Chemical SPROUT CONTROL

of Alaska potatoes, and the influence of pre-storage washing and storage temperature on market quality

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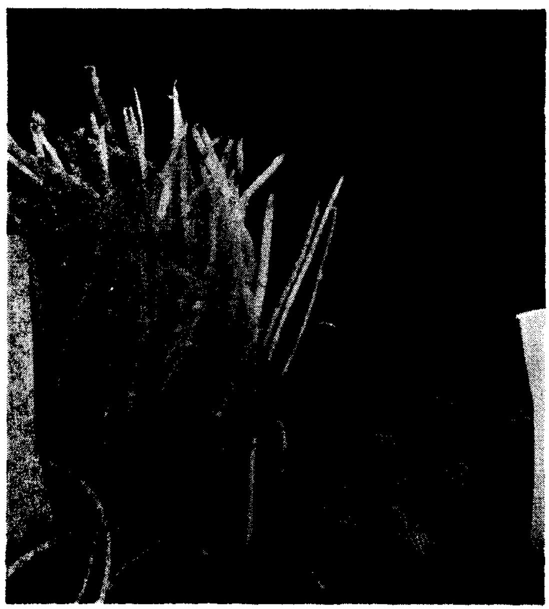

Tubers from plants sprayed with 3 pounds of maleic hydrazide about two weeks before harvesting show little sprouting after 10 months in storage (right). Potatoes from untreated plants (left) grew long sprouts and shriveled in the same storage period.

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CHEMICAL SPROUT CONTROL OF ALASKAN POTATOES

POTATOES sprout in 11 to 15 weeks after harvest if placed in storage where temperatures average 40° F or above. Prior to this, growth regulating substances within the tubers prevent sprouting. If potatoes are stored at room temperature (70° F or higher) their dormant period will be shorter, although differences in varieties are observed.

Varieties also differ in habit of sprout growth*. Some develop long sprouts that are relatively easy to remove. Even so, a new crop of sprouts will grow again from the same eyes if storage temperatures remain above 40°F for ten days or more. In addition to the expense of desprouting, potatoes lose weight and their market appeal.

Potatoes can be and are stored at 30° to 36° for nearly a year with very little sprouting. Cold storage at this temperature range has some disadvantages. For example, starches are converted to sugar within the tubers. These sugars give cooked potatoes a sweet taste objectionable to some people. Potatoes with a high sugar content are not suitable for chipping and french frying. Sometimes they can be reconditioned by storing at 60° to 70° for a month or more but this warmer environment starts sprouting. Potatoes sprouting extensively in bins (as illustrated in Figure 1) cannot be ventilated properly because sprouts fill the air spaces between tubers. Lack of air movement through the bin causes a low oxygen supply and black heart or black patches soon appear within tubers (Figure 2).

Sprouting is costly to Alaskans in that it reduces the number of potatoes meeting U.S. No. 1 grade and therefore reduces farm income. Sprouting is costly to Alaskan's potato industry because it weakens Alaska's competitive position for summer markets. Summer imports of dormant potatoes often capture a large segment of the Alaskan potato market.

When these studies were begun, workers in other regions (2, 4, 5, 9) had demonstrated several methods of chemical sprout control. These methods included field spraying of tops, dusting or dipping of tubers moving into storage, and gas treatment with volatile substances distributed within binned potatoes.

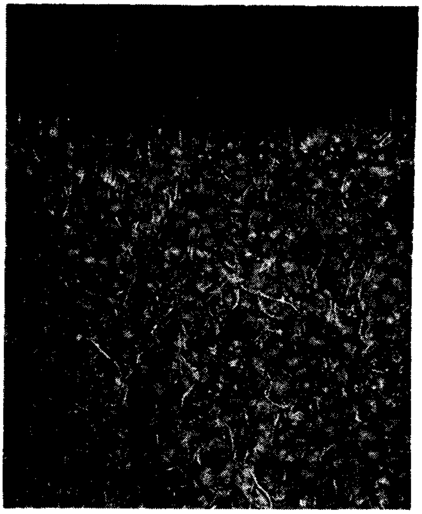

Figure 1.—Unless treated with a preventative agent, potatoes sprout after several months in a warm storage. The temperature in this bin of untreated potatoes ranged from 38 to 45°F. The picture was taken at the end of seven months in storage.

*A potato tuber is a thickened tip of an underground stem with buds (or "eyes" as they are called) arranged spirally. The final whorl ends in what corresponds to the leading bud of a plant stem. In most potato varieties sprouting is first seen on this bud. Other buds in the spiral soon sprout if the environment is favorable.

Figure 2.—Interior of this tuber darkened after prolonged cold storage in a bin with inadequate air circulation.

Chemicals that had given the best control were methyl ester of naphthaleneacetic acid (MENA), indoleacetic acid (IA), maleic hydrazide (MH) and isopropyl N-(3 chlorophenyl) carbamate (CIPC). In other states MH has become so popular that it has been recently sprayed from an airplane (1) and CIPC has been released as an aerosol or vapor (6) within the storage.

Some evidence has been presented (3) showing that healing of tender skins and healing of tuber bruises is delayed by sprout inhibitors. Unwashed potatoes frequently carry enough mud or wet soil into storage to inhibit good air movement through the bin. While washing prior to storage eliminates this particular problem, little is known about the storage characteristics of washed treated tubers (10).

The objectives of these studies were to learn (1) if sprout inhibitor chemicals used in other regions also inhibit sprouting of potatoes grown in Alaska's environment, (2) what effect sprout inhibitors have on yield and quality, (3) when and at what rate the chemical should be applied, (4) how sprout inhibitor treated potatoes store at different temperatures, (5) if washing field-treated potatoes prior to storage influences keeping ability or modifies sprout inhibitor action.

MATERIALS AND METHODS

Cut seed potatoes were planted by machine on Knik loam soil at the Matanuska Farm. Green Mountain was planted for these studies in 1955 and Alaska 114 in 1957 and 1958. An 8-32-16 fertilizer was drilled in at 750 pounds per acre with a conventional potato planter. The ridged row was flattened with a roller attached to the planter. As the soil began to crack from emerging sprouts, a pre-emergence weed control spray of seven quarts of dinitro (Premerge) per acre was applied. Plots were hilled twice in early July.

A sprout inhibitor treatment consisted of one foliar application of one chemical or chemical mixture sprayed over the vines once during the season. Chemicals were applied by hand sprayer in 50 gallons of water per acre. Test plots were 3 ft. 4 in. x 30 ft. or 3 ft. x 46 ft. An untreated plot in each of four replicates served as a check. A different randomized block design was used each year. For each plot (except in the 1955 study) records were taken at harvest of specific gravity, total yield, weight of US No. 1 grade, weight of tubers of less than 1⅞ inches in diameter, and weight of tubers discarded for defects.

In the 1955 study, potatoes were stored directly from the field and evaluated when removed from storage in August of 1956. The potato vines had been frosted on August 30 and again on September 15 when field temperatures fell to 28°F. On September 2, when 6.3- and 10-pounds MH per acre were applied, it was noted that the frost of August 30 had destroyed two-thirds of the leaves and nearly all of the vigorous tip growth. Another group of plots was sprayed with the same MH treatments on September 12, while vine stems were still upright but only a few green leaves remained (Figure 3). Below freezing temperatures occurred on five consecutive nights beginning three days after this spraying. Maximum day temperatures from September 12 through September 19 averaged 56.5°F.

All plots were harvested on October 6 and stored in crates until August 10, 1956. Storage temperatures were held between 36° and 40°F during the cold winter months. After mid-May storage temperatures gradually went up to 50° by August 10.

In 1957 MH was sprayed on vines in the field at 6.3- and 10-pounds per acre on August 31 and September 16. MENA was mixed and applied on the same dates at concentrations of 3500 and 7000 parts per million of active ingredient. Harvesting was by machine on October 1, fifteen days after the last sprout inhibitor was applied.

The 1958 study was similar to that in 1957 except that CIPC plus borax was substituted for the MENA treatment. MH was applied at 6.3 and 10 pounds per acre. CIPC was applied at 3 and 5 pounds of active ingredient per acre, with a pound of borax added to each rate of CIPC. It was reasoned that borax might aid in the absorption of CIPC through the foliage. All plots were harvested October 3.

To determine the effects of washing and storage temperatures on keeping qualities of treated potatoes, two 15-pound samples of U. S. No. 1 tubers from each plot were washed and sacked in open mesh bags. Two similar samples from the same plot were bagged without washing. A 15-pound sample of washed and a 15-pound sample of unwashed tubers from each plot were then stored at 36°F. A complementary pair of samples were stored at 46°F. All samples in storage were handled similarly throughout except that potatoes in the 46°F storage were graded from the 1958-59 experiment in March after six months' storage.

At the end of the storage periods, data taken on the samples included specific gravity, weight of marketable U.S. No. 1 tubers, weight of sprouts and weight loss resulting from decay of tubers. Specific gravity of tubers from all plots was determined by a potato hydrometer

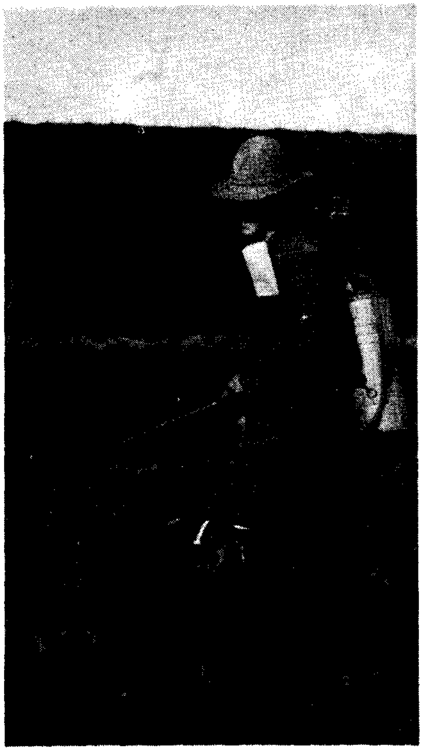

Figure 3.—All plots were treated in the same manner with a knapsack handsprayer.

(8). Readings were not taken prior to storage on samples to be stored unwashed since this would have been equivalent to partial washing. Instead, determinations were made on similar samples that were subsequently discarded. Conversion of specific gravity readings to per cent total solids was made from Von Scheele's table (7). Interpretation of the data was based on analysis of variance.

MH-40 CONTROLS SPROUTING

Potatoes from frosted vines that had been treated with MH-40 in 1955 kept well in storage. In August of 1956, when they were graded, MH treated samples were practically sprout-free whereas tubers from untreated vines were badly sprouted (Figure 4). The late application of September 12 did not control sprouting as well as the September 2 treatment. After grading and weighing from storage, the quantity of marketable potatoes expressed in hundredweight per acre for any MH treatments was as good as those not treated (Table 1). In addition tubers from MH treated plots were firmer than those from untreated vines. Total solids (a measure of starches, sugars and minerals) in the non-sprouting lots were not statistically different from those not treated.

Alaska 114 potatoes grown without MH sprout inhibitor in 1957 and stored at 46°F for ten months sprouted profusely as shown on the cover photograph. Tubers from vines treated with MENA sprouted as badly as tubers from untreated vines. None of the untreated or MENA treated tubers were firm enough to meet US No. 1 grade. Untreated samples from the 1958 crop stored for six months at 46°F lost 5.7 per cent of their weight to sprouts. Sprouting and weight lost to sprouts of the tubers from vines treated with CIPC (plus borax) were no better than untreated tubers. After desprouting, some tubers were shriveled too much to meet US No. 1 grade. Neither MENA nor CIPC as used in this study were effective in controlling sprouting.

On the other hand, MH treated

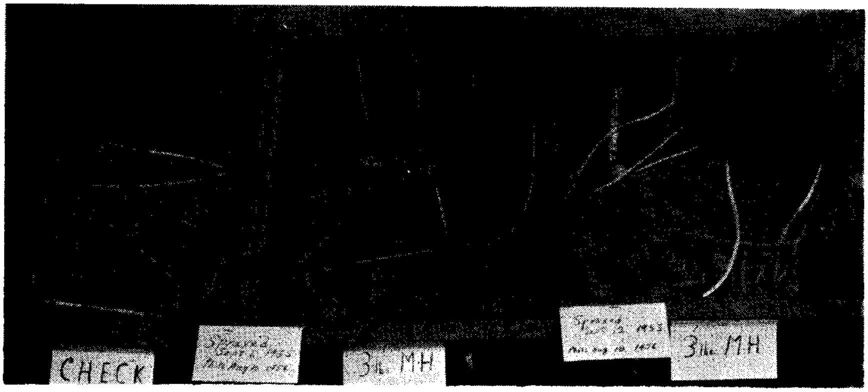

Figure 4.—Tubers in the two boxes on the right are from vines treated with 3 pounds of MH-40 after their tops had been partially frosted. Those in the center box from vines sprayed three days after the frost display effective commercial control. Potatoes from untreated vines in the left box are unmarketable. All three lots had been stored 10 months.

Table 1. Weight of marketable US No. 1 tubers and per cent solids in Green Mountain potatoes stored ungraded for 10 months after field treatment of the vines with MH-40, 1955.

Treatment	Date	Yield	Solids
Lbs/acre		Cwt/acre	Per cent
None		102	18.3
6.3	Sept 2	127	17.7
10.0	Sept 2	118	17.9
6.3	Sept 12	116	17.9
10.0	Sept 12	112	18.1

samples of all rates and dates of application were either free from sprouts or developed only short stubby sprouts or rosettes less than a quarter inch long. Sprouting was effectively controlled with MH foliar sprays in three different years and on two varieties, Green Mountain and Alaska 114.

Yield and grade in cwt of potatoes at harvest from vigorously growing plants that were sprayed with MH in 1957 and 1958 are presented in Table 2. Yields of MH treated plots did not significantly differ from the yields of untreated plots.

As in the 1955 study, US No. 1 tuber yields from treated plots were not significantly different from untreated plots. It is concluded that MH sprays applied between August 31 and September 16 at 6.3- or 10-pounds per acre did not reduce yields.

Potatoes stored ten months at 36° proved markedly superior to others stored at 46°F (Table 3). Of the unwashed, untreated tubers, 82 per cent of marketable tubers were recovered from the 36°F storage while no marketable tubers remained from untreated vines after 10 months of storage at 46°; all had sprouted so badly that they were not fit to be sold. In contrast unwashed and washed tubers from MH treated vines in 36° storage kept for ten months as well as or better than samples from untreated vines in both years. Washed samples from untreated plots in 1957 stored at 36° lost significantly more weight than tubers from treated plots. Washed samples of MH treated potatoes kept as well for ten months as unwashed lots.

When stored at 46° untreated samples began sprouting in about twelve weeks. They continued growing until they were graded, 6 or 10 months later. While it is well known that untreated potatoes can not be held at 46° for ten months, for comparative purposes they were retained in this study throughout the 1957-1958 storage period. Five months is as long as it is safe to gamble on storing untreated potatoes at 46°. On the other hand, tubers from vines treated with MH kept well at 46° for ten months when either unwashed or washed. The 1957 data shows some evidence indicating that the August 31 sprayings gave a higher percentage of marketable tubers after ten months of storage. Shriveling accounted for major grade-out losses. Washing did not appear to lower the keeping qualities of treated tubers.

Table 2. Yield response of Alaska 114 potatoes to pre-harvest foliar sprays of MH-40 in 1957 and 1958.

Treatment	Date	Total	US No. 1 Yield
Lbs/acre		Cwt/acre	
1957 crop year			
None		257	203
6.3	Aug 31	268	202
10.0	Aug 31	248	203
6.3	Sept 16	278	222
10.0	Sept 16	261	207
1958 crop year			
None		265	242
6.3	Sept. 3	262	234
10.0	Sept 3	268	245
6.3	Sept 12	256	232
10.0	Sept 12	267	246

MH-40 MAINTAINS TUBER QUALITY

Total solids in potatoes range from 15 to 25 per cent of their fresh weight, depending on variety, season and tuber maturity at harvest. Starch, sugar and minerals in tubers constitute their solids content. Measuring solids by specific gravity methods is a simple way of estimating composition or change in composition occurring as water transpires from tubers.

MH treatments did not reduce the dry matter content of tubers at harvest (Table 4). After the 1957 crop had been stored ten months the solid content of tubers from MH treated vines was significantly lower than for untreated tubers, indicating they had not lost much moisture through sprout growth. The contrast is particularly sharp in the 46° storage where after ten months tubers from untreated vines contained 23 per cent solids although solids accounted for 21.5 per cent of their bulk at harvest. These lots were unmarketable due to sprouting and shriveling. Untreated potatoes in the 1958 study showed slight moisture losses after ten months although those stored only six months at 46° remained unchanged.

Nearly every sample from MH treated plots retained their moisture content during storage. They did not sprout or shrivel. Tubers remained firm with good market appearance at the close of the storage period. Rate or date of spraying created no marked differences in moisture retention during prolonged storage. Possibly the most critical

Table 3. Marketable potatoes recovered from washed and unwashed tubers of MH-40 pre-harvest treated vines, as per cent of stored weight after storage at 36° and 46°F for the periods indicated. Values are means of four samples.

Treatment	Date	After 36° storage		After 46° storage	
		Unwashed	Washed	Unwashed	Washed
Lbs/acre		Per cent recovered			
1957 crop year					
Storage period		10 months		10 months	
None		82	68	0	0
6.3	Aug 31	93	96**	91**	86**
10.0	Aug 31	94*	93**	88**	90**
6.3	Sept 16	89	85**	78**	74**
10.0	Sept 16	83	83**	70**	88**
1958 crop year					
Storage period		10 months		6 months	
None		94	93	60	65
6.3	Sept 3	93	89	91**	91**
10.0	Sept 3	91	89	93**	90**
6.3	Sept 12	95	91	90**	83**
10.0	Sept 12	94	91	92**	83**

*Different from the untreated samples at the 5 per cent level and at the ** 1 per cent level of significance.

Table 4. Total solids in Alaska 114 potatoes at harvest, from vines sprayed preharvest with MH-40 at the indicated rates, and after storage at 36° and 46° F. Values are means of four samples.

Treatment	Date	When dug	After 36° storage Unwashed	After 36° storage Washed	When dug	After 46° storage Unwashed	After 46° storage Washed
Lbs/acre			Per cent recovered				
1957 crop year							
Storage period			10 months			10 months	
None		21.5	21.3	21.3	21.5	23.0	23.0
6.3	Aug 31	20.8	20.3**	20.4**	21.1	20.9**	21.5**
10.0	Aug 31	21.3	20.2**	20.6*	21.2	21.1**	21.1**
6.3	Sept 16	21.1	20.7	20.4**	21.0	21.5**	21.5**
10.0	Sept 16	21.2	20.2**	20.7*	21.1	21.1**	21.4**
1958 crop year							
Storage period			10 months			6 months	
None		24.3	24.5	24.7	—	24.3	24.0
6.3	Sept 3	24.5	24.1	24.3	—	23.7	23.4
10.0	Sept 3	24.2	24.1	23.6**	—	23.6*	23.6
6.3	Sept 12	24.2	24.1	24.2*	—	24.3	23.3*
10.0	Sept 12	24.1	23.9	23.6**	—	23.2**	23.1*

***Different from the untreated samples at the 5 per cent level and at the ** 1 per cent level of significance.**

test of performance is reflected by the unwashed 1958 MH 10-pound treatments of September 3 and 12 in the 46° storage. These samples retained significantly more moisture than untreated tubers, meaning that good sprout control and tuber firmness had been maintained.

Prestorage washing did not hasten sprouting and consequent moisture losses of tubers from treated vines. It did, however, improve the appearance of tubers as compared to those washed after storage.

Cooking tests indicate that Alaskan potatoes from vines treated with MH and stored at 46°F make satisfactory chips and french fries. Untreated potatoes can not be held long enough in warm storage to accomodate local processors without heavy losses due to sprouting and shriveling.

DISCUSSION

In Alaska's Matanuska Valley MH-40 gave satisfactory sprout control of potatoes when sprayed on either frosted vines or normal green vines. Sprout inhibiting sprays can be applied two or four weeks before harvest. If spraying has not been done before the vines are frosted, sprout control may be obtained if the treatment is applied within three days after vine frosting.

Sprays of MH applied in different years spanning the dates August 31 through September 16 gave satisfactory sprout control. Timing foliar sprays in relation to blossom drop — as has been recommended in other regions — is not practical in Alaska where varieties such as Kennebec and Norland drop their flower buds before they open.

Late applications do not reduce yields. Workers in other regions have found that proper timing of the spray is necessary to avoid loss of yield and still get sprout control.

The effect of different rates of MH-40 as applied in this study was not great or consistent. This probably means that either rate was more than that necessary to control sprouting.

The quality of potatoes from MH-40 sprayed plots was not reduced. On the contrary treated potatoes retained their market quality after being stored as long as ten months at 46°. Even when stored at 36° treated samples kept as well as or better than untreated lots.

Sprout inhibitor treated potatoes chipped well after being stored at 46° for six months. Shrinkage due to sprouting over this period was negligible. Other workers consider 50° more desirable than lower temperatures for holding potatoes that are to be processed into potato chips. Their work also shows that MH satisfactorily controls sprouting at 50°.

Washing MH treated potatoes prior to storage did not affect their keeping characteristics in either 36° or 46° storage. It did, however, markedly improve the appearance of the samples over unwashed tubers. If potatoes are washed prior to storage, surface water on the tubers must be removed so that they appear dry except where tubers rest upon one another.

Washing of freshly dug potatoes is not a common practice. Numerous advantages observed in the present study are worth considering, such as improved appearance, improved aeration of the bins, excellent bin condition for later use of volatile sprout inhibitors in storage, increased storage space for marketable tubers resulting from removal of culls, excess soil and trash, and the possibility of fluming the crop into storage with less damage than dumping potatoes on a conveyor belt.

SUMMARY AND CONCLUSIONS

Foliar sprays of MH-40 at 6.3 and 10-pounds per acre applied August 31 to September 16 gave good sprout control. Neither yields nor grade of Green Mountain and Alaska 114 potatoes were affected by MH-40 sprayed on the vines. Foliar applications of MENA and CIPC plus borax proved ineffective in preventing sprouting.

Foliar sprays of MH in 1955 applied three days after field frosting of tops prevented sprouting of potatoes in common storage for ten months. Such a practice seems worthwhile in emergencies when frosting occurs before spraying has been done.

Washing the crop prior to storage does not affect sprouting or keeping characteristics of tubers from MH treated vines.

The appearance of potatoes washed prior to storage was much better than of those washed after being stored dirty.

Both treated and untreated potatoes that later sprouted showed an apparent gain in dry matter content because of large water losses. Conversely, MH treated samples—well preserved through 6 and 10 months of storage — retained their moisture. Firmness and good market appearance are associated with relatively little change in dry matter and moisture content during storage.

Good quality potato chips were made from MH treated and untreated tubers stored six month at 46°F. Chips made from potatoes stored at 36°F for six months were too dark in color to be competitive with imported chips.

Evidence gathered in these studies shows that Alaska's high quality potato crop can be stored and maintained in good condition from crop to crop by reducing sprouting losses through application of a pre-harvest chemical foliar spray.

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