 51)	2	—[2]	—[2]	—[2]
	State	**35.00**	**0.87**	**24.00**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data on this insecticide.

Herbicide usage: Herbicides were applied to 48% of the potato acres. Herbicide usage data are shown in Table 14. Information on linuron, sethoxydim, and trifluralin herbicides are not presented because of insufficient data. More than 50% of the acreage in region 2 was treated with metribuzin. In region 1, less than 10% of the planted acreage was treated with metolachlor, metribuzin, and pendimethalin.

Table 14. Herbicide usage on potatoes

Herbicide	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
EPTC	1	—[2]	—[2]	—[2]
(N = 8)[1]	2	—[2]	—[2]	—[2]
	State	**6.00**	**4.16**	**18,000**
Metolachlor	1	7.62	1.87	7,500
(N = 19)	2	50.00	1.60	19,500
	State	**28.81**	**1.74**	**27,000**
Metribuzin	1	8.57	0.20	900
(N = 27)	2	81.82	0.41	8,100
	State	**45.19**	**0.31**	**9,000**
Pendimethalin	1	5.71	0.80	2,400
(N = 8)	2	9.09	0.72	1,600
	State	**7.40**	**0.76**	**4,000**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for this herbicide.

Fungicide usage: The percentage of acres treated with each of the five fungicides varied with the chemical and region (Table 15). A greater percentage of the total crop acres (59%) were treated with chlorothalonil in region 2 compared with region 1 (5%). In region 1, maneb was the most widely used fungicide. Except for triphenyltin hydroxide, a slightly higher rate of all four fungicides was used in region 2 than in region 1.

Table 15. Fungicide usage on potatoes

Fungicide	Region	Percent acres treated	Rate per treatment (lbs AI/acre)	Total amount applied (lbs)
Chlorothalonil	1	4.76	2.84	7,100
(N = 18)[1]	2	59.09	3.32	47,900
	State	**31.93**	**3.08**	**55,000**
Mancozeb	1	23.81	2.65	33,200
(N = 31)	2	27.27	5.83	38,800
	State	**25.54**	**4.24**	**72,000**
Maneb	1	36.19	1.50	28,600
(N = 41)	2	13.64	1.62	5,400
	State	**24.92**	**1.56**	**34,000**
Metiram	1	—[2]	—[2]	—[2]
(N = 9)	2	—[2]	—[2]	—[2]
	State	**6.00**	**0.88**	**4,000**
Triphenyltin hydroxide	1	12.38	0.37	2,400
(N = 15)	2	9.09	0.27	600
	State	**10.73**	**0.32**	**3,000**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for this fungicide.

Miscellaneous chemicals: Two chemicals, diquat and sulfuric acid, were used as harvest aids (Table 16). Diquat and sulfuric acid are used to kill potato tops. About 35 and 23% of the acres were treated with diquat in regions 1 and 2, respectively. For sulphuric acid, only the amount used in the entire State was available.

Table 16. Diquat and sulfuric acid usage on potatoes

Chemical	Region	Percent acres treated	Rate per crop year (lbs AI/acre)	Total amount applied (lbs AI)
Diquat	1	35.24	0.36	6,600
(N = 42)[1]	2	22.73	0.25	1,400
	State	**28.99**	**0.31**	**8,000**
Sulfuric acid	1	—[2]	—[2]	—[2]
(N = 10)	2	—[2]	—[2]	—[2]
	State	**13.00**	**143.70**	**1,388,000**

[1] N, number of survey reports for the whole State.

[2] Insufficient reports to publish data for sulfuric acid.

Acknowledgments

We thank the Minnesota Agricultural Statistics Service, St. Paul, Minnesota, for their cooperation in collecting and summarizing survey data. Funds for the survey and publication of this report were made possible by grants from the United States Department of Agriculture, Washington, D.C. Donald L. Breneman, Minnesota Extension Service, provided the cover photo.

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APPENDIX I

Common and trade names of pesticides mentioned in text and tables

Common Name	Trade Name	Chemical Type*
2,4-D	Aqua-kleen, Crotilin, Dacamine, DMA-4, Demise, Dikamin, Dikonirt, Dymec, Emulsamine-E3, Esteron, Fernoxone, Formula 40, Hedonal, Hi-Dep, Lithane, Phenox, Verton, Weed-B-Gon, Weedar-64, Weedone.	H
Acifluorfen	Blazer, Tackle	H
Alachlor	Lasso	H
Atrazine	AAtrex	H
Azinphos-methyl	Guthion	I
Bentazon	Basagran	H
Bromoxynil	Brominal, Buctril	H
Butylate	Genate Plus, Sutan	H
Carbaryl	Sevin, Savit	I
Carbofuran	Furadan	I
Chloramben	Amiben	H
Chlorimuron ethyl	Classic	H
Chlorpyrifos	Lorsban	I
Chlorothalonil	Bravo	F
Clomazone	Command	H
Clopyralid	Curtail	H
Cyanazine	Bladex	H
Diazinon	Basudin, Dazzel, Diazide, Diazital, Diazol, Gardentox, Kayazinon, Kayazol, Knox-out, Nedcidol, Nipsan, Nucidol, Sarolex, Spectracide	I
Dicamba	Banvel	H
Diclofop-methyl	Hoelon	H
Difenzoquat	Avenge	H
Diuron	Direx, Karmex	H
Endosulfan	Thiodan	I

Common and trade names of pesticides mentioned in text and tables (continued)

Common Name	Trade Name	Chemical Type
EPTC	Eptam, Eradicane, Genep	H
Esfenvalerate	Pydrin, Asana	I
Ethalfluralin	Sonalan	H
Ethoprop		H
Fenoxaprop-ethyl	Option, Whip	H
Fluazifop-p-butyl	Fusilade	H
Fonofos	Dyfonate	I
Glyphosate	Honcho, Ranger, Roundup	H
Imazethapyr	Pursuit	H
Imazamethabenz-methyl	Assert	H
Imazaquin	Scepter, Tri-Scept	H
Lactofen	Cobra	H
Linuron	Linex, Lorox	H
Malathion	Carbophos, Chemathion, Cythion Emmatos, Fyfanon, Karbofos, Kypfos, Malamar, Malaphos, MalaSpray, Malphos, Mercaptothion, MLT, Zithiol	I
Mancozeb	Dithane M-45, Fore, Mancofol, Manzate 200, Manzeb, Manzin-80, Nemispor, Penncozeb, Policar-MZ	F
Maneb	Lonocol-M, Maneba, Manebgan, Manessan, Manex, Manzati, MEB, Nespor, Polyram-M, Remasan, Trimangol, Tubothane	F
MCPA	Agritox, Agroxone, Chiptox, Chornox-M, Dikotex, Hedonal-M, Kilsem, Krezone, Linormone, MCP, Mephanac, Metaxon, Raphone, Rhomenc, Rhomene, Rhonox, Shammox, Shamrox, Trasan, Vacate, Weeder MCPA, Weedone MCPA, Zelan	H

Common and trade names of pesticides mentioned in text and tables (continued)

Common Name	Trade Name	Chemical Type
Methamidophos	Monitor	I
Methyl parathion	Bladan-M, Folidol-M, Metacide, Metafos, Methyl Niran, Metron, Nitrox, Partron-M Penncap-M, Tekwaisa, Wofatox	I
Metiram	Polyram	F
Metolachlor	Dual	H
Metribuzin	Lexone, Sencor	H
Naptalam	Alanap	H
Nicosulfuron	Nicosulfuron	H
Paraquat	Gramoxone	H
Pendimethalin	Prowl	H
Permethrin	Ambush, Pounce	I
Phorate	Thimet	I
Phosphamidon	Phosphamidon	I
Primisulfuron	Beacon	H
Propachlor	Ramrod	H
Propanil	Prop-Job, Stam M	H
Propiconazole	Banner, CGA-64250, Desmel, Orbit, Radar, Tilt	F
Quizalofop-ethyl	Assure	H
Sethoxydim	Poast	H
Simazine	Princep	H
Tefluthrin	Force	I
Terbufos	Counter	I
Thifensulfuron	Harmony, Pinnacle	H
Triallate	Far-Go	H
Tribenuron-methyl	Express	H
Tridiphane	Tandem	H
Trifluralin	Trilin, Tri-4, Treflan	H
Trimethacarb	Broot	F
Triphenyltin hydroxide	Du-Ter, Phenostat-H, Suzu H, TPTH, TPTOH, Tubotin	F

* F, Fungicide; H, Herbicide; I, Insecticide.

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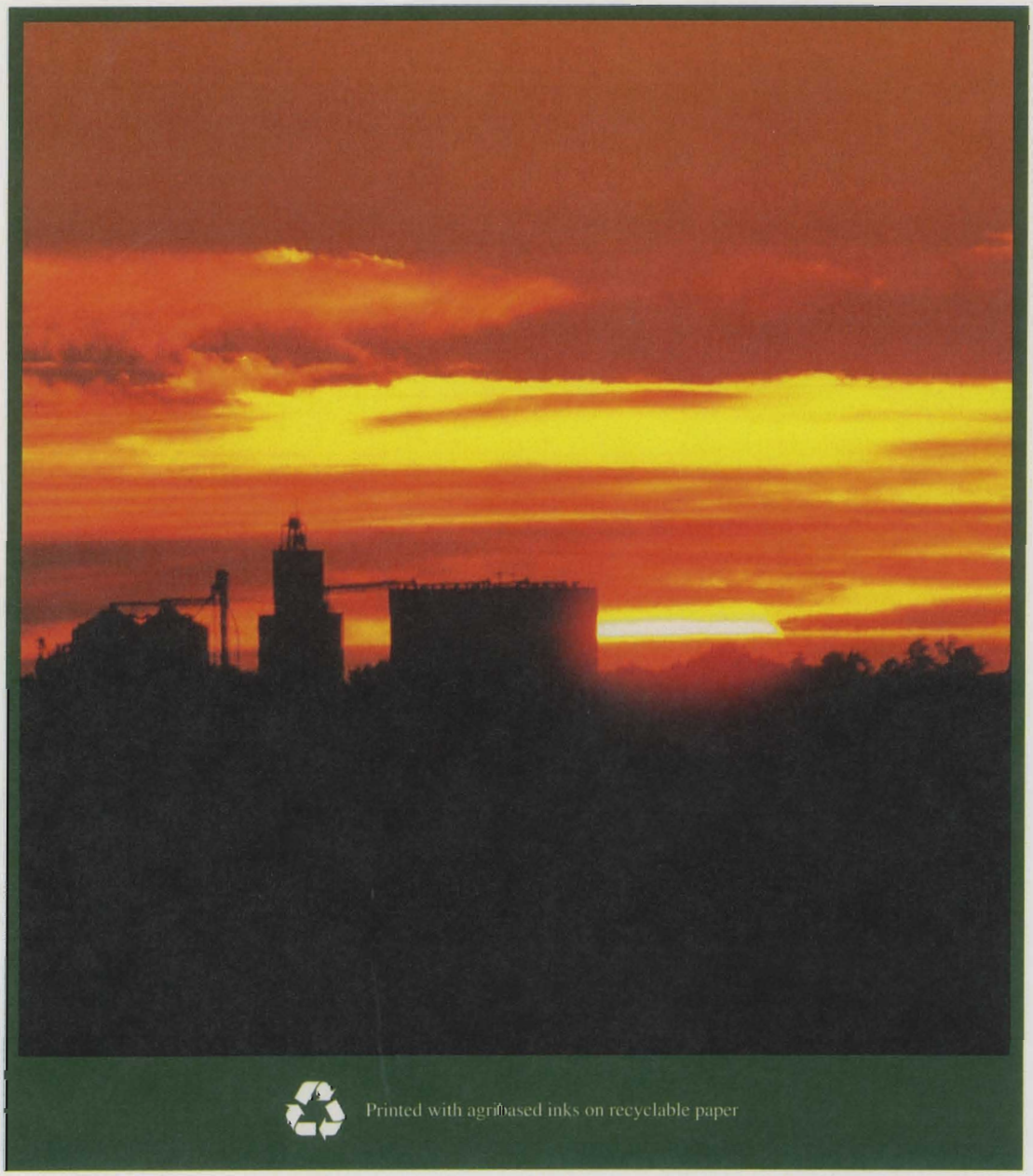

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