NOSB NATIONAL LIST
FILE CHECKLIST

CROPS

MATERIAL NAME: #16 Potassium Chloride

✓ NOSB Database Form

✓ References

___ MSDS (or equivalent)

✓ TAP Reviews from: Walter Jeffery, Joseph Heckman

NOSB/NATIONAL LIST
COMMENT FORM
CROPS

Material Name: #16 Potassium Chloride

Please use this page to write down comments, questions, and your anticipated vote(s).

COMMENTS/QUESTIONS:

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1. In my opinion, this material is:
_____ Synthetic _____ Non-synthetic.

2. This material should be placed on the proposed National List as:
_____Prohibited Natural _____Allowed Synthetic.

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: Sept 15, 1995

Name of Material: Potassium Chloride

Reviewer Name: WALTER JEFFERY

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

non-synthetic

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

____ Synthetic Allowed ____ Prohibited Natural

or, ☒ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Please comment on the accuracy of the information in the file:

Any additional comments? (attachments welcomed)

Potassium chloride is also produced by solution mining where the potassium chloride is dissolved in water, brought to the surface and crystallized from the solution.

Do you have a commercial interest in this material? ✓ Yes [redacted] No

Retained to help Kalium Chemicals in the past & possibly the future.

Signature Walter Jeffery **Date** 9/8/95

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

not that I am aware of

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment; non toxic, chloride can build up in certain soils under certain climatic conditions & probably should be monitored.

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

Short lasting contamination if misused or disposed of improperly.

(4) the effect of the substance on human health;

necessary to human health

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

Dr Smith states that the use of KCl should not be harmful to soil microorganisms if used at reasonable levels. Further to his report - see attached

(6) the alternatives to using the substance in terms of practices or other available materials; and

I know of no alternatives that can provide the required level of potassium in time to do any good should a deficiency exist.

(7) its compatibility with a system of sustainable agriculture.

Yes if used in a reasonable fashion.

United States Department of Agriculture
Agricultural Research Service
Pacific West Area
Land Management & Water Conservation Research Unit
215 Johnson Hall, WSU
Pullman, WA 99164-6421
Telephone: 509-335-1552
FAX: 509-335-3842

July 8. 1993

Walter Jeffery
c/o Village Green Resort
Cottage Grove Oregon 97424

Dear Walter:

I have made some rough calculations. for a soil with a bulk density of 1.3 g/cc and a 50% pore space you would have to apply approximately 10.000 lbs KCl / Ac to induce an electrical conductivity of 12.9 dS / m which is approximately -5 bars or atmospheres osmotic pressure. A five bar potential is small compared to the drastic fluctuations in matric potential organisms see all of the time. In addition liming materials which on a microsite basis is more toxic than KCl considering short term effects is applied to land at rates of 6000 to 10.000 lbs /Ac just to increase the pH by 1 or 1.5 units.

The statement of non toxic aspect of KCl means that people who have conducted experiments to determine the effects of osmotic pressure on some aspect of organism functioning have used KCl because its main affect is to control the osmotic pressure and does not interfere with other aspects of microbial functioning. Why use a solute to control osmotic tension if it also kills half or all of the microbial population or interferes with other aspects of the experiment??

Osmotic potential saturated extracts

Saline soils	> 4 dS / m	-1.4 bars
Arid soils	1 to 2 dS / m	-.36 to -.72 bars
humid soils	< 1 dS / m	<-.36 bars

Sincerely.

Jeffrey L. Smith
Soil Biochemist
USDA-ARS
Washington State University
Pullman. WA 99164-6421

[redacted]

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: September 11, 1995

Name of Material: Potassium Chloride

Reviewer Name: Joseph Heckman

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

____

If synthetic, how is the material made? (please answer here if our database form is blank)

This material should be added to the National List as:

____ Synthetic Allowed ____ Prohibited Natural

or, _____ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Please comment on the accuracy of the information in the file:

accurate

Any additional comments? (attachments welcomed)

See attachment

Do you have a commercial interest in this material? ____ Yes; X No

Signature Joseph R Heckman **Date** Aug 23, 95

Please address the 7 criteria in the Organic Foods Production Act:

(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

(4) the effect of the substance on human health;

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

See attachment

(6) the alternatives to using the substance in terms of practices or other available materials; and

K_2SO_4 produced by solar evaporating natural brines.

(7) its compatibility with a system of sustainable agriculture.

Both K and Cl are essential plant nutrients and should be compatable w. th sustainable agricultu

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Corn Responses to Chloride in Maximum Yield Research

Joseph R. Heckman*

ABSTRACT

Chloride nutrition of corn (*Zea mays* L.) was investigated to determine if Cl limits production in high-yield environments. Experiments were conducted to evaluate the effects of Cl fertilization on a Freehold sandy loam (fine-loamy, mixed, mesic Typic Hapludults) near Adelphia, NJ, using irrigation and intensive crop production practices. Corn was grown at 107 600 plant ha^{-1} with equidistant spacing. All plots received 454 kg K ha^{-1} using KOH, K_2SO_4, or KCl to establish five treatments: 0, 50, 100, 200, and 400 kg Cl ha^{-1}. Positive responses of corn to added Cl were observed each year. In 1990, the Cl treatments averaged 1.1 Mg ha^{-1} more grain than the check yield of 11.3 Mg ha^{-1} ($P = 0.08$). In 1991, the check yield was 19.0 Mg ha^{-1} and the response to Cl was linear up to the 400 kg ha^{-1} rate, which yielded 20.5 Mg ha^{-1}. In 1992, the Cl treatments averaged 0.5 Mg ha^{-1} more grain than the check yield of 14.5 Mg ha^{-1} ($P = 0.07$). Grain yields were positively correlated with increases in ear-leaf Cl concentration. Increases in grain yield were associated with increased ear size. Chloride did not increase stover yield. A linear decrease in incidence of stalk rot with Cl rate was observed in 1992. Results suggest that, when produced in high-yield environments, corn may respond to enhanced levels of Cl nutrition.

CHLORIDE is generally assumed to be in adequate supply for corn production in most field environments. This assumption is supported by Cl fertilization studies reporting grain yields in the range of 6.0 to 11.0 Mg ha^{-1} that have not shown significant responses to Cl (Younts and Musgrave, 1958a; Teater et al., 1960; Parker et al., 1985; Schumacher and Fixen, 1989). Chloride supply may, however, become limiting for the significantly higher yields that can be achieved by employing more intensive production practices. Most research on Cl fertilization has been conducted on wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), for which the yield and quality responsiveness is well documented (Christenson et al., 1981; Engel and Grey, 1991; Fixen et al., 1986a,b; Goos et al., 1987).

Crop species and cultivars apparently vary in responsiveness to Cl fertilization. Several-fold increases in tissue Cl concentration may occur in some crops, with little or no apparent effects on growth and yield (Fixen, 1993). Corn can tolerate tissue Cl concentrations exceeding those of P or S with no apparent toxicity (Parker et al., 1985). Some soybean [*Glycine max* (L.) Merr.] cultivars, however, are quite sensitive to elevated tissue Cl concentrations. Soybean cultivars that exclude Cl from uptake in the shoot are more tolerant of high soil Cl concentrations than cultivars that accumulate Cl (Yang and Blanchar, 1993).

Reductions in the severity of diseases in wheat have often been associated with Cl fertilization. Christensen et al. (1981) showed how higher levels of tissue Cl in wheat affected plant water potential. They suggested that the influence of Cl on water relations may reduce the susceptibility of wheat plants to disease. Cereal yield responses to Cl fertilization are often associated with disease reductions, but yield responses also occur in the absence of detectable disease (Engel and Grey, 1991).

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Published in Agron. J. 87:415-419 (1995).

My objective was to determine responses of corn to Cl fertilization in a minimum-stress field environment. The experiment attempted to control all production inputs using an intensive cropping system so that only Cl was limiting. The effects of Cl supply on yield, harvest index, plant nutrient composition, crop development, stalk rot, and lodging were examined.

MATERIALS AND METHODS

Field experiments were conducted using maximum corn yield research methods similar to those of Karlen et al. (1988). Corn was grown for a 3-yr period on a Freehold sandy loam (fine-loamy, mixed, mesic Typic Hapludults) at the Rutgers University Plant Science Research Center near Adelphia, NJ. Treatments were 0, 50, 100, 200, and 400 kg Cl ha^{-1} arranged in a randomized complete block design with six replications. The Cl source was KCl. Equal amounts of K were applied to all plots. At planting, KCl rates were 0, 53, 107, 213, and 427 kg KCl ha^{-1} and KOH rates were 326, 285, 224, 169, and 0 kg KOH ha^{-1}. After planting, KCl rates of 0, 53, 107, 213, and 427 kg KCl ha^{-1} were split into three equal sidedress applications. In 1990, equivalent sidedress applications of K were achieved using KOH at 326, 285, 224, 169, and 0 kg ha^{-1} and in 1991 and 1992 using K_2SO_4 at rates of 506, 443, 379, 253, and 0 kg K_2SO_4 ha^{-1}. Thus, half of the total season Cl rates were applied before planting, with the remainder split into three equal sidedressings at the V6 (six-leaf), V12 (12-leaf), and R1 (silking) growth stages (Ritchie and Hanway, 1984). Applications of N and P were also split into three equal sidedressings at the same growth stages. A final application of N was sidedressed at the R3 growth stage. Total seasonal N, P, and K applications were 560, 300, and 454 kg ha^{-1}, respectively. The nutrients N, P, K, B, Cu, Mn, and Zn were broadcast and disked in immediately before planting at rates of 112, 75, 224, 2.2, 5.6, 28, and 11 kg ha^{-1}, respectively. The N source used at planting was NH_4NO_3. The N source used for sidedressing was $(NH_4)_2S_2O_3$ in 1990 and $(NH_4)_2SO_4$ in 1991 and 1992. Dolomitic limestone was broadcast at 1.68 Mg ha^{-1} and plowed down prior to planting each year.

Corn seed was treated with lindane (gamma isomer of 1,2,3,4,5,6-hexachloro-cyclohexane) for insect control. Soil was treated with 5.6 kg a.i. ha^{-1} fonophos [*O*-ethyl *S*-phenyl (*RS*)-ethylphosphonodithioate] and disked in before planting. At Growth Stage V8 (eight-leaf), a granular foliar whorl application of 1.1 kg a.i. ha^{-1} carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) was made to control European corn borer [*Ostrinia nubilalis* (Hübner)]. For weed control in 1990, a combination of pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] and atrazine [6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine] was applied at rates of 0.9 and 0.7 kg a.i. ha^{-1}, respectively. Pendimethalin was not used in subsequent years, because it resulted in stunting of corn roots and plant lodging which probably reduced yield. For weed control in 1991 and 1992, a combination of alachlor [2-chloro-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl) acetamide] and atrazine was applied at rates of 1.0 and 0.7 kg a.i. ha^{-1}, respectively.

A commercial corn hybrid (Pioneer 3245)[1] was planted on 9 May 1990, 1 May 1991, and 28 Apr. 1992. Each plot consisted of eight 18-m rows, with row widths of 30.5 cm. Average populations at emergence were >200 000 plants ha^{-1} and thinned to 107 600 plants ha^{-1} using an equidistant 30.5- by 30.5-cm spacing. Weekly rainfall and irrigation amounts were recorded. Data on day of silk emergence were collected from 25 plants in each plot to determine treatment effects on time of midsilk. Eight ear-leaf samples were collected randomly from each plot at silking, excluding the center two rows which were saved for harvest and plants at the edges of the plot. Plant materials were dried at 70°C and ground to pass a 1-mm screen. Chloride tissue concentrations were determined by the potentiometric titration method of Gilliam (1971). Tissue samples for P, K, Ca, Mg, S, Mn, Fe, Cu, Zn, B, and Na, were digested with perchloric/nitric acid and analyzed using inductively coupled plasma spectroscopy (ICP). Tissue N was determined by Kjeldahl procedure (Bremner, 1965). At maturity, corn ears were hand harvested from 12-m-long sections of each of the two center rows of each plot and weighed. Grain yields are reported on the basis of 155 g moisture kg^{-1} shelled grain. Grain Cl concentrations were determined by the methods described above. Ten randomly sampled ears from each plot were dried at 70°C to determine ear size. At harvest, 15 plants minus ears were collected from each plot to determine stover yield and harvest index [harvest index = grain yield ÷ (grain yield + stover yield) × 100]. The incidence of stalk rot was measured immediately following harvest by examining the first fully elongated internode above the brace roots. A stalk was considered rotted if the rind and pith were soft and could be collapsed by hand. One hundred plants were examined in each plot. Lodging counts were taken for unharvested plants 4 wk after harvest in 1991 from the two center rows. Herbicide injury to roots in 1990 and severe storm damage in 1992 precluded collection of lodging data in these years.

Table 1. Initial soil characteristics at the study sites.†

Year	Cl, by depth, cm			Mehlich-3		Extractable		Organic matter	Soil pH
	0–30	30–60	60–90	P	K	Ca	Mg		
	kg ha^{-1}							g kg^{-1}	
1990	9.4	11.8	4.5	98	212	1724	276	15.0	5.6
1991	1.1	0.8	0.0	53	318	1627	310	11.0	5.7
1992	12.1	8.8	13.4	141	258	1454	300	9.5	5.7

† Except as indicated for Cl, all values are for the 0- to 20-cm soil layer.

Soil samples collected from the upper 20 cm prior to initiating the experiment were analyzed for pH on a 1:1 ratio of soil volume to water and for extractable P, K, Ca, and Mg by the Mehlich-3 method (Mehlich, 1984) (Table 1). Organic matter concentration was determined by the modified Walkley-Black method (Walkley and Black, 1934). Composite soil samples, each containing six randomly selected cores, were also taken from each replicate before chloride application at depths of 0 to 30, 30 to 60, and 60 to 90 cm. Soil chloride was determined by potentiometric titration with $AgNO_3$ (Table 1). Soil samples were also collected from the upper 20 cm of each plot just after harvest to determine soil pH.

Analysis of variance was performed with SAS GLM (SAS Inst., 1985). Single degree of freedom contrasts were tested for treatment effects. The relationship between relative grain yield and tissue Cl concentration was evaluated using Cate-Nelson analysis (Cate and Nelson, 1965). Relative yield was calculated each year by dividing the yield for each treatment by the highest yielding treatment.

RESULTS AND DISCUSSION

Grain and Stover Yield Response

Grain yield and ear size were generally increased by Cl fertilization (Table 2). In 1990, yield of Cl treatments averaged 1.1 Mg ha^{-1} more grain than the check yield of 11.3 Mg ha^{-1} ($P = 0.08$). In 1991, the check yielded 19.0 Mg ha^{-1} and the response was linear up to the 400 kg ha^{-1} rate, which yielded 20.5 Mg ha^{-1}. In 1992, yield of the Cl treatments vs. the 0 Cl rate was significant at

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[1] The use of trade names in the publication does not imply endorsement by the New Jersey Agricultural Experiment Station of the products named or criticisms of similar ones not mentioned.

Table 2. Effect of Cl rate on corn grain and stover yield, ear size, harvest index, and moisture content of stover and ear.

Treatment	Grain	Stover	Ear size	Harvest index	Stover moisture	Ear moisture
kg Cl ha^{-1}	— Mg ha^{-1} —		g	%	—— g kg	——
				1990		
0	11.3	10.6	124	52	602	263
50	12.2	11.2	124	52	599	259
100	12.9	10.9	140	54	622	269
200	11.9	10.9	128	52	656	270
400	12.6	11.5	134	52	646	270
				$P > F$		
Treatment	0.40	0.88	0.005	0.60	0.34	0.53
Linear	0.29	0.46	0.04	0.56	0.33	0.22
Quadratic	0.51	0.80	0.15	0.59	0.32	0.49
Check vs. Cl	0.08	0.53	0.03	0.87	0.86	0.54
CV, %	8.2	11.4	4.3	4.0	10.7	4.0
				1991		
0	19.0	11.9	192	63	546	256
50	19.5	11.2	205	65	632	288
100	19.4	10.3	203	67	646	284
200	19.9	11.0	206	66	655	287
400	20.5	10.8	211	67	666	293
				$P > F$		
Treatment	0.34	0.47	0.34	0.05	0.006	0.10
Linear	0.05	0.35	0.09	0.02	0.003	0.07
Quadratic	0.79	0.30	0.47	0.19	0.02	0.16
Check vs. Cl	0.15	0.13	0.07	0.10	0.0004	0.009
CV, %	6.8	13.7	6.3	3.8	12.2	8.2
				1992		
0	14.5	11.3	132	56	748	372
50	14.6	11.3	135	56	765	375
100	15.2	11.7	138	57	757	367
200	15.0	11.3	137	57	765	376
400	15.1	11.8	139	56	778	371
				$P > F$		
Treatment	0.15	0.56	0.22	0.54	0.19	0.83
Linear	0.09	0.81	0.07	0.58	0.02	0.66
Quadratic	0.18	0.19	0.29	0.11	0.75	0.89
Check vs. Cl	0.07	0.81	0.04	0.30	0.13	0.43
CV, %	4.4	9.0	4.8	1.9	9.4	2.4

$P = 0.07$ and the linear response to Cl rate was significant at $P = 0.09$. The Cl treatment averaged 0.5 Mg ha^{-1} more grain than the check yield of 14.5 Mg ha^{-1}. Increases in grain yield were associated with linear increases in ear size, which were significant at $P = 0.04$, 0.09, and 0.07 in 1990, 1991, and 1992, respectively. Yield levels were two- to three-fold higher in this experiment than in previous studies that did not obtain yield increases from Cl fertilization of corn (Younts and Musgrave, 1958a; Teater et al., 1960; Parker et al., 1985; Schumacher and Fixen, 1989). Hybrid effects may also be a contributing factor to variation in corn responses to Cl as with wheat cultivars (Engel and Sanders, 1992).

The positive yield responses to Cl observed in this experiment may also be related to the provision of ammonium nutrition throughout the growing season. Nitrogen was sidedressed in the ammonium form at the V6, V12, R1, and R3 growth stages. It has been suggested (Teyker et al., 1992) that corn grown under enhanced ammonium nutrition may have a higher requirement for Cl, due to the role of Cl as a counterbalancing ion.

Although Cl increased grain yield, it did not increase stover yield. In 1991, stover yield was generally lower with Cl fertilizer, and the harvest index exhibited a positive

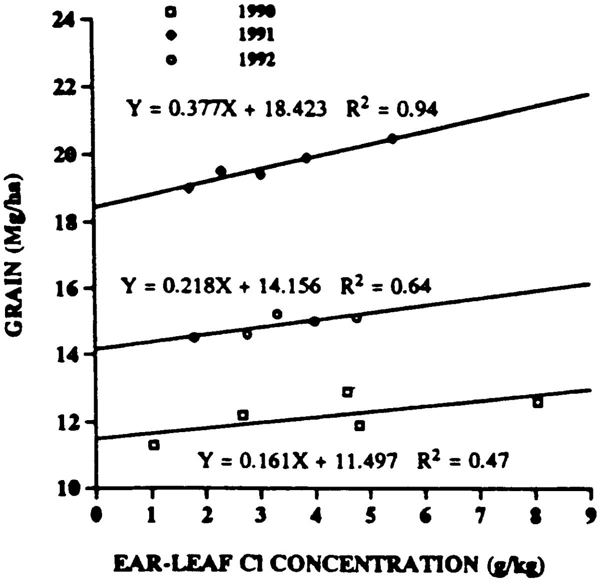
Table 3. Effect of Cl rate on the Cl concentration of the corn ear-leaf at silking.

Treatment	Cl concentration 1990	1991	1992
		g kg^{-1}	
0	1.04	1.72	1.79
50	2.67	2.31	2.76
100	4.59	3.03	3.31
200	4.81	3.87	3.99
400	8.07	5.46	4.77
		$P > F$	
Treatment	0.0001	0.0001	0.0001
Linear	0.0001	0.0001	0.0001
Quadratic	0.03	0.03	0.0006
Check vs. Cl	0.0001	0.0001	0.0001
CV, %	15.1	11.5	24.8

grain yield increases in 1991 were achieved by partitioning a higher proportion of the total dry matter to the grain. Linear increases in stover moisture concentration were observed in 1991 and 1992 and in ear moisture concentration in 1991. Higher levels of Cl nutrition may be beneficial to corn during grain fill by enhancing retention of water in plant tissues during this period. Fixen et al. (1986b) also observed increases in harvest index of Cl-fertilized wheat and suggested that Cl may influence carbohydrate translocation within the plant. Chloride fertilization may, however, also result in unfavorable responses. Grain harvest time may be delayed, or there may be an increased need for drying after harvest.

Plant Nutrient Composition

Concentrations of Cl in the ear-leaf increased linearly with increased Cl rates each year (Table 3). Although leaf Cl concentrations were strongly influenced by Cl rate, there was no effect of Cl rate on the concentration of Cl in the grain which averaged 641 mg kg^{-1} for all treatments (data not shown). In a study by Parker et al. (1985) that used a similar range of Cl fertilizer rates but a different hybrid,



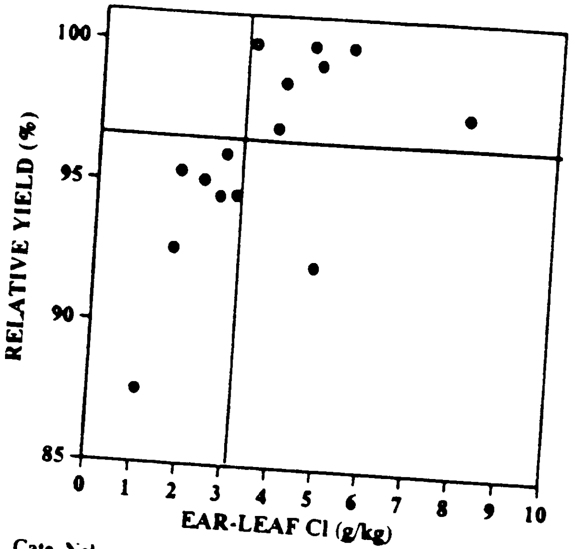


Fig. 2. Cate–Nelson analysis of the relationship between ear-leaf Cl concentration at silking and relative grain yield.

the grain Cl concentration averaged 447 mg kg^{-1} and also was not influenced by Cl rate. Corn apparently excludes Cl from uptake into grain.

Grain yield was positively correlated with ear-leaf Cl concentrations (Fig. 1). The relationship was strongest in 1991, when the highest yield was produced and when soil Cl concentrations were lowest (Table 1). As plant Cl concentration increased, relative yield also increased (Fig. 2). Cate–Nelson analysis shows a critical ear-leaf Cl concentration of 3.2 g kg^{-1}, which corresponds to 97% of maximum grain yield. The linear ear-leaf Cl concentration and grain yield response to Cl in 1992, however, indicates that the critical ear-leaf Cl concentration may be ≥5.5 for grain yield levels near 20 Mg ha^{-1}. This concentration is considerably higher than the critical concentration shown by Cate–Nelson analysis or than the 1.5 g kg^{-1} whole plant Cl concentration reported as critical for spring wheat (Fixen et al., 1986b).

The concentrations of macro- and micronutrients in the ear-leaf at silking were within the sufficiency ranges published for corn (Jones et al., 1990). Generally, they were not influenced by Cl rate (Table 4). Previous studies (Parker et al., 1985; Teater et al., 1960; Younts and Musgrave 1958a) also found no influence of Cl fertilization on the concentration of other elements in the ear-leaf.

Table 5. Effect of Cl rate on percent silking in corn at approximately mid-anthesis.

Treatment	Silking 1990	Silking 1991	Silking 1992
kg Cl ha^{-1}		%	
0	57	56	45
50	58	59	41
100	60	59	46
200	50	51	31
400	52	52	33
		$P > F$	
Treatment	0.79	0.81	0.10
Linear	0.29	0.38	0.03
Quadratic	0.78	0.84	0.46
Check vs. Cl	0.77	0.87	0.18
CV, %	18.9	27.4	38.8

Although increasing rates of Cl application were accompanied by decreasing rates of OH$^-$ and SO_4^{2-} application, ear-leaf analysis did not indicate an influence of OH$^-$ and SO_4^{2-} rate on plant nutrient status. Soil pH levels at harvest were not above 6.2 (a point at which excessive liming can cause Mn deficiency; Mehlich, 1957). Soil pH at harvest of the 0 kg Cl ha^{-1} plots (which received the greatest amount of applied OH) was only 0.2 units higher than the 400 kg Cl ha^{-1} treated plots not receiving KOH. Theoretically a large increase in Cl uptake, without compensatory changes in the uptake of other ions, could shift the cation/anion uptake ratio (Nye, 1981). Thus, even though the bulk soil pH was slightly lower at high Cl rates, it is conceivable that rhizosphere pH may have been elevated by increased Cl uptake.

There are few reports of nutrient concentrations in the ear-leaf for exceptionally high corn yield levels. In 1991, when grain yield was >19.0 Mg ha^{-1}, the concentrations of N, P, K, Ca, Mg, and S in the ear-leaf at silking were 28.3, 2.9, 23.4, 4.8, 2.0, and 2.2 g kg^{-1}, respectively, and 8, 9, 31, and 23 mg kg^{-1} for B, Cu, Mn, and Zn. In comparison, Flannery (1982) reported ear-leaf concentrations of 31.8, 4.0, 22.8, 5.1, 1.7 and 2.0 g kg^{-1} and 14, 11, 43, and 39 mg kg^{-1} for the same 10 nutrients (with a 19.6 Mg ha^{-1} yield).

Silk Emergence

Application of Cl at rates of 200 and 400 kg ha^{-1} generally delayed silk emergence (Table 5). In 1992, the effect

Table 4. Effect of Cl rate on the average nutrient composition of the corn ear-leaf at mid-silk in 1990–1992.

Treatment	N	P	K	Ca	Mg	S	Na	B	Cu	Fe	Mn	Zn
			g kg^{-1}							mg kg^{-1}		
0	28.6	2.9	23.3	4.5	2.0	2.2	59	10	9	115	46	23
50	28.7	3.0	23.1	4.6	2.1	2.2	54	9	10	119	45	23
100	28.0	3.0	23.7	4.5	2.0	2.1	55	9	9	116	49	23
200	29.0	3.0	23.3	4.6	2.2	2.2	55	9	10	116	50	25
400	28.8	3.0	23.3	4.6	2.0	2.2	54	9	10	114	55	26
							$P > F$					
Treatment	0.14	0.92	0.74	0.33	0.09	0.24	0.81	0.36	0.16	0.81	0.0003	0.008
Linear	0.85	0.99	0.87	0.30	0.05	0.92	0.16	0.56	0.49	0.71	0.32	0.27
Quadratic	0.68	0.98	0.90	0.52	0.06	0.88	0.27	0.47	0.98	0.87	0.86	0.88
Yr	0.0001	0.0001	0.01	0.0001	0.11	0.80	0.51	0.0001	0.0001	0.0001	0.0001	0.0001
Linear Yr	0.54	0.18	0.13	0.75	0.22	0.10	0.85	0.17	0.76	0.74	0.51	0.69
Quadratic Yr	0.64	0.37	0.13	0.46	0.22	0.15	0.92	0.18	0.44	0.93	0.14	0.90
CV, %	4.2	5.3	5.8	5.2	8.6	5.7	13.1	19.2	9.5	23.5	16.7	10.6

Table 6. Effect of Cl rate on percent incidence of stalk rot and lodging in corn.

Treatment	Stalk rot 1991	Stalk rot 1992	Lodging 1991
	%		
0	6.8	10.9	12.7
50	7.2	9.4	12.3
100	7.3	4.7	11.8
200	8.0	4.2	9.3
400	6.2	4.2	7.0
		$P > F$	
Treatment	0.89	0.2	0.44
Linear	0.68	0.008	0.07
Quadratic	0.36	0.04	0.95
Check vs. Cl	0.81	0.01	0.44
CV, %	44.5	45.4	54.6

of Cl on percent silking exhibited a significant linear decrease. Younts and Musgrave (1958a) reported that low applications of Cl (10 kg ha^{-1}) in the row favor earlier maturity and that higher rates (34 kg ha^{-1}) tend to delay silk emergence. In spring wheat, Cl accelerates the rate of reproductive development (Engel and Sanders, 1992).

Stalk Rot and Lodging

Incidence of stalk rot was not influenced by Cl treatment in 1991, but there was a linear decrease ($P = 0.07$) in lodging with rate of Cl (Table 6). An evaluation by Liebhardt and Munson (1976), however, found no effect of Cl on lodging. In 1992, Cl rate resulted in a linear decrease in incidence of stalk rot. Younts and Musgrave (1958b) compared the effects of various K fertilizers and also found that Cl application reduced stalk rot. Retention of water in the plant (Table 2) and delayed maturity may be a reason for such a response.

CONCLUSIONS

Results indicate that Cl fertilization may increase corn grain yield when yield levels are >12 Mg ha^{-1}. Reduced stalk rot and lodging are also potential benefits. Enhanced levels of Cl nutrition may favorably influence corn production as a result of (i) retention of water in plant tissues and extending the period of grain fill, (ii) partitioning more photosynthate into grain, and (iii) suppression of disease. Chloride may also have an unfavorable influence on corn production by delaying time to grain harvest or increasing the need for drying after harvest. Further research is needed to better understand the physiological basis for crop responses to Cl fertilization.

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NOSB Materials Database

Identification

Common Name	**Potassium Chloride**	**Chemical Name**	
Other Names	Muriate of Potash.		
Code #: CAS	7447-40-7	**Code #: Other**	
N. L. Category	unknown	**MSDS**	no

Chemistry

Family	
Composition	KCl, usually obtained from sylvinite ore. The potassium salt of hydrochloric (muriatic) acid.
Properties	Highly soluble in water.

How Made

Usually mined from solid ores, but about 3% of world production is produced by solar evaporation of natural brines. Once mined, the ores are crushed to a suitable size and then refined by physical processes, usually froth flotation. This purification separates the potassium chloride from the sodium chloride and other impurities in the ore. It is done by adding a saturated brine of NaCL and KCl to produce a pulp containing 50-75% solids, then wet grinding the ore, then adding conditioning agents to help the KCl separate from the NaCl. These conditioning agents can consist of an amine to make the potassium chloride more hydrophobic, a blinder to depress slime flotation, and an alcohol to act as a frothing agent. Through agitation and air flow, a froth is created in which the sylvite rises to the surface and is then skimmed off. Major potash mines in the United States are in North Dakota, New Mexico, Utah and California.

Use/Action

Type of Use	Crops
Use(s)	Fertilizer
Action	
Combinations	

Status

OFPA			
N. L. Restriction			
EPA, FDA, etc			
Safety Guidelines		**Directions**	
Registration		**State Differences**	
Historical status	controversial among US certification groups.		
Internationl status			

OFPA Criteria

2119(m)1: chemical interactions

Salts in soil at high levels have an inhibitory effect on nitrification reactions. This leaves more nitrogen in an ammoniacal form which cuts down on leaching of nitrate.

2119(m)2: toxicity & persistence

Highly soluble material readily leaches from soil or is taken up by the soil complex or by plants.

2119(m)3: manufacture & disposal consequences

The world has enormous potash reserves. The waste from potassium chloride refining consists of sodium chloride primarily. This is usually pumped to a storage area where it is left to solidigy gradually. Occasionally it is pumped into an ocean or river, howver this practice is coming under much environmental regulation or banning.

2119(m)4: effect on human health

Potassium is an essential element for humans.

2119(m)5: agroecosystem biology

Microorganisms require potassium just as plants do. Studies on the effects of high levels of soluble salts on microorganisms have been inconsistent, with small amounts stimulating microbes while large amounts inhibit nitrificatio but showing many microbes tolerant of a wide range of conditions. Depressive effects from high salt concentrations tend to be short-lived because of the buffering effect of soil and organic matter.

2119(m)6: alternatives to substance

Ashes, seaweed, compost

2119(m)7: Is it compatible?

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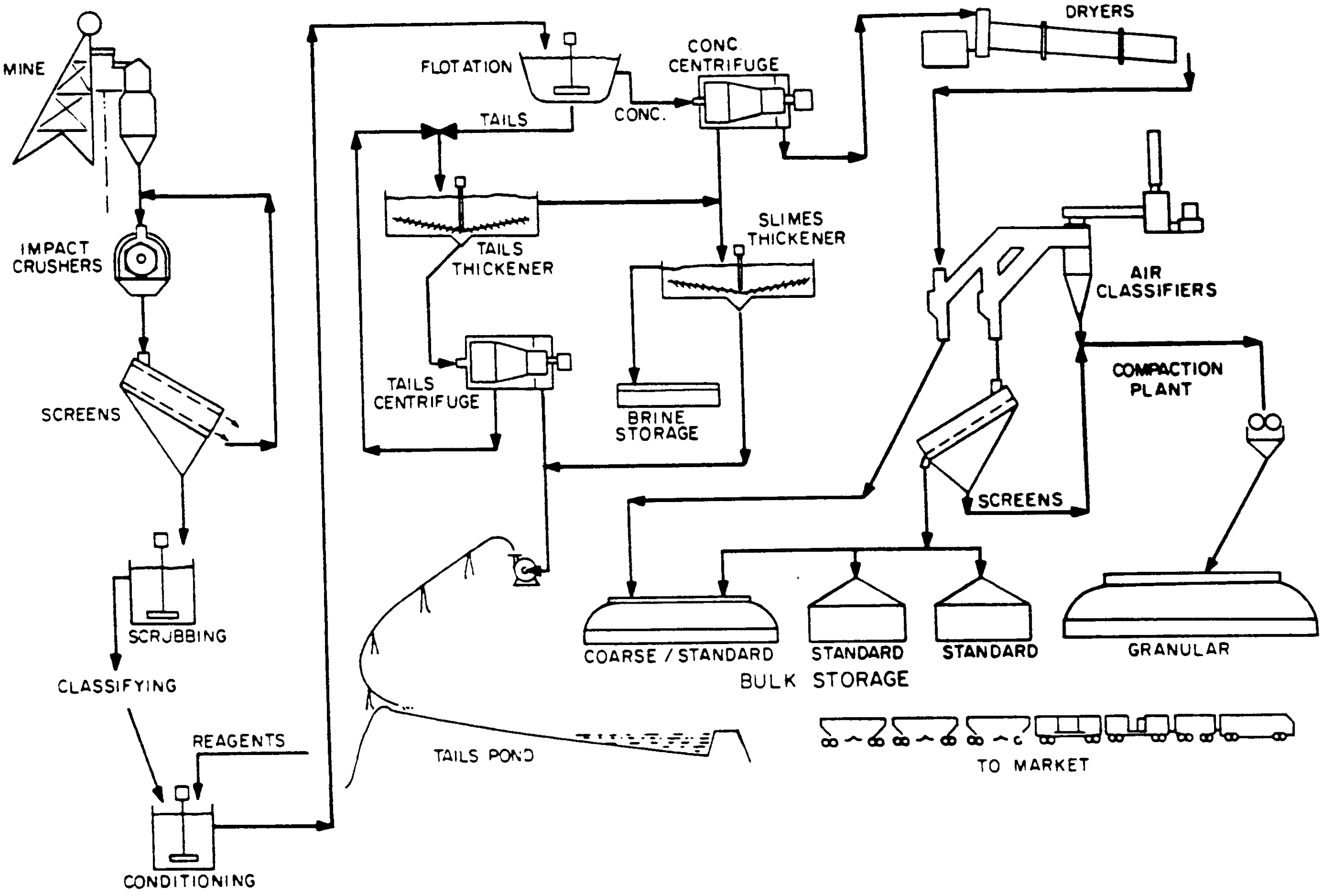

Source: Amax Chemical Corporation.

Figure 2. Simplified Flowsheet of Potash Refining System Using Flotation.

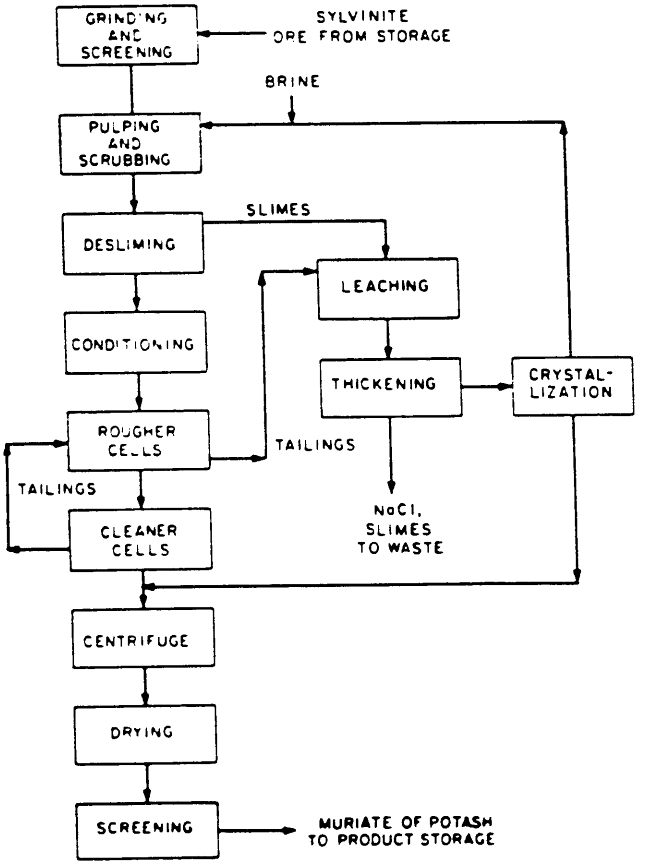

Figure 3. Diagram of Flotation Process for Recovery of Muriate of Potash.

agent in the liquor. This liquor is suitable for separation in the magnetic separator at high efficiency. The underflow is treated to separate ore impurities from the weighting suspension. This may be accomplished by means of a fine screen."

Solution-Crystallization--Dissolution of the ore with recovery of KCl by crystallization is necessarily used in solution mining. It is also used to some extent for beneficiating shaft-mined ore. Its advantages are that it can utilize ores with a high percentage of insoluble materials such as clay, and it produces a high-grade (62%-63% K_2O) product that is fully soluble and hence suitable for use in liquid fertilizers. The beneficiation process is based on the solubilities of NaCl and KCl in hot and cold water which are:

	Solubility, g/100 ml of Water	
	at 20°C	at 100°C
KCl	34.7	56.7
NaCl	35.4	39.1

The data shown above are the separate solubilities of KCl and NaCl. For solutions containing both salts, the solubility of NaCl decreases slightly as the temperature increases. Thus, when a brine that is saturated with both NaCl and KCl at 20°C is heated to 100°C, it is capable of dissolving substantial amounts of KCl but no NaCl.

Figure 4 shows a typical flow diagram of a solution-crystallization process. Sylvinite ore is crushed to minus 3-mesh and washed with a cool, saturated